Appendix B
Supplemental Information and Additional Figures and Tables

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Abbreviations and Acronyms

°F	degree Fahrenheit
μPa	micropascal
$\mu Pa^2 s$	micropascal squared second
AMSL	above mean sea level
BA	Biological Assessment
BMP	best management practice
BOEM	Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
COP	Construction and Operations Plan
CPT	cone penetrometer testing
dB	decibel
dB re 1 μPa	decibels referenced to 1 micropascal
EEZ	Exclusive Economic Zone
EFH	essential fish habitat
EIS	Environmental Impact Statement
$ER_{95\%}$	95th percentile exposure-based range
ESA	Endangered Species Act
ESP	electrical service platform
ETRB	Engineering and Technical Review Branch
FMP	Fisheries Management Plan
h/D	water depth divided by pile diameter
HFC	high-frequency cetacean
HRG	high-resolution geophysical
IPF	impact-producing factor
kJ	kilojoule
LFC	low-frequency cetacean
LOA	Letter of Authorization
MA	Massachusetts
MFC	sound exposure level over 24 hours
NA	not applicable
NARW	North Atlantic right whale
NCDC	National Climatic Data Center
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf
OECC	offshore export cable corridor
Pa	pascal
PBR	potential biological removal
PK	peak sound pressure level
PPW	pinnipeds in the water
Project	New England Wind Project
PTS	permanent threshold shift
RI	Rhode Island
RI/MA Lease Areas	Rhode Island and Massachusetts Lease Areas
RI DEM	Rhode Island Department of Environmental Management
SEL	sound exposure level
SEL_{24h}	sound exposure level over 24 hours
S/h	scour depth divided by water depth
SPL	root-mean-square sound pressure level
SPUE	sightings per unit effort

SWDA	Southern Wind Development Area
TTS	temporary threshold shift
UME	unusual mortality event
USGS	U.S. Geological Survey
UXO	unexploded ordnance
VMS	vessel monitoring system
VTR	vessel trip report
WDA	Wind Development Area
WTG	wind turbine generator

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B Supplemental Information and Additional Figures and Tables

B.1 Environmental and Physical Setting

This appendix discusses the physical, geological, and biological settings in the vicinity of the New England Wind Project (proposed Project). In addition, it addresses potential impacts on these settings as determined from field and laboratory studies within the United States (mainly from the Block Island Wind Farm) and from outside the United States. Although projects in the United States may utilize larger monopile foundations and larger turbines than those used in the well-studied projects of the North Sea, the basic science behind how monopile size, water depth, currents, and waves interact to affect local hydrodynamics and create seabed scour and other effects are well understood and applicable to projects in the United States. The Bureau of Ocean Energy Management (BOEM) recently compared the long-term monitoring results from Europe to monitoring results from the first project in U.S. waters (the Block Island Wind Farm) and found that benthic scour at the Block Island Wind Farm was minor. BOEM has gathered the information in this document through direct outreach and dialogue with European regulatory agencies and private industry partners, as well as by reviewing both peer-reviewed and gray literature.

B.1.1 General Regional Setting

The proposed Project is located in southern New England and includes land areas in the Commonwealth of Massachusetts and adjacent nearshore and offshore waters. Figure B.1-1 shows the region surrounding the proposed Project.

The geologic history of the Atlantic coast of the United States is that of a passive margin, where the coastal mountains and continental sediments have been eroded over the millennia and deposited as thick layers of unconsolidated sediments in the Outer Continental Shelf (OCS). More recently in geologic time, periods of glaciation reworked, eroded, and deposited sediments along the northeastern Atlantic, leaving behind glacial formations offshore that include deep infilled channels, glacial moraine deposits, boulder fields, areas of highly consolidated sediments, and highly variable, heterogeneous conditions. Glacial moraines identified on the islands of Long Island (New York), Block Island (Rhode Island), Martha’s Vineyard (Massachusetts), and Nantucket Island (Massachusetts) roughly connect through a series of offshore moraine deposits. Glacial deposits are found in and around BOEM lease areas off the coast of Rhode Island and Massachusetts and lease areas offshore New York. In areas in and around the glacial moraines, sediments are expected to be generally coarser grained, highly variable, and consolidated with erratics such as boulders deposited both on the seabed and in the subsurface.

The proposed Project’s offshore cables would make landfall in south-central Cape Cod in Barnstable County. The Covell’s Beach Landfall Site would be located within the Town of Barnstable, the largest community on Cape Cod; the Town of Barnstable includes forests, wetlands, ponds, protected open space, public use areas, low- to medium-density residential development, and some commercial and industrial uses along major roads. The Town of Barnstable management plan prioritizes preserving the historic character of the area and preserving natural resources (Town of Barnstable 2010). The proposed Project would also include office, storage, and port facilities on Martha’s Vineyard. About 2 percent of Martha’s Vineyard is zoned for commercial or industrial use, 40 percent is preserved from development, and nearly all of the remaining land area is developed for residential uses (Martha’s Vineyard Commission 2010).

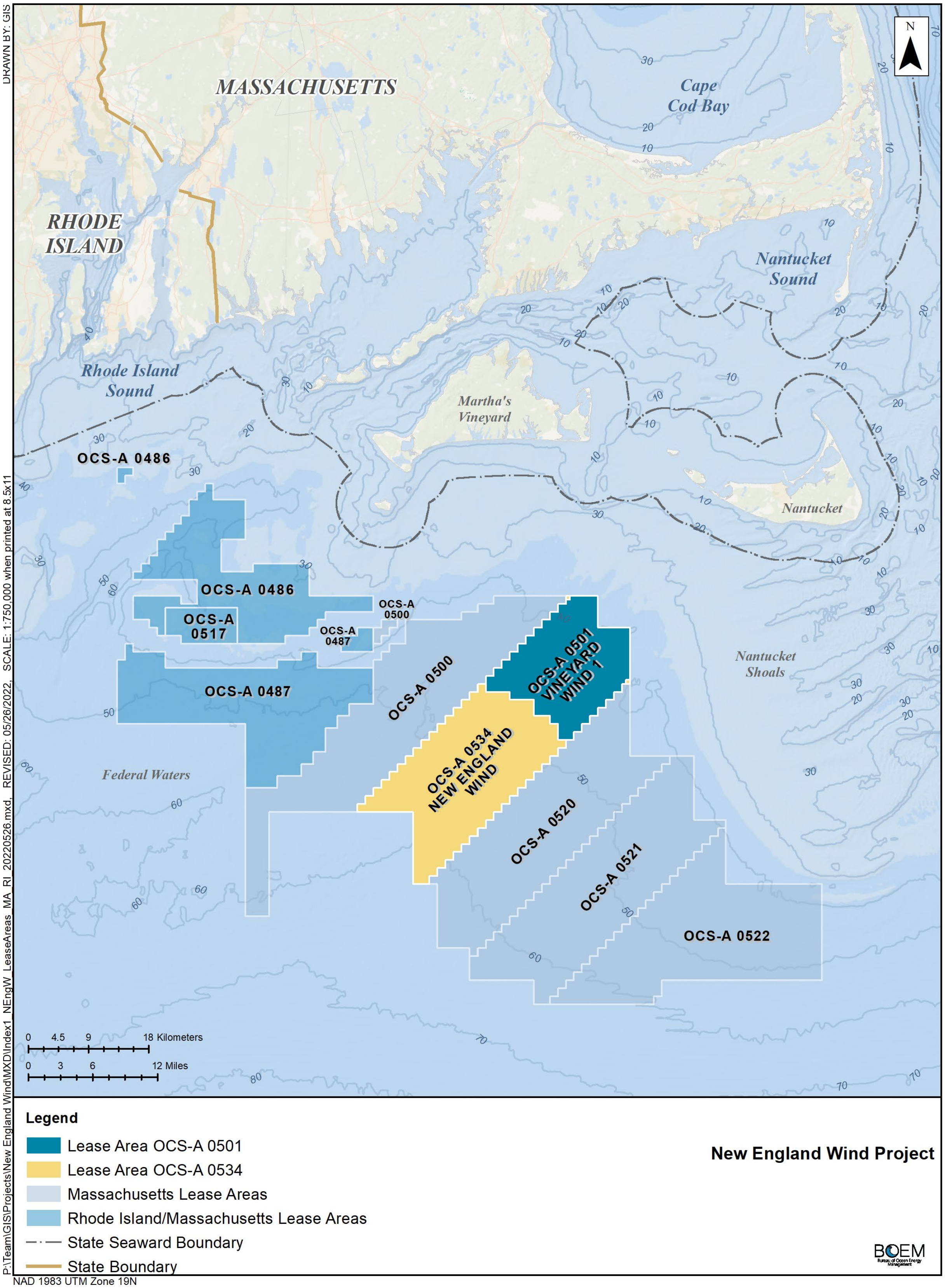


Figure B.1-1: Proposed Project Region

From the Cape Cod coast, the proposed Project would extend south/southwest through Nantucket Sound, pass between Martha's Vineyard and Nantucket via Muskeget Channel, and continue south offshore. Offshore waters in the proposed Project area would be located within the greater Georges Bank area (though not part of the bank itself) of the Northeast U.S. Continental Shelf Ecosystem. This ecosystem extends from the Gulf of Maine to Cape Hatteras, North Carolina (BOEM 2014). The Southern Wind Development Area (SWDA) and offshore export cable corridor (OECC) would be located within the southern New England subregion of the Northeast U.S. Continental Shelf Ecosystem, which is distinct from other regions based on differences in productivity, species assemblages and structure, and habitat features (Cook and Auster 2007).

B.1.2 Climate and Meteorology

Understanding atmospheric physical processes are vital to offshore wind energy development. National Oceanic and Atmospheric Administration (NOAA) buoys collect site-specific information on air and water temperature, wind speeds and direction, and air pressure via the National Data Buoy Center. Current and historical data is available to the public. NOAA satellites collect a wide variety of atmospheric data over much larger regions. Several lessees are already collecting site-specific data within their lease area(s) using specialized buoy systems to inform their project engineering designs. This data may also provide a baseline for comparison in the future.

The Atlantic seaboard is classified as a mid-latitude climate zone based on the Köppen Climate Classification System. The region is characterized by mostly moist subtropical conditions, generally warm and humid in the summer with mild winters. During the winter, the main weather feature is the nor'easter in the northeastern United States. During the summer, convective thunderstorms occur frequently. The Atlantic hurricane season runs from June 1 to November 30.

The Massachusetts climate is characterized by frequent and rapid changes in weather, large daily and annual temperature ranges, large variations from year-to-year, and geographic diversity. The National Climatic Data Center (NCDC) defines distinct climatological divisions to represent areas that are nearly climatically homogeneous. Locations within the same climatic division are considered to share the same overall climatic features and influences. The site of the proposed Project is located within the Massachusetts coastal division.

B.1.2.1 Ambient Temperature

According to NCDC data for the Massachusetts coastal division, the average annual temperature is 50.5 degrees Fahrenheit (°F), the average winter (December through February) temperature is 31.7°F and the average summer (June through August) temperature is 69.6°F, based on data collected from 1987 through 2019. Table B.1-1 summarizes average temperatures at the individual recording stations within the general area of the proposed Project. Data for some stations are reflective of different years of weather observations; however, the general pattern shows little difference across the listed locations.

Table B.1-1: Representative Temperature Data

Station	Annual Average °F	Annual Maximum °F	Annual Minimum °F
Coastal Division	50.5	59.2	41.8
Nantucket	50.7	57.6	43.9
Martha's Vineyard	51.2	59.1	43.2
Hyannis	51.1	58.8	43.4
Buzzards Bay Buoy	50.4	NA	NA
Nantucket Sound Buoy	52.4	NA	NA

Sources: NOAA 2019a (Coastal Division 2019 data; Nantucket 2019 data; Martha's Vineyard 2019 data; Hyannis 2019 data), 2019b (Buzzards Bay Buoy 2009–2019 data; Nantucket Sound Buoy 2009–2019 data)

°F = degrees Fahrenheit; NA = not applicable

B.1.2.2 Wind Conditions

Table B.1-2 summarizes wind conditions in the Massachusetts coastal division. Table B.1-2 shows the monthly average wind speeds, monthly average peak wind gusts, and the hourly peak wind gusts for each individual month. Data from 2009 through 2019 show that monthly wind speeds range from a low of 11.97 miles per hour in July to a high of 17.02 miles per hour in January. The monthly wind peak gusts reach a maximum during November at 21.23 miles per hour. The 1-hour average wind gusts reach a maximum during October at 64.65 miles per hour.

Table B.1-2: Representative Wind Speed Data

Month	Monthly Average Windspeed (miles per hour)	Monthly Average Peak Gust (miles per hour)	Peak 1-Hour Average Gust (miles per hour)
January	17.02	20.97	61.29
February	15.77	19.35	63.53
March	15.91	19.44	64.42
April	14.90	18.12	49.21
May	13.14	15.89	58.16
June	12.31	14.93	44.52
July	11.97	14.49	57.04
August	12.48	15.14	59.95
September	13.92	17.08	51.90
October	16.45	20.40	64.65
November	17.01	21.23	57.71
December	15.99	19.84	59.50

Source: NOAA 2019b (National Data Buoy Center, Nantucket Sound Station 44020, 2009–2019)

Throughout the year, wind direction is variable. However, seasonal wind directions are primarily focused from the west/northwest during the winter months (December through February) and from the south/southwest during the summer months (June through August). Figure B.1-2 shows a 5-year wind rose for Buoy Station 44020 (Nantucket Sound). Wind speeds are in meters per second. Percentages indicate how frequently the wind blows from that direction.

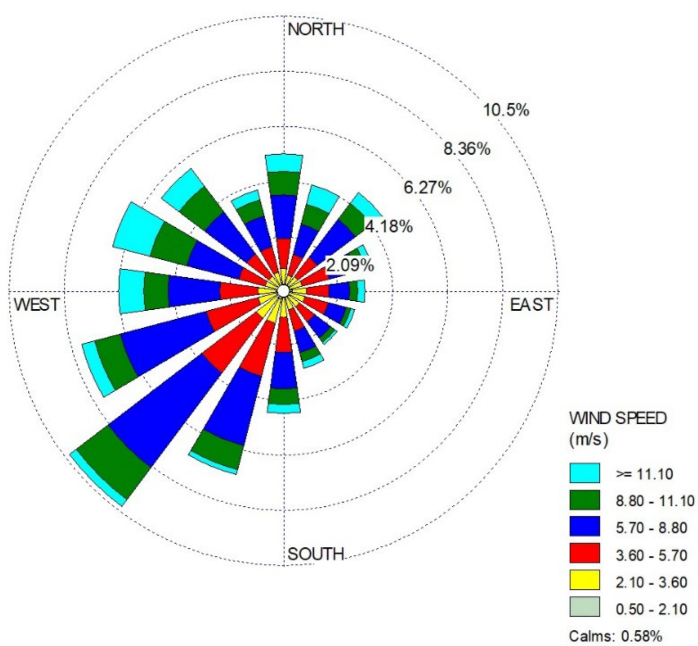


Figure B.1-2: 5-Year (2015–2019) Wind Rose for Buoy 44020

B.1.2.3 Precipitation and Fog

Data from NCDC show that the annual average precipitation is 49.75 inches in the Massachusetts coastal division. Table B.1-3 shows monthly variations in average precipitation, which range from a high of 5.59 inches for October to a low of 3.30 inches in May.

Table B.1-3: Representative Monthly Precipitation Data (2009–2019)[a]

Month	Average Precipitation (Inches)
January	4.04
February	3.86
March	4.67
April	4.14
May	3.30
June	4.20
July	3.72
August	3.67
September	3.56
October	5.59
November	4.15
December	4.87
Annual Average	49.75

Source: NOAA 2019a

[a] Precipitation is recorded in melted inches (snow and ice are melted to determine monthly equivalent). Data are representative of the Massachusetts coastal division.

Snowfall amounts can vary quite drastically within small distances. Data from the Martha's Vineyard Station shows that the annual snowfall average is approximately 23 inches, and the month with the highest snowfall is February, averaging around 8 inches.

Fog is a common occurrence along coastal Massachusetts. Fog is especially dense across the water south of Cape Cod toward the islands of Martha's Vineyard and Nantucket. Fog data were collected from 1997 to 2009 at the BUZM3 meteorological station in Buzzard's Bay, approximately 25 miles from the proposed Project site; and from 2007 to 2009 at the Martha's Vineyard Coastal Observatory meteorological station 2 miles south of Martha's Vineyard (Merrill 2010). The data show that fog is most common in the proposed Project area during the months of June, July, and August, with a typical range of 6 to 11 days per month with at least 1 hour of fog. In the winter, fog is much less frequent, with 3 or fewer days with at least 1 hour of fog.

The potential for icing conditions (i.e., atmospheric conditions that can lead to the deposition of ice from the atmosphere onto a structure) was also predicted based on data collected at the BUZM3 tower (Merrill 2010). Icing is rare when the water temperature is greater than 43°F, so in most months of the year and for many days during the winter months, there is no potential for icing to occur. The data show that moderate icing (defined by the Federal Aviation Administration as a rate of accumulation such that short encounters become potentially hazardous) is unlikely to occur more than 1 day per month, while the potential for light icing is above 5 days per month in December, January, and February. Icing would be unlikely to occur any time from April through October.

B.1.2.4 Hurricanes

During the 160 years for which weather records have been kept, ten hurricanes have made landfall in Massachusetts and five others have passed through the SWDA without making landfall. The latest hurricane that made a direct landfall was Hurricane Bob in 1991. Of those ten hurricanes, five ranked as Category 1 on the Saffir-Sampson Scale, two were Category 2 hurricanes, and three were Category 3 hurricanes. Since records have been kept, no Category 4 or 5 hurricanes have made landfall in

Massachusetts. Of the hurricanes that passed through the SWDA without making landfall in Massachusetts, one was Category 2, one was Category 1, and three were tropical storms when they passed through the SWDA. The most recent of these storms was Beryl in 2006. NOAA 2019c defines the winds speeds and typical damage associated with each category of hurricane.

In addition to hurricanes, Nor'easters (cold-core extratropical cyclones) may occur several times per year in the fall and winter months. Wind gusts during the strongest Nor'easters can cause similar damage to a Category 1 hurricane, although Nor'easters typically are larger and last longer than hurricanes.

B.1.2.5 Mixing Height

Table B.1-4 presents atmospheric mixing height data from two nearby stations. As shown Table B.1-4, the minimum average mixing height is 1,276 feet, while the maximum average mixing height is 4,662 feet. The minimum average mixing height is much higher than the height of the top of the proposed rotors (1,171 feet).

Table B.1-4: Representative Seasonal Mixing Height Data

Season[a]	Data Hours Included[b]	Nantucket Average Mixing Height (feet)[c]	Chatham Average Mixing Height (feet)[c]
Winter	Morning – no precipitation hours	2,559	2,192
	Morning – all hours	2,969	2,149
	Afternoon – no precipitation hours	2,595	2,539
	Afternoon – all hours	2,920	2,451
Spring	Morning – no precipitation hours	1,929	2,234
	Morning – all hours	2,408	2,178
	Afternoon – no precipitation hours	2,448	3,996
	Afternoon – all hours	2,713	3,642
Summer	Morning – no precipitation hours	1,276	1,867
	Morning – all hours	1,470	1,864
	Afternoon – no precipitation hours	1,998	4,662
	Afternoon – all hours	2,188	4,249
Fall	Morning – no precipitation hours	2,051	1,857
	Morning – all hours	2,425	1,913
	Afternoon – no precipitation hours	2,510	3,399
	Afternoon – all hours	2,726	3,100
Annual Average	Morning – no precipitation hours	1,952	2,034
	Morning – all hours	2,320	2,028
	Afternoon – no precipitation hours	2,385	3,678
	Afternoon – all hours	2,638	3,373

Source: MMS 2009

[a] Winter = December, January, February; Spring = March, April, May; Summer = June, July, August; Fall = September, October, November

[b] Missing values not included

[c] Data from MMS 2009

B.1.2.6 Potential General Impacts of Offshore Wind Facilities

A known impact on the atmospheric environment as a result of offshore wind facilities is the wake effect. The presence of a wind facility extracts energy from the free flow of wind, creating a "wake" downstream of the facility. The resulting "wake effect" is the aggregated influence of the wake on the available wind resource and the energy production potential of any facility located downstream. Christiansen and Hasager (2005) observed offshore wake effects from existing facilities via satellite with synthetic aperture radar to last anywhere from 1.2 to 12.4 miles depending on ambient wind speed, direction, degree of atmospheric stability and the number of turbines within a facility. During stable atmospheric conditions, these offshore wakes can be longer than 43.5 miles.

A less understood impact is the formation of a microclimate. Past modeling studies suggest a change in temperature and moisture downwind of offshore wind energy facilities. From September 2016 to October 2017, a study using aircraft observations accompanied with mesoscale simulations provided a look into the spatial dimensions of micrometeorological impacts from a wind energy facility in the North Sea (Siedersleben et al. 2018). Large offshore wind facilities can potentially have an impact on the local microclimate. However, this potential is fairly low because very specific conditions must be met for the impact to occur. The local redistribution of moisture and heat due to rotor-induced vertical mixing has no influence on the local climate outside of the immediate vicinity of a wind facility. Only a permanent change in the air-sea interactions could change the local climate. For example, warmer air over a cold ocean would result in an increased heat transfer to the ocean, thereby causing more water vapor transport into the atmosphere because of the dryer air within the wake of a turbine/facility. Such events are rare because they can only occur when there is a strong increase in temperature with altitude at or below hub height to create the warming and drying within the wake of large offshore wind energy facilities. The increase of temperature with height is an inversion, better explained as a reversal of the normal decrease of air temperature with altitude. These specific conditions are not likely to occur off the south coast of Massachusetts.

B.1.3 Geology and Seafloor Conditions

B.1.3.1 Historical Formation

The continental shelf off the U.S. Eastern Seaboard and New England today resides on a passive continental margin with minimal tectonic and seismic activity. Prior to this relatively quiescent period, numerous orogenies (continental plate collisions) hundreds of millions of years ago produced the multiple mountain chains that are prominent on the present landscape, including those of the Appalachian (Blue Ridge, Allegheny, Catskill, Berkshire, Green, and White Mountains) and Adirondack systems. Weathering and erosion from various geologic processes have supplied sediment from the bedrock-based mountains and piedmont to the coastal plain regions sloping down toward the Atlantic Ocean. The sediment forms a wedge that thickens toward the sea and is modified by fluvial, estuarine, and coastal processes, as well as sea level rise at lands' edge. In more recent times, a series of glaciations during the Quaternary period (starting approximately 2.6 million years ago) has greatly modified the landscape in the northern latitudes of the United States, scouring, transporting, and depositing materials along the glaciers' paths, with results of the latest Wisconsin glacial stage (110,000 to 11,700 years ago) being the most evident.

Prior to Quaternary glaciation in southern New England, an extensive coastal plain consisting of Tertiary (now Neogene and Paleogene) and Cretaceous rocks and semi-lithified sediments extended seaward from Cape Cod to at least the location of present-day Martha's Vineyard and Nantucket Island, if not farther south. Sea level then varied with glacial and inter-glacial periods from well below to significantly above present-day elevation. During glacial episodes, a mature fluvial drainage system dissected the coastal plain, eroding and transporting sediment southward, while marine sediments accumulated during inter-glacial periods.

B.1.3.2 Current Seafloor Conditions

A wide range of current seabed conditions persist that are a direct result of these historical geologic events. Past geologic processes shaped the stratigraphic foundation of the continental shelf, the upper layers of which have been subsequently reworked during sea level rise by currents, waves, and storms. A limited supply of terrigenous sediment exists in the region, so the surficial sediment layer is primarily sourced from older underlying glacial deposits. A direct correlation between grain size and bottom current velocities is evident moving in the onshore-to-offshore direction, from the strong tidal components in and around Nantucket Sound to the open water, general shelf circulation south of the islands. Where very high current velocities exist in the Nantucket Sound region, abundant bedforms rework the sandy surficial layer, and in highly erosive areas only the coarsest material (gravel, cobbles, boulders) persists (Baldwin et al. 2016; Poppe et al. 2012). Sediment types and bedforms in the SWDA are indicative of post-glacial material mixed with upper continental shelf deposits. These deposits consist primarily of medium- to fine-grained material (sand, silt, clay) that has been winnowed from glacial drift by marine and fluvial processes (Baldwin et al. 2016).

Marine scientific data acquired from five seasons of offshore survey programs have been analyzed to provide information on existing site conditions in the SWDA. Table B.1-5 and B.1-6 provide data and results related to geological resources in the SWDA and OECC, respectively.

Table B.1-5: Geological Survey Data and Results in the Southern Wind Development Area

Data/Results	Summary
Data	• > 12,328 miles of geophysical trackline data • 8 deep boreholes • 56 deep downhole CPTs • 210 seabed CPTs • 187 vibracores • 96 benthic grab samples with still photos • 36 underwater video transects
Surface conditions	• Water depths 141 to 203 feet, offshore slope of < 1 degree toward the south-to-southwest • Minimal seafloor topography, minimal relief • Generally homogenous surficial sediments, varying percentages of sand and silt • Irregular, northeast-to-southwest bathymetric lows up to 16.4 feet deep • Rippled scour depressions 0.7 to 3.3 feet deep with lateral extents ranging from tens to hundreds of feet; contain ripple bedforms < 1.0 foot high and wavelengths 1.6 to 9.8 feet; slopes at edges of ripple scour depressions up to 6 degrees • Benthic habitats of uniform, unconsolidated sediment • Trawler drag marks on the seafloor indicate some fishing • Very few human-made objects (mostly fishing gear and debris); two possible shipwrecks identified in the SWDA
Subsurface conditions	• Consistent stratigraphy underlying the site • Materials range from clay to gravel, with isolated coarse material • Discontinuous coarse deposits associated with lag deposits with possible isolated boulders • Abundant channeling apparent throughout, few other structures • Ravinement surface 3.3 to 19.7 feet below the seafloor • Magnetic variability in localized areas associated with strong sub bottom reflectors in the upper 6.6 to 23.0 feet, likely associated with natural ferrous-rich deposits
Hazards	• Paleochannels throughout the SWDA, often with gravels at the base of the channel and clays to sands on the channel margins • Peat/organic material in paleochannels scattered throughout SWDA • Boulders possible in subsurface throughout the SWDA, patchy and scattered, approximately 33 to 302 feet below the seabed • Weakly cemented beds are possible throughout the SWDA at depths below 105 feet below the seabed • Two possible wreck sites identified in the western portion of the SWDA

Source: COP Volume II-A, Table 6.0-1; Epsilon 2022

CPT = cone penetrometer testing; SWDA = Southern Wind Development Area

Table B.1-6: Geological Survey Data and Results in the Offshore Export Cable Corridor

Data/Results	Summary
Data	• > 3,921 miles of geophysical trackline data over a 2,182- to 5,479-foot-wide corridor • 2 deep bore holes • 3 deep downhole CPTs • 134 seabed CPTs • 192 vibracores • 163 benthic grab samples with still photos • 119 underwater video transects
Surface conditions	• Water depths < 3.6 to 150.9 feet; local slopes up to 25 to 30° on bedforms • Numerous natural slopes/topography, < 10-degree gradients • Overall homogenous surficial sediments, mainly sand • Mobile surface layer with sand waves > 6.6 feet high locally • Sand with some gravel, cobbles in shallow, higher current areas • Localized concentrations of boulders with gravel and sand in the northern portion of the OECC • Sand with silt in deeper water areas, less tidal current • Soft surficial layer (biogenic sediments) offshore in deeper water, immediately seaward of the offshore slope south of Muskeget in depths of 82 to 98 feet • Variable benthic habitats due to different substrates; some sensitive habitats possible locally • Rippled scour depressions offshore, bedform fields with isolated, larger sand waves over 16.4 feet in Nantucket Sound • Coarse deposits with boulders in Muskeget Channel area • Overall low concentration of manmade objects with moderate concentration locally • Sediments relatively consistent, sand with coarse material particularly in higher current areas and silt in deeper and quiescent locations
Subsurface conditions	• Abundant buried channels north of Horseshoe Shoal; no unusual sediments of concern identified • Fine-grained, organic-rich layers associated with channel bank/terrace deposits adjacent to some paleochannels • Often acoustically transparent mobile sand layer • Coarse deposits with boulders in Muskeget Channel area
Hazards	• Large sand waves in some areas • Paleochannels with top sections in the upper 6.6 feet; all sediments sampled by geotechnical investigations and pose no threat to cable installation • Localized subsurface gas in Centerville Harbor; no issue for cable installation • Coarse deposits with boulders in Muskeget Channel area • Possible sensitive habitats for avoidance, if possible, mainly Muskeget area • Isolated manmade objects in the corridor, one debris pile/possible shipwreck in the OECC, approximately 6.8 miles southwest of Craigville Beach; one unidentified buried possible cable is located southeast of Martha's Vineyard

Source: COP Volume II-A, Table 6.0-2; Epsilon 2022

CPT = cone penetrometer testing; OECC = offshore export cable corridor

Marine geological resources in this region are very stable on the scale of a human lifetime, except for surficial sediments, which can be dynamic. Surficial sediments, especially clays/muds, silts, and sands are subject to movement by currents driven by tides, storms, and broad-scale circulation patterns. While most of the OECC is very stable, the seafloor running from just south of Martha's Vineyard and Nantucket to north of Horseshoe Shoal in Nantucket Sound is a dynamic environment characterized by highly mobile bedforms, deep (greater than approximately 131 feet) tidal channels, and patches of exposed coarse material (i.e., boulders, cobbles, and gravels derived from glacial till). Volume II-A, Section 2.0 of the Construction and Operations Plan (COP) presents conditions relevant to geological resources (Epsilon 2022). Human activities have the potential to alter sediment structure, slope, and particle size distribution patterns; coastline morphology; exposed or buried channel morphology; patterns of erosion, sediment transport, and deposition; sediment chemical characteristics; weathering processes; surface movements (e.g., landslides); and the shape, structure, and strength of bedrock, as well as physically extract geological resources through mining.

Very homogenous seafloor conditions exist in offshore areas, dominated by fine sand and silt. Water depths range from 114.8 to 170.6 feet over a gently sloping seafloor that dips toward the south/southwest. There is a distribution of localized patches of ripples and sand waves throughout the area. These features represent the only vertical relief in an otherwise relatively flat, featureless seafloor that slopes gradually offshore. These features range from 32 to 656 feet wide by 328 to 1,640 feet long but may exceed 3,280 feet in length. These features are typically less than 3.3 feet in height but can reach up to 22.9 feet.

Seafloor features that are stable and exhibit vertical relief provide a significant rare habitat amidst the broad sand flats. Such habitats include gravel or pebble-cobble beds, sand waves, biogenic structures (e.g., burrows, depressions, sessile soft-bodied invertebrates), shell aggregates, boulders, hard-bottom patches, boring sponge (*Cliona celata*) beds, and cobble beds with and without sponge cover. These coarser substrates provide complex interstitial spaces for shelter and generally exhibit greater faunal diversity. Other special, sensitive, and unique habitats (living bottom, hard/complex bottom, eelgrass beds, and marine mammal habitats) occur in places in and near the proposed Project (COP Volume II-A, Section 5.2; Epsilon 2022).

The seafloor near Muskeget Channel is particularly complex, being composed mostly of sand, but with a variety of slopes, contours, and sand wave dimensions (COP Volume II-A, Section 2.1; Epsilon 2022). This area also includes a significant amount of hard/complex bottom habitat, as well as boulders that are buried shallowly and could be exposed by shifting sands. Water depths in the Muskeget Channel area range from 0 to 100 feet, with the main part of the channel lying mostly between 23 and 65 feet. The seafloor in the proposed OECC is primarily a flat bed of sand and silt, but it includes sparse small patches of minor vertical relief, as well as several eelgrass beds nearby. Water depths in the proposed OECC, which the applicant has routed to avoid shoals and eelgrass beds, are around 40 to 50 feet for most of the route, becoming gradually shallower over the final 2 miles approaching land.

