OCS-A 0501

MASS USA

VINEYARD WIND

Draft
Construction and Operations Plan

Volume III
Text

Vineyard Wind Project

October 22, 2018

Submitted by
Vineyard Wind LLC
700 Pleasant Street, Suite 510
New Bedford, Massachusetts 02740

Submitted to
Bureau of Ocean Energy Management
45600 Woodland Road
Sterling, Virginia 20166

Prepared by
Epsilon Associates, Inc.
3 Mill & Main Place, Suite 250
Maynard, Massachusetts 01754

Epsilon
ASSOCIATES INC.

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EPSILON ASSOCIATES, INC.
3 Mill & Main Place, Suite 250
Maynard, MA 01754

In Association with:

Biodiversity Research Institute
C2Wind
Capitol Air Space Group
Clarendon Hill Consulting
Ecology and Environment
Foley Hoag
Geo SubSea LLC
Gray & Pape
JASCO Applied Sciences
Morgan, Lewis & Bockius LLP
Public Archaeology Laboratory, Inc.
RPS
Saratoga Associates
Swanson Environmental Associates
Wood Thilsted Partners Ltd
WSP

October 22, 2018

Table of Contents

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

List of Appendices

List of Figures

List of Figures (Continued)

List of Figures (Continued)

List of Figures (Continued)

List of Figures (Continued)

List of Tables

List of Tables (Continued)

List of Tables (Continued)

List of Acronyms

AC	Alternating current
ACS	American Community Survey
ADLS	Aircraft Detection Lighting System
AGL	Above ground level
AMAPPS	Atlantic Marine Assessment Program for Protected Species
AMSL	Above Mean Sea Level
AIS	Automatic Identification System
APE	Area of Potential Effect
AR	Avangrid Renewables
ASMFC	Atlantic State Marine Fisheries Commission
ATC	Air Traffic Control
ATON	Aids to Navigation
BACT	Best Available Control Technology
BIA	Biological Important Area
BLS	Bureau of Labor Statistics
BMP	Best Management Practices
BOEM	Bureau of Ocean Energy Management
°C	Degrees Celsius
CAD	Confined Aquatic Disposal
Call	Call for Information and Nominations
CBA	Community Benefit Agreement
CBP	County Business Patterns
CCC	Cape Cod Commission
CCS	Center for Coastal Studies
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CIP	Copenhagen Infrastructure Partners
CL	Carapace (i.e., shell) lengths
cm	Centimeters
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COA	Corresponding Onshore Area
COP	Construction and Operations Plan
CPT	Cone penetrometer test
CSV	Construction support vessel
CTV	Crew Transfer Vessel
CVA	Certified Verification Agent
cy	Cubic yard
dB	Decibels
DMF	Massachusetts Division of Marine Fisheries
DO	Dissolved Oxygen

List of Acronyms (Continued)

DoD	United States Department of Defense
DOE	United States Department of Energy
DOER	Massachusetts Department of Energy Resources
DP	Dynamically positioned
DPS	Distinct Population Segments
DPW	Department of Public Works
E	Endangered
E	Extensive
EA	Environmental Assessment
ECA	Emission Control Area
ECC	Export Cable Corridor
EEA	Executive Office of Energy and Environmental Affairs
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
eGRID	Environmental Protection Agency's Emissions & Generation Resource Integrated Database
EJ	Environmental Justice
EMF	Electromagnetic Field
ENF	Environmental Notification Form
EO	Executive Order
EPA	Environmental Protection Agency
ERC	Emission Reducing Credits
ERP	Environmental Results Program
ERP	Emergency Response Plan
ESA	Endangered Species Act
ESP	Electrical service platform
EU	European Union
EWB	New Bedford Regional Airport
f	Fall
°F	Degrees Fahrenheit
FAA	Federal Aviation Administration
FDR	Facilities Design Report
FIR	Fabrication and Installation Report
FL	Fishery Liaison
FMP	Fishery Management Plan
FNP	Federal Navigation Project
FONSI	Finding of No Significant Impact
FR	Fishery Representative
ft	Feet
ft^2	Square feet

FTZ	Federal Trade Zone
G&G	Geophysical and geotechnical
gal	Gallons
GDP	Gross domestic product
G.L.	General Law
HAPs	Hazardous air pollutants
HDD	Horizontal directional drilling
HFO	Heavy fuel oils
HPWMA	Hyannis Ponds Wildlife Management Area
hr	Hour
HRG	High-resolution geophysical
HSE	Health, Safety and Environment
HVAC	High-voltage alternating current
HVDC	High-voltage alternating current
Hz	Hertz
IALA	International Association of Lighthouse Authorities
IEC	International Electrotechnical Commission
IFR	Instrument flight rules
IHA	Incidental Harassment Agreement
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
IPF	Impact Producing Factor
ISO	Independent System Operator
kHz	KiloHertz
kJ	Kilojoules
km	Kilometers
km^2	Square kilometers
kV	kilovolt
L	Liters
L	Localized
LAER	Lowest Achievable Emission Rate
LOA	Letter of Authorization
Lpk	Peak sound pressure
LT	Long-term
m	Meters
m^2	Square meters
m^3	Cubic meters
MA	Massachusetts
Max	Maximum

List of Acronyms (Continued)

MAAQS	Massachusetts Ambient Air Quality Standards
MAFMC	Mid-Atlantic Fisheries Management Council
MA CZM	Massachusetts Coastal Zone Management
MA DEP	Massachusetts Department of Environmental Protection
MA DMF	Massachusetts Division of Marine Fisheries
MA EFSB	Massachusetts Energy Facility Siting Board
MA WEA	Massachusetts Wind Energy Area
MassCEC	Massachusetts Clean Energy Center
MassDFW	Massachusetts Division of Fisheries and Wildlife
MassDOT	Massachusetts Department of Transportation
MassGIS	Massachusetts Bureau of Geographic Information
MARPOL	Marine Pollution
MEPA	Massachusetts Environmental Policy Act
mg/L	Milligram per liter
μg/L	Microgram per liter
μm	Micromolar
μPa	MicroPascal
mi	Miles
MHC	Massachusetts Historic Commission
MLLW	Mean Lower Low Water
mm	Millimeters
mm^2	Square millimeters
MMPA	Marine Mammal Protection Act
MMS	Mineral Management Service
MP	Monopile
m/s	Meters per second
MSD	Marine sanitization device
MVC	Martha's Vineyard Commission
MVY	Martha's Vineyard Airport
MW	Megawatt
NAAQS	National Ambient Air Quality Standards
NRA	Navigational Risk Assessment
NUWC	Naval Undersea Warfare Center
NAICS	North American Industry Classification System
NARW	North Atlantic Right Whale
NBDC	National Data Buoy Center
NCCA	National Commission for Certifying Agencies
NEAMAP	Northeast Area Monitoring and Assessment Program

List of Acronyms (Continued)

NEFMC	New England Fisheries Management Council
NEFSC	Northeast Fisheries Science Center
NEXRAD	Next Generation Radar
NHESP	National Heritage and Endangered Species Program
NH DES	New Hampshire Department of Environmental Services
NJDEP	New Jersey Department of Environmental Protection
nm	Nautical miles
NMFS	National Marine Fisheries Service
No.	Number
NOAA	National Oceanic and Atmospheric Administration
NODEs	Density Estimates
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxide
NOI	Notice of Intent
NOTAMs	Notice to Airmen
NPDES	National Pollutant Discharge Elimination System
NRLM	Non-road, locomotive, or marine
NROC	Northeast Regional Ocean Council
NTMs	Notices to Mariners
NTU	Nephoelometric Turbidity Unit
NUWC	Naval Undersea Warfare Center
NWS	National Weather Service
O_3	Ozone
O&M	Operations and Maintenance Facilities
OCS	outer continental shelf
OCSLA	Outer Continental Shelf Lands Act
OECC	Offshore Export Cable Corridor
OEM	Original Equipment Manufacturers
OPAREA	Navy Operation Area
OSP	Optimum Sustainable Population
OSRP	Oil Spill Response Plan
PAL	Public Archaeological Laboratory
PAM	Passive acoustic monitoring
PATON	Private aids to navigation
PAVE/PAWS	Precision Acquisition Vehicle Entry/Phased Array Warning System
PD	Pile driving
Pb	Lead
PEIS	Programmatic Environmental Impact Statement

List of Acronyms (Continued)

people/mi^2	People per square mile
PEP	Population Estimate Program
PM	Particulate matter
ppm	Parts per million
PSO	Protected species observer
psu	Practical Salinity Units
PTS	Permanent threshold shift
PVC	Polyvinyl chloride
RFI	Request for Interest
RFP	Request for Proposals
RI	Rhode Island
RI DEM	Rhode Island Department of Environmental Management
rms	Root mean squared
RNA	Rotor Nacelle Assembly
ROTV	Remotely operated towed vehicle
ROV	Remotely operated vehicle
ROW	Right-of-way
RPS ASA	Applied Science Associates, Inc.
RSD	ripple scour depressions
RTA	Regional Transit Authority
RV	Research vessel
s	Spring
SAP	Site Assessment Plan
SARs	Stock Assessment Reports
SCADA	Supervisory control and data acquisition
SD	Standard Deviation
SEFSC	Southeast Fisheries Science Center
SELcum	Cumulative sound exposure level
SMAST	University of Massachusetts School of Marine Science and Technology
SMS	Safety Management System
SO_2	Sulfur dioxide
Sound	Nantucket Sound
SOV	Service Operations Vessel
SPUE	Sightings per unit effort
ST	Short-term
STSSN	Sea Turtle Stranding and Salvage Network
su	Summer
T	Threatened
TBD	To be determined
TBF	To be filed

List of Acronyms (Continued)

TDWR	Terminal Doppler Weather Radar
THPO	Tribal Historic Preservation Officer
TN	Total nitrogen
TNASS	Canadian Trans-North Atlantic Sighting Survey
TP	Total phosphorous
TP	Transition piece
tpy	Tons per year
TSHD	Trailing suction hopper dredge
TSS	Total suspended sediment
TSS	Traffic separation scheme
TTS	Temporary threshold shifts
Typ	Typical
u	Uncommon
US	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USCGC	United States Coast Guard Cutter
USDOE	United States Department of Energy
USDOI	United States Department of Interior
USFWS	United States Fish & Wildlife Service
Utility ROW	Utility Right of Way
VFR	Visual flight rules
VMS	Vessel Monitoring System
VOC	Volatile organic compounds
VT	Vessel Traffic
VTA	Vineyard Transit Authority
w	Winter
WDA	Wind Development Area
WEA	Wind Energy Area
WNS	White nose syndrome
WQI	Water Quality Index
WTG	Wind turbine generator
XLPE	Cross-linked polyethylene

Section 1.0

Applicant's Purpose and Need

1.0 APPLICANT'S PURPOSE AND NEED

The purpose of the Vineyard Wind Project is to provide a commercially sustainable wind energy project within its leased area, as described in Lease OCS-A 0501, located in the federally designated Wind Energy Area on the Outer Continental Shelf offshore of Massachusetts to meet New England's need for clean energy. More specifically, the Project will deliver ~800 megawatts of power to the New England energy grid to make a substantial contribution to the region's electrical reliability and to meet individual state renewable energy requirements, including under long-term contracts entered into with Commonwealth of Massachusetts distribution companies to meet their obligations under Massachusetts law to purchase energy from offshore wind generators.

Section 2.0

Project Summary

2.0 PROJECT SUMMARY

Vineyard Wind, LLC (Vineyard Wind) proposes to construct, operate, and decommission an ~ 800 MW wind energy project consisting of up to 100 offshore wind turbine generators (WTGs) arranged in a grid-like pattern located in the Atlantic Ocean south of Martha's Vineyard. The Project also includes up to four electrical service platforms (ESPs), inter-array cables connecting the WTGs to the ESPs, inter-link cables between ESPs, and two offshore export cables. Each WTG will independently generate approximately 8 to 10 MW of electricity and will interconnect with the ESPs via the inter-array submarine cable system. The offshore export cable transmission system connects the ESPs to a Landfall Site in either Barnstable or Yarmouth. It is approximately 158 kilometers (98 miles) in length, assuming that two export cables are used. After the offshore export cables are brought to shore at one of two potential Landfall Sites, the physical connection between the offshore export cables and the onshore export cables will be made in an underground concrete vault(s). The onshore export cable route, located principally in established right-of-ways, will connect the underground vault at the Landfall Site to a new onshore substation located within the Independence Park commercial/industrial area in Barnstable. The Project will then connect to the New England transmission system at Eversource's Barnstable Switching Station or the West Barnstable Switching Station.

The Lease Area is within the Massachusetts Wind Energy Area identified by BOEM, following a public process and environmental review, as suitable for wind energy development. The proposed ~800 MW Project is located within the northern portion of the Lease Area, referred to as the Wind Development Area (WDA). The WDA is 306 km^2 (75,614 acres). At its nearest point, the Lease Area is just over 23 kilometers (14 miles) from the southeast corner of Martha's Vineyard and a similar distance to Nantucket (Figure 2.1-1 of Volume I).

The Project has significant environmental benefits. The electricity generated by the WTGs, which do not emit air pollutants, will displace electricity generated by higher-polluting fossil fuel-powered plants and significantly reduce emissions from the ISO New England power grid over the lifespan of the Project. Based on air emissions data for New England power generation facilities from EPA's Emissions & Generation Resource Integrated Database (eGRID), the Project is expected to reduce CO_2 emissions from the ISO NE system by approximately 1,630,000 tons per year (tpy). In addition, NO_x and SOx emissions across the New England grid are expected to be reduced by approximately 1,050 tpy and 860 tpy, respectively. Furthermore, the Project is likely to benefit marine mammals and other marine life. These benefits include reduction in greenhouse gasses that induce climate change which in turn potentially impacts species' ranges and access to prey as prey species' shift or decline, a particular concern for migratory species, such as some baleen whales which rely on high-latitude areas for feeding. In addition to these important environmental benefits, the Project is expected to bring significant employment and other economic benefits to the south coast of Massachusetts and the region. Finally, the Project should be an important foundational step in creating a thriving, utility scale, domestic offshore wind industry.

This section provides a summary of the Project; the complete Project Description is included in Section 3.0 of Volume I. Standard terms used to describe the Project are defined in Section 1.4 of Volume I.

2.1 Design Envelope/Phasing

The Project is being developed and permitted using an "Envelope" concept. The evolution of offshore wind technology and installation techniques often outpaces the speed of permitting processes. The Envelope concept allows for optimized projects once permitting is complete while ensuring a comprehensive review of the project by regulators and stakeholders, as BOEM recognized in its National Offshore Wind Strategy. The flexibility provided in the Envelope is important because it precludes the need for numerous permit modifications as infrastructure or construction techniques evolve after permits are granted but before construction commences. The parameters of the Envelope are presented in Table 2.1-1, with the maximum design scenario for environmental analysis. Construction of the ~800 MW Project will be continuous and is expected to start in late 2019.

Table 2.1-1 Vineyard Wind Project Envelope with Maximum Design Scenario

CAPACITY	Maximum	
Wind Farm Capacity	~800 megawatt ("MW")	
WIND TURBINE GENERATORS	**Smallest Turbine**	**Largest Turbine**
Turbine Size	8 MW	10 MW
Total Height[1]	191 meters ("m") (627 feet ["ft"])	212 m (696 ft)
Number of Positions (up to)[2]	106	
Number of WTGs (up to)	100	
WTG FOUNDATIONS		
Foundation Envelope	-100% monopiles or -Up to 10 jackets, remainder monopiles	
Foundation Type	Jackets (Pin Piles)	Monopiles
Number of Piles/Foundation	3-4	1

Table 2.1-1 Vineyard Wind Project Envelope with Maximum Design Scenario (Continued)

CAPACITY	Maximum	
FOUNDATIONS		
Maximum Area of Scour Protection at each Foundation	up to 1800 square meters ("m^2") (19,375 square feet ["ft^2"])	up to 2100 m^2 (22,600 ft^2)
Maximum Number of Foundations Installed per Day (24 hours)	1 (up to 4 pin piles)	2
ELECTRICAL SERVICE PLATFORMS		
ESP Type	400 MW Conventional ESP	800 MW Conventional ESP
Number of ESPs	**2**	1
ESP Foundations		
Foundation Types for Conventional ESP	Monopiles	Jackets
Number of Piles/Foundation	1	3-4
Maximum Area of Scour Protection at each Foundation	up to 2100 m^2 (22,600 ft^2)	up to 2500 m^2 (26,900 ft^2)
Maximum Height above Mean Low Water ("MLLW")	65.5 m (215 ft)	**66.5 m (218 ft)**
INTER-ARRAY CABLES		
Inter-array Cable Voltage	66 kilovolts ("kV")	
Maximum Length of Inter-array Cables	**275 kilometers ("km") (171 miles ["mi"])**	
EXPORT AND INTER-LINK CABLES		
Export and Inter-link Cable Voltage	220 kV	
Maximum Length of Inter-link Cable[3]	**10 km (6.2 mi)**	
Maximum Number of Export Cables	2	
Maximum Length of Offshore Export Cables(for two export cables)	**158 km (98 mi)**	

Notes:

Maximum Design Scenario indicated by double lined box and bold text.

1. Turbine output not necessarily proportionately linked to size, so smallest turbine size may not be an eight MW turbine.
2. Additional WTG positions are included to account for spare positions in the event of environmental or engineering challenges.

2.2 Construction and Installation

2.2.1 Offshore Activities and Facilities

The Project's offshore elements include the wind turbine generators (WTGs) and their foundations, the electric service platforms (ESPs) and their foundations, scour protection for all foundations, the inter-array cables, the inter-link cable that connects the ESPs, and the offshore export cables. The WTGs, the ESPs, the inter-array cables, the inter-link cable, and portions of the offshore export cables are located in federal waters. The balance of the export cable run is located in Massachusetts waters.

2.2.1.1 Wind Turbine Generators

The Project will install 8 MW to 10 MW WTGs. Although the Project is including 106 WTG positions in the Project Envelope, only up to 100 positions will be occupied by a WTG. The site layout for up to 106 turbine locations is shown on Figure 3.1-2 of Volume I.

The WTGs are arranged in a grid-like pattern. Spacing between WTGs will vary from approximately 1,400 m to over 1,850 m (0.76 to 1.0 nautical miles)[1] with a one nautical mile wide corridor (1,850 m) running from northwest to southeast and a second one nautical mile wide corridor running from northeast to southwest within the grid design.

The WTGs consists of two main components, the rotor nacelle assembly (RNA) and the Tower. The nacelle houses the energy-generating components of the turbine, including the gear box, generator, controller, low- and high-speed shafts, and brake. A pitch and yaw system will allow the wind turbine to optimize its performance by positioning the direction of the rotor and the angle of the blades. The brake, pitch, and yaw systems may be controlled using hydraulics. The RNA is mounted on the steel tower which is mounted on a foundation and/or transition piece via a bolted connection. The WTGs will have three-bladed rotors manufactured from fiberglass and carbon, which are connected to a steel hub.

The WTGs will be no lighter than RAL 9010 Pure White and no darker than RAL 7035 Light Grey in color to reduce their visibility against the horizon. In accordance with FAA requirements and/or BOEM guidelines, two synchronized Federal Aviation Administration (FAA) "L-864" aviation red flashing obstruction lights will be installed on each WTG nacelle. Depending upon commercial availability and regulatory approval, the Project will use either an Aircraft Detection Lighting System (ADLS) that is activated automatically by approaching aircraft or a system that automatically adjusts lighting intensity to accommodate visibility conditions to reduce potential impacts. A report on how often the ADLS system would be activated is included in Appendix III-N for informational purposes. If

[1] The listed dimensions describe the typical grid spacing. The minimum distance between nearest turbines is no less than 1.2 km (0.65 nm) and the maximum distance between nearest turbines is no more than 2.1 km (1.1 nm). The average spacing between turbines is 1.6 km (0.86 nm).

the use of ADLS is not feasible, reduced lighting for the interior will be reviewed and discussed with BOEM and the FAA. Marine navigation lighting will consist of two yellow flashing lights at each turbine and lights on the corners of ESPs approximately 20 - 23 m above MLLW. Other temporary lighting (e.g. helicopter hoist status lights) may be utilized for safety purposes when necessary. In accordance with International Association of Lighthouse Authorities (IALA) guidance, each WTG foundation will be painted with high visibility yellow paint from the water line to an approximate height of at least 15m (50 ft). Sound signals and AIS transponders are included in the Project design to enhance marine navigation safety.

The WTG parameters are provided in the table below and are shown on Figure 3.1-1 of Volume I.

Table 2.2-1 WTG Parameters

WTG Parameter	Envelope
Tip height	191-212 m (627-696 ft) MLLW*
Hub height	109-121 m (358-397 ft) MLLW
Rotor diameter	164-180 m (538-591 ft) MLLW
Platform level and expected Interface level towards foundations	19-23 m (62-75 feet) MLLW
Tip clearance	27-31 m (89-102 ft) MLLW

Note: MLLW is mean lower low water, which is the average height of the lowest tide recorded at a tide station each day during the recording period. Elevations relative to mean higher high water are approximately 1 m (3 ft) lower than those relative to MLLW.

The WTGs are expected to be amongst the most efficient renewable energy generators currently demonstrated for offshore use.

The WTGs will be installed with one or two jack-up or dynamic positioning (DP) vessel(s). The tower will first be erected followed by the nacelle and finally the hub, inclusive of the blades. Alternatively, the nacelle and hub could be installed in a single operation followed by the installation of individual blades. The WTG installation phase represents the most intense period of vessel traffic in the offshore site with wind turbine foundations, inter-array cables and wind turbines being installed in parallel; however, this is a relatively short time period compared to the life of the Project.

2.2.1.2 WTG Foundations

The WTG foundations will either be all monopiles or a combination of monopiles and jackets. Up to ten jackets are expected to be used in deeper water locations. Scour protection will be used to protect the foundations from scour development, which is the removal of the sediments near structures (such as the foundation) by hydrodynamic forces. Scour protection consists of the placement of stone or rock material that can withstand the increase seabed drag that is created by the presence of the foundation.

The monopile is a single, hollow cylinder fabricated from steel that is secured in the seabed. The diameter of the monopiles will range from 7.5 to 10.3 meters (25 to 34 feet) and will be driven into the seabed approximately 20 to 45 meters (66 to 148 feet) depending upon seabed conditions and water depths (Figure 3.1-3 of Volume I). Each monopile will typically be topped by a transition piece (Figures 3.1-3 and 3.1-4 of Volume I), although in some cases an extended monopile may be used (no transition piece; Figure 3.1-5 of Volume I). The transition piece provides a level surface for the WTG tower above it and contains secondary structures, such as tower flange for mounting the WTG, boat landing, internal and external platform, and various electrical equipment needed during installation and operation.

The Jacket design concept consists of 3-4 piles, a large lattice jacket structure and a transition piece (TP), see Figures 3.1-6 through 3.1-8 of Volume I. The jacket will also contain secondary structures, such as boat landings and cable tubes. The piles for the jacket foundation will range from 1.5 to 3 meters (5 to 10 feet) and will be driven into the seabed approximately 30 to 60 meters (98 to 197 feet), depending on seabed conditions and water depths.

The monopiles (or jackets) are expected to be installed by one or two heavy lift or jack-up vessel(s). Anchored vessels will not be used as primary construction and installation vessels within the WDA. Any anchoring that does occur within the WDA will occur within the Area of Potential Effect (APE) defined in Volume II-C. Pile driving will begin with a "soft-start" to ensure that the monopile remains vertical and allow marine life to move away before the pile driving intensity is increased. The intensity (hammer energy level) will be gradually increased based on the resistance that is experienced from the sediments. Typical pile driving for a monopile is expected to take less than approximately three hours to achieve the target penetration depth. It is anticipated that a maximum of two monopiles or one complete jacket could be driven into the seabed per day. No drilling of monopiles is anticipated, but it could be required if a large boulder or monopile refusal is encountered.

2.2.1.3 Electric Service Platforms (ESPs)

The ESP(s) will serve as the common interconnection point for the WTGs within the array. Each WTG will interconnect with the ESP via a 66kV submarine cable system. These cable systems will interconnect with circuit breakers and transformers located on the ESP to increase the voltage level and transmit wind-generated power through the offshore export cable systems to the final connection point to the New England Transmission System.

The Project may use one 800 MW conventional ESP or two 400 MW conventional ESPs. Like the WTGs, the ESPs will be secured to the seabed with either a monopile or jacket foundation and will also have scour protection. The foundations for the ESPs will be installed in the same manner as the WTG foundations. The ESP will have a maximum height above MLLW of approximately 65.5 meters to 66.5 meters (215 to 218 feet) depending upon the foundation used. The approximate size and design of topside components of conventional ESPs are depicted in Figures 3.1-10 through 3.1-13 of Volume I). If multiple ESPs are used, each ESP will be inter-linked with a inter-link cable the same 220 kV cable as used for the export cable. Figure 3.1-14 of Volume I provides representaive pictures of ESPs installed in Europe.

2.2.1.4 Inter-array Cables

The WTG's will be connected to the ESPs via 66kV inter-array cables. The expected cable type is a three-core alternating current ("AC") cable, which will also be the type of cable used for export cables, described in Section 2.2.1.5.

The inter-array cables will connect radial "strings" of 6 to 10 WTGs to the ESPs. The inter-array cable system will be designed and optimized for the Project during the final design and will consider cable design and capacity, ground conditions, Project operating conditions, installation conditions, and potential cultural resources. Therefore, the Envelope for the inter-array cables includes any potential layout within the WDA. One potential layout is provided as Figure 3.1-18 of Volume I, for illustrative purposes. As shown in Figure 3.1-18, the farthest WTG will have one outgoing connection and each subsequent WTG will have both an incoming and outgoing cable. The maximum anticipated length of the inter-array cables for an ~800 MW Project is approximately 275 km (170.8 miles). The inter-array cables are anticipated to be installed up to 1.5 to 2.5 meters (4.9 to 8.2 feet) below the seafloor, likely by jetting or jet plow embedment, after the cables are placed on the seafloor.

2.2.1.5 Offshore Export Cables

Two offshore export cables will connect the ESPs to the bulk power grid. Each offshore export cable, as well as the inter-link cables that connect the ESPs together, will be comprised of a three-core 220 kV AC cable for power transmission and one fiber optic cable for communication and temperature measurement, which serves to monitor the high-voltage system. The three-cores of the cable consist of three copper or alumimum conductors which will each be encapsulated by cross-linked polyethylene (XLPE) insulation and waterproof sheathing will prevent the infiltration of water.

Each of the export cables will be installed below the seafloor. In certain locations, sand waves are present, and since part of the sand waves may be mobile over time, the upper portions of the sand waves may need to be dredged so that the cable laying equipment can achieve the proper burial depth below the sand waves and into the stable sea bottom. Where required, dredging will occur within a 20 m (66 foot) wide dredged corridor by various techniques depending upon site conditions. Dredge volumes are dependent on the final route and cable installation method: a cable installation method that can achieve a burial depth of 2.5 m will require less dredging; a cable installation method that can achieve a burial depth of 1.5 m will require more dredging. The average dredge depth is 0.5 meters and may range up to 4.5 meters in localized areas. The maximum length of export cables (assuming two cables) is 158 kilometers (98 miles).

The majority of the export and inter-link cable is expected to be installed using simultaneous lay and bury via jet plowing or one of the other techniques listed in Section 4.2.3.3.2 of Volume I. However, other methods may be needed in areas of coarser or more consolidated sediment, rocky bottom, or other difficult conditions in order to ensure a proper burial depth. While anchored vessels are not expected to be the primary vessels used for cable installation, some anchored vessels may be needed along portions of the cable route. It is expected that there will be some areas where it will be difficult to achieve the proper burial depth. In those areas the cable will be protected by techniques such as placing rocks on top of the cable or placing prefabricated flexible concrete coverings on top of the cable (referred to as concrete mattresses).

There is one primary Offshore Export Cable Corridor ("OECC") with two route options through Muskeget Channel and two potential Landfall Sites (see Figure 3.1-15 of Volume I). The OECC will pass through Muskeget Channel, turn west, and will make landfall either at Covell's Beach parking lot in the Town of Barnstable or New Hampshire Avenue/Lewis Bay in the Town of Yarmouth.

2.2.2 Onshore Activities and Facilities

2.2.2.1 Landfall Site and Onshore Export Cable Route

The offshore export cable will make landfall at either New Hampshire Ave or Covell's Beach. The New Hampshire Avenue landing site is located inside Lewis Bay where a road dead-ends just west of Englewood Beach at a low concrete bulkhead. A paved parking area is located approximately 300 feet north of the dead-end where construction staging operations could occur. The Covell's Beach landing site is located on Craigville Beach Road near the paved parking lot entrance to a public beach that is owned and managed by the Town of Barnstable.

In both cases, the ocean to land transition could be made using Horizontal Directional Drilling (HDD). The HDD rig would be setup in a parking lot or other previously disturbed area; the drill would be advanced seaward. However, the Lewis Bay/New Hampshire Ave landing area may be suitable for a direct lay approach. This landing area is unique in that the shoreline area has been entirely altered with manmade structures (road, sea wall, riprap, etc.). Moreover, there is no eelgrass or other sensitive habitat in the shallow water immediately offshore from the end of New Hampshire Ave.

Upon making landfall, the transmission line would follow one of two potential routes to connect the underground vault at the Landfall Site to the new onshore substation (Figure 2.2-1 of Volume I). For both routes, the onshore cables will be located entirely underground, primarily beneath public road right-of-ways with some shorter stretches in existing electric or railroad ROWs. The underground onshore cable routes are approximately 9 to 10 km (5.4 to 6.0 miles) in length.

The physical connection between the offshore export cables and the onshore export cables at the Landfall Site will be made in an underground concrete vault(s). From the surface, the only visible components of the cable system are the manhole covers. Inside the vault(s), each three-core submarine cable will be separated and spliced into three separate single-core cables and placed within a single duct bank. The duct bank is constructed using heavy wall PVC pipes encased in concrete. The duct bank installation is done with conventional construction equipment (e.g., hydraulic excavator, loader, dump trucks, flatbed trucks to deliver PVC pipe, crew vehicles, cement delivery trucks, paving equipment). Once the duct bank is in place, the cables are pulled into place via underground splice vaults and associated manholes, which are placed every 457 to 607 m (1,500 to 2,000 ft) or more along the duct bank.

2.2.2.2 Onshore Substation

The onshore substation site will be constructed on the eastern portion of a previously developed site, adjacent to an existing substation, within the Independence Park commercial/industrial area in Barnstable. The buried duct bank will enter the substation site by way of an access road that provides access to the electric transmission corridor from Mary Dunn Road. The substation will house up to four 220 kV /115 kV "step-down" transformers, switchgear, and other necessary equipment. The Project will connect to the bulk power grid via available positions at Eversource's Barnstable Switching Station, located just to the north of the substation site, though Vineyard Wind is also including the option to connect at the West Barnstable Switching Station. If a connection is made at West Barnstable, the Project substation would include step-up transformers (220 kV to 345 kV).

2.2.2.3 Port Facilities

Vineyard Wind has signed a letter of intent to the use the New Bedford Marine Commerce Terminal facility to support Project construction; the terminal is owned by the Massachusetts Clean Energy Center. The 26-acre New Bedford facility, located on the City's extensive industrial waterfront, was purposely built to support offshore wind energy projects. The terminal is just upstream of the Army Corps of Engineers hurricane barrier and has ready access to interstate highways.

The New Bedford facility is expected to be used to offload shipments of components, prepare them for installation, and then load components onto jack-up barges or other suitable vessels for delivery to the lease area for installation[2]. Some component fabrication and fitup may take place in New Bedford or other nearby ports as well.

Given the scale of the Project and the possibility that one or more other offshore wind projects may also use portions of the 26-acre New Bedford facility in parallel with Vineyard Wind, it is possible that Vineyard Wind may stage certain activities from other Massachusetts, Rhode Island, Connecticut, or Canadian ports. These possible ports are listed in Table 3.2-1 of Volume I.

2.3 Operations and Maintenance

2.3.1 Offshore Activities and Facilities

The WTGs are designed to operate without attendance by any operators. Continuous monitoring is conducted using a supervisory control and data acquisition (SCADA) system from a remote location. Examples of parameters that are monitored include temperature limits, vibration limits, current limits, voltage, smoke detectors, etc. The WTG also includes self-protection systems that will be activated if the WTG is operated outside its specifications or the SCADA system fails. These self-protection systems may curtail or halt production or disconnect from the grid.

Weather conditions will also be monitored. The forecasts will cover key parameters covering both meteorological (wind, temperature, visibility, warnings (e.g. lightning), as well as oceanographic parameters (wave conditions). In addition, it is likely that a small weather station (wind, temperature sensors) will be installed on the ESP, as such operations personnel will have an indication of real time conditions offshore which can be used to support the planning and execution of work.

Routine inspection and maintenance activities will be performed for all offshore facilities and may include such things as multi-beam echosounder inspections, side scan sonar inspections, depth of burial inspections, and other geophysical surveys.

2.3.2 Onshore Activities and Facilities

In support of Project operations and the necessary maintenance activities, operations and maintenance facilities (O&M Facilities) will be developed that include offices, a control room, training space for technicians and engineers, shop space, and warehouse space for parts and tools. These functions will be co-located, if feasible.

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2 Monopiles may not be loaded onto vessels for transport but may instead be pulled by tugs while floating in the water.

The O&M Facilities will also include pier space for crew transport vessels (CTV) and other larger support vessels. CTVs are purposely built to support offshore wind energy projects; they are typically about 23 m (75 ft) in length and are set up to safely and quickly transport personnel, parts and equipment. It is expected that approximately 1-2 CTV trips will occur daily during the operation period.

The CTVs are typically used in conjunction with helicopters. Helicopters can be used when rough weather limits or precludes the use of CTVs as well as for fast response visual inspections and repair activities, as needed. The helicopter(s) used to support O&M operations would ideally be based at a general aviation airport in reasonable proximity to the O&M Facilities.

Vineyard Wind plans to locate the Project's O&M Facilities in Vineyard Haven on Martha's Vineyard. However, Vineyard Wind intends to use port facilities at both Vineyard Haven and the New Bedford Terminal to support O&M activities (see Table 3.2-2 of Volume I). Smaller vessels (e.g. CTVs or SOVs) used for O&M activities will likely be based out of Vineyard Haven. Larger vessels used for major repairs during O&M (e.g. jack-up vessels, heavy cargo vessels, etc.) would likely use the New Bedford Terminal. Improvements to Vineyard Haven may be needed to accommodate Vineyard Wind's needs, such as improvements to existing marine infrastructure (e.g., dock space for CTVs, access, etc.) and to structures (office and warehouse space). It is expected that any needed improvements would be coordinated with lessor.

2.4 Decommissioning

2.4.1 Offshore Activities and Facilities

As currently envisioned, the decommissioning process is essentially the reverse of the installation process. Decommissioning of the Project is broken down into the following steps:

- Retirement in place or removal of offshore cable system (e.g., 66 kV inter-array and 220 kV offshore export cables).
- Dismantling and removal of WTGs.
- Cutting and removal of monopile foundations (and/or jackets) and removal of scour protection.
- Removal of ESPs.
- Possible removal of onshore export cables.

The offshore export cables could be retired in place or removed, subject to discussions with the appropriate regulatory agencies on the preferred approach to minimize environmental impacts. If removal is required, the first step of the decommissioning process would involve disconnecting the inter-array 66 kV cables from the WTGs. Next, the inter-array cables would be extracted from their embedded position in the seabed. If protective mattresses or rocks were used to cover portions of the cables, they will be removed prior to recovering the cable.

Prior to dismantling the WTGs, they would be properly drained of all lubricating fluids, according to the established operations and maintenance procedures and the OSRP. Removed fluids would be brought to a port area for proper disposal and / or recycling. Next, the WTGs would be deconstructed (down to the transition piece) in a manner closely resembling the installation process. It is anticipated that almost all of the WTG will be recyclable, with the potential exception of fiberglass components.

After removing the WTGs, the steel transition pieces and foundation components would be decommissioned. Sediments inside the foundations may be removed and temporarily stored on a barge to allow access for cutting. The foundation and transition piece assembly is expected to be cut below the seabed using one or a combination of: underwater acetylene cutting torches, mechanical cutting, or a high-pressure water jet. The portion of the foundation below the cut will likely remain in place. The cut piece(s) would then be lifted out of the water and placed on a barge for transport to an appropriate port area for recycling. Sediments that were previously removed from the inner space of the foundation would be replaced after the foundation is removed. To minimize sediment disturbance and turbidity, a vacuum pump and diver or ROV-assisted hoses would likely be used.

Subject to consultation with the fishing community, appropriate marine fisheries agencies and BOEM approval of the decommissioning plan, the stone scour protection pads will be removed. The stone would likely be excavated with a clamshell dredge, placed on a barge, and returned to shore for reuse or disposal at an onshore location. The process of disassembling the ESPs and their foundations will closely resemble the process used to dismantle the WTGs and their foundations.

The decommissioning of the offshore facilities would require the involvement of an onshore recycling facility with the ability to handle the large quantities of steel and other materials from the Project. There are such facilities currently in operation in New England. Currently, the fiberglass in the rotor blades has no commercial scrap value. Consequently, it is anticipated that the fiberglass from the blades would be cut into manageable pieces and then disposed of at an approved onshore solid waste facility.

2.4.2 Onshore Activities and Facilities

Decommissioning of onshore facilities would be coordinated closely with the host town to ensure that decommissioning activities meet the host town's needs and have the fewest environmental impacts. Subject to those future discussions, it is envisioned that the onshore cables, the concrete encased duct bank itself, and vaults would be left in place for future reuse as would elements of the onshore substation and grid connections. If onshore cable removal is determined to be the preferred approach, removal of cables from the duct bank would be done using truck mounted winches, cable reels and cable reel transport trucks.

Section 3.0

Project Evolution

3.0 PROJECT EVOLUTION

3.1 Introduction

The Vineyard Wind Project is intended to deliver up to ~800 megawatts ("MW") of power to the New England grid, providing a commercially sustainable offshore wind energy project within its leased area, as described in Lease OCS-A 0501. In order to ensure that the Project fulfills its purpose and need, Vineyard Wind evaluated numerous technologies and designs for their technical and commercial feasibility, as well as their potential environmental impacts. The main project elements driving the concept for the proposed project envelope are (1) the wind turbine generators ("WTGs"); (2) the WTG foundations; (3) the electrical service platform; and (4) potential cable routes. In addition, the project layout design was driven by conditions and existing uses within Vineyard Wind's Lease Area. As described in Section 2.1 of the Project Summary (Section 2.0 of Volume III), the evolution of offshore wind technology and installation techniques often outpaces the speed of permitting processes. The envelope concept allows for optimized projects once permitting is complete while ensuring a comprehensive review of the project by regulators and stakeholders, as BOEM recognized in its National Offshore Wind Strategy. The flexibility provided in the envelope is important because it precludes the need for numerous permit modifications as infrastructure or construction techniques evolve after permits are granted but before construction commences.

3.2 WTG Selection

Vineyard Wind considered WTGs ranging in size from 3.6 MW to more than 10 MW. The project envelope proposes eight to 10 MW WTGs because these WTGs: (1) will be commercially available at the time of construction; (2) are cost effective; and (3) produce fewer potential environmental impacts.

Commercial Availability: Currently, WTGs up to 9.5 MW WTGs are commercially available. A 10 MW is expected to be available at the time of project construction. While WTGs larger than 10 MW are under development, they are not expected to be commercially available in the time needed for planned construction.

Cost Effectiveness: Cost effectiveness considers the fabrication, installation, maintenance, and decommissioning costs of individual WTGs. While smaller WTGs may be less costly to fabricate, they are commercially unattractive because a significantly larger number of units and foundations are needed to deliver ~800MW of power; smaller WTGs are also generally less efficient than the larger WTGs. Thus, installation, maintenance, and decommissioning costs are significantly higher. Considering all of these factors, WTGs between eight and 10 MW are the most cost effective.

Environmental Impacts: Vineyard Wind considers the principal potential environmental impacts associated with the WTGs to be the Project design footprint and construction-related impacts. Eight to 10 MW WTGs will have a project footprint of up to 100[3] positions, while smaller capacity WTGs could almost double the number of positions needed to deliver ~800 MW of power. Thus, the Project footprint and its attendant potential environmental impacts would be significantly larger as would construction-related impacts associated with installation of the increased number of WTGs.

3.3 WTG Foundations

Vineyard Wind evaluated three foundation types for technical and commercial feasibility and potential environmental impacts: (1) monopile foundation; (2) jacket foundation with piles; and (3) self-floating gravity base foundations. These foundations represent the majority of foundation concepts that have been used for commercial offshore wind projects to-date. Concept designs were prepared to support the evaluation, and quotes were obtained from potential installation and fabrication contractors. The Project Envelope includes two of the three foundations considered (monopile and jacket foundations). As discussed in more detail below, gravity based foundations were determined to not be preferable based on the site-specific conditions of the Project. Similarly, suction bucket and floating foundations were not considered appropriate for the Project.

Monopile Foundation

Technical feasibility: Monopiles are a proven technology, having been used in large numbers of offshore WTG installations in Europe. The principal considerations for using monopile foundations are sea depths and soil conditions. Seabed conditions within the Wind Development Area ("WDA") area are considered well-suited for monopiles due to soils of an appropriate stiffness (see Volume II for further detail). The soils allow for a feasible installation while at the same time providing enough support for an operating project. Water depths within the wind development area range from 35-50 meters ("m") (115164 feet ["ft"]). Vineyard Wind has conducted detailed calculations to validate the technical feasibility of using monopiles, and concluded that monopiles are compatible with the ocean depths and conditions within the WDA. Although the monopile is the preferred technology, transportation techniques (i.e. available vessels for transport to the site), may be limited due to the size of monopiles needed for deeper waters.

Commercial feasibility: Because monopiles are a proven technology for offshore wind, there is a robust supply chain in Europe. Suppliers are able to fabricate monopiles to needed specifications with a relatively short lead-time. In addition, installation of

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3 Up to 106 turbine locations are being permitted to allow for spare positions (in the event of environmental or engineering challenges); however, only up to 100 positions will be occupied by a WTG.

monopiles is not unduly complicated and can be accomplished relatively quickly, typically within one to three hours per pile. There are also lower commercial risks associated with monopile installation because of their simple design and installation methods used.

Environmental impacts: Installation of monopiles does not involve dredging the seabed and the need for scour protection is expected to be limited (i.e., a total of 1,500- 2,100 square meters ["m^2"] [0.37-0.52 acres]) per pile. Therefore, seabed disturbance will be limited. The most significant potential impact from monopile installation is noise associated with pile-driving. However, because individual monopile installation occurs over hours, rather than days or weeks, noise impacts are temporary and of short duration. In addition, noise mitigation measures can be considered.

Jacket Foundation

Technical feasibility: Jacket foundations are also a proven technology, having been used in numerous offshore wind projects in Europe. Jacket foundations are also regularly used in oil and gas projects in the US and throughout the world. As with monopile foundations, seabed conditions within the WDA are well-suited for jacket foundations; these foundations are also compatible with the ocean depths and conditions within the WDA.

Commercial feasibility: Jacket foundations are not as widely used as monopile foundations for offshore wind projects. It is expected that jacket foundations would require a significantly longer lead-time for fabrication and would be more costly than monopiles. Each jacket foundation may require up to four piles, which could increase installation time and costs.

Environmental Impact: Like monopiles, jacket foundations will not require dredging of the seafloor at this site. Scour protection is similarly limited (a total of 1,300- 1,800 m^2 [0.32-0.44 acres]) per jacket. Therefore, seabed disturbance is limited. The piles required for the jacket foundation are typically smaller than monopiles, but each jacket requires up to four piles. Noise generated by the installation of individual piles may be less intense than monopile installation, but there would be more piles to install. Nevertheless, noise impacts would be temporary and of short duration. In addition, noise mitigation can be considered.

Gravity-Based Foundations

Technical feasibility: Gravity-based foundations are best-placed on stable soils. The WDA is not conducive for gravity-based foundations because of the soft top soils throughout the area. In addition, gravity-based foundations require a large concrete-based structure in order to provide the weight needed for the WTGs. Because of the foundations' significant weight, the foundations could not be installed using heavy lift vessels and equipment. Instead, they would have to be fabricated as self-floating foundations. To date, industry has had limited experience with self-floating gravity-based foundation structures.

Commercial feasibility: As gravity-based foundations have had limited application, supply chains are not readily available. Also, because of their size and weight, fabrication would have to be done locally and there is no local harbor readily available that could serve as a fabrication yard. Thus, there would be significant lead times and excessive costs required to establish a suitable fabrication yard (e.g., installing necessary extensions and reinforcements) and to fabricate the foundations. These combined costs far exceed costs associated with monopiles and jacket foundations and are thus not considered a commercially viable option for the Project.

Environmental impact: The size of gravity-based foundations and the scour protection necessary would displace large areas of the seafloor. In addition, excessive dredging could be required to remove the sand layer found throughout the WDA. Thus, seafloor impacts would be significant and there are no mitigation measures that would meaningfully reduce them.

Other Foundation Types

Vineyard Wind did not do a detailed analysis on the use of suction bucket foundations and floating foundations. Both are considered uneconomical for the project. In addition, suction bucket foundations would have added risk due to variable soil conditions and low permeability soil layers overlaying dense sands in large areas of the WDA. In particular, these soil conditions are known to pose a high risk of suction bucket refusal during installation. The floating foundation technologies are considered risky and unproven for large turbines. In addition, the water depth at VW is too shallow for the most floating foundation concepts.

Scour Protection

Vineyard Wind considered whether scour protection was necessary because the currents within the WDA are considered to be relatively low. However, as an extra measure of conservatism, scour protection was included in the project design to ensure proper engineering and operation of the foundations. The size of the rock to be used in the scour protection was designed to be compatible with available scour protection installation techniques and tools. At the request of some fishermen, using larger rock was considered to potentially promote habitat creation. This option was ultimately not included because it would be more difficult to control the exact placement of larger rocks. This would potentially reduce the effectiveness of the scour protection and increase bottom impacts during installation.

3.4 Wind Development Area and WTG Layout

The WDA is in the northern part of the Vineyard Wind Lease Area where water depths do not exceed 49.5 meters ("m") (162 feet ["ft"]) mean lower low water. The area, as well as the WTG layout proposed in the Project Envelope, was determined after consideration of water depths and non-technical restraints, and after consultation with relevant federal agencies and stakeholders. Costs associated with the area and various layouts were also considered.

In addition to optimizing the Project design (e.g., energy yield and ground conditions) the WTG layout proposed in the Project Envelope is designed to:

- Avoid major navigation routes;
- Avoid known or mapped shipwreck locations by locating a WTG a minimum of 500 m (1,640 ft) from the location;
- Minimize potential interference with known fishing activities within the area;
- Provide corridors through the WDA to facilitate navigation; and
- Provide a buffer zone against adjacent lease areas.

Vineyard Wind considered a more random layout of the project design to fully optimize wind energy production. This included additional density around the edges of the WDA. As the principle concern from mariners and particularly fishermen was transit, Vineyard Wind agreed to provide transit lanes within the random layout. However, after further consideration, and discussions with the USCG and fishermen, Vineyard Wind modified the Project design to a grid pattern with the primary WTG layout being aligned with the primary transit direction (NE to SW). This is the final layout submitted in the COP. To address navigation concerns, there is a one nautical mile (nm) transit corridor in the center of the WDA and all turbines allow for direct passage in the NE to SW direction. In addition, the large spacing between the turbines[4] (0.8 nm on average) allow for direct passage in other directions, including north/south and east/west. Vineyard Wind also included a buffer for wind turbines located near adjacent leases (OCS A – 0500 and OCS A – 0502) to further reduce potential navigational conflicts and increase space for passage of vessels.

The Project layout was designed to address many competing interests, including competing fishing interests. Of particular concern was the potential impact of the Project on the scallop fishery out of New Bedford, which according to NOAA data, has an annual average value of over $281 million. The orientation of the transit corridor through the Project was specifically designed in consultation with the scallop industry to allow passage through the Project to fishing areas, and the wide distances between the turbines allows for mobile and fixed gear fishing within the Project area.

[4] The distance between the turbines is a balance between energy loss due to shadowing of other turbines and putting turbines in deeper water and therefore increasing the cost of the foundation due to increased need for steel.

The current layout provides a balance between mariner concerns and lease commercial viability. Additional spacing between turbines and/or larger transit lanes would further reduce the commercial viability of the Project, the purpose and need of which is to deliver 800 MW of wind power to the New England energy grid. As an example, doubling the spacing between WTGs would correspondingly halve the number of WTGs and would not meet the Project's purpose and need. Doubling or otherwise increasing the width of the transit lanes would similarly significantly decrease the available portion of the WDA for wind power generation and jeopardize the commercial viability of the Project. The adequacy of the transit lane dimensions based on an analysis of fishing vessel use and size is addressed in Appendix III-I. Changing from a random layout to a grid pattern already reduced energy production.

Nevertheless, as discussed in more detail in Section 3.1.1.1 of Volume I, Vineyard Wind intends to adopt a 2 nm (3.7 km) wide transit lane that was developed through discussion among fishing stakeholders and state agencies. This transit lane, which was presented during the September 20th, 2018 Massachusetts Fisheries Working Group (FWG) on Offshore Wind meeting, is shown in Figure 7.6-53 and Figure 2.1-2 of Volume I. This transit lane layout represents a compromise of the various desired transit directions and corridor widths to/from priority areas identified by various fishing sectors and ports. Scallopers, fixed gear, squid, and whiting/scup fishermen from MA, NY, and RI ports all agreed this was a workable compromise at the meeting. MA Coastal Zone Management and the USCG have also expressed support of these transit lanes. Vineyard Wind also supports adopting a north/south transit lane directly to the east of the WDA to allow passage for fisheries travelling between squid and whiting fishing grounds.

3.5 Electrical Service Platform

The number and locations of Electrical Service Platforms ("ESPs") consider reliability and cost. The Project Envelope proposes one 800 MW conventional ESP or two 400 MW conventional ESPs to maximize reliability and electrical design. Cost considerations are driven by the distance to shore and optimizing the inter-array cable layout. For this reason, the ESPs are proposed in the northwest corner of each of the 400 MW layouts.

3.6 Export Cable

Potential Offshore Export Cable Corridors were identified by considering a number of factors, including mapping of special, sensitive or unique (SSU) areas from the Massachusetts Ocean Management Plan (OMP), bathymetric data, the locations of navigation corridors, water currents, and mapped obstacles such as rock outcroppings and shipwrecks. In the initial desktop analysis for an offshore cable route, critical considerations included, but were not limited to:

- Avoiding SSU areas mapped in the Massachusetts OMP;

- Maintaining a water depth of at least 20 feet, and avoiding shoals;
- Avoiding slopes where the seafloor bathymetry changes dramatically; and
- Crossing navigation corridors in a perpendicular orientation.

In August/September 2017, an initial geophysical survey was performed along more than 125 miles (200 km) of potential offshore route segments. Vineyard Wind performed geophysical surveys and sampling in the offshore environment to examine potential Offshore Export Cable Corridors that would connect with potential Landfall Sites (New Hampshire Avenue, Covell's Beach, and the now-eliminated Great Island).

Results from the 2017 preliminary survey were used to distill the offshore route segments into a Western Offshore Export Cable Corridor and an Eastern Offshore Export Cable Corridor.

Western Offshore Export Cable Corridor

The Western Offshore Export Cable Corridor ("OECC") travels north between Martha's Vineyard and Nantucket via Muskeget Channel to the east of mapped North Atlantic Right Whale Core Habitat. Two possible variations of this route through the Muskeget Channel area have been identified: the western route, which travels through the channel itself, where water depths are greater but are accompanied by stronger currents, and the Eastern Route, which avoids the scoured channel itself. The Western OECC then continues northward on the west side of Horseshoe Shoals. As the cables approach the Cape Cod mainland, the western corridor has options for reaching the Landfall Sites at Covell's Beach, New Hampshire Avenue, or Great Island.

Eastern_Offshore Export Cable Corridor

The Eastern OECC traveled north between Martha's Vineyard and Nantucket via Muskeget Channel to the east of mapped North Atlantic Right Whale Core Habitat. In the Muskeget Channel areas, the eastern corridor avoided the scoured channel itself, passing to its east. The eastern corridor then continued northward on the east side of Horseshoe Shoals. As the cables approach the Cape Cod mainland, the eastern corridor had options for reaching the Landfall Sites at New Hampshire Avenue or Great Island, but not Covell's Beach.

The Eastern Offshore Export Cable Corridor has been eliminated from further consideration after extensive review. The Western Offshore Export Cable Corridor has been selected as the optimum solution as it is technically suitable for cable installation and is the most direct. This route is shorter to the remaining two landfall locations (NH Avenue and Covell's beach). A shorter route allows for less impact area, less electrical line loses and less installation and operational costs. As more ferry traffic travels east from Lewis Bay, use of the Western Offshore Export Cable Corridor minimizes potential impacts, during construction, to ferry traffic as well.

3.7 Inter-array Cables

The Project has defined an area within the WDA where inter-array cables may be located (see Figure 3.1-19 of Volume I). The inter-array cables will connect radial "strings" of six to 10 WTGs to the ESPs. Vineyard Wind is permitting an Envelope approach for the inter-array cables that will include any potential layout within areas of the WDA that have been surveyed.

The development of the inter-array cable layout is highly dependent upon the WTG layout (selected turbine, number, and positions of WTGs). To support the Section 106 process, Vineyard Wind has surveyed an extensive amount of the WDA to designate areas where the inter-array cables may be located. Survey areas were based on an assessment of multiple potential WTG layouts (all of which are generated from the up to 106 turbine positions included in the Project Envelope). The design and optimization of the inter-array cable system will occur during final design of the Project, and will consider cable capacity and design, ground conditions, wind farm operating conditions, and installation conditions. If the number or position of WTGs changes, this has a ripple effect on the inter-array cable layout, as multiple strings of inter-array cables must be recreated to accommodate the change. This could lead to an inter-array cable layout in a different orientation than the pattern that has already been surveyed. Therefore, any change in the planned positions of WTGs, such as eliminating WTG positions in certain portions of the WDA or eliminating WTGs to add or widen transit corridors, would likely necessitate additional survey work to accommodate a new inter-array cable layout. Such survey work would impact the Project schedule and potentially cause Vineyard Wind to miss agreed deadlines for demonstrating the scheduled energy delivery date will be met.

3.8 Interconnection Points and Cable Routes

To ensure that all reasonable routing options were considered, Vineyard Wind delineated a study area that encompassed all of southeastern Massachusetts as well as eastern Rhode Island. In selecting cable routes, considerations focused on:

- Locations of possible interconnection points to the electrical grid;
- Existing transmission infrastructure and its capacity for accommodating the ~ 800-MW Project; and
- Existing offshore cables.

Vineyard Wind considered a wide range of potential routing options including through Narragansett Bay, Buzzards Bay, Nantucket Sound, and Cape Cod Bay and landfall Sites ranging from municipal beach parking lots to unimproved ways and other developed and undeveloped areas. The potential export cable routes also encompassed possible interconnections at several substations located in southeastern Massachusetts as well as Rhode Island. The universe of routing options considered and their distance from the WDA and to interconnection points are presented in the table below.

Table 3-1 Universe of Cable Route Options (all lengths approximate, miles)

Route #	*Interconnection Point*	*Export Cable Length*		
		Offshore[5]	*Onshore*	*Total*
1	Kent County Substation (National Grid), Rhode Island	78	3	*81*
2	Brayton Point	66	<1	*67*
3	Pine Street Substation, New Bedford	62	<1	*63*
4	Canal Station, via Cape Cod Canal	77	<1	*78*
5	Canal Station, via onshore	71	7	*78*
6	Falmouth Tap Switching Station, via Buzzards Bay	58	4	*62*
7	Bourne Substation, via Buzzards Bay	65	10	*75*
8	Falmouth Substation, via south coast of Cape Cod	33	2	*35*
9	Mashpee Substation, via south coast of Cape Cod	31	14	*45*
10	Barnstable (West Barnstable Substation or Barnstable Switching Station)	41	6	*47*
11	Barnstable (West Barnstable Substation or Barnstable Switching Station), via Yarmouth Landfall Site	43	6	*49*
10/11A	Barnstable, via east end of Nantucket to Yarmouth	63	6	*69*
12	Canal Station, via ocean route	135	<1	*136*
13	Pilgrim Station, via ocean route	127	<1	*128*

The first step in screening initial route options was to eliminate routes that equaled or exceeded 62 miles in total length because 62 miles is the maximum distance cables can be laid without requiring a mid-way reactor station and associated equipment, which would impose significant additional costs and could make the Project uncompetitive on a cost basis. This eliminated 10 routes, which are highlighted in gray in the table above.

The second step considered potential interconnection points, landfall Sites, distance from landfall to grid interconnection point, and locations for the proposed substation. The Falmouth substation was eliminated because it would require significant transmission system reinforcements, potentially including a new transmission line to one of the substations. Similarly, the Mashpee substation was eliminated because it would require significant transmission system reinforcements, including adding another transmission circuit to West Barnstable (more than 15 miles to northeast). The West Barnstable substation could accommodate an 800 MW project, but an interconnection into this substation at either 115 kV or 345 kV would require potential system upgrades and substation modifications. Eversource estimated that a 115 kV expansion at the West Barnstable Substation, which would accommodate the Project, would take approximately

[5] 1 mile = 0.87 nautical miles

42 months to complete, thus significantly delaying the Project's schedule. Eversource did not provide a timeline estimate for modifications necessary to complete a 345 kV interconnection, which would require a new four-breaker ring bus and transformer additions/modifications, although it is estimated that these modifications would take more time than the 115 kV expansion. A 115 kV interconnect at West Barnstable would require additional bus work, and a 345 kV interconnect at West Barnstable would be a radial interconnection, which would still require the 115 kV work. Therefore, although the West Barnstable Substation could be considered a potential interconnection point for the Project, it is considered inferior to the Barnstable Switching Station for connection of the initial 800 MW.

The Barnstable Switching Station was determined to be the most feasible interconnection point for several reasons. It has the capacity to accommodate the full 800 MW with a 115 kV interconnect. This 115 kV switching station connects a number of 115 kV lines which supply power to the middle and eastern portions of the Cape. Three 115 kV lines from Barnstable Switch run to the west and connect with other major elements of the Eversource transmission system at the recently-constructed West Barnstable 345/115 kV Substation. In addition, Barnstable Switching Station has two spare bays that could accommodate the Project without any significant infrastructure work.

Vineyard Wind did consider the option of regional transmission and, as required, included an option for regional transmission in a bid to the Massachusetts electric utilities for the sale of power. This option was not selected by the Massachusetts utilities. In addition, regional transmission was not included in this COP for the following reasons:

- Vineyard Wind studied a regional transmission approach and was not able to identify any advantages over a generator lead line approach to grid connection, whether from economic, environmental, technical, or other considerations.
- A regional transmission approach would of necessity be a larger undertaking, and involve more project participants, than the Vineyard Wind generation project alone; participation by these other entities is beyond Vineyard Wind's control.
- At this time, there is no policy or commercial framework for regional transmission that is sufficiently developed to be at the point of undertaking permitting, whether or not in coordination with Vineyard Wind's COP.

The project, however, is utilizing the largest commercially available AC cables in order to minimize the number of cables to support the 800MW project, minimize impacts associated with transmission, and maximize efficiencies and economies of scale.

3.9 Landfall Sites

Having selected the Barnstable Switching Station as the most favorable interconnection point for the Project, Vineyard Wind examined potential Landfall Sites where the transition from offshore cabling to onshore cabling could occur. The criteria used to identify potential Landfall Sites included:

- Ideally, a beach-front public parking area or similar available land able to accommodate the offshore-to-onshore transition and the necessary transition vault(s);
- Potential for direct access to offshore allowing for an open trench cofferdam transition, possibly eliminating a need for HDD or minimizing length and time to execute landfall;
- Clear egress onto a road of sufficient width to accommodate the duct bank;
- Enough space to accommodate the entry pit and drilling equipment associated with HDD, should that methodology be selected over open trench;
- In the case of residential surrounding land uses, a preference for seasonal use, rather than year-round, to avoid and minimize construction-period impacts to the public;
- Environmental considerations such as wetland resource areas and mapped eelgrass habitat; and
- Onshore route length.

Initially, approximately 50 possible landfall sites were identified along the south coast of Cape Cod and on the east coast of Buzzards Bay. These initial sites were reviewed in the context of cable length limitations and potential interconnection points, as well as fatal flaws. As a result of this analysis, most of the initial Landfall Sites were eliminated from further consideration.

For example, Kalmus Beach in Barnstable, where one of the existing Nantucket cables comes ashore, was initially considered as a potential landfall site but was eliminated from consideration for multiple reasons. First, an onshore route from this site would have passed directly through downtown Hyannis, which would impact many businesses in a high-traffic area. Barnstable town officials strongly advised that the Project avoid this area because of congested buried utilities in the downtown Hyannis area. Second, with the existing Nantucket Cable coming ashore at this location and additional in-road utilities, this location would not contain sufficient space for the proposed infrastructure for the Vineyard Wind Connector.

To avoid congested areas, eight locations along the stretch of the south coast of Cape Cod from Mashpee to Yarmouth were considered. Vineyard Wind held discussions with local officials in the Towns of Mashpee, Barnstable, Yarmouth, and Falmouth to discuss potential sites and likely onshore routes. As a result of these discussions and reviews, two potential landfall sites and associated routes were eliminated from further consideration (Keys Beach, Barnstable and Bay View Beach, Yarmouth).

While the closest landfall site to the WDA, South Cape Beach was eliminated because it would require a lengthy onshore cable route of approximately 18 miles to the Barnstable Switching Station by way of Great Neck Road and a utility right-of-way. Much of the ROW has not been maintained to its full width, thus installation of the underground cables would likely necessitate a large amount of land clearing. The ROW also passes through some relatively dense residential neighborhoods. The landfall site is also within the Waquoit Bay Area of Critical Environmental Concern (ACEC) and is a component of the Waquoit Bay National Estuarine Research Reserve, which is based in Falmouth and managed by the Massachusetts Department of Conservation and Recreation (DCR) and the National Oceanic and Atmospheric Administration (NOAA).

The Baxter Avenue, Yarmouth site was eliminated because there is insufficient workspace available for HDD operations without the use of one of two adjacent private properties. In addition, the route inland from this potential site would be along busy sections of Route 28 and Willow Street in Yarmouth. Finally, Seagull Beach, Yarmouth was eliminated because construction would be in close proximity to areas of salt marsh and bordering vegetated wetlands. The area is also mapped with a wide swath of eelgrass. Thus, potential environmental impacts associated with this site informed elimination for further consideration.

Through this process of elimination, three of the eight potential landfall sites were retained (New Hampshire Avenue and Great Island in Yarmouth, and Covell's Beach in Barnstable). However, Great Island was subsequently eliminated because, although Vineyard Wind initially engaged in productive discussions with the landowner about potential use of this site, upon further investigation it was determined that certain property rights were not as understood based on early-stage research. In addition, the Mass Wildlife's Natural Heritage & Endangered Species Program expressed concern over potential use of the site due to the presence of possible nesting habitat for Piping Plover.

Thus the New Hampshire Avenue and Covell's Beach were selected as the viable landfall sites.

3.10 Transmission Cables

The project will employ high-voltage alternating current ("HVAC") technology for the proposed transmission. HVAC is preferred to high-voltage direct current (HVDC), as it is more flexible (transmission cables and substation capacity can be expanded as needed) and is more reliable for an 800 MW project with multiple circuits. In Europe, HVAC is widely used for projects less than 120 kilometers ("km") (75 miles ["mi"]) from shore; the Vineyard Wind's WDA is located approximately 56 km (35 mi) south of the Cape Cod mainland.

While HVDC is used for long-distance power transmission in overseas markets, and has been proposed for long-distance domestic projects such as the Champlain Hudson Power Express and the Emera Atlantic Link project, both of which are significantly greater in length than the approximately 68 to 80 km (42 to 50 mile) distance from the WDA to Landfall Sites, it requires large and expensive converter stations at both ends of the cable system. With its relatively short distance to shore, the higher cost and complexity of an HVDC system is not justified. Furthermore, lead times for HVDC platforms are currently approximately 48 to 54 months, which is incompatible with the Project schedule.

3.11 Transmission Voltage

The voltage of the proposed export transmission system will be 220 kV, which is the standard and accepted operating voltage for comparable connections of offshore projects in Europe. These 220 kV AC three-core offshore cables are the highest voltage commercially available and type-tested in the market from multiple manufacturers. Other higher voltages such as 345 kV could theoretically be used for an offshore wind project, but they are not currently manufactured in a three-core submarine cable configuration. Voltages lower than 220 kV are not desired for this Project, as they could increase the number of cables required for the connection and increase overall losses. For example, using 115 kV cables could require significantly larger offshore and onshore cables, and, in some cases, additional cables, since each 115 kV cable would have approximately half the capacity of a 220 kV cable. Not only would this increase Project costs, but it would also enlarge the impact areas in the offshore and onshore environments.

3.12 Cable Installation Techniques

Section 4.2.3.3.2 of Volume I describes the cable installation techniques that are included in the Project Envelope. The primary installation techniques may include jet plowing (jet trenching), mechanical plowing, or mechanical trenching, though the other techniques described in Section 4.2.3.3.2 may be used where needed. Vineyard Wind intends to analyze conditions along the entire offshore export cable corridor and to select the most appropriate cable installation tool or tools for each segment of the route. The Project intends to use engineering best practice to select the optimum burial solution for the Project with the goal of minimizing the potential for there to be areas where sufficient cable burial is not achieved, and to thereby minimize the extent of cable protection that may be required.

3.13 Project Schedule

On May 23, 2018, Vineyard Wind was selected to provide the Commonwealth of Massachusetts with 800 MW of wind energy power through a competitive solicitation process. A key component of Vineyard Wind's bid was an early delivery schedule for 800 MW of wind energy, with energization beginning in 2021 and reaching completion in 2022. Vineyard Wind is accordingly proposing continuous construction of the 800 MW Project. Constructing the Project in stages or with gaps between phases will not meet the power generation timeframe stipulated with the Commonwealth of Massachusetts.

Section 4.0

Summary of Potential Benefits, Impacts, and Mitigation Measures

4.0 SUMMARY OF POTENTIAL BENEFITS, IMPACTS, AND MITIGATION MEASURES

4.1 Project Benefits

The purpose of the Project is to provide the Commonwealth of Massachusetts with ~800 MW of clean, renewable wind energy, and is in direct response to 2016 energy legislation passed by the Commonwealth and signed by Governor Baker. Massachusetts's *Act to Promote Energy Diversity* requires the Commonwealth to procure cost-effective long-term contracts for 1,600 megawatts ("MW") of offshore wind energy within the next decade (Mass.Gov, 2016). Construction of the Project will serve the public interest by increasing the reliability and diversity of the regional and statewide energy supply.

The Project is also expected to create a range of environmental and economic benefits for southeastern Massachusetts (including New Bedford, the Cape, and the Islands), Massachusetts as a whole, and the entire New England region. Project benefits will extend across the design, environmental review, and permitting phase, the procurement, fabrication, and construction/commissioning phase, the multi-decade operating phase, as well as the future decommissioning effort.

A description of the Project's community and environmental benefits associated with Vineyard Wind's winning bid for offshore wind power to the Commonwealth of Massachusetts is included in Appendix III-Q.

4.1.1 Energy Reliability Benefits

The Vineyard Wind Project would enhance the reliability and diversity of the energy mix on Cape Cod and in the Commonwealth of Massachusetts. This is particularly important given that several base load/cycling plants have already retired or are slated for retirement, including:

- Brayton Point Power Plant (Somerset, MA): 1,600 MW, shut down May 31, 2017;
- Pilgrim Nuclear Power Plant (Plymouth, MA): 690 MW, to be closed by May 31, 2019;
- Vermont Yankee Nuclear Power Plant (Vernon, VT): 620 MW, shut down December 29, 2014;
- Montaup Power Plant (Somerset, MA): 174 MW, shut down in 2010; and
- Mt. Tom Station (Holyoke, MA): 136 MW, shut down in 2014.

In addition, other plants such as Canal Generating Station (1,200 MW, oil/natural gas-fired, two units commissioned in 1968 and 1976), are approaching their normal end of life, making it important for other energy generation alternatives to fill the gap. In addition to the plants mentioned above, ISO-NE has identified over 5,000 MW of oil and coal capacity "at risk" for retirement in the coming years.[6]

The Project would be a major source of clean, renewable electric power. Just 400 MW of the ~800 MW Project could supply two-thirds of the peak Cape Cod load. With higher hub heights and longer, more efficient blades, Vineyard Wind's wind turbine generators ("WTGs") will take full advantage of the superior offshore wind regime. Accordingly, the Vineyard Wind Project is expected to operate at an annual capacity factor in excess of 45%.

The Project will enhance energy supply diversity. The Project will not be affected by possible cold weather gas limitations or supply shortages. Additionally, summer offshore wind patterns will allow the Project to produce substantial power during summer afternoons/early evenings, typical peak power demand periods on the Cape and the Islands.

Lastly, Cape Cod is at the outer reaches of the regional transmission system. The Cape is essentially supplied by one 345 kV and two 115 kV radial feeds. While recent significant investments in transmission reliability have strengthened the electricity supply to Cape Cod, Vineyard Wind would further improve the situation by feeding power into the center of the on-Cape transmission system. By connecting to the bulk power system on Cape Cod, the Project will increase the supply of power to the Cape and southeastern Massachusetts, which is an area that has experienced the largest impact from recent generation retirements.

4.1.2 Economic Benefits

The Project is expected to generate numerous economic benefits across Massachusetts and the entire New England region. Economic benefits from the Project will occur throughout the preconstruction, construction, operations and maintenance ("O&M"), and decommissioning phases and include:

- The Project has already opened and staffed a New Bedford office and has engaged a number of Massachusetts-based professionals to support elements of the design effort, licensing, and permitting.
- Project construction will create opportunities for area maritime industries (tug charters, other vessel charters, dockage, fueling, inspection/repairs, provisioning).

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[6] ISO-NE. https://www.iso-ne.com/about/regional-electricity-outlook/grid-in-transition-opportunities-and-challenges/power-plant-retirements

- The construction and installation process will make use of existing port facilities, and the Project has already signed a letter of intent to utilize the New Bedford Marine Commerce Terminal. To the extent feasible, construction materials and other supplies, including vessel provisioning and servicing, will be sourced from within the Project Area. The Project may also perform fabrication work in Massachusetts.

- As described in Sections 7.1.2.1.1 and 7.1.2.2.1, the Project will create a number of job opportunities within the marine trades and affiliated industries, and will have a positive impact on those sectors, particularly those heavily influenced by seasonal hiring. Once operational, the Project will also create a significant number of O&M jobs.

- The Project may provide additional recreational opportunities. The WTG and ESP foundations may become popular fishing locations, and recreational fishing activities may increase. Angler's interest in visiting the WDA may also lead to an increased number of fishing trips out of nearby ports which could support an increase in angler expenditures at local bait shops, gas stations, and other shore side dependents (Kirkpatrick et al., 2017). The Project may become a popular tourist destination that could provide opportunities for sightseeing vessel operations.

- The Project will make local and regional purchases of goods and services throughout the multi-decade O&M period.

- The Project will continue its efforts to work cooperatively with southeastern Massachusetts educational institutions such as Massachusetts Maritime Academy, UMass Dartmouth, and others to help create opportunities for their students and faculty.

- The Project will continue to work with their local partner, Vineyard Power Cooperative, throughout the phases of the Project.

- In accordance with the lease terms, the Project will make substantial annual rent and operating fee payments to the Federal Treasury. Prior to commercial operations, the Project will make annual lease payments of $500,658. As WTGs are commissioned and become operational, the Project's annual lease payments will decrease and be replaced by annual operating fee payments that are currently not known.

- It is estimated that the Vineyard Wind Project will generate $14.7 - $17 million in state and local taxes as a result of the development, construction, and first year of operations of the 800 MW Project. This includes an estimated $4.7 - $5.3 million increase in Massachusetts personal income and other personal tax payments, a $3.0

- $3.5 million increase in sales taxes, a $5.2 - $6.1 million increase in property taxes, a $1.3 – $1.5 million increase in corporate taxes and payroll taxes, and a $0.5 – $0.6 million increase in fees, fines, and other taxes. Although these tax benefits include only one year of expenditures during the O&M phase, tax benefits will continue annually over the Project's lifetime. In addition, Vineyard Wind is in the process of negotiating Host Community Agreements with these two towns; we anticipate these agreements will stipulate payments from Vineyard Wind to the local towns above and beyond the annual tax payments.

- Lastly, the Project should be an important foundational step in creating a thriving, utility scale, domestic offshore wind industry. The Project is committed to working with the Bureau of Ocean Energy Management ("BOEM"), Massachusetts, local and regional officials, and other stakeholders to maximize this unique and timely opportunity to establish Massachusetts as center for the offshore wind industry in the United States.

4.1.3 Environmental Benefits

The Project has significant environmental benefits. The Vineyard Wind Project would enable ~800 MW of zero-carbon electric power to be delivered to the ISO New England ("ISO NE") grid, which would displace electricity generated by higher-polluting fossil fuel-powered plants and significantly reduce air emissions reductions in the New England region over the lifespan of the Project. Based on air emissions data for New England power generation facilities from EPA's Emissions & Generation Resource Integrated Database, an 800 MW Project will reduce ISO NE carbon dioxide emissions by approximately 1,630,000 tons per year (tpy). Nitrogen oxides (NO_x) and sulfur dioxide emissions across the New England grid are expected to be reduced by approximately 1,050 tpy and 860 tpy, respectively (see Section 5.1.2.2.1 and Appendix III-B for more details).

A reduction in carbon emissions and other greenhouse gas emissions will have wide-reaching benefits for terrestrial, avian, and marine life. For example, the anticipated reduction in air emissions resulting from the Project will ameliorate the impacts of climate change on many species, which has been predicted to impact habitat ranges and access to prey as prey species shift or decline. Thus, the potential impacts of the Project discussed in Section 4.2 below should be considered in the conjunction with the Project's energy reliability, economic, and environmental benefits.

4.2 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures

Vineyard Wind has thoroughly analyzed the potential impacts of the Project to physical, atmospheric, biological, economic, cultural, and historic resources and identified measures to avoid, minimize, and mitigate these impacts. In accordance with 30 CFR §585.621(d), the Project will not cause undue harm or damage to natural resources, human life or the human environment, wildlife, property, the marine environment, the coastal environment, or sites, structures, or objects with historical or archeological significance.