Seafloor habitats can also be classified more broadly as biogenic structures, hard bottom, complex seafloor, and other, which would include the majority of flat sand and mud habitat in the SWDA and OECC (Epsilon 2018). Hard bottom in the OECC typically consists of a combination of coarse deposits such as gravel, cobble, and boulders in a sand matrix. These coarse deposits form a stable surface over which sand waves forced by tidal currents periodically migrate. Certain hard-bottom areas also include piles of exposed boulders, but no bedrock outcrops are present in the OECC or SWDA. Complex seafloor in the OECC and SWDA consists of bedforms such as rugged fields of sand waves; although these mobile features are less amenable to benthic macroinvertebrates, they may be attractive to finfish. Figures 3.5-2 through 3.5-6 in Section 3.5, Coastal Habitats and Fauna, delineate these seafloor areas.

The proposed Project would be located south of Cape Cod in the Atlantic Ocean and Nantucket Sound, where the physiographic regions known as the Seaboard Lowland section of the New England Province and the Atlantic Coastal Plain Province meet. The proposed Project would straddle these two physiographic regions. The Lowland, which includes part of the continental shelf, is a broad belt that extends from south of Rhode Island northeast to central Maine. Erosion and deposition related to glacial processes produced numerous changes in drainage patterns and observed topography over geologic time. The land formations in the Coastal Plain are low relief and are composed of a wedge of unconsolidated sediments that overlay much older consolidated rock. The north bounds of the Coastal Plain run from the north side of Long Island through Rhode Island Sound to Martha’s Vineyard. Offshore water depths generally range from approximately 131 to 262 feet, with some areas as shallow as 65 feet. North of Martha’s Vineyard, Nantucket Sound exhibits water depths mostly around 40 to 50 feet, with several shallower shoals, and it generally becomes shallower as one approaches Cape Cod. The sea has also influenced landforms in this region, creating barrier spits and longshore accretions of sandy beaches with the prevailing currents (Fenneman 1938; Denny 1982; Oldale 1992).

Geology and seafloor conditions are a fundamental factor determining whether a potential site could support wind turbine foundations. The major possible factors relating to a seafloor failing to support a pile-driven wind turbine generator (WTG) or other marine structure are liquefaction due to earthquakes or wave action, seafloor suitable for foundation type (monopile), soil cohesion and soil strength, repeat loading (structural), inadequate damping (structural), sediment transport and sand waves, and scour.

Liquefaction is a process in which solid material behaves as a liquid. Earthquakes can produce vibrations that interact with soil particles in such a way that they become suspended while agitated by that energy. While the soil particles are suspended, they behave like a liquid, allowing structures attached or imbedded into the seafloor to sink or tip over. The frequency at which this phenomenon can occur is related to the frequency and intensity of earthquake activity within an area, the composition and depth of the soil, and the underlying stratigraphy of the area. To a lesser degree, wave action can also create shallow liquefaction effects depending on wave and sediment characteristics.

Foundation types for particular offshore wind projects are selected based on the seafloor's characteristics. Seafloor conditions that may be challenging for one foundation type may be well suited for another. Structures that are pile driven into the seafloor are designed to be sited in locations where there is ample loose sediment to allow for it. For these foundation types, some amount of rocks or boulders intermixed within the sediment can be tolerated through avoidance, micro-routing, or drilling, and the depth a pile is driven can be increased to accommodate for looser sediments. For other types of foundations and engineering strategies, rocky seafloor conditions are preferable.

Soil cohesion is how strongly bound together soil particles are, and soil strength is the amount of shear stress a soil can sustain. The underlying layers, types, and depths of soils of a seafloor affect how much strength and stiffness are exhibited by the soil. The particles that make up soil vary in compactness, size, and abundance. Material with different proportions of particle sizes will have different properties. If a seafloor is composed of material that lacks cohesion and soil strength, it may deform or displace around the structure under the forces of pile installation.

Repeat loading refers to repeated, externally applied forces on a structure. Changes in environmental conditions created by wind and wave forces can vary in direction, intensity, and duration. This repeat loading can have a cumulative impact on a structure's ability to stand and must be accounted for within the design of the structure.

Damping is the suppressing of energy or decrease in swaying or swinging. Inadequate damping is when forces are able to create enough movement that can affect the function or integrity of a structure. Structures sway from receiving energy from dynamic wind and wave forces. These oscillations can become amplified over time if they are not mitigated through damping and can potentially compromise the structure. Damping can be done by increasing the size and depth of the foundation and adding components to the structure that act to mitigate or negate loading by absorbing and counter-acting the oscillation.

Sediment transport is the movement of sediment, typically due to a combination of gravity acting on the sediment and/or movement of the water with sediment particles in it. Sand waves are ridge-like structures that are formed by waves or currents of the water. Typically, sand waves are not static. They are migrating bedforms and evidence of active sediment transport.

Scour is the removal of sediment, such as silt, sand, and gravel, from around the base of obstructions due to a current's flow in the sea. An obstruction in a waterbody that is moving may cause flow changes, including higher or lower velocities around the obstructions. Foundations installed in the seabed are subject to scour around the base of the structure where it contacts the seabed.

To determine whether the seafloor can support WTGs, geologic surveys are performed. Geologic surveys can be broadly divided as either physiographic or geotechnical. Physiographic, also known as geophysical, surveys involve passive or remote techniques that provide information about the surface and near-surface of the seafloor, without physically contacting it. Examples of these physiographic surveying techniques include hydrographic, bathymetric, sonar, and magnetometer surveying. Geotechnical surveys physically sample and penetrate the seafloor. These are the surveys that provide the information most pertinent to the ability of the seafloor to support a given type of foundation design. Two types of geotechnical surveys, boring and vibracore, are techniques that extract material from below the seafloor that can have their composition and characteristics analyzed in a laboratory. Cone penetration tests provide information about the layers of material under the seafloor surface, including bearing capacity and soil strength of the sediment, by measuring the pressure and resistance as the instrument is driven into the seafloor. Benthic grabs directly pick up sediment samples at the surface of the seafloor. All these direct samplings and measurements provide input to computer modeling that engineers use to assess the ability of the seafloor to support WTGs.

When selecting the foundation type and design for a wind energy project, water depth and the underlying material of the seafloor are some of the most important considerations. Structural problems can be avoided by matching foundation design to site characteristics. The most widely used foundation type is a monopile that is driven into the seafloor in locations with sufficiently thick sediment above the bedrock, few boulders, and less than 100 feet water depth.

Foundations and towers are among the least likely WTG components to require repair or replacement. An analysis of several European offshore wind facilities during the first 10 years of operations was conducted, which included hundreds of WTGs between 2 to 4 megawatts in size of varying ages (Carroll et al. 2016). At the time the study was published, approximately 80 percent of all offshore wind foundations in European waters were monopiles (EWEA 2016). Failure rates of component groups in the study were examined as a combination of replacements, minor repairs, and major repairs per turbine each year. The study found that the replacement rate of a single foundation and tower was 0.0, indicating there was no occurrence of a foundation and tower failing to stand during this time frame. Foundations and towers had a combined repair rate of 0.181 per year. Repairs to the foundation and tower are among the quickest and cheapest relative to the other WTG component categories (Carroll et al. 2016). A review of cable failures found an average failure rate for offshore alternating current cables of approximately 0.003 failure per kilometer per year (Warnock et al. 2019).

Physiographic and geotechnical surveys have explored the subsurface geological conditions in the proposed SWDA and OECC (COP Volume II-A, Section 2.1.2.2, Epsilon 2022). BOEM's Engineering and Technical Review Branch (ETRB) has reviewed all the geophysical and geotechnical information provided in the New England Wind Project COP and other data submissions from Park City Wind, LLC (the applicant). ETRB concurs with the applicant's conclusion that fixed bottom foundations, as described in the COP, are technically feasible and safe for WTG and electrical service platform (ESP) installations to a depth below the seafloor of up to 279 feet (for pin piles). If the COP is approved and the applicant intends to install foundations beyond these depths, further information from the applicant would be required with the facility design report and fabrication and installation report. This information would then be evaluated by ETRB prior to allowing the installation of components beyond the above stated depths.

If the COP is approved, the applicant must then submit a facility design report and a fabrication and installation report. The facility design report provides specific engineering details of the design of all facilities, including structural drawings, environmental and engineering data, a complete set of calculations used for design, proposed Project-specific geotechnical studies, and a description of loads imposed on the facility. The facility design report must demonstrate that the design conforms to the responsibilities under the lease. The fabrication and installation report describes how the facilities would be fabricated and installed in accordance with the design criteria identified in the facility design report, the COP, and generally accepted industry standards and practices. Both of these reports must be reviewed and certified by a BOEM-approved third-party certified verification agent prior to submittal. BOEM has 60 days to review these reports and provide objections to the applicant. If BOEM has no objections to the reports, or once any BOEM objections have been resolved, the applicant may commence construction of the proposed Project.

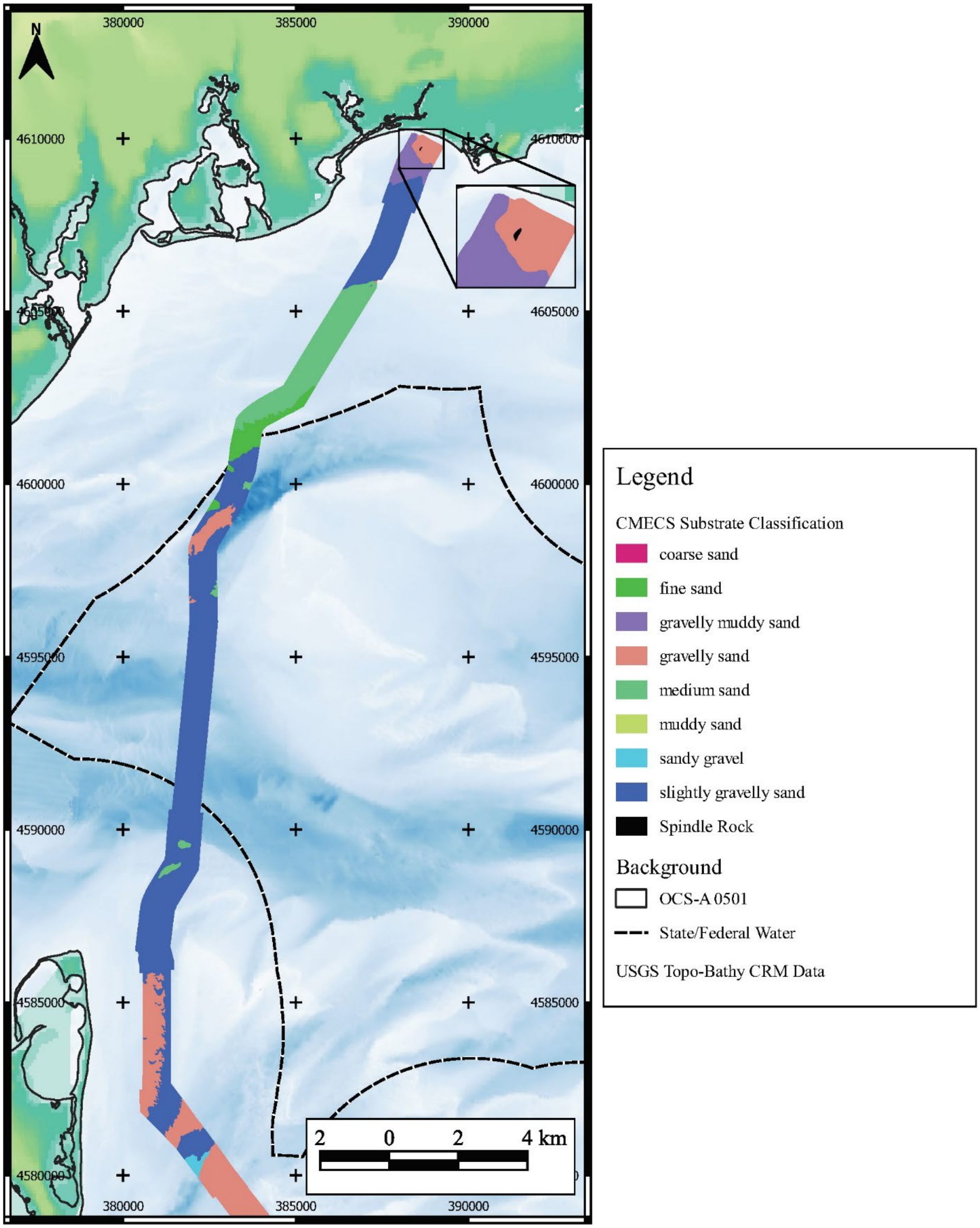
Seafloor conditions can also be described according to the Coastal and Marine Ecological Classification Standard substrate component, which classifies seafloor types based on the composition and particle size of the surface layers of the substrate (FGDC 2012). Maps delineating seafloor conditions according to Coastal and Marine Ecological Classification Standard substrate classifications, based on the results of a 2018 survey reported in Attachment E of Epsilon 2018 (as cited in Vineyard Wind 2020), are shown on Figures B.1-3 and B.1-4.

B.1.3.3 Potential General Impacts of Offshore Wind Facilities

Scour, turbidity, and sedimentation are all conditions related to the strength of oceanographic forces, geologic conditions, and sediment processes. Scour occurs when the oceanographic forces are strong enough to mobilize the local sediments away from their current location, without additional sediments being added to the system to replace the mobilized sediments. Turbidity occurs when either sufficient force is present to mobilize sediments from the seabed into the water column, or additional sediments are being put into the system in such a way that they remain suspended for a period of time. Turbid conditions would remain as long as the particles are suspended in the water column. Lastly, sedimentation occurs when the oceanographic conditions are not strong enough to mobilize sediments, and additional sediments are actively being deposited.

Geologic conditions heavily influence the feasibility and technical complexity of installing and operating offshore wind facilities. Geologic conditions such as sediment uniformity, density, and grain size can contribute to the potential for an installation or facility to have occurrences of scour, turbidity, and/or sedimentation. The presence of bedforms, such as ripples and sand waves, indicate local oceanographic forces are mobilizing surficial sediments, and a lack of fine sediment indicates current and tidal forcing can be strong enough to remove smaller sized particles.

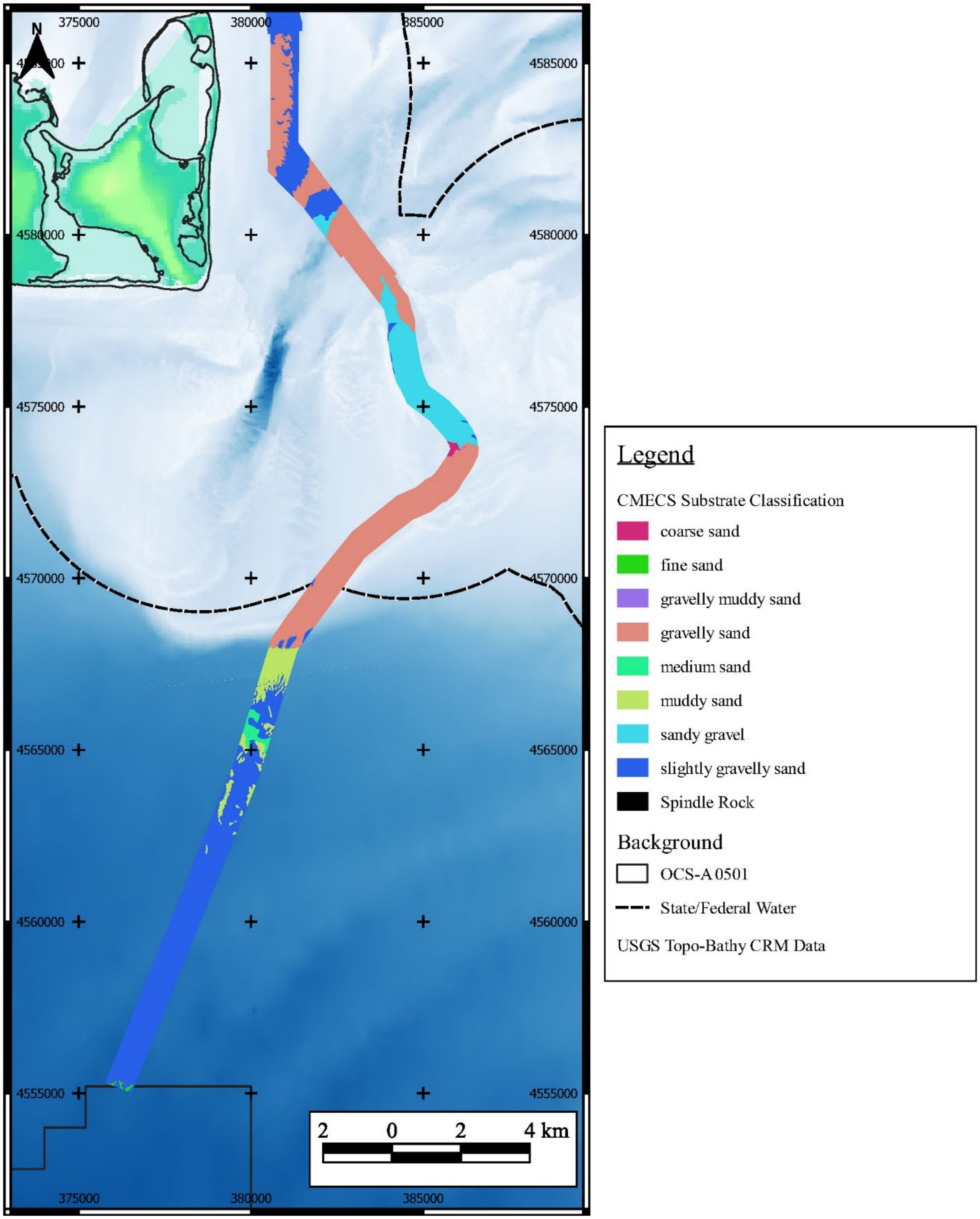
BOEM Atlantic lease areas are described as sediment-starved due to continental geology and the distance from shore, meaning there are no additional sediment inputs to the OCS. Thus, surficial sediments are continually reworked by oceanographic forces such as tides, currents, and storms, and sedimentation is not expected at lease areas. As documented at the Thanet and London Array offshore wind facilities in the United Kingdom, the potential exists for the formation of surficial sediment plumes at WTG monopiles (Vanhellemont and Ruddick 2014). Sediment plumes tend to form when the following conditions are present: shallow water, significant speed of tidal currents, and mobile sediments. The Thanet and London Array offshore wind facilities, which are both located in the Thames River Estuary, are composed of 100 and 175 WTGs, respectively, located in 0 to 82 feet water depths with tidal velocities that vary up to 0.8 to greater than 1 meter per second (Vanhellemont and Ruddick 2014; COP Appendix III-Q, Section 2.1; Epsilon 2022). In contrast, the proposed Project WTGs would be sited in water depths from 141 to 203 feet with tidal velocities less than 0.1 meter per second (0.2 knot) (COP Appendix III-Q, Section 2.1; Epsilon 2022). Sediment transport and mobility is low within the proposed SWDA given the slow tidal current velocity (COP Appendix III-Q, Section 2.1; Epsilon 2022). The lack of conditions required for the formation of sediment plumes are expected to greatly reduce, if not eliminate, the potential for surficial sediment plumes to form. Additionally, the proposed use of scour protection around each of the WTG monopile foundations would be expected to further reduce the already low likelihood of sediment plume formation (Swanson 2019).



Source: Modified from Vineyard Wind 2020

USGS = U.S. Geological Survey

Figure B.1-3: Coastal and Marine Ecological Classification Standard Substrates within the Vineyard Wind 1 Offshore Export Cable Corridor



Source: Modified from Vineyard Wind 2020
USGS = U.S. Geological Survey

Figure B.1-4: Coastal and Marine Ecological Classification Standard Substrates within the Vineyard Wind 1 Offshore Export Cable Corridor

Turbidity is most closely associated with activities such as cable installation and pile driving, which occur primarily during installation where seabed sediments are actively being disturbed. The sediments are temporarily suspended and then resettle within a short time period of minutes to hours depending on site-specific conditions such as sediment grain size.

Scour is a highly complex response to a multidimensional set of local conditions that include oceanographic forces, sediment properties, and anthropogenic inputs. Current understanding includes strong associations between scour, structure diameter, water depth, and sediment conditions. In general, the larger the diameter of the structure, the shallower the water depths, the more uniform and sandier the sediment conditions; the stronger the oceanographic forces, the more likely an area is to experience scour (Harris and Whitehouse 2014). Scour in uniform sandy soils is expected to increase over time until reaching an equilibrium, while the scour in non-uniform soils is more variable (Harris and Whitehouse 2014).

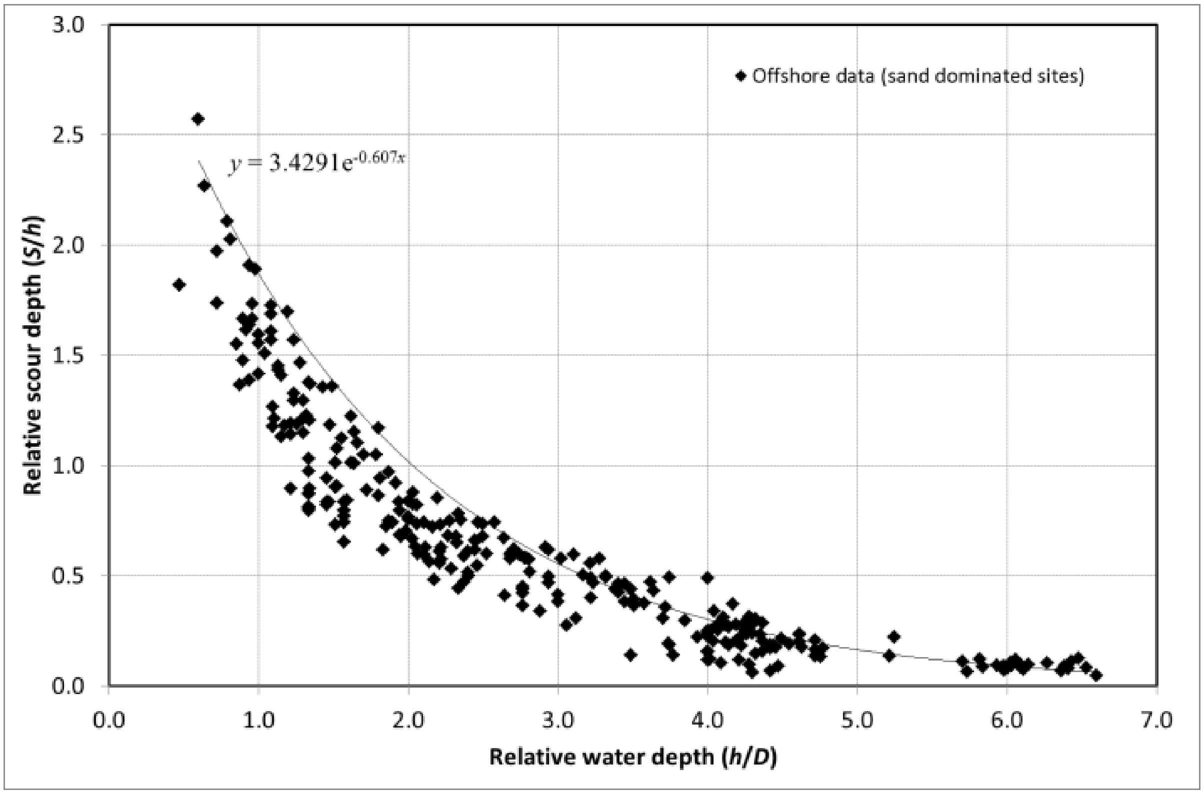
Site conditions and foundation diameter tend to dominate scour potential analysis. Sand-dominated seabeds are more susceptible to severe scour than finer grained or mixed sediments; as the foundation diameters increase, the potential depth (severity) of scour also increases. Based on field measurements at offshore wind energy facilities installed in uniform sand conditions, the relationship between scour and foundation diameter is described as scour (S)/diameter (D) = 1.8 (Harris and Whitehouse 2014). Non-uniform marine soils—a combination of gravel, sand, silt and clay—respond differently than uniform sandy soils, and scour predictions are more complex. Offshore wind energy facilities with non-uniform soils typically experience scour more slowly.

Scour became a significant issue in early offshore wind development during the 2000s as turbine sizes began to increase and facilities were often located close to shore in shallow waters. The most commonly referenced examples of offshore wind energy facility scour often include observations from North Sea sites Scroby Sands and Arklow Bank (Whitehouse et al. 2011). These two sites were located in water depths ranging from about 6.56 to 39.37 feet with pile diameters of 13.78 and 17.06 feet, respectively. As described above, sandy dominated seabeds, such as those found at Scroby Sands and Arklow Bank, are more susceptible to severe scour than finer grained or mixed sediments. In addition, subsequent research has shown the ratio of the water depth to foundation diameter can be a significant indicator for severe scour and was a major contributing factor to the scour experienced as the Scroby Sands and Arklow Bank offshore wind energy facility sites (Figure B.1-5). Other case studies on scour at offshore wind energy facilities include field data from three offshore wind energy facilities located in non-uniform marine soils.

The Barrow Offshore Wind Farm scour survey undertaken in a glacial till area showed modest local scour (S/D = 0.04) (Harris and Whitehouse 2014). Values of S/D = 0.4 were found at the Kentish Flats Offshore Wind Farm, located on a coarse sandy seabed with shell gravel and clay outcrops overlying soft to firm clay deposits. North Hoyle Offshore Wind Farm, located in a strongly heterogeneous region with poorly sorted sediments and a sandy gravel or gravelly sand seabed where larger patches of gravel are found offshore, showed limited scour just after installation; however, within a year, no scour was recorded at any foundation. In general, current industry research indicates scour predictions have vastly improved since large scour pits were identified as a significant issue for offshore wind development, and scour protection has been shown to be effective (Harris et al. 2011).

B.1.4 Physical Oceanography

Oceanographic forces such as waves, currents, and tides vary along the Atlantic OCS, depending on bathymetry, winds, and other factors. The Atlantic OCS is generally wide and shallow, with water depths reaching 492 feet. Although there is some data available, BOEM recognizes that in-situ oceanographic data is limited along the Atlantic Coast of the United States. To fill these data gaps, extensive worldwide effort has been invested in developing and refining ocean models capable of providing detailed oceanographic information not only along the U.S. coast but on a global scale. Several ocean models run in real-time on a continual basis, receiving data from buoys, gliders, ships, and satellites, updating results accordingly. These models provide daily and long-term oceanographic data sets that span decades, grounded by in-situ measurements.



Source: Harris and Whitehouse 2014

S/h = scour depth divided by water depth; h/D = water depth divided by pile diameter

Figure B.1-5: Measured Data from European Wind Energy Facilities Showing a Decrease in Relative Scour Depth with an Increase in Relative Water Depth

Offshore wind developers also contribute to the oceanographic knowledge base through the deployment of data collection buoys during their site assessment phase. Buoys collect data for 1 to 5 years, measuring meteorological and oceanographic (metocean) conditions such as winds, waves, currents, and temperature. Knowing the site-specific metocean conditions is key to facility design and safe navigation and, therefore, a necessity for developers to collect. Some developers have proposed to continue data collection throughout the construction and operations stages.

Key physical factors nearshore include the daily modification of the seabed by tidal currents and episodic extreme storm events that are capable of extensive erosion and redistribution of coastal materials. Offshore, an area immediately west of the proposed Project has been extensively studied, the Rhode Island Ocean Special Area, and the results are informative for the offshore portions of the proposed Project (Rhode Island Coastal Resources Management Council 2010).

B.1.4.1 Water Temperatures

Water temperature is seasonally variable and at the surface ranges from approximately 37°F in winter to 75°F in summer. Offshore temperatures also vary with depth and season due to seasonal stratification and thermoclines; for details, see the COP (Volume III, Section 5.1.2). Although waters on the OCS experience considerable vertical mixing in fall, winter, and spring, an important seasonal feature influencing finfish and invertebrates is the cold pool, a mass of cold bottom water in the Middle Atlantic Bight overlain and surrounded by warmer water. The cold pool forms in late spring and persists through summer, gradually moving southwest, shrinking, and warming due to vertical mixing and other factors (Chen et al. 2018). During summer, local upwelling and local mixing of the cold pool with surface waters provides a source of nutrients, influencing the ecosystem's primary productivity (Lentz 2017; Matte and Waldhauer 1984). The cold pool is a dynamic feature of the middle to outer portions of the OCS, but its nearshore boundary typically lies at depths from 66 to 131 feet (Brown et al. 2015; Chen et al. 2018; Lentz 2017). Offshore wind lease areas are mostly sited within depths less than 197 feet. While offshore wind foundation structures would affect local mixing of cool bottom waters with warm surface waters, the extent to which these local impacts may cumulatively affect the cold pool as a whole is not well understood. Given the size of the cold pool, approximately 11,580 square miles, (NOAA 2020a), future offshore wind structures as described in the expanded planned action scenario would not affect the cold pool, although they could affect local conditions.

B.1.4.2 Regional Ocean Forces

Clockwise movement around Georges Bank and flow toward the equator dominates large-scale regional water circulation, which is strongest in late spring and summer (Whitney 2015). The edge of the continental shelf creates a shelf-break front that encourages upwelling. Weather-driven surface currents, tidal mixing, and estuarine outflow all contribute to driving water movement through the area (Kaplan 2011). Variable temperature-salinity water masses occupying nearshore and offshore regions converge over Nantucket Shoals, creating a persistent frontal zone in the area. Offshore from the islands, shelf currents flow predominantly toward the southwest, beginning as water from the Gulf of Maine heading south veers around and over Nantucket Shoals. Tidal water masses from nearshore transitioning through Nantucket Sound mix with the shelf current generally following depth contours offshore.

Offshore water masses may extend northward onto the shelf toward the islands and through the OCS lease areas offshore Massachusetts at different times of the year (Ullman and Cornillon 1999), while nearshore waters appear to be affected by freshwater runoff in the spring and show increased sea surface temperature gradients extending seaward from Nantucket Sound tidal exit points. A southeasterly flow along the inner shelf depth contours from Nantucket Sound (Limeburner and Beardsley 1982) may be a factor in maintaining the frontal system over Nantucket Shoals. While the dynamics of this system may not be completely understood at this time, the variability observed in shelf water characteristics plays a role in supporting the diverse marine ecology present offshore New England.

B.1.4.3 Tides and Tidal Currents

Tidal range in the Nantucket Sound area is typically 2 to 3.3 feet, and tidal currents can exceed 3.5 knots in Muskeget Channel. Elsewhere, 1- to 1.5-knot flows run west to east in the Main Channel of Nantucket Sound (NOAA 2018a) immediately south of Horseshoe Shoal.

In the SWDA, previous studies found that currents are tidally dominated (Spaulding and Gordon 1982), with wind and density variations playing a smaller role. Data suggest that the depth-averaged current speed is approximately 0.6 knot and the surface current speed is approximately 0.7 knot. While there are no SWDA-specific observational data available, the applicant developed a three-dimensional tide- and wind-driven model described in COP Appendix III-A (Epsilon 2022). In the SWDA, the bottom flood current is predicted to move toward the northeast and the ebb current toward the southwest. Peak predicted current speeds are 0.4 to 0.6 knot (COP Appendix III-A; Epsilon 2022).

B.1.4.4 Waves

In the Rhode Island Ocean Special Area Management Plan, average wave height ranges from 3 to 10 feet, and waves are likely to have little impact on the bottom at depth. Extreme wave height estimates range from 21 to 23 feet in a 10-year span to 29 to 30 feet in a 100-year span. Within the SWDA, the annual average of the monthly average significant wave height is approximately 4.3 feet and a maximum significant wave height of 19.7 feet. The annual average of the monthly average wave period is approximately 5.3 seconds (Rhode Island Coastal Resources Management Council 2010).

In many portions of Nantucket Sound, wave heights are limited by the short distance over which the wind can generate waves. This effect can be dramatic in places close to shore, such as a west wind off Chappaquiddick Island or a north wind offshore from the Cape. In addition, the presence of shoals (e.g., Muskeget area, Horseshoe Shoal) scattered around the area force the waves to increase in height locally and break, thereby diminishing further wave building.