Table 4.2-1, below, summarizes the Project's potential impacts on these resources and environmental protection measures that are proposed to minimize adverse effects. Table 4.2-1 is not meant as an exhaustive description of the Project's findings. A more detailed discussion of the Project's potential impacts and associated avoidance, minimization, and mitigation measures can be found in Sections 5, 6 and 7. Low probability events are discussed in Section 8.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Air Quality	Short-term air emissions will come primarily from vessels used during construction, operations and maintenance ("O&M"), and decommissioning. Since the Wind Development Area ("WDA") is approximately 23 km (14 miles) offshore, to the southeast of the mainland, and prevailing winds are from the west, the emissions within the WDA are unlikely to have any effect on onshore areas. For all phases of the Project, vessel activities within the port(s) are within the realm of normal harbor activities and will likely contribute only a small fraction of air pollution that is already caused by marine vessel traffic within the port(s). Air emissions from Project activities are not anticipated to cause any violation of Massachusetts or National Ambient Air Quality Standards.	Electricity generated by the wind turbines generators ("WTGs") will displace electricity generated by higher-polluting fossil fuel-powered plants, which will aid in the continued improvement of ambient air quality within the New England Region. The Project is expected to reduce emissions from the ISO New England power grid by approximately 1,630,000 tons per year ("tpy") for carbon dioxide, by 1,050 tpy for nitrogen oxides (NOx), and by 860 tpy for sulfur dioxide. Air emissions from the Project will be minimized through the use of low-sulfur fuels, limited engine idling time, and through the use of internal combustion engines designed and operated to minimize the formation of air pollutants. All engines and generators used in this Project will be certified by the manufacturer to comply with applicable on-road, non-road, and marine engine emission standards. The Project's air quality impacts will be further mitigated and minimized through EPA's OCS Air Permit process under 40 C.F.R. Part 55. Some construction phase NOx and VOC emissions from the Project will be mitigated through purchasing and retiring Emission Reduction Credits.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Water Quality and Water Resources	Pile driving, offshore cable installation, horizontal directional drilling ("HDD"), installation of scour protection, dredging, and removal of the Project's offshore facilities may impact water quality via sediment resuspension and dispersion. Impacts to water quality from the Project will be short-term and localized. In most cases, during installation of the offshore cable system, mobilized sediment will not be transported far by the currents and will settle rapidly. Routine releases from vessels, such as domestic water, bilge water, engine cooling water, deck drainage and/or ballast water are expected, but these releases would quickly disperse, dilute, and biodegrade so that impacts to water quality would be minimal.	Although impacts to water quality are expected to be minimal, the Project will use best management practices ("BMPs") where practicable to minimize sediment suspension during pile driving, cable burial, placement of scour protection, replacement of sediments into temporary cofferdams for HDD operations (if used), and removal of offshore facilities during decommissioning. See BMPs # 1, 12, 37, and 39 in Table 4.2-2. The Project will require all vessels to comply with regulatory requirements related to the prevention and control of discharges and the prevention and control of accidental spills. See Section 5.2 for a discussion of relevant regulatory requirements and control technologies vessels will use to prevent discharges of contaminated bilge and ballast water. The Project has also developed a draft Oil Spill Response Plan (see Appendix I-A).
Geologic Resources	Project impacts to geological resources are largely expected to be short-term and localized. Installation of Project components will not change the sediment composition or overall context of the geological resource. Construction activities will simply displace and rework some of the materials locally and in many instances, disturbances will occur to sediments from the same layer with common physical characteristics. Pile driving, dredging, HDD, cable installation, and scour protection installation will primarily result in short-term, localized impacts that are limited to the area of the activity. Cable installation and any cable repairs during O&M may result in a slight modification to the seafloor morphology (seabed scar), but these impacts will be limited to the narrow cable installation trench. Cable protection may replace existing hard bottom with rock or man-made hard bottom.	WTG and electrical service platform ("ESP") foundations have been sited in suitable geologic locations to minimize maintenance due to geotechnical issues over the structure's life span. Micro-siting after the 2018 survey will further refine WTG and ESP positions to minimize risk and impacts. The Offshore Export Cable Corridor ("OECC") has been sited to avoid areas with adverse seabed conditions to the extent feasible. The Project will micro-site cable positions within the final OECC to minimize impact to the largest seabed features and adverse conditions. To the extent feasible, the Project will avoid using cable protection in sand wave fields by dredging and using the appropriate installation tool to achieve burial into the underlying stable sediment layer. The Project will use appropriate installation methods and tools to minimize disturbance. Post-construction monitoring for cable exposure will be conducted.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Terrestrial Fauna	Short-term, localized impacts to terrestrial fauna during construction may be associated with physical habitat disturbance, displacement due to construction noise and vibration, and direct mortality from contact with construction equipment. Long-term impacts potentially affecting wildlife are limited to habitat loss or alteration. The clearing of vegetation at the onshore substation site will result in the permanent loss of approximately six acres of Pitch Pine-Oak forest habitat. Normal O&M activities will not cause further habitat alteration or involve activities expected to have a negative impact on wildlife. Project activities will not affect rare or protected habitat types or species.	The Project's Onshore Export Cable Route is sited almost entirely within paved roadways or other previously developed corridors, thereby avoiding undisturbed forest interiors and other significant wildlife habitat. Construction staging areas will be located within previously developed areas whenever practicable. The Onshore Export Cable Route has been sited to avoid crossing any wetlands. Siltation fencing will be installed at the proposed onshore substation site before beginning any land-disturbing activities. Any required maintenance or repairs to the onshore export cable will primarily take place within splice vaults, without any disturbance to adjacent wildlife habitat. Any previously undisturbed areas of wildlife habitat affected by expanded work zones or elsewhere along the Onshore Export Cable Route will be restored in consultation with local officials.
Coastal and Marine Birds	The primary potential impact of the Project to birds is mortality or injury due to collision with offshore Wind Turbine Generators (WTG). Project activities occurring in the Offshore Project Area are unlikely to cause population level impacts to any coastal or marine bird species. Coastal birds (primarily peregrine falcons and songbirds) are expected to be briefly exposed to construction and operation activities during migration. Although coastal birds may encounter construction equipment and may land on vessels, mortality from collision is unlikely. Impacts to coastal birds from displacement are expected to be insignificant. Marine birds (primarily gulls) are expected to be briefly exposed to construction, operations, and decommissioning activities during all seasons. Marine birds may be disturbed by vessels, helicopters, and other equipment used during the Project, which may lead to temporary displacement. While there may be short-term	The Project is located in the Massachusetts Wind Energy Area ("MA WEA"), which was selected by the Bureau of Ocean Energy Management ("BOEM") to minimize and mitigate impacts to avian species. The offshore location of the WTGs avoids impacts to many bird species. To minimize impacts to birds, the Project will reduce lighting as much as is practicable during construction. During construction, the Project will follow Federal Aviation Administration ("FAA") recommendations to use red-flashing lights. In addition, when practicable, the Project will down-shield lighting and/or use down-lighting to limit bird attraction and disorientation. During O&M, the Project will reduce lighting as much as is practicable by (1) reducing the number of lights, (2) using low intensity lights, (3) avoiding white lights, and (4) as appropriate, using flashing lights rather than steady burning lights, when practicable. In addition, when practicable, the Project will use hooded lighting,

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Coastal and Marine Birds (Continued)	disturbance of resident birds during construction, most birds that are initially disturbed will return to the area once construction has been completed. Noise from pile driving may cause birds to avoid the construction area and may disperse the local abundance of prey fish. Any short-term reduction in the prey base is expected to recover completely once construction was completed. Federally listed species (Roseate Terns, Red Knots, and Piping Plovers) may have limited exposure to the Project, which would largely be restricted to few individuals during the migration periods. Impacts to these birds are expected to be unlikely or insignificant.	colored lighting, or down-lighting to limit bird attraction and disorientation, limit outside light to necessary/required lighting, and close blinds on all windows in boat living quarters. Lighting will also be only used when necessary for work crews. Anti-perching is incorporated in the design of the turbines through the use of tubular WTG support towers. In accordance with safety and engineering requirements, the Project will consider anti-perching devices, where and if appropriate, to reduce potential bird perching locations Using a standardized protocol, the Project will document any dead or injured birds found on vessels and structures during construction and O&M. Vineyard Wind is developing a framework for a post-construction monitoring program for birds. During decommissioning, the Project will use the best practices available at the time to reduce any potential adverse effects to birds.
Bats	During construction and decommissioning, bats may be attracted to vessels associated with the Project, but behavioral vulnerability to collision is expected to be insignificant and population level impacts are unlikely. During the operational phase, the primary potential impact of the Project to bats is mortality or injury from collision with WTGs. Bats are not expected to forage in the BOEM Wind Energy Area, but may be present during migration. Bats may experience behavioral vulnerability to collision with WTGs, but overall bat exposure to the WDA is likely to be limited to a few individuals and population level impacts are unlikely.	Bats have the potential to be attracted to vessels to forage on insects, if insects are drawn to vessel lights. Where practicable, the Project will minimize lighting during construction activities in order to mitigate the risk of attracting bats. The WDA is far offshore and there are no nearby landing areas (e.g. islands), which might otherwise increase the presence of bats in the WDA.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Coastal Habitats	Depending on the final Landfall Site selected, some disturbances or alteration to coastal habitat may be required. At the Covell's Beach Landfall Site, no disturbance to the adjacent dune or beach habitats will occur. At the New Hampshire Avenue Landfall site, impacts to coastal habitats will be avoided unless the conventional open cut trench method is used, in which case impacts to coastal habitats would be short-term and highly localized. Normal O&M activities will not cause further habitat alteration or involve activities expected to have a negative impact.	Landfall Sites are located in previously disturbed areas and have sufficient work space that can be effectively segregated from any nearby coastal habitats. To the greatest extent practicable, the OECC has been routed to avoid impacts to sensitive coastal habitat, including mapped eelgrass. If sensitive resources are known to exist along vessel routes, vessels will be advised to avoid the area to the greatest extent practicable. HDD can be employed to minimize any impacts to eelgrass habitat or coastal wetlands. At the Covell's Beach Landfall Site and potentially the New Hampshire Avenue Landfall Site, disturbance to the adjacent dune or beach habitats will be avoided through use of HDD and by performing all construction operations and staging within a paved road surface and adjacent parking area. If the conventional open cut trench method is used at the New Hampshire Avenue Landfall Site, the site will be restored in consultation with local officials. Refueling and lubrication of onshore equipment will be conducted in a manner that protects coastal habitats from accidental spills. A Construction Spill Prevention Control and Countermeasures Plan will be prepared in accordance with all applicable federal, state, and local requirements. This Plan will identify all measures that will be implemented to prevent spills and the best management practices that that will be in place to contain spills that may occur. Additionally, the Oil Spill Response Plan ("OSRP Plan"), included in Appendix 1-A, will provide for rapid spill response, clean-up, and other measures that should also help to minimize any potential impact to affected resources as it relates to spills and accidental releases that might occur. Maintenance or repairs to the onshore export cable will take place primarily within splice vaults, without any disturbance to adjacent coastal habitat.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Benthic Resources	During construction, impacts from the alteration of habitat in the WDA and along the OECC are expected to be insignificant and recovery of natural assemblages is likely. Installation of WTG and ESP foundations is expected to result in short-term and localized loss of habitat, such that population level impacts are unlikely. Mortality of benthic organisms is expected within the WDA where temporary disturbance of the seafloor occurs due to cable and foundation installation, but the impacts are expected to be localized and unlikely at the population level. This is because the surrounding vicinity has an abundant area of similar habitat type, the portion of the WDA that will be disturbed is relatively small (0.5% of the entire WDA), and the sandy bottom community typical to the area has adapted to frequent natural sediment movement that already creates temporary impacts. Impacts to benthic resources due to the introduction of WTGs and ESPs as structured habitat will be direct, long-term (over the operation lifetime of the Project) and localized. WTG and ESP foundations may support more taxa than the surrounding primarily homogenous sand habitats.	The Project is located in the MA WEA, which has been sited to avoid the most sensitive areas for benthic and other resources. WTGs are widely-spaced so that the foundations (and associated scour protection) for the WTGs, along with the ESPs, inter-link cables, and inter-array cables, only occupy a minimal portion of the WDA, leaving a huge portion of the WDA undisturbed. The Project will conduct post-construction monitoring to document habitat disturbance and recovery (see Benthic Habitat Monitoring Plan in Appendix III-D). Anchored vessels will not be used as primary construction and installation vessels, but may be used along portions of the offshore export cable and potentially within the WDA. Any anchoring that does take place within the OECC or WDA will occur within the APE as described in Volume II-C. If used, anchored vessels will avoid sensitive seafloor habitats to the greatest extent practicable. Where feasible and considered safe, the Project will use mid-line buoys on anchor lines to minimize impacts from anchor line sweep. HDD will be used to minimize impacts to benthic habitat at the Covell's Beach Landfall Site, unless future site investigations determine that HDD is technically infeasible. At the New Hampshire Landfall Site, HDD or a conventional trench will be used.
Finfish, Invertebrates, and Essential Fish Habitat	Impacts to finfish species, invertebrate species, and essential fish habitat ("EFH") are expected to be short-term and localized during the construction, operation, and decommissioning of the Project. Pelagic species will be able to avoid construction areas and are not expected to be substantially impacted by construction and installation. Impacts to mobile pelagic fish and invertebrate species include localized and short-term avoidance behavior. Avoidance behaviors due to increased vessel presence in	The Project Area is located in the MA WEA, which was selected by BOEM to exclude most sensitive fish and invertebrate habitat. The low total fish biomass and high species richness in the Project Area makes this location ideal for wind energy as it reduces impacts to individual organisms and targets an area which will likely be able to recover following any potential Project-related disturbances.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Finfish, Invertebrates, and Essential Fish Habitat (Continued)	the WDA are expected to be similar to those already displayed by fish when near fishing or recreational vessels. Immobile life stages of fish species in or on benthic sediment (i.e., demersal eggs) and sessile benthic organisms in the direct path of construction may experience direct mortality. However, loss of many adult fish and population level impacts are not expected as most of these species produce millions of eggs each year and already have low adult survival rates and because the Project Area is only a very small portion of habitat in the region. Overall, current literature indicates noise generated from the operation of wind farms is minimal and only localized avoidance behaviors are expected; acclimation to the noise over time may occur. All habitat within the Project Area is expected to remain the same, except for approximately 0.23 km^2 (57 acres) that would be converted into hard substrate from foundations and scour protection, 0.40 km^2 (99 acres) where cable protection would be installed in the WDA and along the OECC, and the portion of hard bottom habitat that would be covered along the OECC. Alteration of sand wave habitat will likely be temporary and will have little impact on fish in the area, as they may be conditioned to a changing environment. Recovery of disturbed habitats is expected. The addition of structured habitat in the WDA would increase EFH for species that prefer rocky substrate and minimally decrease EFH for species that prefer sandy bottoms. The addition of hard structure habitat will add a complexity to the area that did not exist before and will likely attract species that prefer structured habitat. Electromagnetic field ("EMF") from submarine cables is not expected to impact elasmobranchs or other electro-sensitive fish species.	Loss of immobile benthic organisms or fish species in the direct path of construction may occur. These impacts will be minimized through the use of mid-line buoys, if feasible and safe, and installation equipment that minimizes installation impacts, such as jet plow. The Project will apply a soft-start procedure to the pile driving process to mitigate the potential impacts of injury to fish from pile driving. WTGs will also be widely spaced, leaving a huge portion of the WDA undisturbed by WTG and ESP installation. The OECC has been routed to minimize impacts to sensitive habitats. Vineyard Wind will conduct pre- and post-construction fisheries monitoring. Vineyard Wind is working with the Massachusetts School for Marine Science and Technology and local stakeholders to develop a monitoring plan to measure the Project's effect on fisheries resources. To the extent feasible, the Project will avoid important habitats such as eelgrass and hard bottom sediments. Cables will be buried in the substrate or covered with rock or concrete mattresses to mitigate the impacts of EMF.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Marine Mammals	For all phases of the Project, disturbance to marine mammals may result from increases in vessel traffic and short-term, localized noise caused by survey activities, vessels, and other operations. More significant and widespread disturbance to marine mammals may result from pile driving noise. There is also potential for vessel collision. Species vulnerability to these stressors varies, but it is unlikely that population level impacts will occur for ESA and non-ESA listed species. For Sei Whales, Fin Whales, and North Atlantic Right Whales (endangered species under ESA) there are no anticipated losses of individuals, but disturbance of individuals may occur. Feeding disruption of Harbor Porpoise could be an important impact of response to noise, but feeding can occur in nearby areas if Harbor Porpoises are temporarily displaced. Entanglement of marine mammals in tow lines and anchor lines is highly unlikely because these cables are expected to be under constant tension while deployed.	The Project is located in the MA WEA, which was sited to minimize and mitigate impacts to marine mammals. Vineyard Wind will use acoustic modeling as a tool to inform approaches to mitigation and address sensitive variables relative to potential risk of Project-related noise on marine mammals. Modeling will be used to evaluate potential impacts and identify specific mitigation and BMP options. The National Oceanic and Atmospheric Administration ("NOAA") and BOEM will be engaged in this iterative and adaptive process. Measures such as the establishment of exclusion and monitoring zones, establishment of clearance zones, pile driving soft-start procedures, vessel speed restrictions and avoidance measures, noise reduction technology, and the use of PSOs are expected to be part of the final mitigation plan. To minimize impacts to marine mammals, Project vessels will comply with the National Marine Fisheries Service ("NMFS") Regional Viewing Guidelines while in transit. In addition, environmental training of construction personnel will stress individual responsibility for marine mammal awareness and reporting. To address stakeholder concerns to this highly sensitive resource, Vineyard Wind has established a $3 million fund to develop and demonstrate innovative methods and technologies to enhance protections for marine mammals during offshore wind development, pending successful award of a power contract in 2018.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Sea Turtles	Impacts to sea turtles may include localized noise and vessel traffic, short-term disturbance of local habitat, and long-term modification (not loss) of habitat. These impacts are expected to be short-term and localized. Four turtle species could be exposed to stressors from construction, operation, and decommissioning of the Project, but two of these species (Kemp's Ridley and Green Sea Turtles) are not common in the region and have insignificant vulnerability to impacts. Loggerheads and Leatherbacks may be exposed to stressors that may result in the short-term, localized disturbance of individuals. It is unlikely that population level impacts to any sea turtle species will occur.	The Project is located in an area that lacks critical sea turtle habitat. Landfall Sites and onshore facilities are not located near known sea turtle nesting beaches. Working collaboratively with BOEM and NOAA, Vineyard Wind will develop mitigation that will effectively minimize and avoid risks to sea turtles from construction, operation, and decommissioning. Vineyard Wind plans to use acoustic modeling as a tool to inform approaches to mitigation and address sensitive variables relative to potential risks of noise. Avoidance, minimization, and mitigation measures employed for marine mammals are also applicable to sea turtles. In many cases, measures put in place to minimize impacts for marine mammals are more stringent than those required for sea turtles (e.g., pile driving soft-start procedures and use of noise reduction technology).
Demographic and Employment, and Economics	Impacts associated with the activities are anticipated to have a stimulating effect of the project area economy. Vineyard Wind has staffed a New Bedford office and has engaged a number of Massachusetts-based environmental consultants, engineers and attorneys to support elements of the design effort, licensing, and permitting. Construction, operations and maintenance, and decommissioning activities will provide numerous job opportunities within the marine trades and affiliated industries, and will have a positive impact on those sectors, particularly those heavily influenced by seasonal hiring. Opportunities for marine trades industries include: tug and other vessel charters, dockage, fueling, inspection/repairs, provisioning, and crew work.	To the extent feasible, construction materials and other supplies, including vessel provisioning and servicing, will be sourced from within the Project Region. Vineyard Wind will implement a comprehensive communications plan with the various port authorities; federal, state and local authorities; and other key stakeholders, including commercial and recreational fishermen. The Project will continue to work cooperatively with southeastern Massachusetts educational institutions to help create training and educational opportunities for their students and faculty throughout each phase of the Project. Vineyard Wind is committed to working with BOEM, the Commonwealth of Massachusetts, local and regional officials and other stakeholders to maximize this unique and timely opportunity to establish Massachusetts as center for the offshore wind industry in the United States.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Demographic and Employment, and Economics (Continued)	The construction of the O&M Facilities may require additional engineering, construction, and trades personnel. The O&M Facilities will be staffed by a team of technicians and engineers. Additional service providers will be necessary during planned inspection, maintenance, and repair of the onshore and offshore facilities. The Project anticipates sourcing many goods and services throughout the multi-decade O&M phase from local and regional providers.	
Environmental Justice/Minority and Lower Income Groups/Subsistence Resources	There are no Environmental Justice ("EJ") communities, as defined by the USEPA, near the Project Region. Some areas in the Project Region meet the Commonwealth of Massachusetts' criteria for EJ populations. The construction, operation and maintenance, and decommissioning of the project are not anticipated to create disproportionately high and adverse health or environmental effects of federal actions on minority and low-income populations. Construction and installation activities along the Onshore Export Cable Route may cause traffic and related impacts within the immediate vicinity these activities, though any disruption to normal and routine functions of the project area will be eliminated upon conclusion of the construction and installation activity.	The Project is not anticipated to cause disproportionately high or adverse effects on minority or low-income populations. In accordance with the provisions of E.O. No. 12898 (1994), no mitigation measures are necessary. However, in accordance with Massachusetts' EJ Policy, Project stakeholder engagement plans will include outreach to the communities of the census block groups identified in Section 7.2.1. The Project's activities are expected to increase employment opportunities, job training, and economic activity within the Project Region.
Cultural, Historical, & Archaeological Resources	Public Archaeology Lab ("PAL") completed an archeological due diligence review of potential Onshore Export Cable Routes. The desktop due diligence review determined that the Onshore Export Cable Routes pass through and are adjacent to previously recorded archeological sites. The data from high-resolution geophysical offshore survey along the OECC contain possible paleolandforms and indicate dates that might have permitted habitation during the late Paleoindian through middle Archaic Periods At present, marine survey activities	PAL is presently conducting a reconnaissance level archaeology survey for terrestrial areas, including completion of background research and field surveys under an archaeological approved by Massachusetts Historical Commission (MHC). The survey is being completed in cooperation with local historical commissions and Tribal Historic Preservation Office. Offshore surveys planned for the 2018 field campaign in support of the Construction Operation Plan will extend seafloor and subsurface coverage in all areas where bottom disturbance could occur during construction activities. Survey line spacing, coverage, geophysical system parameters, and

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Cultural, Historical, & Archaeological Resources (Continued)	have located one potential shipwreck site in the WDA but no direct evidence of pre-contact materials in the Project Area.	methodologies will comply with BOEM geophysical and geotechnical as well as archaeological guidelines applicable to this Project. Avoidance, minimization, and mitigation measures for terrestrial and submarine historical and archaeological resources within the Project Area will be determined in consultation with MHC and Massachusetts Board of Underwater Archaeological Resources through the Section 106 process.
Visual Resources	The Project will result in change to landscape conditions for viewers along the Martha's Vineyard and Nantucket coastline, but viewers will only have limited visibility of the WTGs when weather conditions allow. At distances greater than 23 km (14 mi), the Project would likely be considered visually subordinate to the wider landscape. The Project will be indiscernible from Cape Cod. All offshore and onshore cables will be subsurface/buried and will not be visible. The power grid connection will be constructed adjacent to an existing onshore substation. The proposed improvements for the onshore substation will be consistent in scale and visual character with the existing electric substation. The Historic Properties Visual Impact Assessment (Appendix III-H.b) identified a variety of historic properties, including historic buildings and structures, within the proposed Area of Potential Effect ("APE") for the Project. The potential visual impact on historic properties varies by location. The Project may affect the viewshed of limited historic properties situated along the southern coast of Martha's Vineyard, the southwestern coast of Nantucket, and their minor outlying islands.	Due to the distance of the WDA from shore (over 23 km [14 mi]), the Earth's curvature obstructs visibility of the WDA in its entirety from some locations and partially obstructs visibility elsewhere. At no point can any of the ESPs or WTGs be viewed at their full height from shore. The orientation and layout of the WDA (WTGs closer to shore will obstruct the view of WTGs further from shore) further mitigates visual impacts. Meteorological and atmospheric conditions could often obscure views of the WDA. The proposed light gray color and matte finish of the WTGs, blends well with the sky and prevents light from reflecting off the WTGs. The yellow color of the turbine foundation (required by the US Coast Guard ["USCG"]) largely falls below the visible horizon and is nearly undetectable from onshore viewpoints. The impact of FAA and USGC lighting is substantially limited by the distance of the Project from coastal vantage points. The Project will use an Aircraft Detection Lighting System, which is automatically activated by approaching aircraft, or a system that adjusts lighting intensity depending on visibility if commercially available and approved by BOEM and FAA.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Recreation and Tourism	Impacts of the Project on recreation and tourism, if any, are expected to be highly localized and largely temporary in nature. The WDA may provide additional recreational opportunities. Construction at the Landfall Site may result in minor, temporary disturbances at that location. HDD operations may cause temporary conflicts with pedestrian access to limited portions of the Landfall Site. Any impacts to recreational resources associated with the O&M Facilities are anticipated to be limited to a localized area around the O&M Facilities during the facility's construction period. The proximity of the WDA to numerous productive recreational fishing areas suggests that the highly localized impacts of construction and installation activities will have only minimal impacts to recreational species. Shore-based fishing activities at the Landfall Site may be temporarily displaced during the construction and installation phase. Construction vessels servicing the Offshore Project Area may cause navigation impacts around confined navigation channels and turning basins. Increased vessel traffic may occur through inshore traffic zones and any traffic separation scheme along the selected route to the WDA. Construction activities may result in temporary, minimal impacts to recreational boating activities in the Offshore Project Area. When vessels used for construction and decommissioning are in the Offshore Project Area, temporary restrictions on recreational boating and fishing activities in the immediate vicinity of those vessels may be necessary. Vineyard Wind is not proposing any vessel exclusions around the WTGs or other areas of the Project during the operation and maintenance phase.	Vineyard Wind's onshore construction schedule will minimize impacts to recreational uses and tourism-related activities during peak summer months and other times when demands on these resources are elevated (see Section 1.5.3 of Volume I). Likewise, Vineyard Wind will not conduct activities along the onshore transmission route within public roadway layouts from Memorial Day through Labor Day unless authorized by the host town; such work could extend through June 15 subject to consent from the local Department of Public Works (DPW). The Company will consult with the towns regarding the construction schedule and a Traffic Management Plan will be developed so as to minimize disruptions to residences and commercial establishments in the vicinity of construction and installation activities. Typical construction hours will extend from 7:00 AM to 6:00 PM. Nighttime work will be performed only on an as-needed basis, such as when crossing a busy road. When needed, nighttime work/extended construction hours, including possible work on weekends, will be coordinated through each Town. To minimize hazards to navigation, all Project-related vessels, equipment, and appurtenances will display the required navigation lighting and day shapes. Notices to mariners will be distributed by Vineyard Wind to notify recreational and commercial vessels of their intended operations to/from and within the WDA. Vineyard Wind will implement a Fisheries Communication Plan to keep the relevant parties informed throughout this phase of the Project (see Appendix III-E). To aid mariners navigating the Wind Development Area, WTGs and ESP will be lit, marked, and maintained as Private Aids to Navigation (PATONs) in accordance with International Association of Lighthouse Authorities (IALA) Guidance for the marking of man-made offshore structures (IALA Recommendation O-139, edition 2, 2013), and USCG approval.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Recreation and Tourism (Continued)	The WTGs will provide additional aids to navigation. During the O&M phase, WTG and ESP foundations may become popular fishing locations, and recreational fishing activities may increase.	
Commercial Fisheries and For Hire Recreational Fishing	The fisheries that may be affected by the Project are static gear fisheries, ground fish/bottom trawl mobile gear, and Atlantic surfclam/ocean quahog dredge fishery. Impacts of construction and installation activities on commercially harvested species will be highly localized. HDD activities may cause short-term impacts to near-shore commercial shell fishing activities and shellfish habitat. It is anticipated that noise from wind turbine construction, including pile driving, and low-intensity noise from drilling, dredging, or increased vessel traffic may induce commercially targeted species to be temporarily displaced from the immediate vicinity of the construction and installation activities If vessel restrictions are necessary to accommodate the safe operation of cable installation and other vessels, such restrictions would be temporary. Project-related vessel traffic during the O&M phase of the Project is not anticipated to cause impacts to either commercial or for-hire recreational fisheries. WTGs may become fishing locations, and for-hire recreational fishing activities may increase in the WDA. Anglers' interest in visiting the WDA may lead to an increased number of fishing trips out of nearby ports, which could support an increase in angler expenditures at local bait shops, gas stations, and other shoreside dependents (Kirkpatrick et al., 2017, p. 74). Impacts from decommissioning activities will be similar to those associated with construction.	The BOEM WEA, which contains the WDA, was sited to exclude an area of high fisheries value to reduce potential conflict with commercial and recreational fishing activities. Vineyard Wind has developed a Fisheries Communication Plan (see Appendix III-E) and will continue to refine that plan during construction. As described in the Fisheries Communication Plan (Appendix III-E), both Fisheries Liaisons (FL) and Fisheries Representatives (FR) will be employed on the project to ensure effective communication between the Project and the fishermen. More information on the FL and FR roles can be found in Appendix III-E. Vineyard Wind is developing a framework for a pre- and post-construction fisheries monitoring program to measure the Project's effect on fisheries resources. Vineyard Wind is working with the Massachusetts School for Marine Science and Technology (SMAST) and local stakeholders to inform that effort and design the study. The duration of monitoring will be determined as part of the initial effort to determine the scope of the study, but it is anticipated to include the pre-construction period and at least one year of post-construction monitoring. Post-construction monitoring will also be conducted to document habitat disturbance and recovery (see Benthic Habitat Monitoring Plan in Appendix III-D). To minimize hazards to navigation, all Project-related vessels, equipment, and appurtenances will display the required navigation lighting and day shapes. Notices to Mariners ("NTM") will be

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Commercial Fisheries and For Hire Recreational Fishing (Continued)		distributed by Vineyard Wind and the USCG to notify recreational and commercial vessels of their intended operations to/from and within the WDA. Vineyard Wind is currently providing and will continue to provide portable digital media with electronic charts depicting locations of Project-related work to provide fishermen with accurate and precise information on work within offshore Project Area. To aid mariners navigating the WDA, WTGs and ESPs will be lit, painted and marked with high-visibility paint, reflecting panels, and unique identification lettering and numbering, and maintained as Private Aids to Navigation (PATONs). The target burial depth of the cables is of sufficient depth to avoid interactions with fishing gear and/or anchors. The Project's offshore facilities only occupy a minimal portion of the WDA so a large portion of the WDA will remain undisturbed, thereby minimizing impacts to fisheries and improving navigational ability throughout the WDA. Impacts associated with scheduled, periodic maintenance activities during the O&M phase will be adequately mitigated through ongoing communication with fisherman and implementation of BMPs when feasible. See BMPs # 31-35 in Table 4.2-2.
Land Use and Coastal Infrastructure	Vineyard Wind anticipates that each phase of the Project will generate few impacts on extant land use patterns and coastal infrastructure. Any construction impacts will be short term. Impacts from O&M are not anticipated to have adverse effects on the surrounding communities and will not disrupt the communities' routine functions. The construction and installation process will make use of existing port facilities and modifications to those facilities are not anticipated. Vessels will operate from existing port facilities, but the frequency of these vessels operating from the New Bedford Marine Commerce Terminal and the future O&M Facilities will increase.	Construction, O&M, and decommissioning activities will be adequately mitigated through the implementation of BMPs when practicable. See BMPs #1, 3, and 41 in Table 4.2-2. Vineyard Wind's onshore construction schedule minimizes impacts to land uses and coastal infrastructure during peak summer months and other times when demands on these resources are elevated. Likewise, Vineyard Wind will not conduct activities along the onshore transmission route within public roadway layouts from Memorial Day through Labor Day unless authorized by the host town; such work could extend through June 15 subject to consent from the local Department of Public Works (DPW). System repairs typically involve work on transmission cables which are accessed through

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Land Use and Coastal Infrastructure (Continued)	Installation of duct bank beneath paved roadways will require only minimal disturbance to the adjacent road shoulder and is expected to be completed without significant alteration to any land or infrastructure. HDD operations may result in minor, temporary impacts to seawalls, and/or parking and access facilities in the immediate vicinity of the Landfall Site. Establishment of the Project's O&M Facilities may cause temporary and localized impacts in the immediate vicinity of the Facility.	manholes at the installed splice vaults, or within the fenced perimeter of the substation, thus they can be completed within the installed transmission infrastructure without impacts to surrounding land uses or coastal infrastructure. After decommissioning, the O&M Facilities can be easily repurposed for continued use by Vineyard Wind or another site operator.
Navigation and Vessel Traffic	Project-related activities may impact navigation capacity and vessels transiting to and from ports along the south coast of Massachusetts, Cape Cod and the Islands, and Rhode Island. Temporary restrictions on non-Project related vessels transiting in the immediate vicinity of the Project's construction vessels may be necessary. Aside from this, no significant disruptions to the Project Region's established navigation patterns or aids to navigation are anticipated during the construction or decommissioning phases. When less maneuverable Project vessels are transiting confined navigation channels, non-Project related vessels transiting the channel may infrequently need to alter course or adjust their departure/arrival times to avoid navigational conflicts. Ferries operating between Hyannis and the island of Nantucket may need to make minor adjustments to accommodate cable laying vessels working in the OECC. AIS data suggests that commercial vessel traffic through the WDA is infrequent, and construction, operations, and decommissioning activities are not anticipated to affect such vessel traffic. During the O&M	The Project is sited within the MA WEA, which, after public comment, was developed to avoid shipping lanes and USCG-designated Traffic Separation Schemes. Vineyard Wind will continue to work with ferry operators, harbor pilots, other vessel operators, the New Bedford Harbor Development Commission, the New Bedford Harbor Master, USCG, and other entities to ensure disruption to commercial vessel traffic and navigation is minimized to the greatest extent practicable. Vineyard Wind will develop and implement a communication plan to engage these stakeholders. Vineyard Wind will work to coordinate a vessel traffic management plan, as necessary, to ensure construction and installation vessel operations align with established port operations. Vineyard Wind has also engaged with the Northeast Marine Pilots Association to coordinate construction and installation vessel approaches to the Project Region, as required by state and federal law, and to minimize impacts to commercial vessel traffic and navigation. To minimize hazards to navigation, all Project-related vessels, equipment, and appurtenances will display the required navigation lighting and day shapes.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Navigation and Vessel Traffic (Continued)	phase, the presence of WTGs and ESPs may increase risks to navigation, and commercial vessels may select alternate routes around the WDA rather than navigating through the WDA. The O&M Facilities will require deep-water access and quayside facilities. However, because these siting requirements are consistent with existing working ports, the O&M Facilities are not expected to affect commercial vessel traffic. Upon installation of the offshore export cable system, anchoring of vessels in proximity to the OECC is not recommended, but any anchoring limitations along the OECC are not anticipated to affect commercial vessel traffic.	Notices to Mariners ("NTMs") will be distributed by Vineyard Wind and the USCG to notify recreational and commercial vessels of construction and installation activities. Local port communities and local media will be notified and kept informed as the construction progresses. Updated navigational charts (paper and electronic) with the location of the Project will be issued to stakeholders. The Project's website will be updated regularly to provide information on the construction zone, scheduled activities, and specific Project information. To aid mariners navigating the WDA, WTGs and ESPs will contain sound signals and be lit, marked, and maintained as PATONs in reference to International Association of Lighthouse Authorities ("IALA"). The WTGs are laid out in a grid-like pattern with spacing of 0.76-1.0 nm between turbines. In consultation with local fishermen and the USCG, corridors in a northwest/southeast and northeast/southwest direction have been maintained. Temporary safety zones may be established around work areas during the construction and installation phase to improve safety in the vicinity of active work areas. This proposed safety zone would be adjusted as construction work areas change within the WDA, allowing fishermen and other stakeholders to make use of the portions of the WDA not being used for construction and installation activities. Vineyard Wind will work with the USCG to develop a communication plan for search and rescue evacuations and other emergency response situations. To mitigate potential impacts to search and rescue aircraft operating in the WDA, the Project will have a strict operational protocol with the USCG that requires the Project to secure the WTG (stop the blades from rotating) within a specified time (e.g. 2-minutes) upon request from the USCG.

Table 4.2-1 Summary of Potential Impacts and Avoidance, Minimization, and Mitigation Measures (Continued)

Resource	Potential Impacts	Avoidance, Minimization, and Mitigation Measures
Other Uses (Marine Minerals, Military Use, Aviation, Offshore Energy)	No aspects of the Project are anticipated to affect national security, including USCG or Navy interests. At various points during construction and possibly decommissioning, equipment and turbines located in the construction staging area, on vessels en route to the WDA, and at the WDA may have an effect on flight operations. In conformance with the Project's Lease, the Project does not propose activities that will unreasonably interfere with or endanger activities or operations carried out under any lease or grant issued or maintained pursuant to the OCSLA. One of the power cables servicing the Island of Nantucket, which is owned by National Grid, may be crossed depending on the final Landfall Site chosen for installation. Given the limited geographic areas of the WDA and the OECC, any future sand and mineral extraction activities proposed in the Offshore Project Area are not anticipated to be affected. Because the closest NEXRAD (Next-Generation Radar) facility to the WDA is approximately 97 km (60 mi), there are no anticipated impacts to radar systems associated with the WTGs that would require the implementation of mitigation measures. Impacts associated with operations and maintenance of the Project are not anticipated to have adverse effects on national security, aviation and air traffic, offshore energy, sand and mineral extraction, cables and pipelines, or radar systems.	The Project is located in the MA WEA, which was selected by BOEM after an exhaustive process with a goal of minimizing conflicts among existing uses and the environment. BOEM has coordinated with DoD on its final MA WEA. To minimize impacts to other uses within the Project Area, Vineyard Wind will implement BMPs when practicable and develop comprehensive communications plans to keep the relevant parties informed throughout the construction and installation phase of the Project. See BMPs # 41 – 44 in Table 4.2-2. Vineyard Wind has consulted with the Navy and has been informed that the Project does not raise concerns for the Navy. Vineyard Wind will continue to work cooperatively with USCG and Navy personnel to address any navigation, operations, or other concerns with decommissioning activities. Vineyard Wind and the USCG will provide Notices to Mariners that describe Project-related activities that may be of interest to national security interests, including Navy personnel operating within the Project Region. The Project will follow standard techniques for adequately protecting the National Grid cable, the newly installed offshore export cable, and any cable and/or pipeline that is installed prior to decommissioning.

In addition to or in agreement with the avoidance, minimization, and mitigation measures described in Table 4.2-1 above, the Project will comply with BOEM's best management practices ("BMPs") outlined in Appendix A of *Guidelines for Information Requirements for a Renewable Energy Construction and Operations Plan (COP)* (2016). Table 4.2-2 identifies how the Project will address or adhere to all of BOEM's BMPs. However, it is important to recognize that the Project will implement additional BMPs beyond those prescribed by BOEM, as described in Table 4.2-1 above.

Table 4.2-2 BOEM's Best Management Practices

#	Best Management Practice	Project Activities
	Preconstruction Planning	
1	Minimize the area disturbed by preconstruction site monitoring and testing activities and installations.	Vineyard Wind's Site Assessment Plan ("SAP") proposes the use of up to two meteorological and/or oceanographic buoys, which minimize disturbed areas. Similarly, Vineyard Wind's preconstruction geophysical and geotechnical work is designed to minimize impacts in accordance with approved survey plans and lease requirements. Wildlife studies have employed minimally invasive techniques for observing species and habitat presence.
2	Contact and consult with the appropriate affected federal, state, and local agencies early in the planning process.	During the development of the Construction and Operation Plan ("COP") (and other permit filings), Vineyard Wind has engaged with federal, state, and local agencies to identify and address any issues of potential concern. This extensive engagement has informed the design of the Project and the activities presented in the COP. See Section 6 of Volume I for a list of meetings that were in addition to ongoing phone and email consultations with the relevant agencies.
3	Consolidate necessary infrastructure requirements whenever practicable.	Vineyard Wind has made every effort to consolidate infrastructure requirements. This is perhaps most evident with respect to the use of the most technologically-efficient wind turbine generators ("WTGs") currently demonstrated for offshore use, which reduces the offshore infrastructure necessary this amount of energy production. Similarly, all onshore and offshore export cables will be installed in a single corridor.
4	Develop a monitoring program to ensure that environmental conditions are monitored during construction, operation, and decommissioning phases. The monitoring program requirements, including adaptive management strategies, shall be established at the project level to ensure that potential adverse impacts are mitigated.	The Project will be carefully monitored during construction, operation, and decommissioning. Resource specific monitoring plans are discussed throughout Volume III of the COP. The Environmental Management System is discussed in Section 4.2.2 of Volume I. Adaptive management strategies, based on ongoing monitoring results, will be established. A general discussion of proposed adaptive management strategies pertinent to each resource are located in the individual sections throughout Volume III of the COP.

Table 4.2-2 BOEM's Best Management Practices (Continued)

	Best Management Practice	Project Activities
	Seafloor Habitats	
5	Conduct seafloor surveys in the early phases of a project to ensure that the alternative energy project is sited appropriately to avoid or minimize potential impacts associated with seafloor instability or other hazards.	The Project is located within the Massachusetts Wind Energy Area ("MA WEA"), which BOEM has identified as appropriate for development of wind energy. In addition, Vineyard Wind has conducted geophysical and geotechnical surveys to confirm that site conditions are suitable for the Project. See COP Volume II for detailed discussions of site conditions.
	Seafloor Habitats	
6	Conduct appropriate pre-siting surveys to identify and characterize potentially sensitive seafloor habitats and topographic features.	Pre-siting surveys have been conducted to identify and characterize potentially sensitive seafloor habitats and topographic features. See COP Volume II and Sections 6.5 and 6.6 of Volume III for detailed findings. No sensitive seafloor habitats have been identified within the Wind Development Area ("WDA").
7	Avoid locating facilities near known sensitive seafloor habitats, such as coral reefs, hard-bottom areas, and chemosynthetic communities.	No sensitive seafloor habitats have been identified within the WDA. Export cable routes have been designed to avoid as much sensitive habitat as possible including all mapped eelgrass. Some coarse material will be crossed in the area of Muskeget Channel. A small area of mapped hard-bottom is located off the Covell's Beach Landfall Site. If this is the final landfall, it will be mostly avoided by the use of horizontal directional drilling ("HDD").
8	Avoid anchoring on sensitive seafloor habitats.	Anchored vessels will not be used as primary construction and installation vessels within the WDA. Any anchoring that does occur within the WDA will occur within the Area of Potential Effect (APE) defined in Volume II-C. Anchors are also not expected to be the primary method of cable installation. However, anchoring may be used along portions of the route installation, within the APE defined in Volume II-C. If used, anchored vessels will avoid sensitive seafloor habitats to the maximum extent practicable.
9	Employ appropriate shielding for underwater cables to control the intensity of electromagnetic fields.	Cables will be configured as shown in Figure 3.1-17 of Volume I. In addition, cable casing and burial will serve to greatly mitigate potential electromagnetic field impacts.
10	Reduce scouring action by ocean currents around foundations and to seafloor topography by taking all reasonable measures and employing periodic routine inspections to ensure structural integrity.	Scour protection, consisting of rock or stone, will be laid around each WTG and electrical service platform foundation, and will be routinely inspected.
11	Avoid the use of explosives when feasible to minimize impacts to fish and other benthic organisms.	Explosives are not intended to be used during the construction, operation, or decommissioning of the Project.

Table 4.2-2 BOEM's Best Management Practices (Continued)

	Best Management Practice	Project Activities
	Marine Mammals	
12	Take all reasonable actions to minimize seabed disturbance and sediment dispersion during cable installation.	A number of cable installation techniques are being considered that will both minimize seabed disturbance and sediment dispersion and prioritize cable burial. See Section 4.2.3.3.2 of Volume I for detailed discussions of disturbance and sediment dispersion minimization.
13	Evaluate marine mammal use of the proposed project area and design the project to minimize and mitigate the potential for mortality or disturbance. The amount and extent of ecological baseline data required will be determined on a project basis.	The location of the MA WEA was selected to minimize and mitigate impact to marine mammals. Section 6.7.1 of Volume III contains an extensive discussion of marine mammal abundance, status, distribution, and occurrence potentially within the Project Area based on multi-year studies of marine mammal use of the site. The Project has been designed with an understanding of marine mammal presence in the Project Area.
14	Vessels related to project planning, construction, and operation shall travel at reduced speeds when assemblages of cetaceans are observed. Vessels will also maintain a reasonable distance from whales, small cetaceans, and sea turtles, and these will be determined during site-specific consultations.	Vineyard Wind will adhere to legally mandated speed, approach, and other vessel requirements in the Offshore Project Area. As safe and practicable, the National Oceanic and Atmospheric Administration's vessel strike guidance will also be implemented.
15	Minimize potential vessel impacts to marine mammals and turtles by requiring project-related vessels to follow the NMFS Regional Viewing Guidelines while in transit. Operators shall be required to undergo training on applicable vessel guidelines.	Project vessels will comply with the National Marine Fisheries Service ("NMFS") Regional Viewing Guidelines while in transit. In addition, vessel operators will undergo training on applicable guidelines.
16	Take efforts to minimize disruption and disturbance to marine life from sound emissions, such as pile driving, during construction activities.	Vineyard Wind will develop mitigation that will effectively minimize and avoid impacts to marine mammals from pile driving noise. For example, current best practice noise attenuation methods for constructing offshore wind, such as bubble curtains, will be considered. Vineyard Wind also plans to evaluate new and available monitoring technologies as part of the permitting processes.
17	Avoid and minimize impacts to marine species and habitats in the project area by posting a qualified observer on site during construction activities. This observer will be approved by BOEM and NMFS.	BOEM and NMFS qualified observers will be employed during pile driving activities.

Table 4.2-2 BOEM's Best Management Practices (Continued)

#	Best Management Practice	Project Activities
	Fish Resources and Essential Fish Habitats	
18	Conduct pre-siting surveys (may use existing data) to identify important, sensitive, and unique marine habitats in the vicinity of the projects; they will then design the project to avoid, minimize, or otherwise mitigate adverse impacts to these habitats.	Pre-siting surveys have been conducted in the WDA and OECC. Section 6.6 of Volume III contains a discussion of marine habitats in the vicinity of the Project. Appendix III-F contains a discussion of essential fish habitat. Volume II also describes additional site specific surveys. The location of the MA WEA was selected to minimize and mitigate impacts to important, sensitive, and unique marine habitats. The OECC has been routed to minimize impacts to sensitive habitats.
19	Minimize construction activities in areas containing anadromous fish during migration periods.	Avoidance, minimization, and mitigation measures for all fish species are discussed in Section 6.6.2 of Volume III.
20	Minimize seafloor disturbance during construction and installation of the facility and associated infrastructure.	Seafloor disturbance will be minimized to the extent practicable as described in Section 6.5 of Volume III.
	Sea Turtles	
21	Minimize potential vessel impacts to marine mammals and sea turtles by requiring project-related vessels to follow the NMFS Regional Viewing Guidelines while in transit. Operators shall be required to undergo training on applicable vessel guidelines.	Project vessels will comply with the NMFS Regional Viewing Guidelines while in transit. In addition, vessel operators will undergo training on applicable guidelines.
22	Take efforts to minimize disruption and disturbance to marine life from sound emissions, such as pile driving, during construction activities.	As discussed in Section 6.7.2.1.3 of Volume III of the COP Vineyard Wind will develop mitigation that will effectively minimize and avoid impacts to sea turtles from pile driving noise.
23	Locate cable landfalls and onshore facilities so as to avoid impacts to known nesting beaches.	Cable landfalls and onshore facilities are not located near known sea turtle nesting beaches.
	Avian Resources	
24	Evaluate avian use in the project area and design the project to minimize or mitigate the potential for bird strikes and habitat loss. The amount and extent of ecological baseline data required will be determined on a project-to-project basis.	The location of the MA WEA was selected to minimize and mitigate impacts to avian species. Section 6.1 of Volume III contains a discussion of inland birds and Sections 6.2 and 6.4 of Volume III contain a detailed discussion of coastal and marine birds. Appendix III-C contains extensive data on avian use of the Project area. The avian information has informed the Project design and potential mitigation measures. The offshore location of the WTGs avoids impacts to many bird species.
25	Take measures to reduce perching opportunities.	Based on site specific studies, avian activity is minimized due to the distance from shore. Therefore, perching concerns are likewise minimized.

Table 4.2-2 BOEM's Best Management Practices (Continued)

#	Best Management Practice	Project Activities
	Avian Resources	
26	Locate cable landfalls and onshore facilities so as to avoid impacts to known nesting beaches of sensitive species during the breeding season.	The analysis in Section 6.4 of Volume III shows that construction activities would not result in impacts to nesting beaches during the breeding season.
27	Comply with Federal Aviation Administration (FAA) and USCG requirements for lighting while using lighting technology (e.g., low-intensity strobe lights) that minimize impacts on avian species.	Lighting has been designed to minimize impacts on avian species. Section 3.1.1 of Volume I and Section 6.2 of Volume III describe the proposed lighting scheme that is in accordance with FAA and US Coast Guard ("USCG") requirements.
	Acoustic Environment	
28	Plan site characterization surveys by using the lowest sound levels necessary to obtain the information needed.	Site characterization studies conducted to-date have used the lowest sound levels necessary to obtain the information needed. Surveys planned for 2018 will likewise do the same. Field verification results have shown minimal noise generated from geophysical equipment.
29	Take efforts to minimize disruption and disturbance to marine life from sound emissions, such as pile driving, during construction activities.	Vineyard Wind will develop mitigation that will effectively minimize and avoid impacts to marine life during construction. See Sections 6.6, 6.7, and 6.8 of Volume III.
30	Employ, to the extent practicable, state-of-the-art, low-noise turbines or other technologies to minimize operational sound effects.	Vineyard Wind will deploy commercially available turbine technology. Impacts from operational sound are expected to be insignificant. See Section 6.7.2.2 of Volume III.
	Fisheries	
31	Work cooperatively with commercial/recreational fishing entities and interests to ensure that the construction and operation of a project will minimize potential conflicts with commercial and recreational fishing interests.	Vineyard Wind has engaged extensively with various port authorities; federal, state and local authorities, and other key stakeholders; including recreational fishermen and boaters, commercial fishermen, harbormasters, the Northeast Marine Pilots Association and other port operators to identify concerns and minimize potential conflicts. This outreach has informed the Project design and proposed activities. A working Fisheries Communication Plan has been developed, a draft of which is found in Appendix III-E.
32	Review planned activities with potentially affected fishing organizations and port authorities to prevent unreasonable fishing gear conflicts. Minimize conflict with commercial fishing activity and gear by notifying registered fishermen of the location and time frame of the project construction activities well in advance of mobilization; they will also provide updates throughout the construction period.	The Fisheries Communication Plan is found in Appendix III-E. In addition, fishermen have previously been informed of geophysical and geotechnical surveys through handouts, public presentations, working groups, advertisements, and active outreach by Fisheries Representatives and Fisheries Liaisons.

Table 4.2-2 BOEM's Best Management Practices (Continued)

#	Best Management Practice	Project Activities
	Fisheries	
33	Use practices and operating procedures that reduce the likelihood of vessel accidents and fuel spills.	Vineyard Wind is firmly committed to full compliance with applicable environmental protection regulations and codes. Environmental protection measures that reduce the likelihood of vessel accidents and fuel spills are discussed in Section 4.2.2 of Volume I.
34	Avoid or minimize impacts to the commercial fishing industry by marking applicable structures (e.g., wind turbines, wave generation structures) with USCG-approved measures (e.g., lighting) to ensure safe vessel operation.	The WTGs will be appropriately marked in accordance with USCG-approved measures (e.g., lighting) to ensure safe vessel operation. See Section 7.8 of Volume III and Appendix III-I.
35	Avoid or minimize impacts to the commercial fishing industry by burying cables, where practicable, to avoid conflict with fishing vessels and gear operation. If cables are buried, inspect cable burial depth periodically during project operation to ensure that adequate coverage is maintained to avoid interference with fishing gear/activity.	Cables will be buried to depths of 1.5-2.5 meters (4.9-8.2 feet), which will avoid conflict with fishing vessels and gear operation. In areas where cable burial depths cannot be achieved, cables will be covered with concrete mattresses or similar protection that will preclude conflict with fishing vessels and gear operation. Cables will be routinely monitored during the operations period. See Section 4.3.2 of Volume I, which includes a representative schedule of inspection and maintenance activities.
	Coastal Habitats	
36	Avoid hard-bottom habitats, including seagrass communities and kelp beds, where practicable, and restore any damage to these communities.	No sensitive seafloor habitats have been identified within the WDA. Export cable routes have been designed to avoid as much sensitive habitat as possible including all mapped eelgrass. Some coarse material will be crossed in the area of Muskeget Channel. A small area of mapped hard-bottom is located off the Covell's Beach Landfall Site. If this is the final Landfall Site, it will be mostly avoided by the use of HDD.
37	Implement turbidity reduction measures to minimize effects to hard-bottom habitats, including seagrass communities and kelp beds, from construction activities.	Due to the coarse-grained nature of surficial sediments within the Offshore Export Cable Corridor ("OECC"), any Project-generated turbidity related to cable installation or the transition from HDD is expected to be temporary and limited in spatial scope. See Section 5.2 of Volume III and Appendix III-A.
38	Minimize effects to seagrass and kelp beds by restricting vessel traffic to established traffic routes.	No sensitive seafloor habitats have been identified within the WDA. Export cable routes have been designed to avoid as much sensitive habitat as possible including all mapped eelgrass. Vessel travel during construction, operations, and decommissioning is therefore not likely to affect seagrass. If sensitive resources are known along transit routes, vessels will be advised to avoid the area to the greatest extent practicable. See Section 6.4 of Volume III.

Table 4.2-2 BOEM's Best Management Practices (Continued)

#	Best Management Practice	Project Activities
	Coastal Habitats	
39	Minimize impacts to wetlands by maintaining buffers around wetlands, implementing BMPs from erosion and sediment control, and maintaining natural surface drainage patterns.	Through careful route selection and proper use of construction techniques such as HDD, the Project is designed to avoid potential wetlands impacts to the maximum extent practicable, and to minimize and mitigate for unavoidable impacts. See Sections 6.1 and 6.4 of Volume III.
	Electromagnetic Fields	
40	Use submarine cables that have proper electrical shielding and bury the cables in the seafloor, when practicable.	Cables will be configured as shown in Figure 3.1-17 of Volume I. In addition, cable casing and burial will serve to greatly mitigate potential EMF impacts.
	Transportation and Vessel Traffic	
41	Site alternative energy facilities to avoid unreasonable interference with major ports and USCG-designated Traffic Separation Schemes.	The Project is sited within the MA WEA, which, after public comment, was developed to avoid shipping lanes and USCG-designated Traffic Separation Schemes.
42	Meet FAA guidelines for sighting and lighting of facilities.	Section 3.1.1 of Volume I describes the proposed lighting, which is in accordance with FAA guidelines.
43	Place proper lighting and signage on applicable alternative energy structures to aid navigation per USCG circular NVIC 07-02 (USCG 2007) and comply with any other applicable USCG requirements.	The WTGs will be appropriately lit and marked in accordance with USCG-approved measures (e.g., lighting) to ensure safe vessel operation. See Section 7.8 of Volume III and Appendix III-I.
44	Conduct all necessary studies of potential interference of proposed wind turbine generators with commercial air traffic control radar systems, national defense radar systems, and weather radar systems; they must also identify possible solutions.	Vineyard Wind undertook an Aviation Impact Analysis to understand potential inference with commercial air traffic and radar systems, which can be found in Appendix III-J. Mitigation measures are discussed in Section 7.9 of Volume III.
	Visual Resources	
45	Address key design elements, including visual uniformity, use of tubular towers, and proportion and color of turbines.	The WTGs are uniformly tubular towers that will be no lighter than RAL 9010 Pure White and no darker than RAL 7035 Light Grey in color to reduce their visibility from against the horizon. Section 3.1.1 of Volume I provides the dimensions and coloring of turbines.
46	Use appropriate viewshed mapping, photographic and virtual simulations, computer simulation, and field inventory techniques to determine, with reasonable accuracy, the visibility of the proposed project. Simulations should illustrate sensitive and scenic viewpoints.	Viewshed mapping, photographic and virtual simulations, computer simulation, and field inventory techniques have been used to determine the visibility of the Project. The simulations illustrate sensitive and scenic viewpoints See Section 7.4 of Volume III and Appendices II-H.a and H.b.
47	Comply with FAA and USCG requirements for lighting while minimizing the impacts through appropriate application.	Section 3.1.1 of Volume I describes the proposed lighting that is in accordance with FAA and USCG requirements. Details of how and when the lights will be activated to minimize visual impacts will be determined in consultation with BOEM, FAA, and USCG.

Table 4.2-2 BOEM's Best Management Practices (Continued)

#	Best Management Practice	Project Activities
	Visual Resources	
48	Seek public input in evaluating the visual site design elements of proposed wind energy facilities.	Vineyard Wind conducted outreach on visual impacts and visual simulations on both Martha's Vineyard and Nantucket in August and September of 2017, respectively. Notices advertising the meetings were placed in the local newspapers.
49	Within FAA guidelines, directional aviation lights that minimize visibility from shore should be used.	Vineyard Wind is working to reduce the lighting to lessen the potential impacts of nighttime light on aesthetic concerns. The Project will use either an Aircraft Detection Lighting System that is activated automatically by approaching aircraft or a system that automatically adjusts lighting intensity to accommodate visibility conditions if commercially available and approved by BOEM and the FAA.
	Operations	
50	Prepare waste management plans, hazardous material plans, and oil spill prevention plans, as appropriate, for the facility.	Draft waste management plans, hazardous material plans, and oil spill prevention plans have been prepared and will be updated prior to construction. See Section 4.2 of Volume I and Appendix I-A.

Section 5.0

Physical Resources

5.0 PHYSICAL RESOURCES

5.1 Air Quality

This section addresses the potential impacts to ambient air quality that are associated with the onshore and offshore portions of the Project.

5.1.1 Description of the Affected Environment

The Project's wind turbine generators (WTGs) will not generate air emissions. Rather, electricity generated by the WTGs will displace electricity generated by higher-polluting fossil fuel-powered plants and significantly reduce emissions from the ISO New England power grid over the lifespan of the Project.

However, air emissions from construction, operations and maintenance, and decommissioning activities may affect air quality in the New England region and nearby coastal waters. There will be air emissions from commercial marine vessels, non-road construction equipment, helicopters, generators, on-road vehicles, and some fugitive emissions. These emissions will occur both onshore and offshore, within Massachusetts, the Outer Continental Shelf ("OCS"), and possibly another Atlantic port. Onshore emissions will occur at the Landfall Site, along the Onshore Export Cable Route, at the onshore substation, and at the construction staging areas. Offshore emissions will occur within the Wind Development Area ("WDA"), along the Offshore Export Cable Corridor, at one or more ports, and along the vessel routes between the WDA and the port(s).

Within Massachusetts, the geographic areas where Project-related air emissions may occur include Barnstable County, Bristol County, Dukes County and Nantucket County (in waters offshore Nantucket only). The Project intends to use the New Bedford Marine Commerce Terminal ("New Bedford Terminal") as the Project's primary construction staging area. However, as described in Section 3.2.5 of Volume I, Vineyard Wind may need to stage certain activities from other Massachusetts or North Atlantic commercial seaports as listed in Table 3.2-1. If a port besides New Bedford Terminal is used during construction, Project-related air emissions could potentially occur in one or more of the following counties:

- New London, Middlesex, New Haven, and Fairfield (Connecticut);
- Suffolk County (New York); and/or
- Washington, Newport, Kent, Providence, and Bristol (Rhode Island).

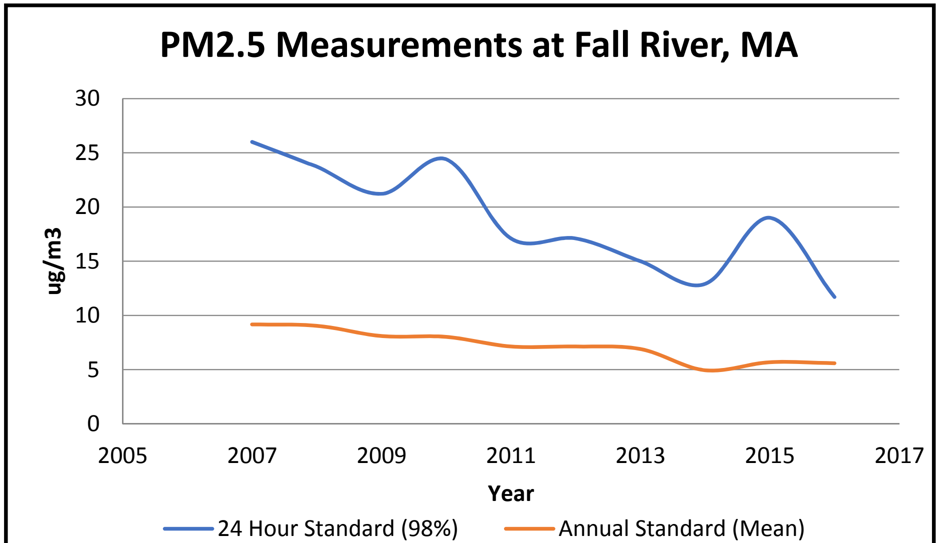
It is also possible that a Canadian port will be used. At this point in time, the Project may use a secondary port facility in Rhode Island for unloading, storing, and loading WTG components, as needed.

One of the basic goals of federal and state air regulations is to ensure that ambient air quality, including the impact of background, existing sources, and new sources, is in compliance with ambient standards. The Environmental Protection Agency ("EPA") has developed National Ambient Air Quality Standards ("NAAQS") for six air contaminants, known as criteria pollutants, for the protection of public health and welfare. The criteria pollutants are sulfur dioxide (SO_2); particulate matter (smaller than 10 microns as PM_{10}, smaller than 2.5 microns as $PM_{2.5}$); nitrogen dioxide (NO_2); carbon monoxide (CO); ozone (O_3); and lead (Pb). NAAQS have been developed for various durations of exposure and consist of primary and secondary standards. Primary standards are intended to protect human health. Secondary standards are intended to protect public welfare from known or anticipated adverse effects associated with the presence of air pollutants, such as damage to property or vegetation.

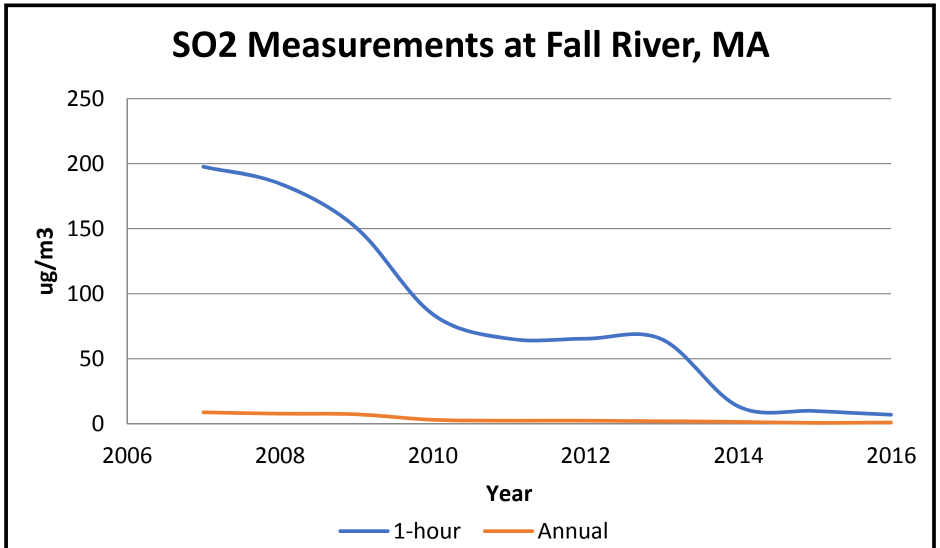
The Massachusetts Ambient Air Quality Standards ("MAAQS") at 310 C.M.R. § 6.00 also establish primary and secondary ambient air quality standards. MAAQS generally follow the EPA's NAAQS, but are not identical (see **bold** text in Table 5.1-1). The more stringent of either the NAAQS or MAAQS is used to document compliance with ambient air quality standards. Table 5.1-1 summarizes the standards as currently presented by the EPA and Massachusetts Department of Environmental Protection ("MassDEP"). The implementation of these standards has led to significant improvement in ambient air quality in Massachusetts. Figure 5.1-1 shows trends of measured ambient air concentrations of key pollutants at nearby monitoring stations, with an overall trend of improvement.

Table 5.1-1 National (NAAQS) and Massachusetts (MAAQS) Ambient Air Quality Standards

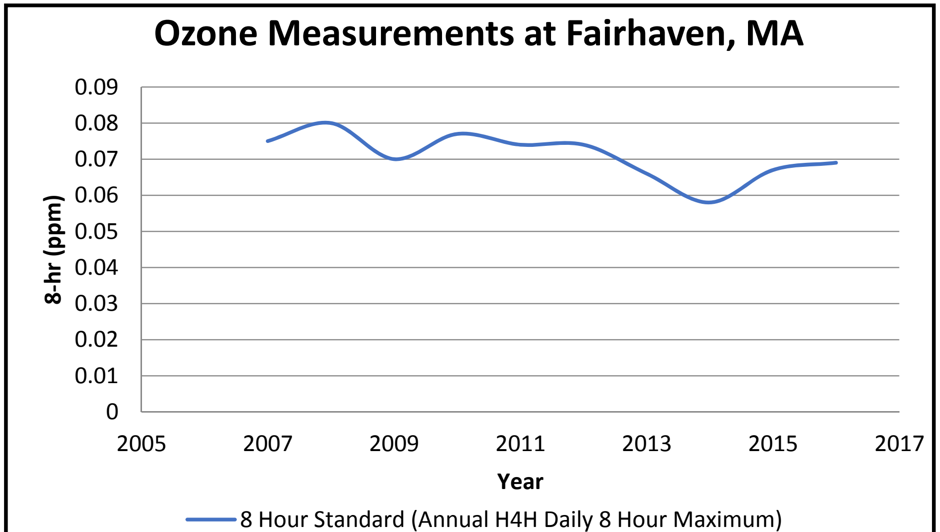
Pollutant	Averaging Period	NAAQS ($\mu g/m^3$)		MAAQS ($\mu g/m^3$)	
		Primary	Secondary	Primary	Secondary
NO_2	Annual (1)	100	Same	100	Same
	1-hour (2)	**188**	None	**None**	None
SO_2	Annual (1)(9)	80	None	80	None
	24-hour (3)(9)	365	None	365	None
	3-hour (3)	None	1300	None	1300
	1-hour (4)	**196**	None	**None**	None
$PM_{2.5}$	Annual (1)	**12**	**15**	**None**	**None**
	24-hour (5)	**35**	**Same**	**None**	**None**



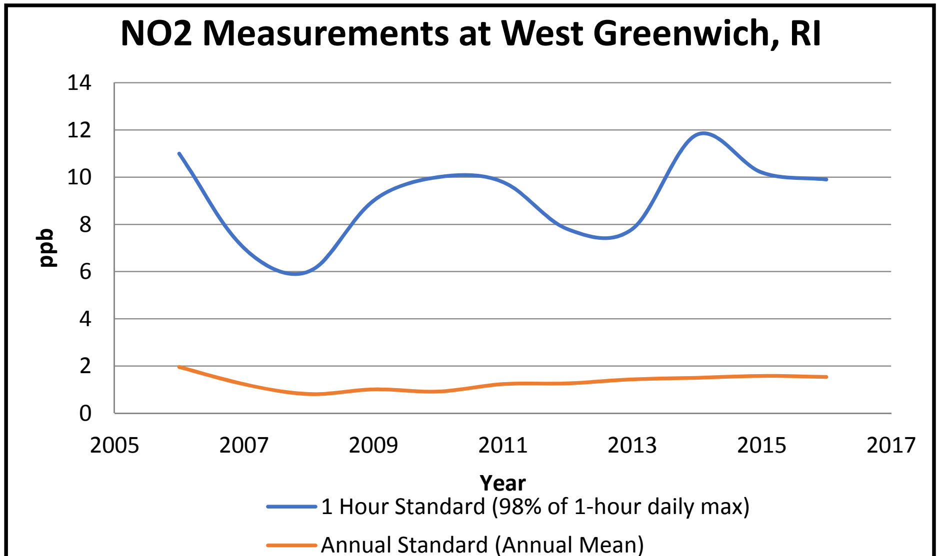
PM2.5 NAAQs: 35 ug/m3 (24-hour, 98th percentile averaged over 3 years) and 12 ug/m3 (Annual, not to be exceeded)



SO2 NAAQs: 196 ug/m3 (1-hour, 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years) and 12 ug/m3 (Annual, not to be exceeded)



Ozone NAAQs: 0.07 ppm (2008 EPA Ozone standard) (8-hour, Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years)



NO2 NAAQs: 100 ppb (1-hour, 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years) and 53 ppb (Annual, not to be exceeded)

Sources: MassDEP Annual Air Quality Reports and US EPA Annual Air Monitor Summary Data

Vineyard Wind

Epsilon ASSOCIATES INC.

Figure 5.1-1
Background Air Quality

Table 5.1-1 National (NAAQS) and Massachusetts (MAAQS) Ambient Air Quality Standards (Continued)

Pollutant	Averaging Period	NAAQS ($\mu g/m^3$) Primary	NAAQS ($\mu g/m^3$) Secondary	MAAQS ($\mu g/m^3$) Primary	MAAQS ($\mu g/m^3$) Secondary
PM_{10}	Annual (1)(6)	**None**	None	**50**	Same
	24-hour (3)(7)	150	Same	150	Same
CO	8-hour (3)	10,000	None	10,000	Same
	1-hour (3)	40,000	None	40,000	Same
O_3	8-hour (8)	**147**	Same	**235**	Same
Pb	3-month (1)	1.5	Same	1.5	Same

(1) Not to be exceeded.
(2) 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years.
(3) Not to be exceeded more than once per year.
(4) 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years.
(5) 98th percentile, averaged over 3 years.
(6) EPA revoked the annual PM_{10} NAAQS in 2006.
(7) Not to be exceeded more than once per year on average over 3 years.
(8) Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years.
(9) EPA revoked the annual and 24-hour SO_2 NAAQS in 2010. However, they remain in effect until one year after the area's initial attainment designation, unless designated as nonattainment.
Source: EPA. (2016). NAAQS Table. Retrieved from: https://www.epa.gov/criteria-air-pollutants/naaqs-table; Ambient Air Quality Standards for the Commonwealth of Massachusetts, 310 C.M.R. § 6.04

All areas of the country have been classified by the EPA as in *attainment*, *nonattainment*, or *unclassified* for the criteria pollutants listed in Table 5.1-1, above. An attainment area is defined as an area in compliance with all NAAQS. A nonattainment area is defined as an area that is not meeting NAAQS for one or more pollutants. An unclassified area is defined as an area that cannot be classified as meeting or not meeting NAAQS based on available information, but is treated as an attainment area. Additionally, if an area was in nonattainment within the last 20 years, but is currently in attainment or unclassified, the area is called a maintenance area. The official record of an area's attainment status can be found in Designation of Areas for Air Quality Planning Purposes, 40 C.F.R. Part 81. Revisions to 40 C.F.R. Part 81 are periodically published by the EPA in the Federal Register and made available in the EPA's Green book (EPA, 2017c). For coastal areas, the nonattainment or maintenance area boundary extends to the state's seaward boundary, which is three nautical miles for most states) (EPA, 2010).

At its nearest point, the Vineyard Wind Lease Area is just over 23 kilometers ("km") (14 miles) from the southeast corner of Martha's Vineyard, located in Dukes County. Dukes County, Barnstable County, Bristol County, Nantucket County are presently designated as unclassified, which is treated as attainment, or in attainment for five of the six criteria pollutants: SO_2, CO, PM (PM_{10} and $PM_{2.5}$), NO_2, and Pb (EPA, 2017c).

The entire Commonwealth of Massachusetts ("Commonwealth" or "Massachusetts") was formerly classified as in moderate nonattainment for ozone under the 1997 8-hour standard of 0.08 parts per million ("ppm"). This standard was replaced with a standard of 0.075 ppm, effective May 28, 2008. The entire Commonwealth, except for Dukes County, was classified as being in attainment with the 2008 8-hour ozone standard. The 1997 standard was officially revoked on April 6, 2015. As a result, the entire Commonwealth, except for Dukes County, is no longer considered an ozone maintenance area (EPA, 2017c). Effective December 28, 2015, the 8-hour ozone standard was further reduced to 0.07 ppm. Initial attainment designations for the 2015 standard were published by EPA on November 16, 2017 and became effective January 16, 2018. Because air quality in Massachusetts has improved, under the new designation, the entire Commonwealth, including Dukes County, is in attainment/unclassifiable with the stricter 2015 ozone standard. It is anticipated that EPA will issue a rulemaking to revoke the 2008 ozone standards effective one year after making the initial 2015 attainment designations, after which Dukes County would no longer be a nonattainment or maintenance area (EPA, 2015).

The New York-Northern New Jersey-Long Island, NY-NJ-CT Area, also known as the New York Metro Area, is comprised of the region surrounding New York City, Long Island, the southwestern portion of Connecticut, and the northern half of New Jersey. Areas within the New York Metro Area where Project emissions may occur include Fairfield County, Middlesex County, and New Haven County in Connecticut and Suffolk County in New York. The New York Metro Area is currently classified as being in moderate nonattainment with the 2008 8-hour ozone standard (EPA, 2017c). The New York Metro Area has not yet received an initial designation for the revised 2015 ozone standard. However, EPA intends to designate the New York Metro Area as nonattainment for the 2015 ozone standard (EPA, 2017b). The New York Metro Area will likely be designated as moderate nonattainment[7]. Depending on the ports used for the Project, air emissions will also occur in New London, which is within the Greater Connecticut Area. The Greater Connecticut area is currently designated as moderate nonattainment for the 2008 ozone NAAQS (EPA, 2017c). Although 2015 ozone standard attainment designations for the Greater Connecticut Area have not been published by EPA, the area is expected to be designated as marginal nonattainment with the 2015 ozone standard (EPA, 2017a).

[7] Proposed classifications for the 2015 ozone NAAQS of 0.070 ppm are provided in Table 1 – Subpart 2 of Federal Register Vol. 81, No. 222 (November 17, 2016). Based on the table, areas with an 8-hour ozone design value between 0.071 – 0.081 ppm would be classified as marginal and areas with a design value of 0.081 – 0.093 ppm would be classified as moderate. Since the highest 2014 – 2016 8-hour ozone design value for any county in the New York Metro Area is 0.083 ppm, the region is expected to be classified as moderate nonattainment. The highest 2014 – 2016 8-hour ozone design value for any county in the Greater Connecticut Area is 0.074; therefore, the region is expected to be classified as marginal nonattainment.

The entire State of Rhode Island is currently in attainment for all six criteria pollutants and does not include any maintenance areas (EPA, 2017c). Attainment designations for all counties where Project emissions may occur are summarized in Table 5.1-2. All counties potentially affected by the Project's air emissions are in attainment with the NAAQS for Pb, SO_2, and NO_2, which are not included in the following table.

Table 5.1-2 Air Quality Designations for Areas Where Project-Related Emissions May Occur

<table>
<tr><th>Area/County</th><th>2015 Ozone Standard</th><th>2008 8-Hour Ozone Standard</th><th>1997 & 2006 $PM_{2.5}$</th><th>1987 PM10 standard</th><th>1971 CO Standard</th></tr>
<tr><td>Barnstable, MA</td><td>Attainment</td><td>Attainment</td><td>Attainment</td><td>Attainment</td><td>Attainment</td></tr>
<tr><td>Bristol, MA</td><td>Attainment</td><td>Attainment</td><td>Attainment</td><td>Attainment</td><td>Attainment</td></tr>
<tr><td>Nantucket, MA</td><td>Attainment</td><td>Attainment</td><td>Attainment</td><td>Attainment</td><td>Attainment</td></tr>
<tr><td>Dukes, MA</td><td>Attainment</td><td>Dukes County Marginal Nonattainment Area</td><td>Attainment</td><td>Attainment</td><td>Attainment</td></tr>
<tr><td>Suffolk, NY</td><td rowspan="4">EPA Intends to Designate as New York Metro Nonattainment Area</td><td rowspan="4">New York Metro Moderate Nonattainment Area</td><td rowspan="3">New York-N. New Jersey-Long Island, NY-NJ-CT Maintenance Area</td><td>Attainment</td><td>Attainment</td></tr>
<tr><td>Fairfield, CT</td><td>Attainment</td><td>New York-N. New Jersey-Long Island, NY-NJ-CT / New Haven-Meriden-Waterbury, CT Maintenance Area</td></tr>
<tr><td>New Haven, CT</td><td>New Haven Maintenance Area</td><td>New Haven-Meriden-Waterbury, CT Maintenance Area</td></tr>
<tr><td>Middlesex, CT</td><td>Attainment</td><td>Attainment</td><td>Hartford-New Britain-Middletown, CT Maintenance Area</td></tr>
<tr><td>New London, CT</td><td>EPA Intends to Designate as Greater CT Nonattainment Area</td><td>Greater CT Moderate Nonattainment Area</td><td>Attainment</td><td>Attainment</td><td>Attainment</td></tr>
<tr><td>All Rhode Island Counties</td><td>Attainment</td><td>Attainment</td><td>Attainment</td><td>Attainment</td><td>Attainment</td></tr>
</table>

The Vineyard Wind Project is not the only offshore activity that could potentially impact ambient air quality in the region. Similar neighboring projects may also have impacts. Massachusetts's *Act to Promote Energy Diversity* requires the Commonwealth to procure cost-effective long-term contracts for 1,600 megawatts ("MW") of offshore wind energy within the next decade (Mass.Gov, 2016). Consequently, other companies may propose to construct offshore wind farms in response to the solicitation for an initial 800 MW of offshore wind issued by several Massachusetts electric distribution companies, in coordination with the Massachusetts Department of Energy Resources ("DOER"), on June 29, 2017 (DOER, 2017).

In addition to the impacts of neighboring offshore wind projects on ambient air quality, emissions from commercial marine vessel activity in US waters will continue to impact offshore ambient air quality. Table 5.1-3 shows the tons of NO_x, PM_{10}, $PM_{2.5}$, SO_2, and volatile organic compounds ("VOC") emitted by commercial marine vessels in US waters in 2014, according to EPA's 2014 National Emissions Inventory.[8]

Table 5.1-3 Total Emissions from US Commercial Marine Traffic, 2014

Pollutant	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC
Total Emissions (tons)	1,215,718	36,614	34,735	167,058	36,654

During the peak year of construction, offshore emissions associated with the Project are expected to be less than 0.32% of the total emissions from commercial marine vessel activity in US waters for any of the above pollutants. Additionally, during operation, the Vineyard Wind Project would provide ~ 800 MW of zero-emission electricity that would displace electricity from conventional power generation thereby resulting in a significant reduction in regional emissions (see table 5.1-7, below).

5.1.2 Potential Impacts of the Project

While the proposed wind turbines do not generate air emissions, there will be air emissions from Project construction, and subsequent operations, maintenance and decommissioning activities.

Some air emissions from the Project are regulated through the EPA's OCS Air Permit process under the Outer Continental Shelf Air Regulations, 40 C.F.R. Part 55. This regulation establishes air pollution control requirements for OCS sources (i.e., stationary sources and vessels directly or indirectly attached to the seabed) located within 25 miles of a state's seaward boundaries. Air emission estimates in the OCS Air Permit application must include emissions from OCS sources and vessels traveling in and around the Project Area when within 25 miles of an OCS source.

The potential direct and indirect impacts of the Project on air quality during construction, operations and maintenance, and decommissioning are summarized in Table 5.1-4. The actions that have the potential to emit air pollutants during the Project are discussed in more detail in the following sections. The following sections also quantify the direct emissions subject to the OCS Air Permitting Program during construction and O&M.

[8] Based on EPA's *2014 National Emissions Inventory, Version 1 Technical Support Document* (December 2016), Table 4-115. US waters include the waters of the 50 states, Puerto Rico, and US Virgin Islands (out to 200 nautical miles from the US coastline).

Table 5.1-4 Impact-producing Factors for Air Quality

Impact-Producing Factors	Wind Development Area	Offshore Export Cable Corridor	Onshore Export Cable Route and Onshore Facilities	Construction Staging Areas	Construction & Installation	Operations & Maintenance	Decommissioning
Onshore substation installation			x	x	x		
Installation of duct bank and vaults			x	x	x		
Cable pulling			x	x	x		
Horizontal directional drilling		x	x	x	x		
Scour protection installation	x	x		x	x		
Offshore cable installation	x	x		x	x		
Transport of WTGs, ESPs, and foundations	x			x	x		
ESP and WTG installation	x			x	x		
WTG and ESP commissioning	x			x	x		
Scour protection repairs	x			x		x	
Foundation maintenance and repairs	x			x		x	
WTG maintenance and repairs	x			x		x	
WTG and ESP inspections	x			x		x	
Onshore substation and vault inspections			x	x		x	
Offshore cable removal	x						x
WTG and ESP removal	x			x			x
Onshore export cable removal			x	x			x

5.1.2.1 Construction and Installation

5.1.2.1.1 Description of Potential Impacts

The majority of air emissions from the Project will come from the main engines, auxiliary engines, and auxiliary equipment on marine vessels used during construction activities. Emissions from marine vessel engines will occur while vessels maneuver within the WDA, during installation of the offshore export cables, during vessel transit to and from port, and while vessels are in port.

During construction, heavy lift vessels, tugboats, barges, and jack-up vessels will be used to transport the wind turbine generators ("WTG"), monopiles, transition pieces, and electrical service platforms ("ESP") components to the WDA. Installation of the WTGs, monopiles, transition pieces, and ESPs is expected to be performed using a combination of jack-up vessels and dynamically positioned ("DP") crane vessels. It is anticipated that scour protection will be installed around the WTG and ESP foundations and cable protection will be placed over limited sections of the offshore cable system using specialized rock-dumping or other vessels. Cable-laying is expected to be performed by specialized cable-laying vessels. Prior to cable-laying, a pre-lay grapnel run will be made by multipurpose offshore support vessels to locate and clear obstructions such as abandoned fishing gear and other marine debris from the Offshore Export Cable Corridor. To achieve proper cable burial depth, a specialized dredging vessel may also be used in certain areas prior to cable laying to remove the upper portions of sand waves. Crew transfer vessels and helicopters are expected to be used to transport personnel to and from the WDA and may be used for marine mammal observations.

Additional offshore construction-related emissions will come from diesel generators used to temporarily supply power to the WTGs and ESPs so that workers can power up lights, controls, and other equipment before cabling is in place. There will also be emissions from engines used to power pile driving hammers and air compressors used to supply compressed air to noise mitigation devices (e.g. bubble curtains) during pile driving.

Emission sources used during offshore construction include:

- Crew transfer/service vessels
- Heavy lift crane vessels
- Heavy cargo vessels
- Cable installation vessels
- Scour protection installation vessels
- Multipurpose support vessels
- Tugboats
- Anchor handling tug supply vessels
- Jack-up vessels

- Dredging vessels
- Survey Vessels
- Temporary diesel generators
- Air Compressors
- Pile driving hammer engines
- Helicopters
- Fugitive emissions of solvents, paints, coatings, and diesel fuel storage/transfer

Emission sources from onshore construction activities will include non-road equipment and vehicles used during the unloading and loading of equipment at the construction staging areas, horizontal directional drilling, installation of the onshore export cable, and construction of the onshore substation. Onshore emission sources include:

- Non-road construction and mining equipment, such as backhoes, bore/drill rigs, compactors, concrete trucks, concrete saws, cranes, excavators, forklifts, graders, light plants, off-highway trucks, and pavers
- Non-road commercial equipment, including generators, pumps, and welders
- Non-road industrial equipment, such as AC units and aerial lifts
- Worker vehicles
- Delivery and heavy-duty vehicles
- Fugitive emissions from incidental solvent release
- Particulate emissions from construction dust

A more detailed description of offshore and onshore construction activities can be found in Sections 3.1, 3.2, 4.1, and 4.2 of Volume I.

The estimate of the Project's potential construction emissions in terms of tons per year is shown in Table 5.1-5, below. The estimate of the Project's potential air emissions was conducted assuming that 106 WTG positions, four light-weight ESPs, and the maximum length of inter-array, inter-link, and export cables would be installed for the 800 MW Project, which represents the maximum design scenario.[4] Based on the most aggressive construction schedule under consideration for the 800 MW Project, it was conservatively estimated that half of the WTGs, three quarters of the inter-array cables, and all of the scour protection, offshore export and inter-link cables, electrical service platforms, and foundations could be constructed in one year[9]. It was also conservatively assumed that all

9 Several refinements to the Project Envelope and schedule have been made since conducting this estimate of the Project's potential emissions. For example, the Project will only install up 100 WTGs and has eliminated the option to install light-weight ESPs. The Project's Outer Continental Shelf (OCS) Air Permit application, which was submitted to EPA on August 17, 2018 after conducting this air emissions analysis, incorporates these refinements to the Project Envelope. Further minor refinements to the construction period air emissions estimate are expected through the EPA review process.

onshore construction could be completed in one year. To account for the envelope of possible ports used during construction, the emission estimate uses the combination of ports with the longest transit distances to and from the Offshore Project Area within US waters (all state and federal waters within the 200 NM US Exclusive Economic Zone). The emissions estimate also accounts for delays caused by inclement weather and possible time of year restrictions.

Construction-related air emissions are associated with fuel combustion and some incidental solvent use. The air pollutants include NO_x, SO_2, CO, PM_{10}, $PM_{2.5}$, VOCs, greenhouse gas emissions as carbon dioxide equivalent (CO_{2e}), and total hazardous air pollutants ("HAPs", individual compounds are either VOC or particulate matter). Table 5.1-5 quantifies the maximum air emissions that could occur within the US in one year during construction.

Table 5.1-5 Maximum Air Emissions During Construction

Activity	CO_{2e}	NO_x	SO_2	VOC	CO	PM_{10}	$PM_{2.5}$	HAPs
OCS Air Permit Emissions (tons/year)	205,780	3,269	32.1	87	699	109	104	7.3
All Construction Emissions (tons/year)	262,461	4,070	35.6	105	899	143	138	10.0

A complete description of all emission points associated with the construction of Vineyard Wind's 800MW offshore wind project including engine sizes, hours of operation, load factors, emission factors, and fuel consumption rates, along with a description the air emission calculation methodology is provided in Appendix III-B.

During construction, indirect impacts to air quality may result from the activities of additional workers, increased traffic congestion, additional commuting miles for construction personnel, and increased air-polluting activities of supporting businesses. For example, the Project's demand for scour protection rock may increase the rate of quarrying and therefore increase air emissions at a rock quarry. These indirect impacts are no different than the air quality impacts that would result from any other project providing economic development by building infrastructure.

5.1.2.1.2 Avoidance, Minimization, and Mitigation Measures

The Project avoids, minimizes, and mitigates air quality impacts to the extent feasible. The Project itself is an air quality impact avoidance measure, as the electricity generated by the wind turbines will displace electricity generated by fossil fuel power plants and avoid the air quality impacts resulting from those fossil fuel power plants. Air emissions from the construction and installation, operations and maintenance, and decommissioning of the Project will be minimized through the use of low sulfur fuels, limited engine idling time, and through the use of internal combustion engines designed and operated to minimize the formation of air pollutants. Some emissions from internal combustion engines will be mitigated by post-combustion catalysts and filters. Some NO_x and VOC emissions from the Project will be mitigated through purchasing and retiring Emission Reduction Credits ("ERC"), if required. ERCs are a type of pollution credits generated by controlling existing NO_x and VOC sources beyond regulatory requirements. These credits can then be sold to projects in the same air quality region to offset emissions.

Avoidance Measures

Emissions of regulated pollutants during construction are temporary and will be quickly offset by emissions reductions on the New England power grid during the operational period. SO_2 and CO_2 emissions from construction activities will be offset within the first year of operation. NO_x emissions from construction will be offset within approximately five years of beginning operation. The avoided emissions are discussed below in Section 5.1.2.2.

Minimization Measures

Project-related emissions are primarily from internal combustion engines. These include marine diesel, non-road diesel, transportation diesel, stationary diesel, and helicopter engines. While the specifics vary by engine type, emissions are generally minimized by ensuring complete combustion to avoid formation of CO, PM, and VOC, and by controlling mixing of fuel and oxygen in the combustion process to avoid hot spots that generate NO_x. Engine manufacturers will optimize the combustion process to avoid incomplete combustion and hot spots. For example, marine engine optimization steps, which will differ from engine to engine, can include changes to "fuel injection timing, pressure, and rate (i.e., rate shaping), fuel nozzle flow area, exhaust valve timing, and cylinder compression volume" (International, 2016). Controls can also include the use of water injection and exhaust gas recirculation to cool the combustion temperature.

The Project will minimize sulfur and particulate emissions through the use of clean, low-sulfur fuels in compliance with the air pollution requirements detailed in this section. Annex VI of the MARPOL treaty is the main international treaty that addresses air pollution from marine vessels. In the US., MARPOL Annex VI is implemented through the Act to Prevent Pollution from Ships, 33 U.S.C. §§ 1901-1905 and Control of NO_x, SO_x, and PM Emission from Marine Engines and Vessels Subject to the MARPOL Protocol, 40 C.F.R. Part 1043. Under MARPOL Annex VI and EPA's corresponding regulations, any foreign vessel used during the Project will comply with the fuel oil sulfur content limit of 1,000 ppm. All domestic vessels will comply with the marine fuel oil sulfur limits under Regulations of

Fuels and Fuel Additives, 40 C.F.R. Part 80.[10] All non-road engines will comply with the non-road diesel fuel sulfur limit of 15 ppm under 40 C.F.R Part 80. Per Air Pollution Control, 310 C.M.R § 7.00, applicable stationary engines will comply with the fuel sulfur limits of 15 ppm under 40 C.F.R. Parts 80.29, 80.500, and 80.520 (a) and (b).

The engines and generators used in this Project will be certified by the manufacturer to comply with applicable on-road, non-road, and marine engine emission standards. Applicable marine engine standards include:

- MARPOL Annex VI for foreign vessels;
- Control of Emissions from New and In-Use Nonroad Compression-Ignition Engines, 40 C.F.R. Part 89, for Tier 1 and 2 domestic marine diesel engines below 37 kilowatts ("kW") (~50 horsepower);
- Control of Emissions from Marine Compression-Ignition Engines, 40 C.F.R. Part 94, for Tier 1 and 2 domestic marine diesel engines over 37 kW; and
- Control of Emissions from New and In-Use Marine Compression-Ignition Engines and Vessels, 40 C.F.R. Part 1042, for Tier 3 and 4 domestic marine diesel engines.

To the extent practicable, non-road engines will be certified as meeting emission standards (i.e., Tier 4) under Control of Emissions from New and In-Use Nonroad Compression-Ignition Engines, 40 C.F.R. Part 1039.

Under the OCS Air Regulations, OCS sources located within the Offshore Project Area are subject to the federal, state, and local requirements of the Corresponding Onshore Area ("COA") set forth in 40 C.F.R. Parts 55.13 and 55.14. Vineyard Wind submitted a Notice of Intent (NOI) for the Project to EPA Region 1, MassDEP, RI DEM Office of Air Resources, and NH DES Air Resources Division on December 11, 2017. A copy of the NOI can be found in Appendix III-B. In the NOI, Vineyard Wind identified Massachusetts as the nearest onshore area (NOA) to the Project Area. EPA did not receive a request from any neighboring state air pollution control agencies to be designated as the COA within the 60-day period allotted in 40 CFR Part 55.5(b)(l). As a result, Massachusetts (the NOA) became the designated COA without further Agency action after 90 days (see 40 CFR Part 55.5(c)(l)). Therefore, the Project's OCS sources will be required to comply with the applicable Massachusetts air quality regulations, which include Best Available Control Technology ("BACT") and Lowest Achievable Emission Rate ("LAER") under 310 CMR § 7.00.

10 As of June 1, 2012, under 40 C.F.R. Part 80 Subpart I, all domestic non-road, locomotive, or marine ("NRLM") diesel fuel must have a sulfur content of less than 15 ppm. NRLM diesel fuel does not include heavier residual fuel oils used in Category 2 and Category 3 marine diesel engines or ECA marine fuel (i.e., any fuel oil used in Category 3 marine engines while operating in an emission control area).

The Project's emergency generators will comply with the performance standards of New Source Performance Standards Subpart IIII (Standards of Performance for Stationary Compression Ignition Internal Combustion Engines, 40 C.F.R. Part 60).

Emissions from on-road vehicles will be further minimized by limiting idling to five minutes except when engine power is necessary for the delivery of materials or to operate accessories to the vehicle, such as power lifts, in accordance with Massachusetts' anti-idling law (M.G.L. c. 90, § 16A; M.G.L.c. 111, §§ 142A–142M; 310 C.M.R. § 7.11). Particulate emissions from construction activities will be minimized by removing waste in covered trailers, wetting exposed soils, and minimizing the storage of construction waste onsite.

Mitigation Measures

Engine manufacturers use minimization and mitigation techniques specific to their engine type to ensure compliance with air quality regulatory standards. Depending on the engine's age, type, and size, add-on pollution controls are one approach used to mitigate air emissions formed in the combustion process. For example, selective catalytic reduction reverses the NO_x formation reaction, returning NO_x to nitrogen and water in the presence of a catalyst. Oxidation catalysts can also be used to eliminate products of incomplete combustion (e.g., CO, VOC, and PM) using technology similar to the catalytic converter found in automobiles. A diesel particulate filter can remove PM from some engine exhausts. Vineyard Wind's OCS Air Permit will contain, at a minimum, requirements for emission controls, emission limitations, monitoring, testing, and reporting. Additionally, through the OCS Air Permit Process, the Project will offset applicable NO_x and VOC emissions by purchasing ERCs in compliance with the Nonattainment New Source Review, if required.

The General Conformity Rule, codified in 40 C.F.R. Part 93 Subpart B and 40 C.F.R. Part 51 Subpart W, ensures that federal actions do not interfere with states' plans to attain and maintain National Ambient Air Quality Standards in areas that are or have been out of attainment with those standards. Before determining whether the General Conformity Rule is applicable, BOEM must first estimate emissions from the Project. BOEM's estimate will not include emissions that are already accounted for in the OCS Air Permit. General Conformity air emissions will only include direct and indirect emissions from the Project that occur beyond 25 miles from an OCS source *and* within a maintenance or nonattainment area.

If construction emissions within a nonattainment or maintenance areas are below certain *de minimis* thresholds, a General Conformity determination is not required for that area. For all ozone nonattainment or maintenance areas potentially affected by the Project (see Table 5.1-2), the NOx and VOC de minimis thresholds are 100 tpy and 50 tpy, respectively. For CO and PM_{10} maintenance areas, the CO and PM_{10} de minimis thresholds are both 100 tpy. For $PM_{2.5}$ maintenance areas, the $PM_{2.5}$, SO_2, NOx, and VOC thresholds are all 100 tpy.

Regardless of the combination of ports used for the Project, the emissions from the construction of the Project will not exceed de minimis thresholds for VOC, $PM_{2.5}$, SO_2, or CO. However, NOx emissions during construction may require a General Conformity determination for Dukes County or the New York Metro Area as shown in Table 5.1-6 below. See Appendix III-B for more detailed General Conformity calculations.