Tidal currents can similarly play a role in modifying wave action nearshore. Wind-generated waves working against the tidal current quickly build and can develop standing waves under certain conditions. Conversely, a strong tidal current flowing in the same direction as the waves can actually diminish wave height as a result of the reduced opposing force. These effects come into play where large volumes of water are moving in and out of the Nantucket Sound, such as through Muskeget Channel and surrounding passages, as well as the channels north and south of Horseshoe Shoal.

The presence of offshore WTGs has the potential to alter wind-driven waves as they pass through the offshore facility (Swanson 2019). Generally, such changes are expected to reduce wave energy and would not be expected to result in increased shoreline erosion. Using computer modeling, Christensen et al. (2014) showed that an offshore wind facility located 2, 3, and 6 miles offshore would have a beneficial impact on shoreline accretion that decreased as the offshore wind facility distance from shore increased. While the general model estimated some parameters that may not be directly comparable to the proposed Project, the model shows that an offshore wind energy facility at any distance will decrease wave energy, with effects similar to a breakwater. As such, shoreline erosion is not expected to increase as a result of the proposed Project (Swanson 2019).

B.1.4.5 Potential General Impacts of Offshore Wind Facilities

There have been relatively few studies to analyze the impact of offshore wind facilities on oceanographic processes, primarily due to the fact that changes to these processes are often highly localized and difficult to measure relative to the natural variability of the environment. Further, the studies that exist tend to focus on direct structural impacts. Even less readily available are analyses on wind-wave interaction impacts because the physics behind this interaction are difficult to quantify, model, and validate. Studies conducted thus far rely heavily on small scale tank testing and ocean modeling rather than actual site measurements. These studies have shown, however, that the magnitude of the impact foundations have on oceanographic conditions depends on pile diameter, turbine density, and facility layout. For example, larger diameter piles have a greater impact than the smaller piles used for jacket foundations.

Tank and modeling tests, such as those conducted by Miles et al. (2017) and Cazenave et al. (2016), conclude that mean flows are reduced/disrupted immediately downstream of a monopile foundation but return to background levels within a distance proportional to the pile diameter (D). These results indicate disruptions for a horizontal distance anywhere from 3.5 D to 50 D, depending on whether it is a current-only regime or a wave and current regime, and a width of 65.6 to 164 feet. Thus, for foundations like those proposed by Vineyard Wind, background conditions would be expected from 164 to 1,148 feet downstream from each monopile foundation. Cazenave et al. (2016) also conducted a shelf-scale modeling exercise on the Irish Sea, home to Walney (+extensions) and west of Duddon Sands, contiguous offshore wind facilities that together contain 297 turbines (with 1.4 gigawatts total power generation capacity). The shelf-scale model of the eastern Irish Sea indicated a 5 percent reduction in peak water velocities and found that this reduction may extend up to approximately 0.5 nautical mile (0.57 mile) downstream of a monopile foundation; impacts varied based on array geometry. In general, modeling studies indicate that water flow typically returns to within 5 percent of background levels within a relatively short distance from the structure. Modeling studies, such as the one conducted by Broström (2008), indicate that the combined impact of wind and oceanographic changes anticipated at offshore wind facilities may have the potential to alter upwelling patterns localized to the wind facility. This experiment was modeled assuming a shallow water depth of 65.62 feet and included additional boundary assumptions. Further modeling studies, such as Carpenter et al. (2016), indicate that offshore wind facilities could impact large-scale stratification in the German Bight but only when they occupy extensive shelf regions, not at current capacity. Nearly all tank and modeling studies indicate that further studies using more realistic systems are required.

As evaluated in Swanson (2019), export cable-laying operations for the Vineyard Wind 1 Project are not expected to have a measurable impact on tidal flows that would result in increased shoreline erosion. The proposed Project export cables are similarly expected to not have measurable impacts because they would be laid adjacent to the Vineyard Wind 1 cables.

Vessel traffic may lead to shoreline erosion from vessel wakes, but this would be limited to approach channels and locations near ports and bays; given the amount and nature of vessel traffic, vessels associated with offshore wind energy would cause a negligible increase, if any, to wake-induced erosion of associated channels (BOEM 2019).

B.1.5 Biological Resources

This section discusses the biological resources present in the vicinity of the proposed Project. Potential impacts on biological resources are assessed in detail in Sections 3.6 through 3.9 and G.2.3 through G.2.5 of the Draft Environmental Impact Statement (EIS).

B.1.5.1 Sea Life

Moderate productivity and a mostly sand bottom, which has a large impact in shaping the biological resources of the area, characterize the marine areas near the proposed Project.

Marine Mammals

Marine mammals use the coastal waters of the northwest Atlantic OCS and the proposed Project area for feeding, breeding, nursery grounds, socializing, and migration (Stone et al. 2017; Leiter et al. 2017). Around 15 species of marine mammals, many of which are migratory, are likely to occur within the proposed Project area (Table 3.7-1 in EIS Section 3.7, Marine Mammals). In particular, the federally endangered North Atlantic right whale (NARW; *Eubalaena glacialis*) frequents the area. Accordingly, several marine zones near the proposed Project are managed using seasonal or year-round restrictions to protect right whales and their habitats. The COP (Volume III, Section 6.7; Epsilon 2022) and BOEM 2014 present a list of all marine mammals that may occur in the area and corresponding detailed descriptions.

Marine mammals are highly migratory, and seasonal occurrences near the proposed Project vary for each species. The biological assessment (BA) includes distribution maps of the listed species near the proposed Project and details regarding their seasonal occurrence (BOEM 2022a). Seasonal distributions for humpback whales (*Megaptera novaeangliae*), minke whales (*Balaenoptera acutorostrata*), harbor porpoise (*Phocoena phocoena*), and three dolphin species in the proposed Project area are shown on Figures 3.7-1 through 3.7-4 in EIS Section 3.7. The applicant submitted comprehensive acoustic modeling of underwater sound propagation and potential impacts on marine species during piling installation for the proposed Project (COP Appendix III-M; Epsilon 2022) that provided detailed information for the pile-driving analysis.

Finfish and Other Species of Commercial Importance

Resident and migratory finfish species, as well as demersal (bottom feeders) and pelagic (inhabiting the water column) types, occur in portions of the Rhode Island and Massachusetts Lease Areas (RI/MA Lease Areas) and within the SWDA. Many of these species have designated essential fish habitat (EFH), a delineation of important marine and diadromous (migratory between salt and fresh waters) fish habitat for all federally managed species mandated through the Magnuson-Stevens Fishery Conservation and Management Act in the Code of Federal Regulations, Title 50, Part 600 (50 CFR Part 600) (BOEM 2022b). A complete list of species with EFH near the proposed Project can be found in BOEM 2022b. Table B.1-7 shows some of the most significant species occurring in this area and indicates species of commercial/recreational importance. For more information on commercial and for-hire recreational fishing activities and species, see EIS Section 3.9, Commercial Fisheries and For-Hire Recreational Fishing, and BOEM 2022b.

Benthic Invertebrates

Typical invertebrates in the region include polychaetes (bristle worms), crustaceans (particularly amphipods), mollusks (gastropods and bivalves), echinoderms (e.g., sand dollars, brittle stars, and sea cucumbers), and various others (e.g., sea squirts and burrowing anemones) (BOEM 2014). Overall, the region experiences strong seasonality in water temperature and phytoplankton concentrations, with corresponding seasonal changes in the densities of benthic organisms (COP Volume III, Section 6.5; Epsilon 2022).

The SWDA is part of the southern New England shelf as described by Theroux and Wigley (1998), which has a higher biomass and density of benthic fauna than neighboring geographic areas such as the Gulf of Maine and Georges Bank. Common sand dollars (*Echinarachnius parma*) are abundant in the SWDA, as are hydrozoans, bryozoans, hermit crabs, euphausiids, sea stars, anemones, sand shrimp (*Crangon septemspinosa*), nematode worms, pandalid shrimp, and fig sponge (*Suberites ficus*) (COP Volume III, Section 6.5; Epsilon 2022). Polychaete worms and amphipod crustaceans dominate infaunal assemblages. These are all common in the Nantucket Shelf region. Similar communities exist near Cape Cod along the proposed OECCs landfall sites, with abundant nut clams, polychaetes, and amphipods, as well as oligochaetes and nemertean ribbon worms (COP Volume III, Section 6.5; Epsilon 2022). As mentioned in Table B.1-7, the region is also home to commercially important benthic invertebrates, including American lobster (*Homarus americanus*), Atlantic sea scallop (*Placopecten magellanicus*), Atlantic surf clam (*Spisula solidissima*), and ocean quahog (*Arctica islandica*), among others.

Sea Turtles

Four species of sea turtles may occur near the proposed Project area: leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), Kemp's ridley (*Lepidochelys kempii*), and green (*Chelonia mydas*). Each of these is protected under the Endangered Species Act (ESA; EIS Section 3.8, Sea Turtles). All these sea turtles are migratory and enter New England waters primarily in the summer and fall. However, hawksbill sea turtles (*Eretmochelys imbricata*) are rarely sighted in Massachusetts and are unlikely to occur near the proposed Project area. The other species may use the proposed Project area for travel, foraging, diving at depth for extended periods, and possibly for extended rest periods on the seafloor (COP Volume III, Section 6.8; Epsilon 2022). Targeted surveys have been conducted for sea turtles near the proposed Project area, and the results can be found in Kraus et al. (2016a). A more detailed discussion regarding aspects of sea turtles potentially affected is available in the proposed Project BA (BOEM 2022a).

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Table B.1-7: Major Finfish and Invertebrate Species in Southern New England

Common Name	Scientific Name	Regional Species	Proposed Project Area Species	Listing Status	Federally Managed, EFH in SWDA	Federally Managed, EFH in OECC	Resident[a]	Migratory[a]	Benthic[b]	Demersal[b]	Pelagic[b]	Commercial/Recreational Importance	Current Condition (Source)
Alewife	*Alosa pseudoharengus*	X	X					X			J A	X	Depleted (NMFS 2019)
American eel	*Anguilla rostrata*	X	X					X			A	X	Depleted (ASMFC 2017)
American lobster	*Homarus americanus*	X	X					X	E J A		L	X	Declining (ASMFC 2015)
American sand lance	*Ammodytes americanus*	X	X				X			E J A		X	Common (Staudinger et al. 2020)
American shad	*Alosa sapidissima*	X	X					X			J A	X	Depleted (ASMFC 2020)
Atlantic albacore tuna	*Thunnus albacares*	X	X		X	X		X			J A	X	Above target population levels (NOAA undated a)
Atlantic bluefin tuna	*Thunnus thynnus*	X	X		X	X		X			J A	X	Unknown overfished status, not undergoing overfishing (ICCAT 2017)
Atlantic butterfish	*Peprilus triacanthus*	X	X		X	X		X			E L J A	X	Common (Guida et al. 2017)
Atlantic cod	*Gadus morhua*	X	X		X	X		X		J A	E L	X	Significantly below target population levels (NOAA undated b), overfished (NEFSC 2017)
Atlantic croaker	*Micropogonias undulatus*	X					X			J A	E L	X	Stable (CBP undated b)
Atlantic herring	*Clupea harengus*	X	X		X	X		X			L J A	X	Common (Guida et al. 2017)
Atlantic horseshoe crab	*Limulus polyphemus*	X	X				X		E J A		L	X	Neutral (ASMFC 2019b)
Atlantic mackerel	*Scomber scombrus*	X	X		X	X		X			E L J	X	Significantly below target population levels (NOAA undated c), overfished, undergoing overfishing (NEFSC 2018a)
Atlantic menhaden	*Brevoortia tyrannus*	X	X					X			E L J A	X	Stable (SEDAR 2020)
Atlantic salmon	*Salmo salar*	X		X				X			J A		Endangered (BOEM 2022b)
Atlantic sea scallop	*Placopecten magellanicus*	X	X		X	X	X		E L J A		L	X	Common (NEFSC 2018b)
Atlantic skipjack tuna	*Katuwonus pelamis*	X	X		X	X		X			J A	X	Above target population levels (NOAA undated d)
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	X	X	X				X			A		Endangered (BOEM 2022a)
Atlantic surf clam	*Spisula solidissima*	X	X		X	X	X		J A			X	Above target population levels (NOAA undated e)
Atlantic wolffish	*Anarhichas lupus*	X	X		X	X	X			E J A	L		Overfished, not undergoing overfishing (NEFSC 2017)
Atlantic yellowfin tuna	*Thunnus albacares*	X	X		X	X		X			J A	X	Above target population levels (NOAA undated f)
Barndoor skate	*Dipturus laevis*	X	X		X		X			J A			Depleted (Oceana undated)
Basking shark	*Cetorhinus maximus*	X	X		X			X			J A		Declining (Rigby et al. 2019a)
Bay scallops	*Argopecten irradians*	X	X				X		A	L		X	Depleted (MBA 2017)
Black drum	*Pogonias cromis*	X					X			J A		X	Stable (CBP undated c)
Black sea bass	*Centropristis striata*	X	X		X	X		X		J A		X	Not overfished, not undergoing overfishing (SEDAR 2018)
Blue mussel	*Mytilus edulis*	X	X				X		A	L		X	Abundance levels of moderate concern (Safina Center and MBA 2017)
Blue shark	*Prionace glauca*	X	X		X	X		X			J A		Declining (Rigby et al. 2019b)
Blueback herring	*Alosa aestivalis*	X	X					X			J A	X	Depleted (NMFS 2019)
Bluefish	*Pomatomus salatrix*	X	X		X	X		X			J A	X	Depleted (ASMFC 2019a)
Channeled whelk	*Busycotypus canaliculatus*	X	X				X		E J A			X	Depleted and declining (MA DMF 2020)
Cobia	*Rachycentron canadum*	X	X		X	X		X			E L J A	X	Above target population levels (NOAA undated g)
Common thresher shark	*Alopias vulpinus*	X	X		X	X		X			J A		Unknown (NOAA undated h)
Dusky shark	*Carcharhinus obscurus*	X	X		X	X		X			J A		Declining (Rigby et al. 2019c), overfished (SEDAR 2016)
Eastern oyster	*Crassostrea virginica*	X	X				X		A		L	X	Stable (CBP undated a)
Giant manta ray	*Manta birostris*	X		X				X			J A		Endangered (BOEM 2022a)
Haddock	*Melanogrammus aeglefinus*	X	X		X	X		X			E L	X	Above target population levels (NOAA undated i)
Jonah crab	*Cancer borealis*	X	X					X	E J A		L	X	Unknown (NOAA undated j)
King mackerel	*Scomberomorus cavalla*	X	X		X	X		X			E L J A	X	Above target population levels (NOAA undated k)
Knobbed whelk	*Busycon carica*	X	X				X		E J A			X	Depleted and declining (MA DMF 2020)
Little skate	*Leucoraja erinacea*	X	X		X	X	X			J A		X	Common (Guida et al. 2017)
Longfin squid	*Doryteuthis pealeii*	X	X		X	X		X	E		J A	X	Common (Guida et al. 2017)
Monkfish	*Lophius americanus*	X	X		X	X	X			J A	E L	X	Above target population levels (NOAA undated l)
Northern sea robin	*Prionotus carolinus*	X	X					X		J A	E L		Stable (CBP undated d)
Northern shortfin squid	*Illex illecebrosus*	X	X			X		X			A	X	Unknown (NOAA undated p)
Ocean pout	*Zoarces americanus*	X	X		X	X		X		E J A		X	Overfished, not undergoing overfishing (NEFSC 2017)
Ocean quahog	*Arctica islandica*	X	X		X		X		J A			X	Above target population levels, declining (NOAA undated m)
Pollock	*Pollachius virens*	X	X		X			X		J	E L	X	Above target population levels (NOAA undated n)
Porbeagle shark	*Lamna nasus*	X	X		X			X			J A		Stable, overfished but not undergoing overfishing (Curtis et al. 2016)
Red hake	*Urophycis chuss*	X	X		X	X		X		J A	E L	X	Common (Guida et al. 2017)
Sandbar shark	*Carcharhinus plumbeus*	X	X		X	X		X			J A		Declining (Musick et al. 2009)
Sand tiger shark	*Carcharias taurus*	X	X		X	X		X			J A		Species of concern, declining (NOAA 2010)

Common Name	Scientific Name	Regional Species	Proposed Project Area Species	Listing Status	Federally Managed, EFH in SWDA	Federally Managed, EFH in OECC	Resident[a]	Migratory[a]	Benthic[b]	Demersal[b]	Pelagic[b]	Commercial/Recreational Importance	Current Condition (Source)
Scup	*Stenotomus chrysops*	X	X		X	X		X		J A		X	Common (Guida et al. 2017)
Shortfin mako shark	*Isurus oxyrinchus*	X	X		X			X			J A		Significantly below target population levels (NOAA undated o), overfished and undergoing overfishing (ICCAT 2017)
Shortnose sturgeon	*Acipenser brevirostrum*	X		X				X		A			Endangered (BOEM 2022a)
Silver hake	*Merluccius bilinearis*	X	X		X	X		X			E L J	X	Common (Guida et al. 2017)
Smooth dogfish	*Mustelus canis*	X	X		X	X		X			J A		Not overfished, not undergoing overfishing (SEDAR 2015)
Spanish mackerel	*Scomberomorus maculatus*	X	X		X	X		X			E L J A	X	Above target population levels (NOAA undated q)
Spiny dogfish	*Squalus acanthias*	X	X		X	X		X		A	A	X	Common (Guida et al. 2017)
Spot	*Leiostomus xanthurus*	X						X		J A	E L J A		Stable (CBP undated e)
Spotted sea trout	*Cynoscion nebulosus*	X					X			E L J A		X	Overfished, undergoing overfishing (ASMFC 2011)
Striped bass	*Morone saxatilis*	X	X					X		J A	J A	X	Significantly below target population levels (NOAA undated r), overfished, undergoing overfishing (NEFSC 2019)
Summer flounder	*Paralichthys dentatus*	X	X		X	X		X		J A	E L	X	Below target population levels (NOAA undated s)
Tautog	*Tautoga onitis*	X	X					X		E L J A	E	X	Overfished, undergoing overfishing (ASMFC 2016)
Tiger shark	*Galeocerdo cuvier*	X	X		X			X			J A	X	Declining (Ferreira and Simpfendorfer 2019)
Weakfish	*Cynoscion regalis*	X						X			E L J A	X	Depleted (ASMFC 2019c)
White hake	*Urophycis tenuis*	X	X		X	X		X		J	E L J	X	Not overfished, not undergoing overfishing (NEFSC 2017)
White shark	*Carcharadon carcharias*	X	X		X	X		X			J A	X	Declining (Rigby et al. 2019d)
Windowpane flounder	*Scophthalmus aquosus*	X	X		X	X		X		J A	E L	X	Not overfished, not undergoing overfishing (NOAA 2018b)
Winter flounder	*Pseudopleuronectes americanus*	X	X		X	X		X		L	E J A	X	Significantly below target population levels (NOAA undated t), overfished, not undergoing overfishing (NEFSC 2015)
Winter skate	*Leucoraja ocellata*	X	X		X	X		X		J A		X	Common (Guida et al. 2017)
Witch flounder	*Glyptocephalus cynoglossus*	X	X		X	X		X			E L	X	Overfished (NEFSC 2017)
Yellowtail flounder	*Limanda ferruginea*	X	X		X	X		X		J A	E L	X	Significantly below target population levels (NOAA undated u), overfished, undergoing overfishing (NEFSC 2015)

A = adult; E = egg; EFH = essential fish habitat; L = larvae; J = juvenile; OECC = offshore export cable corridor; SWDA = Southern Wind Development Area

[a] Migration encompasses movements potentially affecting the presence of a species in the proposed Project area. It includes short inshore/offshore seasonal movements (e.g., flatfish, skates), as well as long-distance migrations (e.g., tuna).

[b] Habitat use was separated by life stage based on information from several sources (ASMFC 1998; ASMFC 2018a; BOEM 2018; Collette and Klein-MacPhee 2002; Miller and Klimovich 2017; Nelson et al. 2018; Roberts 1978). Some species with EFH in the proposed Project area did not have EFH designation for all life stages, while for other species, some life stages may not occur near the proposed Project.

Strandings data for sea turtles from 1998 to 2017, sightings per unit effort (SPUE), indicate similar trends in the seasonal occurrence for loggerhead, leatherback, Kemp's ridley, and unidentified sea turtles in the proposed Project area (Figures 3.8-2 through 3.8-5 in EIS Section 3.8). These SPUE maps do not depict the full level of distribution of a species in an area, but rather show the number of animal SPUE where surveys occurred. Additional information on sea turtle occurrence in the proposed Project area is available in the Vineyard Wind 1 BA (BOEM 2022a).

B.1.5.2 Terrestrial Resources

Habitats

The terrestrial portion of the proposed Project is located within the Long Island-Cape Cod Coastal Lowland Major Land Resource Area. Much of this area exhibits sandy soils, mixed hardwood-softwood forests, and scrublands subject to periodic fires (USDA 2006). Pine-oak forest is one of the most common habitat types on Cape Cod. This area also includes important habitats such as coastal wetlands, isolated freshwater wetlands, and a few small streams, although none of these habitats are present at locations where proposed Project work would take place. Table G.2.5-1 in EIS Section G.2.5, Terrestrial Habitats and Fauna, shows some of the threatened and endangered plant species potentially occurring in this area.

Land Animals

Table G.2.5-2 in EIS Section G.2.5 lists terrestrial and coastal faunal resources that are known to occur near the proposed Project. Prominent animal communities include residents of woodlands (e.g., white-tailed deer [*Odocoileus virginianus*], fox [*Vulpes vulpes*], raccoon [*Procyon lotor*], among others), scrub grasslands (e.g., New England cottontail [*Sylvilagus transitionalis*], coyote [*Canis latrans*]), and wetlands (e.g., American beaver [*Castor canadensis*], muskrat [*Ondatra zibethicus*], diamondback terrapin [*Malaclemys terrapin*]). Amphibians and reptiles, including turtles, snakes, and a variety of frogs, may belong to several of these communities and may move between and among them.

B.1.6 Protective Measures and Monitoring

Thus far, there is only one operational offshore wind facility on the Atlantic coast (Block Island Wind Farm), one under construction (Vineyard Wind 1 Project), and several more in various stages of development. This section highlights some of the lessons learned from the first U.S. project and projects in Europe regarding monitoring and mitigating impacts on the physical environment, including physical habitat.

B.1.6.1 Protective Measures

Scour was a significant concern and focus of the offshore wind facility industry after installation of monopile foundations in relatively shallow waters and mobile sediments resulted in extensive scour pits and scour fields (English et al. 2017). Extensive research was conducted on scour development, and best management practices (BMP) have been established to reduce scour occurrence. Current scour models are consistent with field data collected at offshore wind facilities, and mitigation measures for scour protection (e.g., rock placement) have been shown to be highly effective. At the moment, scour does not appear to be a major concern of offshore wind facility developers due to the effectiveness of scour protection as a mitigation, the accuracy of scour predictions, and the establishment of BMPs.

All COP submittals for offshore wind facilities to date, including the proposed Project COP, have included scour protection to mitigate the possibility of scour occurrence and monitoring programs to monitor scour both on a regular time schedule and with environmentally triggered monitoring, such as post storm event monitoring. These protective measures are in line with BMPs established by international industry stakeholders.

Survey data show the proposed Project seabed consists of fine-grained sediments that overlay coarse-grained sands. The mixed seabed and presence of fine-grained material indicates scour is less likely to occur; however, the applicant has proposed a conservative approach that includes the installation of scour protection around all foundations.

B.1.6.2 Environmental Monitoring

Direct observations of the Block Island Wind Farm show turbidity associated with cable installation to be nearly indistinguishable from background turbidity measurements and 100 times lower than model predictions; overspill levee deposits were in line with model predictions (Elliot et al. 2017).

Scour around the foundation of the Block Island Wind Farm show about 0.66 foot of seabed lowering over 14 months with average monthly variability of up to 1.97 feet. Data appear to suggest a correlation between the greatest levels of scour and the highest significant wave heights, thus raising the possibility that increased wave action leads to increases scour during more extreme winter weather with some recovery during spring and summer months (HDR 2019).

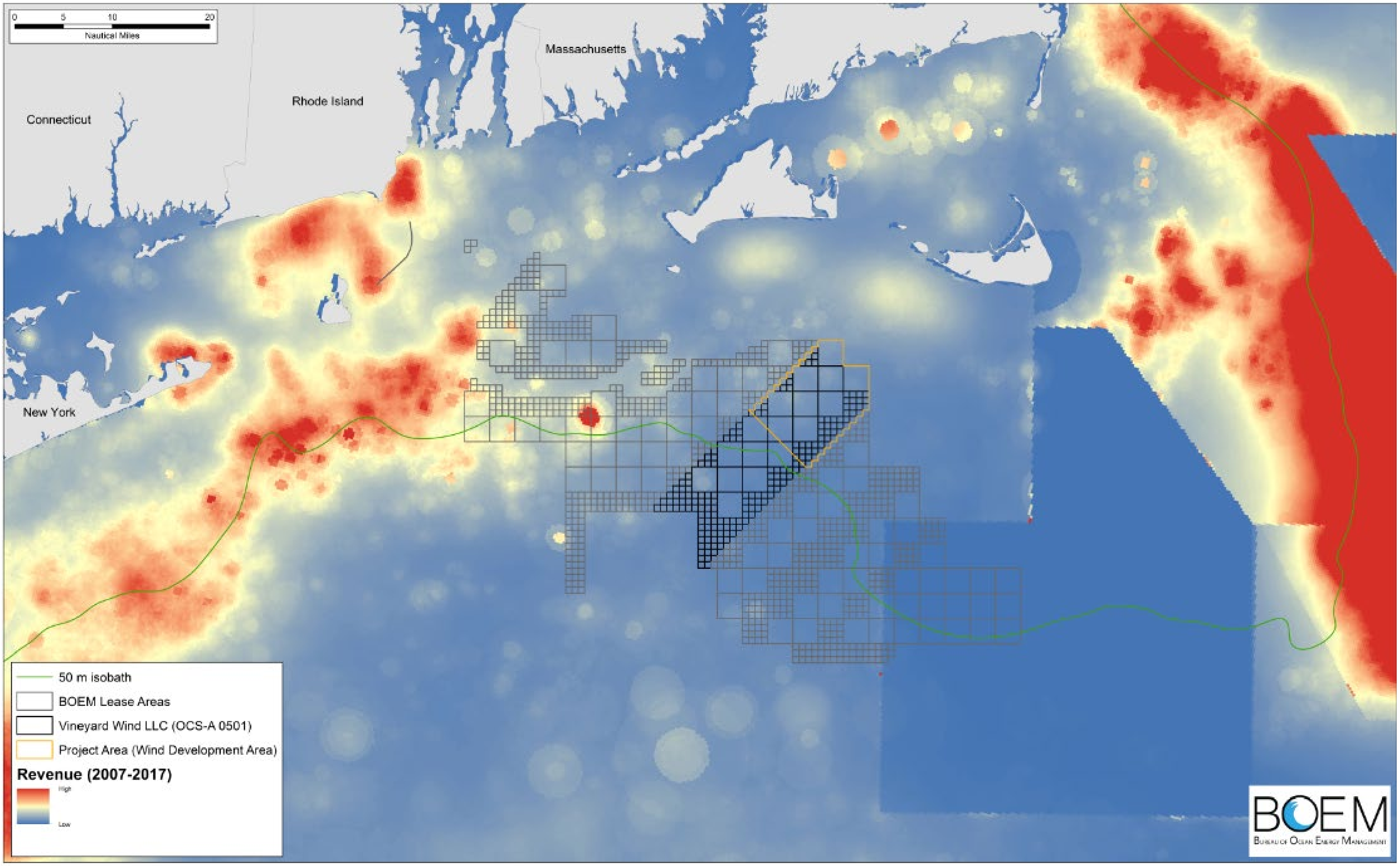
BOEM is working with state and federal partners to develop a regional monitoring strategy that focuses on biological resource impacts and builds off the lessons from Atlantic OCS and European wind development activities. Wind developers will also have site-specific monitoring requirements related to potential impacts that might be anticipated for their project. This includes monitoring of foundations for epibenthic growth, scour, and monitoring of cable burial effectiveness.

B.2 Commercial Fisheries and For-Hire Recreational Fishing Data

The analysis in this section is reprinted (with revisions to clarify geographic locations, project names, and figure and table numbers) from the Final EIS for the Vineyard Wind 1 Project (BOEM 2021) and reflects data, information, and trends through 2018. While more recent data may be available, the Vineyard Wind 1 information remains valid to broadly characterize and support the analysis of the New England Wind Project's impacts on commercial fisheries and for-hire recreational fishing in EIS Section 3.9.

The fisheries resources in federal waters off New England provide a significant amount of revenue. New Bedford, Massachusetts, has consistently been the highest value-producing U.S. fishing port (NOAA 2018c). In 2018, commercial fisheries harvested more than 1.2 billion pounds of fish and shellfish in the North and Mid-Atlantic region, for a total landed value of over $1.8 billion; from 2009 to 2018, average annual landings were 1.3 billion pounds with a value of $1.6 billion (ACCSP 2018). From 2009 to 2018, the value of landings has ranged from $1.2 billion to over $1.8 billion, while landings weight ranged from 1.16 billion pounds to 1.40 billion pounds. In Massachusetts, commercial fisheries harvested over 222 million pounds of fish and shellfish in 2018 for a total landed value of over $630 million.

Commercial fisheries in the northeast United States are known for the large landings of herring, menhaden, clam, squid, scallop, skate, and lobster, as well as being a notable source of profit from scallop, lobster, clam, squid, and other species (NOAA 2019d). Figure B.1-6 shows fishing revenue intensity in the region around the Vineyard Wind 1 Project Wind Development Area (WDA); the fishing revenue is for all federally managed fisheries aggregated for the years 2007 to 2017 (Geret DePiper, Pers. Comm., April 2019). Commercial fisheries obtained the greatest concentration of revenue from around the 164-foot contour off Long Island and Georges Bank. The National Marine Fisheries Service (NMFS) excluded mobile gear fishing in parts of Georges Bank for fish stock rebuilding. Moderate revenue fishing areas (yellow on Figure B.1-6) are apparent within and in the vicinity of the WDA. Chart plotter data submitted by commercial vessels targeting squid and whiting (*Merlangius merlangus)* reflect fishing in these areas.



m = meter; NEFSC = Northeast Fisheries Science Center; VTR = vessel trip report

This is based on federally reported VTRs and conversion by NEFSC (Geret DePiper, Pers. Comm., April 2019). The top 5% of revenue was clipped to lessen high-value scallop revenue skew of regional revenue. Without clipping, the top 5 percent areas important to lesser value fisheries would not appear. Removing the top 5% does not remove any areas that are not already represented in the red (high) end of the color ramp.

Figure B.1-6: Fishing Intensity Based on Average Annual Revenue for Federally Managed Fisheries (2007–2017)

Over 4,300 federally permitted fishing vessels were in the northeast in 2017, landing fish in several major northeast ports (Table B.1-8) (NOAA 2019e). In 2018, at the New Bedford port, commercial fishing landed more than 113.5 million pounds of products valued at $438.8 million (Table B.1-8). Point Judith, Rhode Island, landed 47.5 million pounds in 2017, valued at $64.8 million. Table B.1-8 lists the value and volume of landings of selected regional ports. The regional setting extends primarily over the fishing ports and waters in Massachusetts, Rhode Island, Connecticut, New York, and New Jersey, although vessels from other ports may occasionally operate in the area. Commercial vessels active in the RI/MA Lease Areas may be homeported and/or land product in ports in those states. Other ports such as Nantucket are much smaller but of importance to vessels homeported in those ports; however, for small ports, landing and fishing revenue data are often confidential because of the small number of fishing vessels involved. Unless noted otherwise, fishing revenue data in tables were converted to 2019 dollars using the quarterly, seasonally adjusted Gross Domestic Product Implicit Price Deflator provided by Federal Reserve Economic Data.

Table B.1-8: Value and Volume of Commercial Fishery Landings by Port (2019 dollars), 2016–2018

	2016	**2017**	**2018**	**2016**	**2017**	**2018**
Port	**Pounds (millions)[a]**			**Value (million $)[a]**		
New Bedford, Massachusetts	106.6	110.8	113.5	346.7	406.0	438.8
Cape May-Wildwood, New Jersey	46.6	101.6	101.2	89.9	84.4	67.5
Point Judith, Rhode Island	53.4	44.3	47.5	59.1	59.8	64.8
Hampton Roads Area, Virginia	12.3	15.5	14.7	64.8	60.6	55.7
Gloucester, Massachusetts	63.4	63.9	59	55.6	54.8	54.2
Provincetown-Chatham, Massachusetts	26.5	22.3	22.5	34.8	35.2	35.4
Reedville, Virginia	321.3	319.9	352.5	33.1	33.9	36.8
Point Pleasant, New Jersey	26.3	37.5	43.3	34.1	36.8	33.0
Long Beach-Barnegat, New Jersey	7.2	7.6	6.3	28.6	25.7	24.7
Atlantic City, New Jersey	24.3	24.7	24.8	20.9	19.4	18.5
Boston, Massachusetts	12.2	15.8	17	18.1	18.0	16.7
Montauk, New York	11.8	10.1	11.3	17.3	15.4	17.6
North Kingstown, Rhode Island	17.6	27	22.8	14.5	18.4	16.3
Accomac, Virginia	7.6	5.9	6.2	21.3	13.3	12.3
Fairhaven, Massachusetts	3.9	3.2	3.2	23.1	10.7	8.6
Newport, Rhode Island	6.6	7.3	5.5	8.5	8.9	8.0
Hampton Bay-Shinnicock, New York	5.2	3.8	3.6	8.5	6.4	5.8
Ocean City, Maryland	4	4.4	4.2	6.1	4.8	4.9
Stonington, Connecticut	2.1	1.8		6.3	6.5	
New London, Connecticut	9	5.6	7.2	5.4	2.8	4.3
Chincoteague, Virginia	2.4	1.9		5.2	4.1	
Belford, New Jersey	2.5	5.1	4.9	3.2	2.8	1.9
Little Compton, Rhode Island			3.1			3.0
Cape Charles-Oyster, Virginia		0.3			1.1	
Greenport, New York		0.2			0.3	

Sources: NOAA 2019f, 2019g

[a] Empty cells indicate that data were not collected or not available.

The commercial fishing fleets contribute to the overall economy in the region through direct employment, income, and gross revenues, as well as products and services to maintain and operate vessels, seafood processors, wholesalers/distributors, and retailers. In 2015, commercial fisheries in Massachusetts, Rhode Island, Connecticut, New York, and New Jersey created 61,865 jobs, generated $2,761 million in sales, and contributed $1,380 million in value added (gross domestic product; NOAA 2017a). In Massachusetts, of the 52,710 jobs created, commercial harvesters held 10,923 and retail created 39,323, with the remaining in seafood processing (1,509) and seafood wholesaling and distribution (955). Further, commercial harvesters received $302.5 million in income, retailers $369.6 million, seafood processors $83.1 million, and seafood wholesalers and distributors $55.2 million. In Rhode Island, of the 4,522 jobs created, 2,016 were held by commercial harvesters, and 2,107 were created in retail, with the remaining in seafood processing (284) and seafood wholesaling and distribution (115); commercial harvesters generated $42.5 million in income (NOAA 2017a).

Input-output models can be used to estimate the economic impacts associated with the harvesting of fish by commercial fishermen and the seafood industry. A study conducted by the University of Rhode Island (undated) on the *Economic Impacts of the Rhode Island's Fisheries and Seafood Sector* investigated the contributions of commercial fishing, charters, processing, professional service firms, retail and wholesale seafood dealers, service and supply firms, and tackle shops to assess their contributions to the state and national economy. The study concluded that the Rhode Island seafood industry generated 3,147 jobs and $538.3 million in gross sales with the total spillover effect to other industries of 4,381 jobs and output of $419.8 million. The vessel landings job multiplier was estimated at 32.43 jobs per $1.0 million, while the vessels landings economic impact multiplier was estimated at 1.98 (value added basis).

Table B.1-9 was provided by the NOAA Northeast Fisheries Science Center (NEFSC). NOAA NEFSC used the federal vessel trip report (VTR) to collect landings data. VTR data is collected by all NMFS permitted vessels, regardless of where fishing occurs or what species are targeted. The only federally permitted vessels not required to provide VTRs is the lobster fishery. Other non-federally permitted fisheries (e.g., Jonah crab [*Cancer borealis*] and menhaden) also do not have a federal reporting requirement. To compile data listed in Table B.1-9, NOAA NEFSC queried VTR data for positional data and linked it to dealer data for value and landings information. However, VTR data may misrepresent the actual location where the fish were harvested on a given trip. Fishermen are required to record the haul back position where the majority of fishing occurred, and separate VTRs are required only when fishermen change statistical areas or gear. Consequently, a single location can be used to record multiple tows, and this may not be representative of where fishing actually occurred.

The Rhode Island Department of Environmental Management (RI DEM) analysis (Table B.1-10) shows substantial variability in catch over time. Point Judith landings varied from just over $550,278 in 2011 to over $3.0 million in 2016, which coincides with a peak year for the squid industry that is primarily based in that port.[1] This information regarding the area's use as a fishery matches Point Judith- and Montauk-based vessel chart plotter data regarding the use of this area (Figure B.1-7). Similar variability in catch, likely due to squid landings, is shown for New Bedford, which had a landings revenue of $126,017 in 2011 and over $1.5 million in 2016. The RI DEM analysis identified New Bedford and Point Judith ports as having relatively higher value of landings from the Vineyard Wind 1 lease area.

[1] VMS was not required until 2014 for squid vessels.

Table B.1-9: Value of Port Landings Harvested from the Vineyard Wind 1 Lease Area (Vessel Trip Report Data, 2019 Dollars), 2008–2017

Vineyard Wind 1 Lease Area	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Montauk, New York								$50,116	$227,598	$84,711
New Bedford, Massachusetts		$46,151	$179,883	$164,171	$108,842		$107,469		$317,624	
Point Judith, Rhode Island	$193,649	$42,152	$58,605	$254,534	$88,828	$372,726	$391,784	$432,069	$1,494,979	$206,102
Other ports	$100,830	$168,845	$214,111	$108,652	$354,925	$473,058	$167,723	$177,539	$429,707	$84,735

Source: Benjamin Galuardi, Pers. Comm., April 3, 2019

Empty cells indicate that data were not collected or not available.

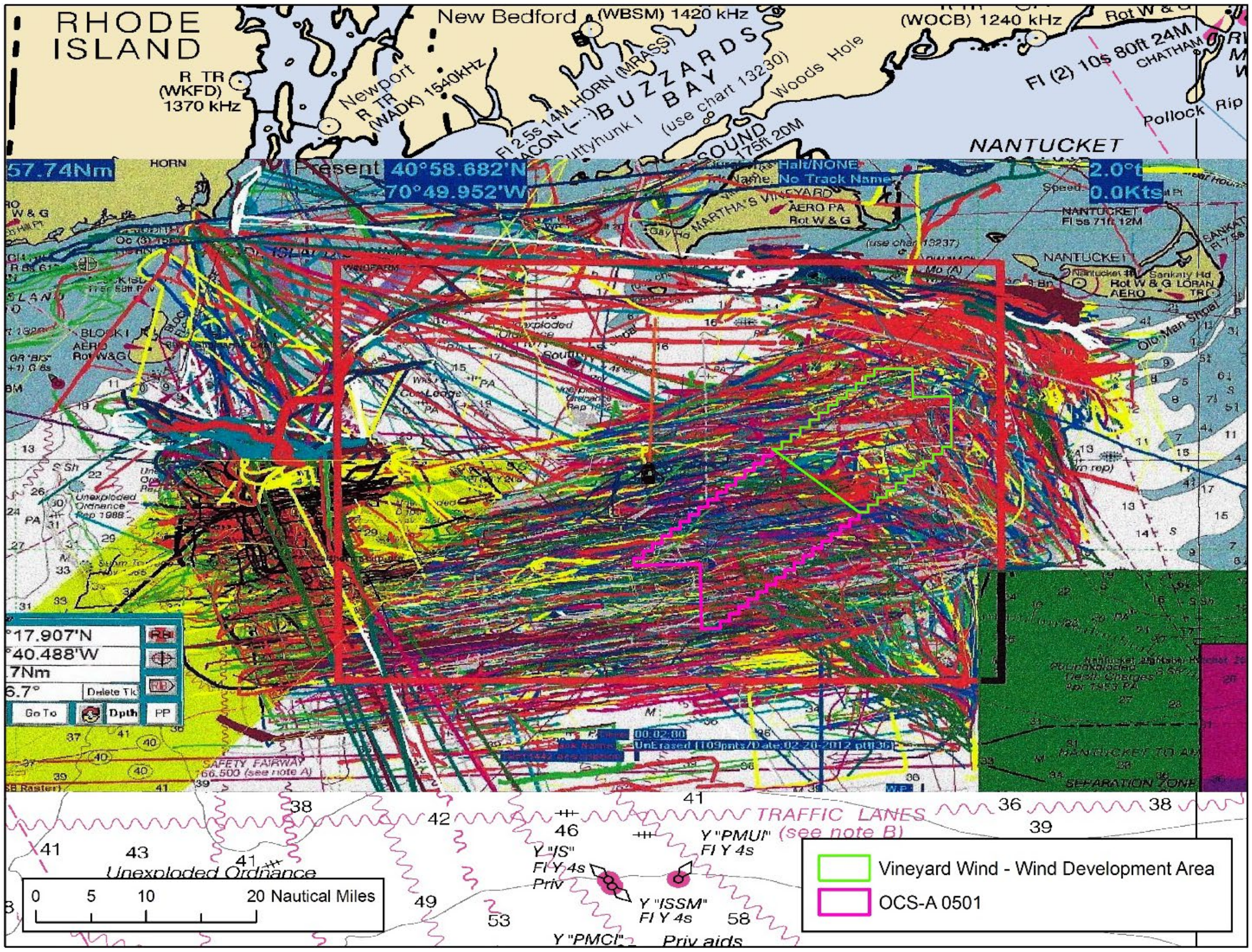
Table B.1-10: Value of Port Landings Harvested from the Vineyard Wind 1 Lease Area (Vessel Monitoring System Data, 2019 Dollars), 2011–2016

Port	2011	2012	2013	2014	2015	2016
Montauk, New York	Confidential landings (fewer than three vessels)	Confidential landings (fewer than three vessels)	$295,840	Confidential landings (fewer than three vessels)	$160,458	$426,771
New Bedford, Massachusetts	$126,017	$1,768,982	$1,227,439	$793,864	$590,584	$1,547,916
Point Judith, Rhode Island	$550,278	$872,311	$1,341,593	$1,318,362	$1,424,764	$3,165,239
Chatham, Massachusetts	$116,844	$162,645	$78,299	$41,058	Confidential landings (fewer than three vessels)	Confidential landings (fewer than three vessels)
New London, Connecticut	$63,854	Confidential landings (fewer than three vessels)	Confidential landings (fewer than three vessels)	No landings	Confidential landings (fewer than three vessels)	Confidential landings (fewer than three vessels)

Source: RI DEM 2017

The following ports were also considered; however, the data were either confidential (i.e., fewer than three separate contributors to the data) or there were no landings in those ports from the Vineyard Wind 1 lease area: Barnegat Light, NJ; Belford, NJ; Boston, MA; Cape May, NJ; Gloucester, MA; Hampton Bays, NY; Harwich Port, MA; Little Compton, RI; Mystic, CT; Newport, RI; North Kingstown, RI; Point Pleasant, NJ; Providence, RI; Provincetown Wharf, MA; Shinnecock Reservation, NY; Stonington, CT; Wakefield, RI; Westport, MA; and Woods Hole, MA.

Commercial Fisheries Center of Rhode Island - Chart Plotter Tow Tracks



Source: BOEM 2021

A general pattern of east to west or northeast to southwest (following Loran line orientation) fishing activity is apparent; however, a substantial number of tracks proceed in other directions.

Figure B.1-7: Chart Plotter Tow Tracks near the Wind Development Area

VTR data compiled by the NOAA NEFSC also show substantial variability in the year-to-year revenue (Table B.1-10). VTRs show that Point Judith landed a revenue of $1.5 million in 2016 compared to $3.2 million recorded by the vessel monitoring system (VMS) data (Table B.1-9). As another example, VMS data show a revenue of $872,311 in 2012 for Point Judith compared to $88,828 compiled from VTRs. In general, the total landed value in 2016 using VTRs is estimated at $2.5 million, substantially higher compared to the revenue landed in any other year in the investigated period (Table B.1-10). The differences in values with these two approaches are due to the different spatial data used (VTR point data versus VMS data) and the weighting done in the RI DEM analysis. Specifically, the RI DEM analysis took the raw fishing density maps by species caught to weight the value of fishing location points within each trip. Rather than assuming all fishing activity is equal, to scale the landings by the amount of fishing activity within each area per trip, each individual fishing point within a trip was weighted by the fishing density map for that fishery that year. Weighting the values based on fishing density places higher weights on points where the fishing density was higher. This strategy assumes that fishermen target the most profitable areas (i.e., where species abundances are higher) (RI DEM 2017). Together, these two approaches create a range of harvest revenue that occurred across the entire Vineyard Wind 1 lease area.

Table B.1-9 and Table B.1-10 show how various data collection and analysis methods (VMS versus VTR) can provide varying estimates of the fishing activity in the Vineyard Wind 1 lease area. More details about commercial fishing ports are available in the COP (Volume III, Section 7.6; Epsilon 2022).

The ports of Point Judith and New Bedford also support other economic activities through spending and job creation that depend on commercial and for-hire recreational fishing such as preparation and packaging of seafood, wholesale and retail seafood sales, purchase of fishing equipment, accommodation, and other goods and services related to commercial fishing.

Figure B.1-8 shows the relative squid fishing vessel density between 2015 and 2016 using VMS, both with all recorded squid fishing vessels traveling at any speed and speed filtered to show only those vessels traveling less than 4 knots. Figure B.1-9 shows the total number of unique squid fishing vessels (92) and orientation of fishing direction (roughly east to west) between 2014 and 2019 across the entire RI/MA Lease Areas. As previously noted, VMS as a source of location data for the squid fishery may underrepresent fishing activity prior to 2017. Also, VMS data show vessel presence but do not indicate whether the vessel is fishing or not. The presence of vessels traveling less than 4 knots may better indicate squid fishing activity because higher-speed vessels are more likely to be transiting.

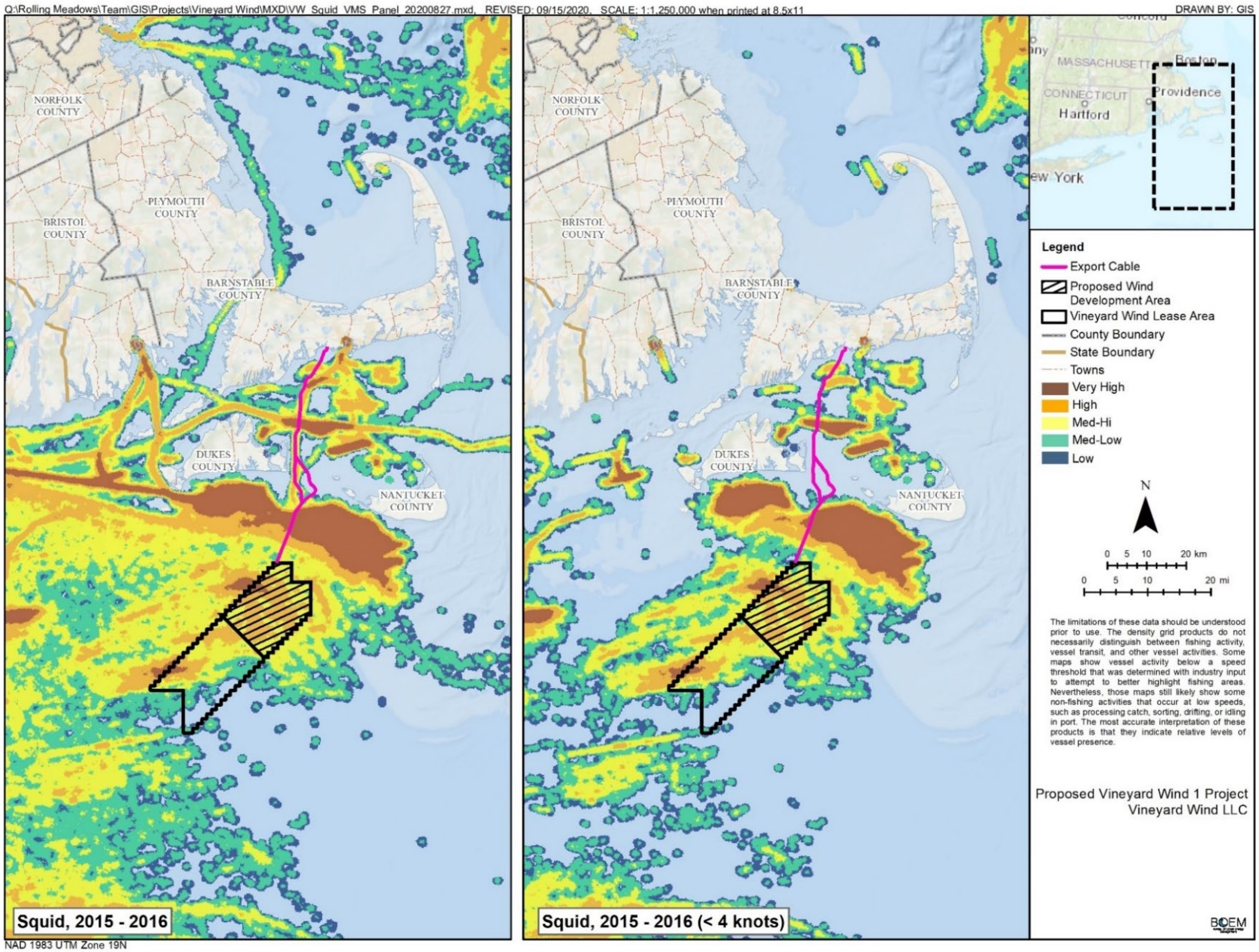
NOAA NEFSC also identified that more than $280,000[2] of lobster pot gear revenue comes from within the Massachusetts Wind Energy Area, which is primarily landed in Massachusetts (Kirkpatrick et al. 2017). After scallops, the state's second most valuable fishery is lobster, which has annual average landings of approximately $61 million. Much of the southern New England lobster fleet has transitioned to a mixed crustacean fishery targeting both Jonah crabs and lobsters (ASMFC 2022). Comments during scoping for the Vineyard Wind 1 and New England Wind EISs indicated that a majority of lobster effort is south and west of the proposed Project area (Figure B.1-10). However, lobster pot landings may be underestimated due to incomplete reporting for trap vessels that are not subject to mandatory reporting.

BOEM analyzed an expanded data set (Geret DePiper, Pers. Comm., August 2018) that is isolated to federally permitted commercial fishing activity within the WDA. Figure B.1-11 shows that commercial fisheries harvested $3.67 million in revenue in the Atlantic Mackerel, Squid, and Butterfish Fisheries Management Plan (FMP) and Atlantic surf clam and Ocean Quahog FMP over a 12-year period.

Looking at the value of catch within the WDA for each FMP as a percentage of the total revenue for each FMP in the region, the largest absolute shares occur in the Northeast Multispecies FMP (small mesh) and the Atlantic Mackerel, Squid, and Butterfish FMP, but in each case, less than 0.5 percent of the FMP's total revenue is harvested within the WDA.

Table B.1-11 and Table B.1-12 show the annual value of landings (2019 dollars) for the top seven FMPs in the WDA during 2007 to 2018. There has been substantial variability in the year-to-year harvest of various species in the WDA. NOAA NEFSC provided additional data on the value and volume of fishing in the WDA. The data are based on the VTRs; value of fishing is provided in 2019 dollars by species, gear, port, and state, while volume landed is provided in pounds (Table B.1-11 through Table B.1-20).

[2] This is based on 2007 to 2012 data and stated in 2015 dollars.



Source: Northeast Regional Ocean Council 2020

Figure B.1-8: Squid Fishing Vessel Density Based on Vessel Monitoring System Data (2015–2016)

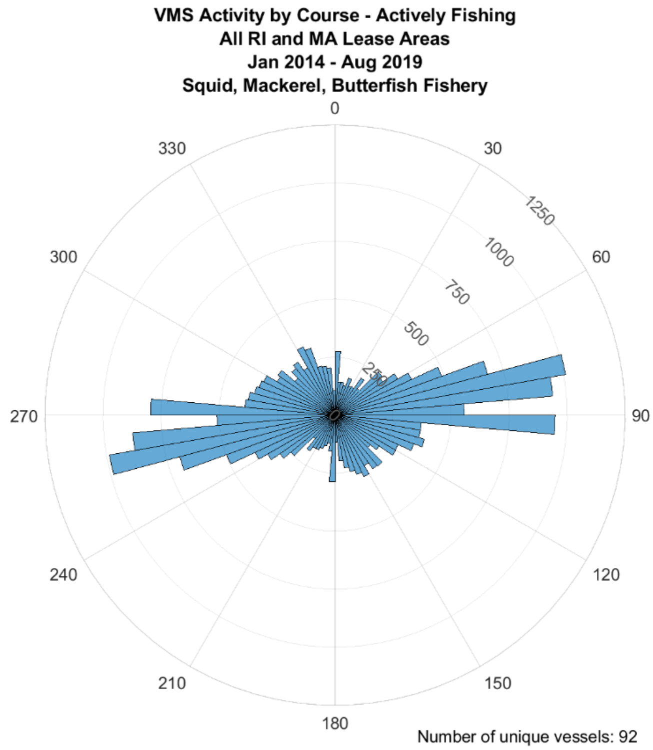
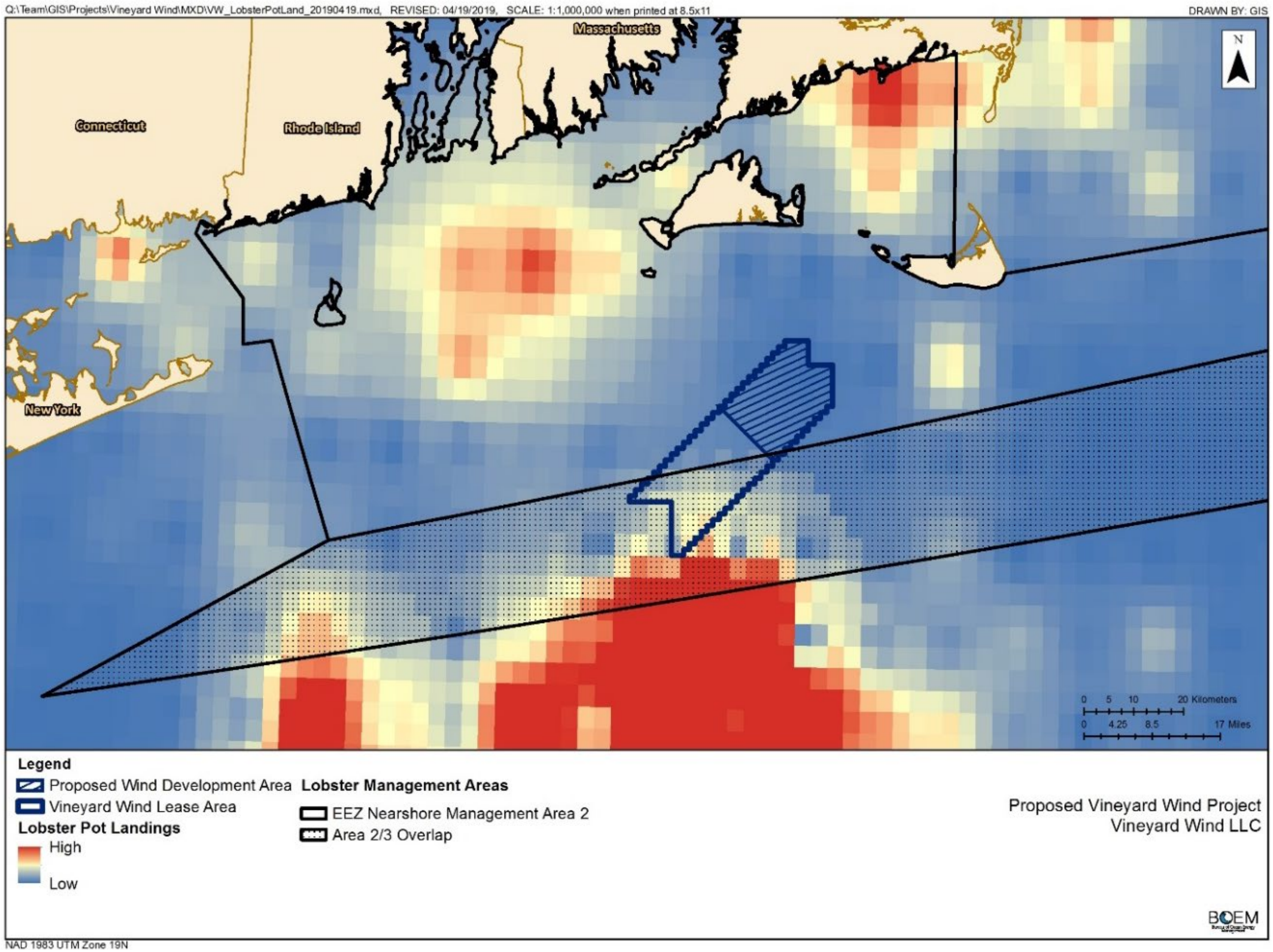


Figure B.1-9: Squid, Mackerel, Butterfish Fishery in Rhode Island/Massachusetts Lease Areas—Fishing

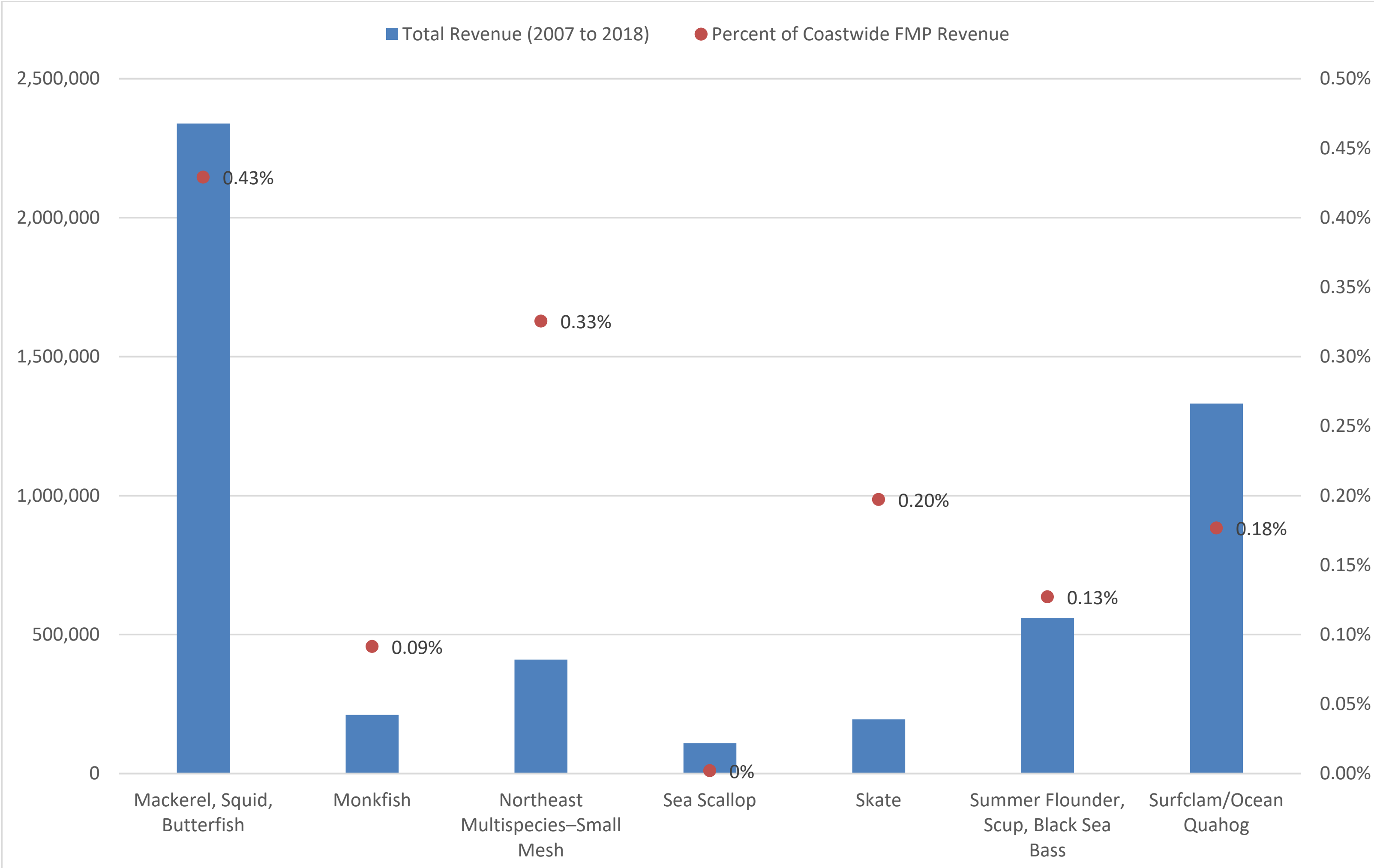
MA = Massachusetts; RI= Rhode Island; VMS = vessel monitoring system

Although Table B.1-11, Table B.1-12, and Table B.1-13 through Table B.1-20 are based on the same underlying VTR data, Table B.1-11 and Table B.1-12 use a VTR mapping model developed by the NMFS NEFSC. The VTR mapping model allows for a more conservative analysis using VTR data by taking into account some of the uncertainties around each reported point. Using observer data, for which precise locations are available, the model was developed to derive probability distributions for actual fishing locations around a provided VTR point. Other variables likely to affect the precision of a given VTR point, such as trip length, vessel size, and fishery, were also incorporated into the model. This model allows for generating maps that predict the spatial footprint of fishing. In this case, the modeled data indicate greater revenue exposure than that indicated by the VTR reported position alone over the same period.



EEZ = Exclusive Economic Zone

Figure B.1-10: Lobster Pot Landings 2001–2010



FMP = Fisheries Management Plan
Revenue was converted to 2019 dollars using the monthly, not seasonally, adjusted Producer Price Index by Industry for Fresh and Frozen Seafood Processing provided by the U.S. Bureau of Labor Statistics.