Table 5.1-6 Maximum NOx Emissions During Construction (tpy)

Port Scenarios	NOx Emissions During Construction (tpy)		
	Dukes County, MA	New York Metro Area	Greater Connecticut
New Bedford Terminal, exclusively	**219**	0	0
New Bedford Terminal (primary) & Bridgeport (limited use)	**204**	98	0
New Bedford Terminal (primary) & New London (limited use)	**204**	13	30

A General Conformity Determination will likely be required for Duke's County since NOx emissions exceed the de minimis threshold during the most intense year of construction. A General Conformity determination would only be required for the New York Metro Area if the Project uses Bridgeport as a construction staging area. If BOEM determines that a General Conformity determination is required, Vineyard Wind may purchase additional NO_x ERCs to further mitigate NO_x emissions.

5.1.2.1.3 Summary

As described in Section 5.1.2.1.1, the majority of air emissions from the Project will come from the engines on marine vessels used during construction and will occur within the WDA. These air emissions will be minimized through the use of low sulfur fuels, limited engine idling time, and through the use of internal combustion engines that are in compliance with applicable air quality regulatory standards. Since the WDA is approximately 23 km (14 miles) offshore, to the southeast of the mainland, and prevailing winds are from the west, the emissions within the WDA are unlikely to have any effect on onshore areas. Construction vessel activities within the port(s) are within the realm of normal harbor activities and will likely contribute only a small fraction of air pollution that is already caused by marine vessel traffic within the port(s). Further, both onshore and offshore construction emissions will be temporary. Finally, the Project's impacts will be minimized and mitigated through the OCS Air Permit process and potentially through the General Conformity process.

Since Massachusetts was designated as the COA per 40 C.F.R. § 55.5, emissions from OCS sources during construction will need to meet applicable Massachusetts BACT and LAER limits and will need to offset NO_x and VOC emissions through the use of ERCs. Since the Project will meet BACT and LAER and offset NOx and VOC emissions by purchasing ERCs, the Project will provide a net air quality benefit.

5.1.2.2 Operations and Maintenance

5.1.2.2.1 Description of Impacts

During the Project's up to 30-year operational period, crew transfer vessels and helicopters will transport crew to the Offshore Project Area for inspections, routine maintenance, and repairs. Jack-up vessels, multipurpose offshore support vessels, and rock-dumping vessels will travel to the Offshore Project Area infrequently for significant maintenance and repairs. Emergency generators located on the WTGs and ESPs will only operate during emergencies and reliability testing. Onshore operations and maintenance activities will include occasional inspections and repairs to the onshore substation and splice vaults, which will require minimal use of worker vehicles and construction equipment. Vineyard Wind intends to use port facilities at both Vineyard Haven on Martha's Vineyard and the New Bedford Terminal to support O&M activities. Smaller vessels used for O&M activities will likely be based out of Vineyard Haven. Larger vessels used for major repairs during O&M (e.g. jack-up vessels, heavy cargo vessels, etc.) would likely use the New Bedford Terminal. Emission sources during the operational period may include:

- Crew transfer/service vessels
- Scour protection installation vessels
- Multipurpose offshore support vessels
- Tugboats
- Jack-up vessels
- Heavy cargo vessels
- Survey vessels
- Emergency generators
- Helicopters
- Non-road construction equipment
- Worker and delivery vehicles
- Fugitive emissions of solvents, paints, coatings, diesel fuel storage/transfer, and sulfur hexafluoride ("SF_6")

A more detailed description of offshore and onshore operations and maintenance activities can be found in Section 4.3 of Volume I. A detailed description of all emission points associated with operations and maintenance of the Project including engine sizes, hours of operation, load factors, emission factors, and fuel consumption rates, along with a description the air emission calculation methodology is provided in Appendix III-B. Table 5.1-7 quantifies the maximum annual air emissions that could occur in one year within US waters during operations and maintenance, assuming a 30-year lifespan. To account for the envelope of ports used during O&M, O&M emissions were estimated assuming all vessels use the New Bedford Terminal, which represents the port with the farthest transit distances to and from the Offshore Project Area that may be used during O&M.

Table 5.1-7 Air Emissions During Operations and Maintenance (O&M)

Activity	CO_{2e}	NO_x	SO2	VOC	CO	PM_{10}	$PM_{2.5}$	HAPs
OCS Air Permit Emissions (tons/year) [11]	5,282	47.2	0.28	1.6	12	1.6	1.5	0.9
All O&M Emissions	8,047	70.8	0.30	2.0	18	2.4	2.3	1.1

The WTGs for this Project will be among the most efficient machines currently demonstrated for offshore use, with an annual capacity factor in excess of 45%. Table 5.1-8 quantifies the emissions associated with conventional power generation that would be avoided by using electricity generated from the 800 MW Project over the Project's up to 30-year lifespan. The displacement analysis uses Northeast Power Coordinating Council New England air emissions data from EPA's Emissions & Generation Resource Integrated Database (eGRID)[12]. The constituents included in the analysis are nitrogen oxides (NO_x), sulfur dioxide (SO_2), and carbon dioxide (CO_2). The methodology used to calculate the air emissions that will be avoided as a result of the Project is described in more detail in Appendix III-B.

Table 5.1-8 Avoided Air Emissions in New England

Pollutant	CO_2	NO_x	SO_2
Annual Avoided Emissions (tons/year)	1,632,822	1,046	855
Avoided Emissions over Project Lifespan (tons)	48,984,670	31,385	25,641

Based on 2015 emissions data from ISO New England (2017), the Project would displace 4% of CO_2 emissions, 6% of NO_x emissions, and 9% of SO_2 emissions produced by New England's electric grid annually.

As shown in this analysis, the Project would result in vastly lower emissions in the New England region. In addition, the Project would decrease the regional reliance on fossil fuels and enhance the reliability and diversity of the energy mix on Cape Cod and in the Commonwealth of Massachusetts. This is particularly important given that several thermal baseload and cycling plants have already retired, are slated for retirement, or are

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11 The Project's OCS Air Permit application, which was submitted to EPA on August 17, 2018 after conducting this air emissions analysis, reflects refinements to the emission estimates based on minor updates to the planned vessel use during O&M activities. Further minor refinements to the O&M air emissions estimate are expected through the EPA review process.

12 The displacement analysis uses subregion annual non-baseload output emission rates from eGRID2014(v2) released 2/27/2017 https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

approaching the end of life. According to ISO New England (2017), 1,050 MW of coal, 567 MW of residual oil, and 604 MW of nuclear-fired power generation facilities retired between 2011 and 2015.

5.1.2.2.2 Avoidance, Minimization, and Mitigation Measures

Avoidance, minimization, and mitigation techniques that are employed during the construction of the Project described in Section 5.1.2.1, above, will also be used to minimize air emissions during operations and maintenance.

Equipment at the onshore substation will meet the applicable requirements of 310 CMR 7.72. Per the regulation, "this type of switchgear is pre-charged with SF_6, sealed at the factory, and cannot be refilled by its user." Emissions will be certified by the manufacturer to have a 1.0% maximum annual leak rate, and Vineyard Wind will follow manufacturer-recommended maintenance procedures and best industry practices to avoid leakage. Upon equipment removal, Vineyard Wind will be responsible for the secure storage, reuse, recycling, or destruction of the SF_6. Vineyard Wind expects little to no leakage of SF_6, based on the purchase and maintenance of equipment with leakage guarantees.

5.1.2.2.3 Summary

Air emissions from operations and maintenance of the Project will be significantly less than emissions from construction. As with construction air emissions, emissions from operations and maintenance activities will be minimized through the use of low sulfur fuels, limited engine idling time, and through the use of internal combustion engines that are in compliance with applicable air quality regulatory standards. Vessel activities within the port(s) during O&M will be well within the realm of normal harbor activities and will likely contribute only a small fraction of air pollution that is already caused by marine vessel traffic within the port(s). Furthermore, any air emissions during O&M will be quickly offset by reductions in emissions from higher-polluting conventional power generation facilities. Consequently, it is not anticipated that emissions from the Project during O&M will cause any violation of Massachusetts or National Ambient Air Quality Standards. Rather, by displacing emissions from higher-polluting power generation facilities, the Project should aid in the continued improvement of ambient air quality within the New England Region.

5.1.2.3 Decommissioning

5.1.2.3.1 Description of Impacts

As described in Section 4.4 of Volume I, the decommissioning processes will be largely the reverse of the installation process. As a result, the impacts of decommissioning on air quality will resemble the impacts produced during construction. During decommissioning, commercial marine vessels will be used to remove the offshore cable system, WTGs, ESPs, foundations, and scour protection. It is anticipated that equipment and vessels used for decommissioning will be similar to those used during construction, but will likely have lower-polluting engines (historically, emission standards for marine vessels have become increasingly stringent over time). For offshore work, emission sources will likely include:

- Crew transfer/service vessels
- Heavy lift crane vessels
- Cable laying vessels
- Multipurpose offshore support vessels
- Tugboats
- Anchor handling tug supply vessels
- Jack-up vessels
- Generators
- Helicopters

For onshore decommissioning activities, removal of onshore export cables from the duct bank would be performed using truck mounted winches, cable reels, and cable reel transport trucks. The concrete encased duct bank and splice vaults may be left in place for future reuse as would elements of the onshore substation and grid connections. Consequently, onshore decommissioning emissions will be significantly less than onshore construction emissions.

Potential emissions from decommissioning, which is expected to take place in approximately 30 years, were not quantified or included in the estimate of potential emissions generated for the OCS Air Permit program because a separate OCS Air Permit will be issued for decommissioning, if needed. Nevertheless, Vineyard Wind anticipates that emissions during decommissioning will be significantly less than emissions during the Project's construction.

5.1.2.3.2 Avoidance, Minimization, and Mitigation Measures

Avoidance, minimization, and mitigation techniques that are employed during the construction of the Project described in Section 5.1.2.1, above, will also be used during the Project's decommissioning.

5.2 Water Quality

This section discusses water quality in the Offshore Project Area. The area consists of Nantucket Sound, which is located between the south coast of Cape Cod and Martha's Vineyard and Nantucket Island, and the area south of both islands where both the Offshore Export Cable Corridor ("OECC") and the Wind Development Area ("WDA") are located (see Figures 2.1-1 and 2.2-1 in Volume I). Information sources consulted on existing water quality include publicly available resources for the marine waters. The section also includes a discussion of potential impacts of various aspects of the Project to marine water quality.

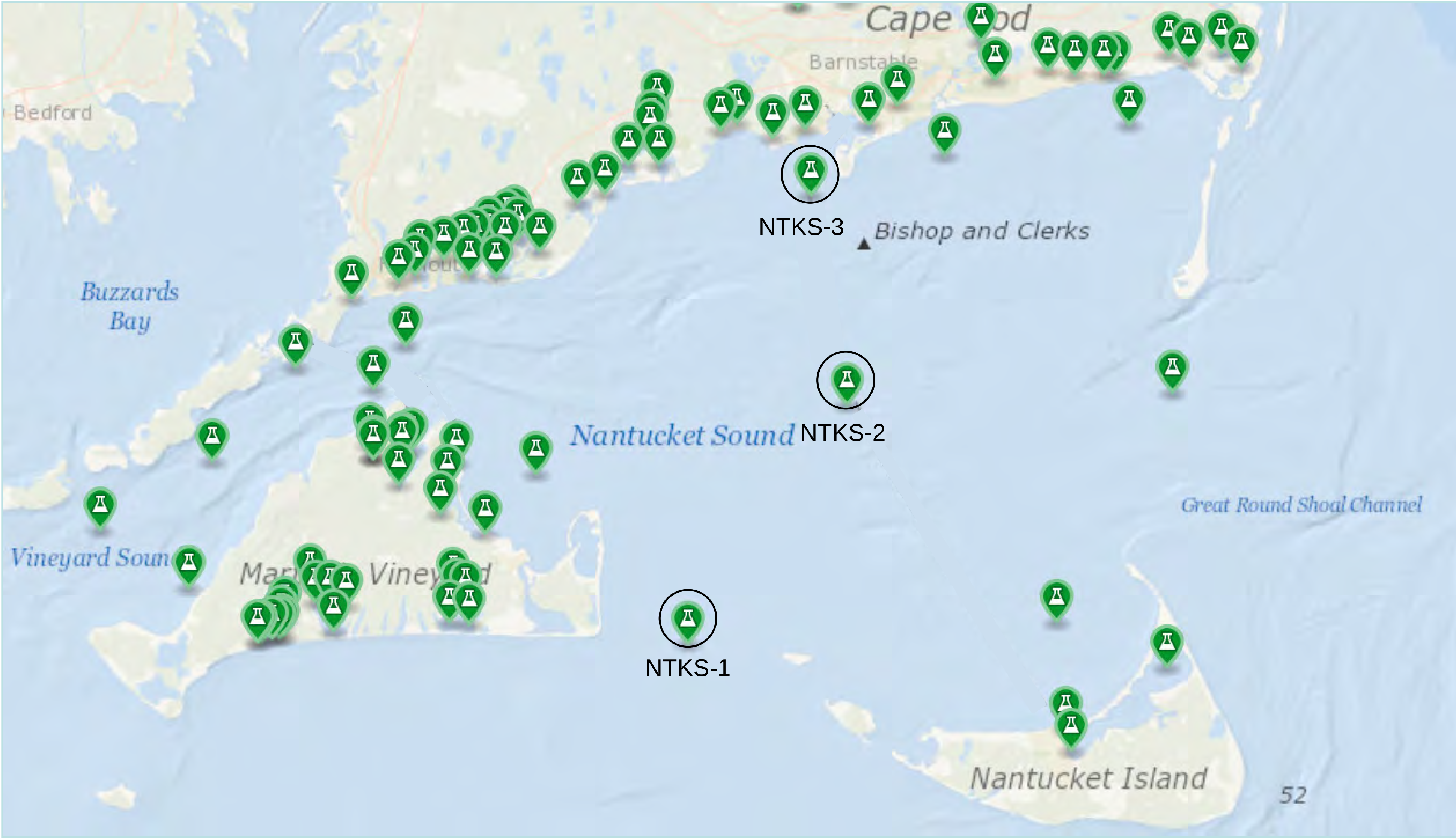
5.2.1 Description of the Affected Environment

Water quality generally refers to the physical, chemical, and biological attributes of water. For the purposes of this section, water quality specifically refers to the ability of waters in the southern New England coastal and shelf areas to maintain their ecosystems. Factors such as pollutant loading from both natural and anthropogenic sources can contribute to changes in water quality, which are usually detrimental. Natural pollutants can be delivered into water systems via atmospheric deposition, freshwater drainage, transport of offsite marine waters, and influx from sediments. Anthropogenic pollutant sources often include those from direct discharges, runoff, dumping, seabed activities, and spills.

For the offshore area south of Martha's Vineyard and Nantucket, known as the outer continental shelf ("OCS"), oceanic circulation (see Section 5.3) patterns play an increasingly larger role in transporting and dispersing anthropogenic contaminants and determining water quality. Water quality data available for coastal and offshore marine waters include temperature expressed in degrees Celsius ("°C") (degrees Fahrenheit ["°F"]), salinity expressed in Practical Salinity Units ("psu"), chlorophyll *a* expressed as microgram per liter ("µg/L"), nutrients expressed micromolar ("µm"), dissolved oxygen expressed as milligram per liter ("mg/L"), and turbidity expressed as Nephelometric Turbidity Unit ("NTU").

Water Quality Data Sources

One of the major water quality data sets available for Nantucket Sound, as well as Cape Cod Bay to the north, is that from the Center for Coastal Studies ("CCS") (CCS, 2017). Sampling is performed through a collaboration of CCS with volunteer citizen scientists and partnering organizations. The sampling stations for Nantucket Sound are shown in Figure 5.2-1. Of particular interest are the set of three offshore stations extending from south to north in the area of the OECC and shown circled and labeled as NTKS-1, NTKS-2, and NTKS-3. The data for these stations included over 60 sampling times between 2010 and 2016. The minimum, mean, and maximum parameter values are shown in Table 5-2.1. The individual parameters will be discussed below.



Vineyard Wind Project

VINEYARD WIND

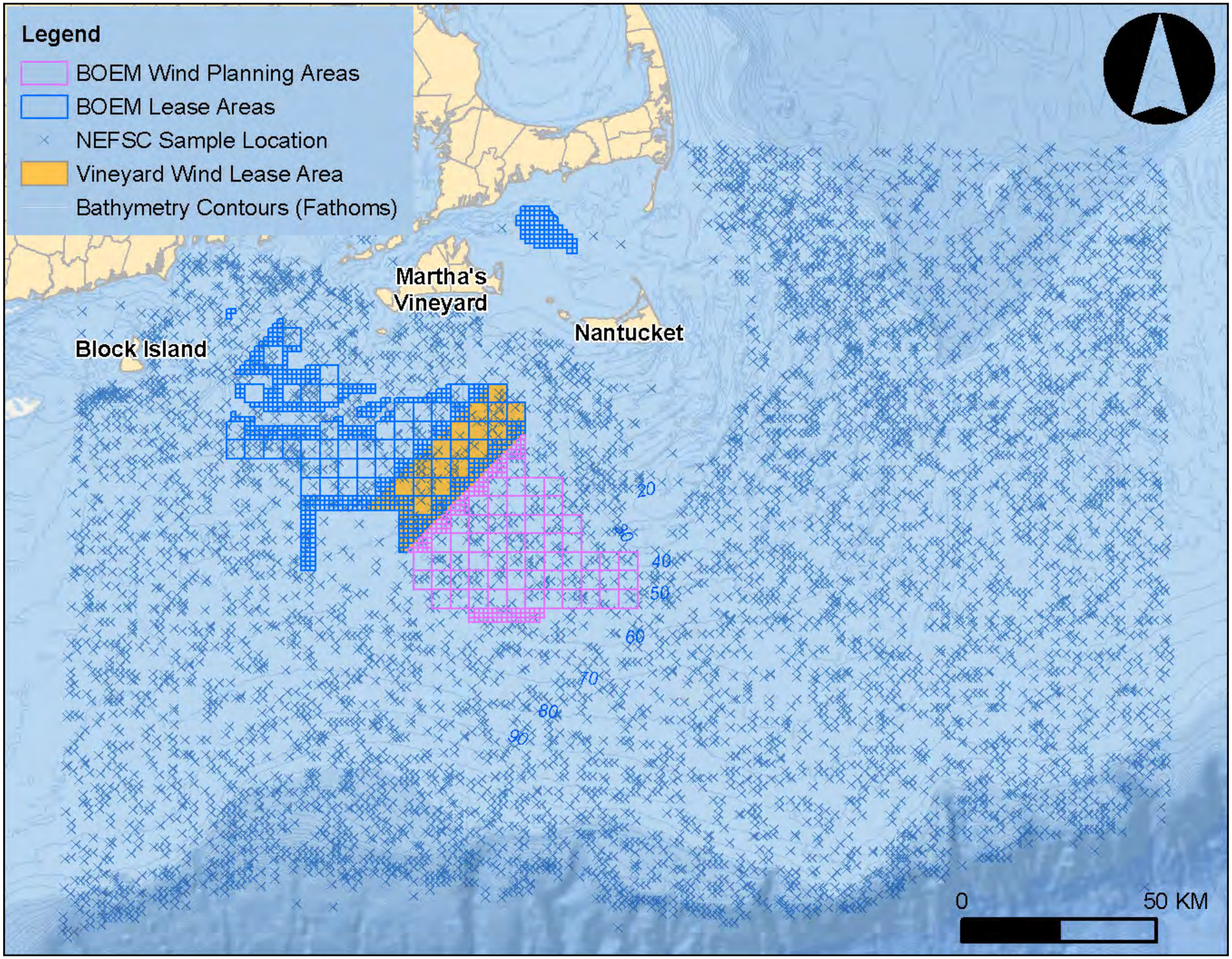
Figure 5.2-1

Locations of Water Quality Data Used from Center for Coastal Studies Stations (Circled)

Table 5.2-1 Minimum, Mean, and Maximum Values of Water Quality Parameters Reported in Nantucket Sound by the CCS for the period 2010-2016

Parameter	Value	Station NTKS_1 (South)	Station NTKS_6 (Central)	Station NTKS_13 (North)
Temperature (°C)	Min	8.70	8.15	9.87
	Mean	17.95	19.21	20.36
	Max	22.76	24.23	26.31
Salinity (psu)	Min	30.72	30.71	30.56
	Mean	31.75	31.76	31.60
	Max	32.71	32.51	32.49
Dissolved Oxygen [DO] (mg/L)	Min	6.89	6.39	5.37
	Mean	8.00	7.59	7.32
	Max	9.63	11.39	8.75
Chlorophyll *a* (mg/L)	Min	0.45	0.23	0.59
	Mean	1.79	1.93	1.81
	Max	4.73	4.80	4.33
Turbidity (NTU)	Min	0.09	0.09	0.13
	Mean	0.66	0.70	0.58
	Max	3.17	2.27	2.19
Total Nitrogen (µm)	Min	4.438	3.285	3.120
	Mean	10.645	11.143	12.984
	Max	18.057	20.420	75.799
Total Phosphorus (µm)	Min	0.285	0.205	0.331
	Mean	0.648	0.814	0.853
	Max	1.627	1.881	2.584

Another large data set is held by the Northeast Fisheries Science Center Multispecies Bottom Trawl Survey ("NEFSC") (NEFSC, 2017). This survey has collected temperature and salinity data in addition to its primary biological data collection function. Three seasons have been monitored for many years: autumn since 1963, spring since 1968, and winter between the years 1992-2007; the summer season has not been monitored. Results are shown in Table 5.2-2. The data collected is mostly for the offshore areas south of Nantucket Sound and includes the Project Area as shown in Figure 5.2-2. The individual parameters will be discussed below.



Vineyard Wind Project

VINEYARD WIND

Figure 5.2-2

Locations of Water Quality Data Used from NEFSC Trawls (1948-2014)

Table 5.2-2 Mean and Standard Deviation for Seasonal (Spring, Fall, and Winter only) Temperature and Salinity Data from the NEFSC Multispecies Bottom Trawl Survey

Season	Average Bottom Depth (m)	Layer	Temperature (ºC) (Mean ± 1 SD)	Salinity (psu) (Mean ± 1 SD)
Spring	94	Surface	6.3 ± 2.0	32.9 ± 0.7
		Bottom	7.2 ± 2.9	33.5 ± 1.1
Summer			(No data taken)	(No data taken)
Fall	88	Surface	17.5 ± 3.2	32.9 ± 1.1
		Bottom	12.7 ± 3.1	33.4 ± 1.2
Winter	104	Surface	5.4 ± 1.6	32.9 ± 0.5
		Bottom	7.5 ± 3.3	33.8 ± 1.1

In addition, the National Oceanic Atmospheric Administration ("NOAA") National Data Buoy Center ("NBDC") has two data collection buoys, one (44020) located in the Nantucket Sound Main Channel in 11 meters ("m") (36 feet ["ft"]) of water and the other (44097) in the offshore area to the west of the WDA between Block Island and Martha's Vineyard in 48 m (157 ft) of water (see Figure 5.2-3). Data were downloaded from the NBDC website (NBDC, 2017) for the period from 2009 through 2016 with seasonal values shown in Table 5.2-3. The individual parameters will be discussed below.

Table 5.2-3 Mean Seasonal Surface Temperature Data from the NOAA NDBC Buoys 44020 and 44097 for the Period 2009-2016

Season	Station 44020 Mean Surface Temperature (ºC)	Station 44097 Mean Surface Temperature (ºC)
Spring	12.5	7.7
Summer	21.8	19.6
Fall	11.8	17.0
Winter	5.9	8.5

A large study conducted by the Environmental Protection Agency ("EPA") evaluated over 1,100 coastal locations in 2010, as reported in their National Coastal Condition Assessment (EPA, 2015). No results from this program after 2010 have been reported. The EPA used a Water Quality Index ("WQI") to determine the quality of various coastal areas including the northeast coast from Virginia to Maine and assigned three condition levels for a number of constituents: good, fair, and poor. Fortunately the data was available online so that eight individual stations in Nantucket Sound were identified. Figure 5.2-4 shows the larger northeast coastal area as well as the eight stations in Nantucket Sound. It should be noted, however, that the purpose of this study was not designed to characterize conditions on as fine a scale as Nantucket Sound. With that caveat, both the regional and local constituent condition level results are reported in the following paragraphs.

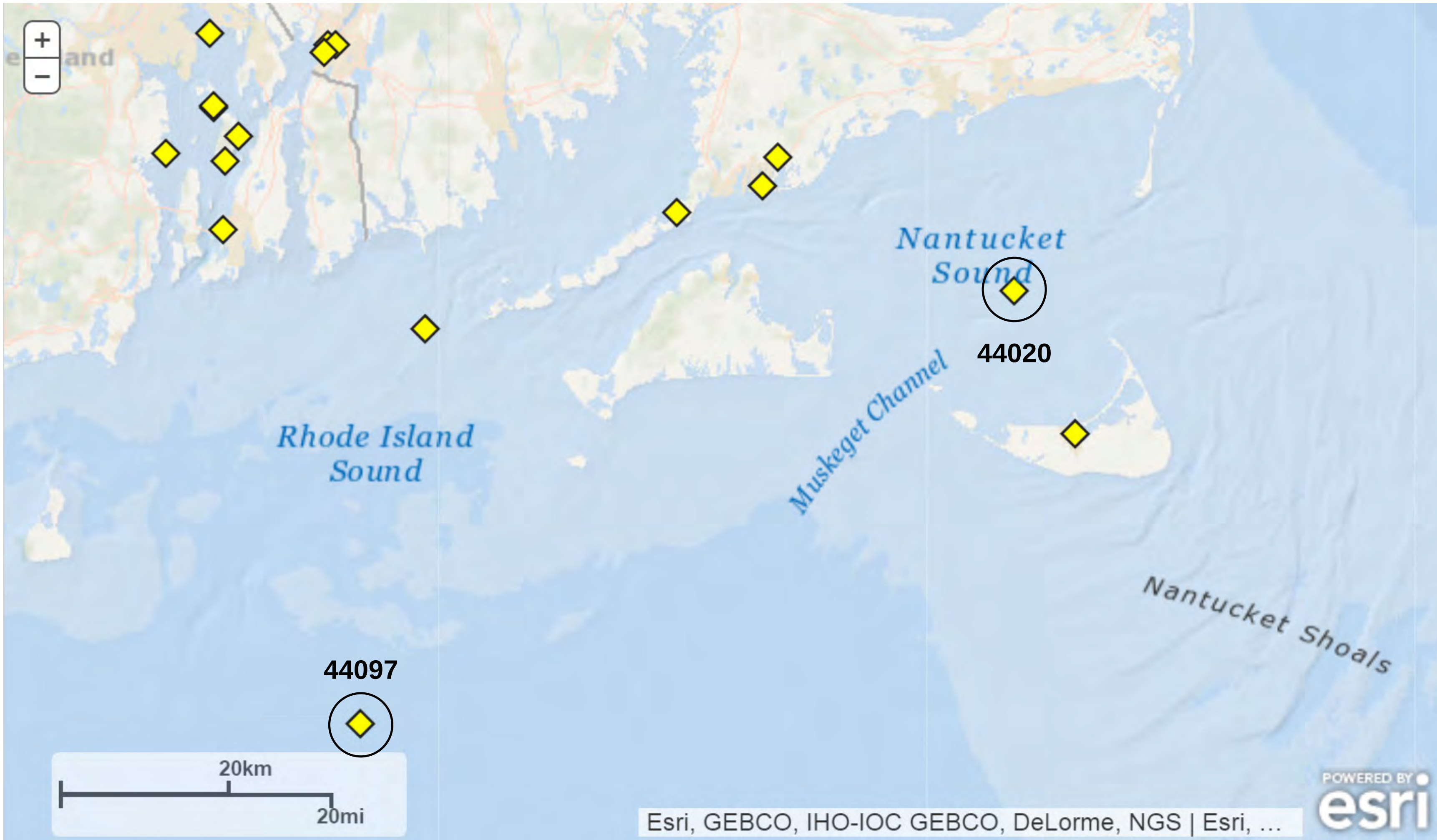


Figure 5.2-3

Locations of NOAA NBDC Buoys (Circled)

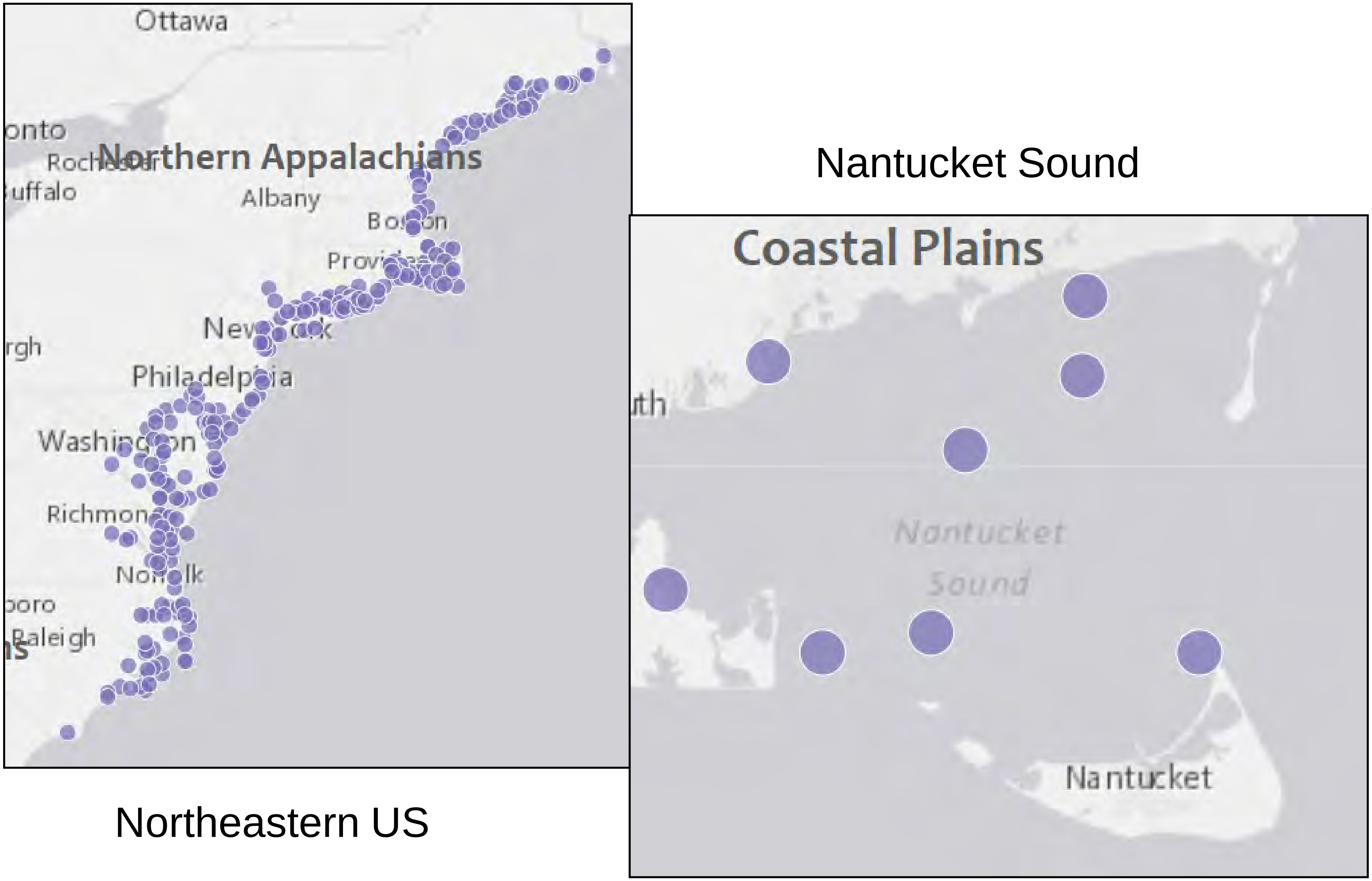


Figure 5.2-4

Locations of EPA NCCA Stations for Northeastern US (Left) and Nantucket Sound (Right)

Temperature

Three of the four data sources identified above reported temperature measurements. The recent seven year (2010-2016) CCS data showed an increase in temperature from south to north for the three stations in Nantucket Sound with means of 17.95, 19.21, and 20.36 °C (64.31, 66.58, and 68.65 °F) that was generally reflected in the minima and maxima as well. The seasonality of mean surface temperature differs between the NDBC stations. The lowest winter mean is 5.9 °C (10.6 °F) and was recorded at Nantucket Station 44020, while the lowest spring mean is 7.7 °C (13.9 °F) and was recorded at Station 44097. Both stations showed warmest mean surface temperatures of 21.8 °C (71.2 °F) (44020) and 19.6 °C (67.3 °F) (44097) during summer. The range over the seasons between mean surface and bottom temperatures in the NEFSC data indicated that surface waters showed a difference of 12.1 °C (21.8 °F) while the bottom waters showed a much smaller difference of 5.5 °C (9.9 °F) at water depths of approximately 90-100 m (300-330 ft).

Salinity

Unlike temperature, only small variations in the salinity of Nantucket Sound are reported in the CCS data. The mean salinities from south to north for the three stations are 31.75, 31.76 and 31.60 psu with similarly small variability of less than 2 psu between maximum and minimum at each station. This effect is also seen in the NEFSC data where the mean surface salinity is the same (32.9 psu) for the three seasons while the mean bottom salinity varies only slightly (between 33.4 and 33.8 psu) over the seasons.

Chlorophyll a

Chlorophyll *a* concentrations, an indicator of primary productivity, vary substantially on a seasonal basis but little spatially in Nantucket Sound. The recent seven year (2010-2016) CCS data show small spatial differences from south to north for the three stations in Nantucket Sound with means of 1.79, 1.93, and 1.81 mg/L that is generally reflected in the minima (0.45, 0.23, and 0.50 mg/L) and maxima (4.73, 4.80, and 4.33 mg/L). The variability seen between minima and maxima is due to natural seasonal variations.

Chlorophyll *a* levels in northeastern coastal waters are generally rated as fair (45%) to good (51%) condition, as measured by the EPA WQI, based on measurements collected in 2010 (EPA, 2015). Further review of the data specific to the eight stations in Nantucket Sound revealed that these eight stations had only single measurements each in 2010, which resulted in 88% identified as good condition and 12% as fair.

Nutrients

Nutrients in the oceanic context consist of nitrogen, phosphorus, and silica (BOEMRE, 2011). Nitrogen in marine environments is mostly derived from dissolved nitrogen gas, with the rest formed by the dissolved inorganic nitrogen forms of nitrate, nitrite, and ammonium ion, as well as dissolved and particulate organic nitrogen. Inorganic phosphate is the primary form of phosphorus, known as orthophosphate, with lower levels of organic phosphate found in surface waters. Silicate makes up most of the silica in marine environments.

Sources of nutrients that enter New England marine waters in general include:

- Recycling or resuspension from sediments;
- River discharges;
- Transport onto the shelf from offshore waters;
- Atmospheric deposition; and
- Upwelling from deeper waters.

Nutrient information is available from the data reported by CCS. This data shows increasing levels from south to north for the three stations in Nantucket Sound with means for total nitrogen ("TN") of 10.645, 11.143, and 12.984 µm. This trend is not reflected in the minima (4.448, 3.285, and 3.120 µm) but is reflected in the maxima (18.057, 20.420, and 75.799 µm). The total phosphorus ("TP") levels also show an increase from south to north for the three stations with means of 0.648, 0.814, and 0.853 µm. This trend is not reflected in the minima (0.285, 0.205, and 0.331 µm) but is in the maxima (1.627, 1.881, and 2.584 µm). The maxima of TN and TP for the northern station is particularly high compared to other measurements at that site.

Nitrogen levels in northeastern coastal waters are generally rated as fair (13%) to good (82%) condition while phosphorus levels are rated as fair (62%) to good (26%), as measured by the EPA WQI, for the northeastern coast based on 2010 data (EPA, 2015). For the eight stations in Nantucket Sound, one measurement at each of the eight stations indicated a rating of 100% good for nitrogen and 100% fair for phosphorous.

Dissolved Oxygen

Dissolved oxygen ("DO") mainly enters the ocean via exchange with the atmosphere. Concentrations are also controlled by physical factors (e.g., water temperature) and biological factors (e.g., respiration, photosynthesis, and bacterial decomposition), which may result in concentration changes through the water column.

The CCS data shows a decrease from south to north for the three stations in Nantucket Sound with means of 8.00, 7.59, and 7.32 mg/L that is reflected in the minima (6.89, 6.39, 5.37 mg/L) but not in the maxima (9.63, 11.39, 8.75 mg/L).

Dissolved oxygen levels in northeastern coastal waters are generally rated as fair (14%) to good (80%) condition, as measured by the EPA WQI, based on results of the 2010 NCCA (EPA, 2015). The eight stations in Nantucket Sound were sampled a total of 14 times in 2010, with 93% rated as good and 7% rated as fair.

Turbidity

Turbidity is a measure of the scattering of light by suspended particulate matter and is different from total suspended sediment, which is a measure of the concentration of sediment particles in the water column. The only accurate way to convert from one to the other is to take simultaneous measurements of both and perform a regression analysis. Historically, turbidity has been measured directly in NTUs, while suspended sediment concentrations were determined in the laboratory in units of mg/L although newer instruments can now measure total suspended sediment directly. Suspended sediment concentrations are typically used to evaluate biological exposure, particularly from seabed activities such as submarine cable burial.

The CCS data does not show a consistent variation from south to north for the three stations in Nantucket Sound with means of 0.66, 0.70, and 0.58 NTU, but these differences are small. The minima show a slight increase (0.09, 0.09, 0.13 NTU) while the maxima show a decrease (3.17, 2.27, and 2.19 NTU) from south to north.

Turbidity levels in northeastern coastal waters are generally rated as fair (10%) to good (78%) condition, as measured by the EPA WQI, based on results of the 2010 NCAA (EPA, 2015). No turbidity data for the eight Nantucket Sound stations was acquired in 2010.

5.2.2 Potential Impacts of the Project

The following impact- producing factors listed in Table 5.2-4 may affect the marine water quality due to activity in the Project Area.

Table 5.2-4 Impact-Producing Factors for Water Quality

Impact-Producing Factor	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommis-sioning
Pile driving for WTG and ESP foundations	X		X		
Offshore cable installation	X	X	X		
Horizontal directional drilling	X	X	X		
Scour protection installation	X		X		
Routine releases from vessels	X	X	X	X	X

5.2.2.1 Construction and Installation

5.2.2.1.1 Pile Driving for Wind Turbine Generator ("WTG") and Electrical Service Platform ("ESP") Foundation Installation

Pile driving is necessary since piles support the WTG and ESP foundations which are located exclusively in the WDA. The potential impacts to water quality via sediment resuspension from repeated hammer blows to the pile would be local to the pile outer diameter. No studies of offshore pile driving were identified that concluded this activity would cause any significant sediment resuspension.

5.2.2.1.2 Cable Installation in Marine Waters

Cable burial operations will occur both in the WDA for the inter-array cables connecting the WTGs to the ESPs and the OECC for the cables carrying power from the ESPs to landfall. In order to assess the impacts of these activities, a set of computer simulation models was used. A hydrodynamic model, HYDROMAP, was used to provide the current velocities necessary for use in the sediment dispersion model, SSFATE, which calculated the resulting excess total suspended sediment ("TSS") concentrations in the water column mobilized by the cable burial activity and the bottom deposition patterns resulting from settling of the mobilized sediment. Details of the models, their applications, and the results of the calculations are provided in Appendix III-A.

The HYDROMAP hydrodynamic model domain extended from approximately Provincetown (northeast extent) at the northern tip of Cape Cod to Sandy Hook, New Jersey (southwest extent) south of New York City, including Nantucket Sound, Martha's Vineyard Sound, Buzzards Bay, Narragansett Bay, Block Island Sound, Rhode Island Sound, and Long Island Sound. This domain is significantly larger than the Project Area, however, but this was chosen to best locate and define open boundary conditions. The model was forced with tidal harmonics and wind so it could reproduce patterns of tides and currents at multiple locations within the domain. After the model application was verified, a second model run was performed for a period exhibiting winds close to the average winds in the region. This second HYDROMAP model application was used as the hydrodynamic forcing in the sediment dispersion modeling using SSFATE.

Sediment dispersion modeling and analysis was performed to simulate the installation (i.e., burial) of multiple offshore cable systems. A representative inter-array cable within the WDA was modeled as were the variants of the OECC. Figure 5.2-5 shows the plan view of the representative inter-array cable and the OECC variants. The simulations utilized the identical HYDROMAP modeling output with a model timestep of 10 minutes with output every 20 minutes, and a concentration grid of 50 m (160 ft) resolution in the horizontal dimensions and 0.5 m (1.6 ft) resolution in the vertical dimension. The sediment source load for each simulation was developed based on sediment and installation characteristics.

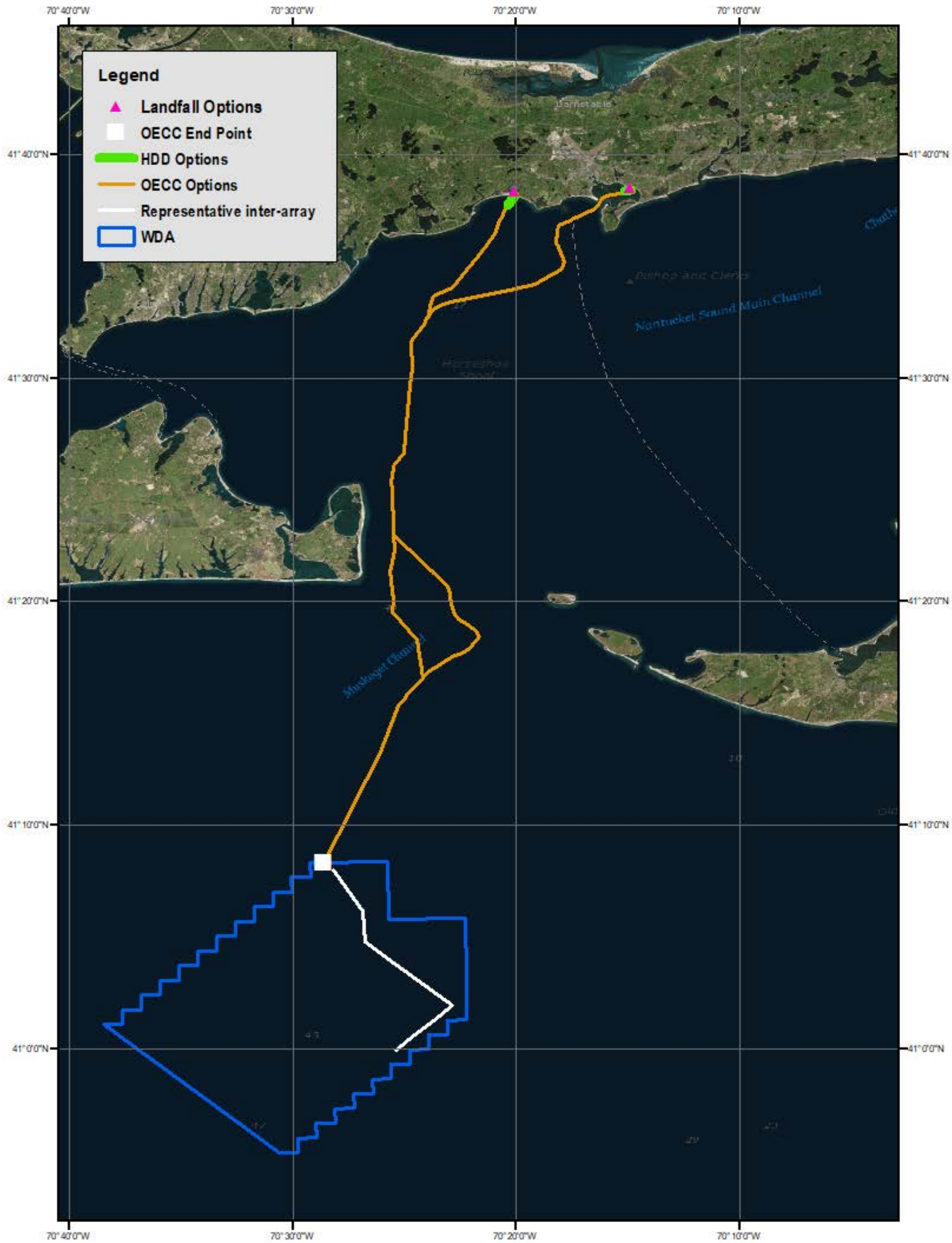


Figure 5.2-5
Location of Project Components for Dispersion Modeling

The simulations were run in SSFATE and post processed to determine the spatial and temporal characteristics of excess (i.e., above ambient) TSS concentrations and the spatial patterns of deposition.

Inter-Array Cable

For the representative inter-array cable, a single inter-array route was simulated which was selected as the longest individual route within a representative configuration (see Figure 5.2-5). The route was simulated for typical and maximum impact installation parameters.

- Typical installation reflected a one meter (3.3 ft) wide x two meter (6.6 ft) deep trench, a production rate (i.e., installation rate) of 200 m/hour ("hr") (656 ft/hr) and a sediment mobilization fraction of 0.25 (25% of total trench volume).

- Maximum impact installation reflected a one meter (3.3 ft) wide x three meter (9.8 ft) deep trench, a production rate (installation rate) of 300 m/hr (985 ft/hr) and a sediment mobilization fraction of 0.35 (35% of total trench volume).

It is anticipated that the typical parameters would be utilized for approximately 90% of the cable installation and that the maximum impact parameters would only be utilized for 10% of the cable installation. The vertical initialization of mobilized sediments was based on the possible burial methods and was limited to the bottom three meters (9.8 ft) of the water column with 85% of the sediment introduced to the bottom one meter (3.3 ft) of the water column.

In order to be conservative, the entire route was assumed to have the sediment characteristics associated with the sample with the greatest relative fraction of fine material, which was ~23% for the two-meter-deep (6.6 ft) trench and ~29% for the three-meter-deep (9.8 ft) trench. The sediment characterization was developed based on depth weighted averages of sediment grain sizes.

The simulation of the typical installation of the inter-array cable predicts the 10 mg/L plume to oscillate about the route centerline and typically extend approximately 200 m (660 ft) from the centerline, though it may extend up to 3.1 km (1.9 mi) from the centerline as shown in Figure 5.2-6. Higher concentrations are limited to a small extent from the centerline, with the 50 mg/L plume extending up to 160 m (525 ft) from the centerline. The associated deposition thickness (see Figure 5.2-7) is 1.0 millimeter ("mm") (0.04 inches ["in"]) or greater within approximately 100 m (328 ft) of the centerline and maximum deposition thickness was less than 5 mm (0.2 in).

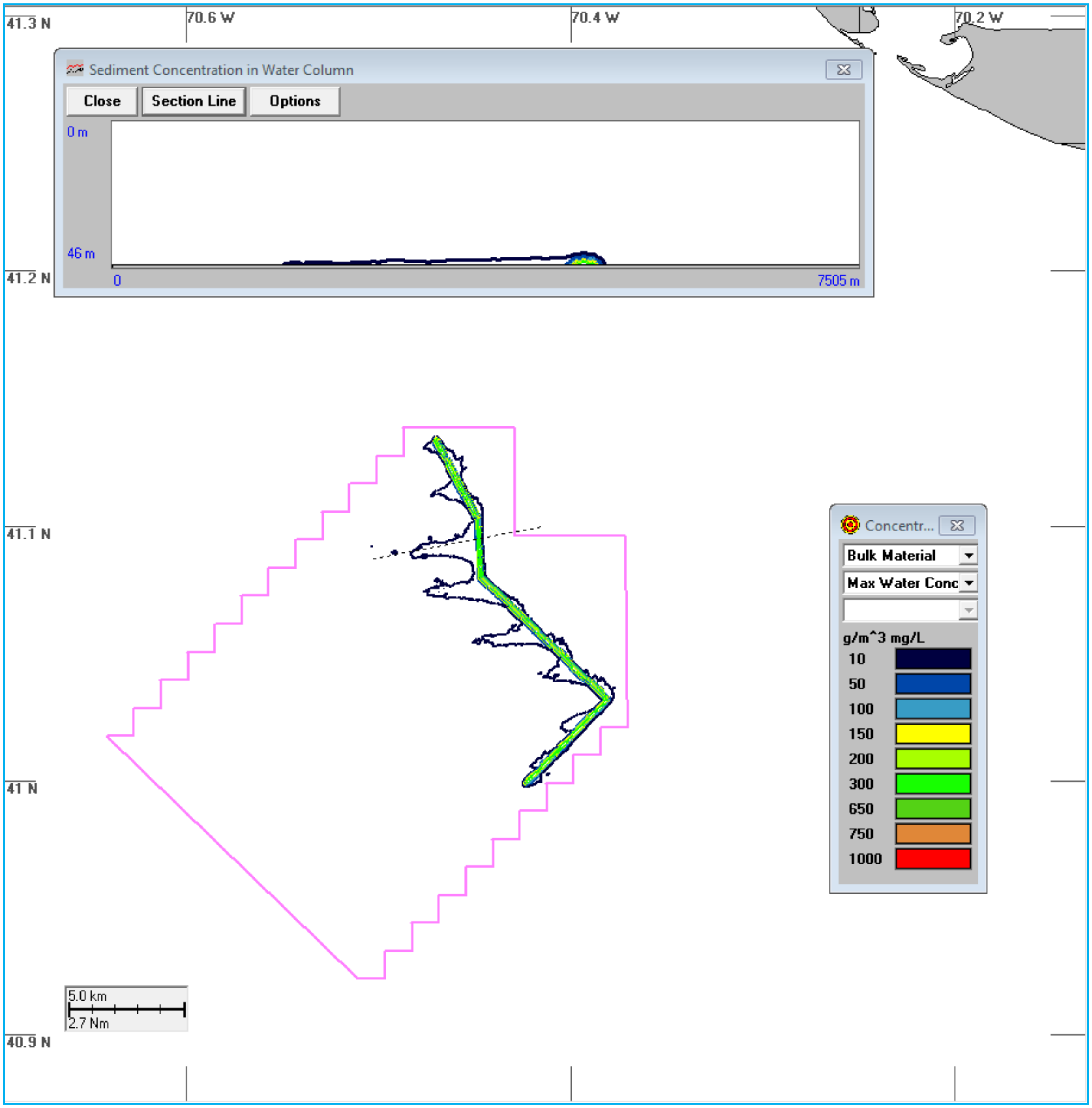


Figure 5.2-6

Time-Integrated Maximum TSS Concentration for Inter-Array Cable Installation Using Typical Burial Parameters with Plan View (Lower Panel) and Vertical Section View (Upper Panel).

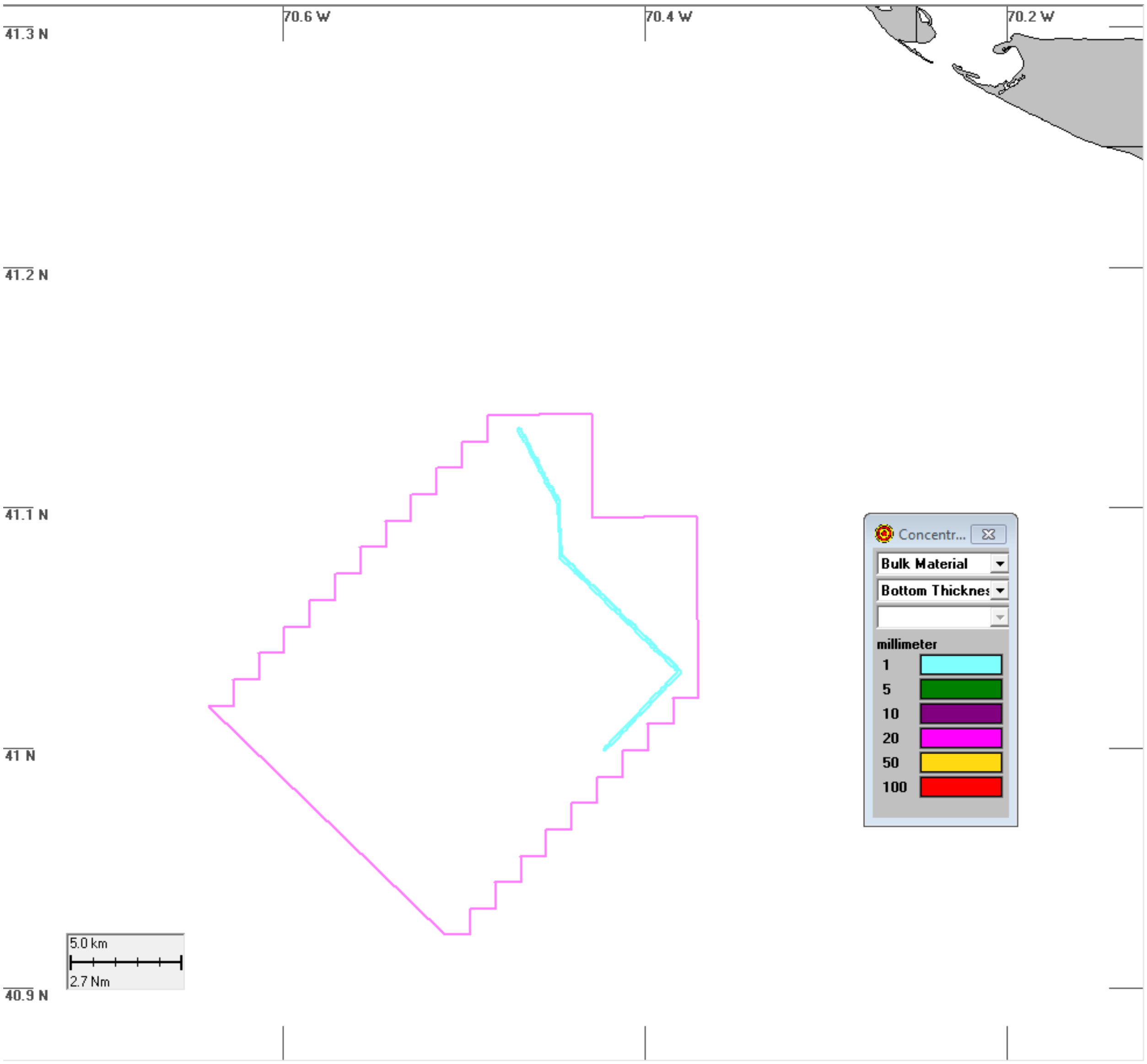


Figure 5.2-7

Plan View of Deposition Thickness for Inter-Array Cable Installation Using Typical Burial Parameters.

The simulation of the maximum impact installation parameters for the inter-array cable in Figure 5.2-8 showed a noticeably larger footprint, with the 10 mg/L, 50 mg/L, and 100 mg/L contours extending up to ~7.5 km (~4.7 mi), ~2 km (~1.2 mi), and ~0.86 km (~0.53 mi) from the centerline, respectively.

The maximum impact deposition (see Figure 5.2-9) of 1.0 mm (0.04 in) or greater is limited to ~140 m (~460 ft) from the route centerline and the deposition thickness is less than 5 mm (0.2 in). These increases are as expected due to the increased total mass and mass flux associated with the maximum impact parameters. As depicted in the vertical section views (top panels) in Figures 5.2-6 and 5.2-8, both simulations showed the maximum concentrations are located near the bottom of the water column, which is expected based on the initialization of sediments due to the bottom activity.

Table 5.2-5 compares the modeling results for the typical and maximum impact scenarios using four metrics: (1) maximum extent in km of the 10 mg/L contour of TSS concentrations, (2) the maximum extent in km of deposition greater than 1 mm (0.04 in) from the inter-array cable centerline, (3) the maximum extent in km of deposition greater than 20 mm (0.8 in) from the inter-array cable centerline, and (4) the area in km^2 with TSS concentrations greater than 10 mg/L for various durations.

Table 5.2-5 Maximum Extents and Duration Areas for Representative Inter-Array Cable for Typical and Maximum Impact Installation Parameters

Project Component	Activity	Typical ("Typ") or Maximum ("Max")	Maximum Extent of 10 mg/L Contour[1]	Maximum Extent of Deposition > 1 mm[1]	Maximum Extent of Deposition > 20 mm[1]	Area (square kilometers ["km^2"]) over 10 mg/L for various durations (hrs)				
			(km)	(km)	(km)	1	2	3	4	6
Representative Inter-array	Cable Installation	Typ	3.1.	0.1	N/A	9.73	4.67	1.3	0.27	-
Representative Inter-array	Cable Installation	Max	7.500	0.14	N/A	36.4	21.4	12.1	6.88	1.33

1. As measured from the route centerline.

In summary, the model results indicate that most of the mass settles out quickly and is not transported for significant distances by the currents. Excess (i.e., above ambient) TSS concentrations higher than 10 mg/L only persist at any given point for less than six (assuming typical installation parameters) or 12 (assuming maximum impact installation parameters) hours. The plume is confined to the bottom three meters (9.8 ft) of the water column, which is only a fraction of the water column in the WDA. Deposition greater than

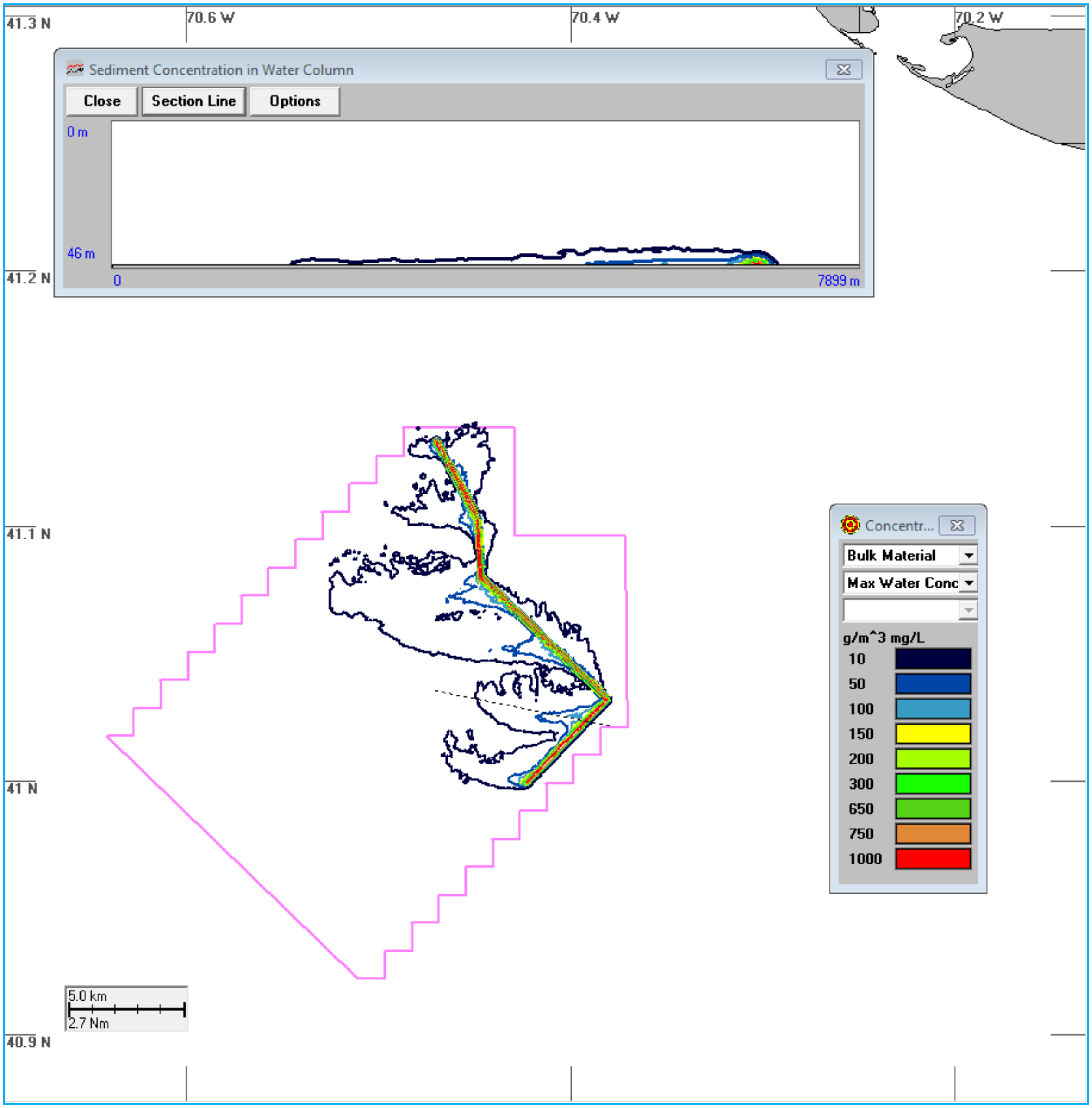


Figure 5.2-8

Time-Integrated Maximum TSS Concentration for Inter-Array Cable Installation Using Maximum Impact Burial Parameters with Plan View (Lower Panel) and Vertical Section View (Upper Panel).

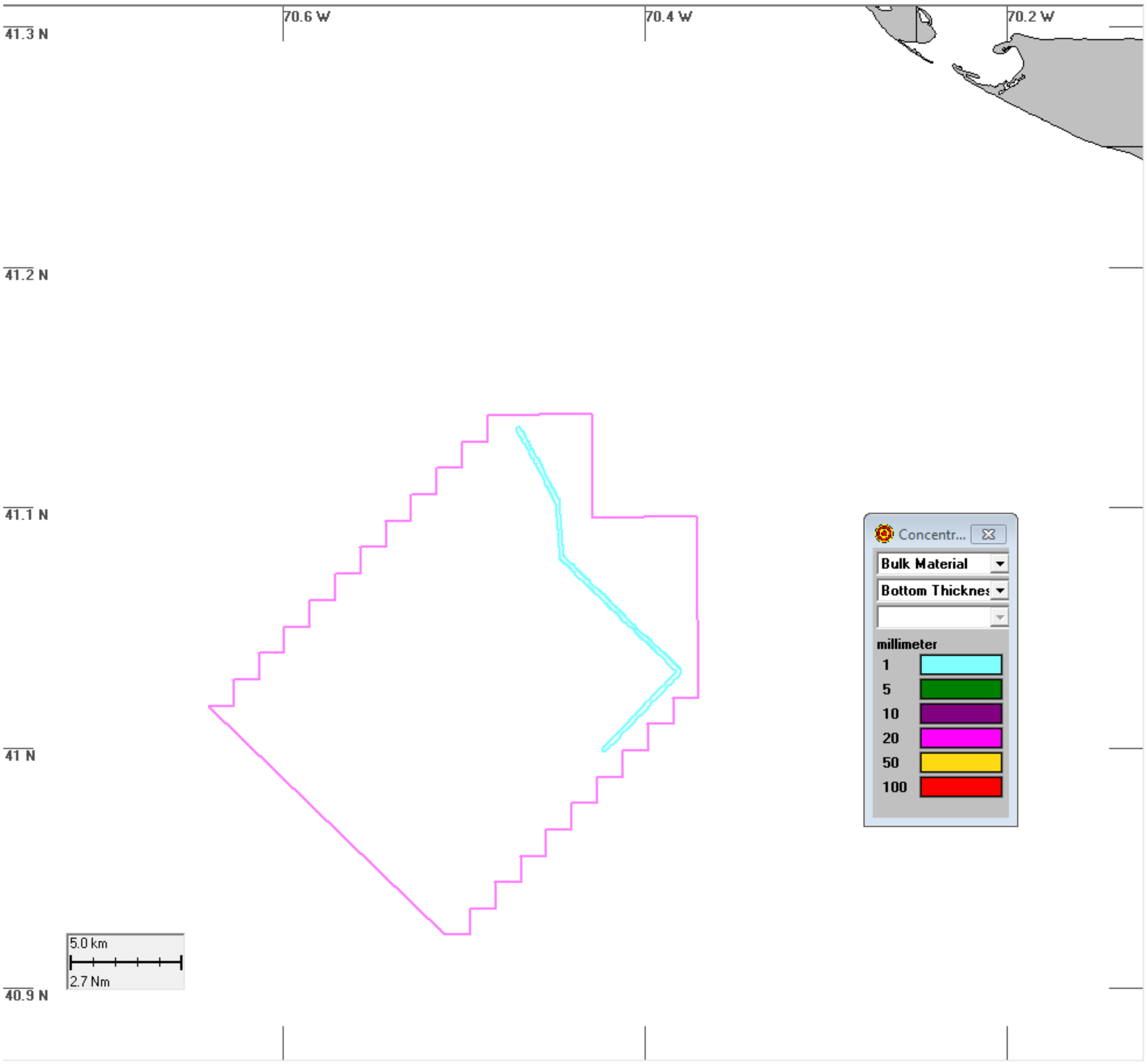


Figure 5.2-9

Plan View of Deposition Thickness for Inter-Array Cable Installation Using Maximum Impact Burial Parameters).

0.2 mm (0.008 in) is confined within 200 m (656 ft) to 250 m (820 ft) of the trench centerline for the typical and maximum impact simulations, respectively, and maximum deposition in both simulations is less than 5 mm (0.2 in). Water quality impacts from the inter-array cable installation are therefore short-term and localized.

Offshore Export Cable Corridor

The Project includes one predominate OECC which has two options through Muskeget Channel (Western Muskeget [WM] and East Muskeget [EM]) and two options for landfall (Covell's Beach and New Hampshire Avenue); these combine for four variants of the OECC:

1. OECC WM to Covell's Beach
2. OECC WM to New Hampshire Avenue
3. OECC EM to Covell's Beach
4. OECC EM to New Hampshire Avenue

Sand waves of varying height occur along the OECC. Portions of the sand waves may be mobile over time; therefore, the upper portions of the sand waves may need to be removed via dredging so that the cable laying equipment can achieve the proper burial depth below the sand waves and into the stable sea bottom. The amount of sand wave dredging required varies depending on the cable installation methods employed. More information on sand wave characteristics are found in Sections 2.0 and 3.0 of Volume II-A.

The Project is considering two distinct approaches to remove the upper portions of the sand waves above the stable seabed where necessary along the OECC. The first technique is a trailing suction hopper dredge ("TSHD"). The second approach involves jetting (also known as mass flow excavation), which uses a pressurized stream of water to push sand to the side. The dredging could be accomplished entirely by the TSHD on its own (the "TSHD Pre Dredge" option) or the dredging could be accomplished by a combination of jetting and TSHD, where jetting would be used in smaller sand waves and the TSHD would be used to remove the larger sand waves (this is referred to as "Limited TSHD Pre Dredge + Jetting"). Once any needed sand wave removal occurs, burial of the cable will occur.

- For the "TSHD Pre Dredge" approach, cable installation is a separate activity that occurs after dredging is complete (this is referred to simply as "Cable Installation"). Therefore, the model first simulates the TSHD dredging, then separately simulates the cable installation. This combined approach of TSHD dredging followed by cable installation is referred to as "TSHD Pre Dredge + Cable Installation]".

- For the "Limited TSHD Pre Dredge Approach + Jetting" approach, the jetting activity both removes the tops of sand waves and buries the cable. (Such jetting occurs only for very limited portions of the cable corridor.) Therefore, the model accounts for cable installation both through jetting (in smaller sand wave segments only) and through one of the other potential cable burial methods (such as a jet plow) that may be used in areas without sand waves requiring removal; this approach is referred to as "Cable Installation aided by Jetting." Accordingly, the model first simulates the limited TSHD dredging, then separately simulates the cable installation (which consists of jetting in limited segments for sand wave clearance and cable burial plus jet plow or one of the other cable installation techniques listed in the project's Construction and Operations Plan [COP] for the remainder of the route). This combined approach of limited TSHD dredging (in larger sand waves) followed by cable installation via either jetting (in smaller sand waves) or one of the other potential cable burial methods (such as a jet plow) is referred to as "Limited TSHD Pre Dredge + Cable Installation aided by Jetting."

For the two approaches a total of eight simulations were run, the pre cable installation dredging and the cable installation for each of the four route variants. An additional simulation was run with maximum impact burial parameters for one of the route variants. As with the inter-array cable installation described above, it is anticipated that the typical parameters would be utilized for approximately 90% of the offshore export cable installation and that the maximum impact parameters would only be utilized for 10% of the offshore export cable installation.

As detailed in Appendix III-A, the sediment characteristics were based on the characterizations from sediment sample analysis along the route and were therefore spatially varied along the route. In general, the total set of sediment grain size distribution analyses showed that the samples were predominately coarse sand with some exceptions.

For each simulation, maps of time integrated maximum excess TSS concentration and seabed deposition were generated. Model results (the area over specific thresholds for specific durations and deposition) were also tabulated.

The results from one OECC route variant (EM to NH Avenue) were presented in greater detail to provide more insight as to the impacts. Due to the similarity between the routes and the impacts, this route serves as a proxy for the results of any of the OECC variants (see Appendix III-A for more details). The cable installation without jetting or aided by jetting are negligibly different; however, the dredging impact footprint associated with the Limited TSHD Pre Dredge + Jetting approach is smaller than that of the TSHD Pre Dredge approach due to the reduced required volume of sediment to be dredging.

TSHD Pre-Dredge

Details of the model results for each OECC are provided in Appendix III-A. Figures 5.2-10 and 5.2-11 show model results for a representative example OEEC, the "EM to NH Avenue using typical installation parameters." In viewing the entire extent of the TSS concentrations (Figure 5.2-10) the plume is more extensive adjacent to the areas where sand wave dredging will occur, which is intermittent along the route. Further it can be seen that the plume may be present at varying orientations relative to the route centerline in response to the prevailing direction of the oscillating current synchronous with the simulated activity; in that sense it is noted that this footprint corresponds to the modeled time period and multiple perturbations of the footprint are possible through the tide cycle, though the general trends are expected to be the same. The footprint and contours for the dredging, overflow and disposal activity show that excess concentrations are expected throughout the water column as shown in the upper panel of Figure 5.2-10. This is due to the overflow release located at the surface and therefore a plume is noted throughout the water column as the sediments settle. Similarly the dumping will initiate sediments approximately 6 m below the surface (through the opened hull) and therefore the resulting plume occupies waters throughout most of the water column. The plume of excess TSS at 10 mg/L and 750 mg/L extends up to 16 km ((9.9 mi) and 5 km (3.1 mi) from the route centerline, though may be less extensive at varying locations along the route. Relatively high concentrations (>1000 mg/L) are predicted at distances up to 5 km (3.1 mi) in response to the relatively high loading of dumping and swift transport of the dumped sediments.

The map of seabed deposition thickness associated with the TSHD dredging approach (dredging/overflow/dumping of pre-cable installation dredging of sand waves for the EM to NH Avenue OECC) with typical installation parameters is shown in Figure 5.2-11. This figure demonstrates that the deposition above 0.2 mm (0.008 in) is generally in very close proximity to the dredge and dump sites. The deposition greater than 1.0 mm (0.04 in) associated with the TSHD drag arm is mainly constrained to within 80 m (260 ft) from the route centerline, whereas the deposition greater than 1.0 mm (0.04 in) associated with overflow and disposal extends to greater distances from the source (disposal location ~250 m [820 ft] east of the route centerline), mainly within 1 km (0.6 mi) though such deposition can extend up to 2.3 km (1.4 mi) in isolated patches when subject to swift currents through Muskeget Channel. Deposition greater than 20 mm (0.8 in) resulted only from the dumping activities. Since the dumping takes place away from the route centerline the majority of the 20 mm (0.8 in) thickness was located in isolated patches offset from the route centerline. Very small patches of areas greater than 20 mm (0.8 in) were noted up to ~0.9 km (~0.56 mi) from the dumping location, however such occurrences were not typical; typically the 20 mm (0.8 in) deposition was within 0.35 km (0.22 mi) from the source.

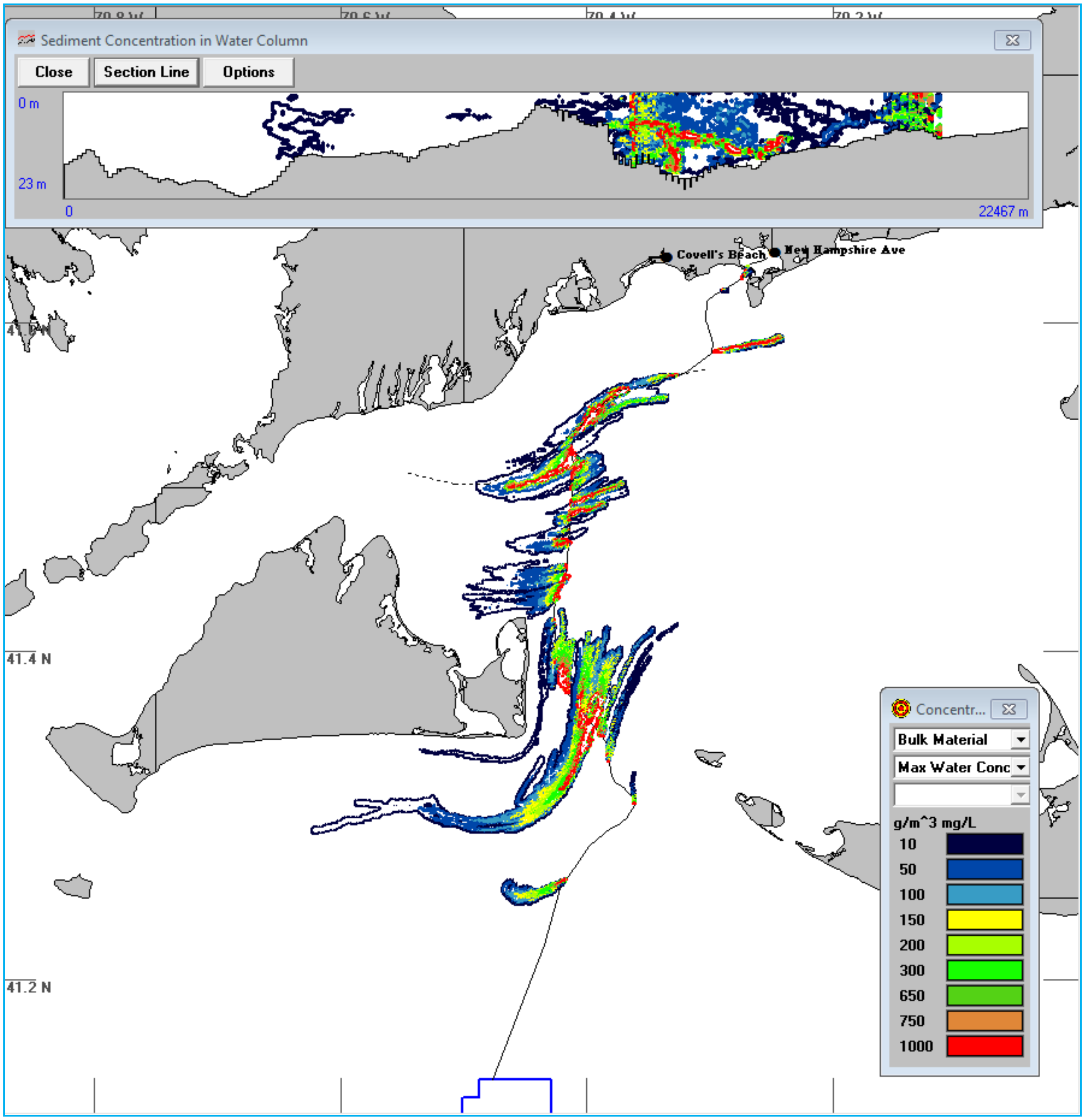


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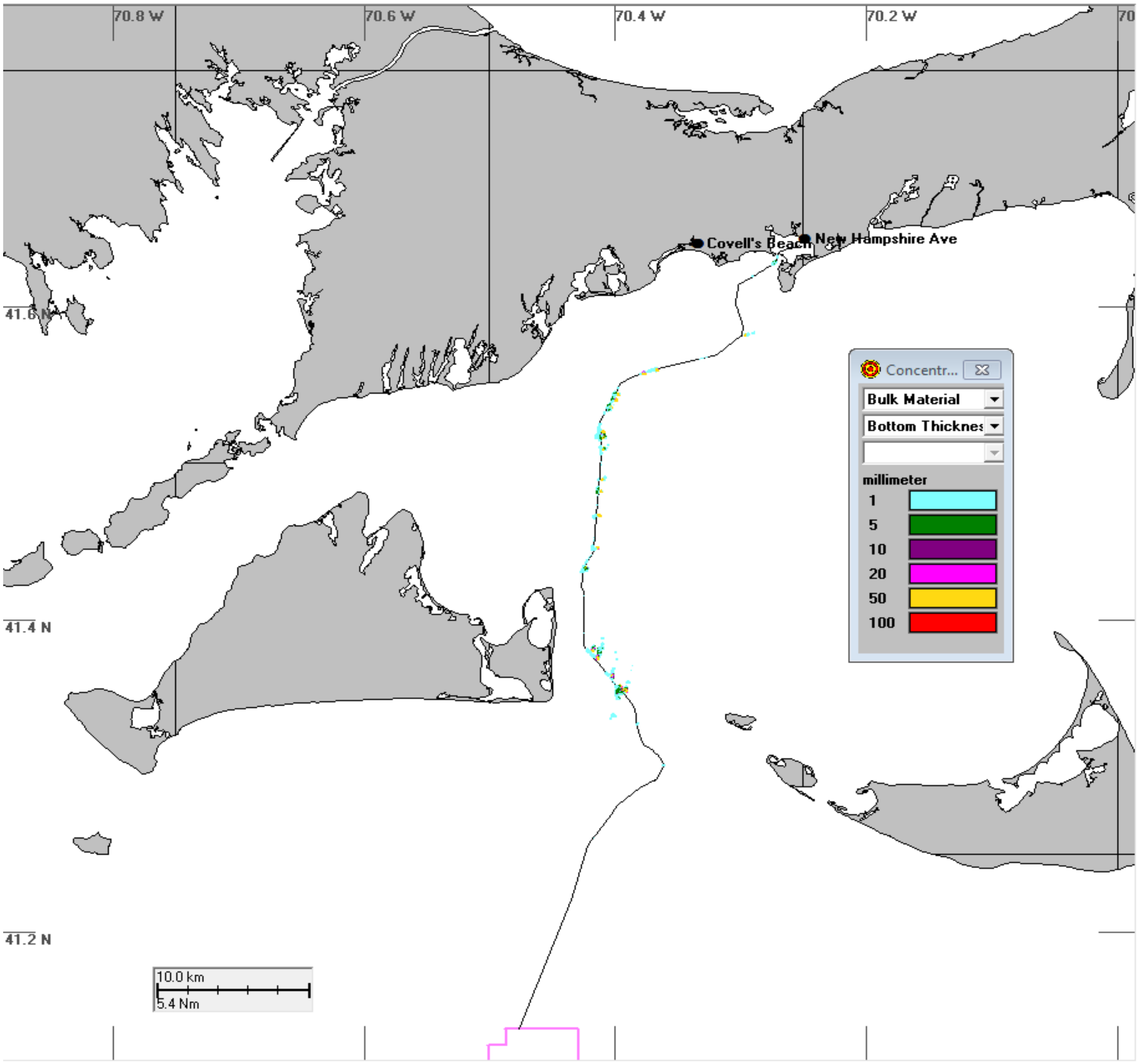
Figure 5.2-10

Time-Integrated Maximum TSS Concentration Associated with Dredging, Overflow and Disposal for ETM to NH Avenue OEEC Using Typical Burial Parameters with Plan View (Lower Panel) and Vertical Section View (Upper Panel).



VINEYARD WIND

Figure 5.2-11

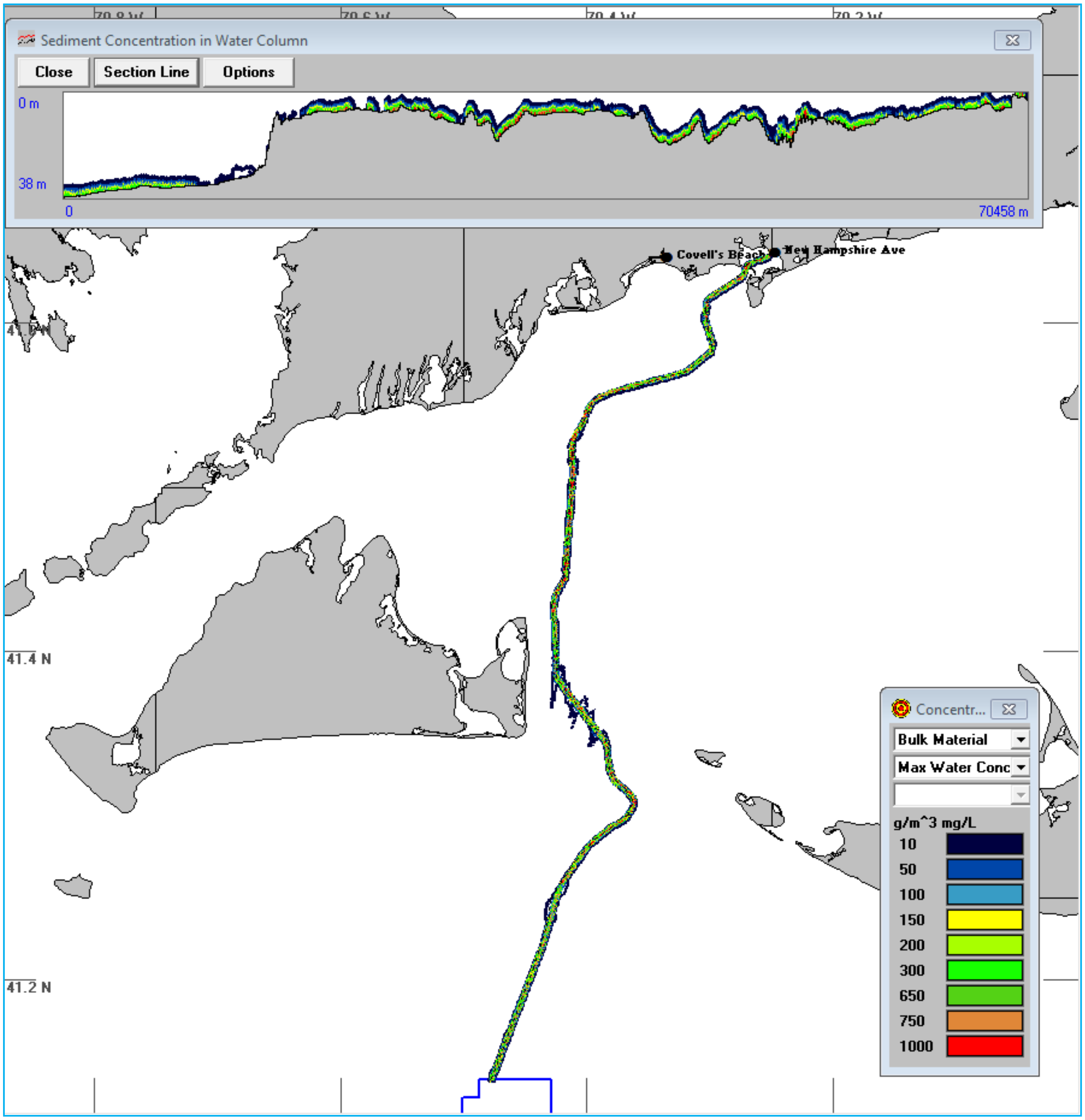
Plan View of Deposition Thickness Associated with Dredging, Overflow and Disposal for ETM to NH Avenue OEEC Using Typical Burial Parameters.

Cable Installation

Subsequent to the pre-installation dredging via TSHD, cable installation will take place. The map of time-integrated maximum concentrations of the corresponding cable installation using typical installation parameters for the EM to NH Avenue OECC is presented in Figure 5.2-12. This figure shows the entire route with a cross section along the route centerline at the top. The overall plume extent as delineated by the 10 mg/L excess TSS concentration contour remains relatively close to the route centerline for most of the route with some areas extending farther from the centerline in response to the currents or relatively higher volume of finer material within the sediments. The higher concentrations, above 10 mg/L, generally remain centered around the route centerline. The 10 mg/L contour has a maximum excursion of ~2 km (~1.2 mi) from the centerline though typically remains within less than ~200 m (~660 ft) from the centerline. In this figure, the vertical section view (top panel) runs along the centerline and shows that the plume is contained within the bottom of the water column close to the disturbance.

The map of deposition thickness for this scenario is presented in Figure 5.2-13. This figure shows that deposition is centered on the route centerline with deposition of 1 mm (0.04 in) or greater limited to within ~100 m (~330 ft) from the centerline, though was mainly within 80 m (260 ft). Both Figures 5.2-12 and 5.2-13 indicate that most of the mass settles out quickly and is not transported for significant distances by the currents.