Figure B.1-11: Top Seven Fisheries Management Plans with Harvests from the Wind Development Area (2007–2018)

Table B.1-11: Value of Landings by Fisheries Management Plan for the Wind Development Area (2019 Dollars), 2007–2018

FMP	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total	Annual Average
Mackerel, Squid, Butterfish	$11,390	$156,363	$133,246	$36,666	$114,983	$161,675	$98,477	$193,134	$236,455	$978,455	$131,544	$86,104	$2,338,493	$194,874
Monkfish	$24,348	$4,937	$4,927	$16,982	$34,421	$47,055	$17,757	$11,904	$10,631	$22,636	$8,347	$7,111	$211,056	$17,588
Northeast Multispecies–Small Mesh	$32,286	$42,149	$78,763	$22,542	$28,903	$25,763	$31,865	$26,500	$26,832	$35,074	$41,835	$17,359	$409,872	$34,156
Sea Scallop	$12,071	$22,676	$11,266	$5,078	$3,939	$8,185	$1,822	$2,660	$6,992	$28,642	$3,324	$2,224	$108,877	$9,073
Skate	$46,139	$16,181	$19,791	$19,582	$34,594	$10,550	$16,503	$8,390	$4,142	$11,692	$3,427	$3,693	$194,685	$16,224
Summer Flounder, Scup, Black Sea Bass	$27,937	$4,045	$12,543	$13,602	$27,487	$32,310	$62,906	$49,273	$95,594	$96,519	$74,597	$63,547	$560,360	$46,697
Surf Clam/Ocean Quahog	$327,689	$283,269	$306,663	$147,807	$49,682	$6,111	$20,155	$8,738	$17,278	$112,401	$11,222	$40,192	$1,331,207	$110,934
None–Unmanaged	$15,441	$26,504	$23,048	$26,110	$20,744	$20,214	$32,230	$35,094	$33,284	$23,965	$24,104	$25,953	$306,691	$25,558
All Other	$81,215	$11,047	$7,756	$35,880	$7,430	$7,097	$49,817	$40,475	$20,250	$7,036	$6,376	$10,264	$284,643	$23,720
Total	$578,515	$567,172	$598,004	$324,249	$322,183	$318,960	$331,531	$376,168	$451,459	$1,316,420	$304,775	$256,448	$5,745,884	$478,824

Source: Geret DePiper, Pers. Comm., August 2018

FMP = Fisheries Management Plan
Revenue was converted to 2019 dollars using the monthly, not seasonally, adjusted Producer Price Index by Industry for Fresh and Frozen Seafood Processing provided by the U.S. Bureau of Labor Statistics. American lobster and Jonah crab fisheries are included in the "None–Unmanaged" row.

Table B.1-12: Value of Landings by Wind Development Area Fisheries Management Plan as a Percentage of Total Coast-wide Fisheries Management Plan, 2007–2018

FMP	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Mackerel, Squid, Butterfish	0.02%	0.35%	0.31%	0.10%	0.26%	0.36%	0.29%	0.52%	0.62%	1.61%	0.24%	0.14%
Monkfish	0.09%	0.02%	0.03%	0.11%	0.16%	0.22%	0.10%	0.07%	0.06%	0.11%	0.05%	0.05%
Northeast Multispecies–Small Mesh	0.27%	0.42%	0.72%	0.18%	0.25%	0.24%	0.35%	0.24%	0.26%	0.33%	0.51%	0.20%
Sea Scallop	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
Skate	0.44%	0.20%	0.27%	0.23%	0.44%	0.14%	0.13%	0.08%	0.06%	0.18%	0.06%	0.05%
Summer Flounder, Scup, Black Sea Bass	0.07%	0.01%	0.04%	0.04%	0.07%	0.09%	0.16%	0.13%	0.24%	0.24%	0.20%	0.18%
Surf Clam/Ocean Quahog	0.39%	0.38%	0.44%	0.23%	0.08%	0.01%	0.04%	0.02%	0.03%	0.19%	0.02%	0.07%

Source: Geret DePiper, Pers. Comm., August 2018

FMP = Fisheries Management Plan; WDA = Wind Development Area; VTR = vessel trip report
Table B.1-11 shows the value of landings for the WDA by the FMP; Table B.1-12 shows the percentage of each FMP's revenue from landings within the WDA compared to each FMP's total revenue from landings in the entire region covered by the FMP. The data represent the revenue-intensity raster developed using fishery dependent landings' data. To produce the data set, VTR information was merged with data collected by at-sea fisheries observers, and a cumulative distribution function was estimated to present the distance between VTR points and observed haul locations. This provided a spatial footprint of fishing activities by FMPs.

Table B.1-13: Value of Landings by Species for the Wind Development Area (Vessel Trip Report, 2019 Dollars), 2008–2017

Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Black sea bass					$1,001	$1,747		$1,307	$795	$5,406	$10,257
Bluefish	$314		$667	$2,920	$547	$162	$637	$855	$276	$1,000	$7,378
Butterfish	$1,754	$1,420	$1,739	$2,004		$8,166	$2,912	$2,170	$3,711	$5,795	$29,673
Crab, Jonah	$645		$2,996	$8,205	$31,405	$92,197					$135,448
Crab, rock				$5,124							$5,124
Dogfish, smooth, fins										$2,122	$2,122
Dogfish, spiny, fins										$287	$287
Eel, conger										$9	$9
Flounders	$10,917			$9,112		$75,535	$33,636	$62,155	$6,571	$32,286	$230,212
Hakes	$68,210	$15,631	$95,466	$37,024		$147,956	$39,432	$40,828	$46,560	$61,734	$552,841
Lobster, American	$35,456	$30,539	$26,600	$89,701	$49,682	$29,094	$5,345		$25,915	$2,897	$295,229
Mackerel, Atlantic									$13		$13
Monkfish	$10,100	$2,587	$36,213	$61,199	$147,521	$48,449	$43,175	$16,387	$32,073	$31,474	$429,179
Scallops/shells	$545					$118,081	$4,542		$1,666		$124,834
Scup			$11,954	$34,878		$17,454		$53,685	$4,502	$80,630	$203,103
Skate, rack	$8,547	$12,904	$17,926	$20,266	$58,747	$44,949	$39,410	$27,723	$32,805	$11,627	$274,905
Squids	$31,252	$7,535	$9,613	$4,925		$79,560	$38,805	$45,661	$526,582	$7,795	$751,728
All others	$8,800	$19,904	$120,677	$8,219	$24,153	$3,754	$67,989	$60,905	$3,567	$1,402	$319,370
Total	$176,542	$90,521	$323,851	$283,578	$313,056	$667,105	$275,883	$311,678	$685,036	$244,464	$3,371,714

Source: Benjamin Galuardi, Pers. Comm., April 3, 2019

Empty cells indicate that data were not collected or not available.

Table B.1-14: Volume of Landings by Species for the Wind Development Area (Vessel Trip Report, Landed Pounds), 2008–2017

Species	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Black sea bass					218	335		357	149	1,319	2,378
Bluefish	664		1,149	3,899	786	195	891	863	318	1,020	9,785
Butterfish	1,944	2,855	1,944	2,043		15,830	3,100	3,242	9,564	9,426	49,948
Crab, Jonah	994		5,155	10,341	36,458	105,190					158,138
Crab, rock				8,301							8,301
Dogfish, smooth, fins										3,507	3,507
Dogfish, spiny, fins										1,099	1,099
Eel, conger										10	10
Flounders	4,099			3,317		33,274	8,645	23,471	1,286	7,770	81,861
Hakes	93,784	41,015	90,708	53,819		189,158	54,456	66,232	98,906	107,786	795,863
Lobster, American	7,899	7,301	5,857	21,023	12,739	6,320	1,012		4,544	530	67,225
Mackerel, Atlantic									35		35
Monkfish	4,501	1,314	22,487	28,504	70,787	35,890	30,622	10,151	20,735	22,122	247,112
Scallops/shells	62					10,241	353		144		10,800
Scup			22,276	69,464		27,348		58,626	5,053	120,684	303,451
Skate, rack	60,160	35,210	30,287	34,339	88,488	51,991	46,248	43,033	66,971	32,623	489,349
Squids	28,186	5,940	7,075	3,277		67,388	34,440	37,488	405,651	3,878	593,323
All others	8,830	15,629	18,254	8,003	51,526	10,331	65,270	5,463	2,984	967	187,257
Total	211,123	109,264	205,192	246,330	261,002	553,491	245,038	248,926	616,338	312,740	3,009,443

Source: Benjamin Galuardi, Pers. Comm., April 3, 2019

Empty cells indicate that data were not collected or not available. Values are reported in landed pounds.

Table B.1-15: Value of Landings by Gear Type for the Wind Development Area (Vessel Trip Report, 2019 Dollars), 2008–2017

Gear Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Gillnet-sink				$78,873		$85,447		$39,135		$37,394	$240,849
Pot		$31,507	$32,495	$102,699	$85,362	$123,203			$27,124		$402,390
Trawl-bottom	$132,630	$46,213	$129,383	$99,829		$341,190	$178,591	$211,315	$595,795	$203,909	$1,938,854
All others	$43,912	$12,800	$161,972	$2,176	$227,696	$117,268	$97,290	$61,228	$62,120	$3,160	$789,623
Total	$176,542	$90,520	$323,850	$283,576	$313,058	$667,109	$275,881	$311,677	$685,039	$244,463	$3,371,715

Source: Benjamin Galuardi, Pers. Comm., April 3, 2019

Empty cells indicate that data were not collected or not available.

Table B.1-16: Volume of Landings by Gear Type for the Wind Development Area (Vessel Trip Report, Landed Pounds), 2008–2017

Gear Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Gillnet-sink				68,048		86,257		48,931		44,444	247,680
Pot		8,852	18,358	39,792	54,476	114,160			6,244		241,882
Trawl-bottom	194,035	86,126	124,107	137,741		343,217	157,024	195,226	523,556	267,443	2,028,474
All others	17,088	14,286	62,727	749	206,526	9,857	88,014	4,769	86,539	853	491,408
Total	211,123	109,264	205,192	246,330	261,002	553,491	245,038	248,926	616,339	312,740	3,009,443

Source: Benjamin Galuardi, Pers. Comm., April 3, 2019

Empty cells indicate that data were not collected or not available. Values are reported in landed pounds.

Table B.1-17: Value of Landings by Port for the Wind Development Area (Vessel Trip Report, 2019 Dollars), 2008–2017

Port	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Montauk										$40,629	$40,629
New Bedford		$46,151	$179,883	$66,084	$13,553		$20,164		$100,867		$426,702
Point Judith	$116,149		$58,605	$83,392		$286,689	$160,234	$242,957	$452,756	$119,803	$1,520,587
Point Pleasant										$26,108	$26,108
Westport				$60,428							$60,428
All others	$60,393	$44,369	$85,361	$73,674	$299,505	$380,418	$95,483	$68,720	$131,416	$57,922	$1,297,260
Total	$176,542	$90,520	$323,849	$283,578	$313,058	$667,108	$275,881	$311,677	$685,039	$244,462	$3,371,713

Source: Benjamin Galuardi, Pers. Comm., April 3, 2019

Empty cells indicate that data were not collected or not available.

Table B.1-18: Volume of Landings by Port for the Wind Development Area (Vessel Trip Report, Landed Pounds), 2008–2017

Port	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Montauk										56,022	56,022
New Bedford		27,226	58,609	35,007	10,286		17,638		97,357		246,123
Point Judith	137,296		68,664	121,160		208,264	140,186	186,758	378,589	187,326	1,428,241
Point Pleasant										10,975	10,975
Westport				30,113							30,113
All others	73,827	82,038	77,919	60,050	250,716	345,227	87,214	62,168	140,393	58,417	1,237,969
Total	211,123	109,264	205,192	246,330	261,002	553,491	245,038	248,926	616,339	312,740	3,009,443

Source: Benjamin Galuardi, Pers. Comm., April 3, 2019

Empty cells indicate that data were not collected or not available. Values are reported in landed pounds.

Table B.1-19: Value of Landings by State for the Wind Development Area (Vessel Trip Report, 2019 Dollars), 2008–2017

State	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Connecticut									$44,948		$44,948
Massachusetts		$49,364	$241,696	$181,889	$210,955	$130,524	$101,223	$53,757	$182,414	$41,400	$1,193,221
New Jersey										$26,108	$26,108
New York										$43,784	$43,784
Rhode Island	$132,736	$40,751	$58,605	$83,392	$94,914	$383,233	$167,113	$242,957	$457,322	$122,733	$1,783,758
All others	$43,806	$405	$23,548	$18,295	$7,187	$153,352	$7,545	$14,963	$354	$10,438	$279,892
Total	$176,542	$90,520	$323,849	$283,576	$313,057	$667,109	$275,881	$311,677	$685,038	$244,462	$3,371,711

Source: Benjamin Galuardi, Pers. Comm., April 3, 2019

Empty cells indicate that data were not collected or not available.

Table B.1-20: Volume of Landings by State for the Wind Development Area (Vessel Trip Report, Landed Pounds), 2008–2017

State	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Connecticut									50,935		50,935
Massachusetts		33,979	119,758	108,050	161,338	121,793	94,743	55,763	179,187	47,982	922,593
New Jersey										10,975	10,975
New York										57,619	57,619
Rhode Island	176,776	75,216	68,664	121,160	97,583	310,638	145,876	186,758	386,160	192,486	1,761,315
All others	34,347	69	16,770	17,120	2,081	121,060	4,419	6,405	57	3,678	206,006
Total	211,123	109,264	205,192	246,330	261,002	553,491	245,038	248,926	616,339	312,740	3,009,443

Source: Benjamin Galuardi, Pers. Comm., April 3, 2019

Empty cells indicate that data were not collected or not available. Values are reported in landed pounds.

Analysis prepared by the RI DEM for the WDA, using VMS and VTR data, provides an estimate of the ex-vessel value (the price received at port of landing) of the Rhode Island commercial fishing industry that is derived from the WDA (RI DEM 2019). The study suggests that the value of fishing in the area is $35.6 million for a 30-year period (corresponding to the length of the lease and construction time). The values are premised on existing trips that either fully or partially intersect the WDA area, including a 2-nautical-mile (2.3-mile) section north or south of the WDA. The study further showed that almost $21 million of the total 30-year value would be from the Atlantic Mackerel, Squid, and Butterfish FMP; $4.7 million from the Northeast Multispecies FMP, small mesh species (hakes); $4.6 million from Summer Flounder, Scup, and Black Sea Bass FMP; $2.2 million from groundfish, $1.5 million from American lobster; $1 million from scallops; and the remaining from other species. Again, the RI DEM (2019) analysis was specific to vessels landing in Rhode Island ports.

The Summer Flounder, Scup, Black Sea Bass FMP landed up to 0.2 percent of the total coast-wide revenue (Table B.1-12). Between 2007 and 2018, annual revenue from landings of summer flounder (*Paralichthys dentatus*), scup (*Stenotomus chrysops)*, and black sea bass (*Centropristis striata*) in the WDA ranged from $4,045 to $96,519, with a total revenue of $560,360 for 2007 to 2018 (2019 dollars, Table B.1-11). Summer flounder is most often landed from January to September, with the peak in June through August. Three periods comprise the scup's quota. In spring and summer, scup migrate to northern and inshore waters to spawn. The black sea bass peak harvest is typically June through September.

Many potentially affected fisheries, including the whiting, summer flounder, scup, and black sea bass, are not required to use VMS. Therefore, these fisheries are underrepresented in evaluations of impacts from the WDA or the cable corridor. Data from several sources are provided in this section to show how the estimates of catch from the WDA may differ depending on the measurement method.

Data provided by NOAA NEFSC (Table B.1-13 and Table B.1-14) that were collected through VTRs show low revenue from the WDA for black sea bass ($10,257 for 2008 through 2017). Revenues for scup total $203,103, and revenues for flounders total $230,212 between 2008 and 2017 (2019 dollars).

The Atlantic Mackerel, Squid, Butterfish FMP covers longfin and illex squid, which make up the majority species landed in this FMP. Bottom and mid-water trawling account for most landings (ASMFC 2018b). As shown on Figure B.1-8, density was variable in vessels targeting squid throughout the WDA with patches of medium-low to medium-high density, and an area of very high density along the OECC. Revenue from the Atlantic Mackerel, Squid, and Butterfish FMP from the WDA ranged from a low of $11,390 in 2007 to a high of $978,455 in 2016 (Table B.1-11). For 2007 to 2018, the total revenue for this FMP was $2.3 million (Table B.1-11). Based on VMS data and the RI DEM analysis, 2016 was also a high revenue year ($5.1 million for the entire lease area around the WDA [Table B.1-9]) but with higher activity densities also seen north of the WDA.

To the contrary, Table B.1-8 shows no revenue from Atlantic mackerel (*Scomber scombrus)* from the WDA ($13 for 2008 to 2017), $751,728 in revenue from squids, and $29,673 from butterfish. For the period of 2008 to 2017, the squid fishing revenue from Rhode Island is estimated at $192.1 million with 235.1 million pounds landed. In general, squid landings in Rhode Island represented 53 percent of total squid landings from the Atlantic and 54 percent of total squid revenue from the Atlantic (based on nominal revenue data for 2008 to 2017; NOAA 2019f). With $643,551 in squid revenue from the WDA from 2008 to 2017, the WDA accounts for 0.18 percent of squid revenue from the Atlantic (or 0.33 percent of squid revenue from Rhode Island).

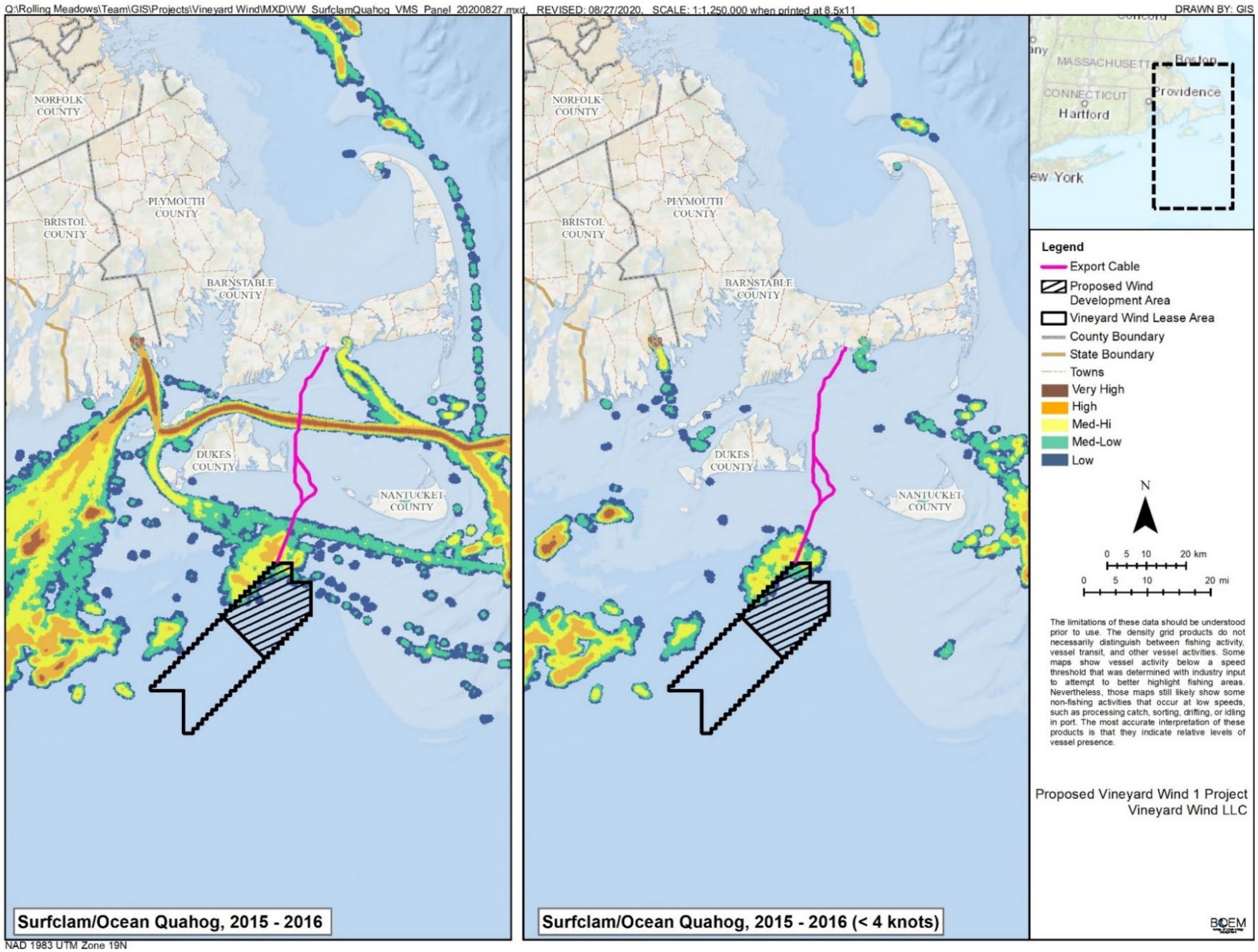
As shown on Figure B.1-12, VMS data indicate that surf clam/ocean quahog fishing vessels are not typically found within the WDA; however, along the OECC, there were areas where very high density of catch were indicated. Figure B.1-12 shows the relative surf clam/ocean quahog fishing vessel density during the year 2015 to 2016, with all recorded fishing vessels traveling at any speed, and speed filtered to show only those vessels traveling less than 4 knots. VMS data show vessel presence but do not indicate whether the vessel is fishing or not. The presence of vessels traveling less than 4 knots may better indicate surf clam/ocean quahog fishing activity because higher-speed vessels are more likely to be transiting. Figure B.1-13 shows a majority of the 24 unique vessels in the surf clam and ocean quahog fishery transiting in a northeast to southwest direction through the southern New England lease areas. Surf clams are harvested principally via hydraulic dredging. The harvest of surf clam and ocean quahog in the WDA provided a high value of landings prior to 2011; however, since then, the harvest has substantially decreased in the WDA, valued at only $17,278 in 2015, increasing to $112,401 in 2016 and down to $11,222 in 2017. From 2007 to 2018, the total revenue for this FMP was $1.3 million from the WDA (Table B.1-11).

Atlantic sea scallop vessels had medium-low or medium-low to medium-high VMS density in the WDA and higher VMS density (up to high) along the OECC (Figure B.1-14). Figure B.1-15 shows the relative sea scallop fishing vessel density between 2015 and 2016, with all recorded fishing vessels traveling at any speed, and speed filtered to show only those vessels traveling less than 5 knots. VMS data show vessel presence but do not indicate whether the vessel is fishing or not. The presence of vessels traveling less than 5 knots may better indicate sea scallop fishing activity because higher-speed vessels are more likely to be transiting. Figure B.1-5 shows a majority of the 418 unique vessels in the sea scallop fishery transiting in a northwest to southeast direction through the southern New England lease areas. Dredges are the primary fishing gear. Table B.1-11 shows that the annual revenue for this FMP from the WDA ranged from $1,822 to $28,642, with $108,877 landed from 2007 to 2018. To compare, VTR data show $118,081 in revenue from sea scallops/shellfish from the WDA in 2013; less than $4,600 in 2008, 2014, and 2016; and no revenue in the remaining years (Table B.1-13).

VTR data inform that other important sources of revenue from the WDA from 2008 to 2017 were Jonah crab (totaling $135,448), hakes ($552,841), American lobster ($295,229), monkfish ($429,179), and skate ($274,905; Table B.1-13 and Table B.1-14).

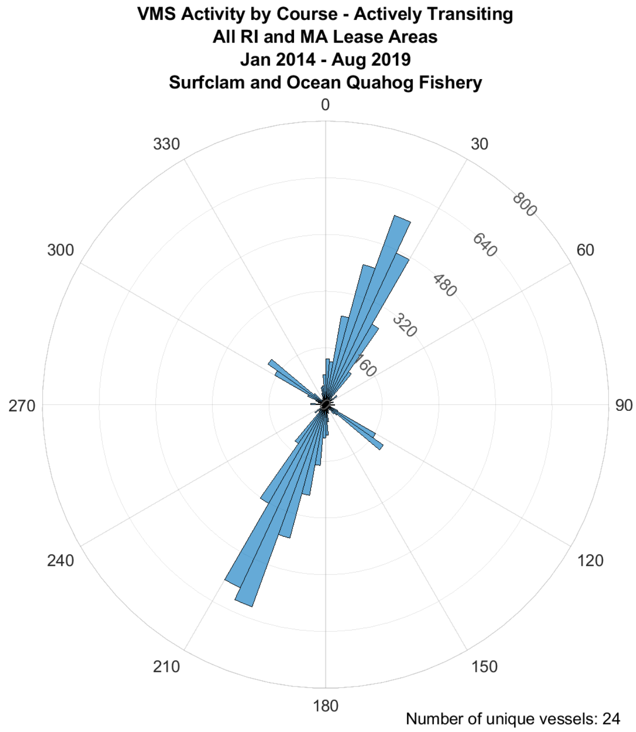
Table B.1-15 and Table B.1-16 show the value and volume of landings for the WDA from 2008 to 2017. Bottom trawl is the primary gear type used in the WDA, where an estimated 57 percent of all revenue from the WDA and more than 65 percent of landed fish was caught using bottom trawl. Bottom trawl targets bluefish *(Pomatomus salatrix)*, monkfish, summer flounder, winter flounder (*Pseudopleuronectes americanus*), silver hake (*Merluccius bilinearis*), whiting, spiny dogfish (*Squalus acanthias*), smooth dogfish (*Mustelus canis*), scup, and black sea bass. The nearshore bottom-trawl fishery targets butterfish, bluefish, and other finfish species; the deeper water fisheries target bluefish, Atlantic mackerel, Loligo squid, black sea bass, and scup (NOAA 2019h). Other deployed gear types in the WDA include pot and sink gillnet. Pot targets crabs, lobsters, scup, and black sea bass. Sink gillnet targets species such as yellowtail flounder (*Limanda ferruginea),* winter flounder, witch flounder (*Glyptocephalus cynoglossus*), windowpane flounder (*Scophthalmus aquosus*), spiny dogfish, monkfish, silver hake, red hake (*Urophycis chuss*), white hake (*Urophycis tenuis*), skate, mackerel, and other.

Commercial fishing vessels homeported in Point Judith fish in the WDA most intensively. From 2008 to 2017, Point Judith fishing revenue from the WDA is estimated at $1.5 million with 1.4 million pounds of catch landed in the port (Table B.1-17 and Table B.1-18). Most of Point Judith fishing revenue is from squid, lobster, summer flounder, Atlantic sea scallop, scup, monkfish, silver hake, Jonah crab, and yellowtail flounder sales (NMFS 2018a). In fact, 53 percent of fishing revenue from the WDA is landed in Rhode Island, with 35 percent landed in Massachusetts, and the remaining landed in other states (Table B.1-19).



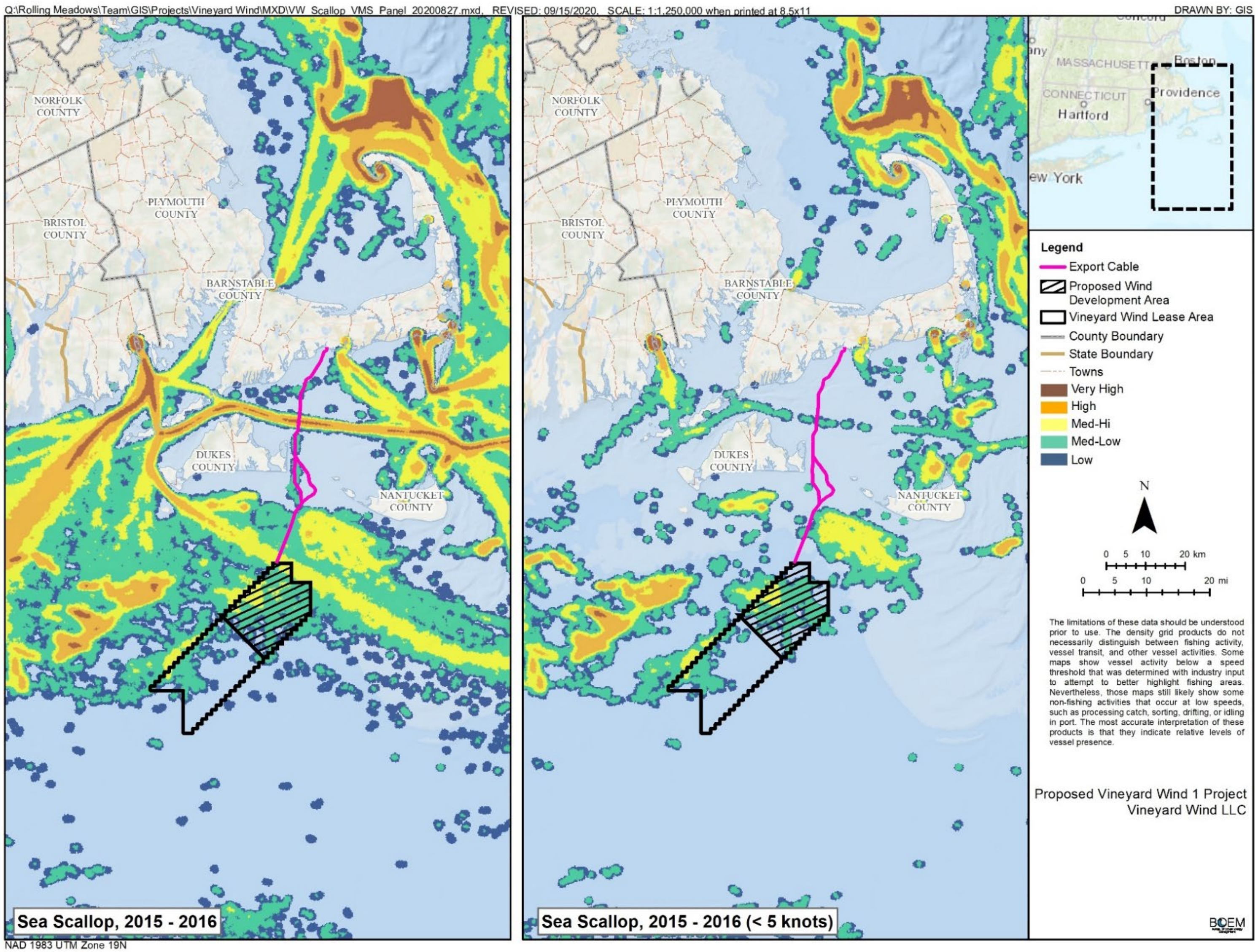
Source: Northeast Regional Ocean Council 2020

Figure B.1-12: Surf Clam/Ocean Quahog Fishing Vessel Density Based on Vessel Monitoring System Data (2015-2016)



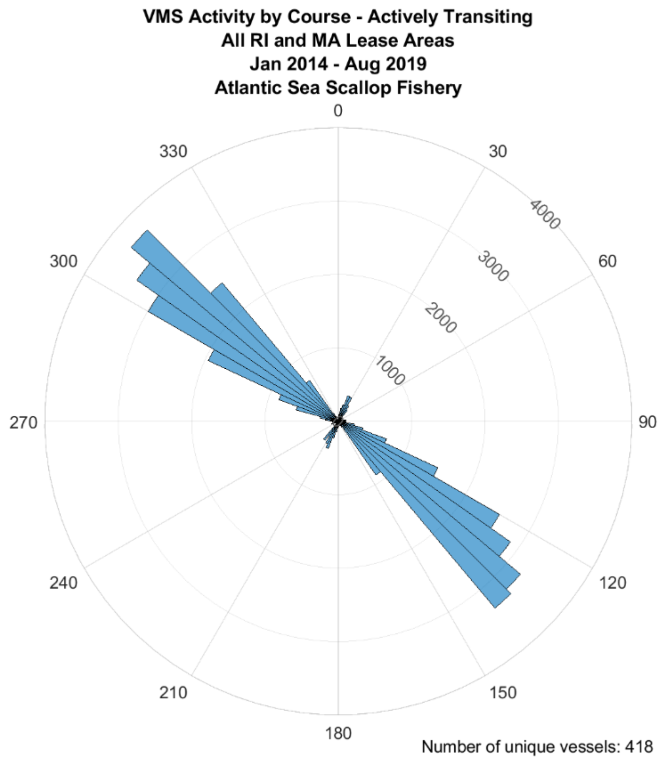
MA = Massachusetts; RI= Rhode Island; VMS = vessel monitoring system

Figure B.1-13: Surf Clam and Ocean Quahog Fishery in Rhode Island/Massachusetts Lease Areas—Transiting



Source: Northeast Regional Ocean Council 2020

Figure B.1-14: Sea Scallop Fishing Vessel Density Based on Vessel Monitoring System Data (2015–2016)



MA = Massachusetts; RI= Rhode Island; VMS = vessel monitoring system

Figure B.1-15: Sea Scallop Fishery in Rhode Island/Massachusetts Lease Areas—Transiting

It is more challenging to quantitatively characterize fishing along the OECC because it is a linear feature. In addition, fewer impacts are expected along the OECC due to the relatively narrow area potentially disturbed. As shown on Figures B.1-8, B.1-11, and B.1-14, the OECC intersects areas with high vessel density for fishermen targeting squid, surf clams/ocean quahogs, and Atlantic sea scallops. In addition, as shown on Figure B.1-16, part of the OECC within state waters intersects an area of "high commercial fishing effort and value" identified in the Massachusetts Ocean Management Plan (EEA 2015). There is also low, medium-low to medium-high vessel density along the OECC, whereas vessel density in the WDA is characterized as low (Figures B.1-17 and B.1-18).