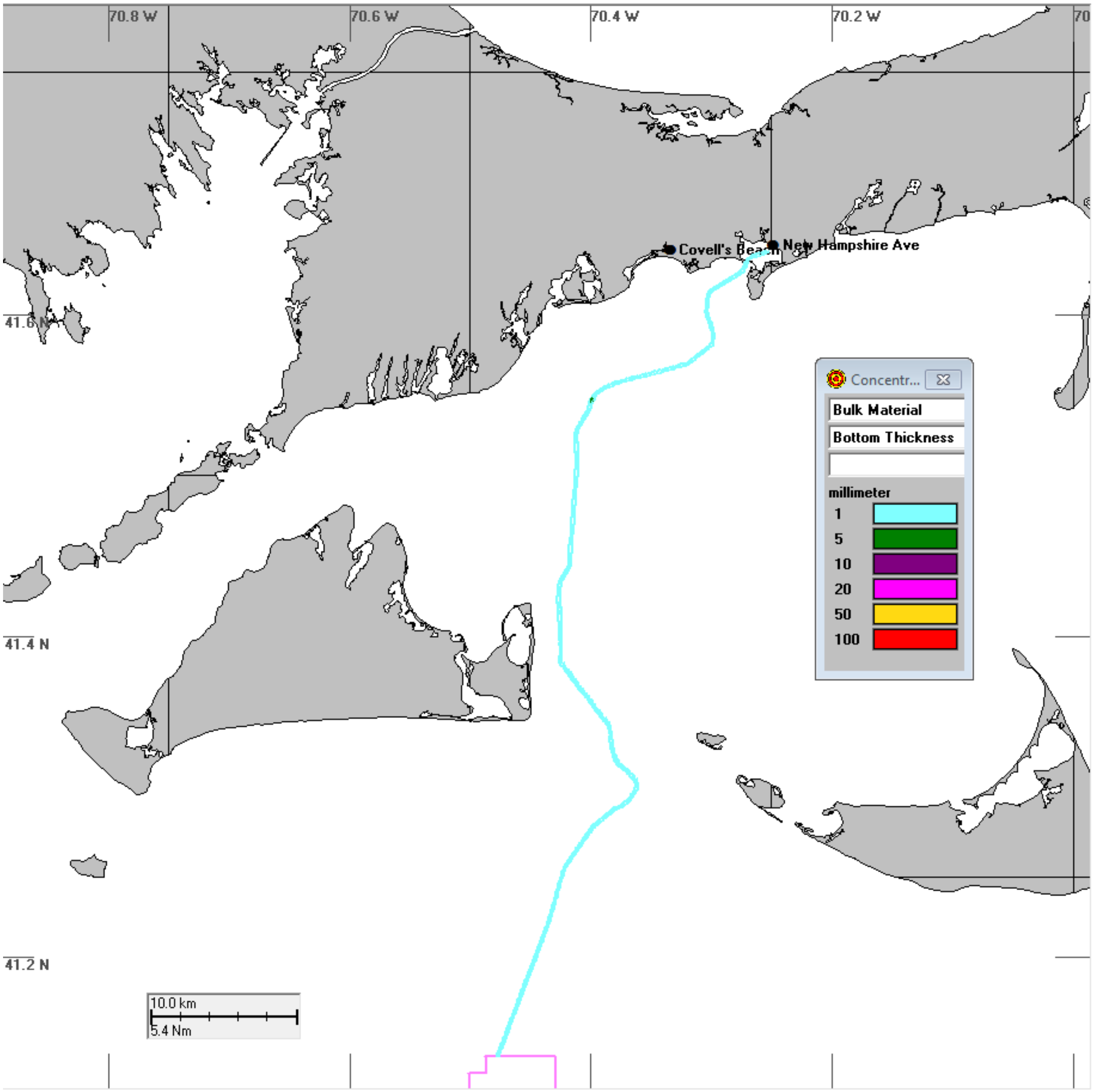
A sensitivity run for the EM to NH Avenue OECC using maximum impact cable burial parameters was simulated to assess the impact of some of the uncertainties associated with the cable burial assumptions. The map of time-integrated maximum TSS concentrations associated with this maximum impact scenario is presented in Figure 5.2-14. This figure shows the entire route with a cross section along the route centerline at the top. The overall footprint shows that the plume as delineated by excess concentrations of 10 mg/L and greater remains relatively close to the route centerline for the majority of the route with some areas transported farther from the centerline in response to the currents or relatively higher volume of finer material within the sediments. The higher concentrations, above 10 mg/L, generally remain centered on the route centerline. The 10 mg/L contour has a maximum excursion of ~2.8 km (~1.7 mi) from the centerline though typically remains within less than ~200 m (~660 ft) from the centerline. In this figure, the vertical section view (upper panel) runs along the centerline and shows that the plume is contained within the near bottom of the water column close to the disturbance. The footprint is similar to that associated with the



Vineyard Wind Project

Figure 5.2-12

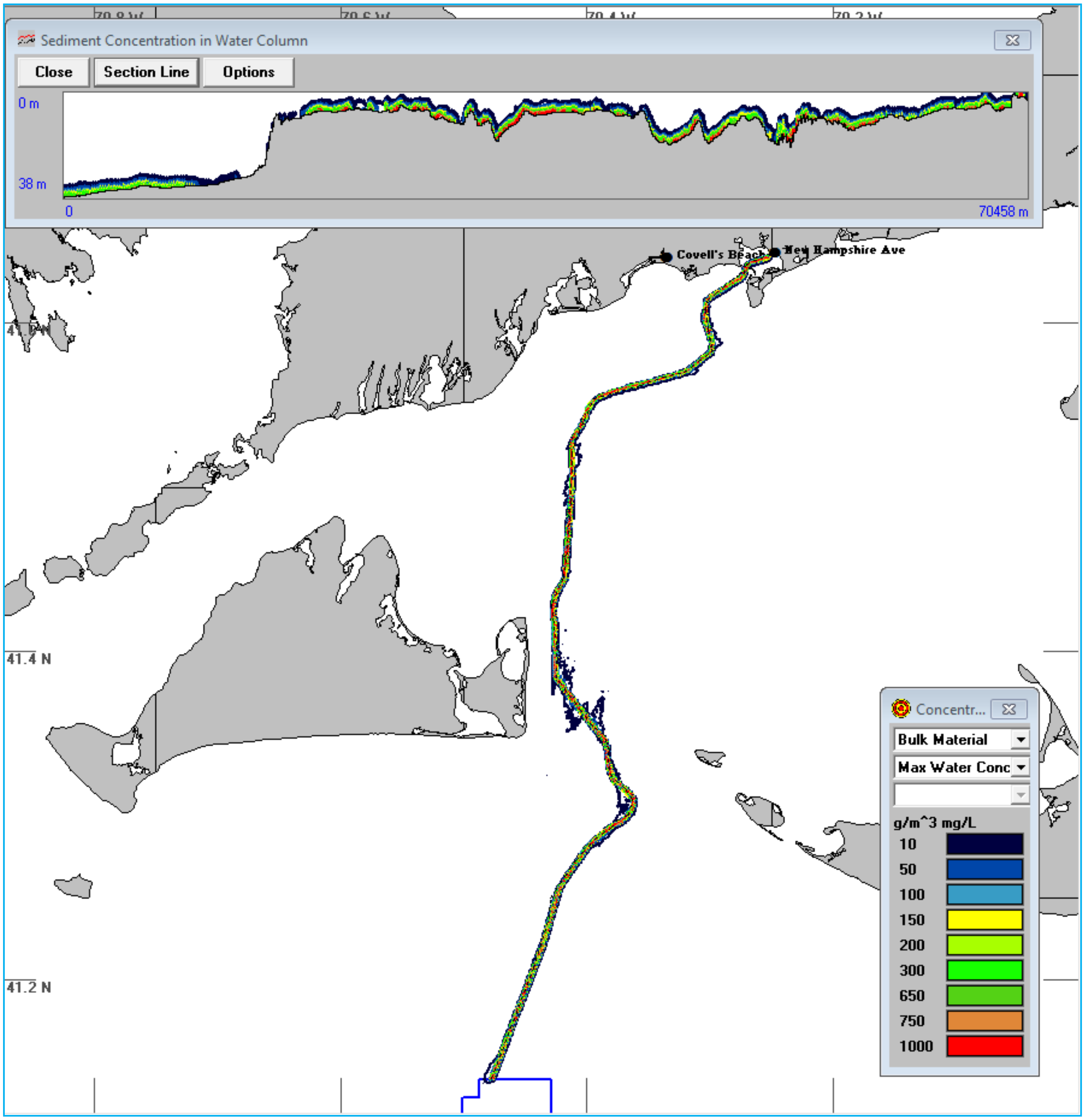
Time-Integrated Maximum TSS Concentration Associated with Cable Installation of One Cable for ETM to NH Avenue OEEC Using Typical Burial Parameters with Plan View (Lower Panel) and Vertical Section View (Upper Panel)



Vineyard Wind Project

Figure 5.2-13

Plan View of Deposition Thickness Associated with Cable Installation of One Cable for ETM to NH Avenue OEEC Using Typical Burial Parameters.



Vineyard Wind Project

VINEYARD WIND

Figure 5.2-14

Time-Integrated Maximum TSS Concentration Associated with Cable Installation of One Cable for ETM to NH Avenue OEEC Using Maximum Impact Burial Parameters with Plan View (Lower Panel) and Vertical Section View (Upper Panel) route simulated with typical parameters. Small differences between these two simulations of typical and maximum impact cable burial parameters exists, such as higher concentrations directly along the route and larger excursions of the 10 mg/L plume in places for the maximum impact parameters. Similarly the map of deposition associated with the maximum impact parameters is similar to that of typical parameters.

The map of deposition for the maximum impact OECC is presented in Figure 5.2-15. This figure shows that deposition is mainly centered on the route centerline with deposition of 1 mm (0.04 in) or greater limited to within ~140 m (~460 ft) from the centerline, though typically within 100 m (330 ft). Both Figures 5.2-14 and 5.2-15 indicate that most of the mass settles out quickly and is not transported for significant distances by the currents.

A comparison of modeling results is shown in Table 5.2-6 for the four OECC routes with four dredging and burial activities and typical installation parameters (plus one OECC route with maximum impact installation parameters) using four metrics: (1) maximum extent in km of the 10 mg/L contour of time-integrated maximum TSS concentrations, (2) the maximum extent in km of deposition greater than 1 mm (0.04 in) from the cable centerline, (3) the maximum extent in km of deposition greater than 20 mm (0.8 in) from the cable centerline, and (4) the area in km^2 with maximum TSS concentrations greater than 10 mg/L for various durations.

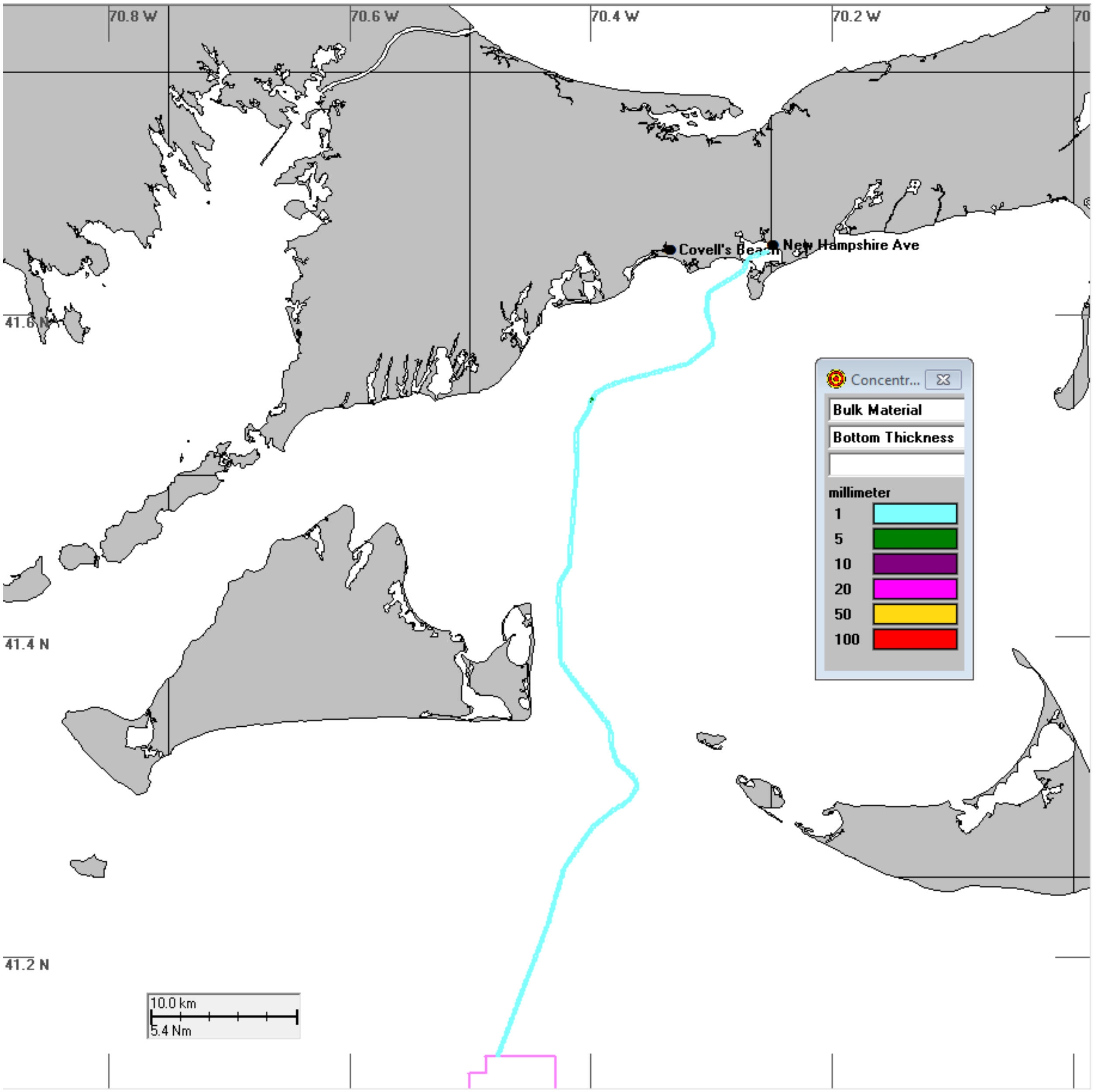


Figure 5.2-15

Plan View of Deposition Thickness Associated with Cable Installation of One Cable for ETM to NH Avenue OEEC Using Maximum Impact Burial Parameters.

Table 5.2-6 Maximum Extents and Duration Areas for the Four OECC Variants for Four Activities with Typical Installation Parameters and a Comparative Maximum Impact

OECC Route	Activity	Typ or Max	Maximum Extent of 10 mg/L Contour[1]	Maximum Extent of Deposition > 1 mm[1]	Maximum Extent of Deposition > 20 mm[1]	Area (km^2) over 10 mg/L for various durations (hrs)				
			(km)	(km)	(km)	1	2	3	4	6
WM to NH Ave	Limited TSHD Pre Dredge	Typ	20	0.95	0.70	2.36	0.168			
EM to NH Ave	Limited TSHD Pre Dredge	Typ	8.5	2.3	0.90	5.27	0.877	0.105		
WM to Covell's Beach	Limited TSHD Pre Dredge	Typ	20	0.95	0.7	2.26	0.178			
EM to Covell's Beach	Limited TSHD Pre Dredge	Typ	8.5	2.3	0.9	5.27	0.877	0.105		
WM to NH Ave	Cable Installation aided by Jetting	Typ	0.67	0.10	N/A	13.7	1.51	0.178		
EM to NH Ave	Cable Installation aided by Jetting	Typ	2	0.10	N/A	14.8	1.14	0.098		
WM to Covell's Beach	Cable Installation aided by Jetting	Typ	0.62	0.10	N/A	12.3	1.06	0.153		
EM to Covell's Beach	Cable Installation aided by Jetting	Typ	2.1	0.10	N/A	13.3	0.722	0.07	0.005	
WM to NH Ave	TSHD Pre Dredge	Typ	15.75	1.3	0.85	19.7	5.94	1.69	0.453	
EM to NH Ave	TSHD Pre Dredge	Typ	16	2.3	0.35	19.7	7.12	3.87	1.9	0.058

Table 5.2-6 Maximum Extents and Duration Areas for the Four OECC Variants for Four Activities with Typical Installation Parameters and a Comparative Maximum Impact (Continued)

OECC Route	Activity	Typ or Max	Maximum Extent of 10 mg/L Contour[1]	Maximum Extent of Deposition > 1 mm[1]	Maximum Extent of Deposition > 20 mm[1]	Area (km^2) over 10 mg/L for various durations (hrs)				
			(km)	(km)	(km)	1	2	3	4	6
WM to Covell's Beach	TSHD Pre Dredge	Typ	1575	1.3	0.85	17.4	3.85	0.833	0.085	
EM to Covell's Beach	TSHD Pre Dredge	Typ	16	2.3	0.35	17.2	5.7	2.78	1.18	
WM to NH Ave	Cable Installation	Typ	1.02	.10	N/A	13.5	1.45	0.181	0.015	
EM to NH Ave	Cable Installation	Typ	2	0.10	N/A	14.7	1.09	0.075		
WM to Covell's Beach	Cable Installation	Typ	0.86	0.10	N/A	12.1	1.06	0.15	0.015	
EM to Covell's Beach	Cable Installation	Typ	1.85	0.10	N/A	13.3	0.714	0.058		
EM to NH Ave	Cable Installation	Max	2.8	0.10	N/A	9.94	0.654	0.14	0.008	

1. Distances were measured from the nearest source, either the route centerline or disposal site. The disposal sites were approximately 250 m (820 ft) east of the centerline. Therefore the distances listed when measured from the disposal site are either +/- 250 m (820 ft) from the route centerline. The 20 mm (0.8 in) deposition was almost exclusively associated with the disposal site.

Specifically Table 5.2-6 presents the modeling results for both TSHD (either as part of the "TSHD Pre Dredge + Cable Installation" approach or as part of the "Limited TSHD Pre Dredge + Cable Installation aided by Jetting" approach) and for cable installation. Simulations of pre-cable installation dredging using a TSHD along the OECC show that plumes originating from the source are intermittent along the route, due to the intermittent need for dredging. The plume of excess TSS at 10 mg/L and 750 mg/L extends up to 16 km (9.9 mi) and 5 km (3.1 mi) from the route centerline for 2-3 hours, respectively, though may be less extensive at varying locations along the route. Relatively high concentrations (>1000 mg/L) are predicted at distances up to 5 km (3.1 mi) from the route centerline in response to the relatively high loading of dumping and swift transport of the dumped sediments, but this high concentration only persists for <2 hours. In general, the excess concentrations over 10 mg/L from dredging can extend several km (several mi) from the route centerline and may be present throughout the entire water column but are temporary and typically dissipate within about six hours. The deposition greater than 1.0 mm (0.04 in) associated with the THSD drag arm is mainly constrained to within 80 m (260 ft) from the route centerline whereas the deposition greater than 1.0 mm (0.04 in) associated with overflow and disposal extends to greater distances from the source (disposal locations ~ 250 m (820) east of the route centerline), mainly within 1 km (0.6 mi) though such deposition can extend up to 2.3 km (1.4 mi) in isolated patches when subject to swift currents through Muskeget Channel. Deposition greater than 20 mm (0.8 in) resulted only from the disposal activities. Since the disposal takes place away from the route centerline the majority of the 20 mm (0.8 in) thickness was located in isolated patches offset from the route centerline. Very small patches of areas greater than 20 mm (0.8 in) were noted up to ~0.9 km (~0.6 mi) from the disposal site, however such occurrences were not typical; typically the 20 mm (0.8 in) deposition was within 0.35 km (0.22 mi) from the source.

The simulations of the cable installation showed that both the footprint of the 10 mg/L excess concentration plume and the footprint of deposition over 1.0 mm (0.04 in) stayed close to the route centerline. The maximum excursion of the 10 mg/L excess plume extended up to ~2 km (~1.2 mi), though typically less than 200 m (660 ft) from the route centerline. The excess concentrations stemming from cable installation, both with and without jetting for sand wave clearance, remain relatively close to the route centerline, are constrained to the bottom of the water column, and are also short-lived (typically dissipating within 4-6 hours). Deposition greater than 1.0 mm was limited to within 100 m (330 ft) from the route centerline, though was mainly within 80 m (260 ft).

A simulation of one variant of the OECC was also run using maximum impact parameters for cable installation. This simulation showed relatively similar results as compared to the simulation with typical cable installation parameters; however, the maximum impact simulation had more areas of higher concentration directly along the route and a slightly larger excursion of the 10 mg/L plume. The deposition patterns of the maximum impact cable installation simulation were similar to the typical cable installation parameters, with deposition greater than 1.0 mm (0.04 in) limited to within 140 m (460 ft) from the route centerline, though typically within 100 m (330 ft).

5.2.2.1.3 Impact of Horizontal Directional Drilling at Cable Landfall

HDD may be used, as described in Section 4.2.3.8 of Volume I, to avoid impacts of standard cable burial techniques in the nearshore region. These activities will only occur in the OECC. HDD operations may involve temporary removal of sediments from within a partial cofferdam. After cable connection activities are completed, the sediment will be replaced. It is possible that potential, limited sediment releases could occur during the refilling operation but impacts would be localized and short-term.

5.2.2.1.4 Scour Protection Installation

Installation of the rocks or stones for scour protection will occur at each WTG and ESP foundation. The area of scour protection will be limited to 2,100 square meters ("m^2") (0.52 acres) at each WTG and 2,500 m^2 (0.62 acres) at each ESP. Placement of the rock may yield a temporary increase in suspended sediments due to resuspension of bottom sediments as the rock is placed; however, such impacts are anticipated to be a short-term and temporary due to the predominately sandy composition of the upper sediments in the WDA.

5.2.2.1.5 Routine Releases from Vessels

Some liquid wastes are allowed to be discharged to marine waters in both the WDA and OECC. These discharges include domestic water, uncontaminated bilge water, treated deck drainage and sumps, uncontaminated ballast water, and uncontaminated fresh or seawater from vessel air conditioning. As defined, these discharges will not pose a water quality impact. Other waste generation such as sewage, solid waste or chemicals, solvents, oils and, greases from equipment, vessels or facilities will be stored and properly disposed of on land or incinerated offshore and will not generate an impact.

5.2.2.1.6 Avoidance, Minimization, and Mitigation Measures

Water quality related to suspended sediments from cable installation, dredging and other construction activities, as appropriate, will be monitored. Details of the monitoring effort will be developed with the appropriate state and federal agencies (Massachusetts Department of Environmental Protection 401 Regulatory Program and the US Army Corps of Engineers) during other permitting processes. The monitoring is anticipated to consist of using a hand-held or similar turbidity sensor deployed from a small vessel to collect turbidity readings from multiple depths within the water column. If determined to be appropriate, collection of water samples for subsequent analysis for total suspended solids (TSS) could be made from the vessel to quantify the sediment concentration in the plume. Background levels outside of the plume for turbidity (and TSS, if appropriate) could also be acquired.

The Project will require all vessels to comply with regulatory requirements related to the prevention and control of discharges and the prevention and control of accidental spills. All vessels will comply with the USCG ballast water management requirements at 33 CFR Part 151 and 46 CFR Part 162. The USCG regulations include the same discharge standards as the International Maritime Organization (IMO) Ballast Water Management Convention (BWM) standards, but also include additional requirements beyond the IMO's requirements. Under the USCG regulations, additional measures to prevent the discharge of contaminated bilge water include:

- Regular cleaning of ballast tanks to remove sediments

- Rinsing of anchors and chains when anchors are retrieved
- Removing fouling from the hull, piping, and tanks on a regular basis
- Maintaining a ballast water management (BWM) Plan
- Maintaining records of ballast and fouling management
- Submitting a report containing vessel and ballast water management information 24 hours before calling at a US port

Ballast water management options that may be used by the Project's vessels include:

- Performing an exchange of ballast water (refilling the ballast tanks with sea water from the open ocean) beyond the Exclusive Economic Zone in areas more than 200 nm from any shore;
- Retaining the vessel's ballast water on board the vessel in a sealed tank;
- Using only water from a US public water system as ballast water in ballast tanks that have been cleaned; or
- Installing and operating a Ballast Water Treatment System (any system that processes ballast water to kill, render harmless, or remove organisms) which use technologies such as filtration, chemical disinfection using biocides, ultra-violet treatment, deoxygenation, heat, cavitation, electric pulses, and magnetic fields.

Since it is not known exactly which vessels will be used during the Project, the specific ballast water management option used by the Project's vessels are unknown.

The Project's vessels will meet USCG bilge water regulations in 33 CFR Part 151, which are based on the MARPOL Annex I Regulations for the Prevention of Pollution by Oil. Bilge water will either be retained onboard vessels in a holding tank and discharged to an onshore reception facility or treated onboard with an oily water separator, after which the treated water can be discharged overboard. Among several other conditions, bilge water cannot be discharged into the sea unless the oil content of the bilge water without dilution is less than 15 ppm. For vessels operating within 3 nm from shore, bilge water regulations under EPA's NPDES program apply to any vessel of the Project's vessels that are covered by a Vessel General Permit (those that are 79 ft or greater in length). Bilge discharges within 3 nm from shore are subject to the rules in Section 2.2.2 of Vessel General Permit and must occur in compliance with 40 CFR Part 110, 40 CFR Part 116, 40 CFR Part 117, and 33 CFR 151.10.

The Project has also developed a draft Oil Spill Response Plan, which is included in Appendix I-A.

5.2.2.1.7 Summary

The modeling analyses conducted above indicate that, for both the inter-array cables and the OECC, mobilized sediment is not transported far by the currents in most cases and settles rapidly. Sediment plumes greater than 10 mg/L typically persist at any given point for less than six hours, and in no case for more than 12 hours. The plume is generally confined to the bottom three meters (9.8 ft) of the water column, which is usually only a fraction of the water column, and maximum deposition is typically less than 5 mm (0.2 in). The plume from dredging, however, extends from the surface to the bottom due to overflow and disposal. Other water quality impacts from HDD operations or scour protection installation are similarly anticipated to be short-term and localized. Routine release from vessels will be limited to uncontaminated or properly treated liquids. Therefore, impacts to water quality from the Project will be short-term and localized.

5.2.2.2 Operations and Maintenance

5.2.2.2.1 Routine Releases from Vessels

Routine releases from vessels used during operations and maintenance, such as crew transfer vessels, are expected. These discharges may include domestic water, bilge water, engine cooling water, deck drainage and/or ballast water. BOEM (2014) determined the following related to potential water quality impacts from routine vessel discharges: "[I]n the WEA, coastal and oceanic circulation and the large volume of water would disperse, dilute, and biodegrade vessel discharges relatively quickly, and the water quality impact would be minor."

5.2.2.2.2 Avoidance, Minimization, and Mitigation Measures

Similar to the requirements above for construction and installation, the Project will require all vessels to comply with regulatory requirements related to the prevention and control of discharges and the prevention and control of accidental spills. The Project has also developed a draft Oil Spill Response Plan, which is included in Appendix I-A.

5.2.2.3 Decommissioning

The decommissioning of Project facilities and equipment will likely include removing the WTGs and ESPs above the mudline, removal of scour protection, and may include retirement in place or removal of offshore export cables. Removal of export cables and scour protection may cause short-term and localized generation of suspended sediments. To the extent feasible and appropriate, the Project will follow the avoidance, minimization and mitigation measures listed above under construction and installation for the decommissioning of the Project. Due to the long lifespan of the Project, it is also expected that technology will be enhanced by the time decommissioning occurs and impacts reduced.

5.3 Geology

5.3.1 Description of the Affected Environment

This section presents an overview of the site geology in the Wind Development Area ("WDA") and the Offshore Export Cable Corridor ("OECC"). For a more detailed and comprehensive description of site conditions, see Volume II-A.

Geology Background

The upper veneer of the earth's crust forms the foundation of the northern Atlantic Ocean and Nantucket Sound underlying the Project Area, and is comprised of thick deposits of coastal plain sediments that accumulated over hundreds of thousands of years. Multiple glacial advances then scoured and transported pieces of bedrock and coastal plain materials south, depositing thick discontinuous sheets of sediments in a variety of sub- (under) and pro- (in front of) glacial environments. Meltwater streams further reworked and deposited materials under the ice and carried sediment farther south, away from the glacier (outwash plains), sorting the material with distance. Associated sea level fluctuations subsequently reshaped this landscape at the land-sea interface as periods of transgression and regression further modified the coastal zone. Ultimately, the majority of the sediments on and around the Cape and Islands were deposited there by the last major glacial episode during the Wisconsin stage (18,000-24,000 years ago) of the Pleistocene Epoch (Oldale, 1992).

At the end of the last Ice Age (20,000–26,000 B.P.), when the Wisconsinan glacier started to retreat, sea level is believed to have been 120-130 m (394-427 ft) lower than it is today. Sea level began to rise, but not in a linear fashion, with periods of faster and slower increase (BOEM, 2013; National Aeronautics and Space Administration ["NASA"], 2015). Since that time, the sea has risen at different rates, but has continued to inundate the coast, submerging and eroding previously exposed land areas and features during its transgression landward throughout the Holocene Epoch. The process of transgression is a destructive mechanism that removes and reworks the upper layers of the land surface; the depth of erosion depends on the location along the coast (open and exposed vs. in an estuary). Initially, the ocean floods low lying areas, such as river channels and embayments, infilling those depressions with reworked sediment from shoreface retreat. As a result of this transgression, depressions in the onshore topography scoured by the glacier were eventually inundated by the sea and formed coastal estuaries and sounds. Today's sea level elevation was attained 3,000-5,000 years ago.

Existing Geologic Conditions

Geologically, conditions today are not much different than 10,000 years ago; coastal processes continue to modify the nearshore geomorphology as the shoreline retreats due to sea level rise. The general lack of any major rivers in southeastern Massachusetts means there is no terrigenous sediment supply to the nearshore environment and inner continental shelf. As a result, sediments on the seafloor are primarily reworked from older glacial deposits. Sediment is transported by longshore drift and tidal currents on a daily basis, with episodic storm events causing more severe erosion and redistribution.

Sediments in the WDA and along the OECC in water depths greater than 30 m (98.4 ft) are predominantly fine sand with some silt, becoming slightly finer in the offshore direction. Heading north through Muskeget, median grain size increases, with sand and gravel dominant, along with coarser deposits (cobbles and boulders) locally. This zone of coarse material between Martha's Vineyard and Nantucket is believed to mark the position of the terminal moraine deposited at the southernmost limit of the Wisconsin glacier. Continuing north into the main body of Nantucket Sound, sand still dominates the seabed, with coarser deposits concentrated around shoals and in high current areas; finer grained sediments occupy deeper water and/or more quiescent flow areas. Bedforms (see Hazards and Unique Geologic Features, below) are common due to the response of the sandy surficial layer to tidal currents with active sediment transport in many areas.

Environmental Conditions

While met-ocean data offshore in the vicinity of the WDA are scarce, publicly available datasets acquired for nearby projects (RICRMC, 2010) and estimates from a tide and wind driven model indicate currents throughout the water column are generally low at <0.36 m/s (0.7 kn) with average bottom current flows <0.2 m/s (0.39 kn). Refer to Appendix III-K for a discussion of currents and scour.

Oceanographic factors around Cape Cod and the Islands can be dramatic, as the coastal geomorphology plays a significant role in constricting the movement of water masses horizontally, between land and shoals, as well as vertically over shoals, which increases the flow velocity locally. Muskeget Channel is an excellent example of this, routinely experiencing tidal flow velocities in excess of 3.5 knots (1.8 + meters per second ["m/s"]). Elsewhere in the main body of Nantucket Sound (the "Sound"), tidal currents are generally 1-1.5 knots (0.51-0.77 m/s) with higher flows locally. The tides are semi-diurnal (two highs and two lows daily) and thus redistribute material and reshape the bottom during each maximum flow period, four times each day.

In the central portion of the Sound on and around Horseshoe Shoal, sand is transported in both directions by the tide but an overall net movement to the east has been suggested by previous research (Sanford & Flick, 1975), as the flood tide (easterly flow) is slightly stronger than the ebb (flows west). In the southern portion of the Sound along the OECC and east of Martha's Vineyard, flood and ebb directions turn more north-south as the water transits in and out through Muskeget Channel. Recent studies in this area suggest the ebb tidal component of the tide may be slightly stronger than the flood (SMAST study; Howes et al., 2011). Relative strength and velocities of the tidal currents also change with the lunar cycle and may be enhanced or reduced by episodic environmental conditions (discussed below).

Wind and seas are more of a factor offshore south of the islands, since any southerly component (SW, S, and SE) to the wind can result in large seas and swell in open water. Conversely, while seas can build in Nantucket Sound and create difficult conditions, there is limited fetch available between the islands and Cape Cod such that, for most wind speeds and directions, wave height will be less in the Sound than offshore. Numerous shoals also force waves to build and break, acting, to some extent, as barriers that prevent longer period wave trains from reaching the coastlines.

Coincidental opposition or alignment of these natural forces is simply a function of timing and can cause worse conditions than normal. Strong winds opposing maximum tidal flow can create above average wave heights and even standing waves, particularly in constricted waterways like Muskeget Channel. Similarly, water levels can rise above normal and flood low lying coastal regions when a passing storm system pushing water onshore combines with spring tides (new moon or full moon tidal phases). While Category 3 hurricanes are fairly rare in New England, nor'easters are much more common and also bring increased winds, seas, and coastal water levels.

The annual average wind speed is approximately 13 knots (6.7 m/s) just above the sea surface, compared to a higher average value calculated for the Project Envelope hub height of 109-121 m. The highest maximum mean wind speeds for the year occur during the months of October and November. The resulting waves generated by the average wind speeds produce mean significant wave heights of less than 1 m (3.3 ft) in Nantucket Sound and 1.8 m (5.9 ft) offshore south of the islands. Maximum average significant wave heights offshore range from 5.0 m (16.4 ft) in August to 11.5 m (37.7 ft) in September (NOAA buoy 44008, 1982-2008) with larger waves generated during isolated storm events. The protected waters of Nantucket Sound exhibit much lower maximum wave conditions, with an average of 1-2 m (3.3-6.5 ft), which may be exceeded during episodic meteorological events. Dominant wind and sea direction is from the southwest and south with a secondary component from the northwest.

Hazards and Unique Geologic Features

A dynamic equilibrium exists on the seabed between the tidal currents and surficial sediment, which in many locations around Nantucket Sound generates extensive fields of bedforms (ripples, megaripples, and sand waves) indicating active sediment transport and scour on the bottom. The sediment moves back and forth with the flood and ebb tidal currents, often with a slight net movement in one direction over the other. These conditions frequently maintain the bedforms over long periods of time, with the size of the features dependent upon the velocity of the currents, sediment grain size, water depths, bottom slope, and more. Average bedform relief in the WDA is 0.3-0.5 m (1.0-1.6 ft) within discontinuous patches of ripples-megaripples; in the vicinity of the OECC, average relief is 1-1.5 m (3.3-4.9 ft). Increased sand wave heights of up to 5-9 m (16.4-29.5 ft) exist locally in high current areas within the Sound.

Coarse material (gravel, cobbles, and boulders in a sand matrix) is prevalent in the region due to proximity to the southernmost extent of the ice sheet in the last glacial episode during the Wisconsin stage. The glacier deposited huge volumes of coarse material as a terminal moraine that follows the north shore of Martha's Vineyard and Nantucket, extending slightly south of the islands in-between Martha's Vineyard and Nantucket. Sonar and video data thus reveal an abundance of surficial coarse deposits in the Muskeget Channel area, ranging from a sparse distribution to a high concentration locally; boulders greater than 1 m (3.3 ft) diameter have been identified. In a number of places, sandy bedforms are migrating over this coarse layer which is exposed in the troughs between individual sand waves.

Offshore in the WDA, coarse deposits do not exist on the seafloor but are interpreted from seismic profiles to be buried deeper below the surface, primarily in the southwestern portion of the area. Potential boulders and associated coarse/dense sediments may be found at depths of 20-45 m (65.6-147.6 ft) below the seafloor, and appear to be related to an extensive buried channel that crosses the southwestern portion of the WDA. The location and distance of the WDA from the mapped southern extent of the last glacial maximum (during the late Pleistocene), and depth of the deposits in the stratigraphic column, indicate this coarse material was likely deposited here during earlier glaciations (early-mid Pleistocene, >130,000 years ago), which are believed to have extended farther south on the then-exposed coastal plain. In addition, several buried channel systems are evident on the seismic profiles at similar and shallower depths below the seafloor that are indicative of former glacial meltwater drainage. Like the lithologic units the channels are incised into, fill materials range from clay to gravel and boulders. No large sediment type changes or stratigraphic inconsistencies have been identified across the channel basal unconformities.

5.3.2 Potential Impacts of the Project

Table 5.3-1 below summarizes the analysis of the impact of Project activities on geologic resources.

Table 5.3-1 Impact-producing Factors on Site Geology

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommiss-ioning
Pile driving for WTG and ESP foundations	X		X		X
Scour protection installation	X		X		X
Cable installation	X	X	X	X	X
Cable protection		X	X	X	X
Dredging		X	X		
Horizontal directional drilling		X	X		X

5.3.2.1 Construction and Installation

5.3.2.1.1 Pile- Driving for WTG and ESP Foundations

Wind Development Area

Pile-driving WTG and ESP foundations into the subsurface will displace and disturb sediments slightly during this action. Some sediment will be suspended locally in the water column and will settle back out on the seafloor on the same sediment type. Generally, low current velocities means that suspended material will not be transported very far (see Section 5.2). This impact is anticipated to be short-term and localized.

5.3.2.1.2 Scour Protection

Wind Development Area

Placement of scour protection materials around the WTG and ESP foundations will cover, but not alter, the finer granular soils (fine sand-silt) around the offshore component bases. The scour protection material may be rocks or stones placed on the bottom around the WTG and ESP foundations. The area of scour protection will be limited to 2,100 m^2 (0.52 acres) at each WTG and 2,500 m^2 (0.62 acres) at each ESP. Some finer sediment will be suspended during placement of this material and moved laterally by currents, but it will be redeposited on the same sediment type nearby.

While the *in situ* sediment composition of the existing geologic resource is not being changed, and the material is only being covered by the scour protection, after installation, the surficial geology could be viewed as having a long-term modification since rock would be on the seafloor instead of finer grained sediment.

5.3.2.1.3 Cable Installation

Wind Development Area

During installation of the export and inter-array cables, finer grained sediment offshore (fine sand to silt) will be displaced by the cable installation tool (cable installation methods are described in Section 4.2.3.3 of Volume I). Sediment suspension will occur with minimal transport and settling on the adjacent seafloor, resulting in a very thin veneer of newly deposited sediment (see Section 5.2). No change in sediment type will occur as all materials in the upper 2 m (6.5 ft) of the seabed are similar.

Offshore Export Cable Corridor

Prior to cable installation, dredging is planned in discrete locations along the cable corridor where sand waves exceed a height tolerance and prevent the cable from being installed at a suitable depth below the seabed. Sediment from the top portion of individual bedforms will be removed and side-cast temporarily. Seabed disturbance from any dredging is temporary due to the high mobility rate of the surficial sands, which would immediately work toward attaining the original dynamic equilibrium that existed prior to construction activity.

After any needed dredging is completed, cable installation will occur. Greater variability in geologic conditions along the ECCs will require a range of installation techniques to be employed. Finer granular sediments (silt-sand-gravel) will be displaced during cable installation. As sediments become coarser and more concentrated, particularly for materials larger than gravel, different installation tools may have to be used to achieve suitable cable burial (as described in Section 4.2.3.3 of Volume I, these include plowing, trenching, boulder clearance, etc.). As grain size increases, the amount of suspended sediment is reduced with more material redeposited closer to the installation tool. Additionally, limited vessel anchoring may occur during cable installation. Overall, the geology resource is not being modified by the construction activity and sediment deposition; rather, the sediments are simply being reworked in place.

Finally, where planned burial depths cannot be achieved, cable protection may be deployed. See the section on cable protection below for additional information.

5.3.2.1.4 Cable Protection

Wind Development Area and Offshore Export Cable Corridor

Where coarse material may prevent export cable burial deep enough below the seafloor or in other instances where sufficient burial cannot be achieved, protective covering such as rock or concrete mattresses may be placed on top to reduce risk to the cable (see Section 3.1.5.3 of Volume I). In areas of existing coarse material, the cable protection will not modify the coarse deposits underneath (though if concrete mattresses are used, a man-made hard bottom material will be placed over a natural hard bottom layer). This may increase the seafloor relief slightly in that localized area.

5.3.2.1.5 Horizontal Directional Drilling

Offshore Export Cable Corridor

Horizontal directional drilling ("HDD") may be conducted under the shoreline at the Landfall Sites to avoid impact to the nearshore subtidal, intertidal, and beach or backshore zones. As described in Section of 4.2.3.8, after completion of the HDD, all portions of the

HDD conduit are safely buried below the seafloor and offshore ground surface. Since HDD involves drilling a relatively small borehole through the sediment layers underlying the coastal zone, it will not affect the stability or structural integrity of the stratigraphic units that are the foundation of the shoreline.

5.3.2.1.6 Avoidance, Minimization, and Mitigation Measures

Methods to avoid, minimize, and mitigate impacts during construction and installation are summarized below.

- Site WTG and ESP foundations in suitable geologic locations to minimize maintenance due to geotechnical issues over the structure's life span. Micro-siting after the 2018 survey will further refine WTG and ESP positions.
- To the extent feasible, avoid areas with adverse seabed conditions during cable route feasibility and planning.
- Micro-site cable positions within the final export corridor to minimize impact to sensitive habitats.
- Use appropriate installation methods and tools to minimize disturbance.
- To the extent feasible, avoid using cable protection in sand wave fields by allowing dredging and using the appropriate installation tool to achieve deep burial into the underlying stable sediment layer.

5.3.2.1.7 Summary of Impacts

Geologic resources include the seafloor and subsurface materials, as well as any features or structures associated with the local and regional geology (e.g. stratigraphic formations, faults, buried channels). The installation of Project components does not change the sediment composition or overall context of the geological resource. Construction will simply displace and rework some of the materials locally. Further, the localized disturbance may be modifying sediments from the same layer with common physical characteristics (grain size, shell and water content, etc.).

Accordingly, pile driving, dredging, HDD, cable installation, and scour protection installation will primarily result in short-term, localized impacts that are limited to the area of the activity. Cable installation may result in a slight modification to the seafloor morphology (seabed scar), though impacts will be limited to the immediate and narrow cable installation trench. Additionally, cable protection may replace existing hard bottom with rock or man-made hard bottom. Overall, Project impacts to geological resources are largely expected to be short-term and localized.

5.3.2.2 Operations and Maintenance

Limited activities during operations and maintenance are anticipated to impact geologic resources. If a section of an export cable becomes exposed on the seafloor due to the natural removal of sand by the bedform migration process or an extreme storm event, maintenance operations in that area will need to be performed to rebury or cover the cable. The activities involved in this maintenance are generally the same as previously discussed above under Construction and Installation.

5.3.2.2.1 Cable Reburial

Offshore Export Cable Corridor and Wind Development Area

As described above under Construction and Installation, some displacement of sediments may occur during any needed cable reburial, though no change in sediment type will occur.

5.3.2.2.2 Cable Protection

Offshore Export Cable Corridor and Wind Development Area

If exposure, scour, or risk to the export cable(s), inter-array cables, or inter-link cables cannot be mitigated through reburial or other means, adding cable protection for exposed sections may be considered. As described above under Construction and Installation, the cable protective material will cover but not alter the underlying sediments. Some suspended sediment will occur during installation and may be transported down current from the point of construction.

5.3.2.2.3 Avoidance, Minimization, and Mitigation Measures

Methods to avoid, minimize, and mitigate impacts to geologic resources during operations and maintenance are summarized below.

- ♦ Conduct post-construction monitoring for cable exposure.
- ♦ Should cable reburial be necessary, rebury the cable into the stable seabed.

5.3.2.2.4 Summary

In summary, any cable reburial or protection activity is anticipated to be a localized, short-term impact to geologic resources.

5.3.2.3 Decommissioning

As described in Section 4.4 of Volume I, decommissioning includes removing WTGs and ESPs, cutting each monopile or jacket at the mudline (including removing and then replacing sediments from inside the foundation), removing scour protection and cable protection, and potentially removing the offshore export cable system (export cables, inter-array cables, and inter-link cables). Removal of Project components will create some suspended sediment locally that will only be transported a short distance away and produce only a thin veneer of new accumulation. If cable removal is required, some impact to seafloor morphology may occur, including the creation of new seafloor relief. Likewise, removal of the scour protection at each foundation or cable protection materials may result in a long-term change in surficial geology from rock, stones or other hard bottom materials back to finer grained sediments or the previously-exposed hard bottom sediments. Overall, removal of the WTG and ESP foundations above the seafloor is interpreted as a short-term, localized impact.

Section 6.0

Biological Resources

6.0 BIOLOGICAL RESOURCES

6.1 Terrestrial Fauna Including Inland Birds

This section addresses impacts to terrestrial wildlife species, including inland birds, associated with the Project's onshore facilities. These facilities, which include a duct bank, splice vaults, and an onshore substation, are described in detail in Section 2.2.1 and are located between the potential Landfall Sites in Barnstable or Yarmouth and the Project's utility interconnection point in Barnstable.

Coastal and marine birds are discussed in Section 6.2 and bats are discussed in Section 6.3. Coastal habitats are discussed in Section 6.4.

6.1.1 Description of the Affected Environment

The terrestrial areas impacted by the Project include those along the Onshore Export Cable Route, the Project's onshore substation, and utility interconnection point at the Barnstable Switching Station or West Barnstable Substation. Coastal areas and habitat impacted by the Project's horizontal directional drilling ("HDD") Landfall Site are discussed in Section 6.4, below.

6.1.1.1 Terrestrial Habitats

Onshore Export Cable Route

As described in Section 3.0 of Volume I and as shown on Figure 2.2-1 in Volume I, the Project Envelope includes two main Onshore Export Cable Routes: one from the Covell's Beach Landfall Site to the onshore substation (the Western Onshore Export Cable Route) and a second from either the New Hampshire Avenue to the onshore substation (the Eastern Onshore Export Cable Route). For both Onshore Export Cable Routes, the majority of each route is located beneath paved roadways that pass through residential and commercial areas and have sufficiently wide shoulders to avoid impacts to terrestrial wildlife habitat.

The segments of the Onshore Export Cable Routes that are not located beneath paved roadways follow other previously disturbed corridors, such as railroad and electric transmission rights-of-way ("ROW"), thereby minimizing potential impacts to terrestrial wildlife. A description of the two potential Onshore Export Cable Routes is included below.

Western Onshore Export Cable Route from Covell's Beach Landfall Site

- Approximately 2.6 kilometers ("km") (1.6 miles ["mi"]) of the Western Onshore Export Cable Route is located off-road and along a utility ROW. This route crosses active sand and gravel mining and processing facility, several commercial properties, and an area controlled by the Town of Barnstable and subject to a conservation restriction. Outside of the active industrial and commercial areas, the ROW is managed by the utility to exclude incompatible vegetation, including most trees and all tall-growing plant species. As a result of these management practices, the habitat within the utility ROW is predominantly grass and scrubland.

Eastern Onshore Export Cable Route from New Hampshire Avenue

- Approximately 0.8 km (0.5 mi) of the Eastern Onshore Export Cable Route is located along a railroad corridor owned and operated by the Massachusetts Department of Transportation. Within this segment, the duct bank would be installed beneath the existing rail bed, requiring temporary removal of the rails and ties. This work would take place during the winter months when the railroad is not in service. The rail bed would then be restored to preconstruction condition. The duct bank installation for this segment can be completed entirely within a previously disturbed area thereby minimizing direct disturbance to any adjacent wildlife habitat.

- Approximately 1.9 km (1.2 mi) of the Eastern Onshore Export Cable Route is located off-road and along a utility ROW. This route traverses a rolling landscape that is actively managed by the utility to exclude incompatible vegetation, including most trees and all tall-growing plant species. As a result of these management practices, the habitat within the utility ROW is predominantly grass and scrubland with graminoids, goldenrods (*Solidago* spp.), asters (Asteraceae), and various forbs. Low-growing shrubs include Scrub Oak (*Quercus ilicifolia*), Sweet Fern (*Comptonia peregrina*), Bayberry (*Morella pensylvanica*), Southern Arrowwood (*Viburnum dentatum*), Northern Arrowwood (*V. recognitum*), Green Briar (*Smilax rotundifolia*), Highbush Blueberry (*Vaccinum corymbosum*), Lowbush Blueberry (*V. angustifolium*), and Huckleberry (*Gaylussacia baccata*).

  The Project is also evaluating a route variant that would follow a proposed bike path approximately 2.1 km (1.3 mi) through the Hyannis Ponds Wildlife Management Area ("HPWMA") as an alternative to the preferred routing within the utility ROW. The HPWMA is predominately a Pine-Oak forest community. Vegetation is comprised primarily of Pitch Pine *(Pinus rigida)* and Scarlet Oak *(Quercus coccinea)* in the tree layer with Black Huckleberry *(Gaylussacia baccata)* and Lowbush Blueberry *(Vaccinium angustifolium)* dominant in the understory. Bracken Fern *(Pteridium aquilinum)* and Teaberry *(Gaultheria procumbens)* are common ground covers. The HPWMA is managed by the Massachusetts Division of Fisheries and Wildlife ("MassDFW") for both hunting and passive recreation purposes.

Approximately 0.6 km (0.4 mi) of the Eastern Onshore Export Cable Route is located along an unimproved dirt access road that leads from Mary Dunn Road to the utility ROW and Barnstable Switching Station. This access road varies in width from 3.7 to 6.1 meters ("m") (12 to 20 feet ["ft"]) and is located directly south of the Route 6 highway layout. Duct bank installation in this segment would require clearing of approximately 740 square meters ("m^2") (8,000 square feet ["ft^2"]) of vegetation, primarily Pitch Pine and Oak saplings, along the more narrow sections of the access road.

Along the portion of either Onshore Export Cable Route, no areas of rare species habitats have been mapped by the MassDFW, Natural Heritage and Endangered Species Program ("NHESP"). Coastal rare species habitat associated with the Landfall Sites are discussed in Section 6.4.

Additionally, no segment of any Onshore Export Cable Route crosses wetlands. However, the Onshore Export Cable Route from the New Hampshire Avenue Landfall Sites crosses over a culvert that carries Thornton Brook beneath Higgins Crowell Road in Yarmouth (see Figure 6.1-1). For this route, there are also two wetland areas adjacent to the utility ROW: one on the north side of the corridor just west of the railroad in Yarmouth (see Figure 6.1-1) and another along the south side of the corridor and just west of Mary Dunn Road (see Figure 6.1-2). At both of these locations, the Onshore Export Cable Route is more than 30 m (100 ft) from these wetland areas and they will not be impacted by the Project. There are no other wetland areas within 30 m (100 ft) of the Project's onshore facilities.

Onshore Substation Site

The Project's onshore substation is located on the eastern portion of a previously developed site within the Independence Park commercial/industrial area in Barnstable, as shown in Figures 6.1-1 and 6.1-2. The site consists of approximately six acres of mostly wooded land, but also includes some previously developed parking areas. The topography of the site is moderately hilly with elevations ranging from a low of approximately 18 m (60 ft) (NAVD88) in the southern portion to approximately 30 m (100 ft) along the northern boundary (Town of Barnstable GIS).

The site vegetation is comprised primarily of Pitch Pine and Scarlet Oak in the tree layer with Black Huckleberry and Lowbush Blueberry dominant in the understory. Bracken Fern and Teaberry are present as ground covers. These types of Pitch Pine-Oak forests are very common on Cape Cod, often developing in sandy areas that have been subjected to repeated burnings (DeGraaf and Yamasaki, 2001).

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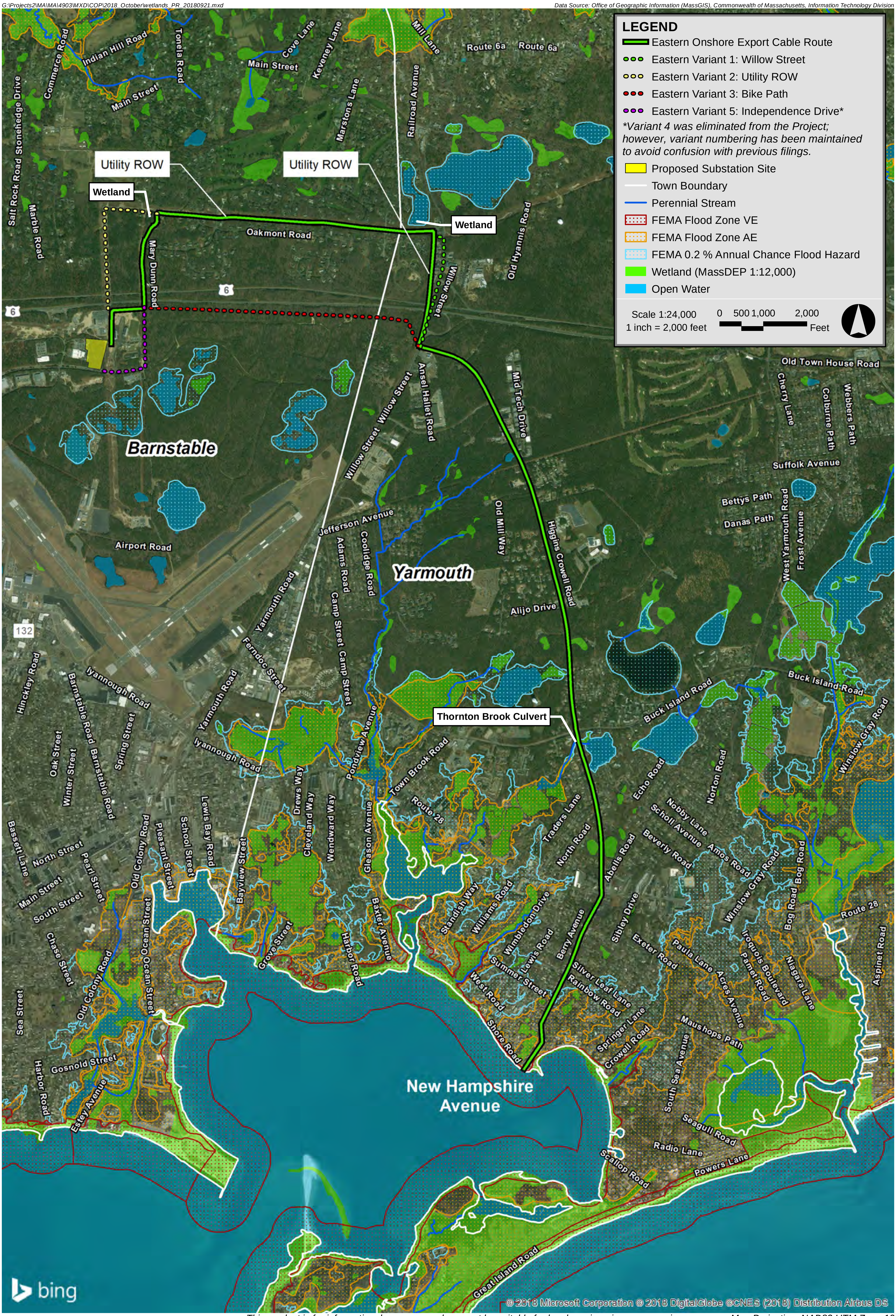
Data Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 6.1-1

Wetlands Proximate to the Onshore Export Cable Route (New Hampshire Avenue)

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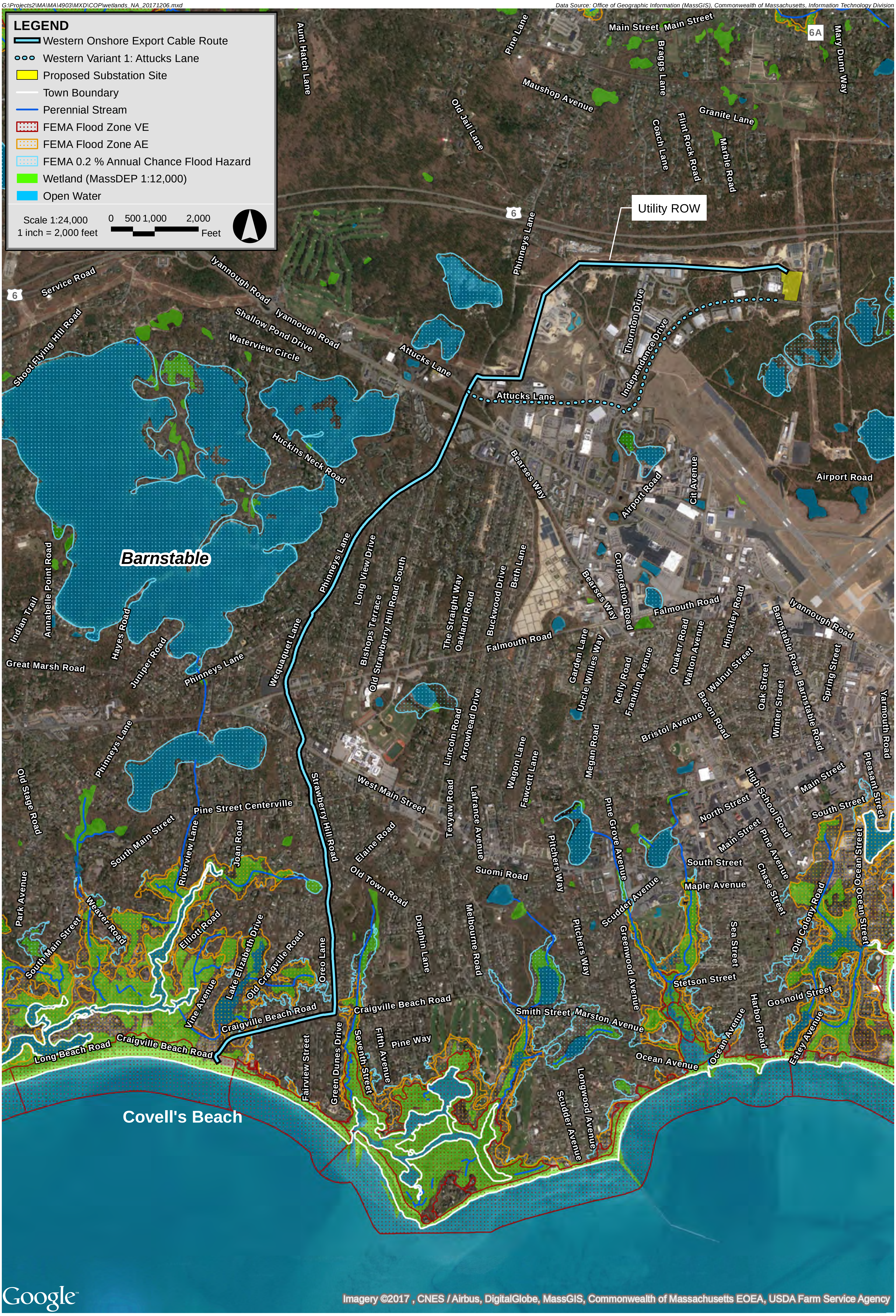
Data Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division



Vineyard Wind Project

VINEYARD WIND

Figure 6.1-2

Wetlands Proximate to the Onshore Export Cable Route (Covell's Beach Landfall)

As the site lacks any available water source, it does not provide suitable habitat for amphibians or other non-avian animal species with limited home range. However, some small ponds are located within 430 m (1,400 ft) of the site, which is well within the range of several mammal species commonly found on Cape Cod (see Section 6.1.1.2).

6.1.1.2 Terrestrial Fauna including Inland Birds

Massachusetts hosts a diversity of wildlife habitats. Species distribution across the state is reflective of this diversity. However, many specialized wildlife species that are known to occur in other parts of the state are virtually absent from Cape Cod, where Pitch Pine-Oak forests and scrub-shrub habitats predominate. Conversely, the coastal areas of the Project Area are favored by many species that are not present in appreciable numbers farther inland (Natural Heritage & Endangered Species Program, 2016). The species that are mentioned in this section are known to commonly occur in areas that are affected by the portion of the onshore export cable installation and onshore substation construction. Refer to Section 6.4 for a discussion of wildlife species that are known to commonly occur along the coast and are likely present at or near the cable Landfall Sites.

Wildlife expected to be present along the Onshore Export Cable Route or at the onshore substation include species known to inhabit Pine-Oak forests, which is the dominant forest type found on Cape Cod and southeastern Massachusetts. Mammals known to occur in this type of habitat include, but are not limited to: White-tailed Deer (*Odocoileus virginianus*), Coyote (*Canis latrans*), Red Fox (*Vulpes vulpes*), Virginia Opossum (*Didelphis virginiana*), Woodchuck (*Marmota monax*), Striped Skunk (*Mephitis mephitis*), Common Raccoon (*Procyon lotor*), White-footed Mouse *(Peromyscus maniculatus),* and other small rodents. (DeGraaf and Yamasaki, 2001)

Reptiles and amphibians at the site include, but are not limited to: Northern Redback Salamander *(Plethodon cinereus)*, AmericanToad *(Bufo americanus)*, Spring Peeper *(Hyla crucifer)*, Wood Frog *(Rana sylvatica)*, Leopard Frog *(Rana pipiens)*, Green Frog *(Rana clamitans)*, Snapping Turtle *(Chelydra serpentina)*, Garter Snake *(Thamnophis sirtalis)*, and Black Racer *(Coluber constricta)* (DeGraaf and Yamasaki, 2001).

Birds that may be present include: Turkey Vulture *(Cathartes aura)*, Sharp-shinned Hawk *(Accipiter structus)*, Cooper's Hawk *(Accipiter cooperii)*, Red-tailed Hawk *(Buteo jamaicensis)*, Wild Turkey *(Meleagris gallopavo)*, Mourning Dove *(Zeneida macroura)*, Northern Saw-whet Owl *(Aegolius acadicus)*, Whip-poor-will *(Caprimulgus vociferous)*, Downy Woodpecker *(Picoides pubescens)*, Blue Jay *(Cyanocitta cristata)*, American Crow *(Corvus brachyrhynchos)*, Fish Crow *(Corvus ossifragus)*, Tufted Titmouse *(Beeoloptus bicolor)*, White-breasted Nuthatch *(Sitta caroliniensis)*, Hermit Thush *(Catharus guttatus)*, Ovenbird *(Seiurus aurcopillus)*, Eastern Towhee *(Pipilo erythro-phtalmus),* Yellow-rumped Warbler *(Setophaga coronate),* Eastern Phoebe *(Sayornis phoebe),* and Chipping Sparrow *(Spizella passerine)*. (DeGraaf and Yamasaki, 2001)

Representative wildlife species lists developed by the US Fish and Wildlife Service for a Pine-Oak forest at the Massasoit National Wildlife Refuge in nearby Plymouth, Massachusetts are provided in Table 6.1-1 through 6.1-4 below (USFWS, 2018). While this list was developed specifically for Plymouth, many, if not all, of these species are also anticipated to be present in the Pine-Oak forest near the proposed onshore substation or along the Onshore Export Cable Route.

Table 6.1-1 Amphibians and Reptiles Confirmed on Massasoit Wildlife Refuge, Plymouth, MA

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]
Plethodontidae Family						
Red-backed Salamander	*Plethodon cinereus cinereus*	-	-	*G5*	-	-
Salamandridae Family						
Red-spotted Newt	*Notophthalmus viridescens*	-	-	*G5*	-	-
Ranidae Family						
American Bullfrog	*Lithobates catesbeianus*	-	-	*G5*	-	-
Green Frog	*Lithobates clamitans*	-	-	*G5*	-	-
Northern Leopard Frog	*Lithobates pipiens*	-	-	*G5*	*S4*	-
Wood Frog	*Lithobates sylvaticus*	-	-	*G5*	-	*NNE, SNE, MAt*
Bufonidae Family						
American Toad	*Anaxyrus americanus*	-	-	*G5*	-	-
Fowler's Toad	*Anaxyrus fowleri*	-	-	*G5*	-	-
Hylidae Family						
Northern Spring Peeper	*Pseudacris crucifer*	-	-	G5	-	-

Table 6.1-1 Amphibians and Reptiles Confirmed on Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]
Hylidae Family						
Gray Treefrog	*Hyla versicolor*	-	-	*G5*	-	-
Colubridae Family						
Eastern Hognose Snake	*Heterodon platirhinos*	-	-	G5	S4	SNE, MAt
Eastern Ribbon Snake	*Thamnophis sauritus*	-	-	G5	S5	-
Milk Snake	*Lampropeltis triangulum*	-	-	G5	-	-
Emydidae Family						
Painted Turtle	*Chrysemys picta*	-	-	G5	-	MAt
Northern Red-Bellied Cooter	*Pseudemys rubriventris*	E	E	G5T2Q	S1	-
Chelydridae Family						
Snapping Turtle	***Chelydra serpentina***	**-**	**-**	**G5**	**-**	**-**
Kinosternidae Family						
Common Musk Turtle	*Sternotherus odoratus*	-	-	G5	-	-

Source: USFWS, 2018

1 Federal Legal Status Codes (under Federal Endangered Species List): E = endangered; T = threatened; C = candidate; "-" = no status.

2 State Legal Status Codes (under Massachusetts Endangered Species Lists): E = endangered; T = threatened; SC = special concern; WL = watch list; "-" = no status.

3 Global Rarity Rank: NatureServe Global Conservation Status Ranks from http://explorer.natureserve.org/ where the conservation status of a species is designated by a number from 1 to 5 (1 = critically imperiled, 2 = imperiled, 3 = vulnerable, 4 = apparently secure, 5 = secure), preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global, N = National, and S = Subnational). Additionally, GNR = unranked (global rank not yet assessed) and "?" = inexact numeric rank.

4 Massachusetts Rarity Rank from 2005 Massachusetts Comprehensive Wildlife Conservation Strategy, Revised 2006: S1 = critically imperiled; S2 = imperiled; S3 = either very rare or uncommon, vulnerable; S4 = widespread, abundant, apparently secure; S5 = secure; SNA = not applicable; "-" = no rank given. State rarity ranks were only provided for "species in greatest need of conservation", therefore although some species were assigned a rank of S5, they are still of conservation concern in Massachusetts.

5 North Atlantic Landscape Conservation Cooperative Representative Species: NNE = northern New England; SNE = southern New England; MAt = mid; "-" = not listed.

Table 6.1-2 Birds Confirmed at Massasoit Wildlife Refuge, Plymouth, MA

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]	BCC Region 5[6]	BCR 30[7]	PIF Area 9[8]
Gaviidae Family (Loons)									
Common Loon	*Gavia immer*	-	SC	G5	S1	NNE, SNE	-	-	-
Ardeidae Family (Wading Birds)									
Great Blue Heron	*Ardea herodias*	-	-	G5	-	-	-	-	V
Black-crowned Night Heron	*Nycticorax nycticorax*	-	-	G5	S2	-	-	M	V
Anatidae Family (Swans, Geese, Ducks)									
Mute Swan	*Cygnus olor*	-	-	G5	-	-	-	-	-
Canada Goose	*Branta canadensis*	-	-	G5	-	-	-	HH	-
Wood Duck	*Aix sponsa*	-	-	G5	-	MAt	-	-	-
Mallard	*Anas platyrhynchos*	-	-	G5	-	-	-	H	-

Table 6.1-2 Birds Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]	BCC Region 5[6]	BCR 30[7]	PIF Area 9[8]
Anatidae Family (Swans, Geese, Ducks)									
American Black Duck	*Anas rubripes*	-	-	G5	S4	NNE, SNE, MAt	-	HH	IIC
Blue-winged Teal	*Anas discors*	-	-	G5	-	-	-	-	-
Anatidae Family (Swans, Geese, Ducks)									
Green-winged Teal	*Anas crecca*	-	-	G5	-	-	-	M	-
Cathartidae, Accipitridae, and Pandionidae Families (Diurnal Raptors and Osprey)									
Turkey Vulture	*Cathartes aura*	-	-	G5	-	-	-	-	-
Red-shouldered Hawk	*Buteo lineatus*	-	-	G5	-	MAt	-	-	V
Red-tailed Hawk	*Buteo jamaicensis*	-	-	G5	-	-	-	-	-
Bald Eagle	*Haliaeetus leucocephalus*	-	T	G5	S1	-	Y	M	-
Osprey	*Pandion haliaetus*	-	-	G5	-	-	-	-	V

Table 6.1-2 Birds Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]	BCC Region 5[6]	BCR 30[7]	PIF Area 9[8]
Phasianidae and Odontophoridae Families (Upland Game Birds)									
Northern Bobwhite	*Colinus virginianus*	-	-	G5	S5	-	-	H	-
Ruffed Grouse	*Bonasa umbellus*	-	-	G5	S5	NNE	-	-	-
Wild Turkey	*Meleagris gallopavo*	-	-	G5	-	-	-	-	-
Columbidae Family (Pigeons and Doves)									
Mourning Dove	*Zenaida macroura*	-	-	G5	-	-	-	-	-
Cuculidae Family (Cuckoos and Allies)									
Yellow-billed Cuckoo	*Coccyzus americanus*	-	-	G5	-	-	-	-	-
Black-billed Cuckoo	*Coccyzus erythropthalmus*	-	-	G5	-	-	-	-	IA
Caprimulgidae Family (Goatsuckers)									
Whip-poor-will	*Caprimulgus vociferous*	-	SC	G5	S4	MAt	Y	H	-
Alcedinidae Family (Kingfishers)									
Belted Kingfisher	*Megaceryle alcyon*	-	-	G5	-	-	-	-	-

Table 6.1-2 Birds Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]	BCC Region 5[6]	BCR 30[7]	PIF Area 9[8]
Picidae Family (Woodpeckers)-									
Red-bellied Woodpecker	*Melanerpes carolinus*	-	-	G5	-	-	-	-	-
Yellow-bellied Sapsucker	*Sphyrapicus varius*	-	-	G5	-	-	-	-	-
Picidae Family (Woodpeckers)-									
Downy Woodpecker	*Picoides pubescens*	-	-	G5	-	-	-	-	-
Hairy Woodpecker	*Picoides villosus*	-	-	G5	-	-	-	-	IIA
Northern Flicker	*Colaptes auratus*	-	-	G5	-	-	-	H	-
Tyrannidae Family (Tyrant Flycatchers)									
Eastern Wood-Pewee	*Contopus virens*	-	-	G5	-	MAt	-	-	IIA
Eastern Phoebe	*Sayornis phoebe*	-	-	G5	-	-	-	-	-
Great Crested Flycatcher	*Myiarchus crinitus*	-	-	G5	-	-	-	H	-

Table 6.1-2 Birds Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]	BCC Region 5[6]	BCR 30[7]	PIF Area 9[8]
Tyrannidae Family (Tyrant Flycatchers)									
Eastern Kingbird	*Tyrannus tyrannus*	-	-	G5	-	-	-	H	-
Vireonidae Family (Vireos)									
Red-eyed Vireo	*Vireo olivaceus*	-	-	G5	-	-	-	-	-
Corvidae Family (Crows and Jays)									
Blue Jay	*Cyanocitta cristata*	-	-	G5	-	-	-	-	-
American Crow	*Corvus brachyrhynchos*	-	-	G5	-	-	-	-	-
Fish Crow	*Corvus ossifragus*	-	-	G5	-	-	-	-	-
Hirundinidae Family (Swallows)									
Barn Swallow	*Hirundo rustica*	-	-	G5	-	-	-	-	-
Tree Swallow	*Tachycineta bicolor*	-	-	G5	-	-	-	-	-
Paridae Family (Chickadees and Titmice)									
Tufted Titmouse	*Baeolophus bicolor*	-	-	G5	-	-	-	-	-

Table 6.1-2 Birds Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]	BCC Region 5[6]	BCR 30[7]	PIF Area 9[8]
Paridae Family (Chickadees and Titmice)									
Black-capped Chickadee	*Poecile atricapillus*	-	-	G5	-	-	-	-	-
Sittidae Family (Nuthatches)									
Red-breasted Nuthatch	*Sitta canadensis*	-	-	G5	-	-	-	-	-
White-breasted Nuthtch	*Sitta carolinensis*	-	-	G5	-	-	-	-	-
Troglodytidae Family (Wrens)									
Carolina Wren	*Thryothorus ludovicianus*	-	-	G5	-	-	-	-	-
Sylviidae Family (Gnatcatchers)									
Blue-gray Gnatcatcher	*Polioptila caerulea*	-	-	G5	-	-	-	-	-
Turdidae Family (Thrushes)									
Eastern Bluebird	*Sialia sialis*	-	-	-	-	-	-	-	-
American Robin	*Turdus migratorius*	-	-	G5	-	-	-	-	-

Table 6.1-2 Birds Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]	BCC Region 5[6]	BCR 30[7]	PIF Area 9[8]
Turdidae Family (Thrushes)									
Wood Thrush	*Hylocichla mustelina*	-	-	G5	S5	NNE, SNE, MAt	Y	HH	IA
Hermit Thrush	*Catharus guttatus*	-	-	G5	-	-	-	-	-
Mimidae Family (Mimids)									
Gray Catbird	*Dumetella carolinensis*	-	-	G5	-	-	-	M	-
Northern Mockingbird	*Mimus polyglottos*	-	-	G5	-	-	-	-	-
Mimidae Family (Mimids)									
Brown Thrasher	*Toxostoma rufum*	-	-	G5	S5	MAt	-	H	-
Bombycillidae Family (Waxwings)									
Cedar Waxwing	*Bombycilla cedrorum*	-	-	G5	-	-	-	-	-
Parulidae Family (Wood Warblers)									
Yellow Warbler	*Dendroica petechia*	-	-	G5	-	-	-	-	-
Prairie Warbler	*Dendroica discolor*	-	-	G5	S5	SNE, MAt	Y	HH	IA

Table 6.1-2 Birds Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]	BCC Region 5[6]	BCR 30[7]	PIF Area 9[8]
Parulidae Family (Wood Warblers)									
Palm Warbler	*Dendroica palmarum*	-	-	G5	-	NNE	-	-	-
Pine Warbler	*Dendroica pinus*	-	-	G5	-	-	-	-	-
Blackpoll Warbler	*Dendroica striata*	-	SC	G5	S1	NNE	-	-	-
Black-and-white Warbler	*Mniotilta varia*	-	-	G5	-	MAt	-	H	IIA
Ovenbird	*Seiurus aurocapilla*	-	-	G5	-	NNE, SNE, MAt	-	-	-
Parulidae Family (Wood Warblers)									
Common Yellowthroat	*Geothlypis trichas*	-	-	G5	-	-	-	-	-
Thraupidae Family (Tanagers)									
Scarlet Tanager	*Piranga olivacea*	-	-	G5	-	-	-	H	IA
Cardinalidae Family (Cardinals and Grosbeaks)									
Northern Cardinal	*Cardinalis cardinalis*	-	-	G5	-	-	-	-	-

Table 6.1-2 Birds Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]	BCC Region 5[6]	BCR 30[7]	PIF Area 9[8]
Cardinalidae Family (Cardinals and Grosbeaks)									
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	-	-			-	-	-	IIA
Emberizidae Family (Emberizine Sparrows and Allies)									
Eastern Towhee	*Pipilo erythrophthalmus*	-	-	G5	S5	NNE, MAt	-	H	IIA
Field Sparrow	*Spizella pusilla*	-	-	G5	S5	-	-	H	-
Chipping Sparrow	*Spizella passerina*	-	-	G5	-	-	-	-	-
Song Sparrow	*Melospiza melodia*	-	-	G5	-	-	-	-	-
Icteridae Family (Icterids)									
Brown-headed Cowbird	*Molothrus ater*	-	-	G5	-	-	-	-	-
Red-winged Blackbird	*Agelaius phoeniceus*	-	-	G5	-	-	-	-	-
Common Grackle	*Quiscalus quiscula*	-	-	G5	-	-	-	-	-
Baltimore Oriole	*Icterus galbula*	-	-	G5	-	-	-	H	IA

Table 6.1-2 Birds Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]	BCC Region 5[6]	BCR 30[7]	PIF Area 9[8]
Fringillidae Family (Finches)									
Purple Finch	*Carpodacus purpureus*	-	-	G5	-	-	-	-	IIA
House Finch	*Carpodacus mexicanus*	-	-	G5	-	-	-	-	-
American Goldfinch	*Carduelis tristis*	-	-	G5	-	-	-	-	-

Source: USFWS, 2018

1 Federal Legal Status Codes (under Federal Endangered Species List): E = endangered; T = threatened; C = candidate; "-" = no status.

2 State Legal Status Codes (under Massachusetts Endangered Species Lists): E = endangered; T = threatened; SC = special concern; WL = watch list; "-" = no status.

3 Global Rarity Rank: NatureServe Global Conservation Status Ranks from http://explorer.natureserve.org/ where the conservation status of a species is designated by a number from 1 to 5 (1 = critically imperiled, 2 = imperiled, 3 = vulnerable, 4 = apparently secure, 5 = secure), preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global, N = National, and S = Subnational). Additionally, GNR = unranked (global rank not yet assessed) and "?" = inexact numeric rank.

4 Massachusetts Rarity Rank from 2005 Massachusetts Comprehensive Wildlife Conservation Strategy, Revised 2006: S1 = critically imperiled; S2 = imperiled; S3 = either very rare or uncommon, vulnerable; S4 = widespread, abundant, apparently secure; S5 = secure; SNA = not applicable; "-" = no rank given. State rarity ranks were only provided for "species in greatest need of conservation", therefore although some species were assigned a rank of S5, they are still of conservation concern in Massachusetts.

5 North Atlantic Landscape Conservation Cooperative Representative Species: NNE = northern New England; SNE = southern New England; MAt = mid; "-" = not listed.

6 U.S. Fish and Wildlife Service Division of Migratory Birds, Birds of Conservation Concern for Region 5 (Northeast) (USFWS 2008). Y = species identified as a species of conservation concern in Region 5; "-" = species not identified.

7 Bird Conservation Region 30: New England/Mid-Atlantic Coast Conservation Priority Category: HH = highest priority; H = high priority; M = moderate priority (http://www.acjv.org/BCR_30/BCR30_June_23_2008_final.pdf).

8 Partners in Flight Bird Conservation Plan for Southern New England: Physiographic Area 09 (Dettmers and Rosenberg 2000). IA = high continental priority and high regional responsibility; IB = high continental priority and low regional responsibility; IIA = high regional concern; IIC = high regional threats; V = additional state listed.

Table 6.1-3 Mammals Confirmed at Massasoit Wildlife Refuge, Plymouth, MA

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]
Canidae Family						
Coyote	*Canis latrans*	-	-	*G5*	-	-
Gray Fox	*Urocyon cinereoargenteus*	-	-	*G5*	-	-
Red Fox	*Vulpes vulpes*	-	-	*G5*	-	-
Procyonidae Family						
Raccoon	*Procyon lotor*	-	-	*G5*	-	-
Mephitidae Family						
Striped Skunk	*Mephitis mephitis*	-	-	G5	-	-
Mustelidae Family						
Fisher	*Martes pennanti*	-	-	G5	-	-
Cervidae Family						
White-tailed Deer	*Odocoileus virginianus*	-	-	G5	-	-

Table 6.1-3 Mammals Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]	North Atlantic LCC Representative Species[5]
Sciuridae Family						
Red Squirrel	*Tamiasciurus hudsonicus*	-	-	G5	-	-
Vespertilionidae Family						
Big Brown Bat	*Eptesicus fuscus*	-	-	G5	-	-
Silver-haired Bat	*Lasionycteris noctivagans*	-	-	G5	SU	-
Eastern Red Bat	*Lasiurus borealis*	-	-	G5	S4	NNE, SNE, MAt
Eastern Pipistrelle	*Pipistrellus subflavus*	-	-	G3	-	MAt
Eastern Small-footed Myotis	*Myotis leibii*	-	SC	G1G3	S1	-

Source: USFWS, 2018.

1 Federal Legal Status Codes (under Federal Endangered Species List): E = endangered; T = threatened; C = candidate; "-" = no status.

2 State Legal Status Codes (under Massachusetts Endangered Species Lists): E = endangered; T = threatened; SC = special concern; WL = watch list; "-" = no status.

3 Global Rarity Rank: NatureServe Global Conservation Status Ranks from http://explorer.natureserve.org/ where the conservation status of a species is designated by a number from 1 to 5 (1 = critically imperiled, 2 = imperiled, 3 = vulnerable, 4 = apparently secure, 5 = secure), preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global, N = National, and S = Subnational). Additionally, GNR = unranked (global rank not yet assessed) and "?" = inexact numeric rank.

4 Massachusetts Rarity Rank from 2005 Massachusetts Comprehensive Wildlife Conservation Strategy, Revised 2006: S1 = critically imperiled; S2 = imperiled; S3 = either very rare or uncommon, vulnerable; S4 = widespread, abundant, apparently secure; S5 = secure; SNA = not applicable; "-" = no rank given. State rarity ranks were only provided for "species in greatest need of conservation", therefore although some species were assigned a rank of S5, they are still of conservation concern in Massachusetts.

5 North Atlantic Landscape Conservation Cooperative Representative Species: NNE = northern New England; SNE = southern New England; MAt = mid; "-" = not listed.

Table 6.1-4 Invertebrates Confirmed at Massasoit Wildlife Refuge, Plymouth, MA

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]
Libellulidae Family					
Blue Dasher	*Pachydiplax longipennis*	-	-	G5	-
Calico Pennant	*Celithemis elisa*	-	-	G5	-
Common Whitetail	*Libellula lydia*	-	-	G5	-
Eastern Pondhawk	*Erythemis simplicicollis*	-	-	G5	-
Golden-Winged Skimmer	*Libella auripennis*	-	-	G5	-
Slaty Skimmer	*Libellula incesta*	-	-	G5	-
White Corporal	*Libellula exusta*	-	-	G4	-
Nymphalidae Family					
Eastern Comma	*Polygonia comma*	-	-	G5	-
Great Spangled Fritillary	*Speyeria cybele*	-	-	G5	-
Mourning Cloak	*Nymphalis antiopa*	-	-	G5	-
Red Admiral	*Vanessa atalanta*	-	-	G5	-
Red-spotted Purple	*Limenitis artemis astyanax*	-	-	G5T5	-
Lycaenidae Family					
Striped Hairstreak	*Satyrium liparops*	-	-	G5	-
Hesperiidae Family					
True Skipper sp. (tauny-orange or brown)	*Hesperia spp.*	-	-	G5	-

Table 6.1-4 Invertebrates Confirmed at Massasoit Wildlife Refuge, Plymouth, MA (Continued)

Common Name	Scientific Name	Federal Legal Status[1]	MA Legal Status[2]	Global Rarity Rank[3]	MA Rarity Rank[4]
Saturniidae Family					
Polyphemus moth	*Antheraea polyphemus*	-	-	G5	-
Carabidae Family					
Six-spotted Green Tiger Beetle	*Cicindela sexguttata*	-	-	G5	-

Source: USFWS, 2018

1 Federal Legal Status Codes (under Federal Endangered Species List): E = endangered; T = threatened; C = candidate; "-" = no status.

2 State Legal Status Codes (under Massachusetts Endangered Species Lists): E = endangered; T = threatened; SC = special concern; WL = watch list; "-" = no status.

3 Global Rarity Rank: NatureServe Global Conservation Status Ranks from http://explorer.natureserve.org/ where the conservation status of a species is designated by a number from 1 to 5 (1 = critically imperiled, 2 = imperiled, 3 = vulnerable, 4 = apparently secure, 5 = secure), preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global, N = National, and S = Subnational). Additionally, GNR = unranked (global rank not yet assessed) and "?" = inexact numeric rank.

4 Massachusetts Rarity Rank from 2005 Massachusetts Comprehensive Wildlife Conservation Strategy, Revised 2006: S1 = critically imperiled; S2 = imperiled; S3 = either very rare or uncommon, vulnerable; S4 = widespread, abundant, apparently secure; S5 = secure; SNA = not applicable; "-" = no rank given. State rarity ranks were only provided for "species in greatest need of conservation", therefore although some species were assigned a rank of S5, they are still of conservation concern in Massachusetts.

6.1.2 Potential Impacts of the Project

Impact-producing factors for the Project are described below. Short-term construction-related impacts are associated with 1) physical habitat disturbance, 2) displacement due to construction noise and vibration, or 3) direct mortality from contact with construction equipment. Permanent impacts potentially affecting wildlife are limited to habitat loss or conversion of habitat type. The sections below detail these potential impacts as well as impact avoidance and mitigation measures.

Table 6.1-5 Impact-Producing Factors for Terrestrial Wildlife

Impact-Producing Factors	Construction & Installation	Operations & Maintenance	Decommiss-ioning
Temporary alteration of habitat	X		
Temporary disturbance due to noise and vibration-producing activities	X	X	
Direct wildlife mortality by equipment contact	X		
Permanent loss or alteration of habitat	X	X	

6.1.2.1 Construction and Installation

As already noted, the Project's onshore facilities are sited to maximize the use of existing ROWs and other previously developed lands, and minimize alteration or loss of unique or protected habitat or known habitats of rare, threatened, or special concern species. The installation of duct bank and splice vaults within existing corridors will not result in any further fragmentation of forested habitat, and construction at the onshore substation site will only affect forested wildlife habitat that is very common in southeastern Massachusetts. However, land clearing and grading associated with construction of the onshore substation has the potential to permanently displace resident wildlife or disrupt select lifecycle activities (e.g., nesting, breeding, hibernation/aestivation). The short-term and permanent impacts to terrestrial fauna are discussed below.

6.1.2.1.1 Temporary Habitat Alteration

As described earlier in this section, a portion of either Onshore Export Cable Route is located along an existing utility ROW that is currently maintained by the utility as grass and scrubland habitat. Installation of duct bank and splice vaults within the utility ROW requires clearing and grading within a corridor of sufficient width to accommodate excavation and stockpiling of soils, and to provide space for construction equipment access along the work zone. This will result in some short-term loss of forage and cover for area wildlife within the utility ROW. The work, however, is confined to a 9-13 meter (30-40 foot) wide corridor and will not impact similar wildlife habitat located elsewhere within the utility ROW.

Any disturbances to terrestrial habitat will be short-term, localized, and will not affect rare or protected habitat types or species. Furthermore, the utility ROW and adjacent woodlands would remain viable wildlife habitats for animals that thrive in the managed grass and scrubland and forest edge communities. Accordingly, population level impacts to wildlife resulting from temporary habitat alteration are unlikely.

6.1.2.1.2 Noise and Vibration

Construction equipment will generate noise and vibration at levels sufficient to temporarily displace nearby wildlife, particularly those in off-road areas, such as the utility ROW, that are removed from the noise generated by local traffic. Regardless of the location, any affected wildlife is expected to return to the area once construction activities are completed; therefore, this short-term impact is unlikely to have population level impacts.

6.1.2.1.3 Direct Mortality

Although the expectation is that wildlife will leave the immediate area as construction progresses along the Onshore Export Cable Route, limited direct wildlife mortality may occur as a result of the construction activities. Impacts are expected to be limited to less mobile animals of commonly occurring species.

6.1.2.1.4 Loss or Alteration of Habitat

The clearing of vegetation at the Project's onshore substation site will result in the permanent loss of approximately six acres of Pitch pine-Oak forest habitat within the Independence Park commercial/industrial area in Barnstable. It is also possible that work within the utility ROW could require some permanent removal of trees located along the edge of the utility ROW, if further surveys indicate that it has not been maintained to its full width. This limited loss of habitat, however, is unlikely to have population level impacts on wildlife for the reasons outlined below.

Forest is the dominant natural habitat in Massachusetts, with over 60% of land area in the Commonwealth currently in a forested state (MADFW, 2013). Pitch pine-Oak forests are among the most common habitat types on Cape Cod, and are not in short supply regionally or locally. One such area of nearby conservation land is the 365-acre HPWMA, located directly west of Mary Dunn Road and approximately 0.4 km (0.25 mi) east of the site. Wildlife species, including birds, mammals, and herpetiles, that may otherwise use the area proposed for the onshore substation would not be limited with regard to the availability of and access to similar habitats in the Onshore Project Area.

Further, the habitat at the onshore substation is neither undeveloped nor unfragmented. The forest area at the site is substantially affected by local development, and does not provide meaningful habitat for species, such as the Scarlet Tanager (*Piranga olivacea),* which require undisturbed land areas. Furthermore, in addition to roadways and ROWs that bound and bisect the forest in the area, the onshore substation is proximate to the Barnstable Airport and other heavy industrial uses commonly seen south of Route 6 between Barnstable and Hyannis. Finally, the habitat that would be lost is not used by any known rare, threatened, or special concern species.

For these reasons, the potential impacts associated with the loss of forested habitat at the onshore substation are unlikely to have population level impacts.

6.1.2.1.5 Avoidance, Minimization, and Mitigation Measures

As noted above, the Project's Onshore Export Cable Route is sited almost entirely within paved roadways or other previously developed corridors (aside from the route variant that would follow a proposed bike path), thereby avoiding undisturbed forest interiors and other significant wildlife habitat. Routing along roadways and other previously developed corridors also minimizes potential construction impacts to adjacent wildlife habitats. Although the development of the onshore substation will require permanent loss of habitat common to the region, its location within a developed industrial area prevents impacts to less common or more valuable habitats, and will minimize impacts to area wildlife.

At certain locations, expanded work zones and construction staging areas may be required to accommodate special construction equipment and materials. Wherever possible, these spaces will be located within previously developed areas, such as nearby parking lots, in order to avoid or minimize disturbance to naturally vegetated areas. Any previously undisturbed areas of wildlife habitat affected by expanded work zones or elsewhere along the Onshore Export Cable Route will be restored in consultation with local officials.

Siltation fencing will be installed prior to commencement of other land-disturbing activities and maintained during the construction period.

6.1.2.1.6 Summary

In summary, due to the nature and location of the Project's onshore construction activities, impacts to terrestrial wildlife will be largely short-term and localized. Permanent loss of terrestrial habitat will be minimal, affecting approximately six acres at the onshore substation. Impacts to terrestrial wildlife will be reduced further by implementing the above avoidance, minimization, and mitigation measures. Consequently, population level impacts to terrestrial wildlife including inland birds in the vicinity of the Project are unlikely.

6.1.2.2 Operations and Maintenance

Under normal circumstances, operations and maintenance of the Project will not result in further habitat alteration or involve activities expected to have a negative impact on wildlife. Onshore facilities will be monitored and controlled remotely from the Project's operations and maintenance center, which will be staffed by the necessary personnel, including managers, engineers, technicians, and support personnel. In the event monitors determine repair work is necessary, a crew would be dispatched to the identified location to complete repairs and restore normal operations. Such work would typically involve the onshore export cables, which are accessed through manholes at the installed splice vaults, or within the fenced perimeter of the onshore substation. This allows repairs to be completed within the installed transmission infrastructure and without additional impact to wildlife habitat.

6.1.2.2.1 Temporary Disturbance by Noise

Maintenance and repairs to the Project's onshore export cable or onshore substation could generate noise that temporarily displaces nearby wildlife, but this impact would be short-term and is unlikely to have population level impacts. The Project substation transformers will also generate some noise, which might affect nearby terrestrial wildlife. However, given the location of the substation within a commercial/industrial area with other noise sources nearby, any possible impact from noise will be insignificant.

6.1.2.2.2 Avoidance, Minimization, and Mitigation Measures

The design of the Onshore Export Cable Route provides for points of access at the splice vaults. Maintenance and/or repairs are expected to take place primarily within these vaults, without any disturbance to adjacent wildlife habitat. These measures will avoid or reduce any further impact to terrestrial habitat and wildlife. Consequently, onshore operations and maintenance activities associated with the Project are not anticipated to have population level impacts on terrestrial species.

6.1.3 Decommissioning

As described in Section 4.4 of Volume I, no decommissioning work is planned for the Project's onshore facilities, although removal of Project cables via existing manholes may occur if required. The splice vaults, duct bank, and onshore substation will likely remain as valuable infrastructure that would be available for future offshore wind projects developed within the Vineyard Wind Lease Area or elsewhere.

6.2 Coastal and Marine Birds

6.2.1 Description of the Affected Environment

6.2.1.1 Overview

The Wind Development Area ("WDA") is located within the Massachusetts Wind Energy Area ("MA WEA"), which is approximately 22 kilometers ("km") (13.7 miles ["mi"]) south of Martha's Vineyard. BOEM established the WEA through an intergovernmental renewable energy task force in 2012. Areas identified as important fishing areas and having "high value sea duck habitat" were excluded from the northeastern portion of the MA WEA (BOEM, 2014).

The WDA is also located within the Lease Area, and is approximately 23 km (14.3 mi) from Martha's Vineyard and Nantucket Island. More specifically, the WDA is located at a faunal break region between two Large Marine Ecosystems ("LMEs"): the Scotian Shelf (LME #8) to the north (the Gulf of Maine) and the Northeast US Continental Shelf (LME #7) to the south (the Mid-Atlantic Bight) (National Oceanic and Atmospheric Administration ["NOAA"], 2017). This region is used by a suite of breeding birds from both oceanographic regions (Nisbet et al., 2013). In addition, non-breeding summer migrants (e.g., shearwaters and storm-petrels) constitute a significant portion of the marine birds in the region (Nisbet et al., 2013). The WDA is no exception, with an influx of southern hemisphere breeders present in the area during the boreal summer/austral winter (Veit et al., 2016).

Around 450 avian species are known to occur in Massachusetts (Blodget, 2002), but many of these species are rarities and/or unlikely to occur offshore. Species of migratory, breeding, and wintering birds that may pass through the WDA include coastal birds, such as shorebirds, waterfowl, wading birds, raptors, and songbirds, and marine birds such as seabirds, and seaducks. The most likely of these to occur in the WDA are waterfowl (18 species), loons and grebes (four species), shearwaters and petrels (10 species), gannet and cormorants (three species), shorebirds (two species), gulls (11 species), terns (nine species) jaegers (three species), and auks (six species) (BOEM, 2014). Bird use of the WDA and surrounding area is well-documented, with multiple studies providing important information on avian presence and abundances at a series of useful scales (see Loring et al., 2017; NOAA, 2016j; Veit, 2015; Veit et al., 2016).

6.2.1.2 Definition of Exposure to the WDA

Exposure to offshore wind farms has spatial and temporal components. Spatially, birds are exposed on the horizontal (i.e., habitat area) and vertical (i.e., flight height) planes; temporally, bird exposure is dictated by a species' life history traits and may be limited to breeding, staging, migrating, or wintering. For the purpose of the exposure assessment, vertical exposure is considered in the impact assessment within the context of vulnerability.

The exposure assessment was conducted for coastal birds (shorebirds, waterbirds, waterfowl, wading birds, raptors, and songbirds), which are rarely found far offshore, and marine birds (loons and grebes, seaducks, shearwaters and storm-petrels, gannets and cormorants, gulls and jaegers, terns, and auks), which are more commonly found offshore. For the purposes of this assessment, "offshore" and the "offshore environment" is generally defined as beyond state waters or further than 5.6 km (3.5 mi) from shore. In addition, the exposure assessment is focused on the WDA because bird exposure to vessels installing the offshore export cable will be transitory and ephemeral (see Section 4.2.3.3 of Volume I for discussion of offshore cable installation). Coastal and marine birds may encounter a cable installation vessel, but exposure to the vessel, in any given location, will be limited to a finite temporal period and is not expected to be an impact-producing factor. As with all construction activities, the Project will reduce lighting to limit any attraction of birds to vessels at night. Federally-listed species (Roseate Tern [*Sterna dougalli*], Red Knot [*rufa* ssp.], Piping Plover [*Charadrius melodus*], and eagles) are assessed individually.

The exposure of birds to the project was evaluated for each species or species group and categorized as insignificant, unlikely, potential, or likely based upon available literature and a quantitative assessment. Definitions of exposure levels are provided in (Table 6.2-1). For marine birds, two data sources were used to assess local and regional marine bird use of the WDA: the Massachusetts Clean Energy Center seabird surveys (Veit et al., 2016), herein referred to as "Veit survey data", and the Marine-life Data and Analysis Team ("MDAT") marine birds abundance and occurrence models (Curtice et al., 2016), herein referred to as "MDAT abundance models". Further details on each data set are available in Appendix III-C. For species where Project-specific data was not available, a determination of exposure was made by synthesizing relevant information from species accounts in the literature.

To quantitatively assess the exposure of marine birds to the WDA, both the Veit survey data and the MDAT abundance models were used to develop an annual exposure score for species groups. The species group annual exposure scores were developed from species- and seasonal-specific exposure scores and maps. A full description of the methods and the quantitative results are available in Appendix III-C.

The final exposure scores for each species and season, as well as the aggregated scores (e.g., the annual scores for each species and taxonomic group), should be interpreted as a measure of the relative importance of the WDA for a species/group, as compared to other surveyed areas in the region and in the northwest Atlantic. It does not indicate the absolute number of individuals likely to be exposed. Rather, the exposure score provides a regional and population-level context for each taxon (see Appendix III-C for further details). The following sections provide a summary of the results for each species group.

Table 6.2-1 Definition of Exposure Levels

Exposure Level	Definition[1]
Insignificant	0-2 annual exposure score AND/OR Based upon the literature, little to no evidence of use of the offshore environment for breeding, wintering, or staging, and low predicted use during migration
Unlikely	3-5 annual exposure score AND/OR Based upon the literature, low evidence of use of the offshore environment during any season
Potential	6-8 annual exposure score AND/OR Based upon the literature, moderate evidence of use of the offshore environment during any season
Likely	9-12 annual exposure score AND/OR Based upon the literature, high evidence of use of the offshore environment, and the offshore environment is primary habitat during any season

1 The annual exposure score is the sum of all seasonal scores where seasons categorized as insignificant scores a 0, low scores a 1, medium scores a 2, and high scores a 3. Twelve is the highest possible score, which would occur if a species received a high score (3) for all four seasons (3 x 4 = 12). For further methods and annual results for each species by season see Appendix III-C.

6.2.1.3 Coastal Birds

The WDA is far enough offshore to be beyond the range of most terrestrial or coastal bird species. Coastal birds that may forage in the WDA occasionally, visit the area sporadically, or pass through on their spring and/or fall migrations, include shorebirds (e.g., sandpipers, plovers), waterbirds (e.g., cormorants, grebes), waterfowl (e.g., scoters, mergansers), wading birds (e.g., herons, egrets), raptors (e.g., falcons, eagles), and songbirds (e.g., warblers, sparrows).

6.2.1.3.1 Shorebirds

Shorebirds are coastal breeders and foragers that generally avoid straying out over deep waters during breeding. Few shorebird species breed locally on the US east coast. Most of the shorebirds that pass through the region are northern or Arctic breeders that migrate along the US east coast on their way to and from wintering areas in the Caribbean islands, Central America, and South America. Some species are clearly capable of crossing vast areas of ocean, and may traverse the WDA during migrations.

Of the shorebirds, only the phalaropes (Red Phalarope [*Phalaropus fulicarius*] and Red-necked Phalarope [*Phalaropus lobatus*]) are considered more marine than coastal (Rubega et al., 2000; Tracy et al., 2002). Very little is known regarding the migratory movements of these species, although they are known to travel well offshore during migration. Prior to the mid-1980s, millions of Red-necked Phalaropes staged in the Bay of Fundy, in the northern Gulf of Maine, during their fall migration. Since that time, these birds have completely disappeared from the area and their current fall staging area(s) is unknown (Nisbet & Veit, 2015).

Given that shorebird exposure will be primarily limited to migration and there is little evidence of shorebird use of the WDA, exposure is expected to be insignificant. See Table 6.2-1 for definition of exposure levels.

The Atlantic population of the Piping Plover, and the *rufa* subspecies of the Red Knot, are both federally- protected under the ESA, and are thus addressed in the "Federally-Listed Species" section, below.

Table 6.2-2 Shorebirds Listed in Massachusetts and their Federal Status

Common Name	Scientific Name	MA Status	Federal Status
Piping Plover	*Charadrius melodus*	T	T
Upland Sandpiper	*Bartramia longicauda*	E	

(E = Endangered; T = Threatened; SC = Special Concern).

6.2.1.3.2 Waterbirds

Waterbirds is a general term used for species associated with all manner of aquatic habitats. For the purposes of this document, this group is defined to include species that are generally restricted to freshwater or use saltmarshes, beaches, and other strictly coastal habitats, and that are not captured in other broad groupings. Given that these species spend the majority of their life in freshwater aquatic and associated terrestrial habitats, and there is little or no evidence of offshore migration in the literature or in the Veit survey data, overall exposure of this group to the WDA is expected to be insignificant.

Table 6.2-3 Waterbirds Listed in Massachusetts and their Federal Status

Common Name	Scientific Name	MA Status	Federal Status
American Bittern	*Botaurus lentiginosus*	E	
Least Bittern	*Ixobrychus exilis*	E	
King Rail	*Rallus elegans*	T	
Common Moorhen	*Gallinula chloropus*	SC	

(E = Endangered; T = Threatened; SC = Special Concern)

6.2.1.3.3 Waterfowl

Waterfowl comprises a broad group of geese and ducks, most of which spend much of the year in terrestrial or coastal wetland habitats (Baldassarre & Bolen, 2006). The diving ducks generally winter on open freshwater, as well as brackish or saltwater. Species that regularly winter on saltwater, including mergansers, scaup, and goldeneyes, usually restrict their distributions to shallow, very nearshore waters (Owen & Black, 1990). Given that coastal waterfowl spend a majority of the year in freshwater aquatic systems and near-shore marine systems, and there is little evidence of coastal waterfowl use of the WDA in the literature or the Veit survey data, overall exposure of this group to the WDA is expected to be insignificant.

A subset of the diving ducks, however, have an exceptionally strong affinity for saltwater either year-round or outside of the breeding season. These species are known as the "sea ducks", and are described separately in the Marine Bird (Section 6.2.1.4) below.

Wading Birds

Like the smaller shorebirds, long-legged wading birds, such as herons and egrets, are coastal breeders and shallow-water foragers that generally avoid straying out over deep water (Frederick, 2001). Most long-legged waders breeding along the Atlantic coast migrate south to the Gulf coast, the Caribbean islands, Central America, and South America (Heron Conservation, 2017), thus they are capable of crossing large areas of ocean, and may traverse the WDA during spring and fall migration periods. Given that long-legged wading birds spend a majority of the year in freshwater aquatic systems and coastal marine systems and there is little evidence of wading bird use of the WDA in the literature or in the Veit survey data, overall exposure of this group to the WDA is expected to be insignificant.

6.2.1.3.4 Raptors (non-eagle)

Overall, use of the WDA by most raptors is insignificant during breeding or winter seasons and will be limited to falcons and possibly Osprey [*Pandion haliaetus*] during migration. Raptor exposure to the WDA during migration will be dictated by a species' body design and general flight strategy (i.e., flapping vs. soaring). Species that use soaring flight depend upon thermals and generally do not cross large expanses of water. *Buteo* hawks (i.e., Red-tailed Hawks [*Buteo jamaicensis*], Broad-winged Hawks [*Buteo platypterus*], and Red-shouldered Hawks [*Buteo lineatus*]) that depend upon soaring flight during migration are rarely observed in offshore settings (Desorbo et al., 2012). *Accipiter* hawks (i.e., Northern Goshawks [*Accipiter gentilis*], Cooper's Hawks [*Accipiter cooperii*], and Sharp-shinned Hawks [*Accipiter striatus*]), which use a mixture of powered and soaring flight, are encountered at offshore islands but only in low numbers and they are rarely observed offshore (Desorbo et al., 2017). Most owls do not utilize the offshore environment, although there is evidence of Northern Saw-whet Owls (*Aegolius acadicus*) passing over Maine islands during migration (Desorbo et al., 2012) and Long-eared Owls (*Asio otus*) are known to migrate along the coast. The exposure of this group of raptors is expected to be insignificant to unlikely and will not be discussed further.

Falcons (e.g., American Kestrels [*Falco sparverius*], Peregrine Falcons [*Falco peregrinus*], and Merlins [*Falco columbarius*]) are the most likely raptors to be encountered offshore because their body design and use of powered flight enables them to endure large open water crossings (Kerlinger, 1985). Merlins and Peregrines are commonly observed in offshore habitats (Cochran, 1985; Desorbo et al., 2012), fly hundreds of kilometers offshore during migration (Desorbo et al., 2015), and have been observed on offshore oil platforms (Johnson et al., 2011; McGrady et al., 2006). There is little data available on falcon migration offshore in Massachusetts, but two fall migrant peregrines fitted with satellite transmitters in Maine did not fly through the WDA. Instead, the birds flew west of Cape Cod through central Massachusetts toward Narragansett Bay, Rhode Island and only flew offshore once they reached the mid-Atlantic (Desorbo et al., 2012). Nevertheless, the number of individual birds exposed to the WDA during fall migration probably represents a small proportion of the overall population.

Ospreys exhibit a wing morphology that enables open water crossings (Kerlinger, 1985); however, satellite telemetry data from Ospreys from New England and the mid-Atlantic suggest these birds generally follow coastal or inland migration routes. In some instances, individuals birds will fly offshore (Bierregaard, 2017), but exposure of Peregrine Falcons, Merlins and Ospreys is expected to be unlikely because the passage of individual birds through the WDA probably represents a relatively small proportion of the overall populations.

Bald Eagles (*Haliaeetus leucocephalus*) are federally protected under the Bald and Golden Eagle Protection Act ("BGEPA"), 16 US.C. § 668 et seqseq, and are thus addressed in the "Federally-Listed Species" section, below.

Table 6.2-4 Raptors Listed in Massachusetts and their Federal Status

Common Name	Scientific Name	MA Status	Federal Status
Bald Eagle	*Haliaeetus leucocephalus*	T	
Northern Harrier	*Circus cyaneus*	T	
Peregrine Falcon	*Falco peregrinus*	T	
Barn Owl	*Tyto alba*	SC	
Long-eared Owl	*Asio otus*	SC	
Short-eared Owl	*Asio flammeus*	E	

(E = Endangered; T = Threatened; SC = Special Concern)

6.2.1.3.5 Songbirds

Songbirds almost exclusively use terrestrial, coastal, and aquatic habitats and do not use the offshore marine system except during migration. Many North American breeding songbirds migrate to the tropical regions of Mexico, the Caribbean islands, Central America, and South America. On their migrations, these neotropical migrants mostly travel at night and at high altitudes, where favorable winds can aid them along their trip. Songbirds regularly cross large bodies of water, such as the Mediterranean Sea or the Gulf of Mexico (Bruderer & Lietchi, 1999; Gauthreaux & Belser, 1999), and there is some evidence that species migrate over the northern Atlantic as well (Drury & Keith, 1962). Some birds may briefly fly over the water while others, like the Blackpoll Warbler (*Setophaga striata*), can migrate non-stop over vast expanses of ocean (DeLuca et al., 2015; Faaborg et al., 2010).

Landbird migration may occur across broad geographic areas, rather than in narrow "flyways" as have been described for some waterbirds (Faaborg et al., 2010). Evidence for a variety of species suggests that over-water migration in the Atlantic is much more common in fall than in spring, when animals presumably migrate preferentially over land due to consistent tailwinds from the northwest (see, e.g., DeLuca et al., 2015; Hatch et al., 2013; Morris et al., 1994). Given that songbirds do not use the offshore marine system as habitat and there is little evidence of songbird use of the WDA outside of the migratory period, exposure is expected to be insignificant to unlikely.

Table 6.2-5 Songbirds Listed in Massachusetts and their Federal Status

Common Name	Scientific Name	MA Status	Federal Status
Sedge Wren	*Cistothorus platensis*	E	
Golden-winged Warbler	*Vermivora chrysoptera*	E	
Northern Parula	*Parula americana*	T	
Blackpoll Warbler	*Dendroica striata*	SC	
Mourning Warbler	*Oporornis philadelphia*	SC	
Vesper Sparrow	*Pooecetes gramineus*	T	
Grasshopper Sparrow	*Ammodramus savannarum*	T	
Eastern Whip-poor-will	*Caprimulgus vociferus*	SC	

(E = Endangered; T = Threatened; SC = Special Concern)

6.2.1.4 Marine Birds

Marine bird distributions are generally more pelagic and widespread than coastal birds. A total of 83 marine bird species are known to regularly occur off the eastern seaboard of the US (Nisbet et al., 2013). Many of these marine bird species use the WDA during multiple time periods, either seasonally or year-round, including loons and grebes, shearwaters and petrels, gannets, gulls and terns, and auks. A summary of marine birds in the region and listing status is in Table 6.2-6.

6.2.1.4.1 Loons and Grebes

Both Common Loons (*Gavia immer*) and Red-throated Loons (*Gavia stellate*) use the Atlantic outer continental shelf in winter. Analysis of satellite-tracked Red-throated Loons, captured and tagged in the mid-Atlantic area, found their winter distributions to be largely inshore of the mid-Atlantic BOEM Wind Energy Areas "WEAs", although they did overlap with the mid-Atlantic BOEM WEAs somewhat during their migration periods, particularly in spring (Gray et al., 2017). Wintering Common Loons generally show a broader and more dispersed distribution offshore in winter (Johnson et al., 2015). During migration Red-throated Loons use Nantucket Shoals, which is east of the WDA, as a stopover site (Gray et al., 2017).

The results of the recent tracking work generally align with the Veit survey data. The regional MDAT abundance models show that the birds are concentrated closer to shore and in the mid-Atlantic. The annual exposure analysis score for the loons and grebe group (three species) was insignificant. Red-necked Grebe (*Podiceps grisegena*) and Red-throated Loon are expected to have insignificant exposure during all seasons, and Common Loon has unlikely exposure during the summer and winter. Local data suggest Common Loons would have greater exposure than regional data sources, so this could be an instance of a species locally preferring a site but fairly small overall numbers are exposed.

6.2.1.4.2 Seaducks

Seaducks include the eiders, scoters, and Long-tailed Ducks (*Clangula hyemalis*), all of which are northern boreal, Gulf of Maine, or Arctic breeders that winter along the US east coast. In winter, seaducks can gather in large flocks in areas of appropriate habitat, sometimes in mixed species groups. Most seaducks forage on mussels and/or other shellfish and benthic invertebrates. They generally winter in shallower inshore waters or out over large offshore shoals, where they can access their benthic prey.

The western side of the Nantucket Shoals, approximately 25 nautical miles ("nm") to the east of the WDA, is a well-recognized important area for wintering seaducks (Meattey et al., in prep.; Silverman et al., 2013), particularly for Long-tailed Ducks (White et al., 2009), and other marine bird species (Veit et al., 2016). Long-tailed Ducks and other seaducks winter on the Nantucket Shoals in large aggregations from November to April; as much as 30% of the continental population of Long-tailed Ducks (White et al., 2009) and a significant proportion of the Atlantic population of White-winged Scoters (*Melanitta deglandi*) can spend the season in that location (Silverman et al., 2012).

Analysis of satellite-tracked Surf Scoters (*Melanitta perspicillata*), captured and tagged in the mid-Atlantic region, revealed their winter distributions to be largely well inshore of the mid-Atlantic BOEM WEAs, although they did exhibit a smaller core wintering area in Nantucket Sound (Berlin et al., 2017). Surf Scoters did overlap somewhat with the mid-Atlantic BOEM WEAs during their migration periods (Berlin et al., 2017). The regional MDAT abundance models and mid-winter aerial waterfowl surveys (Silverman et al., 2012) show that most seaducks are concentrated close to shore and between Nantucket Island, Martha's Vineyard, and Cape Cod.

The annual exposure for the seaduck group (six species) was insignificant. On a seasonal basis, Red-breasted Merganser (*Mergus serrator*), Long-tailed Duck, and Black Scoter (*Melanitta nigra)* are expected to have insignificant exposure in all seasons; Common Eiders (*Somateria mollissima*) have unlikely exposure in the winter; Surf Scoter have unlikely exposure in fall and winter; and overall, White-winged Scoter (*Melanitta fusca*) is expected to have insignificant exposure with peaks of unlikely exposure in spring and winter.

6.2.1.4.3 Shearwaters, Petrels, Storm-Petrels

Petrels and shearwaters that breed in the southern hemisphere visit the northern hemisphere during the austral winter (boreal summer) in vast numbers. These species use the US Atlantic Outer Continental Shelf ("OCS") region so heavily that, in terms of sheer numbers, they easily swamp the locally breeding species and year-round residents at this time of year (Nisbet et al., 2013). Several of these species (e.g., Great Shearwater [*Puffinus gravis*], Cory's Shearwater [*Calonectris diomedea*], and Wilson's Storm-Petrel [*Oceanites oceanicus*]) are found in high densities across the broader region (Veit et al., 2015) and within BOEM's MA WEA (Veit et al., 2016) in summer. The regional MDAT abundance models show that the birds are concentrated offshore south of Maine and Nova Scotia. The annual exposure score for the shearwater group (six species) ranged from insignificant to unlikely. Northern Fulmar (*Fulmarus glacialis*), Sooty Shearwater (*Puffinus griseus*), and Wilson's Storm-Petrel had an overall score of insignificant though the storm-petrels and shearwaters show a peak of potential in the summer. Overall, Manx Shearwater (*Puffinus puffinus*), Cory's Shearwater, and Great Shearwater are expected to have insignificant to unlikely annual exposure with peaks mainly in the summer.

6.2.1.4.4 Gannets and Cormorants

Northern Gannets (*Morus bassanus*) breed in southeastern Canada and winter along the US Atlantic OCS, particularly in the mid-Atlantic region and the Gulf of Mexico. Based on analysis of satellite-tracked Northern Gannets captured and tagged in the mid-Atlantic region, these birds show a preference for shallower, more productive waters and are mostly found inshore of the mid-Atlantic BOEM WEAs in winter (Stenhouse et al., 2017). They are opportunistic foragers, however, capable of long-distance oceanic movements, and generally migrate on a broad front, all of which may increase their exposure to offshore wind facilities, compared with species that are truly restricted to inshore habitats (Stenhouse et al., 2017). The regional MDAT abundance models show that Northern Gannets use the OCS to the south of the WDA. The annual exposure score for Northern Gannets is unlikely with exposure primarily expected during the spring, summer, and fall.

Double-crested Cormorants (*Phalacrocorax auritus*) are expected to be the most likely species of cormorant that may have limited exposure to the Project. While Great Cormorants (*Phalacrocorax carbo*) could possibly pass through the WDA during the non-breeding season, they are likely to remain in coastal waters (Hatch et al., 2000). Double-crested Cormorants tend to forage and roost close to shore. The regional MDAT abundance models show that cormorants are concentrated closer to shore and to the south. This aligns with the literature, which indicates these birds rarely use the offshore environment (Dorr et al., 2014). The annual exposure score for Double-crested Cormorant is insignificant across all seasons.

6.2.1.4.5 Gulls and Jaegers

The gulls present in the region are a large and varied group. The larger gull species (Herring Gull [*Larus argentatus*] and Great Black-backed Gull [*Larus marinus*]) are resident to the region year-round, but roam further offshore outside of the breeding season (Veit et al., 2016). While gulls tend to be coastal, they will follow fishing vessels offshore. Jaegers and skuas are highly pelagic group of dark, gull-like species. The jaegers (Pomarine Jaeger [*Stercorarius pomarinus*], Parasitic Jaeger [*Stercorarius parasiticus*], and Long-tailed Jaeger [*Stercorarius longicaudus*]) are all Arctic breeders that regularly migrate through the western North Atlantic region. Although their wintering ranges are poorly understood, they are known to occur in the Caribbean and off the coast of South America (Wiley & Lee, 1999; Wiley & Lee, 2000), or as far as southwest Africa (Long-tailed Jaeger)(Wiley & Lee, 1998). The Parasitic Jaeger is often observed closer to shore during migration than the others species (Wiley & Lee, 1999). Great Skuas (*Stercorarius skua*) are also northern breeders that may pass along the Atlantic OCS outside the breeding season. In recent decades, skuas observed in the western North Atlantic have increasingly been identified as South Polar Skuas (*Stercorarius maccormicki*) (Lee, 1989), which breed in the southern hemisphere and wander north during the austral winter. The regional MDAT abundance models show that these birds have a wide distribution ranging from near shore (gulls) to offshore (jaegers).

The annual exposure score for the gull and jaeger group (seven species) ranged from insignificant to potential. Icelandic Gull (*Larus glaucoides*) has insignificant exposure during all seasons. Pomerine Jaeger and Laughing Gull (*Larus atricilla*) are also expected to have insignificant exposure over all seasons; Pomerine Jaeger has unlikely exposure in the summer, and Laughing Gull has unlikely exposure during the fall. Over all seasons, Black-legged Kittiwake (*Rissa tridactyla*) and Bonaparte's Gull (*Larus Philadelphia*) are expected to have unlikely exposure; Black-legged Kittiwake exposure ranges from unlikely in the fall to likely in the winter, and Bonaparte's Gull is likely in the spring and insignificant in all other seasons. Overall, Herring Gull and Great Black-backed Gull are expected to have potential exposure primarily during the summer and fall, with peaks to likely exposure in the summer for Herring Gull.

6.2.1.4.6 Terns

Roseate Terns and Common Terns (*Sterna hirundo*) breed in Massachusetts, and Arctic Terns (*Sterna paradisae*) could pass through the WDA during migration. Terns, all migratory, generally restrict themselves to coastal waters during breeding, although they may pass through the WDA on their migratory journeys. This is especially true of a few tern species (Common Terns, Roseate Terns), which are known to aggregate around the Nantucket Shoals, particularly in spring (Veit et al., 2016). The regional MDAT abundance models show that terns are generally concentrated closer to shore than the WDA. The annual exposure score for the tern group (two species) was insignificant. Common Terns had insignificant exposure in all seasons.

Roseate Terns are federally-listed as well as state listed, and are thus addressed in the "Federally-Listed Species" section, below.

6.2.1.4.7 Auks

The auk species present in the region are generally northern or Arctic-breeders that winter along the US Atlantic OCS. The annual abundance and distribution of auks along the eastern seaboard in winter is erratic, however, depending upon broad climatic conditions and the availability of prey (Gaston & Jones, 1998). Recent increases in their abundances off the coast of Massachusetts has been linked to long-term variations in oceanic climate (Veit & Manne, 2015). In winters with prolonged harsh weather, which may prevent foraging for extended periods, these generally pelagic species often move inshore, or are driven considerably further south than usual. As a group, auks are commonly impacted in this way during severe storms, although die-off events also regularly impact the petrels and shearwaters, and occasionally Northern Gannets (Fraser, 2017). The regional MDAT abundance models show that auks are concentrated offshore and south of Nova Scotia.

Table 6.2-6 Basic Ecological Traits of Marine Birds in the Region and Their Conservation Status at State, Federal, and Global Scales[1]

Species	Scientific Name	Map	Regional	Distribution		Diet		Conservation Status[2]			Global	Breeding
			Presence	In/Offshore	At sea	Feeds at	Feeds on	State	Federal	Global	Distribution	Region
Loons & Grebes												
Common Loon	*Gavia immer*	*	winter	pelagic	dispersed	mid-water	fish, inverts	SC	.	LC	circumpolar	temperate
Red-throated Loon	*Gavia stellata*	*	winter	inshore	dispersed	mid-water	fish, inverts	.	BCC	LC	circumpolar	subArctic
Horned Grebe	*Podiceps auritus*		winter	coastal	dispersed	surf-mid	fish, inverts	.	BCC	VU	circumpolar	temp-subArc
Red-necked Grebe	*Podiceps grisegena*	*	winter	coastal	dispersed	surface	fish, inverts	.	.	LC	circumpolar	temp-subArc
Seaducks												
King Eider	*Somateria spectabilis*		winter	coastal	aggregated	benthos	inverts	.	.	LC	circumpolar	Arctic
Common Eider	*Somateria mollissima*	*	year-round	coastal	aggregated	benthos	inverts	.	.	LC	circumpolar	Arc-subArc
Surf Scoter	*Melanitta perspicillata*	*	winter	coastal	aggregated	benthos	inverts	.	.	LC	N America	subArctic
White-winged Scoter	*Melanitta fusca*	*	winter	coastal	aggregated	benthos	inverts	.	.	LC	circumpolar	subArctic
Black Scoter	*Melanitta nigra*		winter	coastal	aggregated	benthos	inverts	.	.	LC	circumpolar	subArctic
Long-tailed Duck	*Clangula hyemalis*	*	winter	coastal	aggregated	benth-mid	inverts	.	.	VU	circumpolar	Arctic
Shearwaters, Petrels & Storm-Petrels												
Northern Fulmar	*Fulmarus glacialis*	*	winter	pelagic	disp-aggreg	surface	fish, squid	.	.	LC	circumpolar	Arctic
Cory's Shearwater	*Calonectris diomedea*	*	summer	pelagic	disp-aggreg	surface	fish, inverts	.	.	LC	circumpolar	subAntarctic
Great Shearwater	*Puffinus gravis*		summer	pelagic	disp-aggreg	surface	fish, inverts	.	BCC	LC	N & S Atlantic	subAntarctic
Sooty Shearwater	*Puffinus griseus*	*	summer	pelagic	disp-aggreg	surface	fish, inverts	.	.	NT	circumpolar	subAntarctic
Manx Shearwater	*Puffinus*	*	summer	pelagic	dispersed	surface	fish, inverts	.	.	LC	N & S Atlantic	temperate
Audubon's Shearwater	*Puffinus lherminier*		summer	pelagic	dispersed	surface	fish, inverts	.	BCC	LC	N America	temp-trop
Wilson's Storm-Petrel	*Oceanites oceanicus*	*	summer	pelagic	dispersed	surface	plankton	.	.	LC	circumpolar	subAntarctic
Leach's Storm-Petrel	*Oceanodroma leucorhoa*		summer	pelagic	dispersed	surface	plankton	E	.	VU	circumpolar	subArctic
Gannets & Cormorants												
Northern Gannet	*Morus bassanus*	*	winter	coast-pelagic	dispersed	mid-water	fish	.	.	LC	N Atlantic	subArctic
Double-crested Cormorant	*Phalacrocorax auritus*	*	year-round	coast-inland	dispersed	mid-water	fish	.	.	LC	N America	subArc-temp
Great Cormorant	*Phalacrocorax carbo*		year-round	coast-inland	dispersed	benthos	fish	.	BCC	LC	Eurasia, Africa	subArc-subAnt
Gulls & Jaegers												
Black-legged Kittiwake	*Rissa tridactyla*	*	winter	pelagic	dispersed	surface	fish, inverts	.	.	LC	circumpolar	Arctic
Bonaparte's Gull	*Larus philadelphia*	*	winter	pelagic	dispersed	surface	fish, inverts	.	.	LC	N America	subArctic
Black-headed Gull	*Chroicocephalus ridibundus*		rare	coastal	dispersed	surface	fish, inverts	.	.	LC	W Europe	temperate
Little Gull	*Hydrocoloeus minutus*		rare	coastal	dispersed	surface	fish, inverts	.	.	LC	circumpolar	subArctic
Laughing Gull	*Larus atricilla*	*	summer	coastal	dispersed	surface	fish, inverts	.	.	LC	Americas	temp-trop
Ring-billed Gull	*Larus delawarensis*		year-round	coastal	dispersed	surface	fish, inverts	.	.	LC	N America	temperate
Herring Gull	*Larus argentatus*	*	year-round	coastal	dispersed	opportunistic		.	.	LC	circumpolar	temperate
Icelandic Gull	*Larus glaucoides*	*	winter	coastal	dispersed	opportunistic		.	.	LC	circumpolar	Arctic
Lesser Black-backed Gull	*Larus fuscus*		rare	coastal	dispersed	opportunistic		.	.	LC	W Europe	temperate
Glaucous Gull	*Larus hyperboreaus*		winter	coastal	dispersed	opportunistic		.	.	LC	circumpolar	Arctic
Great Black-backed Gull	*Larus marinus*		year-round	coastal	dispersed	opportunistic		.	.	LC	circumpolar	temperate
Pomarine Jaeger	*Stercorarius pomarinus*	*	passage	pelagic	dispersed	surface	fish, inverts	.	.	LC	circumpolar	Arctic
Parasitic Jaeger	*Stercorarius parasiticus*		passage	pelagic	dispersed	surface	fish, inverts	.	.	LC	circumpolar	Arctic
Long-tailed Jaeger	*Stercorarius longicaudus*		passage	pelagic	dispersed	surface	fish, inverts	.	.	LC	circumpolar	Arctic

Table 6.2-6 Basic Ecological Traits of Marine Birds in the Region and Their Conservation Status at State, Federal, and Global Scales[1] (Continued)

Species	Scientific Name	Map	Regional Presence	Distribution		Diet		Conservation Status[2]			Global Distribution	Breeding Region
Terns												
Least Tern	*Sternula antillarum*		summer	coastal	dispersed	surface	fish, inverts	SC	SC	LC	N. America	temp-trop
Caspian Tern	*Sterna caspia*		summer	coastal	dispersed	surface	fish, inverts	.	.	LC	N Am, Eura, Afr	temp-trop
Black Tern	*Chlidonias niger*		passage	coastal	dispersed	surface	inverts, fish	.	.	LC	N/S Am, Euro, Afr	inland temp
Roseate Tern	*Sterna dougalli*	*	summer	coastal	dispersed	surface	fish, inverts	E	E	LC	N/S Am, Asia, Afr	temp-trop
Common Tern	*Sterna hirundo*	*	summer	coastal	dispersed	surface	fish, inverts	SC	.	LC	circumpolar	subArc-trop
Arctic Tern	*Sterna paradisae*		passage	coastal	dispersed	surface	fish, inverts	SC	BCC	LC	circumpolar	Arctic
Forster's Tern	*Sterna forsteri*		summer	coastal	dispersed	surface	fish, inverts	.	.	LC	N America	inland temp
Royal Tern	*Sterna maxima*		summer	coastal	dispersed	surface	fish, inverts	.	.	LC	N/S Am, Africa	temp-trop
Auks												
Dovekie	*Alle alle*	*	winter	pelagic	dispersed	mid-water	plankton	.	.	LC	circumpolar	Arctic
Common Murre	*Uria aalge*	*	winter	pelagic	dispersed	mid-water	fish, inverts	.	.	LC	circumpolar	Arc-subArc
Thick-billed Murre	*Uria lomvia*		winter	pelagic	dispersed	mid-water	fish, inverts	.	.	LC	circumpolar	Arctic
Razorbill	*Alca torda*	*	winter	pelagic	dispersed	mid-water	fish, inverts	.	.	NT	N Atlantic	sub-Arctic
Black Guillemot	*Cepphus grylle*		year-round	coastal	dispersed	benth-mid	fish, inverts	.	.	LC	circumpolar	Arc-temp
Atlantic Puffin	*Fratercula artica*		winter	pelagic	dispersed	mid-water	fish	.	.	VU	N Atlantic	subArc-temp
Shorebirds												
Red-necked Phalarope	*Phalaropus lobatus*		passage	pelagic	dispersed	surface	plankton	.	.	LC	circumpolar	Arctic
Red Phalarope	*Phalaropus fulicarius*	*	passage	pelagic	dispersed	surface	plankton	.	.	LC	circumpolar	Arctic

1 Adapted from eBird data (from BOEM, 2014) and cross-referenced with the US Fish and Wildlife Service ("USFWS") IPaC database (https://ecos.fws.gov/ipac/)

2 Conservation Status: E = Endangered, T = Threatened, SC = Special Concern, BCC = Bird of Conservation Concern, VU = Vulnerable, NT = Near Threatened, LC = Least Concern.

The annual exposure score for the auk group (three species) ranged from insignificant to unlikely. Overall, Common Murre (*Uria aalge*) is expected to have insignificant exposure with unlikely exposure limited to the winter; Dovekie (*Alle alle*) is expected to have insignificant exposure with potential exposure in the winter; and Razorbill (*Alca torda*) is expected to have unlikely exposure that ranges from unlikely in the fall and winter, and potential in the spring.

6.2.1.5 Federally-Listed Species

6.2.1.5.1 Roseate Tern

Species General Description: Roseate Terns are a small tern species that breed colonially on islands. The northwest Atlantic Ocean population of Roseate Terns breeds in the northeastern US and Atlantic Canada, and winters in South America, primarily eastern Brazil (Nisbet et al., 2014; USFWS, US 2010). Roseate Terns generally arrive at their northwest Atlantic breeding colonies in late April to late May, with nesting occurring between roughly mid-May and late July. They commonly forage during the breeding season in shallow water areas (i.e., <5 m [16.4 feet ("ft")] water depth), such as sand bars (Nisbet et al., 2014; USFWS, 2010). Roseate Terns forage by plunge-diving or surface-dipping to catch small fish, such as sand lance (*Ammodytes* spp) (Goyert et al., 2014; Nisbet et al., 2014).

Over 90% of Roseate Terns in this population breed at three colony locations in Massachusetts (Bird Island, Ram Island, and Penikese Island in Buzzards Bay) and one colony location in New York (Great Gull Island, near the entrance to Long Island Sound) (Loring et al., 2017; Nisbet et al., 2014). Breeding Roseate Terns generally stay within about 10 km (6.2 mi) of the colony to forage for food, though they may travel 30-50 km (18.6 – 31.0 mi) from the colony while provisioning chicks (Burger et al., 2011; Loring et al., 2017; Nisbet et al., 2014; USFWS, 2010). The closest Roseate Tern nesting colony to the WDA is located at Norton Point/Katama Beach in Edgartown, about 23.5 km (14.6 mi) from the northernmost edge of the WDA, and had 35 breeding pairs as of 2015 (Mostello & Longsdorf, 2017).

Following the breeding season, adult and hatch year Roseate Terns move to post-breeding coastal staging areas from approximately late July to mid-September (USFWS, 2010). There are roughly 20 staging areas in southeastern Cape Cod and nearby islands, which represent the majority of the breeding population for the northwest Atlantic (USFWS, 2010). Foraging activity during the staging period is known to occur up to 16 km (10 mi) from the coast, though most foraging activity occurs much closer to shore (Burger et al., 2011). Monomoy Island and surrounding areas, known as one of the primary pre-migratory staging areas for the species, are about 55-60 km (34.2-37.3 mi) from the WDA. The nearest pre-migratory staging area to the WDA is located at Katama Beach on the south side of Martha's Vineyard (23.5 km [14.6 mi] from the WDA).

Roseate Tern migration routes are poorly understood, but they appear to migrate primarily pelagically (Burger et al., 2011; Mostello et al., 2014; Nisbet, 1984; Nisbet et al., 2014; USFWS, 2010,). Six Roseate Terns tracked with data loggers in the 2000's flew directly between Massachusetts and eastern Caribbean islands during spring and fall migration, crossing the ocean near the edge of the continental shelf, and in some cases spending several days at sea (Mostello et al.; 2014, Nisbet et al., 2014; USFWS, 2010). The trip from Cape Cod to Puerto Rico in the fall took 1.5-2.5 days on average (900-1,500 km/day [559-932 mi/day]), with birds flying all night and stopping to feed at times during the day (Mostello et al., 2014; Nisbet et al., 2014). Spring migration from South America to breeding locations occurred more quickly overall, but migration between the northeastern Caribbean and Massachusetts was less direct, tended farther west than in fall (though still well offshore), and included nocturnal as well as diurnal stopover periods (Mostello et al., 2014; Nisbet et al., 2014). Spring pre-breeding staging locations appear to be similar to post-breeding staging areas (Mostello et al., 2014).

Listing and Population Status: The northwest Atlantic Ocean population of Roseate Terns has been federally-listed as endangered under the Endangered Species Act ("ESA"), 16 U.S.C. ch. 35 § 1531 et seq., since 1987. Other breeding populations of Roseate Terns, such as the Caribbean breeding population, are unlikely to occur in the WDA (BOEM, 2014). Declines in the northwest Atlantic population have been largely attributed to low reproductive productivity, partially related to predator impacts on breeding colonies and habitat loss and degradation, though adult Roseate Tern survival is also unusually low for a tern/small gull species (USFWS, 2010). As of 2015, 50% of the population's approximately 3,900 pairs nested in Massachusetts (Mostello & Longsdorf, 2017).

Regional Information: Areas around Cape Cod that have been identified as important for Roseate Tern foraging activity in past years have largely been concentrated in Buzzard's Bay, Vineyard Sound, and along the southern coast of the Cape in Nantucket Sound (Minerals Management Service ["MMS"], 2008), though foraging locations can be highly dynamic. Non-breeding individuals, including juveniles and non-reproductive adult birds, are thought to move between foraging and staging areas more frequently and to move over longer distances than breeding individuals (USFWS, 2017a).

Recent data suggest that Nantucket Shoals may also be an important area for Common Terns and Roseate Terns in spring (during the month of May), prior to initiation of breeding (Veit et al., 2016). In recent aerial surveys of BOEM's MA WEA and vicinity, *Sterna* terns were observed offshore most commonly during the spring season, though median estimates of terns per square kilometer remained low in all seasons (Veit et al., 2016).

WDA Specific Information: Overall, the regional and site-specific information indicate low use of the WDA by Roseate Tern during spring, summer, and fall (terns are not present in the winter). The MDAT abundance models suggest that Roseate Tern occupancy and abundance in the WDA is likely to be much lower than in Nantucket Sound in all seasons examined- spring, summer, and fall (Kinlan et al., 2016)- though it should be noted that model performance was quite poor, particularly in spring, likely due, in part, to the relatively few Roseate Tern observations in the dataset (n = 328). The Veit survey data only has three records of terns (not identified to species) in the WDA for all seasons and years combined (Veit et al., 2016). Additional surveys were then conducted to gather supplementary information during the spring in which no Roseate Terns were observed in the WDA during boat surveys conducted in April and May of 2018 (see Appendix III-O).

During the breeding and post-breeding periods, very few, if any, Roseate Terns are predicted to occur within the WDA (BOEM, 2014; Kinlan et al., 2016). Survey data from the region suggest that Roseate Terns and other terns are most commonly observed around the Muskeget Channel, between Martha's Vineyard and Nantucket (BOEM, 2014; Veit et al., 2016).

Roseate Terns may occur at the WDA ephemerally during spring and fall migration, as well as during post-breeding movements towards staging areas (BOEM, 2014; Burger et al., 2011). Recent tracking data shows that in July/August, individuals move between staging locations on islands in Nantucket Sound, Block Island, and Montauk, including potential movements through the BOEM MA WEA, BOEM Rhode Island WEA, and Block Island Wind Farm (Loring et al., 2017). Though these data are still being analyzed, there is no evidence of post-breeding movements through the WDA (Loring et al., 2017), likely due to its location to the south of known breeding and staging locations.

In sum, Roseate Terns are expected to have low use of the WDA during all seasons, and any exposure will probably occur only during migration. The Veit survey data recorded only three unidentified terns in the WDA and the annual exposure analysis for Roseate Tern was insignificant. The MDAT abundance models predict low use of the WDA, with birds concentrated generally closer to shore than the WDA. Since Roseate Terns generally forage in shallow water they would not be expected to use the WDA for feeding habitat. Given that terns are rarely observed in the WDA and exposure is likely limited to migration, the expected exposure of Roseate Terns is insignificant.

6.2.1.5.2 Piping Plover

Species General Description: Piping Plovers are a small shorebird that nest on beaches, sand flats, and alkali wetlands along the Atlantic coast of North America, the Great Lakes, and in the Midwestern plains (Elliott-Smith & Haig, 2004). Piping Plovers feed on terrestrial and aquatic invertebrates, particularly in the intertidal zone and along wrack lines, and spend most of their time on the ground rather than aloft (Elliott-Smith & Haig, 2004). The Atlantic coast-breeding subspecies of Piping Plovers, which is the only population likely to occur in the vicinity of the WDA, breeds as individual pairs on sandy beaches from

Newfoundland to North Carolina (BOEM, 2014; Elliott-Smith & Haig, 2004). Breeding generally occurs in May through early August, with variation in onset of breeding related to local pair densities as well as seasonal weather conditions (Elliott-Smith & Haig, 2004). Non-migratory movements in May-August appear to be exclusively coastal (Burger et al., 2011). Nocturnal activities during the breeding period are less well known, but appear to be similar to daytime activities in many respects, including foraging, incubating nests, and short local flights when birds are disturbed (Staine & Burger, 1994). Band recovery data suggests that there may be several distinct breeding populations within the Atlantic coast subspecies, with individuals largely returning to the areas where they were hatched or bred in previous years (Amirault-Langlais et al., 2014; USFWS, 2009).

Migration periods are primarily April-May and August-September (BOEM, 2014), though breeding plovers arrive in Massachusetts beginning around mid-March. Post-breeding movements of fledged chicks (≤50 km [31.1 mi]) and adults can occur prior to initiation of migration (Elliott-Smith & Haig, 2004), and post-breeding migratory movements can begin as early as June, with adult birds departing Massachusetts by late August (Elliott-Smith & Haig, 2004; Loring et al., 2017). There is some suggestion that hatch year birds may be delayed on their first fall migration, arriving at wintering grounds several months after adults, but little data are available (Elliott-Smith & Haig, 2004). Migration occurs primarily during nocturnal periods, with the average takeoff time in Massachusetts and Rhode Island appearing to be around 5:00-6:00 PM (Loring et al., 2017). Both breeding and wintering habitats include islands >5 km [3.1 mi] from the coast, including the Bahamas, which is >160 km (99.4 mi) from the US Atlantic coastline (Normandeau Associates Inc., 2011). This, along with the infrequency of observations of migratory flocks along the Atlantic coast, has been suggested to indicate that many Atlantic plovers, like the inland-breeding subspecies, may make nonstop long-distance migratory flights (Normandeau Associates Inc., 2011).

The species winters in the coastal southeastern United States and Caribbean (BOEM, 2014; Elliott-Smith & Haig, 2004; USFWS, 2009). The winter range of the species is imperfectly understood, particularly for US Atlantic breeders and for wintering locations outside the US, but includes the southeastern coast of the US from North Carolina to Texas, as well as Mexico, and several Caribbean islands (USFWS, 2009). Within the US wintering range, the Atlantic subpopulation appears to primarily winter along the southern Atlantic coast and the Gulf coast of Florida, though Massachusetts-breeding birds are known to winter in Texas as well (Elliott-Smith & Haig, 2004; USFWS, 2009).

<u>Listing and Population Status</u>: The Atlantic population is listed as threatened under the ESA, with approximately 1,765 US nesting pairs as of 2016 (USFWS, 2017b), and is heavily managed on the breeding grounds to promote population recovery (Elliott-Smith & Haig, 2004). Coastal habitat loss and degradation, as well as human-related disturbance, represent some of the biggest threats to the population; predation is also an issue on the breeding

grounds, and in Massachusetts this issue is exacerbated in association with human-related disturbance (BOEM, 2014; Elliott-Smith & Haig 2004; USFWS, 2009). The viability of the species is heavily dependent upon adult and juvenile survival rates (USFWS, 2009). However, the New England recovery unit of the population has exceeded or nearly met the USFWS-defined minimum abundance goal for recovery (625 pairs) every year since 1998 (USFWS, 2009). The Massachusetts population, by far the largest of the New England states, was estimated to be 649 pairs in 2016 (USFWS, 2017b).

Regional Information: Piping Plovers are present in Massachusetts during spring and fall migratory periods and during the breeding season (mid-March to late August or early September) (BOEM, 2014; Elliott-Smith & Haig, 2004). Large numbers of Piping Plovers have been observed in pre-migratory staging in southeastern Cape Cod in late summer (BOEM, 2014).

Only recently have data started to become available on the potential for macro-scale exposure of migrating Piping Plovers to offshore WEAs along the Atlantic coast. The species was historically thought to migrate along the coast (e.g., within ~5 km [3.1 mi] of the coast), because of an observed strong association with beaches and mudflats, although there was little actual evidence regarding migration routes or stopover sites (Burger et al., 2011; Elliott-Smith & Haig, 2004; USFWS, 2009).

However, Piping Plovers that bred in Rhode Island and Monomoy National Wildlife Refuge were recently tracked with nanotags (a type of VHF transmitter; n = 50) and monitored using automated telemetry stations in terrestrial areas. The telemetry stations standard detection range did not extend into the WDA. Migration trajectories in areas well offshore are interpolated from observed flight trajectories in coastal areas, as well as subsequent detections of individuals at other telemetry stations. The tracked individuals primarily chose offshore migration routes from their nesting locations (Loring et al., 2017); approximately 70% of Piping Plovers from Monomoy flew on a southward trajectory over Nantucket Island and eastern Nantucket Sound, apparently east of the WDA. Over half of Rhode Island birds also chose an offshore migration route, flying through Block Island Sound (between Block Island and Montauk), to the west of the WDA (Loring et al., 2017). Most of the remaining birds took more coastal routes west through the Sounds of Nantucket, Rhode Island, Block Island, and Long Island (Loring et al., 2017).

These recent data present evidence for offshore migratory "hops" between coastal areas such as Cape Cod, Long Island, coastal New Jersey/Delaware, and the Outer Banks of North Carolina. Large flocks of Piping Plovers have been observed during migratory stopover in Virginia, Cape May, New Jersey, and Cape Lookout, North Carolina (Elliott-Smith & Haig, 2004), providing additional evidence in support of this hypothesis. BOEM recently suggested that "[d]uring their migratory periods, primarily April and May in springtime and August and September in fall, at least some individuals of this species likely traverse the [BOEM MA] WEA, as migration does not appear to be concentrated along the coast" (BOEM, 2014).

WDA Specific Information: Nanotag telemetry stations did not have coverage of the WDA due to its distance from shore, but migratory flight trajectories generally suggest that migration routes may be located to the east and west of the WDA. There are no records of Piping Plovers in the WDA during diurnal periods, and there is no data available for nocturnal periods. In sum, since Piping Plover exposure to the WDA would hypothetically be only during migration, there are little to no records of the birds offshore, and there is no breeding or foraging habitat for the species in the WDA. Thus, the expected exposure is insignificant.

6.2.1.5.3 Red Knot

Species General Description: Red Knots are medium-sized shorebirds with some of the longest migrations in the world, undertaking nonstop flights of up to 8,000 km (4,970 mi) on their circumpolar travels between breeding and wintering locations (Baker et al., 2013). When not actively migrating, Red Knots feed exclusively in terrestrial locations, primarily in the intertidal zone, on mussels, clams, and other invertebrates, and spend most of their time on the ground rather than aloft.

Red Knots tend to embark on migratory flights a few hours before sunset, on sunny days and days with tailwinds, and to migrate in flocks numbering in the dozens to hundreds of individuals (Baker et al., 2013). Migration routes appear to be highly diverse. Some individuals fly over the open ocean from the northeastern US directly to stopover/wintering sites in the Caribbean and South America, while others make the ocean "jump" from farther south, or follow the US Atlantic coast for the duration (Baker et al., 2013; BOEM, 2014). Some of this variation may be due to birds avoiding large storms in the Atlantic (Baker et al., 2013).

Listing and Population Status: The *rufa* subspecies of the Red Knot is listed as threatened under the ESA, primarily because the Atlantic flyway population decreased by approximately 70% from 1981 to 2012, to <30,000 individuals (USFWS, 2015; Baker et al., 2013; Burger et al., 2011). This subspecies appears to include three distinct populations in the western Hemisphere, with individuals wintering in the southeastern US and Caribbean, northern Brazil, and Tierra del Fuego (Baker et al., 2013). All three populations breed in the high Arctic, and share several key migration stopover areas along the US. east coast, particularly in Delaware Bay and coastal islands of Virginia (Burger et al., 2011). Increasingly limited food resources in these staging areas, as well as breeding conditions in the Arctic and habitat degradation on the wintering grounds, are thought to be contributing to the population's decline (Baker et al., 2013). Impacts of climate change on habitats, food availability, and migration are also expected to negatively influence Red Knot populations. Population status is thought to be strongly influenced by adult survival and recruitment rates, conditions in the breeding grounds, and food availability on stopover sites (97-98% of individuals are estimated to use the same small number of stopover locations in some areas) (Baker et al., 2013).

Regional Information: The Red Knot is present in Massachusetts only during migratory periods (BOEM, 2014). All three populations of *rufa* are known to stop over on Monomoy Island during southward migration in the fall (Baker et al., 2013). The fall migration period is July-October, and is characterized by a concentration of migrant activity and departures in Massachusetts, particularly Cape Cod in August (Baker et al., 2013; Burger et al., 2011). As well as arriving and departing at slightly different times, adults and juveniles appear to use different stopover locations in Cape Cod and mainland Massachusetts (Baker et al., 2013).

During northward migration in spring, all three wintering populations of *rufa* use Delaware Bay as a key stopover location in late April to June, before undertaking long flights to locations in Canada (Baker et al., 2013). Birds in the southeastern US wintering population may also make multiple stops along the eastern seaboard, including in Massachusetts; spring migration through Massachusetts may thus include both offshore migratory activity and more coastal activity after birds make landfall farther south (BOEM, 2014). Reports from the 1800's suggest many thousands of Red Knots stopping over in Massachusetts in late May and early June, but relatively few birds are observed in Massachusetts Bay today (Baker et al., 2013). While at stopover locations, Red Knots make local movements (e.g., commuting flights between foraging locations related to tidal changes), but are thought to remain within 5 km (3.1 mi) of shore (Burger et al., 2011).

WDA Specific Information: There are no records of Red Knot in the WDA. Most adult *rufa* fly offshore over the Atlantic from Canadian or US staging areas to South America (Baker et al., 2013); this is the period in which Red Knots could potentially move through the WDA (BOEM, 2014). However, since Red Knot exposure to the WDA is limited to migration and there is no habitat for the species in the WDA, the expected exposure is insignificant.

6.2.1.5.4 Bald and Golden Eagle

Species General Description: Bald Eagles are broadly distributed across North America. The species generally nests and perches in association with water (lakes, rivers, bays) in both freshwater- and marine-based habitats, often remaining within roughly 500 m (1,640 ft) of the shoreline (Buehler, 2000). Foraging habits are seasonally opportunistic, but individuals generally prefer fish when available. In some regions, the diets of Bald Eagles nesting in offshore coastal settings are dominated by birds (i.e., waterfowl, cormorants, and gulls), whereas inland nesters in New England largely focus on fish (Murie, 1940; Todd et al., 1982). Bald Eagles commonly scavenge dead birds, fish, and mammals, particularly during the winter when live fish prey are more scarce.

Golden Eagle (*Aquila chrysaetos*) diets are generally comprised of small mammals such as rabbits, mice and prairie dogs, but numerous other prey items have also been reported (Kochert et al., 2002). Golden Eagles are generally associated with open habitats, particularly in the western US, but satellite-tracked individuals wintering in the eastern US have also been documented to heavily utilize forested regions (Katzner et al., 2012). In addition to breeding populations in Europe and Asia, Golden Eagles are broadly distributed across western North America, but are comparatively rare in the eastern US (Kochert et al., 2002). Golden Eagles commonly winter in the southern Appalachians and are regularly observed in the mid-Atlantic US, spanning coastal plain habitat in Virginia, Delaware, North Carolina, South Carolina, and other southeastern US states. Individuals migrating between Appalachian states and easternmost breeding populations in Canada generally use inland migration routes following the Appalachian Mountains, rather than coastal migration flyways (Katzner et al., 2012).

Unlike many groups of birds, such as falcons, gulls, and shorebirds, eagles have a high weight to wing area ratio (Mendelsohn et al., 1989). This wing-loading characteristic causes eagles to rely heavily upon thermals during long-distance movements and to generally avoid large water crossings (Kerlinger, 1985). Bald Eagles will, however, travel to islands to nest, forage (i.e., seabird colonies) (Todd et al., 1982), and presumably to stopover during long-distance movements (Mojica et al., 2008).

Listing and Population Status: Bald Eagles were removed from the federal list of threatened and endangered species in 2007; but are currently listed as threatened in Massachusetts. Breeding populations of Golden Eagles are extirpated in the eastern US, (Katzner et al., 2012), and the nearest known breeding populations are in Canada, where they are common in several eastern Canadian Provinces (i.e., Québec, Newfoundland, and Labrador) (Katzner et al., 2012). Both Bald Eagles and Golden Eagles remain federally protected under the BGEPA.

Regional Information: Bald Eagles are present year-round in Massachusetts, and are on Martha's Vineyard, Nantucket, and other nearby islands (eBird 2017). In a study evaluating the space use of Bald Eagles captured in Chesapeake Bay, the Cape Cod region was associated with very low levels of use (Mojica et al., 2016). In 2012-2013, a large offshore area in the mid-Atlantic US surveyed using both boat-based and aerial surveys detected only four Bald Eagles, all <6 km (3.7 mi) from shore (Williams et al., 2015). Given the fact that the study area in that study was near one of the largest Bald Eagle population centers in North America (Chesapeake Bay), this finding supports the hypothesis that Bald Eagles rarely venture large distances offshore.

WDA Specific Information: The general morphology of both Bald Eagles and Golden Eagles dissuades regular use of offshore habitats. These two species generally rely upon thermals, which are poorly developed over the ocean, during migration movements. Golden Eagle exposure in the WDA is expected to be insignificant due to their dietary habits, limited distribution in the eastern US, and reliance on terrestrial habitats (BOEM, 2014). Bald Eagle exposure in the WDA is also expected to be insignificant because the WDA is not located along any likely or known Bald Eagle migration route, Bald Eagles tend not to fly over large waterbodies, and features that might potentially attract them offshore (i.e., islands) are absent in the vicinity. Since exposure is expected to be insignificant for both eagle species and there is no evidence that they will be exposed to the WDA, eagles will not be addressed further.

6.2.2 Potential Impacts of the Project

Potential direct and indirect impacts were evaluated by considering how vulnerable species will be exposed (see Section 6.2.1) to impact-producing factors ("IPFs"). Vulnerability was defined as behavioral factors (e.g., flight, height, and avoidance) that increase the likelihood that a bird will either collide with a turbine or be displaced from the WDA (Goodale & Stenhouse, 2016). For each species group, vulnerability was evaluated based upon existing assessments (e.g., Furness et al., 2013) and documented behavioral response to offshore wind farms in the literature. Levels of behavioral vulnerability are defined in Table 6.2-7.

Table 6.2-7 Definitions Behavioral Vulnerability

Behavioral Vulnerability Level	Definition
Insignificant	Low ranking for collision and displacement risk in Furness et al., 2013 AND/OR No evidence of collisions or displacement in the literature
Unlikely	Low ranking for collision and displacement risk in Furness et al., 2013 AND/OR Little evidence of collisions or displacement in the literature
Potential	Moderate ranking for collision and displacement risk in Furness et al., 2013 AND/OR Evidence of collisions or displacement in the literature
Likely	High ranking for collision and displacement risk in Furness et al., 2013 AND/OR Significant evidence of collisions or displacement in the literature

IPFs are defined as the changes to the environment caused by project activities during each offshore wind farm development phase (i.e., hazards) (BOEM, 2012; Goodale & Milman 2016). IPFs for marine birds are summarized in Table 6.2-8.

Table 6.2-8 Impact- Producing Factors for Birds

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommiss-ioning
Pile driving for WTG and ESP Foundations	X		X		
Increased vessel traffic	X	X	X	X	X
Wind Turbine Generators	X		X	X	X

Vessels installing the offshore export cable are not expected to be an IPF because exposure will be transitory and ephemeral. Coastal and marine birds may encounter a cable installation vessel, but the exposure to the vessel, in any given location, will be limited to a finite temporal period. Therefore, the impact assessment below is focused on activities occurring in the WDA. To be at risk of a direct or an indirect impact, a species must be both exposed to a wind farm and be vulnerable to either displacement or collision (Goodale & Stenhouse, 2016).

The impacts of operating offshore wind farms on birds are generally characterized as direct effects (collision) that cause injury or death, and the indirect effects (displacement) that may cause habitat loss (Drewitt & Langston, 2006; Fox et al., 2006; Goodale & Milman, 2016). While rare for projects built offshore, collisions have been recorded at wind farms built directly adjacent to seabird colonies (Everaert & Stienen, 2007) and generally occur in two ways: birds collide with the superstructure or rotors during operation, or birds are forced to the ground due to the vortex created by the moving rotors (Drewitt & Langston, 2006; Fox et al., 2006). Certain groups of birds are displaced by offshore wind developments through avoidance behavioral responses (Fox et al., 2006; Krijgsveld et al., 2011; Lindeboom et al., 2011), which has been documented for seaducks, gannets, auks, geese, and loons (Desholm & Kahlert, 2005; Garthe et al., 2017; Langston, 2013; Larsen & Guillemette, 2007; Lindeboom et al., 2011; Percival, 2010; Plonczkier & Simms, 2012). Birds that avoid the wind farm area completely experience effective habitat loss (Drewitt & Langston, 2006; Langston, 2013; Masden et al., 2009; Petersen et al., 2011). This avoidance, however, only results in a small increase in energy expenditure (Masden et al., 2009) and there is little evidence to suggest that avoidance and potential displacement from wind developments is reducing fitness, leading to critical habitat loss, or adversely affecting populations.

The risk of impacts caused by collision and displacement occurs when vulnerable species are exposed to the hazard of the wind farms. The offshore wind farm hazards most likely to cause adverse effects for birds are the rotors (collision) and the project's footprint (displacement) (Goodale & Milman, 2016). Individual species vulnerability is based on intrinsic or innate behaviors that will increase exposure rates, such as basic feeding, breeding, migrating, or sheltering behaviors. Behaviors contributing to collision vulnerability are primarily flight behaviors that increase the likelihood that a bird will be struck by a turbine blade. Species vulnerability can also be caused by a species' response to the presence of an offshore wind farm. For some species, this may be avoidance that can lead to partial or complete displacement from a WDA, whereas for others, it may involve an attraction to wind farm structures (Furness et al., 2013).

6.2.2.1 Construction and Installation

During construction, temporary IPFs can range from jack-up barges to the turbines, summarized in Table 6.2-8. For the analysis below, the full range of turbines that may be use by the Project are considered (eight megawatt ["MW"] and 10 MW). Since there is little information on how birds respond to cable construction activities, the IPFs of Offshore Export Cable Corridor and the WDA construction activities are considered together. It is also assumed that foundation type will not significantly change the IPFs during construction. If the larger turbines are used, the overall disturbed area and duration of construction may be less. During construction and installation the primary hazards to birds that may lead to mortality or displacement are:

Temporary hazards potentially causing mortality or injury:

- Vertical structures of construction equipment and turbines that could be a collision hazard
- Lighting of construction vessels that may attract birds

Temporary hazards potentially causing displacement and habitat modification/loss:

- Noise generated by pile-driving that could lead to avoidance
- Boat traffic that could lead to attraction and/or avoidance

(adapted from MMS, 2007).

6.2.2.1.1 Potential Direct and Indirect Impacts of Construction

The potential direct impacts are mortality or injury due to collision with construction equipment. For most bird species, the primary impact of concern is collisions during operations rather than during construction, because the construction period is temporary and of relatively short duration. There is a small possibility of collision with lighted structures (vessels, construction equipment, and turbines) during construction in low light conditions and in severe/poor weather. Mitigation measures will reduce any impacts to insignificant levels because most birds, with exception of gulls, are less likely to be attracted to vessels during fair weather conditions. The potential indirect impact is displacement due to disturbance by construction vessels and/or pile driving noise and is discussed below. Higher levels of boat traffic and human activity, including operation of large machinery during construction, could cause temporary displacement/ avoidance in some species.

Coastal and Marine Birds

Coastal birds (shorebirds, waterfowl, waterbirds, wading birds, falcons, and songbirds) are expected to have insignificant to unlikely behavioral vulnerability to collision with construction equipment and an insignificant behavioral vulnerability to displacement. While birds may encounter the construction equipment during migration and may land on vessels, mortality from collision is unlikely. The potential for colliding with lit structures in the marine environment may increase if there is substantial lighting (e.g., Hüppop et al., 2006), but lighting can be minimized by using best management practices. Any avoidance behavior that coastal birds exhibit would reduce vulnerability to collision; furthermore, exposure of coastal birds will generally be limited to migration (see Section 6.2.1).

In summary, coastal birds are expected to have insignificant to unlikely exposure, primarily during migration, to construction activities in the Offshore Project Area. In the unlikely event that they would be exposed to construction IPFs, they are expected to have insignificant to unlikely behavioral vulnerability. Because of the limited exposure, short-term duration of the IPFs, and lack of behavioral vulnerability, population level impacts are expected to be unlikely. Risks will be further minimized through mitigation measures, as discussed in Section 6.2.2.1.2 below.

Marine birds (loons and grebes, seaducks, gannets, cormorants, jaegers and gulls, terns, shearwaters and petrels, and auks) as a group have unlikely behavioral vulnerability to collision with construction equipment or displacement by construction activities. Marine birds are known to be attracted to offshore vessels and structures, especially when lighted (Montevecchi, 2006; Wiese et al., 2001). Shearwaters and petrels forage on vertically migrating bioluminescent prey and are instinctively attracted to light sources of any kind (Imber, 1975). This may be particularly true during periods of poor visibility, when collision risk is likely to be highest. However, there is little data on avian behavior in the marine environment during such periods, as surveys are limited to periods of good weather during daylight hours. Gulls may be attracted to and perch on construction equipment.

In contrast, some marine birds (e.g., seaducks and loons) may be disturbed by wind farm vessels, equipment, and activities, which may lead to temporary displacement from cable installation and wind farm construction areas (MMS, 2007). Noise from pile driving may cause birds to avoid the construction area and can disturb the local prey base. When pile driving occurs close to tern colonies (within 2 km [1.24 mi]), pile driving noise may disperse the local abundance of prey fish (e.g., herring). The decreased abundance of prey can reduce seabird foraging success and may cause reduced reproductive success for multiple years (Perrow et al., 2011). However, the WDA does not appear to be located in a regionally important seabird foraging area (see Section 6.2.1) and is far from the nearest tern colony. Any short-term reduction in the prey base would be expected to recover completely once construction was completed. In addition, birds may be displaced by boat and helicopter traffic (Fox et al., 2006; Petersen et al., 2006). While there may be short-term disturbance of resident birds during offshore wind farm construction, most birds that are initially disturbed return to the area after construction activities are completed (Adams et al., 2016). Overall, bird exposure to construction IPFs will be ephemeral and limited because the Project is located far offshore.

In summary, marine birds are expected to have insignificant to potential exposure to construction activities in the Offshore Project Area. In the low likelihood that they would be exposed to construction IPFs, they are not expected to have behavioral vulnerability. Because of the limited exposure, short-term duration of the IPFs, and low behavioral vulnerability, population level impacts are expected to be unlikely. Risks will be further minimized through mitigation measures.

Federally-listed species

Because the construction phase of the project is temporary, federally-listed birds are unlikely to collide with construction equipment and will not be permanently displaced.

Roseate Tern: Roseate Terns have insignificant to unlikely behavioral vulnerability to collision with construction equipment and an insignificant behavioral vulnerability to displacement. As described in the above section, marine birds can be attracted to offshore structures that are illuminated, especially during periods of poor visibility. However, there are limited data on Roseate Tern behavior during periods of poor visibility, including inclement weather and nocturnal time periods (MMS, 2008; USFWS, 2008). Data on Roseate Tern flight height indicates that non-migrating birds are generally flying below the WTGs lowest blade position (25 m [82 ft]) (MMS, 2008; Nisbet et al., 2014); the altitude at which Roseate Terns migrate offshore is unknown, but is thought to be higher than foraging and nearshore flight altitudes, perhaps in the hundreds to thousands of meters. (MMS, 2008; Perkins et al., 2004).

Evidence suggests that tern colonies located in areas with high boat traffic are not impacted (Burger et al., 2011). As discussed above, pile-driving can reduce the prey base for terns if construction occurs close to colonies (Perrow et al., 2011). Roseate Terns have a more specialized diet than Common Terns, including a higher dependence on small schooling fishes, and, like many tern species, are highly dependent on food availability for successful reproduction (Nisbet et al., 2014). Construction-related disturbance to prey populations, particularly American Sand Lance (*Ammodytes americanus*), could have potential indirect effects on Roseate Tern populations if construction were to occur in key foraging areas or close to a breeding colony. Sand lance are capable of hearing low-frequency sounds (Strobel & Mooney, 2012), including sounds in the range produced by pile driving. However, since the Project is located far from the nearest Roseate Tern colony and the WDA is not identified as an important foraging area for Roseate Terns, construction activities are expected to have little effect to the prey base.

In summary, Roseate Terns are expected to have insignificant exposure to construction activities occurring in the Offshore Project Area. In the unlikely event that they would be exposed to construction IPFs, they are expected to have insignificant to unlikely behavioral vulnerability to collision with, or displacement from, construction activities. Because of the limited exposure, short-term duration of the IPFs, and the lack of behavioral vulnerability, the loss or disturbance of Roseate Tern individuals is unlikely. Risks will be further minimized through mitigation measures.

<u>Piping Plover and Red Knot</u>: Piping Plover and Red Knot have insignificant to unlikely behavioral vulnerability to collision with construction equipment and insignificant behavioral vulnerability to displacement. Both species are thought to migrate at flight heights well above the rotor swept zone (RSZs) (i.e., >200 m [656.2 ft]) under most circumstances, thus greatly reducing exposure to collisions with turbines, construction equipment, or other structures. Both species also have good visual acuity and maneuverability in the air (Burger et al., 2011), and there is no evidence to suggest that they are particularly vulnerable to collisions or displacement.

In summary, Piping Plovers and Red Knots are expected to have insignificant exposure to construction activities occurring in the Offshore Project Area. In the unlikely event that they would be exposed to construction IPFs, they are expected to have insignificant to unlikely behavioral vulnerability to collision with, or displacement from, construction activities Because of the limited exposure, short-term duration of the IPFs, and the lack of behavioral vulnerability based on flight height during migration, anticipated loss of, or disturbance to, Piping Plover and Red Knot individuals in unlikely. Risks will be further minimized through mitigation measures.

6.2.2.1.2 Avoidance, Minimization, and Mitigation Measures

The Project has taken steps to avoid exposure of birds by locating the WTGs offshore. To further minimize potential bird mortality from collision, the Project will reduce lighting as much as is practicable during construction. The Project will follow Federal Aviation Administration ("FAA") recommendations to use red-flashing lights (Orr et al., 2013). In addition, when practicable, the Project will down-shield lighting and/or use down-lighting to limit bird attraction and disorientation (Poot et al., 2008). Anti-perching is incorporated in

Table 6.2-9 Summary of Potential Impacts to Birds During Construction in the Offshore Project Area and Mitigation Actions

Species Group	Subgroup	Primary Impact Type	Hazard[1]	Hazard Intensifier	Annual Exposure[2]	Behavioral Vulnerability	Mitigation Options
Coastal Birds	Shorebirds	Collision	V & C	Lighting	Insignificant	Insignificant	Reduce lighting
	Waterfowl & waterbirds	Displacement	V & C	# Vessels	Insignificant	Insignificant	None needed
	Wading birds	Collision	V & C	Lighting	Insignificant	Insignificant	Reduce lighting
	Raptors	Collision	V & C	Perching sites	Insignificant-Unlikely	Insignificant	Reduce lighting
	Songbirds	Collision	V & C	Lighting	Insignificant-Unlikely	Unlikely	Reduce lighting
Marine Birds	Loons and grebes	Displacement	V & C	# Vessels	Insignificant (s,w)	Unlikely	None needed
	Seaducks	Displacement	V & C	# Vessels	Insignificant (s,f,w)	Unlikely	None needed
	Gannets	Collision and displacement	V & C	Lighting and perching sites	Unlikely (s,f,w)	Unlikely	Reduce lighting
	Cormorants	Collision	V & C	Perching sites	Insignificant (s,su,f,w)	Unlikely	None needed
	Jaegers and Gulls	Collision	V & C	Lighting and perching sites	Insignificant-Potential (s,su,f)	Unlikely	Reduce lighting
	Terns	Collision and change in prey	V & C	Lighting and perching sites	Insignificant (s,f)	Unlikely	Reduce lighting
	Shearwaters and petrels	None	V & C	None	Insignificant - Unlikely (s,su,f)	Unlikely	None needed
	Auks	Displacement	V & C	# Vessels	Insignificant-Unlikely (s,f,w)	Unlikely	None needed

Table 6.2-9 Summary of Potential Impacts to Birds During Construction in the Offshore Project Area and Mitigation Actions (Continued)

Species Group	Subgroup	Primary Impact Type	Hazard[1]	Hazard Intensifier	Annual Exposure[2]	Behavioral Vulnerability	Mitigation Options
Federally-Listed	Roseate Tern	Collision and change in prey	V & C	Lighting and perching sites	Insignificant (s,f)	Insignificant-Unlikely	Reduce lighting
	Piping Plover	Collision	V & C	Lighting	Insignificant (s,f)	Insignificant-Unlikely	Reduce lighting
	Red Knot	Collision	V & C	Lighting	Insignificant (s,f)	Insignificant-Unlikely	Reduce lighting
	Eagles	Collision	V & C	Perching sites	Insignificant	-	None needed

1 V & C = Vessel and Construction Equipment

2 Exposure categories: s = spring (March-May); su = summer (June-August); f = fall (September – November); w = winter (December – February); r = resident (year-round)

the design of the turbines through the use of tubular WTG support towers (see Section 3.1.1 of Volume I). In accordance with safety and engineering requirements, the Project will consider anti-perching devices, where and if appropriate, to reduce potential bird perching locations. Using a standardized protocol, the Project will document any dead or injured birds found on vessels and structures during construction.

6.2.2.2 Operations and Maintenance

During operation, IPFs can range from WTGs to maintenance activities. In this section, only the IPFs associated with the WDA will be discussed because the offshore cable system is not considered to have IPFs that will impact birds.

Potential impacts from collisions and displacement are not likely to be significantly different between turbine scenarios (eight to 10 MW) because, regardless of turbine type, the same development envelope will be used and the total wind farm rotor swept area would change only by 4%. The top most position of the blade for the 10 MW turbine is only 21 m (68.9 ft) higher than the eight MW turbine; nacelle height 12 m (39.4 ft) higher; and the distance between the mean sea level and lowest position of the blade is nearly identical with only 4 m [13.1 ft] difference between the two turbine types.

Additionally, there are conflicting results in the few modeling studies that have attempted to quantify how change in turbine size will affect collision risk. One effort estimated that a 10% increase in rotor diameter will lead to a 3.55% increase in mortality estimates (Chamberlain et al., 2006) while another predicted that an increase in turbines would lead to a decline in mortality: increasing turbines from two to three MW decreases risk by 29%, and reduces it by an additional 29% when the turbine size is increased to five MW (Johnston et al., 2014). Given the lack of clear evidence in the literature on the effects of turbine size on mortality, and the small difference between the minimum and maximum sizes of potential turbines, the different turbine scenarios are not considered to substantially change the assessment of potential direct impacts.

The foundations for the Project may be all monopiles or a mix of monopile and jacket foundations (up to ten jackets for WTG foundations and up to two jackets for ESP foundations). With the exception of species known to use offshore wind turbines for perching (e.g., gulls and cormorants), the hazard of the different foundation type is not likely to be different for most species of birds. Unless otherwise noted, the hazard associated with the two possible foundation types are considered the same in the impact assessment below. During operation, the primary hazards to birds that may lead to mortality or displacement are:

Hazards potentially causing mortality or injury (direct impacts)

- Wind turbines (eight-10 MW)

- Electrical service platforms
- FAA and US Coast Guard required lighting (see Section 3.1.1 of Volume I)

Hazards potentially causing displacement and habitat modification/loss (indirect impacts)

- Total Wind Development Area
- Maintenance vessels and helicopters

6.2.2.2.1 Potential Direct Impacts of Operations and Maintenance

The primary potential direct impact of the Project to birds is mortality or injury due to collision with offshore WTGs. The mortality from collisions is dependent on many different factors, including site, species, season, weather, and lighting. Collision risk with offshore WTGs for a particular bird species can vary depending on age, behavior, and timing within a breeding cycle (e.g., while feeding chicks) (Drewitt & Langston, 2006). Birds can collide with the superstructure (nacelle and tower) or the rotating turbine blades, and can be forced to the ground by the vortex created by the moving rotors (American Wind Wildlife Institute ["AWWI"], 2016; Drewitt & Langston, 2006; Fox et al., 2006). With the exception of a wind development built on a breakwater located close to a tern colony in Zeebrugge, Belgium (Everaert & Stienen, 2007), few direct mortalities have been observed at operating offshore wind farms (Petersen et al., 2006; Pettersson, 2005).

Coastal and Marine Birds

Coastal birds: The primary groups of coastal birds that will be exposed to the Project are shorebirds, waterfowl, wading birds, falcons, and songbirds. Since the Project is located 23 km (14.3 mi) from shore, exposure of coastal birds is limited and will be most likely during spring and fall migration (see Section 6.2.1).

Shorebirds, coastal waterfowl, waterbirds, and wading birds: Shorebirds, coastal waterfowl, and wading birds are expected to have unlikely behavioral vulnerability to collision. There is little empirical evidence that shorebirds, coastal waterfowl (i.e., ducks, geese, and swans; excluding seaducks), or wading birds are vulnerable to collision with offshore wind turbines. During migration, shorebirds will likely fly significantly above the RSZ (i.e., >200 m [656.2 ft]). They are considered to fly high during migration off Cape Cod (Nisbet, 1963) and have been documented to fly at a mean altitude of 2,000 m (6,562 ft) (5% of birds flew above 4,400 m [14,436 feet] and a maximum height recorded was 6,650 m [21,818 feet]) in a radar study conducted over New Brunswick and Nova Scotia (Richardson, 1979).

No shorebirds are described as being observed with Visual Automatic Recording System ("VARS") at the *alpha ventus* offshore wind farm in Germany (Hill et al., 2014). Studies indicate that waterfowl avoid offshore wind farms and therefore have unlikely vulnerability to collision. Radar studies indicate that geese avoid offshore wind farms both in the vertical and horizontal planes (Plonczkier & Simms, 2012) and Global Positioning System ("GPS") tracking of swans suggest the birds gain altitude to avoid wind farms (Griffin et al., 2011).

Avoidance behavior has also been documented for Tufted Duck (*Aythya fuligula*), Common Pochard (*Aythya ferina*, a species similar to Redhead or Canvasback), and Greater Scaup (*Aythya marila*) (Dirksen & van der Winden, 1998 *in* Langston, 2013). There is little information on wading bird interactions with terrestrial and offshore wind turbines, but some studies suggest wading birds have lower densities around terrestrial turbines (Leddy et al., 1999) and thus would have lower vulnerability to collision. No wading birds are described as being observed with VARS at the *alpha ventus* offshore wind farm in Germany (Hill et al., 2014).