The Massachusetts Division of Marine Fisheries Draft Environmental Impact Report indicates that the OECC would pass through areas of commercial and recreational fishing and habitat for a variety of invertebrate and finfish species, including channeled whelk (*Busycotypus canaliculatus*), knobbed whelk (*Busycon carica*), longfin squid (*Doryteuthis pealeii*), summer flounder, windowpane flounder, scup, surf clam, Atlantic sea scallop, quahog, Atlantic horseshoe crabs (*Limulus polyphemus*), and blue mussel (*Mytilus edulis*) (Epsilon 2018).

Blue mussel and kelp aquaculture operations are also located within Horseshoe Shoals (a subtidal area of Nantucket Sound) (Epsilon 2018). Existing aquaculture operations lie near the southern portion of Horseshoe Shoals, near the main channel of Nantucket Sound. However, this is more than 4 nautical miles (4.6 miles) from the OECC. The proposed Project is not anticipated to affect leased aquaculture sites.

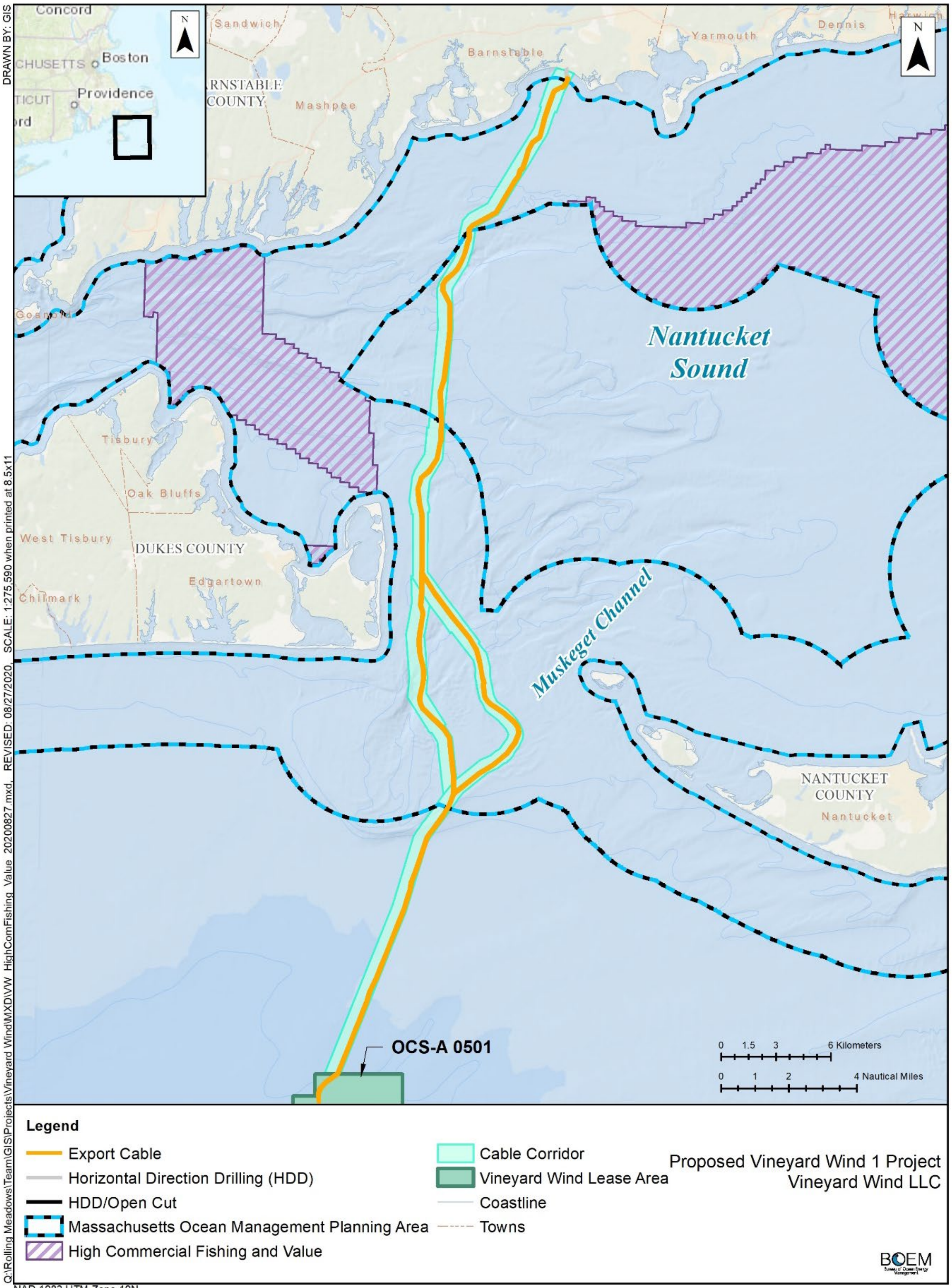
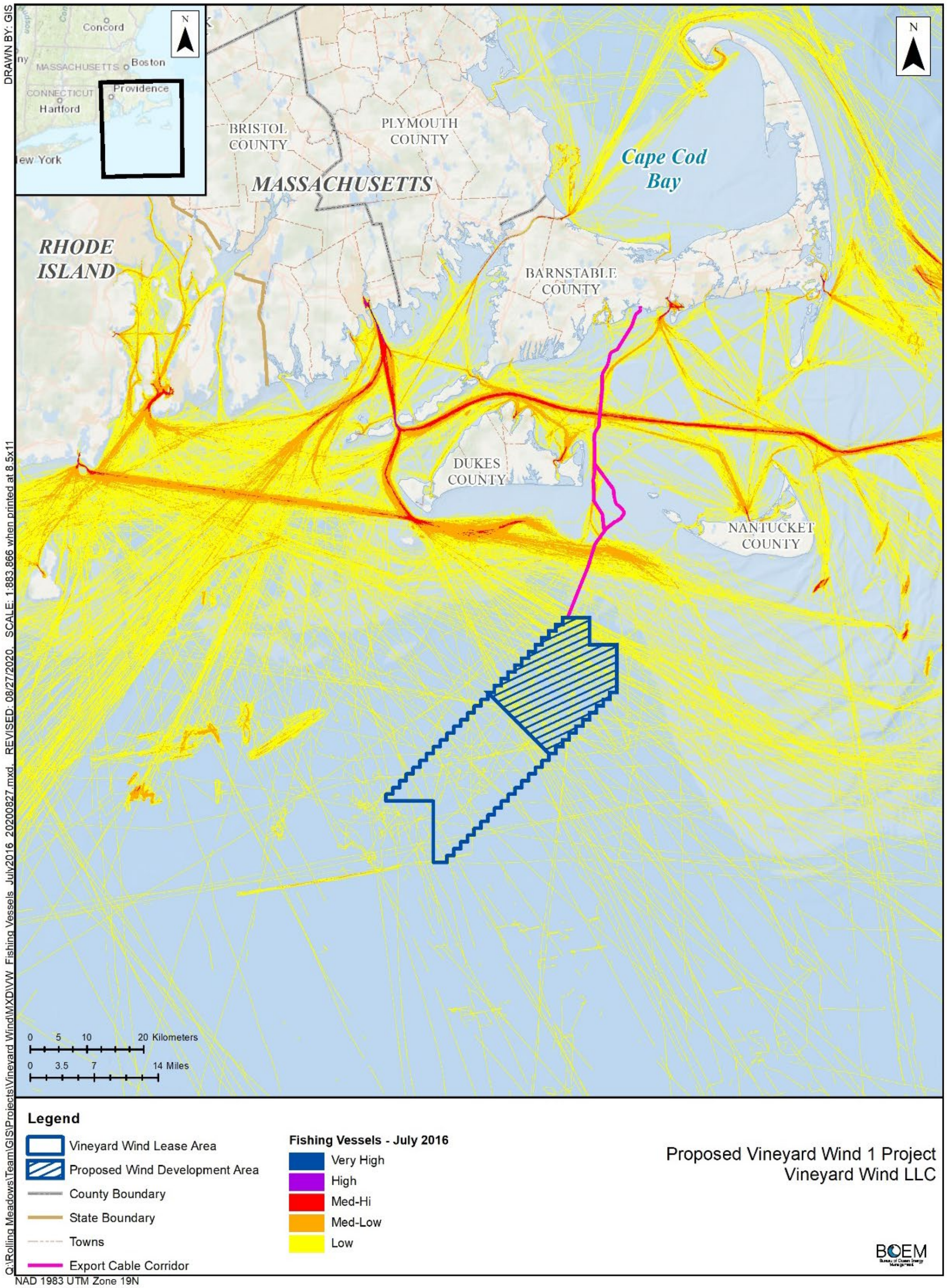
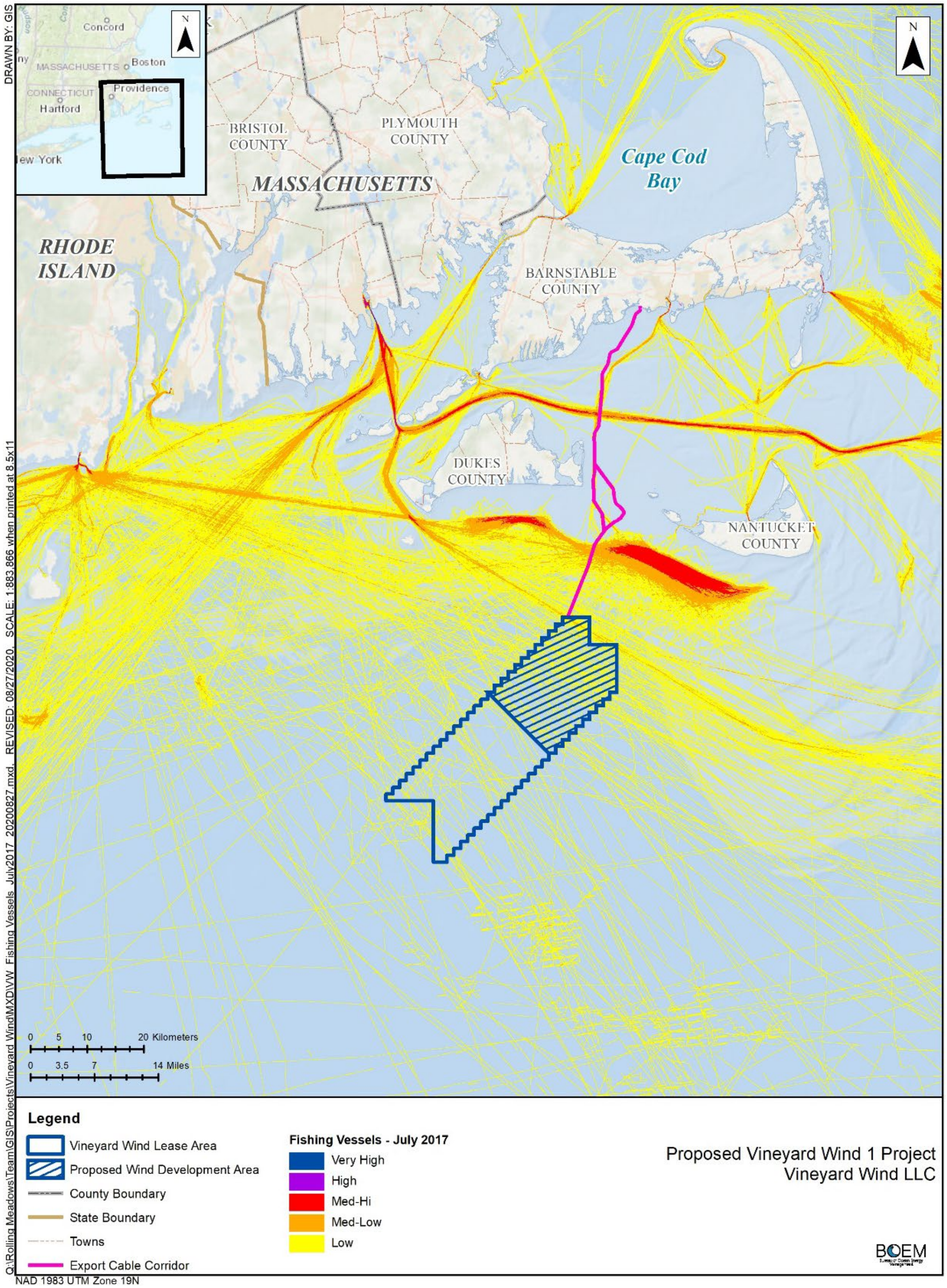


Figure B.1-16: Massachusetts Ocean Management Plan Areas of High Commercial Fishing Effort and Value



Source: Northeast Regional Ocean Council 2020

Figure B.1-17: Fishing Monthly Vessel Transit Counts from July 2016 Automatic Identification System Northeast and Mid-Atlantic



Source: Northeast Regional Ocean Council 2020

Figure B.1-18: Fishing Monthly Vessel Transit Counts from July 2017 Automatic Identification System Northeast and Mid-Atlantic

Fishing for whelk, often referred to locally as conch, is done from Horseshoe Shoals and other areas in Nantucket Sound. This fishery was valued at $4.8 million in 2016. Although this is a relatively new fishery that was not heavily exploited until the early 2010s, signs indicate that the stocks are vulnerable to overfishing and may already be overfished. This fishery operates entirely within state waters, with a plurality of the total catch taken from Nantucket Sound (Nelson et al. 2018). Again, because of the distance from the OECC, proposed Project activities are not expected to affect this fishery.

The lobster fishery in Massachusetts is the most lucrative fishery harvested within the state's waters, but it is now in a depleted condition (Dean 2010; MA DMF 2017). Despite the reduced landings (17.6 million pounds in 2016), rising prices bolster the fishery's value, which was more than $82 million in 2017 (MA DMF 2017). Recently, there has been very little lobster catch from nearshore waters south of Cape Cod; therefore, most vessels from this area now venture far offshore to target lobster in deeper waters (Abel 2017; Dean 2010; MA DMF 2017).

Atlantic horseshoe crab spawning areas are associated with Covell's Beach and Great Island Beach (Epsilon 2018). This fishery, while significant to the state, is patchy and variable from year-to-year. Most of the catch comes from Cape Cod Bay, Nantucket Sound, and near the islands of Nantucket and Martha's Vineyard (Burns 2018; Perry 2017). Surf clam habitat and patchy eelgrass beds also occur in waters offshore of Covell's Beach. For-hire recreational fishing is also an important economic sector regionally with peak activity June through August (NOAA 2017b). Regionally in 2015, the industry created 2,232 jobs, generated $326 million in sales, and contributed $192 million in value added. The Marine Recreational Information Program data show that mackerels, cod, and striped bass (*Morone saxatilis*) were the most-caught species within the Massachusetts for-hire recreational fishery. Black sea bass, scup, striped bass, summer flounder, and tautog (*Tautoga onitis*) were the most-caught species within the Rhode Island for-hire recreational fishery (NOAA 2017c).

In 2018, there were 129,862 party- and charter-boat fishing trips out of Massachusetts and 42,558 out of Rhode Island. However, there is substantial variability year-to-year with as few as 95,000 trips in 2016 and as many as 224,249 trips in 2017 from Massachusetts. Based on the number of trips over the past 10 years, there are, on average, 188,916 party- and charter boat fishing trips per year out of Massachusetts and 45,648 out of Rhode Island (NOAA 2020b). On average, party and charter boats account for 5 percent of all recreational effort onboard boats off the coast of Massachusetts and 4 percent off the coast of Rhode Island based on the Fishery Effort Survey (NOAA 2020b). NOAA estimated that 97 percent of the 2011 recreational effort from Massachusetts occurred within 3 nautical miles (3.5 miles) of shore (BOEM 2012).

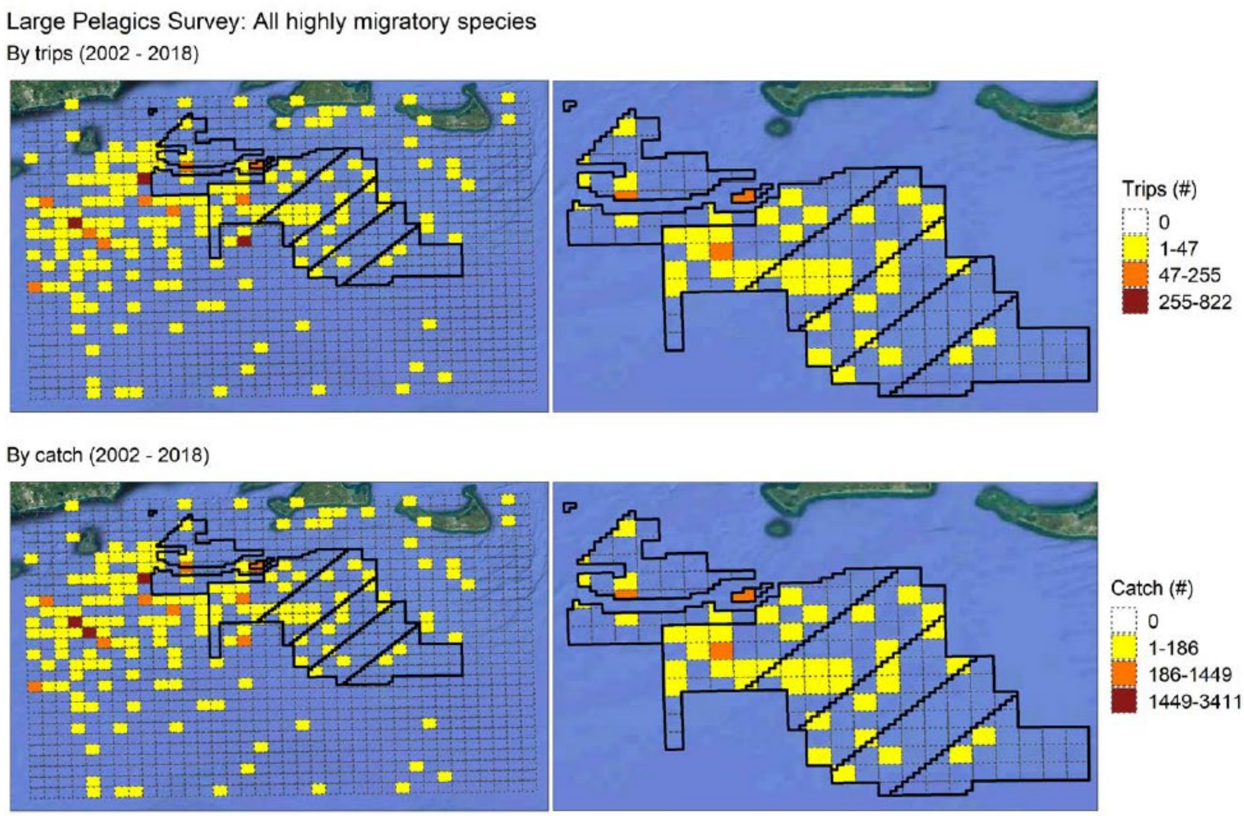
For-hire recreational fishing in the Atlantic provides opportunities for recreational fishing of highly migratory species such as tuna, billfish, swordfish (*Xiphias gladius*), and sharks. Tuna and sharks are found in the WDA where they feed on squid, mackerel, and butterfish found in the area. Tuna and sharks are targeted in the WDA by for-hire fishing boats. Highly migratory species such as tuna and shark are relatively costly to pursue for private anglers, as they require large vessels.

Popular recreational fishing areas across the RI/MA Lease Areas include "The Dump," where recreational vessels harvest Atlantic yellowfin tuna (*Thunnus albacares*), albacore tuna (*Thunnus alalunga*), and mahi-mahi (*Coryphaena hippurus*). Other nearby recreational fishing locations include "The Owl" and the "The Star." "Gordon's Gully" is the only named recreational fishing location within the WDA. "31 Fathom Hole" and the northeast corner of the Dump are wholly and partially in the New England Wind lease area (Figure 3.9-2 in EIS Section 3.9). Species caught by recreational vessels in these areas include bluefin tuna (*Thunnus thynnus)*, shortfin mako shark (*Isurus oxyrinchus*), common thresher sharks (*Alopias vulpinus)*, white marlin (*Kajikia albida*), and Atlantic yellowfin tuna. Along the OECC, harvested species often include striped bass, bluefish, bonito, false albacore (*Euthynnus alletteratus*), and bluefin tuna, as well as summer flounder, black sea bass, and scup (Epsilon 2020). In general, for-hire recreational fishing boats from the Massachusetts area most often catch cod, hake, striped bass, and mackerel (Epsilon 2020).

Figure B.1-19 shows areas of high recreational fishing (both for-hire and private angler recreational fishing) effort (i.e., number of trips and total catch) for highly migratory species throughout the southern New England region from 2002 to 2018 (Kneebone and Capizzano 2020). Based on the interpolation of trips and catch as reported in the Large Pelagics Intercept Survey, generally, the greatest amount of recreational fishing effort for highly migratory species occurred west of the RI/MA Lease Areas in the waters south and east of Montauk Point and Block Island. Within the RI/MA Lease Areas, a large amount of fishing effort for all highly migratory species occurred in "The Dump," "Coxes Ledge," "The Fingers," and "The Claw." Fifty-eight members of the Rhode Island Party and Charter Boat Association stated that they fish in the WDA area, particularly Gordon's Gully for tuna and shark. The Star, The Claw, and the Fingers (inside) are also in proximity. The members are worried that once the proposed Project is in place, shark and tuna would no longer be found there, which could be harmful for business. Tuna and sharks are found in the WDA because they feed on squid, mackerel, and butterfish. If those species are affected, tuna and shark may also leave the WDA. Finding alternative fishing spots could be challenging, as it is uncertain where the species may relocate.

The highest density of recreational vessels is reported within Nantucket Sound and within 1 nautical mile (1.15 mile) of the coastline (Epsilon 2020). Table B.1-21 shows the average annual number of for-hire recreational boat trips by port group based on federally reported VTRs that come within 1 nautical mile (1.15 mile) of the RI/MA Lease Areas. NOAA NEFSC found only about 0.2 percent of for-hire boat trips and 0.325 percent of for-hire boat trips from Massachusetts, New Hampshire, New York, and Rhode Island were near the Massachusetts Wind Energy Area (i.e., BOEM lease areas OCS-A 0500, OCS-A 0501, OCS-A 0520, OCS-A 0521, and OCS-A 0522) (Kirkpatrick et al. 2017). Also, on average, more for-hire recreational fishing trips to the RI/MA Lease Areas originate from Montauk, New York, than any other port or state.

There is substantial variability in the volume and value landed of various species fished within the WDA. For example, as stated in Table B.1-11, surf clam/ocean quahog harvested from within the WDA was valued at $6,111 to $327,689, depending on the year. Similarly, Atlantic Mackerel, Squid, and Butterfish FMP from within the WDA varied from $11,390 to $978,455 per year. In general, based on catch data for the last decade, the total annual revenue from landings within the WDA usually varied from about $300,000 to $600,000 but peaked in 2016 at a high of $1.3 million. Year-to-year variation in available catch and fishing effort, as well as quotas set for commercial and recreational fisheries to protect stocks and prevent overfishing, introduce significant fluctuations in how much is landed every year from within the WDA, the Massachusetts Wind Energy Area, and other locations. As a result, it is challenging to predict what the commercial fishing revenue from specific fishing areas, such as the RI/MA Lease Areas, would look like going forward. However, the activity and value of fisheries in recent years, as described in the previous sections, are expected to be indicative of future conditions and trends.



Source: Kneebone and Capizzano 2020

Figure B.1-19: Recreational Fishing Effort for Highly Migratory Species over the Southern New England Grid (left) and Rhode Island/Massachusetts Lease Areas (right), 2002–2018

Table B.1-21: Average Annual For-Hire Recreational Trips Within 1 Mile of Rhode Island/Massachusetts Lease Areas, 2007–2012

Port Group	Exposed For-Hire Boat Trips
Barnstable, Massachusetts	2
Falmouth, Massachusetts	1
Nantucket, Massachusetts	1
Oak Bluffs, Massachusetts	1
Onset, Massachusetts	1
Tisbury, Massachusetts	~0
Montauk, New York	16
Narragansett, Rhode Island	8
South Kingstown, Rhode Island	2
Westerly, Rhode Island	1

Source: Kirkpatrick et al. 2017

B.3 Potential Impacts on Scientific Research and Surveys

The analysis in this section is reprinted from the Final EIS for the Vineyard Wind 1 Project (BOEM 2021) and reflects input from NOAA and other agencies that occurred as part of the Vineyard Wind 1 Project. While more recent data may be available, the Vineyard Wind 1 information remains valid to broadly characterize and support the analysis of the New England Wind Project's impacts on scientific research and surveys in EIS Section 3.14, Other Uses (National Security and Military Use, Aviation and Air Traffic, Offshore Cables and Pipelines, Radar Systems, Scientific Research and Surveys, and Marine Minerals).

Research activities may continue within the Vineyard Wind 1 WDA during construction, as permissible by survey operators and boat captains. Vineyard Wind 1 would impact survey operations by excluding certain areas within the WDA occupied by project components (e.g., WTG foundations, cable routes) from potential sampling and by impacting survey gear performance, efficiency, and availability. Agencies would need to expend resources to update scientific survey methodologies due to construction and operations of Vineyard Wind 1, as well as to evaluate these changes on stock assessments and fisheries management. NOAA's Office of Marine and Aviation Operations determined that the NOAA ship fleet will not operate in wind facilities with 1 nautical mile (1.15 mile) or less separation between turbine foundations.

The following provides NOAA's evaluation of the potential impacts on these survey operations based on likely foreseeable actions, including the WDA and all other existing federal lease areas from Maine to mid-North Carolina.

Fish and shellfish research programs: Randomized station selection methodologies that are employed by most of the shipboard scientific fish and shellfish surveys would not be applied in wind energy areas. Loss of survey areas would increase the uncertainty in estimates of fish and shellfish stock abundances and oceanographic parameters. If abundances, distributions, biological rates, or environmental parameters differ inside versus outside wind energy areas but cannot be observed, resulting survey indices could be biased and unsuitable for monitoring stock status. Similarly, resulting regional oceanographic time series could also be biased. A broad analysis for the NMFS bottom-trawl surveys that considered current and planned wind areas found that 9 out of 14 offshore strata that contribute most of the area sampled in the southern New England Mid-Atlantic region would likely be affected. Strata for fish and shellfish surveys are defined based on depth and alongshore features to delineate areas of relatively homogeneous species distributions. Random sampling within a stratum is a key attribute of statistical performance of these and many other typical survey designs.

The Vineyard Wind 1 lease area alone overlaps strata associated with three different coast-wide NEFSC fishery resource monitoring surveys. For the spring and fall multi-species bottom-trawl surveys, 6 percent of the area in one stratum would be within the Vineyard Wind 1 lease area. For the ocean quahog survey, 3 percent of the area in one stratum would be within the lease area. As a result, Alternative A would result in major impacts on NOAA's scientific surveys.

The impacts of other offshore wind projects would be similar, over an extended area. For the spring and fall multi-species bottom-trawl surveys, 16 of the southern New England Mid-Atlantic strata would be affected, although overlap is less than 1 percent in 2 strata. Between 3 and 60 percent of each remaining 14 stratum's area would be covered by offshore wind lease areas, including Vineyard Wind 1. The percent of area made unavailable would be higher in inshore strata (mean of 18 percent) than offshore strata (mean of 11 percent). Of the 14 offshore strata that contribute most of the area surveyed in the region, 9 are affected. In the case of offshore stratum 9, for example, which includes Vineyard Wind 1 and contiguous lease areas, up to 37 percent of the area could be unsampleable. For the integrated benthic/Atlantic sea scallop survey, four routinely sampled strata would likely be affected, with 3 to 12 percent of the stratum areas potentially unsampleable. For another two strata that are intermittently dredge sampled through the Virginia Institute of Marine Science Research Set Aside program, 21 to 56 percent of the area within those two strata would potentially be unsampleable. For the ocean quahog survey, 4 of 12 strata would include offshore wind lease areas, with 3 to 19 percent of the stratum areas potentially unsampleable. For the surf clam survey, 3 of 12 survey strata would include offshore wind lease areas, with 7 to 14 percent of the stratum areas potentially unsampleable. Low percentage overlaps for these two shellfish surveys may still have substantial impacts because there are only a few large strata in both surveys. Areas occupied by OECCs, which could not be trawled or dredged, are not included in these estimates. In summary, depending on the survey, up to 33 percent of strata within a survey would potentially be affected, and up to 60 percent of a single stratum within a survey would potentially be affected.

As noted above, removing survey effort to remaining areas that can be sampled would not mitigate the impacts. Without new alternative sampling methods and statistical designs, relocation of survey efforts would affect sampling accuracy. In addition, impacts could extend to operations outside wind energy areas, decreasing remaining survey precision. Based on layout and spacing of WTGs and current survey vessel operation policies, NMFS-supported vessels would not transit through wind energy lease areas. Alteration of survey vessel routes and resultant increased travel times would reduce survey productivity and precision.

Protected species (cetaceans, sea turtles, and pinnipeds) research programs: Aerial survey track lines at the altitude used in current cetacean and sea turtle abundance surveys (600 feet above mean sea level [AMSL]) could not occur in offshore wind areas because the planned maximum-case scenario WTG blade tip height (837 feet AMSL for Vineyard Wind 1 and 853 feet AMSL for other projects) would exceed the survey altitude with current surveying methodologies. The increased altitude necessary for safe survey operations could result in lower chances of detecting marine mammals and sea turtles, especially smaller species. At a minimum, NOAA Office of Marine and Aviation Operations pilots maintain a safety zone of at least 500 vertical feet from structures and hazards. The RI/MA Lease Areas comprise less than 1.5 percent of the aerial survey stratum, although the visual aerial abundance surveys for this stratum contributes to the estimates of 30 or more stocks of cetaceans and sea turtles. Thus, if animal distribution is not affected by offshore wind activities and NMFS surveys do not include these areas, the reduction in survey stratum area would have a minimal impact on abundance estimates for protected species. Impacts would be more substantial if the distribution and/or abundance within the RI/MA Lease Areas was different than the surrounding areas that continue to be surveyed.

Considerable survey efforts have been underway for years using digital aerial surveys for protected species in offshore wind areas. NMFS has begun investigating whether photographic abundance/monitoring surveys flown at a higher altitude are practical, reliable, and result in appropriately accurate and precise distribution and abundance estimates. More work is needed to confirm whether higher-altitude photographic survey methods are appropriate for abundance and monitoring surveys for all cetaceans, sea turtles, and pinnipeds.

A recent study found that the seven contiguous lease areas offshore Massachusetts and Rhode Island encompass important habitat that is utilized by NARWs (Leiter et al. 2017). Over one third of the current population, including up to 30 percent of known calving females, visited the RI/MA Lease Areas between 2010 and 2015. NMFS uses aerial surveys to collect photographs of the NARWs and other species to estimate abundance and monitor the health and status of individuals and populations. Shipboard surveys and small boat work also collect detailed data on NARWs, including photographs and drone images, biopsy samples, fecal samples, acoustic recordings, and other data types. Prey sampling in the vicinity of NARWs and in areas where they are not aggregating is being used to better characterize the habitat drivers behind their distribution. Finally, passive acoustic technology is used to monitor the presence of vocally active NARWs and other endangered large whale species throughout sites along the U.S. East Coast.

Development of offshore wind in the RI/MA Lease Areas would impact approximately 60 percent of the NARW aerial survey blocks in the area. NARW aerial surveys are currently conducted at 1,000 feet AMSL but would need to be conducted at higher altitudes to provide safety margins, as discussed above.

The inability to continue flights at current altitudes (600 or 1,000 feet AMSL) over offshore wind areas would have a significant impact on the ability to use current data collection techniques to monitor the distribution and abundance of marine mammals and sea turtles that may be caused by or are related to offshore wind. Alternative techniques to monitor these species could include high-altitude photographic surveys, passive acoustic monitoring, and data collection on small vessels (including those used by the industry) that can safely navigate within the WTGs.