In summary, shorebirds, waterfowl, waterbirds, and wading birds are expected to have insignificant exposure, primarily during migration, to operational activities in the Offshore Project Area. If this low likelihood event occurred, where they would be exposed to operational IPFs, they are not expected to have likely behavioral vulnerability to collision. Because of the limited exposure and lack of vulnerability, population level impacts to this species group are expected to be unlikely. Risks will be further minimized through mitigation measures.

Raptors: The raptors exposed to the Project are probably limited to fall migrating Peregrine Falcons, Merlins, and Ospreys (see Section 6.2.1) that are expected to have unlikely to potential behavioral vulnerability to collisions. Falcons may be attracted to turbines as perching sites and Peregrine Falcons and Kestrels have been observed landing on the platform deck of offshore wind turbines (Hill et al., 2014). Satellite-tagged Ospreys and Peregrine Falcons have been confirmed to perch on offshore barges and structures. Little information exists documenting Peregrine Falcon mortalities, especially in offshore settings. However, Peregrine Falcon moralities have not been documented at European offshore wind developments. In addition, Desorbo et al., (2015) and Jensen et al., (2014) considered Peregrine Falcons to have a low collision risk vulnerability at the Horns Rev 3 wind development.

While Peregrine Falcon collisions with transmission lines have been documented (Olsen & Olsen, 1980; White et al., 2002), only a few accounts of mortalities are associated with terrestrial-based wind turbines in Europe (Dürr, 2011; Hötker et al., 2006; Meek et al., 1993) and one in New Jersey (Mizrahi et al., 2009). At some projects, with known falcon activity, no carcasses were found in post-construction mortality studies (Bull et al., 2013; DiGaudio & Geupel, 2014; Hein et al., 2013). American Kestrel carcasses have been found in post-construction monitoring with smaller terrestrial turbines (1.8MW) in Washington State (Erickson et al., 2008), but American Kestrel mortality has been demonstrated to decrease as turbine size increases (Smallwood, 2013). Limited tracking studies of Peregrine Falcons and Merlins indicate that falcons generally use overland routes during spring migration, but that during the fall they routinely fly over the ocean (Desorbo et al., 2015; Desorbo et al., 2017; Cochran, 1985). Two fall migrating peregrines tracked from Maine, bypassed Cape Cod and flew through central Massachusetts to the Block Island area in Rhode Island (Desorbo et al., 2012). It remains unclear if the routes of these birds are reflective of broader migrations patterns in the population.

In summary, falcons and Osprey are expected to have insignificant to unlikely exposure, primarily during migration, to operational activities in the Offshore Project Area. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have unlikely to potential behavioral vulnerability to collision. Because exposure is probably limited to individual migrants, population level impacts to falcons and Osprey are expected to be unlikely. Risks will be further minimized through mitigation measures.

Songbirds: Songbirds are expected to have unlikely to potential behavioral vulnerability to collision. Mortalities of songbirds are documented at terrestrial wind turbines (Erickson et al., 2014). In some instances, songbirds may be able to avoid colliding with offshore wind turbines (Petersen et al., 2006), but are known to collide with illuminated terrestrial and marine structures (Fox et al., 2006). Movement during low visibility periods creates the highest collision risk conditions: at an offshore research station with substantial lighting, songbird mortalities have been documented during poor weather conditions (Hüppop et al., 2006). While terrestrial avian fatality ranges from three to five birds per MW per year (AWWI, 2016), direct comparisons between morality rates recorded at terrestrial and offshore wind developments should be made with caution because collisions with offshore wind turbines could be lower either due to differing behaviors or lower exposure (NYSERDA, 2015). At Nysted, Denmark, in 2,400 hours of monitoring with an infrared video camera, only one collision of an unidentified small bird was detected (Petersen et al., 2006). Migrating songbirds have been detected at or in the vicinity of offshore wind developments (Kahlert et al., 2004; Krijgsveld et al., 2011; Pettersson & Fågelvind, 2011) and may have greater passage rates during the middle of the night (Huppop & Hilgerloh, 2012).

Passerines (songbirds) typically migrate at between 90-600 m (NYSERDA, 2010), but can fly lower during inclement weather or with headwinds. In a study in Sweden, nocturnal migrating songbirds flew on average at 330 m above the ocean during the fall and 529 m during the spring (Pettersson, 2005). Given the limited understanding of songbird migration, exposure of migratory songbirds to the WDA is uncertain, but some birds will likely cross the WDA during fall migration. Under poor weather conditions, individual vulnerability to collision may increase as birds fly at lower altitudes and may be more likely to fly through RSZs. Mortality is likely to be highly stochastic and infrequent. However, the mortality from all terrestrial wind turbines in the US and Canada combined is predicted to have a small effect on passerine populations (Erickson et al., 2014).

In summary, songbirds are expected to have insignificant to unlikely exposure, primarily during migration, to operational activities in the Offshore Project Area. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have unlikely to potential behavioral vulnerability to collision during migration. Because exposure is probably limited to individual migrants, and terrestrial wind farms are considered to have a small effect on most songbird populations, population level impacts to songbirds are expected to be unlikely. Risks will be further minimized through mitigation measures.

Marine birds: The primary groups of marine birds that will be exposed to the project are loons, grebes, and seaducks; gannets; cormorants; jaegers and gulls; terns; shearwaters, petrels, and auks.

Loons, grebes, and seaducks: Loons, grebes, and seaducks are expected to have insignificant to unlikely behavioral vulnerability to collision because these birds have consistently been documented to strongly avoid offshore wind projects and are widely considered to have low vulnerability to collision (Furness et al., 2013). Pre- and post-construction monitoring at offshore developments demonstrates that Red-throated Loons consistently avoid wind farms and do not habituate to the development (Lindeboom et al., 2011; Percival, 2010). Consequently, due to consistent avoidance behavior, Red-throated Loons are identified as vulnerable to displacement from offshore developments, but are not likely to collide with offshore wind turbines.

There is little empirical evidence on how Common Loons will respond to offshore wind developments, but they will likely respond similarly to Red-throated Loons and are not considered vulnerable to collision. Grebes rank low for collision risk because they only fly 3% of the time and are only within RSZs 4% of the time (Furness et al., 2013). Seaducks avoid offshore wind developments and avoidance behavior has been clearly documented for Black Scoters (Lindeboom et al., 2011) and Common Eider (Desholm & Kahlert, 2005; Larsen & Guillemette, 2007).

In summary, the loons, grebes, and seaducks group are expected to have insignificant exposure to operational activities in the Offshore Project Area. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have insignificant to unlikely behavioral vulnerability to collision. Because of limited exposure and because this species group has been documented to avoid offshore wind farms, population level impacts to this species group are expected to be unlikely. Risks will be further minimized through mitigation measures.

Northern Gannet: Northern Gannets are expected to have unlikely behavioral vulnerability to collision. While Northern Gannets are considered by some to be vulnerable to collision risk (Cleasby et al., 2015; Furness et al., 2013; Garthe et al., 2014), many studies indicate they avoid wind developments (Garthe et al., 2017; Hartman et al., 2012; Vanermen et al., 2015). Satellite tracking studies indicate near complete avoidance of active wind developments by Northern Gannets (Garthe et al., 2017); for example, avoidance rates have been estimated to be 64-84% (macro) and a 99.1% (total) (Cook et al., 2012; Krijgsveld et al., 2011; Vanermen et al., 2015). When Northern Gannets enter a wind development they fly within RSZs only 9.6% of the time (Cook et al., 2012), and models indicate a low proportion of birds fly at risk height (Johnston et al., 2014). Combined, these studies from Europe suggest that Northern Gannets exhibit unlikely vulnerability to collision. Northern Gannet populations have been increasing in recent decades (Chardine et al., 2013).

In summary, Northern Gannets are expected to have unlikely exposure to operational activities in the WDA. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have unlikely behavioral vulnerability to collision. Because Northern Gannets have been documented to avoid offshore wind farms and the populations of Northern Gannets have been generally increasing, population level impacts to this species group are expected to be unlikely. Risks will be further minimized through mitigation measures.

Double-crested Cormorant: Double-crested Cormorants are expected to have unlikely behavioral vulnerability to collision. Cormorants have been documented to be attracted to wind turbines because of an increase in food resources, due to reduced fishing effort and newly available loafing habitat (Krijgsveld et al., 2011; Lindeboom et al., 2011), but are not considered to have high vulnerability to collisions because they infrequently fly between 20-150 m (65.6 – 492.1 ft) above sea level (Furness et al., 2013). Turbines with jacket foundations may provide additional perching sites for cormorants, which have the potential to increase attraction and possibly intensify vulnerability to collision.

In summary, Double-crested Cormorants are expected to have insignificant exposure to the operational activities in the WDA. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have unlikely behavioral vulnerability to collision. Because Double-crested Cormorants will have insignificant exposure to the WDA and unlikely behavioral vulnerability, population level impacts to this species group are expected to be unlikely. Risks will be further minimized through mitigation measures.

Jaegers and gulls: Jaegers and gulls are expected to have potential to likely behavioral vulnerability to collisions. Little is known about how jaegers will respond to offshore wind turbines, but the birds generally fly below RSZs (0-10 m [0-32.8 ft] above the sea surface), although they could fly higher during kleptoparasitic chases (Wiley & Lee, 1999). Jaegers (called skuas in Europe) rank close to the top of collision vulnerability assessments preceded only by gulls, Northern Gannets, and Black-legged Kittiwakes (Furness et al., 2013). Gulls consistently rank at the top of collision vulnerability assessments (Furness et al., 2013) because they can fly within RSZs (Johnston et al., 2014) and have been documented to be attracted to turbines (Vanermen et al., 2015). Herring Gulls have been detected within the rotor swept height during 28.4% of observations and Great Black-backed Gulls during 33.1% of observations (Cook et al., 2012).

While the collision risk is thought to be greater for gulls, total avoidance rates are estimated to be 98% (Cook et al., 2012). At Horns Rev, Denmark, gull numbers increased at the wind development, possibly due to their attraction to boat traffic, new food resources, or new loafing habitat (i.e., perching areas) (Fox et al., 2006). In Belgium, numbers of Lesser Black-backed Gulls increased by a factor of 5.3 and Herring Gulls by 9.5 turbines (Vanermen et al., 2015).

However, there can be inter- and intra-annual variation in the degree that birds interact with offshore wind developments. Lesser Black-backed Gulls are found to be present at differing levels per year, and the birds' use of the offshore environment was highest during chick-rearing and lowest before breeding and during incubation. In addition, males and females use the area differently, with males present more in the late breeding season (Thaxter et al., 2015). Turbines with jacket foundations may provide additional perching sites for gulls, which have the potential to increase attraction and possibly intensify vulnerability to collision. Based upon jaegers and gulls consistently ranking high in collision vulnerability assessments, gulls attraction to turbines, and the amount of time they fly within RSZs, individual vulnerability to collision is expected to be potential to likely. Jaegers are not identified as species of conservation concern (Audubon, 2017) and resident gull populations in the region are not considered of conservation concern (Burger, 2015; Good, 1998; Nisbet et al., 2017; Pollet et al., 2012).

In summary, the jaegers are expected to have insignificant exposure to the operational activities in the WDA. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have potential behavioral vulnerability to collision. Because jaegers have stable populations, population level impacts to this species are expected to be unlikely. Gulls are expected to have insignificant to potential exposure to operational activities in the WDA and likely behavioral vulnerability to collision. Because gull populations are stable, population level impacts to this species group are expected to be unlikely. Risks will be further minimized through mitigation measures.

Terns: Terns are expected to have unlikely behavioral vulnerability to collisions. Terns rank in the middle of collision vulnerability assessments (Furness et al., 2013; Garthe & Hüppop, 2004) because they fly 2.8-12.7% at rotor swept height, have a 30-69.5% macro avoidance rate (Cook et al., 2012), and have been demonstrated to avoid rotating turbines (Vlietstra, 2007). For Common Terns and Arctic Terns, the probability of mortality is predicted to decline as the distance from the colony increases. Based upon one year of nanotag data collected at Petit Manan Island, Maine, tests of a decision support model suggests that the probability of occupancy and mortality rates at a turbine project drops to near zero beyond 15 km (9.3 mi) from a tern colony (Cranmer et al., 2017). Common Terns and Roseate Terns tended to avoid the airspace around a 660 kilowatt ("kW") turbine at the Massachusetts Maritime Academy in the US when the turbine was rotating and usually avoided the RSZ (Vlietstra, 2007). This finding is corroborated by mortality monitoring of small to medium turbines (200 and 600 kW) in Europe, where mortality rates rapidly declined with distance from the colony (Everaert & Stienen, 2007). Most observed tern mortalities in Europe have occurred at turbines < 30 m from nests (Burger et al., 2011), although turbines located directly between foraging and nesting grounds have also been implicated (MMS, 2008).

In summary, terns are expected to have insignificant exposure to the operational activities in the WDA. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have unlikely behavioral vulnerability to collision. Because exposure will be limited and the birds generally do not fly through the RSZ, population level impacts to terns are expected to be unlikely. Risks will be further minimized through mitigation measures.

Shearwaters, storm-petrels, and auks: Shearwaters, storm-petrels, and auks are expected to have insignificant behavioral vulnerability to collision. Shearwaters, storm-petrels, and auks all rank extremely low for collision risk (Furness et al., 2013). Auks have a 45-68% macro-avoidance rate and a 99.2% total avoidance rate. Atlantic Puffins are estimated to fly 0.1% of the time at rotor swept height, Razorbills 0.4%, Common Murres 0.01%, and storm-petrels 2% (Cook et al., 2012).

In summary, shearwaters, storm-petrels, and auks are expected to have insignificant to unlikely exposure to the operational activities in the WDA. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have insignificant behavioral vulnerability to collision. Because these species have insignificant to unlikely exposure and insignificant behavioral vulnerability population level impacts to these species are expected to be unlikely. Risks will be further minimized through mitigation measures.

Federally-Listed Species

During operation and maintenance, federally-listed birds are unlikely to collide with turbines or electrical service platforms. Roseate Terns, Piping Plovers, and Red Knots may have a low potential to fly over the WDA during migration, but are unlikely to fly within RSZs under most circumstances. None of these species are expected to occur in the WDA during breeding or wintering seasons.

Roseate Tern: As discussed in the Description of the Affected Environment (Section 6.2.1) Roseate Terns are unlikely to occur in the WDA except possibly during migration and post-breeding dispersal to staging sites. Aerial surveys conducted in the WDA only detected three unidentified terns in three years of surveys, and the majority of the WDA is outside tern high use areas (see Section 6.2.1.4.6; Veit et al., 2016). Roseate Terns may fly over the WDA during migration, but are unlikely to fly within the RSZ; moreover, terns have been observed to regularly exhibit micro-avoidance behaviors to avoid actively spinning turbine blades. If Roseate Terns are exposed to the project they are expected to have unlikely behavioral vulnerability to collisions because terns do not rank high in collision vulnerability assessments (Furness et al., 2013), fly less than 13% of time at rotor swept height (Cook et al., 2012), and avoid rotating turbines (Vlietstra, 2007).

Data on Roseate Tern flight height indicates that non-migrating birds are generally flying below the WTGs lowest blade position (25 m [82 ft]). Flight height during foraging typically varies from one to 12 m (39.4 ft) above the water's surface, and is most commonly <6 m (19.7 ft) (Nisbet et al., 2014). Roseate Terns do conduct courtship flights ("High Flights") that can range from 30-300 m (98.4-984.3 ft) in altitude and may continue throughout much of the breeding season (Nisbet et al., 2014); such displays are most common near the breeding grounds, they have also been observed at foraging locations (MMS, 2008). European studies of related tern species have suggested that approximately 4-10% of birds may fly at rotor height (20-150 m [65.6-492.1 ft] above sea level) during local flights (Jongbloed, 2016). In the US, data on Roseate Terns from a single 660 kW terrestrial wind turbine in Buzzard's Bay, Massachusetts suggested that most Roseate Terns flew below the rotor swept zone of the small turbine when flying over land (9-21 m [29.5-68.9 ft]) (Burger et al., 2011). Estimates of tern flight height from surveys in the Nantucket Sound area suggested that 95% of Common/Roseate Terns flew below Cape Wind's proposed RSZ of 23-134 m (75.5-439.6 ft) (MMS, 2008).

The altitude at which Roseate Terns migrate offshore is unknown, but is thought to be higher than foraging altitudes or nearshore flight altitudes (perhaps in the hundreds to thousands of meters) (MMS, 2008; Perkins et al., 2004). However, Roseate Terns tracked with immersion sensors frequently rested on the water's surface during migration and wintering periods (two to three hours/day on average, including at night) (Nisbet et al., 2014), so they do occasionally drop down to lower altitudes. Boat survey data for the Cape Wind project during the post-breeding period suggested that terns flying into headwinds may also maintain lower altitudes, potentially due to weaker headwinds close to the water's surface, while birds are more likely to climb to higher altitudes when taking advantage of tailwinds (MMS, 2008).

A similar pattern has been seen in overland migration in Common Terns and Arctic Terns, with birds migrating at 1,000-3,000 m (3,281-9,843 ft) above sea level except in strong headwinds (Alerstam, 1985). As with Common/Roseate Terns observed during boat surveys in the post-breeding period, data from other tern species suggest that flight height during migration varies with weather; headwinds may constitute optimal weather conditions for combining foraging with low-altitude migration (Jongbloed, 2016), while terns choose to fly at higher altitudes in tailwinds.

There is limited nocturnal and crepuscular data available, but it appears that nocturnal flights during breeding and post-breeding periods are limited to travel to/from foraging areas, and occur only at time periods near dusk and dawn (MMS, 2008). Terns in nocturnal transit between roosting and daytime use areas (e.g., shoals and other foraging locations, coastal loafing locations) may fly at higher altitudes (e.g., 37-60 m [121.4-196.9 ft)] (MMS, 2008).

Studies at operating turbines indicate that terns exhibit avoidance behavior. In Europe, terns have been documented to lower their flight altitude when approaching wind developments to avoid RSZs (Krijgsveld et al., 2011). At the 660 kW terrestrial wind turbine in Buzzard's Bay, Massachusetts, no tern mortalities were found during a multi-year study, though Common Terns regularly flew within 50 m (164 ft) of the turbine (Burger et al., 2011). There was little evidence of terns reducing avoidance of this turbine in fog, but micro-avoidance of actual RSZs occurred when turbines were spinning. Terns may detect turbine blades during operation, both visually and acoustically, and avoid flying between turbine rotors while they are in motion (MMS, 2008; Vlietstra 2007).

In summary, Roseate Terns are expected to have insignificant exposure to the operational activities occurring in the WDA. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have unlikely behavioral vulnerability to collision. Because the exposure will be limited, and the birds generally avoid, or do not fly through the RSZ, the anticipated loss of Roseate Tern individuals is unlikely. Risks will be further minimized through mitigation measures.

<u>Piping Plover and Red Knot</u>: Piping Plover and Red Knot will have insignificant exposure to the WDA (see Section 6.2.1.5). If Piping Plover and Red Knot are exposed to the WDA they are expected to have insignificant to unlikely behavioral vulnerability to collisions.

Piping Plovers are not present in the WDA during breeding and nonbreeding seasons. The average flight height for non-courtship flights among breeding Piping Plovers was estimated one study to be <3 m (9.8 ft) (Stantial, 2014). Males conduct high, fluttering courtship flights prior to and during breeding, but these are located over the land-based territories (Elliott-Smith & Haig, 2004). As such, flight height during non-migratory periods is thought to remain low and to occur in the immediate vicinity of the coastline.

There is a small possibility of ephemeral presence in the WDA during migration. Migratory flight height is unknown (Burger et al., 2011), but evidence from a recent tracking study suggests the potential for high altitude migratory flights in at least some individuals (Paton, 2016). European studies indicate generally low mortality rates for shorebirds at coastal wind facilities, even facilities located in proximity to stopover and wintering habitats (Burger et al., 2011). There are no known interactions of Piping Plovers with wind turbines, including the limited number of turbines built near nesting locations, and no mortalities observed to-date (Burger et al., 2011; USFWS, 2009). Piping Plovers may be able to avoid collisions, though vulnerability to collision may increase in periods of poor visibility (Burger et al., 2011).

Red Knots are not present in the WDA during the breeding season and may only have ephemeral presence during migration. Red Knot flight heights during migration are thought to normally be 1,000-3,000 m (3,281-9,843 ft), except during takeoff and landing at terrestrial locations (Burger et al., 2011), but Red Knots likely adjust their altitude to take advantage of local weather conditions, including flying at lower altitudes in headwinds (Baker et al., 2013). Individuals could fly at lower altitudes during periods of poor weather and high winds, or during shorter coastal migration flights (Burger et al., 2011). Data on Red Knot interactions with wind turbines are not available, but these birds are generally expected to be able to avoid collisions, though vulnerability to collision may increase in periods of poor visibility, high winds, and poor weather (Burger et al., 2011). Exposure to WTGs will depend in part on the degree of migratory movement through the WDA, which is unknown, but thought to be relatively low due to its distance from key stopover habitats (Burger et al., 2011).

In summary, Piping Plover and Red Knot are expected to have insignificant exposure to the operational activities occurring in the WDA. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have insignificant to unlikely behavioral vulnerability to collision. Because the birds have insignificant exposure risk, generally are not expected to fly through the RSZ during migration, and have not been found as fatalities at wind facilities, anticipated loss of Piping Plover and Red Knot individuals is unlikely. Risks will be further minimized through mitigation measures.

6.2.2.2.2 Potential Indirect Impacts of Operations and Maintenance

While direct collision mortality is the primary concern for terrestrial wind, behavioral avoidance responses to offshore wind farms, which can lead to displacement from habitat use areas, may have greater effects on birds in the offshore environment. Birds are displaced by wind developments through behavioral avoidance responses (Fox et al., 2006; Krijgsveld et al., 2011; Lindeboom et al., 2011), which has been documented for seaducks, gannets, auks, geese, and loons (Desholm & Kahlert, 2005; Garthe et al., 2017; Langston, 2013; Larsen & Guillemette 2007; Lindeboom et al., 2011; Percival, 2010; Plonczkier & Simms 2012). This avoidance may be a behavioral response to the visual stimulus (Fox et al., 2006). While macro-avoidance clearly reduces potential mortalities, birds that avoid the wind development area completely experience effective habitat loss (Drewitt & Langston, 2006; Langston, 2013; Masden et al., 2009; Petersen et al., 2011). This avoidance, however, only results in a small increase in energy expenditure (Masden et al., 2009) and there is little evidence to suggest that avoidance and potential displacement from wind developments is reducing fitness, leading to critical habitat loss, or adversely affecting populations.

Habitat change caused by the hard substrate of the offshore wind development can lead to indirect effects. The construction of wind turbines will have both a negative effect of direct loss of habitat (i.e., open ocean) and a positive effect with the gain of new habitat at turbine foundations and scour protection. However, these direct habitat changes represent less than 5% of an wind farm area and are not considered to be significant (Fox et al., 2006).

Coastal and Marine Birds

Coastal birds: Little is known about how most coastal birds may avoid offshore wind farms because they are generally not present in the offshore environment. Since geese, ducks, and swans have been documented to avoid wind farms (see Section 6.2.1.3.3), coastal waterfowl may exhibit avoidance behavior if they pass through the wind farm during migration. However, since most coastal birds are not using the WDA as critical breeding, foraging, staging, or wintering areas, any avoidance behavior would not cause displacement from important habitat. If the birds did exhibit avoidance behavior, they would be reducing potential collisions and reduce overall potential direct impacts.

Therefore, in summary, coastal birds are expected to have insignificant to unlikely exposure limited primarily to migration to the WDA. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have insignificant behavioral vulnerability to displacement. Because coastal birds are unlikely to be exposed to the WDA, there is little to no evidence that coastal birds will be displaced from offshore wind farms, and the WDA does not provide important habitat for this species group, population level impacts are expected to be unlikely.

Marine Birds

Loons and grebes: Loons and grebes are expected to have unlikely to likely behavioral vulnerability to displacement, respectively. Loons are identified as the birds most vulnerable to displacement (Furness et al., 2013; Garthe & Hüppop, 2004), and, as described in Section 6.2.1.4.1, Red-throated Loons consistently avoid offshore wind farms and are potentially permanently displaced. Common Loons may have similar avoidance responses. There is little data on how grebes respond to offshore wind farms, but some grebe species rank higher in displacement vulnerability assessments because they can be disturbed by ship and helicopter traffic (Furness et al., 2013).

In summary, loons are expected to have insignificant exposure to operational activities in the Offshore Project Area. If this low likelihood event occurred where they would be exposed to operational IPFs, they are expected to have potential to likely behavioral vulnerability to displacement. Because the WDA probably does not have important foraging habitat for loons, population level impacts to this species are expected to be unlikely. Grebes are expected to have insignificant exposure to the WDA. In the unlikely event that they would be exposed to operational IPFs, they are expected to have unlikely behavioral vulnerability to displacement. Because grebes have limited exposure to the WDA, population level impacts to this species are expected to be unlikely.

Seaducks: Seaducks are expected to have potential to likely behavioral vulnerability to displacement. After loons, seaducks are considered to have greater displacement vulnerability than all other seabirds (Furness et al., 2013). Avoidance behavior has been documented for Black Scoter, Common Eider (Desholm & Kahlert, 2005, Larsen & Guillemette, 2007), Tufted Duck, Common Pochard, and Greater Scaup (Dirksen & van der Winden, 1998 *in* Langston, 2013). Avoidance behavior of wind projects can lead to permanent or semi-permanent displacement, resulting in effective habitat loss (Langston, 2013; Percival, 2010; Petersen & Fox, 2007); however, for some species, this displacement may cease several years after construction as food resources, behavioral responses, or other factors change (Leonhard et al., 2013; Petersen & Fox, 2007). Avoidance occurs through macro-avoidance (Langston, 2013) and has been demonstrated by a 4.5-fold reduction in waterfowl flocks entering an offshore development post-construction (Desholm & Kahlert 2005). Birds entering the wind farms at night increased their altitude to avoid the turbines (Desholm, 2006).

In summary, seaducks are expected to have insignificant exposure to the operational activities in the WDA. They are expected to have potential to likely behavioral vulnerability to displacement. Because the WDA probably does not have important foraging habitat for seaducks and the birds concentrate closer to shore, and towards Nantucket Shoals (see Section 6.2.1), population level impacts to this species group are expected to be unlikely.

Northern Gannet: Northern Gannets are expected to have a potential behavioral vulnerability to displacement. While Northern Gannets rank low for displacement vulnerability (Furness et al., 2013), as discussed in Section 6.2.1.4.4, many studies indicate that they avoid wind developments (Garthe et al., 2017; Hartman et al., 2012;Vanermen et al., 2015). In Belgium, Northern Gannets have been shown to avoid wind development areas and have decreased in abundance by 85% after a project was constructed (Vanermen et al., 2015). However, there is little information on whether the avoidance behavior leads to permanent displacement. Since Northern Gannets feed on highly mobile surface-fish and follow their prey throughout the outer continental shelf (Mowbray, 2002), avoidance of the Project is unlikely to lead to habitat loss.

In summary, Northern Gannets are expected to have unlikely exposure to operational activities in the WDA. In the unlikely event that they would be exposed to operational IPFs, they are expected to have potential behavioral vulnerability to displacement. Because the species has unlikely exposure, due to a lack of important foraging habitat, population level impacts to this species are expected to be unlikely.

Double-crested Cormorants: Double-crested Cormorants are expected to have an insignificant behavior vulnerability to displacement because the birds have been documented to be attracted to wind developments (Krijgsveld et al., 2011; Lindeboom et al., 2011), are not a species known to exhibit avoidance behavior, and rank towards the middle of displacement vulnerability assessments (Furness et al., 2013).

In summary, Double-crested Cormorants are expected to have insignificant exposure to the operational activities in the WDA. In the unlikely event that they would be exposed to operational IPFs, they are expected to have insignificant behavioral vulnerability to displacement. Because vulnerability and exposure is insignificant, population level impacts to this species are expected to be unlikely.

Jaegers, gulls, and terns: Jaegers, gulls, and terns are expected to have insignificant behavioral vulnerability to displacement. There is little information available on how jaegers will respond to offshore wind farms, but jaegers rank low in vulnerability to displacement assessments (Furness et al., 2013) and there is no evidence in the literature that they are displaced from projects. Gulls and terns rank low in displacement vulnerability assessments (Furness et al., 2013), research suggests gulls and terns distribution and abundance is either not affected by the presence of wind farms or, in the case of gulls, that the birds may be attracted to them (Krijgsveld et al., 2011; Lindeboom et al., 2011).

In summary, the jaeger, gull and tern groups are expected to have insignificant to potential exposure to the operational activities in the WDA. In the unlikely event that they would be exposed to operational IPFs, they are expected to have insignificant behavioral vulnerability to displacement. Because exposure is insignificant to potential and vulnerability to displacement is insignificant, population level impacts to this species are expected to be unlikely.

Shearwaters and storm-petrels: Shearwaters and storm-petrels are expected to have insignificant behavioral vulnerability to displacement. Both taxonomic groups rank at the bottom of displacement vulnerability assessments (Furness et al., 2013).

In summary, the shearwater and storm-petrel groups are expected to have insignificant to unlikely exposure to the operational activities in the WDA. In the unlikely event that they would be exposed to operational IPFs, they are expected to have insignificant behavioral vulnerability to displacement. Because exposure and vulnerability to displacement are insignificant, population level impacts to this species are expected to be unlikely.

Auks: Auks are expected to have potential behavioral vulnerability to displacement. Due to sensitivity to disturbance from boat traffic and a high habitat specialization, many auks rank high in displacement vulnerability assessments (Furness et al., 2013). Auks have a total avoidance rate of 99.2% (Cook et al., 2012); Common Murres decrease in abundance in the area of wind farms by 71%; and Razorbills by 64% (Vanermen et al., 2015). But auk populations are generally stable (Ainley et al., 2002, Lowther et al., 2002, Lavers et al., 2009).

In summary, the auk group is expected to have insignificant to unlikely exposure to the WDA. In the unlikely event that they would be exposed to operational IPFs, they are expected to have potential behavioral vulnerability to displacement. Because the WDA exposure is insignificant to unlikely, and it is not known to support important foraging habitat for auks, population level impacts to this species group are expected to be unlikely.

Federally-Listed Species

During operation and maintenance, the listed species are not expected to have vulnerability to displacement because the WDA does not appear to be a primary foraging location or travel corridor for breeding or staging Roseate Terns, Piping Plovers, or Red Knots.

Roseate Tern: Roseate Terns are expected to have insignificant behavioral vulnerability to displacement. Terns in general are not considered vulnerable to disturbance and do not rank high in displacement vulnerability assessments (Furness et al., 2013). Research also suggests that tern distribution and abundance is not affected by the presence of wind developments (Krijgsveld et al., 2011; Lindeboom et al., 2011). Even if terns avoid the WDA, there is no indication that Roseate Terns would lose important breeding season foraging habitat at the WDA because they prefer shallow waters such as shoals (Burger et al., 2011). If Roseate Terns forage during migration, they could avoid the WDA, but it is unclear if Roseate Terns migrate through the WDA or forage during migration (Burger et al., 2011).

In summary, Roseate Terns are expected to have insignificant behavioral vulnerability to avoidance of offshore wind farms and insignificant to unlikely exposure to the WDA. Because there is no evidence of behavioral vulnerability to displacement, and exposure will be limited, anticipated disturbance of Roseate Tern individuals is unlikely. Additionally, Roseate Terns are expected to have insignificant exposure to the operational activities occurring in the WDA. In the unlikely event that they would be exposed to operational IPFs, they are expected to have insignificant behavioral vulnerability to displacement. Therefore, anticipated disturbance of Roseate Tern individuals is unlikely.

Piping Plover and Red Knot: Piping Plovers and Red Knot are expected to have insignificant behavioral vulnerability to displacement. There is little evidence and research on shorebird avoidance at offshore wind developments. Piping Plovers and Red Knots would not be displaced during breeding or migratory staging because the WDA provides no habitat for the species during these life history stages. The birds could potentially be exposed to the project ephemerally duing migration (see Section 6.2.1), but shorebirds generally fly at high altitudes well above RSZs during migration (Nisbet, 1963; Richardson, 1979) and the WDA is not located near Red Knot (Burger et al., 2011) or Piping Plover stopover locations.

In summary, Piping Plover and Red Knot are expected to have insignificant exposure to the operational activities occurring in the WDA. In the unlikely event that they would be exposed to operational IPFs, they are expected to have insignificant behavioral vulnerability to disturbance. Because the birds have insignificant exposure and behavior risk, anticipated disturbance of Piping Plover and Red Knot individuals is unlikely.

6.2.2.2.3 Avoidance, Minimization, and Mitigation Measures

The Project has taken steps to avoid exposure of birds by locating the WTGs offshore. To further minimize potential bird mortality from collision, the Project will reduce lighting as much as is practicable during operations and maintenance. When practicable, the Project will (1) reduce the number of lights, (2) use low intensity lights, (3) avoid white lights, and (4) as appropriate, use flashing lights rather than steady burning lights (Orr et al., 2013). In addition, when practicable, the Project will use hooded lighting, colored lighting, or down-lighting to limit bird attraction and disorientation (Poot et al., 2008), limit outside light to necessary/required lighting, and close blinds on all windows in boat living quarters (Wiese et al., 2001). Lighting will also be only used when necessary for work crews. As described in Section 6.2.2.1.2, anti-perching is incorporated in the design of the turbines through the use of tubular WTG support towers (See Section 3.1.1 of Volume I). In accordance with safety and engineering requirements, the Project will consider anti-perching devices, where and if appropriate, to reduce potential bird perching locations. Vineyard Wind is developing a framework for a post-construction monitoring program for birds. Using a standardized protocol, the Project will document any dead or injured birds found on vessels and structures during the O&M phase.

Table 6.2-10 Summary of Potential Impacts to Birds in the WDA during Operation and Mitigation Actions

Species Group	Subgroup	Impact Type	Hazard	Hazard Intensifier	Annual Exposure*	Behavioral Vulnerability	Mitigation Options
Coastal Birds	Shorebirds	Collision	Turbines	Lighting	Insignificant	Unlikely	Reduce lighting
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Waterfowl & waterbirds	Collision	Turbines	Lighting	Insignificant	Unlikely	Reduce lighting
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Wading birds	Collision	Turbines	Lighting	Insignificant	Unlikely	None needed
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Raptors	Collision	Turbines	Perching sites	Insignificant-Unlikely	Unlikely-Potential	Reduce lighting
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Songbirds	Collision	Turbines	Lighting	Insignificant-Unlikely	Unlikely - Potential	Reduce lighting
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
Marine Birds	Loons and grebes	Collision	Turbine	Lighting	Insignificant (s,w)	Insignificant-Unlikely	None needed
		Displacement	Project footprint	Number of turbines		Unlikely – Likely	None needed
	Seaducks	Collision	Turbine	Lighting	Insignificant (s,f,w)	Insignificant-Unlikely	None needed
		Displacement	Project footprint	Number of turbines		Potential-Likely	None needed
	Gannets	Collision	Turbine	Lighting and perching sites	Unlikely (s,f,w)	Unlikely	Reduce lighting
		Displacement	Project footprint	Number of turbines		Potential	None needed
	Cormorants	Collision	Turbine	Lighting and perching sites	Insignificant (s,su,f, w)	Unlikely	Reduce lighting
		Displacement	Project footprint	Number of turbines		Insignificant	None needed

Table 6.2-10 Summary of Potential Impacts to Birds in the WDA during Operation and Mitigation Actions (Continued)

Species Group	Subgroup	Impact Type	Hazard	Hazard Intensifier	Annual Exposure*	Behavioral Vulnerability	Mitigation Options
	Cormorants	Collision	Turbine	Lighting and perching sites	Insignificant (s,su,f, w)	Unlikely	Reduce lighting
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Jaegers and gulls	Collision	Turbine	Lighting and perching sites	Insignificant-Potential (r & s,su,f)	Potential-Likely	None needed
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Terns	Collision	Turbine	Lighting	Insignificant (s,f)	Unlikely	Reduce lighting
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Shearwaters and petrels	Collision	Turbine	Lighting	Insignificant - Unlikely (s,su,f)	Insignificant	None needed
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Auks	Collision	Turbine	Lighting	Insignificant-Unlikely (s,f,w)	Insignificant	None needed
		Displacement	Project footprint	Number of turbines		Potential	Node needed
Federally-Listed	Roseate Tern	Collision	Turbine	Lighting and perching sites	Insignificant	Unlikely	Reduce lighting
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Piping Plover	Collision	Turbine	Lighting	Insignificant	Insignificant-Unlikely	Reduce lighting
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Red Knot	Collision	Turbine	Lighting	Insignificant	Insignificant-Unlikely	Reduce lighting
		Displacement	Project footprint	Number of turbines		Insignificant	None needed
	Eagles	Collision	Turbine	Perching sites	Insignificant	-	None needed
		Displacement	Project footprint	Number of turbines		-	None needed

* Exposure categories: s = spring (March-May); su = summer (June-August); f = fall (September – November); w = winter (December – February); r = resident (year-round)

6.2.2.3 Decommissioning

In general, potential impacts during decommissioning are expected to be similar to the construction period. However, there is no equivalent of pile driving during decommissioning, which reduces any noise-related impacts. Vineyard Wind is developing a framework for a post-construction monitoring program for birds. Using a standardized protocol, the Project will document any dead or injured birds found on vessels and structures during decommissioning. The Project will also consider best management practices available at the time of decommissioning to minimize any potential impacts to birds.

6.2.2.4 Summary of Findings

Overall, Project activities occurring in the Offshore Project Area are unlikely to cause population level impacts to any species or species group.

6.2.2.4.1 Coastal and Marine Birds

During construction, operation, and decommissioning, coastal birds are expected to be ephemerally exposed during migration and marine birds during all seasons. Overall, coastal birds are expected to have insignificant to unlikely behavioral vulnerability to construction activities and unlikely to potential vulnerability to WTGs. Of the coastal birds, Peregrine Falcons and songbirds are the only species groups that may have unlikely exposure to the WDA, and this will be limited to fall migration. Depending on the species, marine birds are expected to have range of behavioral vulnerability and range of exposure to the WDA. Of the marine birds, gulls are the species group with the potential exposure to the WDA. Impacts will be minimized though mitigation measures that include reducing lighting. During all phases of the Project, the Project will consider the best management practices available at the time to reduce any potential adverse effects to birds.

6.2.2.4.2 Federally-Listed Species

During construction, operations, and decommissioning, federally-listed species exposure is expected to be insignificant to unlikely, and would largely be restricted to migration. Roseate Terns are expected to have insignificant exposure to the WDA and insignificant to unlikely vulnerability. Piping Plovers are expected to have insignificant exposure due to their proximity to shore during breeding, and insignificant to unlikely vulnerability. Like Roseate Terns, however, they may be exposed during migration periods, though flight heights during migration are thought to be generally well above RSZs (i.e., >200m [656.2 ft]). Red Knots are expected to have insignificant exposure and insignificant to unlikely behavioral vulnerability, due to their proximity to shore during stopovers and high flight heights during migrations. Impacts will be minimized though mitigation measures that include reducing lighting. During all phases, the Project will consider the best management practices available at the time to reduce any potential adverse effects to birds to the negligible level.

6.3 Bats

This section describes bat resources in the Project Area.

6.3.1 Description of the Affected Environment

Nine species of bats are present in Massachusetts. These species can be categorized into two major groups based on their wintering strategy: cave-hibernating bats and migratory tree bats. Both groups of bats are nocturnal insectivores that use a variety of forested and open habitats for foraging during the summer. Cave-hibernating bats are generally not observed offshore (> 5.6 km [3.5 miles]) and migrate in the winter from summer habitat to hibernacula in the New England regional area. The presence of the fungal disease white-nose syndrome ("WNS") in the hibernacula has caused high mortality of cave-hibernating bats and led to the Northern Long-Eared Bat (*Myotis septentrionalis*) being listed as threatened under the Endangered Species Act ("ESA"), 16 U.S.C. ch. 35 § 1531 et seq ,1973. Migratory tree bats, rather than hibernating in the winter months, fly to southern parts of the US and have been observed offshore (> 5.6 km [3.5 miles]) during migration.

Every bat species present in Massachusetts, except for Indiana Bat (*Myotis sodalist*), could be exposed to the Project (see Table 6.3-1). Exposure of cave-hibernating and migratory tree bats to the Onshore Project Area and the Offshore Project Area is assessed below. Then Northern Long-Eared Bat is discussed in separately in this section because it is a federally-listed species.

Table 6.3-1 Bat Species Present in Massachusetts and their Conservation Status

Common Name	Scientific Name	Type[1]	State Status	Federal Status
Eastern Small-Footed Bat	*Myotis leibii*	Cave-Hibernating Bat	E	-
Little Brown Bat	*Myotis lucifugus*	Cave-Hibernating Bat	E	-
Northern Long-Eared Bat	*Myotis septentrionalis*	Cave-Hibernating Bat	E	T
Indiana Bat[2]	*Myotis sodalis*	Cave-Hibernating Bat	E	E
Tri-Colored Bat	*Perimyotis subflavus*	Cave-Hibernating Bat	E	-
Big Brown Bat	*Eptesicus fuscus*	Cave-Hibernating Bat	-	-
Eastern Red Bat	*Lasiurus borealis*	Migratory Tree Bat	-	-
Hoary Bat	*Lasiurus cinereus*	Migratory Tree Bat	-	-
Silver-Haired bat	*Lasionycteris noctivagans*	Migratory Tree Bat	-	-

(E = endangered; T = threatened)

1* "Type" refers to two major life history strategies among bats in eastern North America; cave-hibernating bats roost in large numbers in caves during the winter, while migratory tree bats do not aggregate in caves and are known to migrate considerable distances.

2 Not found in the eastern part of Massachusetts

6.3.1.1 Cave-hibernating and Migratory Tree Bats

6.3.1.1.1 Onshore Project Area

Disturbance of bat habitat by the construction of Onshore Facilities is limited to the Project's Onshore Substation. The Onshore Export Cable Route is not considered an Impact Producing Factor ("IPF") because it will primarily follow previously disturbed corridors. As such, it will not be discussed further in relation to bats.

The Project's Onshore Substation will be located on the eastern portion of a previously developed site within the Independence Park commercial/industrial area in the Town of Barnstable. Construction of the Onshore Substation will require the cutting of approximately six acres of mostly wooded land. Site vegetation is comprised primarily of Pitch Pine *(Pinus rigida)* and Scarlet Oak *(Quercus coccinea)* in the tree layer with Black Huckleberry *(Gaylussacia baccata)* and Lowbush Blueberry *(Vaccinium angustifolium)* dominant in the understory. Bracken Fern *(Pteridium aquilinum)* and Teaberry *(Gaultheria procumbens)* are present as ground covers. This type of Pitch Pine-Oak forest is very common on Cape Cod, often developing in sandy areas that have been subjected to repeated burnings (DeGraaf & Yamasaki, 2001). The Onshore Substation site lacks any available water source, but some small ponds are located within 427 meters (1,400 feet) of the site (see Section 3.2.5 of Volume I for further details). While bats may visit the Onshore Substation site at some point during their life cycle, this forested area is unlikely to provide important habitat due to its small size, proximity to a disturbed area, lack of a water source, and the absence of any caves or mines.

As a general matter, forested areas can serve as important foraging habitat for bats. Preferred foraging habitat, however, varies among species. The type of foraging habitat a bat species selects may be linked to the flight capabilities, preferred diet, and echolocation capabilities of each species (Norberg & Rayner, 1987). Small, maneuverable species like the Northern Long-Eared Bat and the Little Brown Bat (*Myotis lucifugus*) can forage in cluttered conditions, such as the forest understory or small forest gaps. Larger, faster-flying bats, such as the Hoary Bat (*Lasiurus cinereus*), often forage above the forest canopy or in forest gaps (Taylor, 2006). Some species, such as the Little Brown Bat and the Tri-Colored Bats (*Perimyotis subflavus)*, regularly forage over water sources. The Big Brown Bat, Eastern Red Bat (*Lasiurus borealis)*, and Hoary Bat are also known to use waterways as foraging areas, as well as travel corridors.

Forested habitats also provide roosting areas for both migratory and non-migratory species. Some species roost solely in the foliage of trees, while others select dead or dying trees where they roost in peeling bark or inside crevices. Some species may select forest interior sites, while others prefer edge habitats. All bat species present in Massachusetts are known to utilize various types of forested areas during summer for foraging and roosting.

Caves and mines are a key habitat to for bats. These locations serve as winter hibernacula, fall swarm locations (i.e., areas where mating takes place in the fall months), and summer roosting locations for some individuals. Four main factors are understood to determine whether a cave or mine is suitable for use as a hibernaculum: low levels of disturbance; suitable temperature; suitable humidity; and suitable airflow (Tuttle & Taylor, 1998). The Onshore Substation site does not have caves and does not provided the required conditions for a hibernaculum.

As noted at the beginning of this section, the Onshore Substation site is forested but not expected to serve as important habitat for bats. The small size of the area combined with the lack of water and proximity to a commercial/industrial zone provides limited foraging and roosting habitat. In addition, the Onshore Substation site does not provide cave habitat and does not possess the necessary features for a hibernaculum. This assessment is confirmed by the Natural Heritage Species Report (dated November 27, 2017) and online database (MassWildlife, 2017), which does not show any known roosting or hibernaculum sites in the Onshore Substation area or Town of Barnstable, as of November 29th, 2017. Thus, the Onshore Substation site will not be discussed further for non-listed species.

6.3.1.1.2 Offshore Project Area

This section assesses the potential exposure of cave-hibernating and migratory tree bats to the Offshore Project Area. During the Project's construction phase, the Offshore Project Area is inclusive of the Wind Development Area ("WDA") and Offshore Export Cable Corridor. During the operational phase, however, the assessment only includes the Wind Turbine Generators ("WTGs") within the WDA because the Offshore Export Cable Corridor does not have IPFs that affect bats. See Table 6.3-2 for definitions of exposure. See 6.2 of Volume III for further details.

Table 6.3-2 Definitions of Exposure Levels.

Exposure Level	Definition
Insignificant	Based upon the literature, little to no evidence of use of the offshore environment for breeding, wintering, or staging and low predicted use during migration
Unlikely	Based upon the literature, low evidence of use of the offshore environment during any season
Potential	Based upon the literature, moderate evidence of use of the offshore environment during any season
Likely	Based upon the literature, high evidence of use of the offshore environment and the offshore environment is primary habitat during any season

While there is uncertainty on the specific offshore movements of bats, the presence of bats in the marine environment has been documented in the US (Cryan & Brown, 2007; Dowling et al., 2017; Grady & Olson, 2006; Hatch et al., 2013; Johnson et al., 2011; Pelletier et al., 2013). For example, bats have been observed temporarily roosting on structures, such as lighthouses, on nearshore islands (Dowling et al., 2017) and there is historical evidence of bats, particularly the Eastern Red Bat, migrating offshore in the Atlantic Ocean (Hatch et al., 2013). In a mid-Atlantic bat acoustic study conducted during the spring and fall of 2009 and 2010 (86 nights), the maximum distance that bats were detected from shore was 21.9 kilometers ("km") (13.6 miles) and the mean distance was 8.4 km (Sjollema et al., 2014). In Maine, bats have been detected on islands up to 41.6 km (25.8 miles) from the mainland (Peterson et al., 2014). In the mid-Atlantic acoustic study, Eastern Red Bat comprised 78% (166 bat detections during 898 monitoring hours) of all bat detections offshore. In another study, Eastern Red Bats were detected in the mid-Atlantic up to 44 km (27.3 miles) offshore by high-definition video aerial surveys (Hatch et al., 2013).

Cave-hibernating bats generally exhibit lower activity in the offshore environment than migratory tree bats (Sjollema et al., 2014). These species hibernate regionally in caves, mines, and other structures, and feed primarily on insects in terrestrial and freshwater habitats. Their movements occur primarily during the fall. In the mid-Atlantic, the maximum distance *Myotis* bats have been detected offshore is 11.5 km (7.2 miles) (Sjollema et al., 2014). A recent nano-tracking study on Martha's Vineyard recorded Little Brown Bat (n = 3) movements off the island in late August and early September, with one individual flying from Martha's Vineyard to Cape Cod (Dowling et al., 2017). Big Brown Bats (n = 2) were also detected migrating from Martha's Vineyard later in the year, i.e., October-November(Dowling et al., 2017). These findings are supported by an acoustic study conducted on islands and buoys of the Gulf of Maine that indicate the greatest percentage of migration activity for cave-hibernating bats takes place between July and October (Peterson et al., 2014).

Migratory tree bats, on the other hand, leave New England in the winter months and journey to milder climates to overwinter. These bats have been documented in the offshore environment during migration (BOEM, 2014). Eastern Red Bats, for example, have been detected migrating from Martha's Vineyard in the late fall, (i.e., October-November), with one bat tracked as far south as Maryland before records ceased (Dowling et al., 2017). These results are supported by historical observations of Eastern Red Bats offshore as well as recent acoustic and survey results (Hatch et al., 2013; Peterson et al., 2014; Sjollema et al., 2014).

For both cave-hibernating and migrating tree bats, overall exposure to the Offshore Project Area is expected to be insignificant to unlikely. As detailed above, acoustic studies indicate low use of the offshore environment by cave-hibernating bats and such use is likely limited to the fall migration period. In addition, these species do not regularly feed on insects over the ocean. While migratory tree bats are detected more often in the offshore environment, exposure is likely to be limited to the migration period.

6.3.1.2 Federally-Listed Species

As shown in Table 6.3-2 above, two federally-listed bat species are present in Massachusetts: The Northern Long-Eared Bat and the Indiana Bat. The Northern Long-Eared Bat is found in eastern Massachusetts. The range of the Indiana bat, however, does include the eastern part of the state. Historical records only demonstrate its presence in western Massachusetts (Barbour & Davis, 1969). Thus, this assessment will focus solely on the potential exposure of Northern Long-Eared Bat to the Onshore and Offshore Project Areas.

The Northern Long-Eared Bat is an insectivorous bat that hibernates in caves, mines, and other locations (e.g., possibly talus slopes) in winter, and spends the remainder of the year in forested habitats. The bats prefer to roost in clustered stands of large trees with living or dead trees that have large cavities. The Northern Long-Eared Bat forages under the forest canopy, above fresh water, along forest edges, and along roads (MassWildlife 2012). The species' range includes most of the eastern and mid-western US and southern Canada. Due to impacts from WNS, the species has declined by 90-100% in most locations where the disease has occurred, and declines are expected to continue as the disease spreads throughout the remainder of the species' range (USFWS, 2016). WNS has been confirmed in Massachusetts (MassWildlife News, 2008). The devastating and on-going impact of WNS on the Northern Long-Eared Bat resulted in the species being listed as threatened under the ESA in 2015.

The Northern Long-Eared Bat is active from March to November (Brooks & Ford, 2005; Menzel et al., 2002). At summer roosting locations, it forms maternity colonies, which consist of aggregations of females and juveniles and is where females give birth to young in mid-June. Roosting tree-selection varies and the size of tree and canopy cover changes with reproductive stage (USFWS 2016). The bats are born flightless and remain so until mid-July (Carter & Feldhamer, 2005). Adult females and volant juveniles remain in maternity colonies until mid-August, at which time the colonies begin to break up and bats begin migrating to their hibernation sites (Menzel et al., 2002). Bats forage around the hibernation site and mating occurs prior to entering hibernation in a period known as fall swarm (Broders & Forbes, 2004; Brooks & Ford, 2005). Throughout the summer months, and during breeding, Northern Long-Eared Bats have small home ranges of less than 10 hectares (25 acres) (Silvis et al., 2016 *in* Dowling et al., 2017). Migratory movements, however, can be up to 275 km (170 miles) (Griffin, 1945 *in* Dowling et al., 2017).

Northern long-eared bats are present on Nantucket and Martha's Vineyard (Dowling et al., 2017) and are known to occur on Cape Cod in Massachusetts.

6.3.1.2.1 Onshore Project Area

As discussed above, the Onshore Project Area is limited to the Onshore Substation site for the purposes of this assessment. Due to its small size and proximity to a commercial/industrial zone, the location for the Onshore Substation is not expected to serve as valuable habitat for bats in general or Northern Long-Eared Bats, in particular. Furthermore, no known Northern Long-Eared Bat maternity roost trees or hibernaculum are located near the Onshore Substation site or the Town of Barnstable (MassWildlife, 2017). Given that the Onshore Substation site is unlikely to provide important habitat for Northern Long-Eared Bats and there are no known roost trees or hibernacula, it will not be discussed further.

6.3.1.2.2 Offshore Project Area

Northern Long-Eared Bats are not expected to be exposed to the WDA. While there is little information on the movements of Northern Long-Eared Bat with respect to ocean travel, a recent tracking study on Martha's Vineyard (n = 8; July-October 2016) "did not record any offshore movements by [N]orthern [L]ong-[E]ared [B]at" (Dowling et al., 2017, p. iv). If Northern Long-Eared Bats were to migrate over water, movements would likely be from Martha's Vineyard to the mainland. The related Little Brown Bat has been found to migrate from Martha's Vineyard to Cape Cod. As such, Northern Long-Eared Bats may likewise migrate to mainland hibernacula between August and September. Tracking data suggest that at least some Northern-Long Eared Bats overwinter on the island (Dowling et al., 2017). Nevertheless, given that the WDA is located far from shore, the exposure of Northern Long-Eared Bats is expected to be insignificant and will not be discussed further.

6.3.2 Potential Impacts of the Project

The potential direct impacts of the Project to bats were evaluated by considering the exposure of bats (see Affected Environment Section 6.3.1) to IPFs. IPFs are defined as the changes to the environment caused by project activities during each offshore wind development phase (BOEM, 2012; Goodale & Milman, 2016). Except for vessel activity during construction, the Offshore Export Cable Corridor is not considered an IPF for bats and no impact analysis is conducted. Bats may otherwise be exposed to the following IPFs: construction and maintenance vessels and the WTGs (Table 6.3-3). For the analysis below, the full range of turbines that may be used by the Project are considered (8MW and 10MW).

Table 6.3-3 Impact- Producing Factors for Bats

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommiss-ioning
Increased vessel traffic	X	X	X	X	X
Wind Turbine Generators	X		X	X	X

The potential direct impact of the Project to bats is mortality or injury from collision with WTGs. Stationary objects are not generally considered a collision risk for bats (BOEM, 2014) because they are able to detect objects with echolocation (Horn, 2008; Johnson, 2004). Bat mortality has been documented at terrestrial wind farms in the US (Cryan & Barclay, 2009; Hayes, 2013; Martin et al., 2017; Pettit & O'Keefe, 2017; Smallwood, 2013). Although bat mortality has not been documented at offshore wind farms, the collision mortalities detected at terrestrial wind farms suggest that bats, if exposed, may be vulnerable to collisions with rotating offshore WTG.

6.3.2.1 Construction and Installation

6.3.2.1.1 Potential attraction of bats to construction activities in the Offshore Project Area

Bats may be attracted to construction vessels installing WTGs, Electrical Service Platforms ("ESP"), or offshore export cables. However, there is little to no evidence to suggest that these stationary objects pose any special risk to bats and behavioral vulnerability to collision is expected to be insignificant. As such, population level impacts are unlikely. Bats have the potential to be attracted to vessels to forage on insects, if insects are drawn to vessel lights. Where practicable, the Project will minimize lighting during construction activities in order to mitigate the risk of attracting bats.

6.3.2.1.2 Avoidance, Minimization, and Mitigation Measures

The Project has taken steps to avoid exposure of bats by locating the WTGs further offshore. During construction and installation lighting will be minimized to reduce potential attraction of bats to vessels and construction activities.

6.3.2.2 Operations and Maintenance

6.3.2.2.1 Potential collision of bats with WTGs

As discussed in the Description of the Affected Environment (Section 6.3.1), the exposure of cave-hibernating bats to the WDA is expected to be insignificant to unlikely and would only occur rarely during migration when a small number of bats may occur in the MA Wind

Energy Area given its distance from shore (BOEM, 2014). In contrast, migratory tree bats could pass through the WDA, but overall small numbers of migratory bats are expected in the MA Wind Energy Area given its distance from shore (BOEM, 2014).

There is evidence of bats visiting WTGs nearer to shore (4-7 km [2.5-4.3 miles]) in the Baltic Sea, a body of water surrounded by land (Ahlen et al., 2009; Rydell & Wickman, 2015). The WDA, however, is far offshore and there are no nearby landing areas, e.g. islands, which might otherwise increase the presence of bats in the WDA. The need for lighting during the operations and maintenance phase of the Project is expected to be minimal and best practices will be considered when it is necessary to mitigate any risks. In summary, bats have an insignificant to unlikely exposure to the WDA because WDA is located far offshore and bat exposure is likely limited to a few individuals of migrating tree bats in the fall. In the low likelihood event that bats would be exposed to operational IPFs, bats have unlikely to potential behavioral vulnerability to collision with WTG. Risks will be further minimized through mitigation measures. For these reasons, overall bat exposure to the WDA is likely to be limited to a few individuals and population level impacts are unlikely.

6.3.2.2.2 Avoidance, Minimization, and Mitigation Measures

The Project has taken steps to avoid exposure of bats by locating the WTGs further offshore. During operation, lighting will be minimized to reduce potential attraction of bats to WTGs and ESPs.

6.3.2.3 Decommissioning

The decommissioning phase IPFs, which bats will be exposed to (e.g., boat activity), are expected to be similar to the construction period (see Section 6.3.2.1). The Project will discuss best practices available at the time of decommissioning with BOEM and the USFWS to avoid and minimize potential impacts to bats.

6.4 Coastal Habitats

This section addresses impacts to coastal habitats that are located at the potential Landfall Sites in Yarmouth and Barnstable. It also includes a discussion of rare species potentially affected by construction, operation, and maintenance at the potential Landfall Sites, as well as mitigation measures to address potential impacts to coastal habitats.

6.4.1 Description of the Affected Environment

As described in Section 3.0 of Volume I and as shown on Figure 2.2-1 in Volume I, two Landfall Sites are currently being evaluated for the Project: Covell's Beach in Barnstable and at New Hampshire Avenue in Yarmouth. These sites, and any nearby coastal habitats, are described below.

Covell's Beach

The Covell's Beach Landfall Site is located on Craigville Beach Road near the paved parking lot entrance to a public beach owned and managed by the Town of Barnstable. This Landing Site is considered advantageous due to its relatively protected location within the Centerville Harbor bight, superior egress, and favorable onshore routing to the Barnstable Switching Station via public roads and electric transmission ROW.

Use of the Covell's Beach Landfall Site is not anticipated to require any disturbance to coastal habitats. A relatively small eelgrass bed has recently been identified offshore in the vicinity of Spindle Rock, and that area is currently being surveyed to delineate the extent of the eelgrass. The Project intends to avoid to the greatest extent feasible. Otherwise, the Covell's Beach Landfall Site is free of offshore eelgrass or other sensitive habitats in the nearshore area. Construction impacts at this Landfall Site would be entirely limited to paved surfaces, including a public roadway and a parking lot.

New Hampshire Avenue

The New Hampshire Avenue Landfall Site is located just west of Englewood Beach, where a Town-owned road, New Hampshire Avenue, dead-ends. A paved Town-owned parking area is located approximately 91 meters ("m") (300 feet ["ft"]) north of the dead-end road and is a potential location for staging/laydown for horizontal directional drilling ("HDD") operations. Although workspace is limited at this location, the site is a good candidate due to its superior egress and favorable onshore routing to the Barnstable Switching Station via public roads and electric transmission ROW.

The precise Landfall Site is a small beach located at the southern end of New Hampshire Avenue where the road abruptly ends at a low concrete bulkhead. This small bulkhead connects, at either end, to two larger concrete bulkheads that guard the adjacent residential properties fronting on Lewis Bay. These larger bulkheads return toward New Hampshire Avenue along its two sidelines forming a small notch in the shoreline directly in line with the New Hampshire Avenue road layout.

Aside from potential impacts to this small beach area, use of the New Hampshire Avenue Landfall Site does not require any disturbance to coastal habitats. The area is also free of any mapped areas of offshore eelgrass or other sensitive habitats in the nearshore area. Mapped eelgrass resources are shown in Figure 6.4-1.

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\Eelgrass_Locations_20180921.mxd

Data Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division

This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

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Figure 6.4-1

Eelgrass Locations

6.4.2 Potential Impacts of the Project

Table 6.4-1 Impact-Producing Factors for Coastal Habitat

Impact-Producing Factors	Construction & Installation	Operations & Maintenance	Decommiss-ioning
Direct alteration of coastal habitat	x	x	

6.4.2.1 Construction and Installation

Depending on the Landfall Site eventually chosen for the Project, some disturbances to coastal habitat may be required. Although unlikely, some potential also exists for coastal habitat impacts resulting from accidental fuel spills or release of drilling mud used in the HDD operations.

6.4.2.1.1 Direct Alteration of Coastal Habitat

No direct coastal habitat impacts are associated with the Landfall Site at Covell's Beach. On the other hand, direct alterations to coastal habitats may be required at New Hampshire Avenue.

Covell's Beach

The Landfall Site at Covell's Beach will be completed by HDD. All construction operations and staging will be performed within a paved road surface and adjacent parking area. As such, no disturbance to the adjacent dune or beach habitats will occur. A relatively small area of eelgrass located offshore in the vicinity of Spindle Rock has recently been identified and is being surveyed to determine the extent of eelgrass. Avoidance of this area will be a priority.

New Hampshire Avenue

The Landfall Site at New Hampshire Avenue may be completed by HDD or by a conventional open cut trench. If HDD is employed, all construction operations and staging would take place within a paved road surface and adjacent parking area with no disturbance to the beach area. If the conventional method is used, approximately 140 square meters (m^2; 1,500 square feet [ft^2]) of beach would be temporarily impacted from the construction of a temporary, three-sided sheetpile cofferdam.[13] Some riprap removal will

[13] The cofferdam is expected to be approximately 604 m^2 (6,500 ft^2); of this total, approximately 140 m^2 (1,500 ft^2) will be on the beach.

be required at the existing seawall at the Landfall Site to accommodate sheet pile installation close to shore; this riprap and seawall will be restored to original dimensions after the sheet piles are removed.

6.4.2.1.2 Avoidance, Minimization, and Mitigation Measures

The Landfall Sites have been selected because they are located in previously disturbed areas and have sufficient work space that can be effectively segregated from any nearby coastal habitats. In addition, the New Hampshire Avenue Landfall Site is located in an area that is free of offshore eelgrass habitats, and only a relatively small area of eelgrass is located offshore of the Covell's Beach Landfall Site. Avoidance of the eelgrass will be a priority. Thus, potential impacts to coastal habitats have been avoided or minimized.

Best management practices will be used during refueling and lubrication of equipment to protect coastal habitats from accidental spills. For further information on spill prevention, refer to the Oil Spill Response Plan in Appendix 1-A.

6.4.2.1.3 Summary

By implementing the above avoidance, minimization, and mitigation measures, all impacts to coastal habitats will be avoided at Covell's Beach Landfall Site. At the New Hampshire Avenue Landfall site, impacts to coastal habitats will be avoided unless the conventional open cut trench method is used, in which case impacts to coastal habitats would be short-term and highly localized. Additionally, the site will be restored in consultation with local officials. Consequently, population level impacts to any species within the coastal habitat at New Hampshire Avenue are unlikely.

6.4.2.2 Operations and Maintenance

6.4.2.2.1 Direct Alteration of Coastal Habitat

The Project's normal operations and maintenance activities will not result in further habitat alteration or involve activities that are expected to have a negative impact on wildlife. It is anticipated that there may be some required maintenance or repairs at the Landfall Site or transition vault over the up to 30 year life of the Project. Such work would typically occur within the vault, which will be located beneath paved surfaces and accessed through manholes. This would allow such work to be completed within previously-installed onshore infrastructure and without additional impact to coastal habitat.

6.4.2.3 Decommissioning

As described in Section 4.4.3 of Volume I, no decommissioning work is planned for the Project's onshore facilities, although removal of Project cables via existing manholes may occur if required. The splice vaults, duct bank, and onshore substation will likely remain as valuable infrastructure that would be available for future offshore wind projects developed within the Vineyard Wind Lease Area or elsewhere.

6.5 Benthic Resources

This section describes benthic resources in the Offshore Project Area.

6.5.1 Description of the Affected Environment

This section describes the benthic resources present in and adjacent to the Offshore Project Area. A review of regional benthic resources is presented, including a summary of benthic habitat and shellfish in the Wind Development Area ("WDA") and along the Offshore Export Cable Corridor ("OECC"). Data used to describe benthic resources in the Offshore Project Area came from a robust dataset and previous studies conducted within or near the Project Area between 2012-2018. Primary sources included, BOEM Revised Environmental Assessment, Massachusetts Coastal Zone Management Survey, and site-specific data collected by Vineyard Wind (see Volume II for details of site-specific sampling). The non-project specific (i.e., samples not collected by Vineyard Wind) datasets consist of a mix of grab and imagery data collected within the Project Area, covering both spring and fall seasons, over a two-year period, and enabled characterization of seasonal and inter-annual variability. These resources, in addition to the Vineyard Wind sampling, allowed for the characterization of abundance, diversity, community composition, and percent cover of benthic macrofauna and macroflora, both within the Project Area and surrounding area.

6.5.1.1 Benthic Habitat (hard bottoms, living bottoms) in WDA

As discussed in Section 2.1.2.1 of Volume II, seafloor conditions within the WDA are very homogenous, dominated by fine sand and silt-sized sediments that become finer in deeper water. These homogenous conditions were identified by multi-beam echo sounding and side scan sonar imaging techniques that have been ground-truthed via benthic grab samples, borings, and CPTs, and further verified via historic grab sample and still photo data (Stokesbury, 2013; Stokesbury, 2014). There are localized patches of sand ripples and small mega-ripples randomly distributed throughout the WDA, and these patches provide the only relief as compared to the relatively flat seafloor that gradually slopes offshore. While these features within the WDA provide less than one-meter ("m") (3.2 feet ["ft"]) relief, they can be as much as 200 m (656 ft) wide and 500 m (1,640 ft) long and more than 1,000 m (3,280 ft) in length.

No state-managed artificial reefs have been documented within the WDA; other types of potentially sensitive or unique benthic habitat types, such as live bottom, are not present based on the Shallow Hazards Assessment discussed in Section 3 of Volume II.

One shipwreck was identified in the southeast edge of the WDA (see Figure 3.2-16 of Volume II), which may provide artificial reef habitat for benthic resources in the area. A further assessment of the site, which could assist in determining the amount and quality of artificial habitat created by this wreck is planned for the 2018 geophysical data survey.

There have been no observations of living bottom made within the WDA based on data available on the National Oceanic and Atmospheric Administration ("NOAA") Deep-Sea Coral Data Portal (NOAA, 2017c; Figure 6.5-1). However, it is important to note that this database does not include "observations of absence" for corals and sponges. Few areas have actually been surveyed for corals or sponges, so by showing no observations in the database, this does not necessarily indicate no taxa are present (Hourigan et al., 2015). To help fill the gap between surveyed areas often due to the logistical difficulty and expense of surveying the deep ocean, NOAA National Centers for Coastal Ocean Science (NCCOS) uses statistical modeling techniques, which take into account known deep-sea coral locations and other contributions with environmental and oceanographic data, to predict areas that are capable of supporting deep-sea corals. The NOAA NCCOS model results indicate that the area within the WDA has a low habitat suitability index for all soft and hard coral species analyzed (Figure 6.5-2; Kinlan et al., 2016).

According to known observations within the NOAA Deep-Sea Coral Data Portal database, the closest live bottom to the WDA is a patch of stony coral (cup coral [*Astrangia* sp.]) approximately 28 kilometers ("km") (17 mi ["mi"]) to the northwest of the WDA, while the closest unspecified stony coral (Scleractinia) is approximately 30 km (19 mi) to the southwest of the WDA. Farther offshore of the Massachusetts Wind Energy Area ("MA WEA"), designated by BOEM, are patches of Sea Pens (*Stylatula elegans*), stony coral, sponges, soft coral, and gorgonian coral as shown in Figure 6.5-1.

6.5.1.2 Benthic Epifauna, Infauna and Macrofauna in WDA

The benthic community in the WDA, as a subset of New England waters in depths from approximately 40-58 m (131-190 ft), includes amphipods and other crustaceans, lobster, crabs, gastropods, polychaetes, bivalves, sand dollars, burrowing anemones, brittle stars, sea squirts, tunicates, and sea cucumbers (BOEM, 2014; Provincetown Center for Coastal Studies, 2005). These organisms are important food sources for many commercially important northern groundfish species.

Video surveys of benthic epifauna conducted by the University of Massachusetts School of Marine Science and Technology ("SMAST") in 2010-2013 indicate that the Common Sand Dollar (*Echinarachnius parma*) is abundant within the MA WEA, with this species occurring

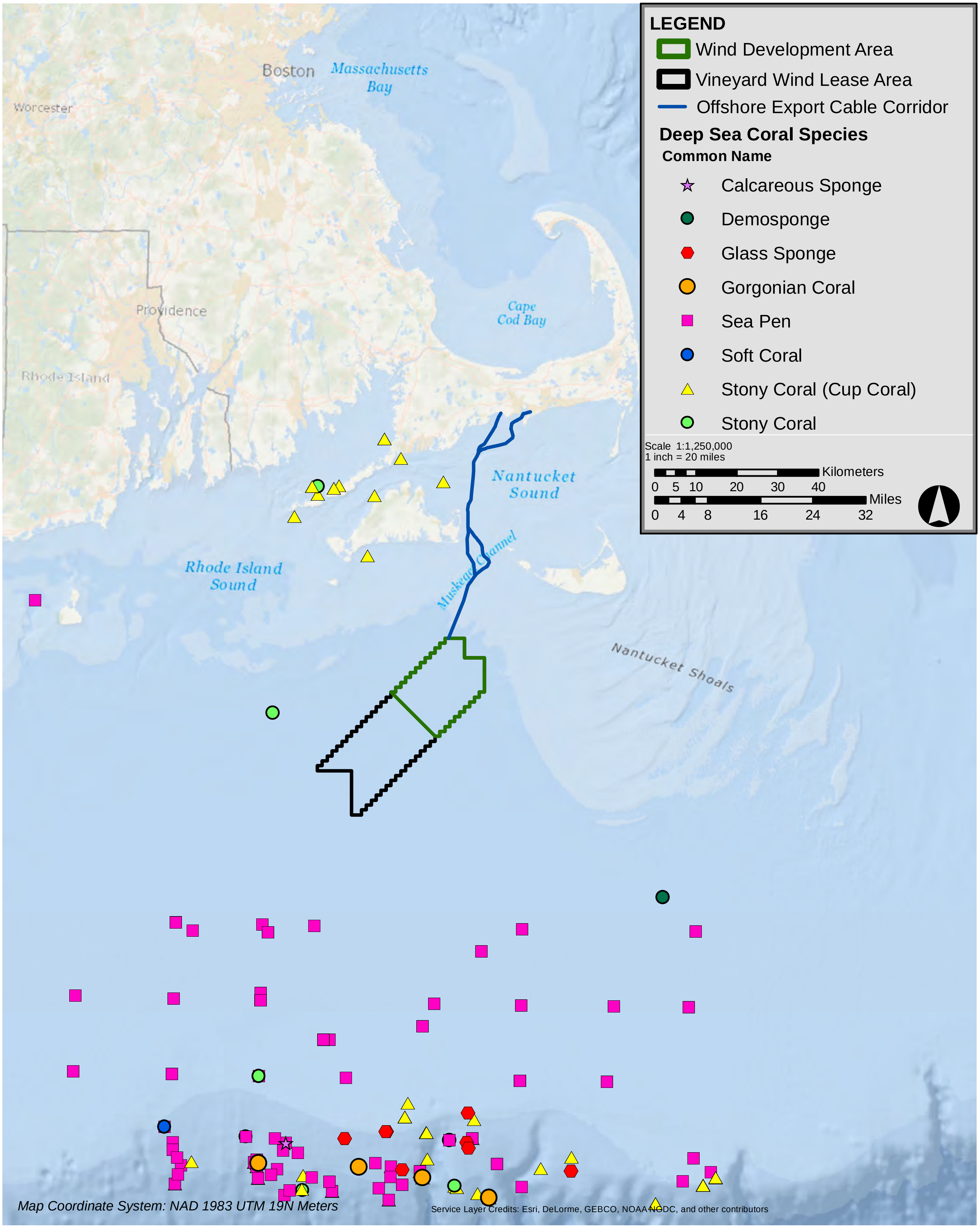

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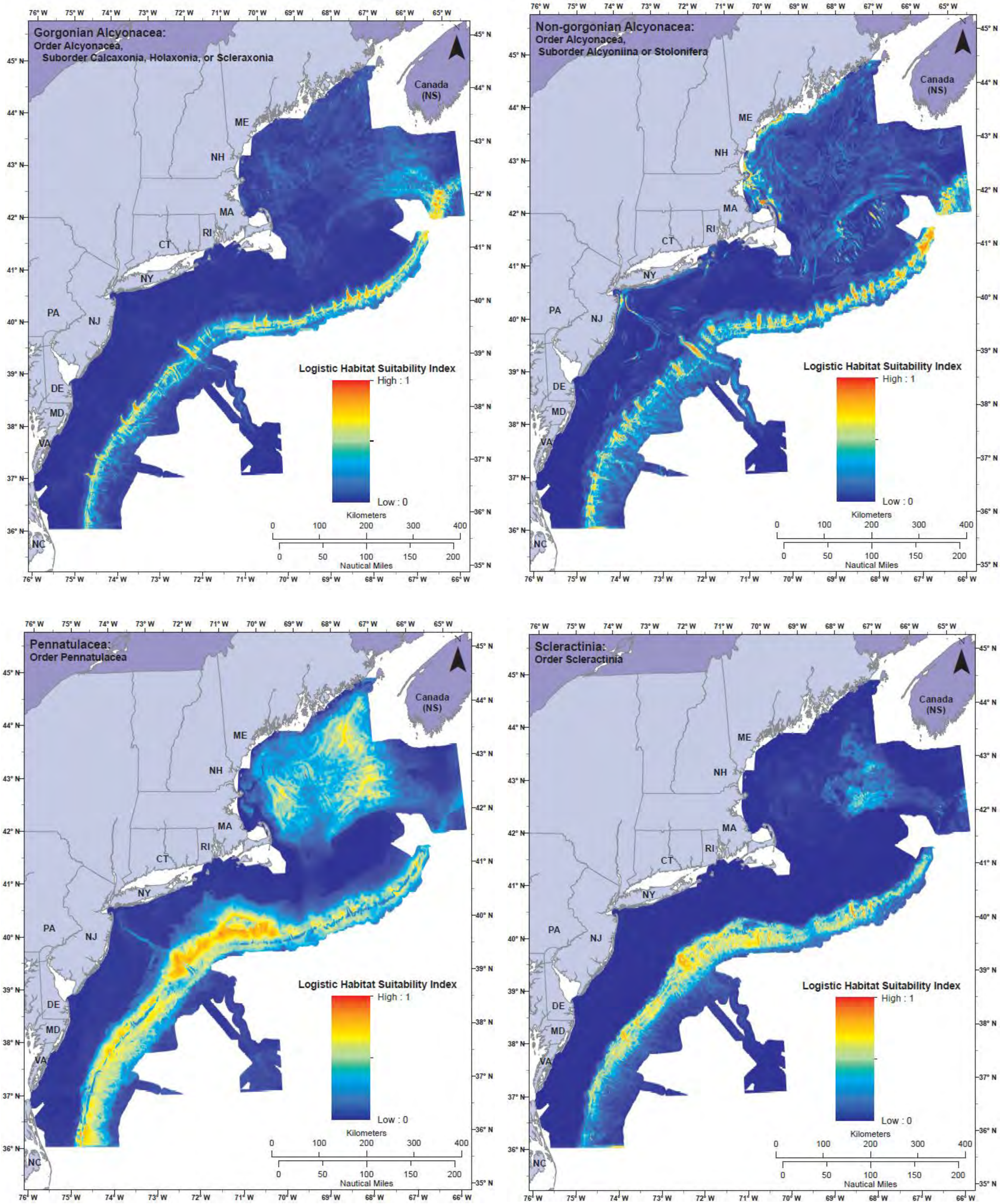
Figure 6.5-1

Locations of Observed Deep-Sea Coral in the Offshore Project Area (NOAA, 2017a)



National Centers for Coastal Ocean Science,
Center for Coastal Monitoring and Assessment, Biogeography Branch
Map Projection: WGS84 UTM Zone 18N

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Figure 6-5.2

NOAA NCCOS Logistic Habitat Suitability Indices for Soft Coral (Alcyonacea), Hard Coral (Scleractinia) and Sea Pens (Pennatulacea) in approximately 70% of a total of 216 samples collected in the WDA (SMAST, 2016). Similar patterns of Sand Dollar abundance were observed during video surveys conducted by the Coonamessett Farm Foundation, Inc. (CFF) as part of a southern New England juvenile fish study between December 2015 and early April 2016 throughout the BOEM Rhode Island and MA WEAs (Siemann and Smolowitz, 2017). In this survey, including video surveys and scallop dredge tows, high abundances of sand dollars were found in areas, such as the WDA, in which sandy substrates predominated. The sampling locations for the SMAST and CFF surveys are provided in Figure 6.5-3.

As part of the 2010-2013 SMAST video survey, two sampling events occurred within the WDA in May 2012 and September 2013 (SMAST, 2016). The differences in numbers of species collected during the two seasons is provided in Table 6.5-1. From this sampling program, more benthic organisms were collected in the spring than fall. Hydrozoans and bryozoans were present in approximately 18% of the 216 samples within the WDA, while hermit crabs, euphausids, sea stars, and anemones, combined, were present in 9% of the samples (SMAST, 2016). It is important to note, however, that none of these benthic epifauna, infauna, or macrofauna have a designated conservation status as they are typically found in the Nantucket Shelf Region.

Table 6.5-1 Seasonal Results of SMAST Video Survey Samples Collected in Wind Development Area in May 2012 and September 2013 (107 samples from 9 locations)

Common name	Number of Organisms Collected in Spring	Number of Organisms Collected in Fall
Hermit Crab	3	0
Euphausids	11	0
Sea Stars	4	0
Sand Dollars	89	63
Anemones	2	0
Hydrozoans	23	17

Numerous benthic trawl and grab samples were also collected in the MA WEA during a shipboard survey conducted by the Northeast Fisheries Science Center ("NEFSC"), Integrated Statistics, Inc., and Woods Hole Oceanographic Institution from April to May 2014 (NEFSC, 2014). This survey, which consisted of 32 grab samples locations with three replicate grabs for grain size and benthic infauna at each location and 23 benthic trawls within the MA WEA, focused on sea birds, cetaceans, and sea turtles. The aim of this survey was to document the relationship between the abundance of these organisms and the biological and physical environment. The grab samples were analyzed to identify benthic infaunal and epifaunal assemblages, as well as sediment textures. Within the 23

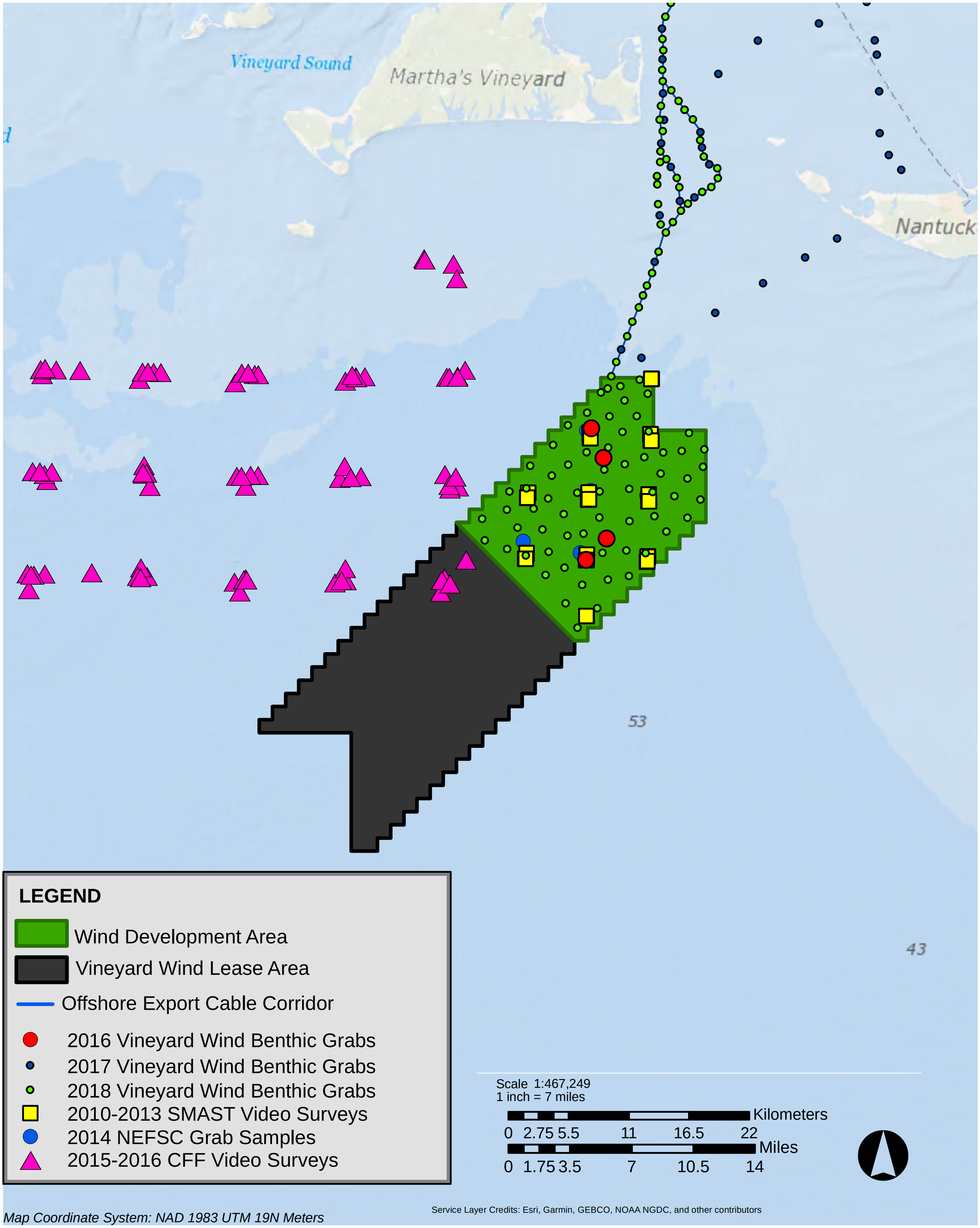

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Figure 6.5-3

Benthic Sampling Locations In and Surrounding the Wind Development Area trawls conducted in the MA WEA, 59 taxa were identified with Sand Shrimp (*Crangon septemspinosa*), sand dollars, Pandalid Shrimp (*Pandalidae*), and Monkey Dung Sponge (*Suberites ficus*) as the top four species by percent count, weight, and frequency (see Table 6.5-2).

Table 6.5-2 Beam Trawl Summary for Epibenthic and Demersal Fauna within the Massachusetts WEA (23 trawls, 59 taxa)

Common name	Taxonomic name	% count	% weight	% frequency
Sand Shrimp	*Crangon septemspinosa*	70.5	5.7	95.7
Sand Dollar	*Echinarachnius parma*	17.4	47.6	39.1
Pandalid Shrimp	Pandalidae	0.5	0.1	52.2
Monkey Dung Sponge	*Suberites ficus*	0.1	15.4	26.1

For the WDA specifically, 21 benthic grabs from the NEFSC Shipboard Habitat Survey were collected from 7 sampling locations in March 2014 (Figure 6.5-3). Within these samples, benthic infaunal assemblages were dominated by polychaete worms (at 49% as a combined taxa) and amphipod crustaceans (at 33%; Figure 6.5-4).

Similar results were found in infaunal sampling performed in areas south of Martha's Vineyard and Nantucket in September 2011. Oligochaetes, polychaetes, and nemertean ribbon worms were the most widely distributed taxa (AECOM, 2012). This survey included benthic grabs at a total of 214 stations, 95 of which were located south of Cape Cod and the Islands, in the vicinity of the Offshore Project Area. A total of 128 different families were identified from the samples collected at these 95 stations with an average of 23 (standard deviation ["SD"] $\pm$ 7) taxa per location. Organism density ranged from 12 to over 1,000 individuals per sample, with an average density of 599.5 (SD $\pm$ 712.1) organisms per 0.04 square meter ("m^2") (4.3 square feet ["ft^2"]). Nut clams, small bivalves in the family Nuculidae, were the most abundant taxon, and comprised over 24% of all organisms. Capitellid polychaetes and four-eyed amphipods (Ampeliscidae) were also abundant, comprising 16.0% and 9.0% of organisms, respectively.