The inability to implement shipboard surveys in current NARW habitat in offshore wind areas could significantly affect NMFS' ability to monitor the health, status, and behavior of individuals within this region, as well as NMFS' ability to monitor changes in prey distribution and other factors affecting NARW habitat use. With the operational restrictions on NOAA vessels entering developed lease areas, surveys within WDAs would necessarily require wind development-compatible vessels and equipment, which could lead to changes in survey methodology, available tools, and appropriate staffing of shipboard fieldwork. This would lead to less effective and efficient on-water data collection. Finally, the impact of collecting passive acoustic data in the region once offshore wind projects are developed is unknown. The use of autonomous vehicles, such as gliders, has been an important component in NMFS' near-real-time monitoring of NARW distribution, and the use of archival recorders has been important for documenting habitat use over time. It is unclear how this would change after the installation of WTGs, whether these data collection methodologies would still be feasible in these areas and how noise from operations (i.e., construction or vessel noise from long-term turbine maintenance) would affect NMFS' ability to continue to acoustically detect animals reliably. In summary, additional work is needed to develop and implement appropriate strategies to collect, analyze, interpret, and share data to monitor the impacts of wind energy activities on all protected species.

Significant resources would be required to quantify and account for the complexity and scope of impacts on NMFS core scientific surveys and the management advice that relies on these surveys and implement necessary survey adaptations. Potential challenges would include identification of appropriate sampling protocols and technology, development and parameterization of new statistical survey models, and calibration of new approaches to existing ones in order to continue to sample within areas occupied by turbine foundations and submarine cables. Preliminary analyses of the impacts on survey areal coverage shows substantial impacts on NMFS' ability to continue using current methods to fulfill its mission of precisely and accurately assessing fish and shellfish stocks for the purpose of fisheries management and assessing protected species for the purpose of protected species management. Changes to protected species survey methodologies could introduce biases or inaccuracies that could impact marine mammal abundance estimates and dedicated NARW studies. These changes could result in management implications for NARW and other protected species, as well as fisheries and shipping industries that impact these species. Similarly, changes to existing survey methodologies or disruption to the long-term survey time series of fish and shellfish would have implications for stock assessments by increasing uncertainty in biomass estimates and other parameters used in projecting fishery quotas. Uncertainty in estimating fishery quotas could lead to unintentional underharvest or overharvest of individual fish stocks, which could have both beneficial and adverse impacts on fish stocks, respectively. Based on existing regional Fishery Management Councils' acceptable biological catch control rule processes and risk policies (e.g., 50 CFR §§ 648.20 and 21), increased assessment uncertainty would likely result in lower commercial quotas that may reduce the likelihood of overharvesting and mitigate associated biological impacts on fish stocks. However, such lower quotas would result in lower associated fishing revenue that would vary by species, which could result in impacts on fishing communities. Development of new survey technologies, changes in survey methodologies, and required calibrations could help to mitigate losses in accuracy and precision of current practices due to the impacts of wind development on survey strata. Until a plan is established to holistically mitigate impacts on NMFS core surveys, information generated from project-specific monitoring plans may be necessary to supplement or complement existing survey data. Such monitoring plans must be developed in a comprehensive and integrated manner consistent with NOAA and NMFS' long-standing surveys. To address this need, these fisheries monitoring plans should be developed collaboratively with NOAA and NMFS and incorporate NMFS survey standards and requirements to ensure collected data is usable. BOEM will continue to work with the NMFS in regard to survey guidelines and update guidelines as appropriate to reflect standard data collection protocols and methodologies.

Federal Survey Mitigation Program: To address Vineyard Wind 1's impacts on NMFS trust responsibilities under the Magnuson-Stevens Fishery Conservation and Management Act, ESA, and Marine Mammal Protection Act, NMFS, in partnership with BOEM, is considering a mitigation program to establish resources for the NMFS NEFSC to design and implement effective survey adaptations. The intent of this mitigation program would be to minimize or avoid impacts from Vineyard Wind 1. If successful, this mitigation program could potentially be applied to future offshore wind projects. Specifically, NMFS recommends implementation of a mitigation program that includes the specific elements listed below to address Vineyard Wind 1's impacts on the multi-species bottom-trawl surveys, Atlantic scallop surveys, ocean quahog and Atlantic surf clam surveys, ecosystem monitoring surveys, marine mammal and sea turtle ship-based and aerial surveys, and NARW aerial surveys. While this mitigation is focused on Vineyard Wind 1, impacts from future offshore wind projects on NOAA scientific surveys would be mitigated through future coordination between BOEM and NOAA, as well as measures included in future National Environmental Policy Act analyses. These analyses would include consideration of the following mitigation measures as they apply to impacts from future projects:

- Evaluate survey designs—Evaluate and quantify Vineyard Wind 1's impacts on the listed scientific survey operations and on provision of scientific advice to management.
- Identify and develop new survey approaches—Evaluate or develop appropriate statistical designs, sampling protocols, and methods while determining if scientific data quality standards for the provision of management advice are maintained.
- Calibrate new survey approaches—Design and carry out necessary calibrations and required monitoring standardization to ensure continuity, interoperability, precision, and accuracy of data collections.
- Develop interim provisional survey indices—Develop interim ad hoc indices from existing non-standard data sets to partially bridge the gap in data quality and availability between pre-construction and operational periods while new approaches are being identified, tested, or calibrated.
- Wind energy monitoring to fill regional scientific survey data needs—Apply new statistical designs and carry out sampling methods to mitigate Vineyard Wind 1's survey impacts over the operational life span of Vineyard Wind 1.
- Develop and communicate new regional data streams—New data streams would require new data collection, analysis, management, dissemination, and reporting systems. Changes to surveys and new approaches would require substantial collaboration with fishery management, fishing industry, scientific institutions, and other partners.

The research and surveys listed above are a subset of all scientific research and surveys that may be executed in the geographic analysis area. Other scientific research surveys utilizing fixed data recorders, automated underwater vehicles, and small vessel research platforms may not be similarly impacted. There are currently no federal requirements to monitor or research construction and operations of offshore wind projects or for advancing new survey technologies. BOEM will continue to work with survey operators to better define and understand these impacts, including whether effective mitigation options could be available to compensate for the potential loss of some scientific surveys. Construction and decommissioning of Alternative A could lead to increased opportunities to study impacts of construction and operations of the offshore components, perform other oceanographic research, and develop or adapt new approaches to research including, but not limited to, use of unmanned aerial vehicles or vessels and remote sensing and digital technologies. Operations activities may present an opportunity to collaborate with researchers on data collection, thus potentially reducing survey costs. NOAA's Uncrewed Systems Strategy (NOAA 2020c), which aligns with the Commercial Engagement Through Technology Act of 2018 (Public Law 115-394), is intended to "directly improve the understanding, coordination, awareness and application of [unmanned systems]." In addition, sampling, monitoring, and/or research contributions from the offshore wind industry and other non-NOAA stakeholders (e.g., other federal or military agencies, industry partners, and academia) could play a key role in development of innovative approaches that would enable to scientific research and surveys to continue in offshore wind development areas. These approaches and opportunities help inform certain types of scientific research and surveys in the long term, but Alternative A would still have major impacts on existing NMFS scientific research and surveys conducted in and around the WDA because long-standing surveys would not be able to continue as currently designed, and extensive costs and efforts would be required to adjust survey approaches, potentially leading to impacts on fishery participants and communities (EIS Sections 3.6 and 3.10), as well as potential major impacts on monitoring and assessment activities associated with recovery and conservation programs for protected species. The loss of precision and accuracy would be a significant hurdle, as new data collection methods are tested and become usable and robust over time. Implementing mitigation measures, including the development of survey adaptation plans, standardization and calibration of sampling methods, and annual data collections following new designs and methods, would help reduce uncertainty in survey data and associated assessment results and increase the utility of additional data collected as part of any required project-specific monitoring plan.

In context of planned environmental trends, the impacts associated with ongoing and planned activities, including Alternative A, would have major impacts on NMFS' scientific research and surveys and the resulting stock assessments, which could lead to potential beneficial and adverse impacts on fish stocks when management decisions are based on biased or imprecise estimates of stock status. Alternative A would contribute to the overall impact rating primarily through placement of structures in the long term within the WDA that pose navigational hazards to survey aircraft and vessels and restrict access to survey locations, thus impacting statistical design of surveys and causing a loss of information within the wind development areas as previously described. Alternative A impacts are similar to those of other planned offshore wind development, but impacts would be spread across the RI/MA Lease Areas, affecting additional survey strata and survey areas. In context of planned environmental trends, the overall impacts on scientific research and surveys from ongoing and planned activities, including Alternative A, would qualify as major because entities conducting surveys and scientific research would have to make significant investments to change methodologies to account for unsampleable areas, with potential long-term and irreversible impacts on fisheries, the commercial fisheries community, protected species research, and programs for the conservation and management/recovery of fishery resources and protected species. While new research approaches and technologies may lessen impacts on scientific research and surveys in the long term, their results and applicability specific to the impacted NOAA and NMFS surveys are not planned at this time.

B.4 Marine Mammal Sound Exposure Estimates

As discussed in EIS Section 3.7, Marine Mammals, marine mammals occur in the RI/MA Lease Areas. Noise from proposed Project-related impact pile driving, vibratory setting, drilling, potential detonations of unexploded ordnance (UXO), and high-resolution geophysical (HRG) surveys has the potential to cause auditory impacts (i.e., permanent threshold shift [PTS]/Level A harassment) and behavioral impacts (i.e., Level B harassment) to marine mammals. As defined by the Marine Mammal Protection Act (U.S. Code Title 16, Section 1362[18][C][i]), Level A harassment "has the potential to injure a marine mammal or marine mammal stock in the wild," while Level B harassment "has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."

Each activity has varying degrees of risk for auditory and behavioral impacts and are therefore discussed separately. The COP (Appendix III-M; Epsilon 2022) and the applicant's Letter of Authorization (LOA) application (JASCO 2022) modeled sound propagation for each activity. Two construction schedules (Schedule A and B) over a construction period of May through December were modeled for impact pile driving of WTG and ESP foundations (Tables B.1-22 and B.1-23). The months of January through April, when NARW are likely to be present in relatively high numbers, were excluded from the analysis as no impact pile driving of foundations is expected to occur during those months (JASCO 2022).

Table B.1-22: Estimated Pile-Driving Days per Month for Proposed Project Construction Schedule A, All Years Summed

	12- Meter Monopile, 5,000 kJ		12-Meter Monopile, 6,000 kJ		13-Meter Monopile, 5,000 kJ		4-Meter Pin Pile, 3,500 kJ
Construction Month	**1 Pile/Day**	**2 Piles/Day**	**1 Pile/Day**	**2 Piles/Day**	**1 Pile/Day**	**2 Piles/Day**	**4 Pin Piles/Day**
May	4	0	4	0	0	0	0
June	2	5	0	3	0	0	0
July	0	9	0	4	0	0	0
August	0	9	0	0	0	0	8
September	0	1	0	0	1	6	9
October	0	0	0	0	0	6	6
November	0	0	0	0	0	3	2
December	0	0	0	0	4	0	1
Total	**6**	**24**	**4**	**7**	**5**	**15**	**26**

Source: COP Appendix III-M, Table 3; Epsilon 2022

kJ = kilojoule

Table B.1-23: Estimated Pile-Driving Days per Month for Proposed Project Construction Schedule B, All Years Summed

	12-Meter Monopile, 5,000 kJ		4-Meter Pin Pile, 3,500 kJ
Construction Month	**1 Pile/Day**	**2 Piles/Day**	**4 Pin Piles/Day**
May	4	0	2
June	6	4	13
July	0	7	19
August	1	5	20
September	0	3	14
October	1	1	6
November	2	0	3
December	1	0	1
Total	**15**	**20**	**78**

Source: COP Appendix III-M, Table 4; Epsilon 2022

kJ = kilojoule

Estimates of marine mammal densities (animals per square kilometer) in the modeling used the Duke University Marine Geospatial Ecological Laboratory model results (Roberts et al. 2016a, 2016b, 2017, 2018, 2021) and included recently updated model results for the NARW. The 2021 NARW habitat density model includes new estimates for NARW abundance in Cape Cod Bay in December and the model predictions are summarized over three eras, 2003 to 2018, 2003 to 2009, and 2010 to 2018, to reflect the apparent shift in NARW distribution that occurred around 2010. As of June 2022, there are updated density data for other species besides the NARW; however, the impacts assessment in this section relies upon the previous version of density estimates for non-NARW species as provided in the LOA application (JASCO 2022). All densities used the May 1 through December 31 construction period. The COP (Appendix III-M; Epsilon 2022) calculated the density estimates for pinnipeds using Roberts et al. (2016a) density data.

B.4.1 Marine Mammal Behavioral Response Thresholds

The applicant submitted comprehensive underwater acoustic propagation and animal exposure modeling for underwater sound and its potential impacts on marine species during piling installation for up to 132 WTG and/or ESP foundations (the proposed Project).[3] The applicant submitted the modeling results as a part of the COP (Appendix III-M; Epsilon 2022) and LOA application (JASCO 2022). Table B.1-24 summarizes the NMFS threshold criteria for PTS and Level A harassment used in the model.

Table B.1-24: Permanent Threshold Shift Onset Acoustic Threshold Levels

Hearing Group	PTS Onset Thresholds to Evaluate Level A Harassment[a] (Received Level)	
	Impulsive	Non-impulsive
LFC	PK 219; SEL_{24h} 183	SEL_{24h} 199
MFC	PK 230; SEL_{24h} 185	SEL_{24h} 198
HFC	PK 202; SEL_{24h} 155	SEL_{24h} 173
PPW	PK 218; SEL_{24h} 185	SEL_{24h} 201

Sources: NMFS 2018b; COP Appendix III-M; Epsilon 2022

µPa = micropascal; $\mu Pa^2 s$ = micropascal squared second; dB = decibel; HFC = high-frequency cetacean (harbor porpoise [*Phocoena phocoena*]); PK = peak sound pressure level; SEL_{24h} = sound exposure level over 24 hours [weighted by hearing group, in units of dB referenced to 1 $\mu Pa^2 s$]; LFC = low-frequency cetacean (all the large whales except sperm whales [*Physeter macrocephalus*]); MFC = mid-frequency cetacean (all dolphins, pilot whales, and sperm whales); PPW = pinnipeds in the water (all seals); PTS = permanent threshold shift
[a] NMFS (2018a) uses a dual-metric acoustic thresholds for impulsive sounds, in which the largest isopleth (mapped distance) from either method is used for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the PK level thresholds associated with impulsive sounds, these thresholds should also be considered.

Because of the complexity and variability of marine mammal behavioral responses to acoustic exposure, NMFS has not yet released updated technical guidance on behavioral threshold criteria (Level B harassment; NMFS 2018b). The traditional method of assessing Level B harassment impacts on marine mammals from impulsive sources, which is currently recommended by NMFS (Endangered Fish and Wildlife; Notice of Intent to Prepare an Environmental Impact Statement, of the *Federal Register*, Volume 70, Issue 7 [January 11, 2005] p. 1871 [70 Fed. Reg. 7 p.1871), is an unweighted sound pressure level (SPL) of 160 decibels (dB) referenced to 1 micropascal (µPa). However, the application of a step function that evaluates weighted exposures as a percentage of animals responding between each step between different threshold levels has gained recent acceptance (Wood et al. 2012; Nowacek et al. 2015). Analyses of both approaches to assess the consequences of sound exposure on marine mammals can produce very different results (Farmer et al. 2018), because the unweighted root-mean-square SPL 160 dB threshold assumption that all animals respond equivalently generally produces greater exposure numbers

[3] Modeling used 132 foundations, although the current proposed Project Design Envelope only includes 130 positions. As a result, the model provides a conservative overestimate of potential impacts.

than the step function response approach. The COP (Appendix III-M; Epsilon 2022) applied both the NMFS-recommended unweighted and the frequency-weighted criteria (Wood et al. 2012) to estimate behavioral response to impulsive pile-driving sound (COP Appendix III-M, Table 8; Epsilon 2022). However, this impacts assessment relies on the ranges to the single step function threshold of SPL 160 dB referenced to 1 µPa (dB re 1 µPa) following the most current recommendations from NMFS (87 Fed. Reg. 126 [July 1, 2022]) and most applicable to marine mammals as an overall faunal group (Table B.1-25).

Table B.1-25: Behavioral Exposure Criteria

Marine Mammal Group	Probability of Response to Frequency-Weighted SPL[a] Impulsive Sources (dB re 1 µPa)				Unweighted SPL[b] Impulsive and Non-impulsive, Intermittent Sources (dB re 1 µPa)	Unweighted SPL[b] Non-impulsive, Continuous Sources (dB re 1 µPa)
	120	140	160	180	160	120
Harbor porpoise (*Phocoena phocoena*)	50%	90%	—	—	100%	100%
Migrating mysticete whales	10%	50%	90%	-	100%	100%
All other species (and behaviors)	—	10%	50%	90%	100%	100%

Sources: COP Appendix III-M; Epsilon 2022

µPa = micropascal; dB = decibel; SPL = root-mean-square sound pressure level; re = referenced to
Probability of behavioral response frequency-weighted SPL (dB re 1 µPa [decibels referenced to 1 micropascal]); probabilities are not additive
[a] Source: Wood et al. 2012
[b] Source: NMFS-recommended threshold (87 Fed. Reg. 126 [July 1, 2022])

For UXO detonations, the exposure assessment conducted by JASCO (2022) used the sound exposure level (SEL)-based PTS thresholds from Table B.1-24, but Level B exposures were estimated using SEL-based temporary threshold shift (TTS) thresholds as shown in Table B.1-26. Additionally, given the nature of underwater explosions, potential mortality and non-auditory injury were considered in the modeling study using peak pressure and acoustic impulse thresholds from the U.S. Navy (Table B.1-27) following the methodology of Hannay and Zykov (2022).

Table B.1-26: Temporary Threshold Shift Onset Acoustic Threshold Levels for Unexploded Ordnance Detonations

Hearing Group	TTS Onset Thresholds for Level B Harassment (SEL_{24h})
LFC	168 dB re 1 μPa^2 s
MFC	170 dB re 1 μPa^2 s
HFC	140 dB re 1 μPa^2 s
PPW	170 dB re 1 μPa^2 s

Sources: JASCO 2022; NMFS 2018b

μPa^2 s = micropascal squared second; dB re 1 µPa = decibels referenced to 1 micropascal; HFC = high-frequency cetacean (harbor porpoise [*Phocoena phocoena*]); SEL_{24h} = sound exposure level over 24 hours; LFC = low-frequency cetacean (all the large whales except sperm whales [*Physeter macrocephalus*]); MFC = mid-frequency cetacean (all dolphins, pilot whales, and sperm whales); PPW = pinnipeds in the water (all seals); TTS = temporary threshold shift

Table B.1-27: Threshold Criteria for Non-Auditory Injury During Potential Detonation of Unexploded Ordnances

Impact Criterion	Threshold
Onset Mortality—Impulse	$103M^{1/3}(1+\frac{D}{10.1})^{1/6}\ Pa-s$
Onset Injury—Impulse (non-auditory)	$47.5M^{1/3}(1+\frac{D}{10.1})^{1/6}\ Pa-s$
Onset Injury—Peak Pressure (non-auditory) for marine mammals	PK 237 dB re 1 μPa

Sources: COP Appendix III-M; Epsilon 2022; U.S. Navy 2017

D = animal depth; dB re 1 μPa = decibels referenced to 1 micropascal; M = animal mass in kilograms; Pa = pascal; PK = peak sound pressure level

JASCO modeled three levels of attenuation for impact pile driving: 0 dB (no attenuation), 10 dB, and 12 dB; and two levels of attenuation for potential UXO detonations: 0 dB and 10 dB (COP Appendix III-M; Epsilon 2022). The 0 dB level was modeled as a reference point to evaluate the effectiveness of the sound reduction technology (e.g., Hydro Sound Damper, bubble curtains, or similar) as proposed mitigation. When comparing the two potential levels of attenuation for impact pile driving (10 dB and 12 dB), 10 dB represents the lowest level of noise attenuation which would result in the greatest risk of impact on marine mammals aside from no attenuation. Although the applicant has proposed to achieve 12 dB attenuation, the EIS assesses an attenuation level of only 10 dB as a maximum-case scenario for all applicable activities.

B.4.2 Noise Exposure from Impact Pile Driving

For impact pile driving, JASCO (2022) provides a 95th percentile exposure-based range ($ER_{95\%}$) to threshold criteria for a "most impactful" scenario that involves installation of up to two 12-meter (39-foot) and 13-meter (42-foot) monopiles per day and four 4-meter (13-foot) jacket piles per day for each marine mammal species with 10 dB attenuation. To determine the exposure-based ranges, pile strikes are propagated within the modeling assessment area to create an ensonified (sound filled) environment while simulated animals (i.e., animats) are moved about the ensonified area following known species-specific behaviors. Modeled animats that have received sound energy that exceeds the acoustic threshold criteria are registered, and the closest point of approach recorded at any point in that animal's movement is then reported as its exposure range. This process is repeated multiple times for each animat to produce the exposure-based ranges, which comprise the closes point of approaches for 95 percent of animats that exceeded the threshold (i.e., $ER_{95\%}$).

The applicant's requested take numbers for Level A harassment authorization were based on an expectation that 10 dB sound attenuation would be the minimal attenuation level achieved during the proposed activity. Information on sound reduction effectiveness reviewed in the COP (Appendix III-M; Epsilon 2022) and LOA application (JASCO 2022) included sources such as California Department of Transportation bubble curtain "on and off" studies conducted in San Francisco Bay in 2003 and 2004 (Caltrans 2015). A review of performance measured during impact driving for wind energy facility foundation installation (Bellmann et al. 2020) provides expected performance for common noise reduction system configurations. Measurements with a single bubble curtain and an air supply of 0.3 cubic meters per minute resulted in 7 to 11 dB of broadband attenuation for optimized systems in up to 131-foot water depth. Increased air flow (0.5 cubic meters per minute) may improve the attenuation levels up to 11 to 13 dB (JASCO 2022). Double bubble curtains add sound impedance and, for optimized systems, can achieve 15 to 16 dB of broadband attenuation (measured in up to 131-foot water depth). An IHC noise mitigation system can provide 15 to 17 dB of attenuation but is currently limited to piles under 8 meters in diameter. Other attenuation systems such as the AdBm noise mitigation system achieved 6 to

8 dB (JASCO 2022), while Hydro Sound Dampers were measured at 10 to 12 dB attenuation and are independent of depth (Bellmann et al. 200). Systems may be deployed in series to achieve higher levels of attenuation).

Based on the best available information (i.e., Bellmann et al. 2020; Caltrans 2015; JASCO 2022), it is reasonable to assume a greater level of effective attenuation due to implementation of noise attenuation during impact pile driving. The applicant has not identified the specific attenuation system that would ultimately be used during the proposed activity (e.g., what size bubbles and in what configuration a bubble curtain would be used, whether a double curtain would be employed, whether Hydro Sound Dampers, noise abatement system, or some other alternate attenuation device would be used). In the absence of specific information regarding the attenuation system that would be ultimately used, and in consideration of the available information on attenuation that has been achieved during impact pile driving, the EIS conservatively assumes that the lower-level effectiveness of 10 dB sound attenuation would be achieved (although greater noise attenuation may be achieved). No noise mitigation was included in the modeling for vibratory setting, drilling, or HRG surveys due to the relatively low risk of impact compared to the other proposed Project activities; however, vibratory setting and drilling would occur on the foundations prior to impact pile driving, so the noise attenuation systems used during impact pile driving would likely be in place for these activities (JASCO 2022) and would thus benefit from the attenuation properties.

The applicant would use a soft-start approach in which the initial hammer blows occur at reduced energy levels, allowing time for mobile animals to leave the affected area before hammer energy is gradually increased to the full hammer energy. Based on the geophysical data at the proposed Project location and assessment by the applicant’s engineers, the full power capacity of the hammer is not necessary to install the foundations.

As shown in Tables B.1-22 and B.1-23, the maximum number of pile-driving days for the proposed Project is 113 under Construction Schedule B (COP Appendix III-M; Epsilon 2022), at the rate of up to two monopiles and four jacket pin piles installed per day (COP Appendix III-M, Tables 3 and 4; Epsilon 2022). The radial distances to sound threshold criteria were modeled using a 5,000 and 6,000 kilojoules (kJ) hammer energy for 12-meter and 13-meter-diameter monopiles, and a 3,500 kJ hammer energy for 4-meter-diameter jacket pin piles. Impact pile-driving noise with 10 dB attenuation has the potential to cause Level A and Level B harassment to marine mammals. The applicant would use sound-reducing technologies to minimize harmful impacts on marine mammals; however, attenuation levels may vary with local conditions such as water depth, current, and technology configuration.

Modeled $ER_{95\%}$ to Level B harassment with 10 dB attenuation during impact pile driving is lower for jacket piles (2.0 to 2.2 miles depending on the hearing group) compared to the monopiles (3.4 to 3.7 miles depending on the hearing group) for all marine mammals (Tables 3.7-6 and 3.7-7 in EIS Section 3.7) (COP Appendix III-M; Epsilon 2022). With a proposed target of 12 dB and maximum-case scenario of 10 dB attenuation, there is a risk of Level B harassment to marine mammals from pile driving due to the large radial distance to this threshold and the number of days that pile driving may occur.

Modeled $ER_{95\%}$ to thresholds for Level A harassment are greater for the two monopiles than the four jacket piles for all hearing groups (COP Appendix III-M; Epsilon 2022). When comparing all hearing groups, $ER_{95\%}$ are the largest for low-frequency cetaceans (LFC) (mysticetes). The isopleths for Level A harassment during impact pile-driving installation of a jacket foundation with 10 dB noise attenuation for NARW, fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), humpback whales, and minke whales average1.9 miles for jacket foundations (pin piles) and 2.2 miles for monopiles. These ranges can be effectively monitored using a combination of visual and acoustic monitoring as is proposed for this Project (EIS Appendix H, Mitigation and Monitoring).

Modeled $ER_{95\%}$ to thresholds for Level A harassment during monopile installation are moderate for seals (pinnipeds in water hearing group; 0.4 mile) and harbor porpoise (high-frequency cetacean [HFC] hearing group; 1.4 mile) and small for dolphins, pilot whales, and sperm whales (mid-frequency cetacean [MFC] hearing group; 3.2 feet).

For construction Schedule A, the exposure modeling in the LOA application (JASCO 2022) assumed that 89 monopile foundations and two jacket foundations are installed in year 1 and up to 18 monopiles and 24 jacket foundations are installed in year 2. The second year of Schedule A includes the potential installation of 13-meter monopiles using a 6,000 kJ hammer. The $ER_{95\%}$ for 13-meter monopile foundations using 6,000 kJ hammer energy were estimated using mathematical scaling rather than a full model in order to estimate mitigation zones that accommodate this design possibility while ensuring the protection of marine mammals (JASCO 2022). Construction Schedule A assumes that foundations for all of Phase 1 of the proposed Project (as defined in EIS Chapter 2, Alternatives) and a portion of Phase 2 are installed in year 1, and that the remaining Phase 2 foundations are installed in year 2.

Construction Schedule B is spread over 3 years, where year 1 includes 55 monopile and 3 jacket foundations and years 2 and 3 include 53 and 22 jacket foundations, respectively. In Schedule B years 2 and 3, jacket foundations are assumed for all positions because they provide a conservative envelope for any of the assessed monopile foundations, up to and including a 13-meter-diameter monopile with a 6,000 kJ hammer. Construction Schedule B assumes that foundations for all of Phase 1 are installed in year 1 and that the Phase 2 foundations are installed in years 2 and 3.

Tables B.1-28 and B.1-29 summarize the numbers of marine mammals estimated to experience sound levels above threshold criteria for Level A and B harassment for each construction schedule with 10 dB noise attenuation during impact pile driving (JASCO 2022). The exposure estimates integrate results from acoustic propagation models (which estimate three-dimensional sound fields resulting from pile driving), animal movement modeling (which provide probabilistic distributions of sound level exposures based on animal movement relative to modeled sound fields), and species density maps/models (which predict animal occupancy as a function of location and month). This modeling predicts the number of individual animals (for each species) that may be exposed to sound levels exceeding various criteria over the course of the two construction schedules. Generally, the numbers of marine mammals potentially exposed to impacts that may receive Level A harassment from pile driving are higher under construction Schedule B (JASCO 2022).

Table B.1-28: Estimated Marine Mammal Exposure to Harassment Thresholds during Impact Pile Driving, Construction Schedule A[a]

Species	Level A Harassment (PK)	Level A Harassment (SEL_{24h})	Level B Harassment (SPL)
Fin whale (*Balaenoptera physalus*)[b]	0.04	21.51	33.58
Humpback whale (*Megaptera novaeangliae*)	0.05	13.69	16.46
Minke whale (*Balaenoptera acutorostrata)*	0.03	9.71	26.79
North Atlantic right whale (*Eubalaena glacialis*)[b]	<0.01	3.09	7.01
Sei whale (*Balaenoptera borealis*)[b]	<0.01	0.53	1.29
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	1.56	0.21	1,334.89
Atlantic spotted dolphin (*Stenella frontalis*)	0	0	3.92
Common bottlenose dolphin (*Tursiops truncatus*)	0.62	0.15	387.83
Long-finned pilot whale (*Globicephala melas*)	0.15	0.06	165.24
Short-finned pilot whale (*Globicephala macrorhynchus*)	0.24	<0.01	121.26
Risso's dolphin (*Grampus griseus*)	0.03	0.02	6.23
Common dolphin (*Delphinus delphis*)	5.09	1.28	6,999.42
Sperm whale (*Physeter macrocephalus*)[b]	<0.01	<0.01	2.64
Harbor porpoise (*Phocoena phocoena*)	5.91	97.62	258.58
Gray seal (*Halichoerus grypus*)	<0.01	1.07	32.11
Harbor seal (*Phoca vitulina*)	0.18	1.95	75.85
Harp seal (*Pagophilus groenlandicus*)	0	0.94	37.64

Source: COP Appendix III-M; Epsilon 2022

ESA = Endangered Species Act; PK = peak sound pressure level; SEL_{24h} = sound exposure level over 24 hours; SPL = root-mean-square sound pressure level

[a] Data are for all construction years combined under construction Schedule A with 10 dB noise attenuation.

[b] ESA-listed species

Table B.1-29: Estimated Marine Mammal Exposure to Harassment Thresholds during Impact Pile Driving, Construction Schedule B[a]

Species	Level A Harassment (PK)	Level A Harassment (SEL_{24h})	Level B Harassment (SPL)
Fin whale (*Balaenoptera physalus*)[b]	0.09	37.72	41.87
Humpback whale (*Megaptera novaeangliae*)	0.02	20.47	19.53
Minke whale (*Balaenoptera acutorostrata*)	0.03	20.59	50.89
North Atlantic right whale (*Eubalaena glacialis*)[b]	<0.01	3.92	6.92
Sei whale (*Balaenoptera borealis*)[b]	<0.01	1.14	1.88
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	1.17	0.87	2,385.18
Atlantic spotted dolphin (*Stenella frontalis*)	0.0	0.0	4.31
Common bottlenose dolphin (*Tursiops truncatus*)	0.41	0.31	526.97
Long-finned pilot whale (*Globicephala melas*)	0.14	0.18	260.80
Short-finned pilot whale (*Globicephala macrorhynchus*)	0.14	0.01	194.21
Risso's dolphin (*Grampus griseus*)	0.02	0.03	8.98
Common dolphin (*Delphinus delphis)*	5.16	2.52	8,248.25
Sperm whale (*Physeter macrocephalus*)[b]	<0.01	<0.01	4.60
Harbor porpoise (*Phocoena phocoena*)	8.82	173.78	400.40
Gray seal (*Halichoerus grypus*)	<0.01	1.55	21.91
Harbor seal (*Phoca vitulina*)	0.10	3.85	77.88
Harp seal (*Pagophilus groenlandicus*)	0.0	1.42	36.14

Source: JASCO 2022

dB = decibel; ESA = Endangered Species Act; PK = peak sound pressure level; SEL_{24h} = sound exposure level over 24 hours; SPL = root-mean-square sound pressure level
[a] Data are for all construction years combined under construction Schedule B with 10 dB noise attenuation.
[b] ESA-listed species

B.4.3 Noise Exposure from Vibratory Pile Setting and Drilling

Exposures for vibratory setting and drilling activities were only calculated for Level B harassment thresholds because the estimate Level A threshold ranges were so small that no Level A harassment is expected to result from these activities (JASCO 2022). The range to the SPL 120 dB re 1 μPa threshold for non-impulsive, continuous sources was calculated and then used to estimate a daily impact area for each activity, calculated as the area of a circle where the radius is the range to the threshold. The threshold ranges were estimated to be 31 miles for vibratory setting and 13.4 miles for drilling, which resulted in impact areas of 3,032 and 561 square miles, respectively. For the exposure assessment, JASCO (2022) assumed that 50 percent of the foundations would face a risk of pile run and require vibratory setting prior to impact pile driving, and that approximately 30 percent of the foundation positions would encounter hard sediments and pile refusal, which would require drilling activities with a 20 percent contingency added to each. The total number of piles per month that may require vibratory setting or drilling under each construction schedule were then multiplied by the daily impact area and the average monthly density for each species to identify the total number of animals exposed each month. The exposure estimates in Tables B.1-30 and B.1-31 consist off all the monthly exposures added together for each construction schedule for vibratory setting and drilling, respectively.