In addition to the prior studies, ESS Group Inc. and RPS, on behalf of Vineyard Wind, analyzed four and 67 samples, respectively, collected from benthic habitats within the WDA (ESS Group, Inc., 2017; RPS, 2018; included in Appendix H of Volume II-A). The 2016 sampling survey involved collecting four grab samples for ground-truthing side-scan sonar imagery and corresponding benthic analysis. The 2018 survey involved more comprehensive coverage and included 67 samples for benthic analysis. The grab sampling locations from both the 2016 and 2018 surveys are also shown in Figure 6.5-3. The primary target of this analysis was benthic macroinvertebrates, or organisms greater than

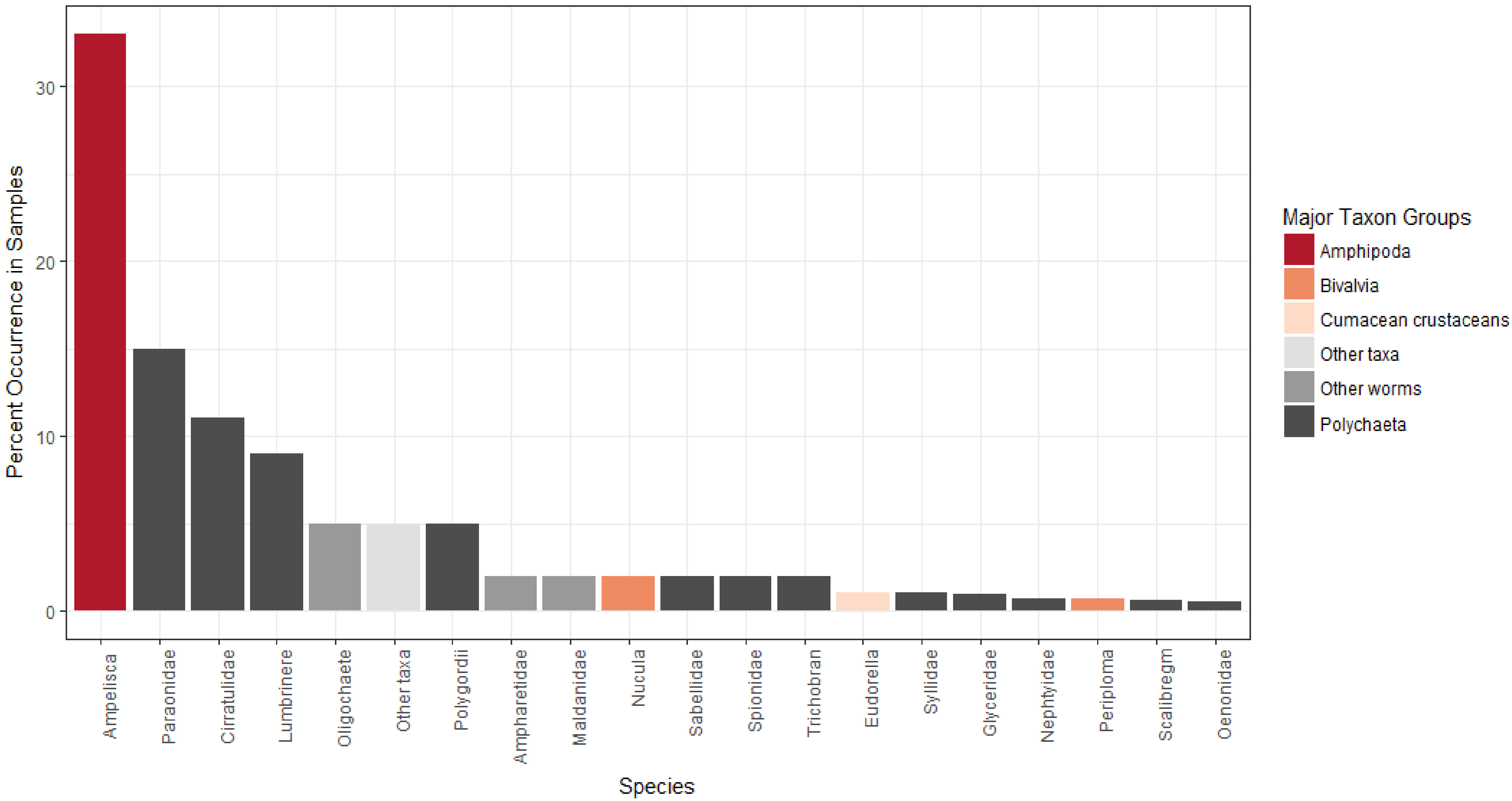

Figure 6.5-4

2014 NEFSC Shipboard Habitat Survey Grab Sample Catch by Percentage of Total Catch Numbers, Color-coded by Major Taxonomic Group

500 microns (μm) in length that either live on or in aquatic sediments, including mollusks, primitive (unsegmented) worms, annelids (segmented worms), crustaceans, and echinoderms. Measures of benthic macrofaunal diversity, abundance, and community composition were recorded to describe the existing condition of benthic resources within the WDA. In the 2016 survey, there were 32 total taxa identified from the four samples examined. Taxa richness per sample ranged from six taxa to 19 taxa per grab, with a mean taxa richness of 15 taxa per grab. The mean macrofaunal density for the analyzed samples was 12,449 individuals per m^2 [14]. The highest macrofaunal density found in the four grab samples was 23,4440 individuals per m^2, and the lowest was 4,823 individuals per m^2. In the 2018 survey, taxa richness per sample ranged from nine to 32 taxa per grab, with a mean richness of 21 taxa. Mean density per m^2 across all samples was 36,539 organisms per grab sample with a range of 119,125 organisms per m^2 at station 210 and 7,625 organisms per m^2 at station 230.

Of the four samples analyzed in 2016, three were characterized by densities of 9,000 individuals per m^2 or more (Appendix A in Appendix H of Volume II-A). The benthic macrofaunal assemblage in the analyzed samples consisted of polychaete worms, crustaceans, mollusks, echinoderms, nematode roundworms, and nemertean ribbon worms. The most speciose taxonomic group was polychaete worms, which contributed approximately 45% of the taxa documented in the analyzed samples. The taxonomic group with the highest density was polychaete worms, followed by nematode roundworms and crustaceans. The most abundant taxa observed were nematode roundworms (Nematoda), the lumbrinerid polychaete (*Scoletoma* sp.), and a paranoid polychaete (Paraonidae). Together, these taxa accounted for more than 50% of all individuals identified in this study. For the 67 samples collected in the WDA in the 2018 survey, the most abundant taxonomic groups included polychaete worms (Polygordiidae, Paraonidae, Lumbrineridae, and Cirratulidae) and nut clams (Nuculidae). Organisms in these families accounted for about 75% of the total abundance in all samples. Results from multivariate analyses of the benthic grab data collected in 2018 indicated overall similarity and homogeneity between the taxonomic assemblages in the WDA (RPS, 2018, see Appendix H of Volume II).

BOEM is also conducting an on-going study designed to assess and characterize benthic habitat and the epibenthic macroinvertebrate community in existing and proposed WEAs from Massachusetts to North Carolina via multibeam sonar, and optical (still and video) imaging of the seafloor. While this study is ongoing, BOEM has provided Vineyard Wind with preliminary data results to incorporate into the evaluation of benthic resources within the Offshore Project Area. NOAA's NEFSC provided an initial small subset of the benthic

[14] Data from the 2016 survey was originally reported as meters cubed (m^3), however to allow for comparison between the 2017 and 2018 datasets, the 2016 data was converted to square meters (m^2), which is typically the metric used to report taxonomic density in benthic grab samples.

grab data to assist in the evaluation of benthic resources for the Offshore Project Area. The results of these preliminary grab data are relatively similar to those from the ESS Group Inc. (2017) and RPS (2018) studies with the most abundant species being tube-dwelling amphipods (*Ampelisca agassizi*), Oligochaete worms, and marine polychaete worms from the families Cirratulidae, Lumbrinere, and Paraonidae.

For benthic macrofauna, species of commercial or recreational importance within the WDA include Atlantic Sea Scallop (*Placopecten magellanicus*), Ocean Quahog (*Artica islandica*), Atlantic Surfclams (*Spisula solidissima*), American Lobster (*Homarus americanus*), Jonah Crab (*Cancer borealis*), and Horseshoe Crab (*Limulus polyphemus*). The immobile, attached egg masses (egg mops) of the Longfin Squid (*Doryteuthis pealeii*) is another species of commercial or recreational importance with a benthic life stage within the WDA, and is discussed in more detail in Section 6.6. The NEFSC Seasonal Trawl data from 2003-2016 indicate that the catch of sea scallops is typically higher in the fall than in spring months, with the only catch of this species in the WDA occurring in the fall (Figure 6.5-5). Juvenile and adult Atlantic Surfclams (*Spisula solidissima*) are typically found in well-sorted, medium sand (Dames and Moore, 1993), but they also occur in fine sand (MacKenzie et al., 1985) and silty-fine sand (Meyer et al., 1981; Cargnelli et al., 1999a) such as is found in the WDA. Ocean Quahogs are usually found in dense beds over level bottoms, typically just below the surface in medium to fine grain sand sediments (MAFMC, 1997; Cargnelli et al., 1999b). Ocean Quahog (*Artica islandica*) have been qualitatively observed within the northern portion of WDA and throughout the MA WEA based primarily on bottom grab samples (Guida et al., 2017). The NOAA NEFSC has also been conducting Atlantic Surfclam-Ocean Quahog Surveys within the vicinity of the WDA since 1999. The region-wide survey has involved five-minute tows at a speed of 1.5 knots with a hydraulic jet dredge at randomly-selected sites (NEFSC, 2018). The survey has not always sampled within this specific area; however, both Atlantic Surfclam and Ocean Quahog have been collected within the vicinity of the WDA as outlined in Table 6.5-3.

Table 6.5-3 Catch Numbers of Atlantic Surf Clam and Ocean Quahog in NOAA Fisheries Service-NEFSC Surfclam/Ocean Quahog Survey at Sampling Locations in Vicinity of the WDA (NEFSC, 2018)

Year	Catch Number of Atlantic Surf Clam	Catch Number of Ocean Quahog
1999	59	12
2002	0	1,136
2005	0	36
2008	1	80
2011	0	46
2013	0	171

NEFSC Seasonal Trawl Survey Data
Sea Scallop Catch Number by Season
2003-2016

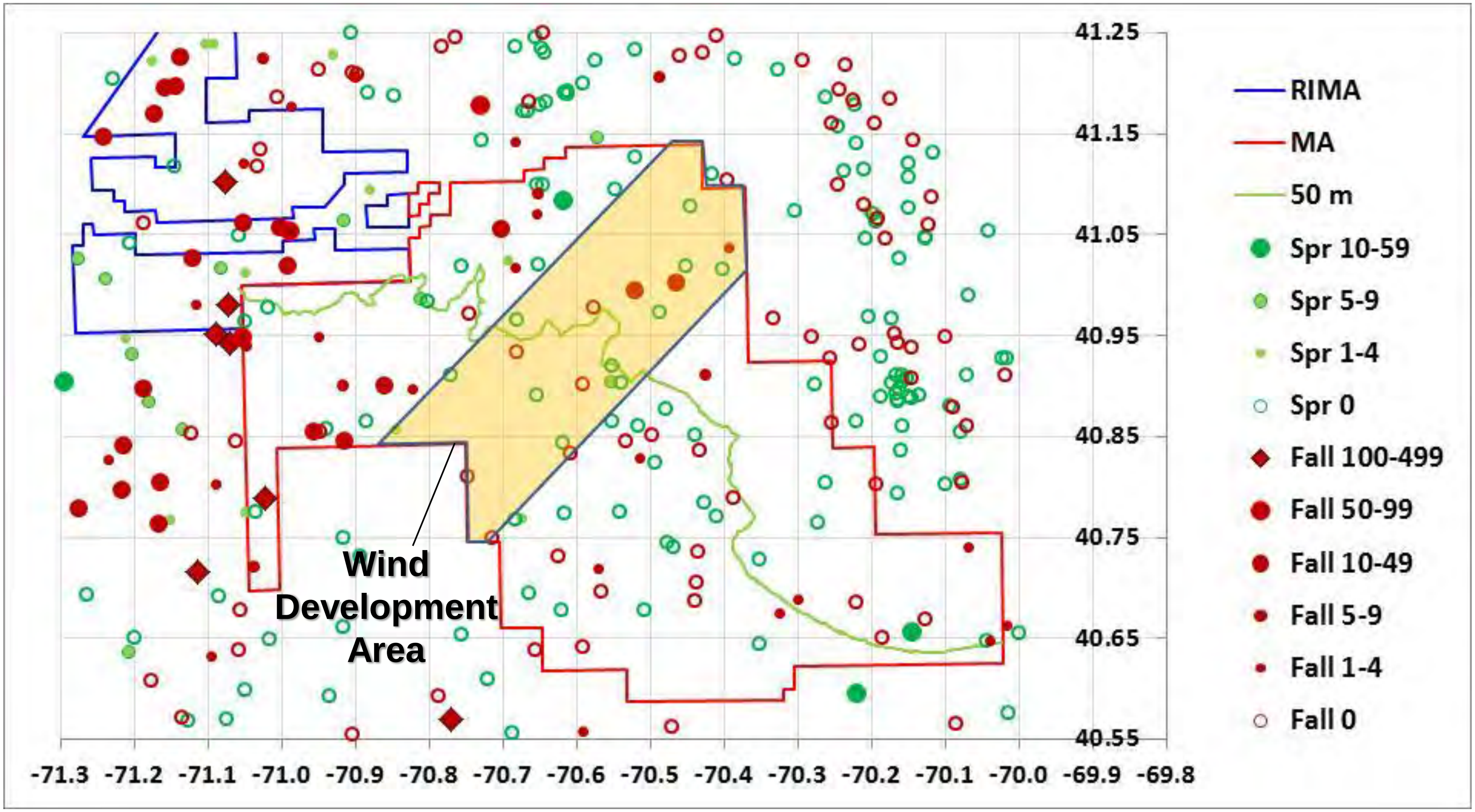

Figure 6-5.5

Sea Scallops Numbers Caught by NEFSC Seasonal Trawl Survey: 2003-2016 (Guida 2017)

NEFSC Fall and Spring Bottom Trawls have also caught American Lobster (*Homarus americanus*) within the WDA (Figure 6.5-6). Spatial analyses by the NOAA NEFSC of their bottom trawl survey data between 2004 and 2014 indicate that the fall and spring distribution of Atlantic Lobster in the vicinity of the WDA is less than 0.8 individuals per tow (NEFSC, 2017b). Jonah Crab have been infrequently encountered in the Massachusetts inshore state water trawl surveys, which are focused primarily on finfish (ASMFC, 2015). Spatial analyses by the NOAA NEFSC of their bottom trawl survey data indicate that the fall distribution of Jonas Crab within the vicinity of the WDA from 2004 to 2014 ranged from approximately 0.03 to 0.1 individuals per tow (NEFSC, 2017b). This same analysis indicated that the spring distribution of Jonah Crab within the WDA was lower (at approximately <0.02 individuals per tow) than during the fall. Little data exists on the distribution of Horseshoe Crab within the vicinity of the WDA; however, older juvenile and adult Horseshoe Crabs could occur in the area, though NMFS NEFSC bottom trawl data suggest they prefer depths less than 30 m (ASMFC, 1998). Figure 6.5-7 provides an overview of the occurrence of Jonah Crab, Horseshoe Crab and American Lobster within the Project Area during fall sampling by the Massachusetts Division of Marine Fisheries (MA DMF) and NOAA NEFSC between 2005-2014. In summary, though these species are present within the WDA, based on available data, they have been only observed in relatively low numbers. For a broader description of the primary mobile benthic invertebrates within the WDA, refer to Section 6.6.1.2.

In terms of the organisms present in the localized patches of sand ripples and small mega-ripples randomly distributed throughout the WDA (see Section 2.1.2.1 of Volume II), mobile sand environments, such as sand ripples, are quite variable with the fauna being often sparse (Jennings et al., 2013).

6.5.1.3 Benthic Habitat (hard bottoms, living bottoms) Along Offshore Export Cable Corridor

As described in Volume II, the majority (75%) of the video transect samples along the Offshore Export Cable Corridor ("OECC") recorded bottom habitats with low complexity, mostly comprised of flat sand/mud, sand waves, and biogenic structure. Areas of shell aggregate, specifically common Atlantic Slipper Shell (*Credula fornicate*) reefs, were observed along the OECC in the northern Nantucket Sound. A number of locations within Muskeget Channel, contained coarse deposits and hard bottom habitats consisting of pebble-cobble habitat with Sulfur Sponge (*Cliona celata*) communities.

There are no artificial reefs directly along the OECC; however, there are two artificial reef locations outside the Project Area, as shown in Figure 6.5-8 (NEODP, 2017).

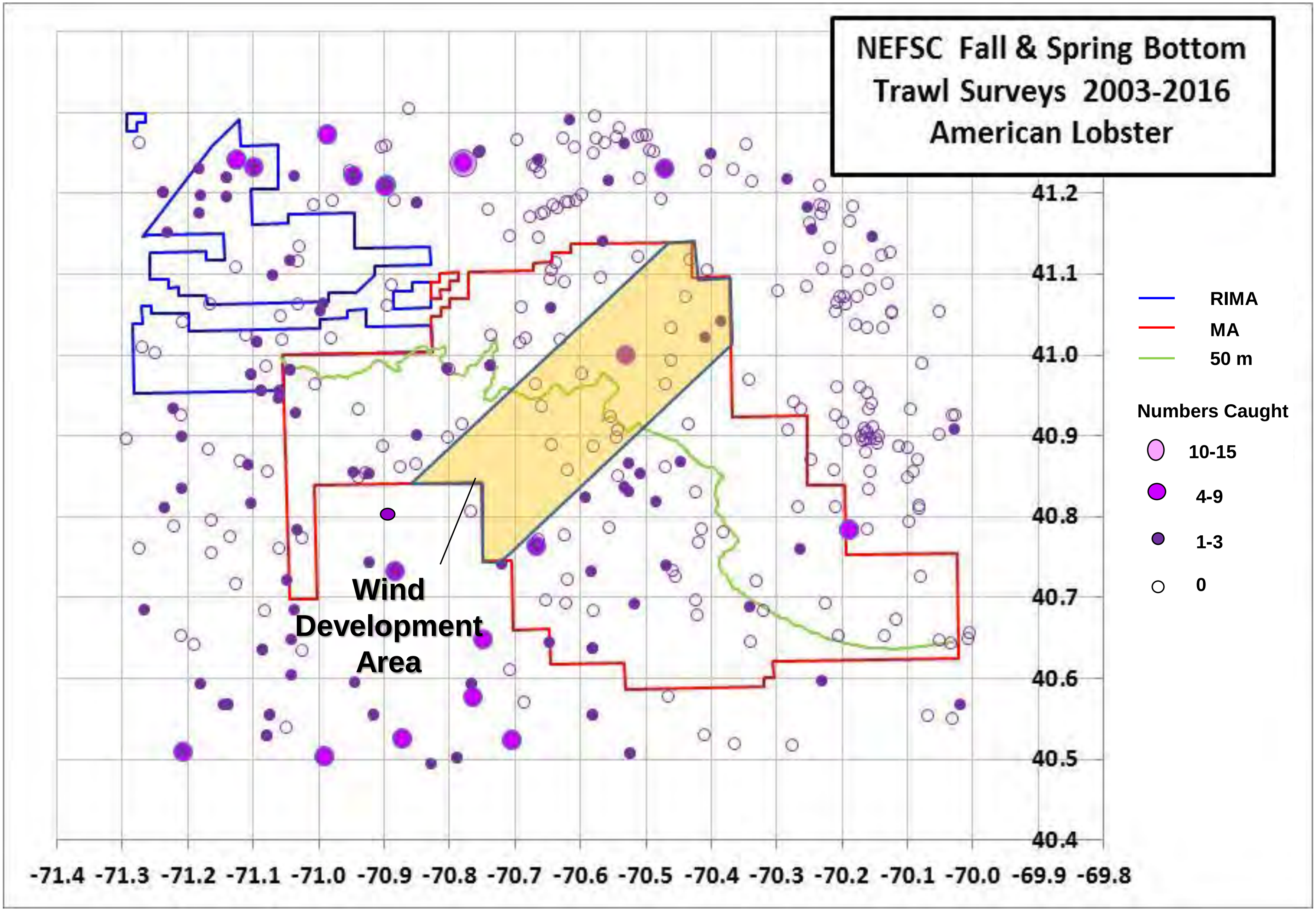

Figure 6-5.6

American Lobster Numbers Caught by NEFSC Fall & Spring Trawl Surveys: 2003-2016 (Guida 2017)

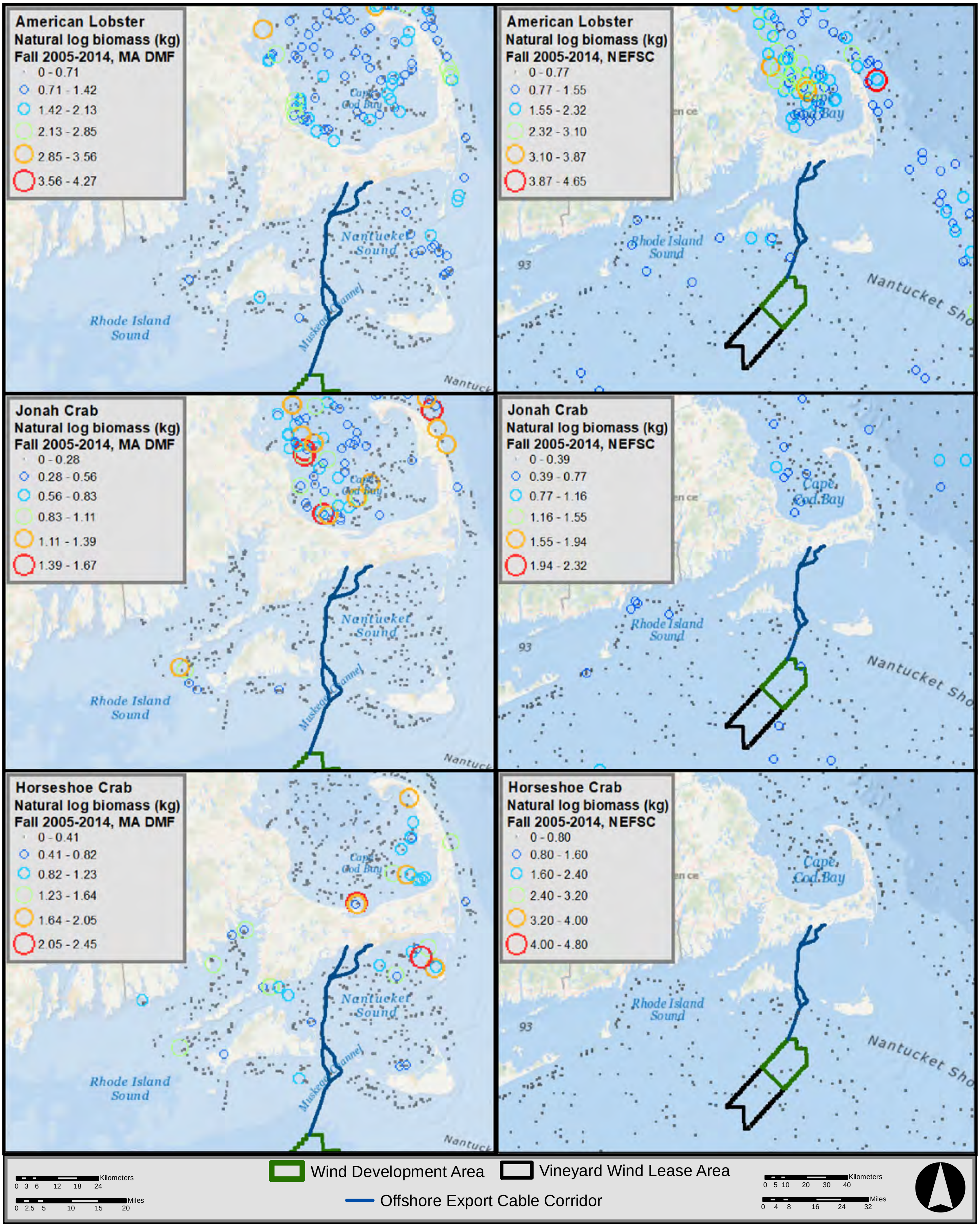

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Figure 6.5-7

Natural log-transformed biomass (kg) per tow for MA DMF and NEFSC Fall Sampling of Horseshoe Crab, Jonah Crab and Atlantic Lobster (NEODP, 2017)

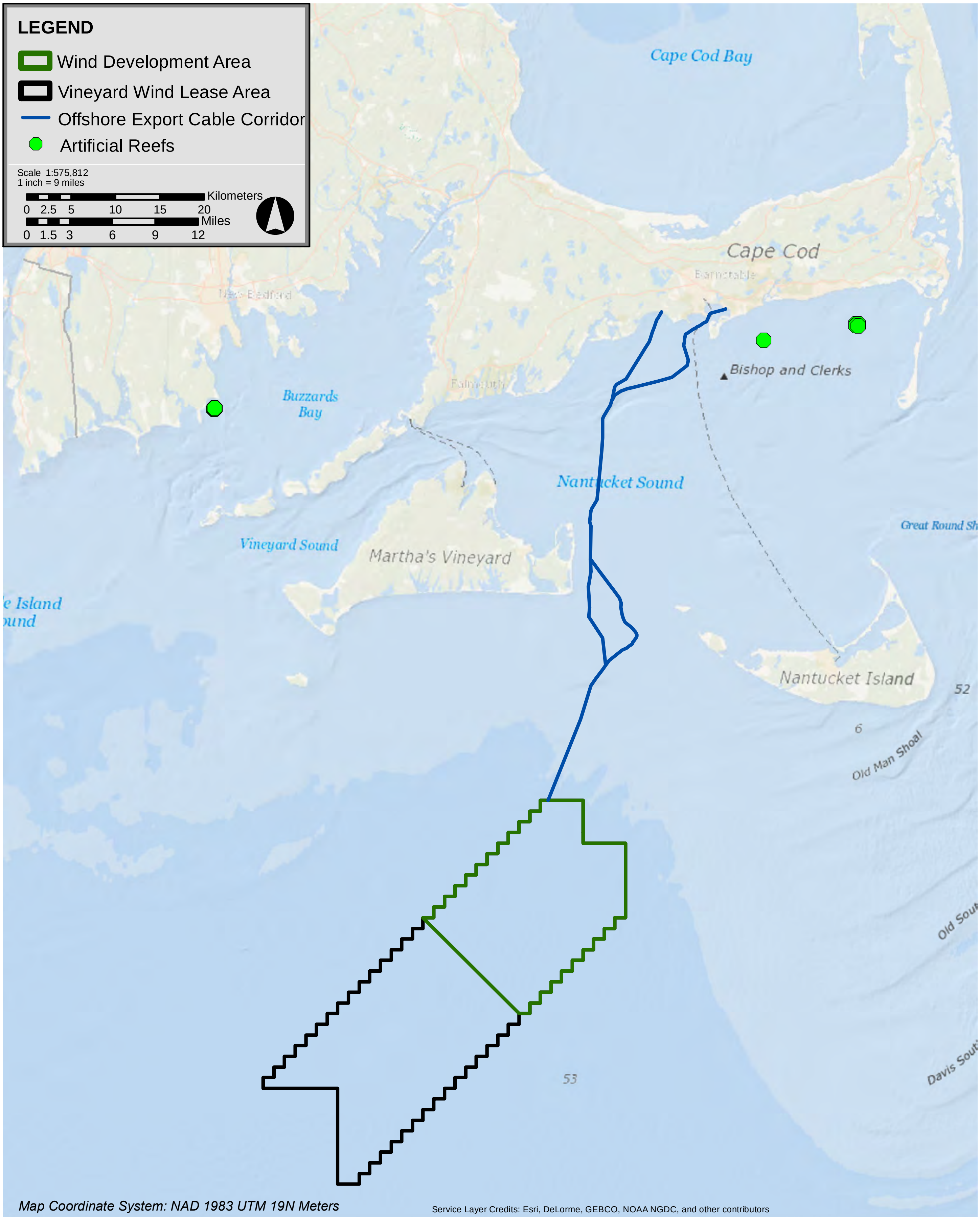

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Figure 6.5-8

Locations of Artificial Reefs in Relation to Two Potential Landfall Sites for the Project's Export Cables (NEODP, 2017)

6.5.1.4 Benthic Epifauna, Infauna and Macrofauna Along Offshore Export Cable Corridor

As described in Section 5.1.1.2 and Appendix H of Volume II, surveys of epifauna and infauna along the OECC were conducted via underwater video transects and sediment grab samples, respectively. The results of the underwater video imagery, which are fully described in the CR Environmental, Inc. final report (2017) and summarized in Table 5.1-4 of Volume II, demonstrate that the epifauna communities vary between habitat type, as expected. The areas of flat sand/mud, sand waves, and biogenic structure were dominated by sand dollars and burrowing anemones in some areas and amphipods, slipper limpets, whelks, sponges, polychaetes and spider crabs in other areas. While areas containing hard bottom, particularly the pebble-cobble habitat, contained Sulfur Sponge (*Cliona celata*), Breadcrumb Sponge (*Halichondria panicea*) and bryozoans.

The results of the 31 grab samples collected in September 2017, as documented by Normandeau Associates (2017) and RPS (2018) and provided in Appendix H of Volume II, indicate the predominate infaunal organisms along the OECC include amphipods, polychaete worms, nematodes, and snails (e.g., slipper limpets, pyram shells, and dove snails). In addition to the 31 benthic grab samples collected along the OECC in 2017, more extensive sampling occurred in June and July of 2018 and included 64 benthic grabs and 42 underwater video transects. Results of the benthic grabs collected in 2018 indicated some dissimilarity in the abundance and predominant infaunal organisms between the two surveys. While samples from both 2017 and 2018 had consistently high occurrence rates and abundances of nematodes, the most abundant organisms collected in 2018 were slightly different than in 2017 and included polychaete worms, nematodes, barnacles, hooded shrimp, and tellins (RPS, 2018. Differences in the taxonomic assemblages between the surveys could be due to seasonal, interannual, or natural environmental variability; increased sampling effort in different and unique habitats in 2018; or other causes. In general, samples along the OECC had lower abundance and highly variable taxonomic assemblages composed of more unique taxa than those in the WDA.

Areas of suitable shellfish habitat have also been observed along the coast of Massachusetts since the mid-1970s with information provided by the Massachusetts Division of Marine Fisheries, local shellfish constables, commercial fisherman, maps, and studies (NEODP, 2017). According to these data (limited to Massachusetts state waters), the OECC will transverse over suitable shellfish habitat for Atlantic Surf Clam (*Spisula solidissima*), Ocean Quahog (*Artica islandica*), Blue Mussel (*Mytilus edulis*), Bay Scallop (*Argopecten irradians*), and Atlantic Sea Scallop (*Placopecten magellanicus*) (see Figure 6.5-9 and Figure 6.5-10; NEODP, 2017). As indicated by Figure 6.5-10, the OECC with a potential landing site in Lewis Bay would transverse over an area of suitable habitat for Bay Scallop. It has also been reported that species of large gastropod whelks (*Busycon carica* and *Busycotypus canaliculatum*) are abundant in Nantucket Sound coastal waters (Davis & Sisson, 1988; USDOE MMS, 2009).

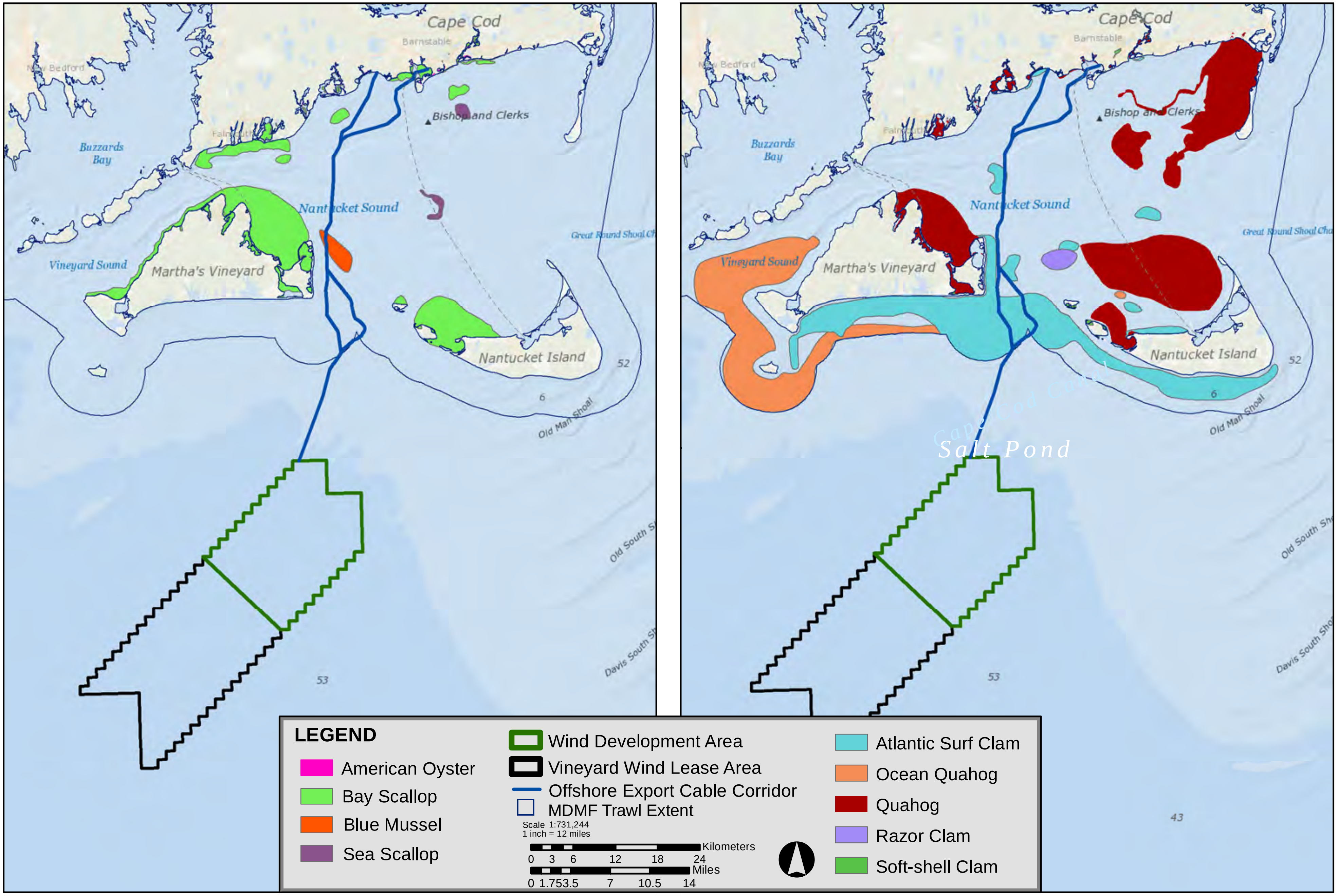

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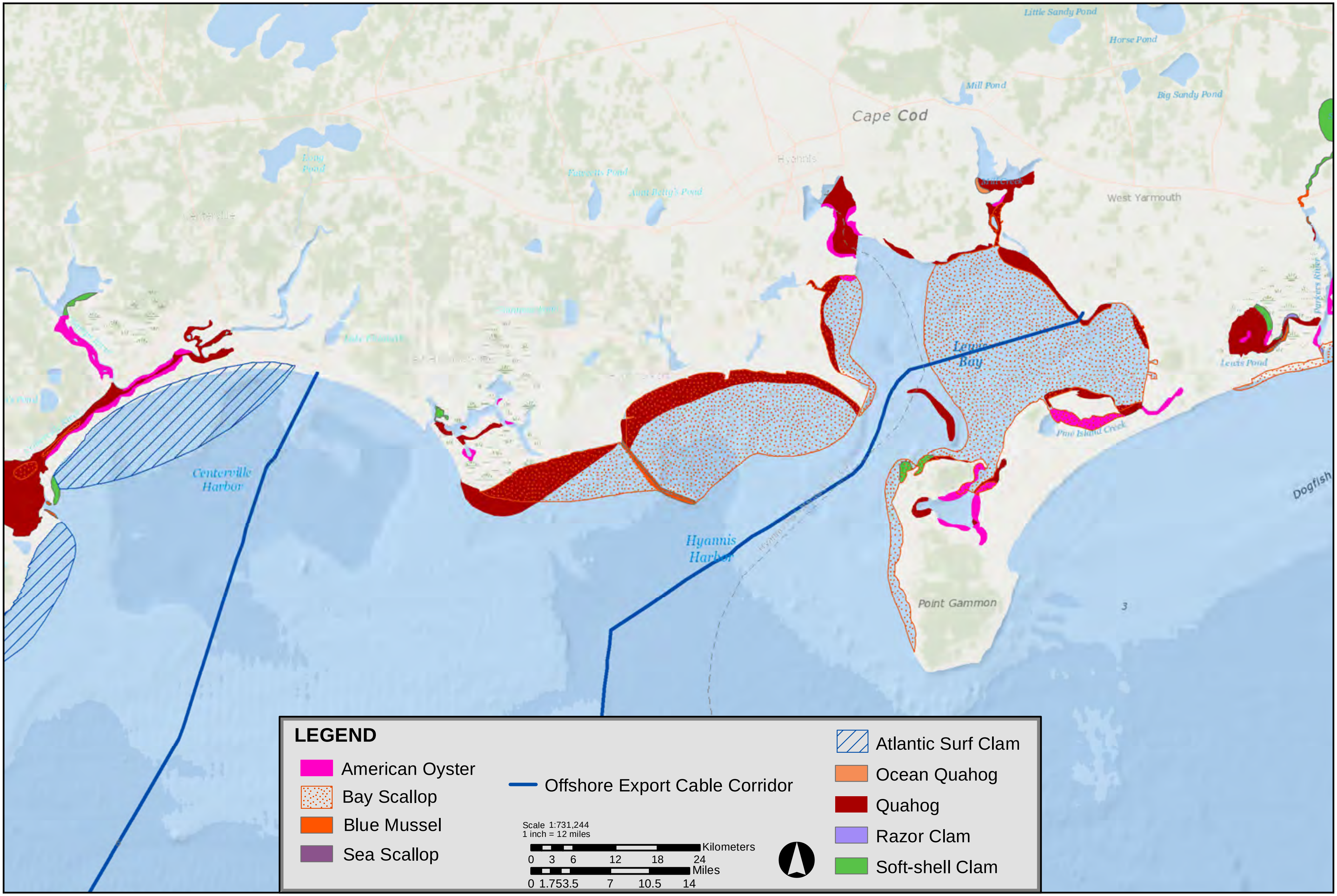
Figure 6.5-9

Suitable Shellfish Habitat Along the Offshore Export Cable Corridor in Massachusetts State Waters Only (NEODP, 2017)



Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

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Figure 6.5-10

Suitable Shellfish Habitat In the Vicinity of the Two Potential Landfall Sites of the Offshore Export Cable Corridor (NEODP, 2017)

In addition to the information provided by the Massachusetts Division of Marine Fisheries, local shellfish constables, commercial fisherman, and maps, and studies as available geospatially within the Northeast Ocean Data Portal ("NEODP"), five separate comprehensive benthic field surveys were conducted from 2001 through 2005 in Nantucket Sound as part of the Cape Wind project development process. The results of these surveys overlap the areas of the OECC.

Between 2001 and 2005, 90 benthic samples were collected from Horseshoe Shoal to Lewis Bay and Popponesset Bay, during a variety of seasons, and analyzed to provide insight into the nature and general characteristics of the benthic communities in the area and allow for characterization of potential effects (USDOE MMS, 2009). Overall, the benthic community composition documented from these surveys is consistent with the results of earlier studies (Pratt, 1973; Sanders, 1956; Theroux and Wigley, 1988; Wigley, 1968), that indicate the Nantucket Sound benthic community has a lower than average invertebrate density when compared with the rest of the southern New England Shelf, even though biomass and density are relatively high (USDOE MMS, 2009). Additionally, there is a high sample-to-sample variability in total invertebrate abundance, which supports conclusions from previous research indicating that the Nantucket Sound benthic community is highly variable from one location to the next and from one season to another. This is likely due to the patchy nature of "microhabitats" related to parameters such as depth, currents, sediment types, availability of food, etc. (Wigley, 1968; USDOE MMS, 2009). Data from these surveys show the microhabitat variable that significantly affects macroinvertebrate abundance is the presence or absence of sand waves.

As described in Section 5.3 and Volume II, bedforms from ripples up to sand waves have been identified locally along the OECC with larger bedforms in deeper waters in which the fast-flowing tidal water masses are located. The sizes of these ripples and sand waves range from two to three meters (6.6-9.8 ft) with a maximum of four meters (13.1 ft) northeast of Muskeget Channel; two to four meters (6.6-13.1 ft) with a maximum of six to seven meters (19.7-22.9 ft) in the Muskeget Channel and vicinity; one to one and half meters (3.3-4.9 ft) with a maximum of five meters (16.4 ft) in the wider Muskeget Region, and one to two meters (3.3-6.6 ft) with a maximum of three to four meters (9.8-13.1 ft) in the Nantucket Sound area. Faunal abundance and composition varies based on where sampling occurs on the sand wave. Fauna tend to be most dense in the trough between sand waves where organic matter accumulates, while mobile species such as amphipods are prevalent on the slope of the sand wave (Jennings et al., 2013; Shepherd, 1983). Previous studies of the species composition within sand waves have found the species present tend to be robust filter feeders, such as mussels and bivalves, as compared to more delicate deposit feeders, such as feather dusters and sea cucumbers, which tend to be found within the more sedimentary areas (Warwick & Uncles, 1980).

6.5.2 Potential Impacts of the Project

The impact-producing factors for benthic resources are provided in Table 6.5-4 and will be discussed in more detail in this section.

Table 6.5-4 Impact-Producing Factors for Benthic Resources

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommiss-ioning
Pile driving for WTG and ESP foundations	X		X		
Cable installation	X	X	X		
Cable maintenance	X	X		X	
Scour protection	X		X	X	
Dredging	X	X	X		X
Geotechnical sampling surveys	X	X	X	X	X
Water withdrawals	X	X	X	X	X
WTG maintenance	X			X	
Use of jack-up barges or anchored vessels	X	X	X	X	x

6.5.2.1 Construction and Installation

6.5.2.1.1 Wind Turbine Generator ("WTG") and Electrical Service Platform ("ESP") Foundation Installation

Wind Development Area

Temporary impacts to the seafloor would be expected in the vicinity of the proposed WTGs and ESPs as a result of the placement of jack-up vessels that will be used for the installation of each WTG and ESP. The impacts from jack-up vessels are quantified in Table 6.5-5; total impacts will be 265,320 m^2 (66 acres), which is 0.09% of the WDA. Soft bottom habitat and benthic fauna, such as the polychaete worms, Oligochaete worms, amphipods, sand dollars, and sea scallops observed in surveys discussed in Section 6.5.1.2, in the direct path of the jack-up barge pads will be crushed and organisms killed. Indirect mortality may occur as disturbed sediments resettle onto nearby areas and smother organisms, as explained below in Section 6.5.2.1.3 Cable Installation.

6.5.2.1.2 Scour Protection and Cable Protection Installation

Wind Development Area

All WTG foundations will have scour protection. Scour protection would involve the use of rock or stone placed around a WTG or ESP foundation. This design may promote deposition of a sand/silt matrix in the interstices of the boulder framework with the eventual burial of all the rock armor (USDOE MMS, 2009). Tidal currents may expose portions of the scour protection at the surface for short periods of time. However, the bi-directional nature of these currents should lead to establishment of a dynamic equilibrium, allowing the average condition of the scour-protected zone to be buried by sand. The scour protection dimensions are provided in Table 3.1-3 and 3.1-4 in Volume I. As listed in Table 6.5-5, the maximum extent of scour protection for WTGs and ESPs is expected to cover an area of 215,000 m^2 (53 acres), or 0.07% of the WDA. Benthic fauna, such as the polychaete worms, Oligochaete worms, amphipods, sand dollars, and sea scallops observed in surveys discussed in Section 6.5.1.2, directly under these scour protection areas will be buried and killed; however, the presence of these structured habitats can also lead to colonization of other organisms.

Since the majority of the WDA is comprised of homogeneous fine sand and silt-sized sediments, the addition of the stone scour protection will alter the nature of the seabed in the immediate vicinity of the Project, thus contributing to higher complexity in the three-dimensional scale. Scour protections have the potential to turn exposed, biodiversity poor soft bottoms into species rich ecosystems (Langhamer, 2012). Under ideal conditions (i.e., sufficient number of larvae and suitable environmental condition), colonization to the areas of scour protection would be by organisms abundant in the water mass or nearby hard bottom habitat. Several examples, such as the Danish Horns Rev, exist in which scour protection has been colonized by species inhabiting rocky substrata, e.g., anemones, crabs, lobsters, barnacles, and sponges (Langhamer, 2012).

There will be bottom disturbance due to cable protection (rock, concrete mattresses, etc.) for cable sections within the WDA that are installed in too shallow of a depth (i.e., when sufficient burial depth cannot be achieved). Based on the parameters provided in Table 6.5-5, which conservatively estimate that up to 10% of the route may require protection, the total area of cable protection for the inter-link cable and inter-array cables would be up to 256,500 m^2 (63 acres) or approximately 0.08% of the WDA.

Offshore Export Cable Corridor

As noted above for the WDA, there will be bottom disturbance due to cable protection for cable sections within the OECC that are installed in too shallow of a depth, or when the target depth cannot be achieved. Based on the parameters provided in Table 6.5-5, along the OECC, total area of cable protection for the offshore export cables would be up to

142,200 m^2 (35 acres). Note that the Project's goal is to minimize the extent of cable protection to the greatest extent possible through careful route assessment and selection of the most appropriate cable burial tool for each segment of the cable route; therefore, these values represent worst case scenarios.

6.5.2.1.3 Cable Installation

Wind Development Area and Offshore Export Cable Corridor

As described in Section 4.2.3.3 of Volume I, cable laying for inter-array cables (in the WDA) or offshore export cables (in the OECC) will be done by either jet plowing, mechanical plowing, mechanical trenching, or other techniques. Table 6.5-5 quantifies cable-laying impacts. Within the WDA, inter-array and inter-link cable laying may impact up to 855,000 m^2 (211 acres), which is less than 0.3% of the WDA. Within the OECC, installation of up to two export cables may impact 474,000 m^2 (117 acres).

To facilitate cable installation, anchoring may occur along the OECC. It is currently anticipated that anchoring may occur through Muskeget Channel or in the shallower waters of Lewis Bay near the New Hampshire Avenue Landfall Site, though anchoring may occur at any point along the OECC. Additionally, while anchored vessels will not be used as primary construction and installation vessels within the WDA, there may be potential anchoring within the WDA. Any anchoring that does occur within the WDA will occur within the Area of Potential Effect (APE) defined in Volume II-C. If used, anchored vessels will avoid sensitive seafloor habitats to the greatest extent practicable. The processes of positioning, anchoring, and moving cable installation barges are expected to result in impacts occurring along the paths of cable installation. Anchors would disturb the substrate and leave a temporary irregularity in the seafloor resulting in localized mortality of infauna. In addition, portions of the seafloor would be swept by an anchor cable as the installation equipment moves along the cable. The use of mid-line anchor buoys would minimize potential impacts; however, it would not completely eliminate them. The impacts from anchor use and anchor sweep are not quantified at this time due to the difficulty of estimating potential anchoring practices at the Project planning stage.

Organisms that may be subject to impacts from anchor line sweep include mollusks such as Soft Shell Clams (*Mya arenaria*), sea scallops, surf clams, whelks, echinoderms, such as sea stars and sand dollars, and sessile species, such as tube dwelling polychaetes or mat forming amphipods, which make up a relatively large portion of the taxa occurring in the area of the proposed action. The level of impact for these organisms could vary seasonally and by species group. For example, the Atlantic Sea Scallop appears to be more abundant within the WDA during the fall months according to NEFSC Seasonal Trawl data (Figure 6.5-5); however, according to the SMAST Video Survey (Table 6.5-1), sand dollars and sea stars may be more prevalent in the spring. Organisms that are mobile, such as certain polychaete species, amphipods, lobsters and crabs may be able to avoid impacts from the anchor line sweep because sediment vibrations would cause avoidance behaviors as the cable laying equipment moves across the seafloor (USDOE MMS, 2009). However, Jonah Crab and Ocean Pout (*Zoarces americanus*) may also be susceptible to impacts if they use the anchor lines as refuge during cable laying disturbance to nearby benthic habitat. Such use will depend upon the length of time the anchoring lines are deployed.

Indirect impacts of cable installation include water withdrawals for jetting or jet plowing and resettlement of sediments. Water withdrawals for the jet plow entrain planktonic larvae of benthic species and result in 100% mortality of the entrained organisms because of the stresses associated with being flushed through the pump system (DOE MMS, 2009). Assuming that 90% of the offshore cable system is installed at a rate of 200 m/hr (656 ft/hr), 10% of the cable system is installed at a rate of 300 m/hr (984 ft/hr), and a jet plow uses 11,300 – 30,300 liters per minute (3,000 – 8,000 gallons per minute) of water, water withdrawal volumes are expected to be approximately 1,700 – 4,540 million liters (450 – 1,200 million gallons). In addition, the resettlement of sediments disturbed during cable installation may smother and cause mortality of benthic fauna in nearby areas.

Taxonomic groups react differently and have varying levels of tolerance for sedimentation, with sessile and attached organisms having the lowest tolerance and highest mortality rate during sedimentation events (Gates & Jones 2012; Wilber et al., 2005). Benthic suspension feeders are also particularly sensitive to deposition because suspended particles can remain suspended in the water column for weeks and interfere with feeding and growth (Smit et al., 2008; Wilber et al., 2005). For example, in the WDA, attached/sessile organisms, such as sea squirts, will likely be the most sensitive to burial, as these taxa are immobile filter feeders. However, some attached bivalve species, such as mussels and oysters, have survived deposition levels of several millimeters ("mm") (Wilber et al., 2005). Organisms that burrow or feed in subsurface sediments, such as sand dollars which are prevalent within the WDA, will likely be less sensitive to burial as they can unbury themselves.

Suspended sediment impacts increase as a function of sediment concentration and duration of exposure, or dose (the product of concentration and exposure time) (Newcombe & Jensen, 1996). Historically, the effects of suspended sediment on marine and estuarine organisms were viewed only as a function of concentrations (Wilber & Clarke, 2001). Therefore, in most experimental studies, concentration was used as the sole variable of interest, and exposure durations were not varied, or in some cases not reported (LaSalle et al., 1991; Sherk & Cronin, 1970; Wilber & Clarke, 2001). However, exposure duration has since been recognized as an important factor, and has been included in most experiments (Newcombe & MacDonald, 1991; Wilber & Clarke, 2001). For benthic organisms, the minimum effects threshold (i.e., the level at which life stages of organisms may be negatively affected either sublethally or lethally) varies by organism group and life stage. The minimum effects threshold for suspended sediment within the water column for mollusk eggs is assumed to be 200 mg/L for 12 hours, as this is the concentration and duration at which sublethal effects were observed to the development of Eastern oyster eggs (Cake, 1983; Wilber and Clarke, 2001). On the other hand, the minimum effects threshold for mollusk juveniles and adults and all stages (egg, larvae and juveniles/adults) of crustaceans is assumed to be 100 mg/L for 1 day based on sublethal effects (i.e., reduced growth and reduced respiration) observed in northern quahog (Murphy, 1985; Turner and Miller, 1991; Wilber and Clarke, 2001) and copepods and euphausiids (Anderson and Mackas, 1986), respectively. For other invertebrates, such as worms, the minimum effects threshold is assumed to be 650 mg/L[15] (Read et al. 1982, 1983; Rayment, 2002). For coral, the minimum effects thresholds are 50 mg/L for 24 hours for eggs (causing prevented fertilization), 10 mg/L for 24 hours for larvae (altering larval settlement) and 25 mg/L for 24 hours for adults (causing reduced calcification rate; Rogers, 1990; Gilmour, 1999; Fabricius, 2005; Erftemeijer et al. 2012).

Modeling of sediment and transport potential in the WDA (see Appendix III-A) indicate that under typical cable installation methods, the maximum anticipated suspended sediment concentrations that persisted for at least 60 minutes would be greater than 200 milligrams per liter ("mg/L") but less than 300 mg/L and would occur in $<$0.02 km^2 (5 acres). These concentrations would drop rapidly and would be below 50 mg/L after two hours. Concentrations of suspended sediments with lower concentrations (10 mg/L) would extend up to 3.1 km (1.2 mi) from the inter-array cable centerline and be suspended at any given location for less than six hours. Therefore, these concentrations and durations of exposure are below those causing sublethal or lethal effects to benthic organisms.

Installation along the OECC requires additional pre-installation sediment removal to remove sand waves and achieve safe burial depths; as described in Appendix III-A, this will likely be accomplished with a trailing suction hopper dredge (TSHD) on its own or through a combination of a TSHD and a jetting technique. Sediment dispersion modeling of sand wave removal via TSHD along the OECC indicated that concentrations of suspended sediments above 10 mg/L extended up to 16 km (10 mi) from the cable trench centerline. Most of the sediment settles out in less than three hours; however, suspended sediments at this concentration can persist for six-twelve hours in smaller areas (0.06 km^2 [15 acres]). In addition, high concentrations ($>$1000 mg/L) occurred at distances up to 5 km (3.1 mi) from the dredge dumping site for short periods of time (less than two hours) due to the TSHD overflow and hopper dumping of sediments. After removing sand waves, a jet plow, mechanical plow, or one of the other techniques listed in Section 4.2.3.3 of Volume I will be used to install cables. The plume from jet plow installation as delineated by excess suspended sediment concentrations greater than 10 mg/L typically extended less than 200 m (656 ft) from the route centerline, though did extend up to 2 km (1.2 mi) in some

[15] For worms, no exposure time was indicated, but they are able to tolerate a large range of suspended sediments, as they inhabit areas of high TSS concentrations.

places. Further, the excess concentrations were confined to the lower portion of the water column, and resettled rapidly (within four-six hours) due to the high proportion of coarse sand throughout the route (see Appendix III-A). Therefore, these concentrations and durations of exposure are below those causing sublethal or lethal effects to benthic organisms.

Sediment deposition may also impact benthic organisms. Two thresholds of concern have been identified: one for demersal eggs and one for shellfish. The most sensitive lifestage of those analyzed for the Project is demersal eggs. For demersal eggs (fish [e.g., Atlantic Wolffish (*Anarhichas lupus)*, Atlantic Herring, and Winter Flounder], squid [e.g., Longfin Inshore Squid (*Doryteuthis pealeii*)]), and and whelk species), deposition greater than one millimeter ("mm") can result in the burial and mortality of that life stage (Berry et al., 2011). Although the early lifestages of some warm, shallow water coral species can be sensitive to deposition levels of 0.2 mm (0.008 in), the coral species observed in Project waters, Star Coral [*Astrangia poculata*], is a cold-water species that is less sensitive to sedimentation (Peters and Pilson, 1985; Erftemeijer et al. 2012). In addition, cold-water corals tend to form in areas with strong bottom currents, which keep corals free of sediment and prevent local deposition (Freiwald et al., 2004; Rogers, 2004). Therefore, greater than one mm of deposition is the lowest threshold of concern for the Project.

For shellfish, reported thresholds for the lethal burial depths of bivalves vary among species, but currently it is understood that the most sensitive species are those that are sessile or surface-oriented, such as blue mussel (*Mytilus edulis*), soft-shell clam (*Mya arenaria*), and oysters (*Ostrea* spp.; Essink 1999). One of the more comprehensive studies available is an early lab and field experiment of the effect of sudden burial on 25 species of bivalves from eight different "life habit types" defined by habitat (infaunal, epifaunal), feeding method (suspension, deposit), and burrowing behavior (Kranz 1974). The author determined that epibenthic suspension-feeders that use byssal attachments (i.e., lack a digging foot) are less capable of escaping deposition via traveling through the sediment, while many deposit feeder mollusks (e.g., *Macoma* clams and others within the Tellinacea or Nuculacea superfamilies) and infaunal mucus tube feeders (e.g., Lucinidae family bivalves) can escape burial thicknesses in native sediment up to 400 mm by rapidly burrowing and/or better tolerating anoxic conditions (Kranz 1974).

In a recent mesocosm experiment by Colden and Lipcius (2015), the authors concluded that oysters are highly tolerant to short-term partial and shallow total burial. The study determined that adult oyster survival declined significantly only when 90% of more of the oyster (as measured relative to total shell height) was buried for 28 days. The authors concluded that the overall low mortality rates in their study for durations less than 28 days indicated that oysters are highly tolerant to partial and shallow total burial on weekly time scales. They also found that increased mortality occured at burial depths of 108% shell height, which for oysters with shell heights between 25 – 90 mm in size would occur at burials of 27 – 97 mm.

Most subtidal shellfish in the genera Ostrea (oysters), Mytilus (mussels), Petricola (Venus clams), Chlamys (scallops) displayed lethal responses to deposition of either fine sand or mud at thicknesses greater 50 mm, with oysters and mussels sensitive to around 20 mm of deposition; while some less sensitive bivalves did not display a lethal response until sedimentation reached thicknesses of 200 – 500 mm (Essink 1999). Conclusions regarding burial thresholds for individual species that can be drawn from the literature cited in the Essink (1999) study are somewhat limited because the studies did not always define "sensitive" or explain the level of effects (i.e., lethal vs. sublethal). For community-level effects, Essink (1999) reported that after the dumping of dredged materials, decreases in species richness and abundance of major species in the benthic community were greatest in areas where the thicknesses of deposited sediments were > 300 mm.

Several studies have indicated that many benthic species can tolerate deposition by coarser sediment sizes more than finer mud/silt sediment sizes and by sediments more similar to their native sediment type than by sediments of very different grain size (Kranz 1974, Essink 1999). However, burial tolerance thresholds are difficult to generalize as they are highly species-specific as well as substrate-specific. For example, large percentages of Gemma gemma, a species of Venus clam, can cope with 230 mm thick burial by sand or a 57 mm thick burial by silt for up to 6 days (Shulenberger 1970, as cited in Kranz 1974). Meanwhile, Venus clams in the genus Petricola appear unable to survive burial of either sediment type greater than 50 mm (Essink 1999).

Research into the survival of Queen scallops (Aequipecten opercularis) to sedimentation indicated depth of burial and sediment type significantly affected emergence ability and therefore survival of individuals (Hendrick et al. 2016). The highest emergence and survival rates for Queen scallops occurred with burials of coarse sediment that were less than 20 mm (0.8 in) deep while the highest mortality occurred with fine sediment at depths of 70 mm (Hendrick et al. 2016). Mortality increased with duration of burial; however, scallops can be highly mobile and may escape burial by rapidly opening and closing their shells to jettison water, unless deposition is very sudden and deep. Similarly, other mobile benthic species such as lobsters, crabs, and demersal fish would be temporarily displaced by sedimentation events, but would likely be able to avoid burial. For example, Dungeness crab (Cancer magister) are able to survive burial depths over 120 mm (5 in) through escape responses and other adaptive behaviors (Vavrinec et al. 2007).

While the literature has shown sensitivity of bivalves to sedimentation varies greatly among species and can range up to several hundred mm of deposition, a sedimentation threshold of 20 mm was used as the general threshold for shellfish. This threshold is inclusive of most shellfish and life stages, including more sensitive subtidal mussel and oyster beds, and is conservatively based on the work of Colden and Lipcius (2015), Essink (1999), and Hendrick et al. (2016). While Kranz (1974) reported an escape potential thickness of 0 cm for the group of attached epifauna least capable of burrowing through sediment, he also noted that mussels can withstand burial for several months, so the escape potential thickness is not synonymous with a sedimentation tolerance threshold. Therefore, while attached shellfish may be unable to escape burial by burrowing up to the sediment surface similar to other bivalve groups (Kranz 1975), they have other adaptive responses that enable survival under sedimentation. For example, oysters can clear themselves of sediment (Wilber and Clarke 2010) and partial burial can lead to increased shell growth rates in order to reach the sediment surface (Colden and Lupcius 2015). Thus, based on these findings and on the wide range of sedimentation thicknesses and durations tolerated by bivalves in general, a 20 mm threshold is a reasonably conservative threshold for assessment of impacts. In addition, sedimentation in the Project area will be subject to currents and tidal flushing over time that may remove sediment before it can affect benthic organisms.

Simulations of typical cable installation methods (without sand wave removal) in the WDA and OECC indicate that deposition of 1 mm (0.04 in) or greater (i.e., the threshold of concern for demersal eggs) were primarily constrained to within 80 m (262 ft) up to 100 m (328 ft) from the route centerline (see Appendix III-A). In areas along the OECC where sand wave dredging was simulated to have occurred, the deposition greater than 1 mm (0.04 in) associated with the TSHD drag arm is mainly constrained to within 80 m (262 ft) from the route centerline, whereas the deposition greater than 1 mm (0.04 in) associated with overflow and disposal extends to greater distances from the source, mainly within 1 km (0.62 mi), though such deposition can extend up to 2.3 km (1.43 mi) in isolated patches when subject to swift currents through Muskeget Channel. However, specifically in relation to potential impacts to beds of shellfish along the complete route of the OECC, the sediment dispersion modeling (see Appendix III-A) results indicate that there will be minimal areas of deposition greater than 5 mm (0.20 in) for cable installation activities and none above 10 mm (0.39 in); therefore, cable installation is not anticipated to affect shellfish. For dredging and disposal activities, which only occur along the OECC and not in the WDA, the largest area of seafloor to be affected by 20 mm (0.79 in) of deposition would be within an area of 0.14 km^2 (34.6 acres).

Recolonization and recovery to pre-construction species assemblages is expected given the similarity of nearby habitat and species. Nearby, unimpacted areas will likely act as refuge areas and supply a brood stock of species, which will begin recolonizing disturbed areas post-construction. Recovery timeframes and rates in a specific area depend on disturbance, sediment type, local hydrodynamics, and nearby species virility (Dernie et al., 2003). Previous research conducted on benthic community recovery after disturbance found that recovery to pre-construction biomass and diversity values took two to four years (Van Dalfsen & Essink, 2001). Other studies have observed differences in recovery rates based on sediment type, with sandy areas recovering more quickly (within 100 days of disturbance) than muddy/sand areas (Dernie et al., 2003).

Operational offshore wind farms in Europe provide insight into potential impacts to the benthic environment. A report for the Barrow offshore wind farm located in the eastern Irish Sea describes post-construction monitoring after the farm became operational in July 2006 (BOWind, 2008). Bathymetry remained consistent between pre- and post-construction surveys, except for remnants of inter-array cable installation and localized scour around some of the individual monopiles ranging from one m (three feet [ft]) – six m (20 ft) deep that increased horizontally over time. Changes in benthic communities did occur, with main differences due to high numbers of *Ophiura* (Large Brittle Star) present post-construction versus more frequent occurrence of *Nephtys* (Cat Worm) and higher abundance of *Amphirua* (Brittle Star) pre-construction. There was also higher abundance and diversity of intertidal species in post-construction surveys. These changes correspond with differences in sediment grain size to coarser sediment post-construction; however, these changes may be due to natural fluctuation in the area as changes were also observed over time pre-construction and at reference sites unlikely to be affected by construction (BOWind, 2008). Similarly, monitoring along the export cable route for the North Hoyle offshore wind farm in Wales determined that sediment deposition, grain size, and benthic community changes to be within the natural variation at the site (English et al., 2017; NWP Offshore Ltd, 2007).

A comprehensive BOEM review of several monitoring reports from European offshore wind construction noted that changes in subtidal benthic habitat and communities were recorded to some extent, but were not attributed to wind farm development due to high environmental variability and insufficient evidence to link cause and effect (English et al., 2017). Monitoring programs in Belgium indicate that the main effects are due to infrastructure modifying sediment and benthic communities around the turbines due to scour, sediment enrichment, and artificial reef effects; but effects remain localized within 50 m (164 ft) of turbines and thus are minor or negligible (English et al., 2017).

6.5.2.1.4 Dredging

Offshore Export Cable Corridor

At isolated locations where large sand waves exhibit greater than 1.5 m (4.9 ft) of relief above the bedform troughs to either side, dredging of the top portion of the sand wave may be necessary to allow the cable installation tool to reach the stable sediment layer under the base of the mobile sand unit/habitat. Pre-dredging for cable installation along the OECC may impact up to 279,400 m^2 (69 acres). Benthic organisms can be affected during the dredging activities required for cable laying activities in areas of sand waves. The effects are a consequence of the physical acts of dredging and the resulting mobilization and subsequent settling of sediments. The dredging techniques under consideration are described in Section 4.2.3.3.2 of Volume I.

Dredging directly impacts organisms in the footprint of the dredging activity (i.e., stationary benthic communities). This includes polychaete worms, amphipods, and shellfish that live in the sediment, and the more motile benthic organisms (e.g., crustaceans), which are unable to escape the dredge, or find suitable unoccupied refuge. Additionally, if a TSHD is used, periodic bottom dumping of sediments will occur within the OECC and there may be temporary areas of accumulated sediments. (At this stage of Project planning, these areas are not quantified separately.) Outside the footprint of the dredging and disposal, impacts may be caused by remobilized and resettled sediments. Although many benthic organisms have developed behavioral and physiological mechanisms to deal with the resuspension of sediments that often follows natural events (i.e., storms, tidal flows, and currents), the scope, timing, duration, and intensity of dredging-related suspended sediment plumes may create an environment that resident and transient species are not able to tolerate. Sedimentation from suspended sediments can bury benthic organisms, and can clog the gills and/or filter feeding apparatus of infaunal invertebrates (USACOE, 2001). The results of the sediment dispersion modeling for dredging and cable installation are provided in Appendix III-A, and, for ease of discussion, are summarized above with the cable installation impacts in Section 6.5.2.1.3.

Table 6.5-5 Vineyard Wind Maximum Area of Seafloor Impacts

BOTTOM DISTURBANCE DUE TO ROCK OR STRUCTURES								
Foundations and Scour Protection	Maximum Number WTG/ESP Foundations		Max Area of Scour Protection per Foundation (m^2)		Total Area of Scour Protection			
					m^2	ft^2	km^2	acres
WTG Foundations and Scour Protection	100		2,100		210,000	2,260,419	0.21	52
ESP Foundations and Scour Protection	2		2,500		5,000	53,820	0.01	1
Cable Protection for Cable Section Installed Too Shallow	Maximum Length of Cable (m)	Percentage of Cable Too Shallow	Length of Cable to be Protected (m)	Width of Scour Protection (m)	Total Area of Cable Protection			
					m^2	ft^2	km^2	acres
Export Cables	158,000	0.1	15,800	9	142,200	1,530,627	0.14	35
Inter-link Cable	10,000	0.1	1,000	9	9,000	96,875	0.01	2
Inter-array Cables	275,000	0.1	27,500	9	247,500	2,664,065	0.25	61
					TOTAL SCOUR + CABLE PROTECTION			
					m^2	ft^2	km^2	acres
TOTAL SCOUR PROTECTION + CABLE PROTECTION IN THE WIND DEVELOPMENT AREA					**471,500**	**5,075,179**	**0.47**	**117**
TOTAL CABLE PROTECTION ALONG THE OFFSHORE EXPORT CABLE CORRIDOR					**142,200**	**1,530,627**	**0.14**	**35**
BOTTOM DISTURBANCE DUE TO CABLE INSTALLATION, JACK-UP VESSELS, AND DREDGING								
Cable Installation	Maximum Number (No.) of Trenches	Max Length of Cable[1] (m)	Trench Width (m)	Skid/track Width (m)	Total Area of Cable Installation Disturbance			
					m^2	ft^2	km^2	acres
Export Cables	2	158,000	1	2	474,000	5,102,089	0.47	117
Inter-link Cable	1	10,000	1	2	30,000	322,917	0.03	7
Inter-array Cables	N/A	275,000	1	2	825,000	8,880,218	0.83	204
				TOTAL	**1,329,000**	**14,305,223**	**1.33**	**328**
Jack-up Vessels	No. of Jack-up Legs	Area Impacted by Each Leg (m^2)	No. of Jack-ups per WTG/ESP	Max No. of WTGs/ESPs	Total Area of Jack-up Disturbance			
					m^2	ft^2	km^2	acres
WTG Installation	4	165	4	100	264,000	2,841,670	0.26	65
ESP Installation	4	165	1	2	1,320	14,208	0.00	0.3
				TOTAL	**265,320**	**2,855,878**	**0.27**	**66**
Dredging	Corridor Where Maximum Dredging Occurs		Max Length of Dredging (m)	Width (m)	Total Area of Dredging Disturbance[2]			
					m^2	ft^2	km^2	acres
Dredging Prior to Cable Install	Western Corridor West thru Muskeget to New Hampshire Ave.		N/A	N/A	279,400	3,007,434	0.28	69
					TOTAL CABLE INSTALL + DREDGING +JACK-UP			
					m^2	ft^2	km^2	acres
TOTAL CABLE INSTALL + JACK-UP IMPACT IN THE WIND DEVELOPMENT AREA					1,120,320	12,059,012	1.12	277
TOTAL CABLE INSTALL + DREDGING ALONG THE OFFSHORE EXPORT CABLE CORRIDOR					753,400	8,109,522	0.75	186

Notes
1. Maximum length for export cable includes length for two export cables.
2. To avoid double-counting impacts, the total area of dredging disturbance does not include a two-meter-wide-export cable installation corridor. Dredging volume and area are for two cables.
3. Vertical extent of impacts is presented in Appendix II-C.

In general, dredging of material from the top of the bedforms in a limited swath along the OECC is anticipated to have limited impact to the benthic habitat. This is due to the mobility of the surficial sand layer which migrates daily with the tidal currents, and the fact that the surrounding area is mostly homogeneous sand bottom habitat. There will be an evolution of the disturbed bedform back to its original morphology over time dependent upon the tidal forces and resulting sand migration rates for that specific location (Roos and Hulscher, 2003; Lichtman et al., 2018).

6.5.2.1.5 Avoidance, Minimization, and Mitigation Measures

Several mitigation measures will be employed to avoid and minimize potential impacts to benthic resources within the WDA and OECC. One of the most important measures is that the MA WEA has been sited to avoid the most sensitive areas for benthic and other resources. Other measures include the following:

- Utilize widely-spaced WTGs, so that the foundations (and associated scour protection) for the WTGs, along with the ESPs, inter-link cables, and inter-array cables, only occupy a minimal portion of the WDA, leaving a huge portion of the WDA undisturbed.

- Conduct post-construction monitoring to document habitat disturbance and recovery (see Benthic Habitat Monitoring Plan in Appendix III-D).

- Where feasible and considered safe, use mid-line buoys on anchor lines to minimize impacts from anchor line sweep.

- As described in Section 4.2.3.8 of Volume I, horizontal directional drilling ("HDD") will be used to minimize impacts to benthic habitat at the Covell's Beach Landfall Site, unless future site investigations determine that HDD is technically infeasible. At the New Hampshire Landfall Site, HDD or a conventional trench will be used.

6.5.2.1.6 Summary of Impacts

In summary, impacts to benthic habitat due to installation of WTG and ESP foundations is expected to result in short-term loss of habitat within a localized area, such that population level impacts are unlikely. Potential impacts will be minimized or offset through the use of scour protection.

While mortality of benthic organisms is expected in the location of the WDA where temporary disturbance of the seafloor would occur due to cable and foundation installation, the impacts are expected to be localized and unlikely at the population level due to the following factors:

1) The surrounding vicinity of the proposed Project has an abundant area of similar habitat type;

2) The portion of the WDA that will be disturbed is relatively small (the total area of alteration within the WDA due to foundation and scour protection installation, jack-up vessel use, inter-array and inter-link cable installation, and potential cable protection installation is 1.59 km^2 [393 acres], which is 0.5% of the entire WDA), given the size of adjacent similar habitat; and

3) The sandy bottom community typical to the area has adapted to frequent natural sediment movement that already creates temporary impacts. Previous scientific research indicates that certain benthic invertebrate species will opportunistically invade substrate areas that are unoccupied once disturbances have occurred (Howes et al. 1997; Rhoads et al. 1978; Rosenberg & Resh, 1993; USDOE MMS, 2009).

Overall, impacts from the alteration of habitat in the WDA and along the OECC are expected to be minimal and recovery of natural assemblages likely.

6.5.2.2 Operations and Maintenance

The possible activities associated with the operation and maintenance activities over the lifetime of the Project that could have an effect on benthic resources include scour protection installation, cable maintenance or repair (including associated dredging, if required), geotechnical sampling surveys, WTG maintenance, use of anchored vessels, and use of jack-up barges (if required for repairs).

6.5.2.2.1 WTG and ESP Foundations

Wind Development Area

The installation of WTGs and ESPs in the WDA introduces structures that would be a source of new hard substrate with vertical orientation, and these structures would be present for the entire time of operation of the proposed action. Since Horseshoe Shoal and Nantucket Sound have limited amounts of this type of habitat, this would be considered a direct impact of operation. Organisms that may settle on the wind turbine towers could include algae, sponges, tunicates, anemones, hydroids, bryozoans, barnacles, and mussels. These organisms are known to occur on other hard substrate areas in Nantucket Sound including substrates such as navigation buoys or pier pilings. Organisms including polychaetes, oligochaetes, nematodes, nudibranchs, gastropods, and crabs are expected to be present on or near the towers as growth of fouling organisms develops.

A 2005 Macroinvertebrate Survey of the Meteorological Tower (ESS Group, 2006) indicated that a benthic macroinvertebrate community similar to the surrounding sea floor community had colonized the support pilings. It was noted that these new taxa were likely to be in the site of the proposed action, but would be expected to inhabit hard substrates such as rocky shoals or boulders (ESS Group, 2006). Therefore, it is expected that the piling would support more taxa because they may attract organisms from both sandy substrate habitats and those that would be attracted to fixed structures. Impacts due to the scour protection will be as discussed above under Construction and Installation.

The presence of the ESP and pilings may affect the soft-bottom benthic invertebrate communities in its immediate vicinity due to shading. However, these possible effects would be dependent upon the approximate height of the structure above the water and the fact that the shadow from the structure would move rapidly across the seafloor during daylight hours.

6.5.2.2.2 Cable Maintenance

Wind Development Area and Offshore Export Cable Corridor

Impacts associated with cable repair would include a temporary increase in turbidity and some localized deposition of sediment during the repair process. The increase in turbidity would be caused by the removal of sediments to uncover the damaged portion of the cable, hoisting of the cable after it is cut, laying the cable back down, and then jetting or otherwise removing sediments for reburial of the repaired cable. Temporary impacts would also occur in the area where anchors are deployed or anchor cable sweeps the bottom.

6.5.2.2.3 Other Impacts

Wind Development Area and Offshore Export Cable Corridor

Benthic sampling is to be conducted in WDA and OECC before and after Project construction. The Benthic Habitat Monitoring Plan (see Appendix III-D) provides the specific details of this sampling. Other geotechnical or geophysical surveys may also occur, which may have highly localized impacts to benthic organisms.

Anchoring of Crew Transfer Vehicles or other accommodation vessels may occur within the WDA during normal operations. If repair work is required, both anchoring (within the WDA or along the OECC) and the use of jack-up vessels (within the WDA) may occur.

The impacts of electromagnetic fields ("EMF") on marine organisms are unclear. Although there is no evidence of negative impacts on benthic fauna, little is known of the abilities of benthic fauna to sense EMF (Normandeau et al., 2011). The electrosensitive invertebrate species, such as sea slugs and sea urchins, that have thus far identified have sensitivity thresholds above the modeled level of induced electric fields from undersea cables (Normandeau et al., 2011), and are therefore not expected to be impacted by those fields. As is the case with fish (discussed in more detail in Section 6.6), invertebrate species that use the geomagnetic field to guide their movements through an area with an undersea cable may be confused as they encounter the magnetic field from the cable (Gill and Kimber, 2005). The species could change their direction of travel or alter their homing capabilities if they rely on a magnetic sense for these actions; however, these potential effects above the threshold known to cause an effect would be restricted within the close proximity of certain cable systems (Normandeau et al., 2011). Modeling of EMF from project specific submarine cables indicated magnetic fields from both AC and DC cables would be much lower than the Earth's magnetic field and likely only able to be sensed, if at all, directly over the cable centerline (Gradient, 2017). Modeling also confirmed that EMF from cables decreases with distance and therefore, because cables in the WDA and OECC will be buried below approximately 2 m (6.6 ft) of sediment, it is unlikely that benthic organisms will be impacted by EMF produced by the cables in Project Area.

6.5.2.2.4 Avoidance, Minimization, and Mitigation Measures

The mitigation measures would be the same as discussed previously for construction and installation. However, there will be no HDD occurring during operation and maintenance activities.

6.5.2.2.5 Summary of Impacts

Impacts to benthic resources due to the introduction of WTGs and ESPs as structured habitat will be direct, long-term (over the operation lifetime of the Project), and localized. It is possible the pilings will support more taxa than the surrounding primarily homogenous sand habitats. Impacts due to the scour protection will be as discussed above under Construction and Installation.

Impacts to benthic resources as a result of cable repair or vessel anchoring would be anticipated to be short-term and localized to a very small area of the seafloor.

Impacts to benthic resources from EMF are expected to be unlikely and mitigated by cable burial.

6.5.2.3 Decommissioning

6.5.2.3.1 Overall Impacts

Wind Development Area and Offshore Export Cable Corridor

The removal of the WTG and ESP foundations would result in a local shift in the habitat from being structure-oriented to the original type of habitat present prior to installation of the proposed action. Therefore, this would be a return to pre-construction conditions. The decommissioning activities would also include potential removal of the export cables, the network of inter-array cables, and the inter-link cable. This action would result in temporary resuspension of bottom sediments along each cable path, and the anchor line impacts associated with any required vessel anchoring would be similar to those previously described for the construction phase of the Project.

6.5.2.3.2 Avoidance, Minimization, and Mitigation Measures

The avoidance, minimization, and mitigation measures would be the same as discussed previously for Construction and Installation.

6.6 Finfish and Invertebrates

This section describes finfish and invertebrate resources in the Project Area. Essential Fish Habitat ("EFH") is discussed in Appendix III-F.

6.6.1 Description of the Affected Environment

The Project Area is located within southern New England. Specifically, the Wind Development Area ("WDA") is located south of Martha's Vineyard in the northern Mid-Atlantic Bight of the Northeast US Shelf Ecosystem. The Offshore Export Cable Corridor ("OECC") extends from the WDA, through Muskeget Channel, to landfall in south-central Cape Cod. This region has a very diverse and abundant fish assemblage that is generally categorized according to life habits or preferred habitat associations, such as pelagic, demersal, and highly migratory.

This discussion of finfish and invertebrates is based on the review of existing literature. Existing data support characterization of distribution, abundance, and composition of fish species within the area potentially affected by Project activities. The most relevant data sources are the Northeast Fisheries Science Center multispecies bottom trawl surveys, the Massachusetts Department of Marine Fisheries Trawl surveys, the Northeast Ocean Data Portal, the School of Marine Science and Technology (SMAST) Survey of the WDA (2012, 2013), and the BOEM Environmental Assessment ("EA"). Additional studies that contribute to the available fisheries information in the region of southern New England include but are not limited to:

- Southern New England Industry-Based Yellowtail Flounder Survey (2003-2005), and
- Northeast Area Monitoring and Assessment Program ("NEAMAP").

A list of major fish assemblages is presented in Table 6.6-1 and described in more detail below. Additional information, including Federal listing, presence of EFH in the Project Area, habitat association, and fishery importance, is also noted in the table.

Table 6.6-1 Major Fish and Invertebrate Species Potentially Occurring in the Project Area (BOEM, 2014)

Species	EFH	Listing Status	Commercial / Recreational Importance	Habitat Association
Acadian Redfish (*Sebastes fasciatus*)			●	Demersal
Alewife (*Alosa pseudoharengus*)		C/S	●	Pelagic
American Lobster (*Homarus americanus*)			●	Benthic
American Sand Lance (*Ammodytes americanus*)			●	Demersal
Atlantic Albacore Tuna (*Thunnus alalonga)*	●		●	Pelagic
Atlantic Bluefin Tuna (*Thunnus thynnus*)	●	S	●	Pelagic
Atlantic Butterfish (*Peprilus triacanthus*)	●		●	Demersal / Pelagic
Atlantic Cod (*Gadus morhua*)	●		●	Demersal
Atlantic Mackerel (*Scomber scombrus*)	●		●	Pelagic
Atlantic Sea Herring (*Clupea harengus*)	●		●	Pelagic
Atlantic Sea Scallop (*Placopecten magellanicus*)			●	Benthic
Atlantic Surf Clam (*Spisula solidissima*)	●		●	Benthic
Atlantic Yellowfin Tuna (*Thunnus albacares*)	●		●	Pelagic
Basking Shark (*Cetorhinus maximus*)	●	C		Pelagic
Bay Scallops (*Argopecten irradians*)			●	Benthic
Beardfish (*Polymixia lowei*)				Demersal
Black Sea Bass (*Centropristis striata*)	●		●	Demersal
Blue Mussels (*Mytilus edulis*)			●	Benthic
Blue Shark (*Prionace glauca*)	●			Pelagic
Bluefin Tuna (*Thunnus thynnus*)			●	Pelagic
Bluefish (*Pomatomus saltatrix*)	●		●	Pelagic
Channeled Whelk (*Busycotypus canaliculatus*)			●	Benthic
Cobia (*Rachycentron canadum*)	●			Pelagic
Common Thresher Shark (*Alopias vulpinus*)	●			Pelagic
Dusky Shark (*Carcharhinus obscurus*)	●	S		Pelagic
Fourspot Flounder (*Hippoglossina oblonga*)			●	Demersal
Golden Tilefish (*Lopholatilus chamaeleonticeps*)			●	Demersal
Haddock (*Melanogrammus aeglefinus*)	●		●	Demersal
Horseshoe Crab (*Limulus Polyphemus)*			●	Benthic
Jonah Crab (*Cancer borealis*)			●	Benthic
King Mackerel (*Scomberomorus cavalla*)	●			Pelagic
Knobbed Whelk (*Busycon carica*)			●	Benthic
Lightning Whelk (*Busycon contrarium*)			●	Benthic
Little Skate (*Leucoraja erinacea*)			●	Demersal
Long-Finned Squid (*Loligo pealeii*),	●		●	Pelagic
Monkfish (*Lophius americanus*)	●		●	Demersal
Northern Quahog (*Mercenaria mercenaria*)			●	Benthic
Northern Sand Lance (*Ammodytes dubius*)			●	Demersal
Northern Sea Robin (*Prionotus carolinus*)			●	Demersal
Ocean Pout (*Macrozoarces americanus*)	●			Demersal
Ocean Quahog *(Artica islandica)*	●		●	Benthic
Pollock (*Pollachius pollachius*)			●	Demersal
Porbeagle Shark (*Lamna nasus*)	●	S		Pelagic
Red Hake (*Urophycis chuss*)	●		●	Demersal
Round Herring (*Etrumeus teres*)			●	Pelagic
Sand Tiger Shark *(Carcharias taurus)*	●	S		Pelagic
Sandbar Shark (*Carcharhinus plumbeus*)	●			Pelagic

Table 6.6-1 Major Fish and Invertebrate Species Potentially Occurring in the Project Area (BOEM, 2014) (Continued)

Species	EFH	Listing Status	Commercial / Recreational Importance	Habitat Association
Scup (*Stenotomus chrysops*)	●		●	Demersal/ Pelagic
Shortfin Mako (*Isurus oxyrinchus*)	●		●	Pelagic
Short-Finned Squid (*Illex illecebrosus*)	●		●	Pelagic
Shortnose Greeneye (*Chlorophthalmus agassizi*)				Demersal
Silver Hake (*Merluccius bilinearis*)			●	Demersal
Spanish Mackerel (*Scomberomorus maculatus*)	●			Pelagic
Spiny Dogfish (*Squalus acanthias*)	●		●	Demersal
Striped Bass (*Morone saxatilis*)			●	Pelagic
Summer Flounder (*Paralichthys dentatus*)	●		●	Demersal
Swordfish (*Xiphias gladius*)			●	Pelagic
Tautog (*Tautoga onitis)*			●	Demersal
Tiger Shark (*Galeocerdo cuvier*)	●			Pelagic
White Hake (*Urophycis tenuis*)			●	Demersal
Weakfish (*Cynoscion regalis*)			●	Demersal
Windowpane Flounder (*Scopthalmus aquosus*)	●		●	Demersal
Winter Flounder (*Pseudopleuronectes americanus*)	●		●	Demersal
Winter Skate (*Leucoraja ocellata*)			●	Demersal
Witch Flounder (*Glyptocephalus cynoglossus*)	●		●	Demersal
Yellowtail Flounder (*Limanda ferruginea*)	●		●	Demersal

*C = candidate, S = species of concern

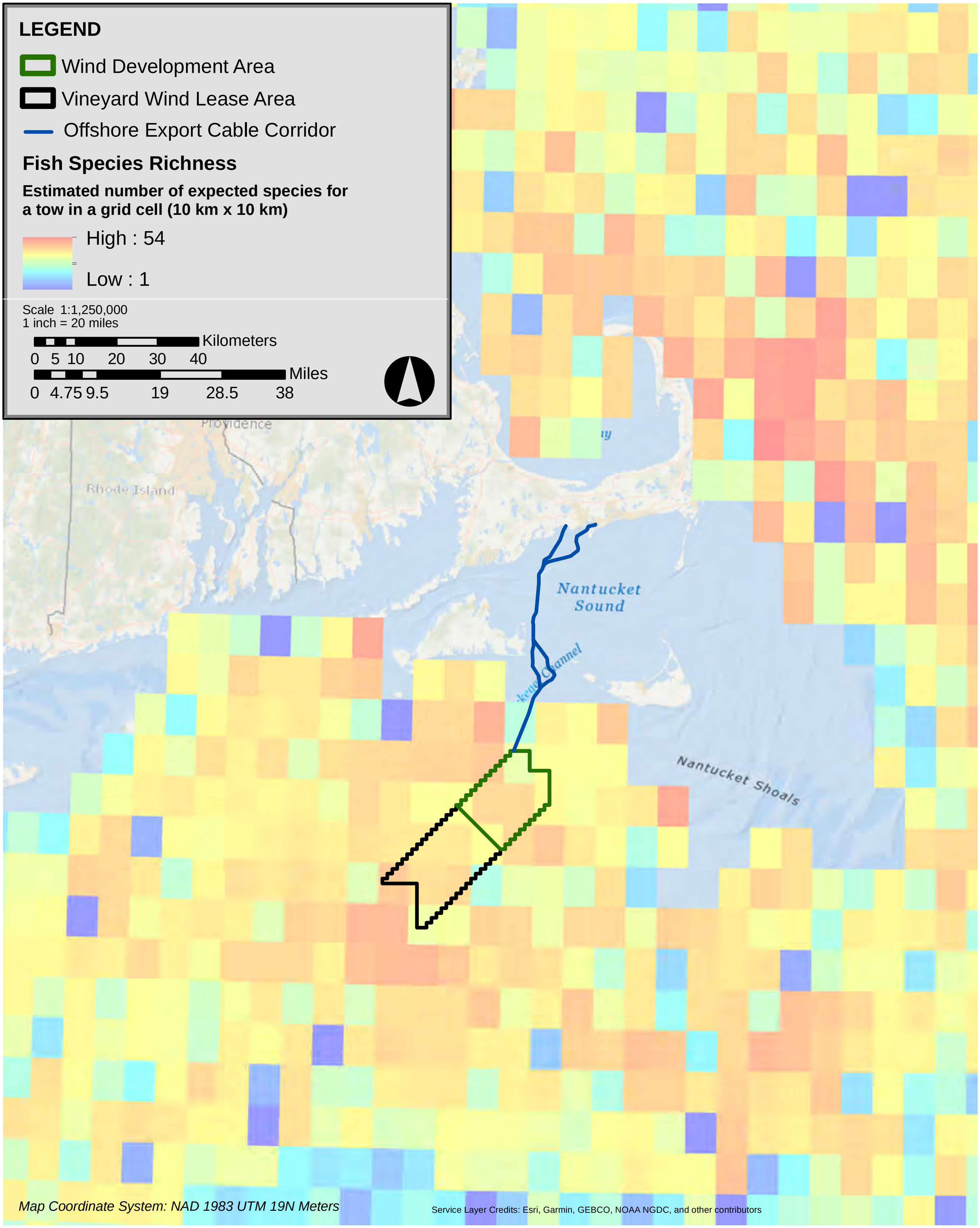
The Northeast Fisheries Science Center ("NEFSC") has been conducting fishery-independent autumn bottom trawl surveys annually since 1963. Two metrics, total biomass and species richness, derived from this survey show the distribution of fish assemblages in the Project Area relative to surrounding locations (Figure 6.6-1 to Figure 6.6-5). Total biomass of fish is low across the Project Area, while species richness is relatively high. High species richness has been linked to increased ecosystem resilience or the ability of an ecosystem to recover from disturbance (MacArthur, 1955).