Table B.1-30: Estimated Number of Marine Mammals Exposed above Level B Harassment Thresholds during Vibratory Pile Setting (All Years Combined, Construction Schedules A and B)

Species	Construction Schedule A	Construction Schedule B
Fin whale (*Balaenoptera physalus*)[a]	1,132.44	1,716.27
Humpback whale (*Megaptera novaeangliae*)	512.25	741.73
Minke whale (*Balaenoptera acutorostrata*)	395.04	596.72
North Atlantic right whale (*Eubalaena glacialis*)[a]	98.62	126.85
Sei whale (*Balaenoptera borealis*)[a]	33.85	50.60
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	13,457.37	20,033.03
Atlantic spotted dolphin (*Stenella frontalis*)	417.37	605.86
Common bottlenose dolphin (*Tursiops truncatus*)	22,148.79	33,705.52
Long-finned pilot whale (*Globicephala melas*)	1,705.43	2,489.92
Short-finned pilot whale (*Globicephala macrorhynchus*)	1,257.88	1,836.50
Risso's dolphin (*Grampus griseus*)	477.82	703.87
Common dolphin (*Delphinus delphis*)	44,577.24	62,093.43
Sperm whale (*Physeter macrocephalus*)[a]	77.51	122.20
Harbor porpoise (*Phocoena phocoena*)	4,184.38	5,825.78
Gray seal (*Halichoerus grypus*)	3,310.76	4,574.98
Harbor seal (*Phoca vitulina*)	7,438.42	10,278.79
Harp seal (*Pagophilus groenlandicus*)	3,310.76	4,574.98

Source: JASCO 2022

[a] ESA-listed species

Table B.1-31: Estimated Number of Marine Mammals Exposed above Level B Harassment Thresholds during Drilling (All Years Combined, Construction Schedules A and B)

Species	Construction Schedule A	Construction Schedule B
Fin whale (*Balaenoptera physalus*)[a]	197.73	203.56
Humpback whale (*Megaptera novaeangliae*)	102.86	104.67
Minke whale (*Balaenoptera acutorostrata*)	68.43	81.75
North Atlantic right whale (*Eubalaena glacialis*)[a]	20.93	25.99
Sei whale (*Balaenoptera borealis*)[a]	5.97	7.56
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	2,986.88	3,301.08
Atlantic spotted dolphin (*Stenella frontalis*)	71.01	65.08
Common bottlenose dolphin (*Tursiops truncatus*)	1,324.85	1,228.61
Long-finned pilot whale (*Globicephala melas*)	349.74	349.74
Short-finned pilot whale (*Globicephala macrorhynchus*)	257.96	257.96
Risso's dolphin (*Grampus griseus*)	30.33	27.70
Common dolphin (*Delphinus delphis*)	7,612.20	7,008.30
Sperm whale (*Physeter macrocephalus*)[a]	13.49	12.66
Harbor porpoise (*Phocoena phocoena*)	674.36	743.11
Gray seal (*Halichoerus grypus*)	241.90	313.27
Harbor seal (*Phoca vitulina*)	543.48	703.84
Harp seal (*Pagophilus groenlandicus*)	241.90	313.27

Source: JASCO 2022

[a] ESA-listed species

B.4.4 Noise Exposure from Unexploded Ordnance

Due to the mitigation and monitoring measures proposed (EIS Appendix H) and the relatively small size of the peak pressure and acoustic impulse threshold ranges for UXO detonations compared to PTS and TTS ranges, no non-auditory injury or mortality is expected for any species (JASCO 2022). For potential UXO detonations, the modeling followed the study conducted by Hannay and Zykov (2022), which groups potential UXOs into five "bins" based on the maximum UXO charge weights (Table 41 in JASCO 2022). These activities could potentially expose animals to Level A and Level B TTS. The radial distances to the SEL-based criteria ranges for PTS and TTS for UXO detonations with 10 dB attenuation are provided in the LOA application (Table 42, JASCO 2022). The LFC radial threshold distances range from 2 miles in shallow water (12 meters/39 feet or less) to 2.2 miles in deep water (45 meters/147 feet or more) while the HFC distances hover around from 3.8 miles in shallow and deep water. Exposures for potential UXO detonations were estimated by multiplying the impact areas in the LOA application Table 42, JASCO 2022) by the highest monthly species density in the deep water OECC segment and the SWDA for the 20- to 45-meter (66- to 147-foot) depths, and by the highest monthly species density in the shallow water OECC segment for the 12-meter (39-foot) depth (JASCO 2022). The result of the areas multiplied by the densities were then multiplied by the number of UXOs estimated at each of the depths from preliminary geophysical and camera survey data to calculate total estimated exposures in Table B.1-32.

Table B.1-32: Maximum Estimated Marine Mammal Exposure above Harassment Thresholds Due to Unexploded Ordinance Detonations[a]

Species	Level A Harassment (PTS SEL_{24h})	Level B Harassment (TTS SEL_{24h})
Fin whale (*Balaenoptera physalus*)[b]	1.31	13.34
Humpback whale (Megaptera novaeangliae)	1.51	15.48
Minke whale (Balaenoptera acutorostrata)	0.95	9.68
North Atlantic right whale (*Eubalaena glacialis*)[b]	3.17	32.30
Sei whale (Balaenoptera borealis)[b]	0.17	1.73
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	0.27	10.23
Atlantic spotted dolphin (*Stenella frontalis*)	0.01	0.20
Common bottlenose dolphin (*Tursiops truncatus*)	0.90	30.33
Long-finned pilot whale (*Globicephala melas*)	0.03	0.96
Short-finned pilot whale (*Globicephala macrorhynchus*)	0.02	0.71
Risso’s dolphin (*Grampus griseus*)	0.00	0.07
Common dolphin (*Delphinus delphis*)	1.25	47.01
Sperm whale (*Physeter macrocephalus*)[b]	0.00	0.05
Harbor porpoise (*Phocoena phocoena*)	165.32	801.06
Gray seal (*Halichoerus grypus*)	8.91	180.73
Harbor seal (*Phoca vitulina*)	20.01	406.05
Harp seal (*Pagophilus groenlandicus*)	8.91	180.73

Source: JASCO 2022

μPa^2s = micropascal squared second; ESA = Endangered Species Act; PTS = permanent threshold shift; SEL_{24h} = sound exposure level over 24 hours [weighted by hearing group, in units of dB referenced to 1 μPa^2s]; TTS = temporary threshold shift; UXO = unexploded ordnance

[a] Data are for possible detonation of up to 10 UXOs with 10 dB noise attenuation.

[b] This is an ESA-listed species.

B.4.5 Noise Exposure from High-Resolution Geophysical Surveys

Proposed HRG surveys assume the use of two pieces of equipment: the Applied Acoustics AA251 Boomer and the GeoMarine Geo Spark 2000 (JASCO 2022). No Level A exposures are expected to occur during HRG surveys from either type of equipment. Level B exposures were estimated using a similar method as described previously for vibratory setting a drilling. The daily impact area was calculated as a circle around the source with the radius being the range to the threshold (SPL 160 dB re µPa for HRG equipment as they are non-impulsive, intermittent sources) multiplied by the average annual density for each species and the total number of expected survey days per year (assumed to be 25) (JASCO 2022). This results in the estimate number of Level B exposures annually for each equipment presented in Table B.1-33

Table B.1-33 Estimated Marine Mammal Exposure above Level B Harassment Thresholds Annually during High-Resolution Geophysical Surveys

Species	Applied Acoustics AA251 Boomer	GeoMarine Geo Spark 2000
Fin whale (*Balaenoptera physalus*)[a]	2.67	2.11
Humpback whale (*Megaptera novaeangliae*)	2.09	1.65
Minke whale (*Balaenoptera acutorostrata*)	1.82	1.44
North Atlantic right whale (*Eubalaena glacialis*)[a]	6.44	0.26
Sei whale (*Balaenoptera borealis*)[a]	0.32	112.02
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	56.24	261.41
Atlantic spotted dolphin (*Stenella frontalis*)	0.93	3.29
Common bottlenose dolphin (*Tursiops truncatus*)	255.89	202.55
Long-finned pilot whale (*Globicephala melas*)	4.22	3.34
Short-finned pilot whale (*Globicephala macrorhynchus*)	3.12	2.47
Risso's dolphin (*Grampus griseus*)	0.38	0.30
Common dolphin (*Delphinus delphis*)	197.42	156.27
Sperm whale (*Physeter macrocephalus*)[a]	0.26	0.21
Harbor porpoise (*Phocoena phocoena*)	112.02	88.67
Gray seal (*Halichoerus grypus*)	261.41	206.92
Harbor seal (*Phoca vitulina*)	3.29	587.32
Harp seal (*Pagophilus groenlandicus*)	1.46	261.41

Source: JASCO 2022

[a] ESA-listed species

B.4.6 Incidental Take Requested

For the proposed Project, the calculated exposure figures in Tables B.1-28 through B.1-33 differ from the total number of takes requested in the LOA application (JASCO 2022). The requested numbers shown in Table B.1-34 were adjusted from the calculated exposures using the following assumptions, summarized from JASCO (2022):

- For impact pile driving, the greater of the two Level A exposure estimates (sound exposure level over 24 hours [SEL_{24h}] or peak sound pressure level [PK]) was rounded up to a whole number and used to compute the requested Level A take.
- Although it was calculated, no Level A take for NARW from any activity was requested because of the proposed mitigation and monitoring measures.
- For the total requested take for impact pile driving, the estimated exposures were corrected for two average group sizes for construction Schedule A (2-year schedule) and for three average groups sizes under construction Schedule B (3-year schedule) using the group size data in LOA application Table 15.
- The total requested take used the construction schedule that resulted in the greatest number of estimated Level B exposures during impact pile driving, vibratory setting, and drilling when all years were combined and rounded up to a whole number for each species (i.e., construction Schedule B was assumed for all species except NARW, gray seals [*Halichoerus grypus*], and harp seals [*Pagophilus groenlandicus*]).

- For days when pile installation was assumed to include both vibratory setting and drilling, only Level B take from vibratory setting was included in the total number of requested takes to avoid double counting as this activity resulted in the greater number of estimated exposures.
- Exposure estimates for potential UXO removal were rounded up to a whole number.
- For HRG surveys, the equipment resulting in the greatest number of estimated exposures was carried forward in the total requested take.
- Common dolphin (*Delphinus delphis*) exposures during HRG surveys were increased to 2,000 for the 5 years of HRG surveys based on protected species observer data collected during surveys in 2020-2021 (JASCO 2022).

Table B.1-34: Total Requested Incidental Take[a]

Species	Takes by Level A Harassment	Takes by Level B Harassment	Total Takes Proposed for Authorization	Total Takes as a Percentage of Stock Taken
Fin whale (*Balaenoptera physalus*)	40	1,948	1,988	29.23
Humpback whale (*Megaptera novaeangliae*)	23	878	901	64.54
Minke whale (*Balaenoptera acutorostrata*)	22	740	762	3.47
North Atlantic right whale (*Eubalaena glacialis*)	0	228	228	61.96
Sei whale (*Balaenoptera borealis*)	3	76	79	1.26
Sperm whale (*Physeter macrocephalus*)	1	149	150	3.45
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	3	25,510	25,513	27.36
Atlantic spotted dolphin (*Stenella frontalis*)	1	898	899	2.25
Common bottlenose dolphin (*Tursiops truncatus*)	2	36,505	36,507	58.08
Long-finned pilot whale (*Globicephala melas*)	2	3,114	3,116	7.95
Short-finned pilot whale (*Globicephala macrorhynchus*)	2	2,283	2,285	7.90
Risso's dolphin (*Grampus griseus*)	1	782	783	2.22
Common dolphin (*Delphinus delphis*)	8	78,887	78,895	45.61
Harbor porpoise (*Phocoena phocoena*)	340	8,244	8,584	8.98
Gray seal (*Halichoerus grypus*)	11	6,390	6,401	23.45
Harbor seal (*Phoca vitulina*)	25	14,382	14,407	23.49
Harp seal (*Pagophilus groenlandicus*)	11	6,405	6,416	0.08

Source: JASCO 2022

[a] The total requested take is based on calculated exposures for all noise-producing proposed Project activities previously described. However, for days when pile installation includes both vibratory setting and drilling, only the vibratory setting Level B takes are included to avoid double counting as this activity resulted in the greater number of estimated exposures.

BOEM reviewed all marine mammal sound exposure and take estimate information taken from the COP (Appendix III-M; Epsilon 2022) and summarized herein. NMFS reviewed the sound exposure and take estimates as part of the applicant's incidental take request in its LOA application (JASCO 2022) submitted under the Marine Mammal Protection Act. The information in the application, including the effectiveness of the proposed mitigation, was evaluated to estimate the potential take numbers of marine mammals.

The applicant's self-imposed measures of using soft start, protected species observers, and passive acoustic monitoring would reduce the risk of threshold-level exposures to marine mammals. The applicant's self-imposed measures are described in detail in EIS Appendix H. Based on the analysis, there is a negligible to minor risk of Level A harassment and a moderate risk of Level B harassment to marine mammals from the combined noise-producing activities (impact pile driving of foundations, vibratory setting, drilling, and HRG surveys). Level B risks are moderate due to the large radial distances to acoustic thresholds produced during piling, vibratory setting, and drilling activities, which results in high take estimates, particularly when applying the non-impulsive noise criteria; and the potential TTS-level exposures resulting from UXO detonations. Level B risks for HRG surveys are negligible. Therefore, BOEM considers impacts from all activities to be moderate for all marine mammals. BOEM could further reduce potential impacts on marine mammals by implementing mitigation and monitoring measures outlined in EIS Appendix H, which could include long-term passive acoustic monitoring; daily, pre-construction passive acoustic monitoring and visual surveys; and the sunrise and sunset prohibition on pile driving as well as requiring the use of noise reduction technologies during all pile-driving activities to achieve a required minimum broadband attenuation (reduction) of 10 dB.

The specific noise attenuation technologies for the proposed Project have not yet been selected. Potential options include a Noise Mitigation System, Hydro Sound Damper, Noise Abatement System, a bubble curtain(s), another similar technology, or a combination of several systems (COP Appendix III-M; Epsilon 2022; JASCO 2022). In addition to the use of noise attenuation system(s), the applicant has committed to complete sound field verification and to have a second attenuation technology on hand, which would be deployed if sound field verification demonstrates a need for greater attenuation. Exposure estimates and underwater noise associated with the proposed Project and the resulting anticipated take of marine mammals is based upon achieving 10 dB reduction of pile-driving noise and potential UXO detonation noise using one or multiple sound attenuation technologies. Should greater attenuation be achieved, fewer individuals than estimated would be exposed to harassing or injurious levels of sound. These measures would reduce noise impacts during construction and the likelihood of impacts on individual marine mammals but would not result in a change to the significance level of impacts.

B.4.7 Summary

As described above, the applicant modeled the potential for marine mammal to be exposed to Project-related harassing or injurious sound levels that may result in take, as defined by the ESA. BOEM has initiated interagency consultation with NMFS under ESA Section 7. Table B.1-35 presents the maximum amount of marine mammal take for ESA-listed species and is consistent with the amount of Level A and B harassment that is presented in the LOA application (JASCO 2022).

Table B.1-35: Take of Endangered Species Act-listed Marine Mammals due to Exposure to All Potential Noise-Producing Proposed Project Activities with 10 Decibel Noise Attenuation[a]

Species	TTS/Behavioral Response	Auditory Injury (PTS)
North Atlantic right whale (*Eubalaena galcialis*)	228	0
Fin whale (*Balaenoptera physalus*)	1,948	40
Sperm whale (*Physeter macrosephalus*)	149	1
Sei whale (*Balaenoptera borealis*)	76	3

Source: JASCO 2022

PTS = permanent threshold shift; TTS = temporary threshold shift; UXO = unexploded ordnance
[a] Noise attenuation was only applied to the take calculations for impact pile driving and potential UXO detonations.

B.5 Impacts on Marine Mammals Potentially Present in the Proposed Project Area

This section provides supplemental information for the discussion of potential impacts on marine mammals provided in EIS Section 3.7 for species that may face additional risk from certain impact-producing factor (IPF) based on their current population status and life history traits that make them more susceptible to anthropogenic impacts. All factors that would influence the risk of impacts are discussed in the following subsections.

B.5.1 North Atlantic Right Whales

NARWs are considered one of the most critically endangered populations of large whales in the world (Hayes et al. 2022). The best current estimate of the living population is 364 whales (Hayes et al. 2022). Since 2010, NARW distribution and patterns of habitat use have shifted, in some cases dramatically (Pettis et al. 2022) and the size of this stock is conserved to be extremely low relative to the optimal sustainable yield (Hayes et al. 2022). The current potential biological removal (PBR) for this stock 0.7 based on the minimum population size and net productivity rate (Hayes et al. 2022), which indicates that removal of any individual from the population could have long-term consequences for the continued viability of the stock.

Eighteen new calves were sighted during the 2021 calving season (Pettis et al. 2022), an increase from 10 calves observed in 2020, and 15 new calves have been sighted so far for the 2022 calving season (NMFS 2022a). Although the increasing birth rate is a beneficial sign, it is still significantly below what is expected, and the rate of mortality is still higher than what is sustainable (Hayes et al. 2022; Pettis et al. 2022). A reduction in adult female survival rates relative to male survival rates has caused a divergence between male and female abundance. In 1990, there were an estimated 1.15 males per female, and by 2015, estimates indicated 1.46 males per female (Pace et al. 2017). This combination of factors threatens the survival of this species (Pettis et al. 2017, 2022). If reduced *Calanus finmarchicus* (the primary prey of NARW) abundance results in a decrease in reproduction similar to that observed in the late 1990s, which authors hypothesize has occurred during the past 5 years, extinction of the NARW could take place in as little as 27 years (Meyer-Gutbrod et al. 2018).

Elevated NARW mortalities documented beginning in 2017 prompted NMFS to declare an unusual mortality event (UME) for this species. A total of 34 confirmed mortalities with an additional 21 free-swimming individuals with serious injury and 37 individuals with sub-lethal injury or illness have been documented to date (NMFS 2022b). Twenty-one of the 34 mortalities were located in Canada and 13 were in the United States (NMFS 2022b). Human interactions (i.e., fishery-related entanglements and vessel strikes) have been identified as the most likely cause of this UME. Of the 34 documented mortalities, 11 have been attributed to vessel strikes and 9 to entanglements (NMFS 2022b). In addition to this recent UME, the reproductive output for the species has declined by 40 percent since 2010 (Kraus et al. 2016b).

Records from 2015 through 2019 indicate an annual average human-caused mortality and serious injury of 5.7 individuals per year by fisheries entanglement and 2.0 individuals per year by vessel strike (86 Fed. Reg. 58887 [October 25, 2021]). Kraus et al. (2016b) suggests that threats to the population are still pervasive and may be getting worse. Indicators of this trend include declining overall body condition (Rolland et al. 2016) and very high and increasing rates of entanglement in fishing gear (Knowlton et al. 2012, 2016), suggesting previous management interventions have not measurably reduced entanglement or entanglement-related mortality (Pace et al. 2014). Research has revealed the substantial energy drain on individual whales from drag related to ongoing entanglements, which likely results in reduced health and fitness (van der Hoop et al. 2015, 2017). Other studies indicate noise from shipping increases stress hormone levels (Rolland et al. 2012), and modeling suggests that their communication space can be reduced substantially by vessel noise in busy traffic lanes (Hatch et al. 2012). In addition to anthropogenic threats, NARWs also face environmental stressors including algal toxins, oceanographic changes from climate change, and, as discussed above, reduced prey availability (Rolland et al. 2007; Doucette et al. 2012; Fortune et al. 2013).

The greatest risk to NARW is from vessel traffic and interactions with fishing gear, which would be present both with and without the Proposed Action. Given the number of vessel strikes documented under the UME, ongoing activities which are not associated with offshore wind development are a large driver of the risk to NARW. These impacts would be expected to continue and potentially increase with the additional vessel traffic associated with future offshore wind projects. However, offshore wind projects would adhere to vessel strike avoidance measures such as visual monitoring and speed restrictions which would reduce the risk of vessel strikes and associated mortality. Similarly, the risk faced by entanglements in fishing gear is a result of ongoing non-offshore wind activities given the number of records under the existing UME. The presence of offshore wind structures (i.e., WTG and ESP foundations) could contribute to the risk of entanglement if discarded fishing gear were caught in the structures. All other IPFs discussed in the DEIS are not expected to result in mortality. Noise-producing activities such as impact pile driving and potential UXO detonations could result in auditory injury, but with mitigation measures such as noise attenuation devices reducing the sound produced by these activities by 10 decibels (COP Appendix III-M; Epsilon 2022); visual and acoustic monitoring before, during and after the activity; seasonal restrictions dictating these activities would only occur between May and December, outside the key seasons which NARW are present in the proposed Project area; and shutdown and ramp-up procedures for impact pile driving, no long-term effects that would rise to the population level are expected to occur due to noise for this species.

B.5.2 Fin Whales

Fin whales in the proposed Project area are listed as Endangered under the ESA (Hayes et al. 2022). The current best abundance estimate available for this stock is 6,802 individuals (Hayes et al. 2022). For 2015 through 2019, the minimum annual rate of human-caused (i.e., vessel strike and entanglement in fishery gear) mortality and serious injury was 1.85 per year (Hayes et al. 2022). There are insufficient data to determine the population trend for fin whales.

Similar to NARW, the greatest risk of vessel strike and entanglement are from ongoing non-offshore wind activities, and the addition of vessel traffic and fishing gear impacts from planned offshore wind development would not appreciably contribute to additional risk to this species. This species has a PBR of 11 individuals; with only up to two individuals documented sustaining serious injury or mortality (Hayes et al. 2022), the likelihood of mortalities exceeding the PBR is low. This species does face a slightly higher risk of exposure to noise sufficient to result in auditory injuries from the Proposed Action because the proposed construction window of May through December overlaps with the season that fin whales are expected to have higher densities in the proposed Project area. However, auditory injuries do not result in mortality or prevent an individual from reproducing and foraging, so this would not count as a removal of the individual from the population. Additionally, while the total number of fin whales exposed to above-threshold noise exceeds the annual PBR (JASCO 2022), the other mitigation measures listed previously for NARW reduce the potential risk of these exposures.

B.5.3 Sei Whales

Sei whales occurring in the proposed Project area are listed as Endangered under the ESA. The current best abundance estimate for this stock is 6,292 individuals (Hayes et al. 2022). Between 2015 and 2019, the average annual minimum human-caused mortality and serious injury was 0.8 sei whale per year (Hayes et al. 2022).

Similar to NARW and fin whales, the primary threats to sei whales include vessel strike and entanglement in fisheries gear. The greatest risk from these IPFs is a result of ongoing, non-offshore wind activities and the planned offshore wind projects would not appreciably contribute to increase risk to this species. Additionally, sei whales are expected to be present in low numbers in the proposed Project area, and the total number of individuals exposed per year to noise above the auditory injury thresholds (JASCO 2022) are below the annual PBR of 6.2 individuals (Hayes et al. 2022); therefore, potential impacts would not be expected to result in population-level effects.

B.5.4 Humpback and Minke Whales

Neither humpback or minke whales in the proposed Project area are listed under the ESA (Hayes et al. 2021, 2022); however, an active UME has been declared for both species due to suspected human interactions from vessel strike, entanglement, or infectious disease (NMFS 2022b, 2022c). Since 2016, there have been 161 reported humpback whale strandings along the U.S. East Coast, approximately a quarter of which showed evidence of human interaction from either a vessel strike or entanglement (NMFS 2022b). Available data indicate that this stock of humpback whale is characterized by a positive population trend, with an estimated increase in abundance of 2.8 percent per year (Hayes et al. 2021). The PBR for humpback whales is 22, and the estimated annual human-caused mortality and serious injury between 2014 and 2018 was 15.25 whales per year (Hayes et al. 2021). The UME for minke whales was declared in 2017 and 123 strandings have been reported along the U.S. East Coast (NMFS 2022c). Preliminary findings from necropsy conducted on approximately 60 percent of the stranded whales indicate evidence of human interactions or infectious diseases (NMFS 2022c). There are no current population trends or net productivity rates for this species due to insufficient data. The PBR for this stock is estimated to be 170 (Hayes et al. 2022). The estimated annual human-caused mortality and serious injury from 2015 to 2019 was 10.55 per year attributed to fishery interactions, vessel strikes, and non-fishery entanglement in both the United States and Canada (Hayes et al. 2022).

Similar to the other species discussed, the greatest risk of vessel strike and entanglement in fisheries gear is a result of ongoing, non-offshore wind activities, and the planned offshore wind development would not appreciably contribute to increased risk for this species. The total number of annual exposures estimated for these species for noise meeting or exceeding the auditory injury thresholds (JASCO 2022) is lower than the PBR for each species indicating that risk of any consequences to the population due to proposed Project-related noise is low.

B.5.5 Sperm Whales

Sperm whales present in the proposed Project area are listed as Endangered under the ESA as a single, global population. The best available estimate for the North Atlantic stock, which is expected to occur in the proposed Project area, is 4,349 individuals (Hayes et al. 2020). There were no reports of fishery-related mortality or serious injury between 2013 and 2017. While there were 12 strandings documented during this period, none showed any indications of human interaction (Hayes et al. 2020).

No vessel strikes for this species have been reported since 2013. However, sperm whales do face a risk from this IPF (Hayes et al. 2022). As discussed previously, ongoing activities from non-offshore wind projects are expected to result in the greatest risk for this species, but future offshore wind development would not appreciably contribute to this risk. This species, unlike the other species previously discussed, belong to the MFC hearing group (NMFS 2018b) so the risk of experiencing noise above auditory injury thresholds is lower than the baleen whale species belonging to the low-frequency cetacean (LFC) hearing group. As a result, the number of calculated exposures to the auditory injury thresholds was <0.01 for all schedules modeled for both impact pile driving and potential UXO detonations (JASCO 2022). Therefore, the risk of any consequences to the population due to proposed Project-related noise is expected to be negligible.

B.5.6 All Other Mid-Frequency Cetacean Species

The other dolphin and small whale species that belong to the MFC hearing group expected to occur in the proposed Project area are not listed under the ESA and are therefore expected to be less susceptible to potential impacts from Alternative A and Alternative B. The estimated annual auditory injury exposures for all these species (JASCO 2022) are below the annual PBR (Table 3.7-3 in EIS Section 3.7, Marine Mammals) so the risk of any consequences to the population due to proposed Project-related noise is expected to be low. Based on the most recent stock assessment reports available for these species, they also face a risk of entanglement in fishing gear, but the number of reported mortalities and serious injuries from the past few years does not exceed the PBR (Hayes et al. 2022) and would therefore not be expected to result in population-level consequences. Although smaller cetaceans are also at risk of vessel strikes, these species tend to be more agile, powerful swimmers and are more capable of avoiding collisions with oncoming vessels (MMS 2007).

Ongoing, non-offshore wind activities present a risk of entanglement in fishing gear that would not be expected to increase as a result of planned offshore wind activities; however, the presence of offshore wind structures may result in discarded fishing gear being caught around the foundations, creating an entanglement risk for MFC species. This risk notwithstanding, the presence of gear caught in foundations is not likely to increase the number of injuries resulting from interactions above the PBR for any species, and the reef effect from the presence of the structures would present a beneficial effect for dolphin species. The increase in fish aggregating around the foundations would present many feeding opportunities for smaller species of dolphins with low body fat percentages (that require multiple feedings) or mother/calf pairs (that have been observed repeatedly at structures in the literature) (Hammar et al. 2010; Lindeboom et al. 2011).

B.5.7 Harbor Porpoises

Harbor porpoises present in the proposed Project area are not listed under the ESA (Hayes et al. 2022). The best available abundance estimate for the Gulf of Maine/Bay of Fundy stock occurring in the proposed Project area is 95,543 based on combined survey data from NMFS and the Department of Fisheries and Oceans Canada between the Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf and Central Virginia (Hayes et al. 2022). The PBR for this stock is 851, and the estimated human-caused annual mortality and serious injury from 2015 to 2019 was 164 (Hayes et al. 2022). This species faces major anthropogenic effects because of its nearshore habitat. Historically, Greenland populations were hunted in large numbers for food and oil. Currently, they continue to suffer incidental mortality from Western North Atlantic fishing activities such as gillnets and bottom trawls (Hayes et al. 2022). Harbor porpoises also face threats from contaminants in their habitat, vessel traffic, habitat alteration due to offshore development, and climate-related shifts in prey distribution (Hayes et al. 2022).

Harbor porpoises belong to the HFC hearing group, which have lower acoustic thresholds for auditory injuries (NMFS 2018b), resulting in higher ranges to the thresholds relative to the other hearing groups and subsequently higher numbers of annual exposures for this species (JASCO 2022). Although the number of annual exposures is higher, they still do not exceed the annual PBR of 851 for this species (Hayes et al. 2022). As such, the risk of any population level consequences due to proposed Project-related noise is expected to be low. Harbor porpoises also face a risk of entanglement in fishing gear, which is primarily a result of ongoing, non-offshore wind activities; thus, the planned offshore wind projects would not contribute a substantial direct increase in risk for this species. The presence of structures may result in discarded fishing gear being caught around the foundations, creating an entanglement risk for this species. This risk notwithstanding, the presence of gear in the foundations is not likely to increase the number of injuries resulting from interactions above the PBR for harbor porpoise, and the reef effect from the presence of the structures would present a beneficial effect for this species (Mikkelsen et al. 2013).

B.5.8 Seals

The species of seals potentially present in the proposed Project area include gray, harbor, and harp seals, none of which are listed under the ESA (Hayes et al. 2022). A UME was declared in June 2022 for harbor and gray seals; however, this UME is limited to seals stranding in Maine, and the cause of the strandings has been determined to be avian influenza rather than human interactions (NMFS 2022d). Human-caused IPFs that present risk to seal species include fisheries interactions and vessel strikes (Hayes et al. 2022), which are primarily a result of ongoing, non-offshore wind activities; thus, the planned offshore wind projects would not appreciably contribute to increased risk to these species. Furthermore, any potential increase in the risk of entanglement in fishing gear resulting from the presence of offshore wind structures would not exceed PBR for any seal species and would likely be offset by the beneficial effects of the reef effect (Arnould et al. 2015; Russell et al. 2014).

The total number of annual exposures estimated for these species for noise meeting or exceeding the auditory injury thresholds (JASCO 2022) is lower than the PBR for each species, indicating that risk of any consequences to the population due to proposed Project-related noise is low.

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