Additional information on habitat and forage preferences and life stage presence in the Project Area for finfish and invertebrate species with EFH designations is provided in Appendix F.

6.6.1.1 Finfish

Pelagic Fishes

Pelagic species spend most of their lives swimming in the water column rather than occurring on or near the bottom. Many coastal pelagic species rely on coastal wetlands, seagrass habitats, and estuaries to provide habitat for specific life stages and many of these species migrate north and south along the Atlantic Coast during some periods of the year



Vineyard Wind Project

VINEYARD WIND

Figure 6.6-1

Expected Species Richness of the Fish Captured in Fall NEFSC Bottom Trawl Surveys (NEODP, 2017)

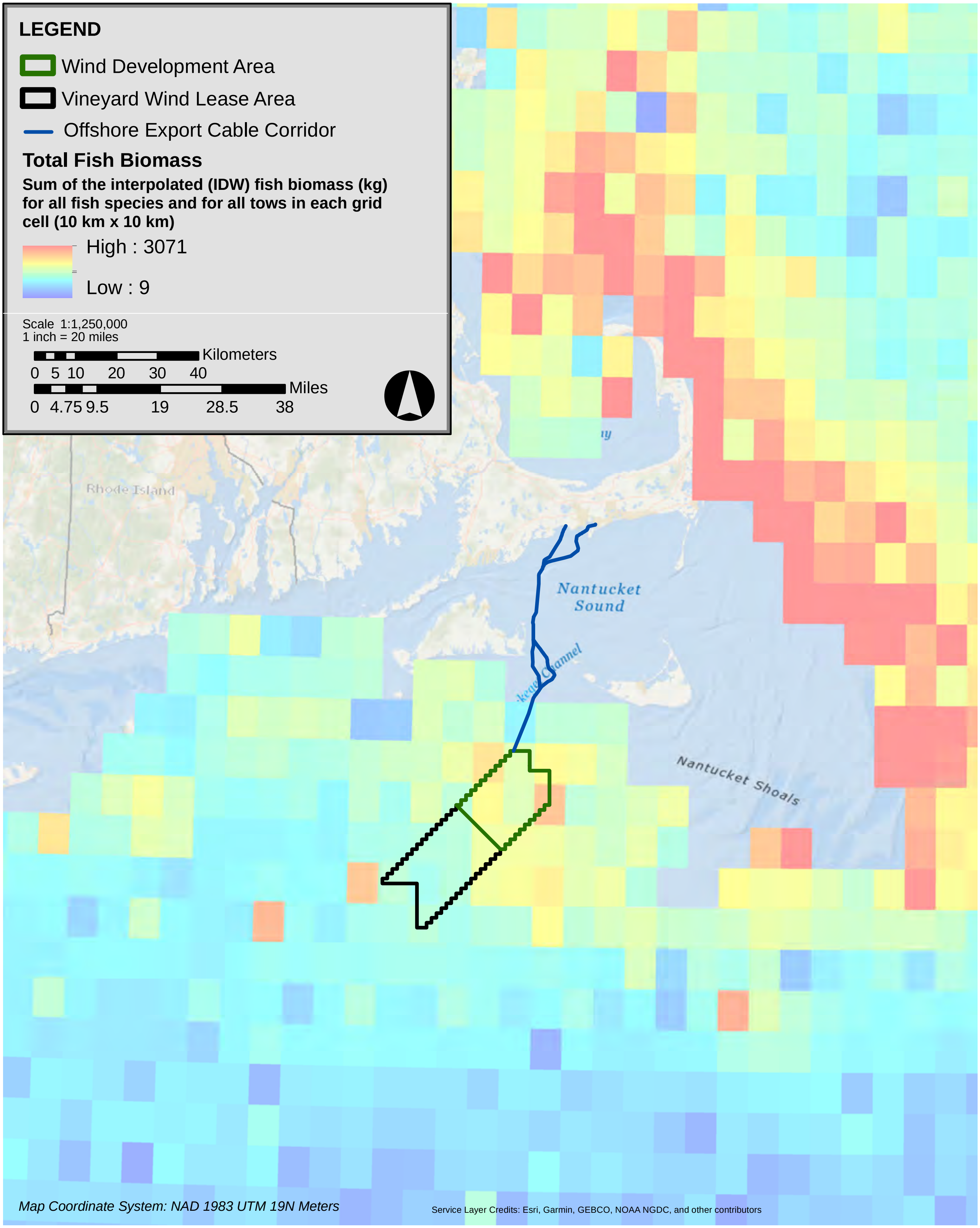


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Figure 6.6-2

Expected Biomass of the Fish Captured in Fall NEFSC Bottom Trawl Surveys (NEODP, 2017)

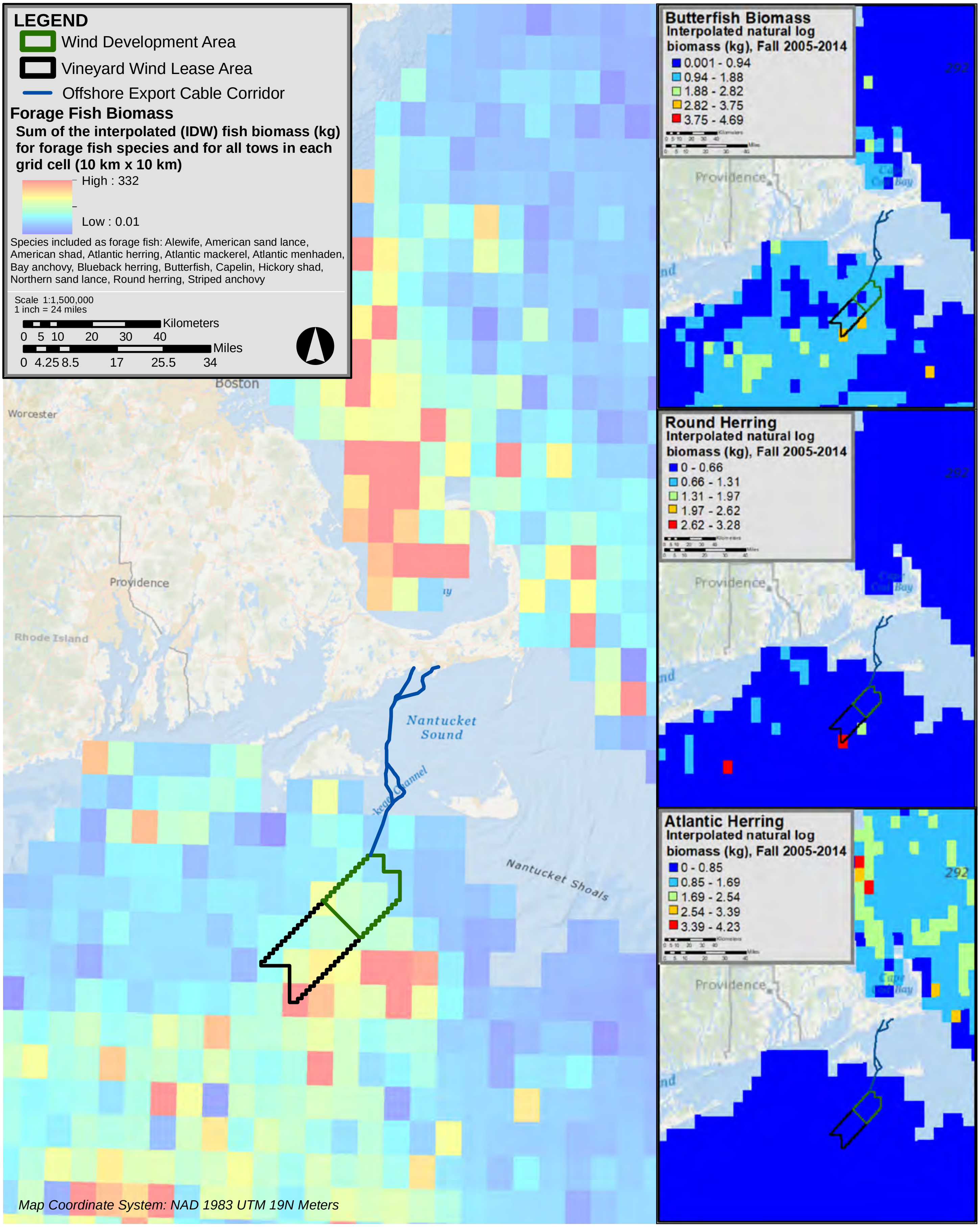

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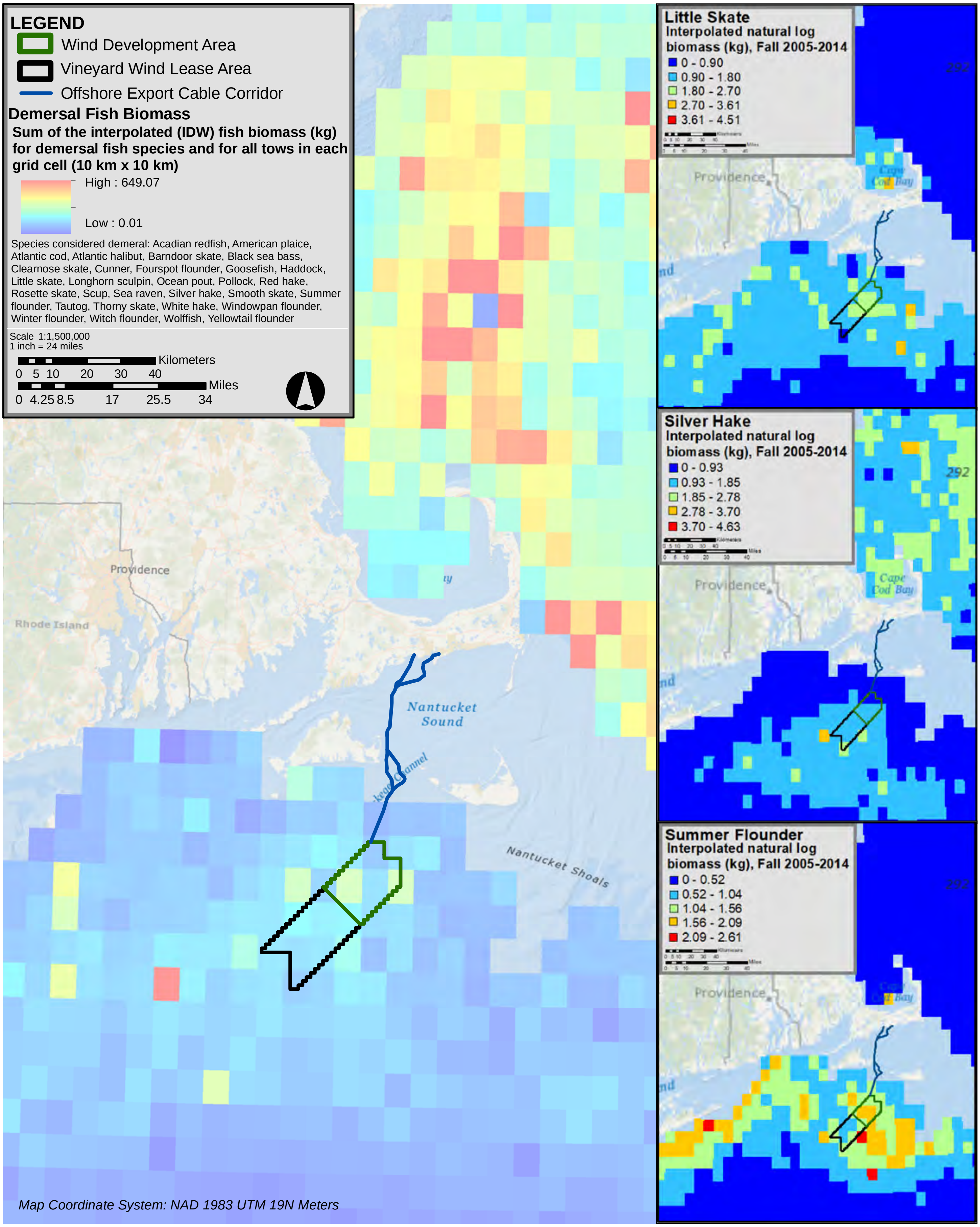
Figure 6.6-3

Expected Forage Fish Biomass and Individual Biomass for Butterfish, Round Herring, and Atlantic Herring Captured in Fall NEFSC Bottom Trawl Surveys (NEODP, 2017)

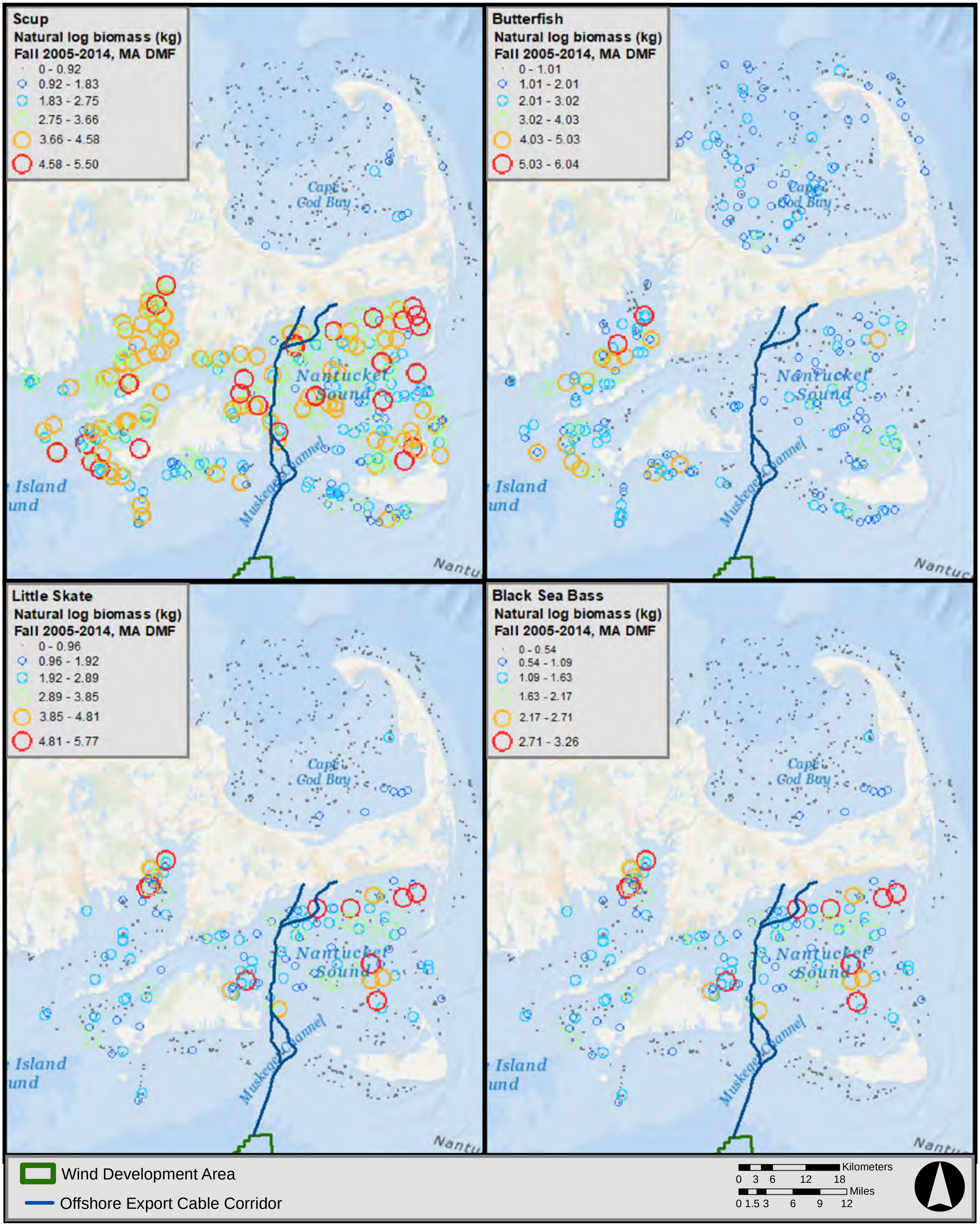


Vineyard Wind Project

VINEYARD WIND

Figure 6.6-4

Demersal Fish Biomass and Individual Biomass for Little Skate, Silver Hake, and Summer Flounder Captured in Fall NEFSC Bottom Trawl Surveys (NEODP, 2017)



Vineyard Wind Project

VINEYARD WIND

Figure 6.6-5

Biomass (natural log) of Commonly Caught Fish in the MA DMF Fall Trawl Surveys (2005-2014). Species included: Scup, Butterfish, Little Skate, Black Sea Bass (NEODP, 2017).

(see Figure 6.6-3). In general, movement is related to sea surface temperature. These fish use the highly productive coastal waters within the Atlantic region during the summer months and migrate to deeper and/or more distant waters during the rest of the year. Important pelagic finfish with ranges that overlap the Project Area, include forage species, such as Atlantic Herring (*Clupea harengus*) and Atlantic Mackerel (*Scomber scombrus*), and predatory fish, such as Yellowfin Tuna (*Thunnus albacares*) and Whiting (*Merluccius bilinearis*). Trawl surveys conducted seasonally by NEFSC from 2003-2016 found that Atlantic Herring, Butterfish, and Round Herring had the highest biomass of forage fish across all seasons in the Massachusetts Wind Energy Area ("MA WEA"). Seasonal variations in biomass were apparent for all three species, with Atlantic Herring primarily caught in the colder seasons (spring/winter) and Butterfish and Round Herring primarily caught in the warmer seasons (fall/summer; Figure 6.6-3; NEFSC, 2016).

Demersal Fishes

Demersal fish (groundfish) are those fish that spend at least a portion of their life cycle in association with the ocean bottom. Demersal fish are often found in mixed species aggregations that differ depending upon the specific area and time of year (see Figure 6.6-4). Many demersal fish species have pelagic eggs or larvae that are sometimes carried long distances by oceanic surface currents. The Project Area supports both the intermediate and shallow demersal finfish assemblages defined by Overholtz & Tyler (1985). Many of the fish species in these assemblages are important because of their value in the commercial and/or recreational fisheries. Important demersal fish in the area include Winter Flounder (*Pseudopleuronectes americanus*), Yellowtail Flounder (*Limanda ferruginea*), and Monkfish (*Lophius americanus*). According to bottom trawl surveys conducted by the Massachusetts Department of Marine Fisheries (DMF) from 1978-2007 in Massachusetts waters within and surrounding the OECC, the most common demersal species captured in the spring included, Little Skate, Winter Flounder, and Windowpane Flounder and in the fall included, Scup, Little Skate, and Black Sea Bass (Figure 6.6-5). Year-round trawl surveys conducted by NEFSC from 2003-2016 found that Little Skate, Winter Skate, Silver Hake, and Spiny Dogfish were consistently dominant in catches from the MA WEA (Figure 6.6-4; NEFSC, 2016; Guida et al., 2017).

Highly Migratory Fishes

Highly migratory fish often migrate from southern portions of the South Atlantic to as far north as the Gulf of Maine. Migrations are correlated with sea surface temperature and these species generally migrate to northern waters in the spring where they remain to spawn or feed until the fall or early winter (NOAA, 2016a). Examples of these species with ranges that overlap the Project Area include Atlantic Bluefin Tuna (*Thunnus thynnus*) and Basking shark (*Cetorhinus maximus*).

Threatened and Endangered Fish

Three federally-listed threatened or endangered fish species may occur off the northeast Atlantic coast, including the Shortnose Sturgeon (*Acipenser brevirostrum*), Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*), and Atlantic Salmon (*Salmo salar*) (see Table 6.6-2). A further description of these species is provided herein. Additional species that have been proposed for endangered status and not deemed candidates (or are currently candidates for listing and the status determination has not yet been made) are known as "Species of Concern" and are included in Table 6.6-2.

<u>Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)</u>

The Atlantic Sturgeon is an anadromous species that spends much of its life in estuarine and marine waters throughout the Atlantic Coast, but ascends coastal rivers in spring to spawn in flowing freshwater. Sturgeon eggs are adhesive and attach to gravel or other hard substrata. Larvae develop as they move downstream to the estuarine portion of the spawning river, where they reside as juveniles for years. Subadults will move into coastal ocean waters where they may undergo extensive movements usually confined to shelly or gravelly bottoms in 10-50 meter ("m") (33-164 feet ["ft"]) water depths (Dunton et al., 2010).

Atlantic Sturgeon distribution varies by season. They are primarily found in shallow coastal waters (bottom depth <20 m [<66 ft]) during the summer months (May to September) and move to deeper waters (20-50 m [66-165 ft]) in winter and early spring (December to March) (Dunton et al., 2010).

There are five distinct population segments (DPS) of Atlantic Sturgeon (*Acipenser oxyrinchus*) along the Atlantic coast including: Gulf of Maine, New York Bight, Chesapeake Bay, and South Atlantic, all of which are listed as federally endangered except for the Gulf of Maine DPS which is listed as threatened (ASSRT, 2007; NMFS, 2013). Currently, there are no published population abundance estimates for any of the five DPSs. Population abundance estimates of mature or spawning adults only exist for two rivers, the Hudson River in New York and the Altamaha River in Georgia. Kahnle et al. (2007) estimated there to be 863 mature adult sturgeon from the Hudson River using fishery-dependent data collected between 1985-1995 and Schueller and Peterson (2006; as cited in NMFS, 2013) estimated 343 adults spawning annually using fishery-independent data collected in 2004 and 2005. Based on these estimates, and the presumption that these stocks are the most robust, the other spawning populations are likely less than 300 individuals per year (ASSRT, 2007; NMFS, 2013).

The National Marine Fisheries Service (NMFS) presumed that Atlantic Sturgeon in the Massachusetts Wind Energy Area (MA WEA) would most likely be from the New York Bight DPS; however, genetic analyses and tagging studies indicated that the range of all five DPSs overlaps and extends from Canada to Florida (ASSRT, 2007; NMFS, 2013).

Of the New York Bight DPS, spawning is only known to occur in the Delaware and Hudson rivers, with some habitat utilization also occurring in the Connecticut and Taunton rivers (ASSRT, 2007; NMFS, 2013). Federally-regulated Critical Habitat for Atlantic Sturgeon is assigned in the freshwater and coastal estuarine regions of the known spawning rivers, none of which overlap with the Offshore Project Area (GARFO, 2016). Primary threats to Atlantic Sturgeon include bycatch in trawl and gillnet fisheries, habitat degradation and loss, ship strikes, and general depletion from historical fishing. Very few Atlantic Sturgeon have been captured as bycatch in fisheries or in fisheries-independent surveys in the MA WEA, with no recorded catches within the Vineyard Wind WDA (Stein et al., 2004b; Dunton et al., 2011).

Shortnose Sturgeon (*Acipenser brevirostrum*)

The Shortnose Sturgeon is an anadromous species found in larger rivers and estuaries of the North America eastern seaboard from the St. Johns River in Florida to the St. Johns River in Canada. In the northern portion of its range, Shortnose Sturgeon are found in the Chesapeake Bay system, Delaware River, Hudson River, Connecticut River, Housatonic River, the lower Merrimack River, and the Kennebec River to the St. John River in New Brunswick, Canada. The closest populations to the Project Area are the Connecticut and Housatonic rivers, which drain into Long Island Sound (Shortnose Sturgeon Status Review Team, 2010). Shortnose Sturgeon occur primarily in fresh and estuarine waters and occasionally enter the coastal ocean. Adults ascend rivers to spawn from February to April, and eggs are deposited over hard bottom, in shallow, fast-moving water (Dadswell et al., 1984). Because of their preference for mainland rivers and fresh and estuarine waters, Shortnose Sturgeon are unlikely to be found in the vicinity of the Project.

The Shortnose Sturgeon was listed as endangered in 1967 because the US Fish and Wildlife Service concluded that the fish had been eliminated from the rivers in its historic range (except the Hudson River) and was in danger of extinction because of pollution, loss of access to spawning habitats, and direct and incidental overfishing in the commercial fishery for Atlantic Sturgeon (NOAA, 2015). DPSs are currently identified in North Carolina, South Carolina, Georgia, and northern Florida river systems (NOAA, 2015).

Atlantic Salmon (*Salmo salar*)

Atlantic Salmon is an anadromous species that historically ranged from northern Quebec southeast to Newfoundland and southwest to Long Island Sound. The Gulf of Maine DPS of the Atlantic Salmon that spawns within eight coastal watersheds within Maine is federally-listed as endangered. In 2009, the DPS was expanded to include all areas of the Gulf of Maine between the Androscoggin River and the Dennys River (NOAA, 2016b).

The life history of Atlantic Salmon consists of spawning and juvenile rearing in freshwater rivers to extensive feeding migrations in the open ocean. Adult Atlantic Salmon ascend the rivers of New England in the spring through fall to spawn. Suitable spawning habitat consists of gravel or rubble in areas of moving water. Juvenile salmon remain in the rivers for one to three years before migrating to the ocean. The adults will undertake long marine migrations between the mouths of US rivers and the northwest Atlantic Ocean, where they are widely distributed seasonally over much of the region. Typically, most Atlantic Salmon spend two winters in the ocean before returning to freshwater to spawn (NOAA, 2016b).

It is possible that adult Atlantic Salmon may occur off the Massachusetts coast while migrating to rivers to spawn. However, only certain Gulf of Maine populations are listed as endangered, and Gulf of Maine salmon are unlikely to be encountered south of Cape Cod (BOEM, 2014).

Table 6.6-2 List of Northeast Atlantic Threatened and Endangered Species and Species of Special Concern with ranges that may overlap the BOEM Massachusetts Wind Energy Area (BOEM, 2014)

Species (Scientific Name)	ESA Status
Atlantic Salmon (*Salmo salar*)	Endangered
Shortnose Sturgeon (*Acipenser brevirostrum*)	Endangered
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)	Endangered/ Threatened
Atlantic Bluefin Tuna (*Thunnus thynnus*)*	Species of concern
Atlantic Halibut (*Hippoglossus hippoglossus*)	Species of concern
Atlantic Wolfish (*Anarhichas lupus*)*	Species of concern
Dusky Shark (*Carcharhinus obscurus*)*	Species of concern
Porbeagle Shark (*Lamna nasus*)*	Species of concern
Rainbow Smelt (*Osmerus mordax*)	Species of concern
Sand Tiger Shark (*Carcharias taurus*)*	Species of concern
Thorny Skate (*Amblyraja radiata*)	Species of concern
Alewife (*Alosa pseudoharengus*)	Candidate species/ species of concern
Blueback Herring (*Alosa aestivalis*)	Candidate species/ species of concern
Cusk (*Brosme brosme*)	Candidate species/ species of concern
American Eel (*Anguilla rostrata*)	Candidate species
Basking Shark (*Cetorhinus maximus*)*	Candidate species
Great Hammerhead Shark (*Sphyrna mokarran*)	Candidate species
Scalloped Hammerhead Shark (*Sphyrna lewini*)	Candidate species

*Indicates species with EFH in Project Area

Note that there are differences between the species listed in Table 6.6-1 and those listed in Table 6.6-2. Those species in Table 6.6-1 are known to have a range and/or habitat overlapping the Project Area, while the species in Table 6.6-2 are those listed as either threatened, endangered, candidate species and/or species of concern in the entire Northeast Atlantic. Those species in Table 6.6-2 that have designated EFH within the Project Area are designated with an asterisk (*).

Commercially and Recreationally-Important Fish

Many of the fish species found off the Massachusetts coast are important due to their value as commercial and/or recreational fisheries.

A detailed description of fishing activities and the economic value of fisheries is provided in Section 7.6, Commercial and Recreational Fisheries.

6.6.1.2 Invertebrates

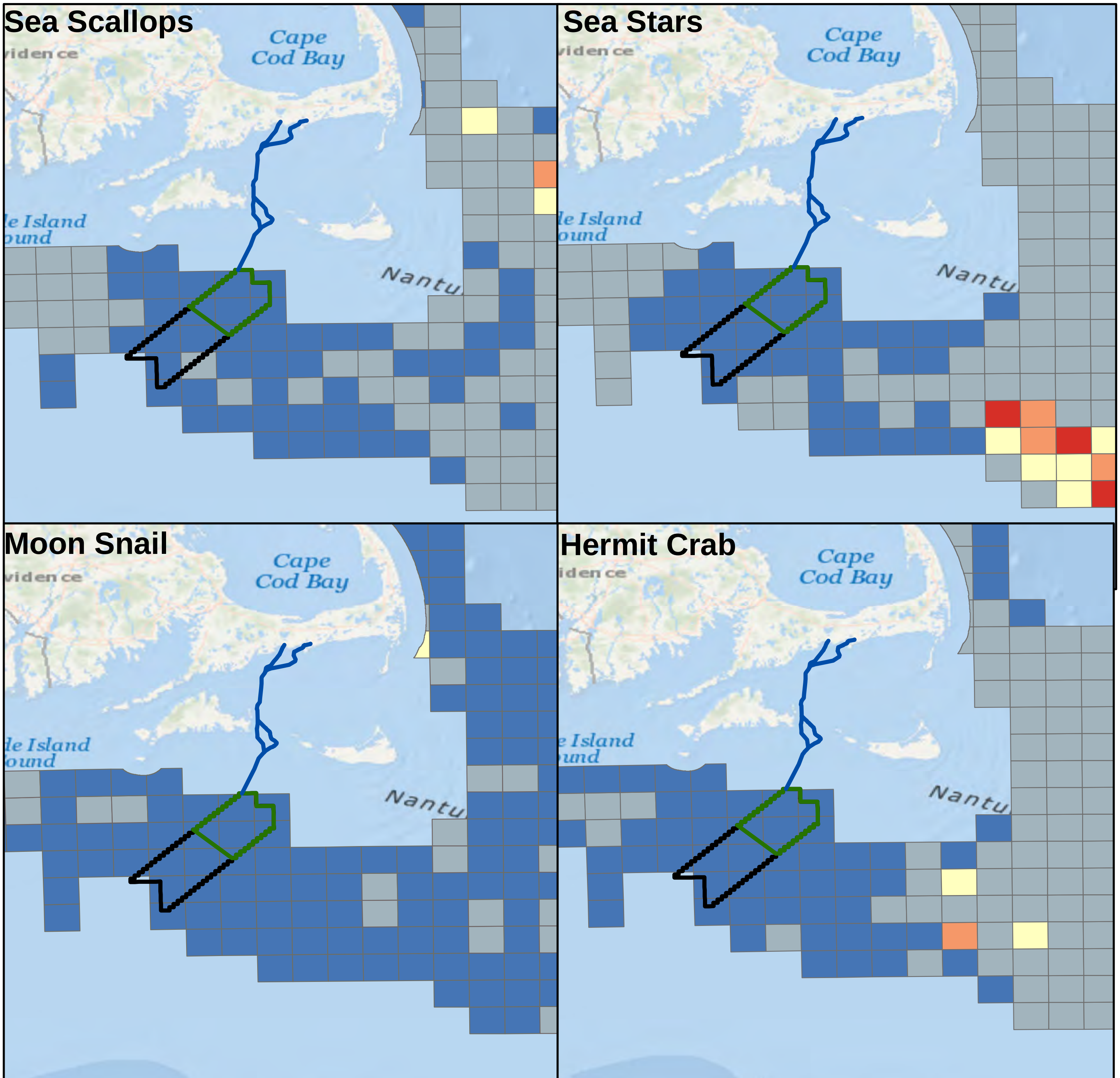
Important managed invertebrates with ranges that overlap the Project Area include Atlantic Sea Scallop (*Plactopecten magellanicus*), Long-finned Squid (*Loligo pealeii*), Short-finned Squid (*Illex illecebrosus*), Atlantic Surf Clam (*Spisula solidissima*), whelks, American Lobster (*Homarus americanus*), Ocean Quahog (*Artica islandica*), Jonah Crab (*Cancer borealis)*, and Horseshoe Crab (*Limulus polyphemus)*. While several of these species (e.g., Long-finned and Short-finned Squid, Atlantic Surf Clam, and Ocean Quahog) have designated EFH in the area (to be discussed in more detail in Appendix III-F), there are some species, such as the American Lobster, Jonah Crab, Horseshoe Crab, and whelks, that are managed in the area but do not have designated EFH.

American Lobster, Jonah Crab, and Horseshoe Crab are ecologically and commercially important crustacean species within the MA WEA. The American Lobster is distributed in coastal rocky habitats and muddy burrowing areas with sheltering habitats offshore in submarine canyon areas along the continental shelf edge. This species has been found to use the following substrates: mud/silt, mud/rock, sand/rock, bedrock/rock, and clay (Cooper & Uzmann, 1980). However, firm, complex, rocky substrate is the preferred habitat for all life stages of lobster. Post-larval and juvenile lobsters tend to stay in shallow, inshore waters (Lawton & Lavalli, 1995), but adolescent and adult lobster are highly adaptable in their choice of substrate and can be found in nearly all substrate types. The life history and habitat preferences of Jonah Crab are poorly understood. Large adults are commonly encountered in offshore rocky habitats; however, they are caught in both hard and soft sediments (ASMFC, 2015, 2018). Seasonal movement to nearshore habitats during the later spring and summer have been observed though motivation for migrations are unclear (ASMFC, 2018). Horseshoe Crabs inhabit sandy beach areas to spawn and juveniles reside in nearshore habitats close to those beaches for two years upon hatching (ASMFC, 2010). Little data exists on adult distribution upon spawning, with trawl sampling data from NMFS NEFSC suggesting they prefer depths less than 30 m (ASMFC, 1998). Refer to Section 6.5 and Figure 6.5-6 for more detailed species distribution within the Vineyard Wind Project Area.

The term "conch" is the generic classification for a variety of whelks found in southern New England waters, including Knobbed Whelk (*Busycon carica*), Channeled Whelk (*Busycotypus canaliculatus*), and Lightning Whelk (*Busycon contrarium*). Channeled Whelk tend to be the most prevalent in the commercial catches. Other shellfish with important commercial fisheries in the vicinity of the Massachusetts Wind Energy Area ("MA WEA") include Bay Scallops (*Argopecten irradians*), Atlantic Sea Scallops, Blue Mussels (*Mytilus edulis*), Ocean Quahogs, sea clams (various species), and Soft Shell Clams (*Mya arenaria*). Bay Scallops are found in the subtidal zone, sandy and muddy bottoms, and offshore in shallow to moderately deep water. Atlantic Sea Scallops are generally found in water depths of 25-200 m (82-650 ft) south of Cape Cod, mainly on sand and gravel where bottom temperatures remain below 68°F (20°C) (Hart, 2006). Blue Mussels are most common in the littoral and sublittoral zones (<99 m [325 ft] depths) of oceanic and polyhaline to mesohaline estuarine environments; however, the species can also be found in deeper and cooler waters (100-499 m [328-1,637 ft depths) (Newell, 1989). Adult Softshell Clams (*Mya arenaria*) live in sandy, sand-mud, or sandy-clay bottoms, with their highest densities at depths of three to four meters (10-13 ft) (Abraham and Dillon, 1986).

Video surveys conducted by SMAST within the MA WEA between 2003-2012, indicated low abundances of most benthic invertebrates in the WDA (Figure 6.6-6, Figure 6.6-7). The most common benthic invertebrate in the WDA were sand dollars, which were found, on average, in 75-100% of samples collected in the area (Figure 6.6-7; SMAST, 2016). Project specific underwater video sampling conducted within the northern section of the WDA also observed sand dollars frequently (Section 5.1.1.1 in Volume II).

The Massachusetts Division of Marine Fisheries (MDMF) has been sampling Longfin Squid and squid egg mops in Massachusetts waters as part of their Spring and Fall Bottom Trawls since 1978. Figure 6.6-8 and Figure 6.6.-9 provide the distribution of Longfin Squid (as number per tow) and squid egg mops (as kg per tow) in the Project Area between the years 2007 and 2017. The highest concentrations of Longfin Squid occurred just south of Nantucket Island in the Fall and south of Martha's Vineyard in the spring. Adult Longfin Squid were present along the OECC in both the spring and the fall with concentrations highest along the route through Nantucket Sound. Although Longfin Squid spawn year-round and egg mops can be found throughout the year, spawning typically peaks in the spring and eggs hatch in the summer (as reviewed in Jacobson, 2005). In Massachusetts state waters, squid egg mops were observed along the OECC in both the spring and fall; however, they were much more frequent in the spring through Nantucket Sound and northwest of Martha's Vineyard.



LEGEND

- Wind Development Area
- Vineyard Wind Lease Area
- Offshore Export Cable Corridor

Scale 1:2,174,811
1 inch = 34 miles

Kilometers: 0 12.5 25 50 75 100
Miles: 0 5 10 20 30 40

SMAST: Average Abundance

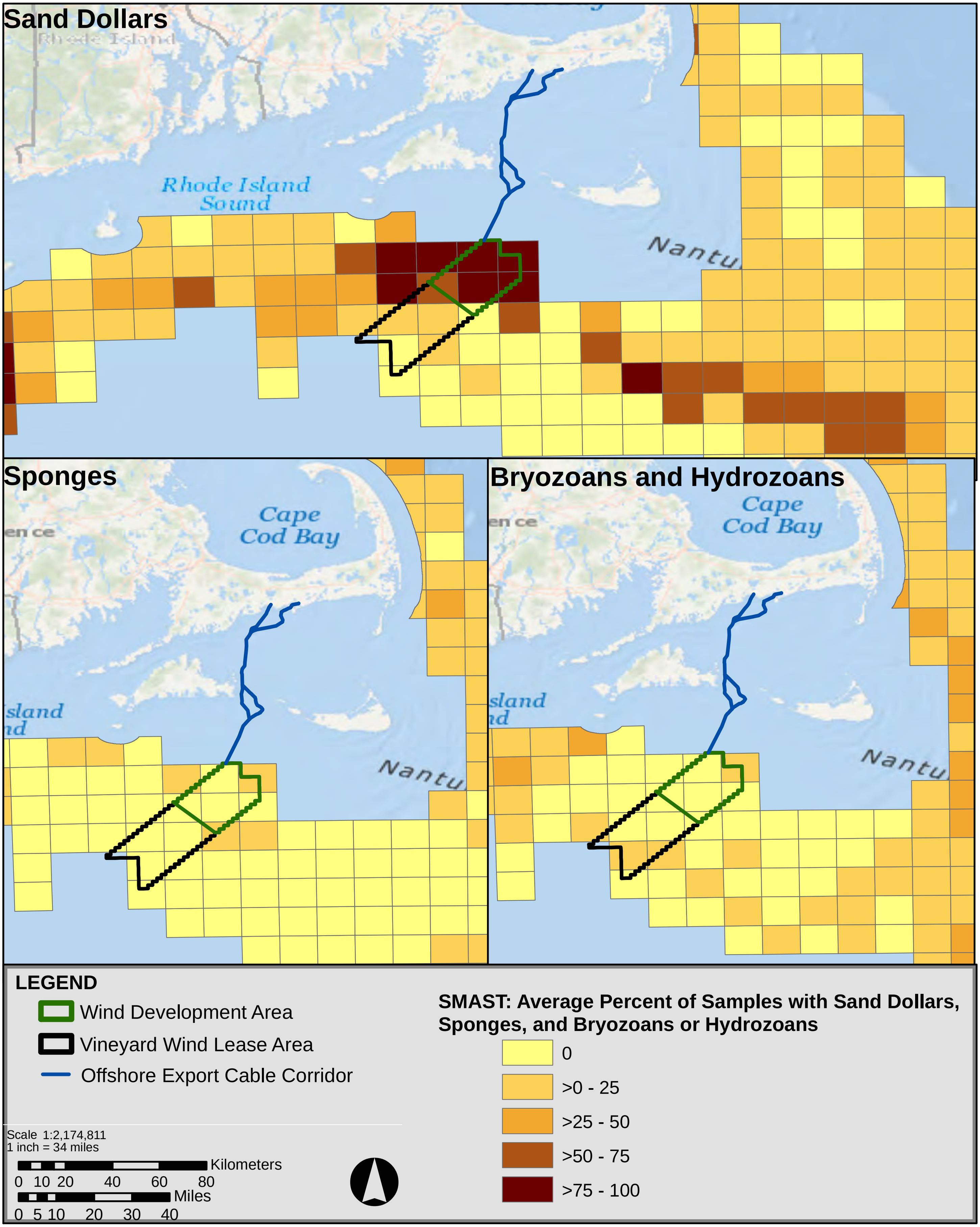
	Sea Scallops	Sea Star	Moon Snail	Hermit Crab
(dark blue)	0	0	0	0
(grey)	>0 - 4	>0 - 24	>0 - 0.2	>0 - 0.78
(yellow)	5 - 7	25 - 40	0.3	0.79 - 1.2
(orange)	8 - 10	41 - 56	0.4	1.3 - 1.7
(red)	11 - 32	57 - 140	0.5 - 0.8	1.8 - 6.2

Vineyard Wind Project

VINEYARD WIND

Figure 6.6-6

Average Abundance of Benthic Invertebrates Observed in SMAST Video Surveys from 2003-2012 (SMAST, 2016)

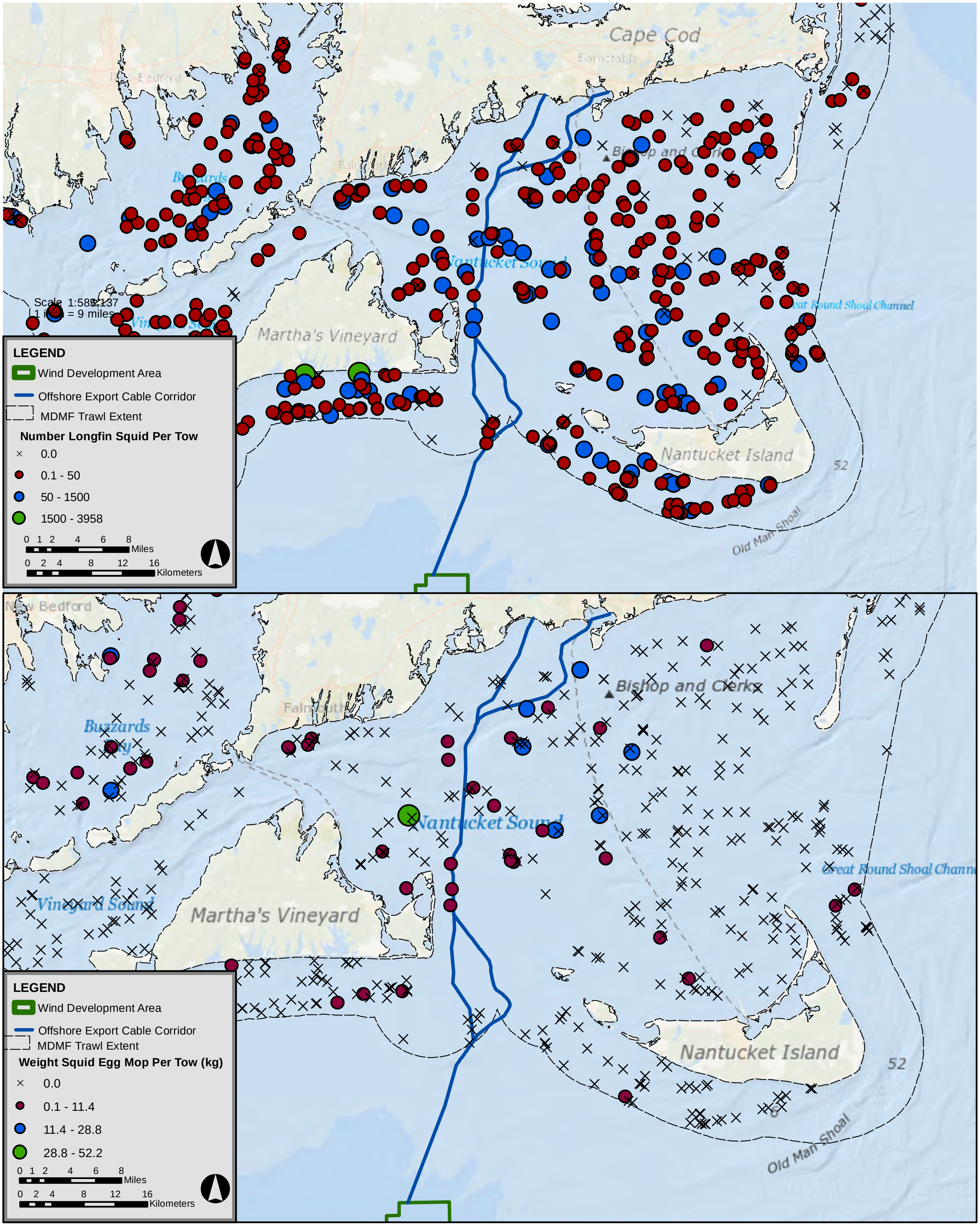


Vineyard Wind Project

VINEYARD WIND

Figure 6.6-7

Average Percent of Samples with Sand Dollars, Sponges, or Bryozoans and Hydrozoans in SMAST Video Surveys from 2003-2012 (SMAST, 2016)

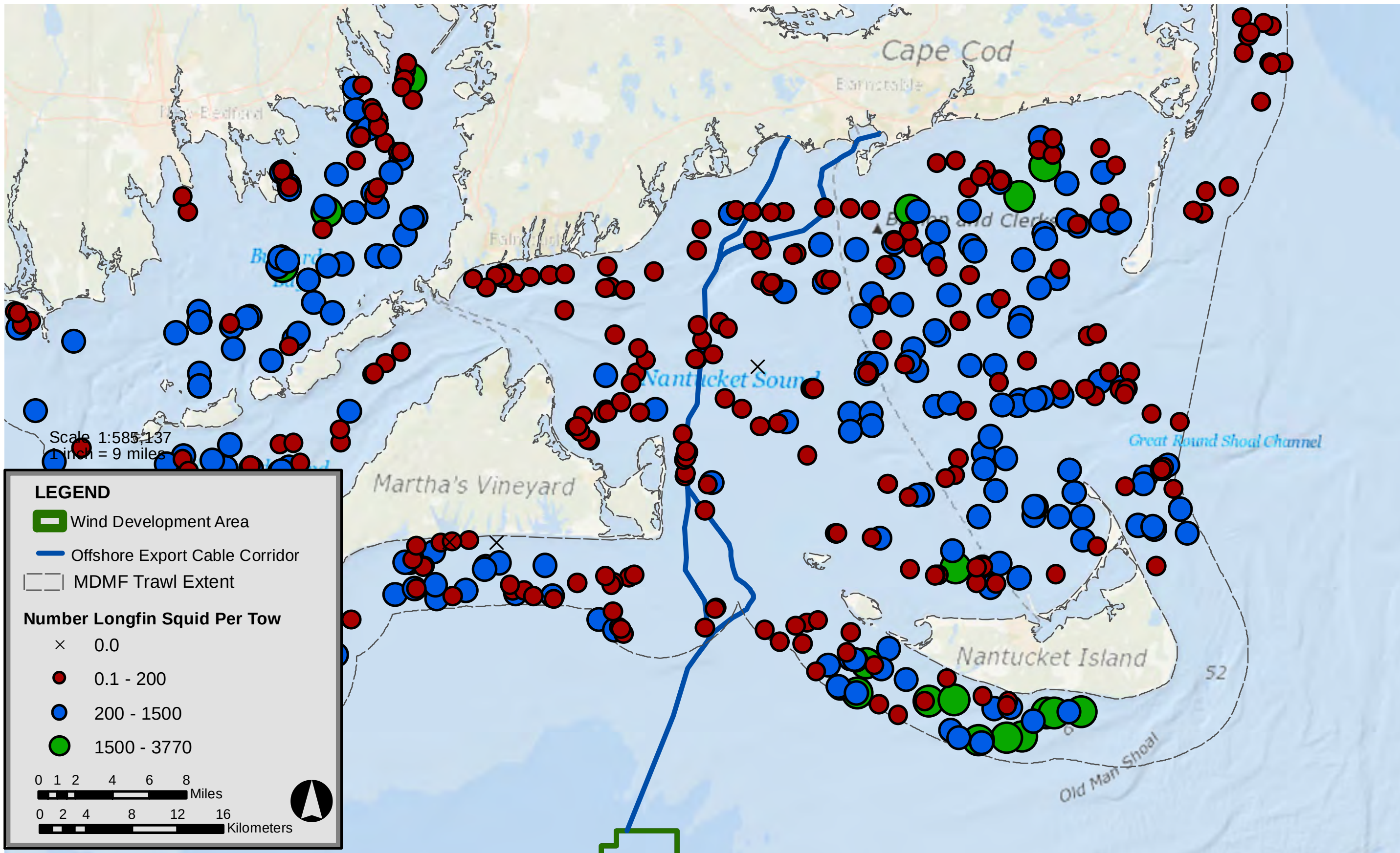


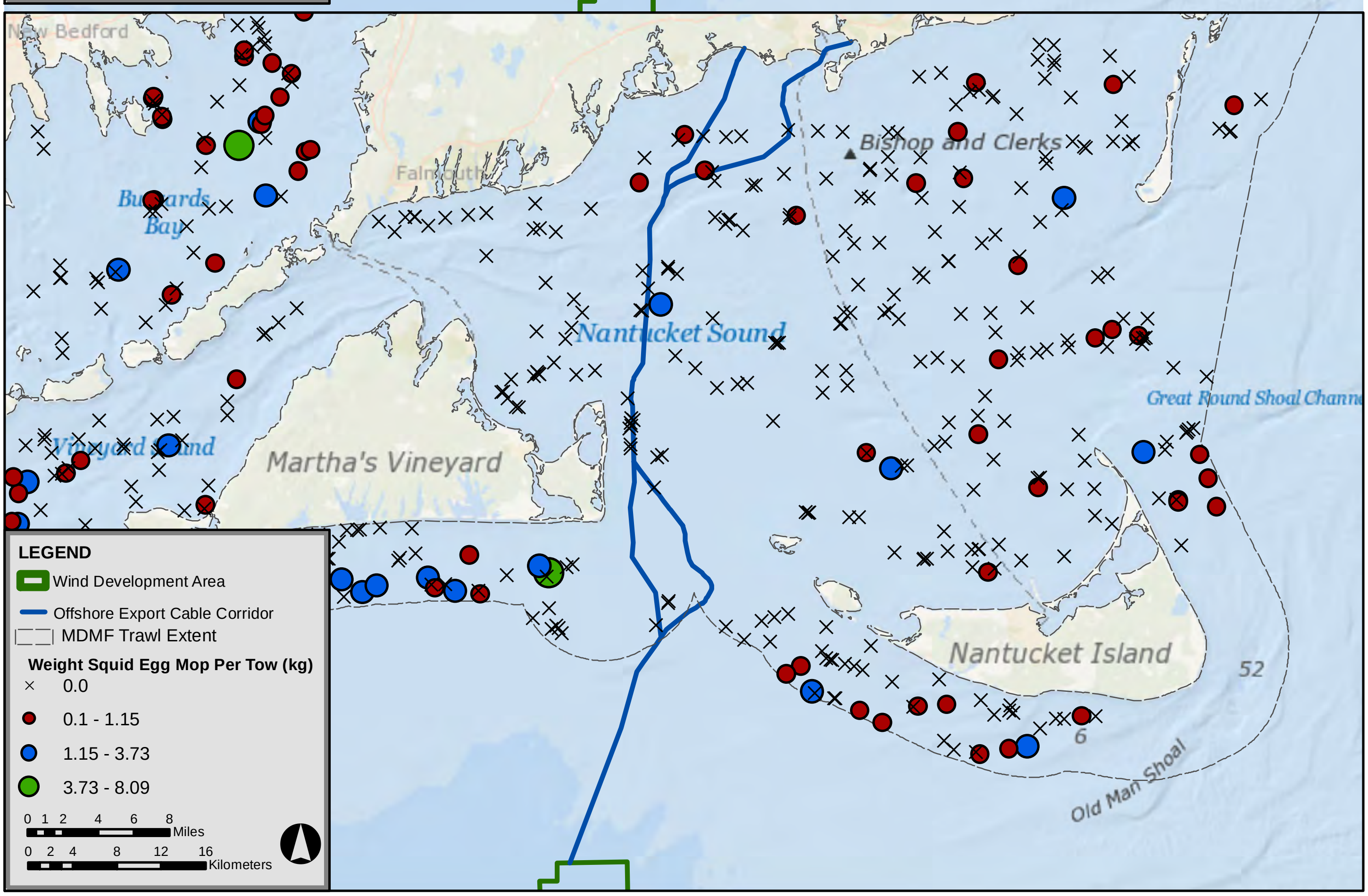
Vineyard Wind Project

VINEYARD WIND

Figure 6.6-8

Longfin Squid and Egg Mop Catch Data from MDMF Bottom Trawl Spring Surveys (2007-2017)





Vineyard Wind Project

VINEYARD WIND

Figure 6.6-9

Longfin Squid and Egg Mop Catch Data from MDMF Bottom Trawl Fall Surveys (2007-2017)

6.6.1.3 Essential Fish Habitat

Essential Fish Habitat is designated in both benthic substrate and water column habitats for 40 fish and invertebrate species within the WDA and OECC. The primary goal of EFH is to identify and protect important fish habitat from certain fishing practices and coastal and marine development. EFH is generally assigned by egg, larvae, juvenile and adult life stages and defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. § 1802(10)). A detailed assessment of EFH and potential project-related impacts is included in Appendix III-F.

6.6.2 Potential Impacts of the Project

The impact-producing factors for finfish and invertebrate resources are provided in Table 6.6-3 and will be discussed in more detail in this section.

Table 6.6-3 Impact- producing Factors for Finfish and Invertebrates

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommiss-ioning
Pile driving for WTG and ESP foundations	X		X		
Cable installation	X	X	X	X	X
Scour protection installation	X		X		
Increased vessel traffic	X	X	X	X	X
Increased noise	X	X	X	X	X
Water Withdrawals	X	X	X	X	X
Dredging		X	X	X	X
Electromagnetic fields	X	X		X	

6.6.2.1 Construction and Installation

6.6.2.1.1 Habitat Loss or Alteration

Wind Development Area

During the construction/installation of the Project, temporary and permanent habitat loss or alteration is expected for both demersal and pelagic fish. Demersal fish species are expected to be the most affected by bottom habitat loss and alteration because of their strong association with benthic environments. Within the WDA, bottom habitat primarily consists of fine sand and silt-sized sediments. Soft bottom habitat would be permanently lost from the installation of Wind Turbine Generators ("WTGs") and Electrical Service Platforms ("ESP") foundations (monopile or jacket) and associated scour protection. The soft bottom habitat at each WTG and ESP would be altered to hard substrate from addition of the foundation and scour protection. As listed in Table 6.5-5, the amount of permanent soft bottom habitat lost would be less than 0.22 square kilometers ("km^2") (53 acres).

Additional bottom habitat loss and alteration is expected from embedment of the inter-array cables and placement of the jack-up legs from construction vessels/barges. The jack-up leg impact is quantified in Table 6.5-5 as an additional 0.27 km^2 (66 acres). Bottom habitat in the direct path of the inter-array and inter-link cables will be disturbed from the surface to a depth of 1.5-2.5 meters (5-8 ft). In areas where the cable cannot reach the desired burial depth, protective measures (as described in Section 3.1.5.3 of Volume I) will be used to cover and protect cables. The addition of rock or concrete protection may alter habitat from soft to hard bottom substrate, though it is likely that some of the protective measures will be placed in areas of existing hard bottom habitat. As listed in Table 6.5-5, the additional area of alteration due to inter-array and inter-link cable installation is 0.86 km^2 (211 acres), and the area potentially requiring cable protection measures is 0.26 km^2 (63 acres). The total area of alteration within the WDA due to foundation and scour protection installation, jack-up vessel use, inter-array and inter-link cable installation, and potential cable protection installation is 1.59 km^2 (393 acres), which is 0.5% of the entire WDA.

Additionally, while anchored vessels will not be used as primary construction and installation vessels within the WDA, there may be potential anchoring within the WDA. Any anchoring that does occur within the WDA will occur within the Area of Potential Effect (APE) defined in Volume II-C. The impacts from anchor use and anchor sweep are not quantified at this time due to the difficulty of estimating potential anchoring practices at the Project planning stage.

Temporary increases in suspended sediments in the water column during construction are also expected and will affect demersal and pelagic fish species and benthic invertebrates. Increased suspended sediment can impair the visual abilities of fish species and impact foraging, navigation, and sheltering behaviors. For mollusks, such as Softshell Clams and Northern Quahog (*Mercenaria mercenaria*), suspended sediments can reduce oxygen consumption and filter feeding abilities and lead to reduced growth (reviewed in Wilber & Clarke, 2001). Concentration and duration of sediment suspension dictate severity of affect to fish and benthic organisms. Sublethal affects (i.e., fine sediment coating gills and cutting off gas exchange with water and resulting in asphyxiation) were observed for White Perch (*Morone americana*) when 650 milligrams per liter ("mg/L") of suspended sediments persisted for five days (Sherk et al., 1974). Lethal effects were observed for other sensitive fish species at concentrations $<$1,000 mg/L that persisted for at least 24 hours (Sherk et al., 1974; Wilber & Clarke, 2001). Reduced growth and oxygen consumption of some mollusk species has been observed when sediment concentrations of 100 mg/L persisted for two days (Wilber & Clarke, 2001). According to sediment transport modeling of the inter-array cables installation using typical cable burial parameters (see Appendix III-A), the maximum anticipated suspended sediment concentrations that persisted for at least 60 minutes would be greater than 200 milligrams per liter ("mg/L") but less than 300 mg/L and would occur in <0.02 km^2 (5 acres). These concentrations would drop rapidly and would be below 50 mg/L after two hours. Concentrations of suspended sediments with lower concentrations (10 mg/L) would extend up to 3.1 km (1.2 mi) from the inter-array cable centerline and would be suspended at any given location for less than six hours, which is below known sublethal thresholds.

Life stages (eggs and larvae), demersal fish species, and benthic invertebrates with limited or no motility would be the most at risk of injury or mortality during construction and installation in the WDA. Mobile demersal/benthic and pelagic fish and invertebrates would be temporarily displaced by increased turbidity and underwater construction, but would likely be able to escape harm and move away from construction/installation areas. Because the avoidance responses of demersal fish species are slower, these species would be more likely to experience some injury or mortality during construction and installation. Additionally, construction activities conducted in the winter may further reduce the avoidance ability of some benthic organisms as movement is delayed when water temperatures are low.

Immobile life stages of fish species in or on benthic sediment (i.e., demersal eggs) and sessile benthic organisms in the direct path of foundations and associated scour protection or inter-array cables may experience direct mortality. The resettling of disturbed sediments may cause additional mortality or injury to these immobile species or life stages through burial and smothering. For demersal eggs (fish [e.g., Atlantic Wolffish (*Anarhichas lupus)*, Atlantic Herring, and Winter Flounder], squid [e.g., Longfin Inshore Squid (*Doryteuthis pealeii*)]), and whelk species), deposition greater than one millimeter ("mm") can result in the burial and mortality of that life stage (Berry et al., 2011). Sediment dispersion modeling (see Appendix III-A) indicates that deposition of 1 mm (0.04 in) or greater (i.e., the threshold of burial for demersal eggs) occurred primarily within 80 m (262 ft) up to 100 m (328 ft) from the cable centerline with a total area of up to 2.42 km^2 (598 acres).

As mentioned in Section 6.5, many benthic bivalve species can withstand deposition levels up to 300 mm [12 in] (Essink, 1999). However, sessile or surface dwelling species, such as Blue Mussels and Queen Scallops, are more sensitive to deposition levels and lethal effects have been observed with burial depths between 20-100 mm [0.8 – 4 in] (Essink, 1999; Hendrick et al., 2016). According to sediment dispersion modeling conducted in the Project Area (see Appendix III-A), there will be minimal areas of deposition greater than 5 mm (0.2 in) for cable installation activities and none over 10 mm (0.39 in); therefore, cable installation is not anticipated to affect shellfish.

Offshore Export Cable Corridor

Up to approximately 158 km (98 mi) of offshore export cables would be installed for the Project. In certain areas, dredging will be required prior to the installation of the offshore export cable. In addition, a maximum of two cables could be installed separately within an 810 m (2,657 ft) wide cable corridor. Benthic habitat in the direct path of the cable installation vessels, dredging vessels, vessel anchors, and anchor sweep zone will be disturbed while cables are being installed along the OECC. As described in Volume II, the OECC will pass through a variety of sediment types including sand/mud, pebble-cobble, and dispersed boulders. Most of the OECC is considered low complexity bottom habitat and 75% of video transect samples taken along the OECC recorded flat sand/mud, sand waves, or biogenic structures (see Volume II). Coarser substrates, like pebble-cobble and boulders, were found mainly in Muskeget Channel and are important for habitat for the juveniles of some fish species, like Atlantic Cod (*Gadus morhua*) (Lindholm et al., 2001).

Once cable installation is complete, permanent habitat alteration may occur due to the resettling of disturbed finer-grained sediment over gravel substrate. For a small portion of the OECC, permanent alteration may also occur where desired burial depth cannot be reached. In these areas, some of which already consist of hard bottom, rock protection or concrete mattresses will be placed over the cables. As listed in Table 6.5-5, the amount of permanent bottom habitat altered by rock protection or concrete mattresses would be less than 0.14 km^2 (35 acres). OECC installation and sand wave dredging along the route will result in temporary disturbance of a maximum of 0.47 km^2 (117 acres) and 0.28 km^2 (69 acres) of bottom habitat, respectively.

To facilitate cable installation, anchoring may occur along the OECC. It is currently anticipated that anchoring may occur through Muskeget Channel or in the shallower waters of Lewis Bay near the New Hampshire Avenue Landfall Site, though anchoring may occur at any point along the OECC. The impacts from anchor use and anchor sweep are not quantified at this time due to the difficulty of estimating potential anchoring practices at the Project planning stage.

As would be the case with the WDA, construction and installation of the offshore export cable will increase suspended sediment in the water column. Installation along the OECC requires additional pre-installation sediment removal to remove sand waves and achieve safe burial depths; as described in Appendix III-A, this will likely be accomplished with a trailing suction hopper dredge (TSHD) on its own or through a combination of a TSHD and a jetting technique. Sediment dispersion modeling of sand wave removal via TSHD along the OECC indicated that concentrations of suspended sediments above 10 mg/L extended up to 16 km (10 mi) from the cable trench centerline. Most of the sediment settles out in less than three hours; however, suspended sediments at this concentration can persist for six-12 hours in smaller areas (0.06 km^2 [15 acres]). In addition, high concentrations

(>1000 mg/L) occurred at distances up to 5 km (3.1 mi) from the dredge site for short periods of time (less than two hours) due to the TSHD overflow and hopper dumping of sediments. After removing sand waves, a jet plow, mechanical plow, or one of the other techniques listed in Section 4.2.3.3 of Volume I will be used to install cables. The plume from jet plow installation as delineated by excess suspended sediment concentrations greater than 10 mg/L typically extended less than 200 m (656 ft) from the route centerline, though did extend up to 2 km (1.24 mi) in some places. Further, the excess concentrations were confined to the lower portion of the water column, and resettled rapidly (within four-six hours) due to the high proportion of coarse sand throughout the route (see Appendix III-A).

Suspension of sediments from dredging and cable installation operations would have little to no effect on motile pelagic organisms (fish and invertebrate larvae, juveniles, and adults, such as *Penaeus* sp. shrimp) or many burrowing invertebrates. This is because the mobility of pelagic species allows them to escape harm and move away from the construction path in areas with increased suspended sediment. The additional pre-installation sand wave sediment removal along the OECC could potentially impact any non-motile organisms, such as pelagic and demersal eggs and sessile invertebrates, because increased suspended sediment can result in egg abrasion and mortality and reduced feeding efficiency in filter-feeding organisms (Wilber & Clarke, 2001). However, according to the sediment transport modeling (see Appendix III-A), suspended sediment concentrations and sediment persistence in the water column will be below known sub-lethal thresholds (Sherk et al., 1974; Wilber & Clarke, 2001).

The resetting of suspended sediments after dredging and export cable installation may also impact fish via burial of demersal eggs (i.e., eggs on or attached to the bottom sediments). If the rate of deposition at any given location exceeds one millimeter over 2 to 21 days (the assumed egg duration for species of concern), demersal eggs could be buried resulting in reduced hatching success and increased mortality (Berry et al., 2011). For most of the cable installation, deposition of greater than 1 mm (0.04 in) was primarily constrained to within 80 m (262 ft) though up to 100 m (328 ft) from the route centerline with a total area of up to 10.3 km^2 (2,545 ares) for one cable. In areas along the OECC where sand wave dredging was simulated to have occurred, the deposition greater than 1 mm (0.04 in) associated with the TSHD drag arm is mainly constrained to within 80 m (262 ft) from the route centerline whereas the deposition greater than 1 mm (0.04 in) associated with overflow and disposal extends to greater distances from the source, mainly within 1 km (0.62 mi), though such deposition can extend up to 2.3 km (1.43 mi) in isolated patches when subject to swift currents through Muskeget Channel. Overall, along the OECC, sedimentation of 1 mm or greater could occur in a maximum area of 10.50 km^2 (2,595 acres) for dredging associated with one cable.

As mentioned in the section above, mortality of sensitive sessile or benthic shellfish species can occur with sedimentation levels of >20 mm (0.8 in). According to sediment dispersion modeling conducted in the Project Area (see Appendix III-A), there will be minimal areas of deposition greater than 5 mm (0.2 in) for cable installation activities and none above 10 mm (0.39 mm); therefore, cable installation is not anticipated to affect shellfish. For dredging and disposal activities, the largest area of seafloor to be affected by 20 mm (0.79 in) would be within an area of 0.14 km^2 (34.6 acres).

Direct mortality of pelagic planktonic life stages would also occur via water withdrawals for vessel functions and potentially from the cable installation and dredging vessels. Mortality of organisms entrained in the water withdrawal pumps is expected to be 100% because of the associated stresses with being flushed through the pump system and temperature changes (USDOE MMS, 2009). Assuming that 90% of the offshore cable system is installed at a rate of 200 m/hr (656 ft/hr), 10% of the cable system is installed at a rate of 300 m/hr (984 ft/hr), and a jet plow uses 11,300 – 30,300 liters per minute (3.000 – 8.000 gallons per minute) of water, water withdrawal volumes are expected to be approximately 1,700 – 4,540 million liters (450 – 1,200 million gallons).

Overall, the slower avoidance response of juvenile and adult demersal fish and benthic invertebrate species subjects them to increased injury or mortality during dredging and cable installation. As mentioned above, slow avoidance responses can be further exaggerated during the cold winter months for some species, such as Horseshoe Crab that bury into the sediment in the winter (Walls et al., 2002). Immobile benthic species or early life stages in the direct path of construction vessels would experience direct mortality or injury. Some displaced fish and invertebrates may be subjected to indirect injury or mortality through increased predation or competition in areas surrounding the construction site.

6.6.2.1.2 Increased Noise

Wind Development Area

During the construction/installation of the Project, related underwater noise would include repetitive, high-intensity sounds produced by pile driving, and continuous, lower-frequency sounds produced by vessel propellers. Ambient noise within the Lease Area was measured as, on average, between 76.4 and 78.3 decibels ("dB") re 1 $\mu Pa^2/Hz$ (Alpine Ocean Seismic Surveying Inc., 2017). Ambient noise can influence how fish detect other sounds as fish have localized noise filters that separate background noise and other sounds simultaneously (Popper & Fay, 1993).

All fish have hearing structures that allow them to detect sound particle motion. Some fish also have swim bladders near or connected to the ear that allows them to detect sound pressure as well, which increases hearing sensitivity and broadens hearing abilities (reviewed in Popper et al., 2014). In general, increased sound sensitivity and the presence of a swim bladder makes a fish more susceptible to injury from anthropogenic noises as these loud, often impulsive noises can cause swim bladders to vibrate with enough force to inflict damage to tissues and organs around the bladder (Halvorsen et al., 2011; Casper et al., 2012). The least sound-sensitive fish species include those that do not have a swim bladder, including flatfish like Winter Flounder and elasmobranchs. Fish, such as Atlantic Sturgeon, with swim bladders not connected or near inner-ear structures also primarily detect noise through particle motion, and are therefore less sensitive to noise. The most sensitive species are those with swim bladders connected or close to the inner ear, such as Atlantic Herring and Cod; these species can acquire both recoverable and mortal injuries at lower noise levels than other species (Thomsen et al., 2006; Popper et al., 2014). Most crustacean species lack swim bladders and are considered less sensitive to sound, though resolution of information on invertebrates and sound is coarse (Edmonds et al., 2016).

Specifically, although research is limited, noise generated from pile driving and intensified vessel traffic could impact fishes and invertebrates in the area as the high-intensity, pulse sounds of pile driving can produce noise over 200 dB re 1 μPa at the source and have been linked to mortality, ruptured gas bladders, damage to auditory processes, and altered behavior in some fish species (Casper et al., 2012; Popper & Hastings, 2009; Riefolo et al., 2016). Noise thresholds derived from Popper et al. (2014) indicate that pile driving sound above 207 dB peak can lead to mortality of the most sensitive fish species, such as Atlantic Herring, while noise above 186 dB can lead to impairment.

Vineyard Wind conducted acoustic modeling (see Appendix III-M and associated appendix) to estimate the noise propagation of pile driving with a target of approximately 12dB noise reduction in relation to thresholds of mortality and recoverable injury for fish with different hearing structures (based on thresholds in Popper et al., 2014). Modeling results indicated that cumulative sound levels causing mortality or injury to fish without swim bladders, such as Winter Flounder, could extend up to 71 m (233 ft) from the source. Cumulative sound levels causing recoverable injury in fish without swim bladders could extend 71-79 m (233-259 ft). For fish, such as Atlantic Sturgeon, with swim bladders not involved in hearing, cumulative sound levels that potentially lead to mortality could extend 127-182 m (417-597 ft) from the source. Fish, such as Atlantic Cod and Herring, with swim bladders involved in hearing could be impacted by pile driving noises at the farthest distances from the source, with mortal impacts potentially occurring at 200-351 m (656-1,152 ft) from the source. Recoverable injury for all fish with swim bladders could occur between 451-691 m (1,480-2,267 ft) from the source. Although there is very little information on the impacts of pile driving to eggs and larvae, Popper et al. (2014) conservatively assigned the same thresholds for mortality or injury as fish with swim bladders not involved in hearing (Popper et al., 2014).

However, impairment from pile driving noise is unlikely to occur during the Project, as a soft-start technique will be employed and most mobile fish and invertebrates will be able to leave the area before full strength pile driving occurs.

In addition to pile driving noises, fish can be impacted by increased noise levels from the intensified vessel traffic and construction related vessel positioning. Continuous noise above 170 dB root-mean-square (rms) for 48 hours can lead to injury, while noise ≥158 dB rms for 12 hours can lead to behavioral disturbance (Popper et al., 2014). Underwater vessel noise can cause avoidance behavior interferes with feeding and breeding, alter schooling behaviors and migration patterns, and mask important environmental auditory cues (Barber, 2017; CBD, 2012). Masking is of particular concern because although fish are generally not loud (120 dB re 1 μPa [at one meter] with the loudest on the order of 160 dB re 1 μPa), species make unique noises that allow for individual identification (Normandeau Associates, Inc., 2012). In addition, behavioral responses in fish differ depending on species and life stage, with younger, less mobile age classes being the most vulnerable (Gedamke et al., 2016; Popper & Hastings, 2009). Avoidance or flight behavior away from vessels has been observed for Atlantic Herring and Atlantic Cod and is likely the behavior exhibited by other species as well (Handegard et al., 2003; Vabø et al., 2002).

Although even less research has been conducted on the impact of anthropogenic noise on invertebrates, studies have observed acoustic trauma in some species, including adult squid and octopus, when exposed to high-intensity, low-frequency noise (André et al., 2011; Solé et al., 2013). In addition, research on the response of Blue Mussels to pile driving indicated that clearance or filtration rate increased with pile driving noise, likely in response to increased metabolic demands triggered by stress (Spiga et al., 2016). Similarly, feeding changes were observed in American Lobster exposed to high sound levels (seismic air gun) and persisted as long as several weeks post-exposure (Payne et al., 2007). Research has also found that larval scallops exposed to seismic noises showed delays in development and malformations (Aguilar de Soto et al., 2013). A lobster species (*Nephrops norvegics*) exposed to pile driving noises showed decreased burying, bioirrigation, and locomotion, which indicated alterations to overall behavior and habitat usage during pile driving activities (Solan et al., 2016). Lower frequency, more continuous noises, such as those from vessels, have been linked to changes in the behavior or recruitment of some benthic invertebrates (Nedelec et al., 2014). However, as described in the BOEM EA and the Alternative Energy Programmatic Environmental Impact Statement ("PEIS") that were prepared for the assessment and designation of WEAs by BOEM, vessel traffic in this area is already relatively high and thus implies that biological resources in the area are presumably habituated to this noise (BOEM, 2007; BOEM, 2014).

Offshore Export Cable Corridor

The principle noise from OECC construction/installation would be from tug and barge vessels used for cable installation. Fish in the OECC would be able to hear the tug and barge vessels; however, at sound levels below those that cause injury or stress (USDOE MMS, 2009). Cable installation is not expected to be a significant source of noise; if a jet plow is used, there will be the sound of water rushing from the nozzles (USDOE MMS, 2009).

6.6.2.1.3 Avoidance, Minimization, and Mitigation Measures

The Project Area is located in the MA WEA, and this area is less sensitive to important fish and invertebrate habitat and therefore reduces impacts.

To mitigate the potential impacts of injury to fish from pile driving, the Project will apply a soft-start procedure to the pile driving process, which delivers initial pile drives at a lower intensity, allowing fish to move out of the activity area before the full-power pile driving begins. In addition, Vineyard Wind will target approximately 12dB of noise reduction. Therefore, the anticipated impact on fish in or near the WDA is temporary avoidance reactions. Although vessel presence in the WDA will be intensified, avoidance behaviors are expected to be similar to those already displayed by fish when near fishing or recreational vessels.

WTGs will also be widely spaced, leaving a huge portion of the WDA undisturbed by WTG and ESP installation.

Immobile life stages of fish species in or on benthic sediment (i.e., demersal eggs) and sessile benthic organisms in the direct path of construction may experience direct mortality. Impacts may be minimized through the use of mid-line buoys, if feasible and safe, and installation equipment that minimizes installation impacts, such as a jet plow. In nearshore areas where sensitive resources are located, horizontal directional drilling may be used to minimize impacts.

Vineyard Wind is developing a framework for a pre- and post-construction fisheries monitoring program to measure the Project's effect on fisheries resources. Vineyard Wind is working with the Massachusetts School for Marine Science and Technology (SMAST) and local stakeholders to inform that effort and design the study. The duration of monitoring will be determined as part of the initial effort to determine the scope of the study, but it is anticipated to include the pre-construction period and at least one year of post-construction monitoring.

6.6.2.1.4 Summary

Overall, impacts to finfish and invertebrate species are expected to be short-term and localized during the construction and installation of the Project. The low total fish biomass and high species richness in the Project Area makes this location ideal for wind energy as it reduces impacts to individual organisms and targets an area which will likely be able to recover following any potential Project-related disturbances. In addition, the WEA was selected by BOEM to exclude most sensitive fish and invertebrate habitat and the Offshore Project Area is primarily composed of uniform sandy bottom habitat, which will likely begin recovering quickly after construction is completed. Previous research indicates that physical habitat recovers and communities begin to repopulate within a few months of disturbance (Dernie et al., 2003; Van Dalfsen & Essink, 2001). Some alteration of non-structured habitat to structured habitat in the WDA may change species assemblages in that area and attract more structure-oriented species.

Pelagic species will be able to avoid construction areas and are not expected to be substantially impacted by construction and installation. Impacts to mobile pelagic fish and invertebrate species include localized and short-term avoidance behavior. These impacts can be minimized or offset through mitigation consisting of a "soft-start" pile driving regime, sound reduction technologies, and efficient construction practices.

Direct mortality may occur to immobile benthic organisms that are in the direct path of construction processes. Mortality of immobile pelagic egg and larval life stages in the construction area (WDA and OECC) may occur through water withdrawals of the construction vessels. Although eggs and larvae may be entrained and will not survive, loss of many adult fish and population level impacts are not expected as most of these species produce millions of eggs each year and already have low adult survival rates. In addition, mortality of pelagic eggs due to increased suspended sediments is not likely as only low concentration sediment plumes are expected and resettlement will occur quickly (less than twelve hours in the water column).

Burial and mortality of some demersal eggs and sessile organisms is also expected during cable installation in the WDA and OECC, where deposition is greater than one millimeter. However, mortal deposition levels are only expected in small, localized areas in the direct vicinity of the cable routes and sediment discharge areas. Burrowing mollusks in the area, such as quahogs, will likely be able to avoid most lethal burial depths and are only expected to be slightly impacted and exhibit short-term avoidance of the area. Overall, although demersal sessile, or less active benthic organisms will incur the brunt of construction impacts, since the impacted area is only a small portion of the available habitat in the area, population level impacts are highly unlikely.

6.6.2.2 Operations and Maintenance

6.6.2.2.1 Habitat Changes, Artificial Reefs, and Fish Attracting Devices

Wind Development Area

The introduction of up to 100 WTG, four ESPs, and the scour protection foundations at the base of each foundation would change habitat from non-structure oriented to a structure-oriented system. The addition of foundations and scour protection, as well as rock or concrete cable protection measures in some areas, may act as an artificial reef and provide rocky habitat previously absent from the area. Increases in biodiversity and abundance of fish have been observed around turbine foundations due to attraction of fish species to new structural habitat (Raoux et al., 2017; Riefolo et al., 2016). However, within the WDA, the total area of impact from scour protection and cable protection is only 0.47 km^2 (117 acres) out of the 306 km^2 (75,614 acres). Cobble and boulder habitats have been identified as particularly important to lobsters, as it serves as both nursery grounds for benthic juveniles and as home substrata for adults (Linnane et al., 1999).

The addition of the turbine structure throughout the water column may also alter local food web dynamics and species distribution. Turbine foundations provide substrata for shellfish to attach and colonization by these species can change nutrient and plankton concentrations and provide a new food source and additional habitat complexity previously absent from the area (Norling and Kautsky, 2007; Slavik et al., 2017). For example, biofouling of Blue Mussels (*Mytilus edulis)*, a filter feeder, on turbine structures in wind farms located in the North Sea notably reduced the daily net primary productivity on a regional scale. However, reduction in primary production resulted in increased production and biodiversity of higher trophic levels (Slavik et al., 2017). Raoux et al. (2017) also observed that total ecosystem activity increased and that high trophic level organisms responded positively to increased biomass near monopiles after the construction of a wind farm. Other research on habitat changes associated with wind farms has observed that new communities of rocky habitat fishes establish near turbine foundations while communities remain unchanged in sandy areas between the turbines (Stenberg et al., 2015). In addition, increases in commercially important species, such as Atlantic Cod and Whiting, were observed near deep water wind farms (Hille Ris Lambers & ter Hofstede, 2009; Løkkeborg et al., 2002). There is also evidence that turbine reef habitats and the resources they provide increase the growth and condition of juvenile Atlantic Cod and Whiting-Pout (*Trisopterus luscus*; Reubens et al., 2014). Although reef habitat created by turbine foundations may increase biodiversity and ecosystem production, these introduced habitats could also act as a stepping-stone for the establishment and dispersal of nonindigenous species (Glasby et al., 2007).

The presence of the turbines in the WDA may also alter the local ocean circulation in the region, potentially changing current plankton distribution and dispersal patterns. Hydrodynamic modeling simulating larval transport around turbines in the MA WEA found that the presence of turbine structures would not have significant influence on southward larval transport during storm events (Chen et al., 2016).

Offshore Export Cable Corridor

As in the WDA, rock or concrete mattresses may be required along the OECC in areas where target burial depths cannot be achieved. The addition of rock or concrete mattresses would permanently alter soft bottom habitat to hard bottom habitat in some areas. In other areas, rock protection would be placed on bottom habitat already classified as hard bottom substrate. The maximum amount of permanent bottom habitat altered by rock protection would be less than 0.14 km^2 (35 acres). As noted above for the WDA, the addition of hard bottom structure in these previously flat, soft sediment areas may attract different species and act as artificial reef habitat.

6.6.2.2.2 Increased Noise

Wind Development Area

The ability of fish to detect noise varies greatly among species. Fish with swim bladders involved in hearing, such as cod, are the most sensitive to anthropogenic noises (Popper et al., 2014; Wahlberg & Westerberg, 2005). Research on the impact of wind turbine operational noises is very limited due to the small number of farms in operation today. A review conducted on five offshore wind farms in the UK found that some wind farm areas produced enough noise to mildly disturb Atlantic Cod from up to 200 m (656 ft) (Cheesman, 2016).

Underwater noise level is also related to turbine power and wind speed, with increased wind speeds creating increased underwater sound (Wahlberg & Westerberg, 2005; Cheesman, 2016). At high wind speeds, Wahlberg & Westerberg (2005) estimated permanent avoidance by fish would only occur within a range of four meters (13 ft) of a turbine. In a study on fish near the Svante wind farm in Sweden, Atlantic Cod and Roach (*Rutilus rutilus*) catch rates were significantly higher near turbines when rotors were stopped, which could indicate fish attraction to turbine structure and avoidance to generated noise (Westerberg, 2000 *as cited in* Thomsen et al., 2006). Alternatively, no avoidance behavior was detected and fish densities increased around turbine foundations of the Lillgrund offshore wind farm in Sweden (Bergström et al., 2013). In addition, ambient noise can influence how fish detect other sounds and a change in background noise could alter how fish perceive and react to biological noise stimuli (Popper & Fay, 1993). Overall, current literature indicates noise generated from the operation of wind farms is minor and does not cause injury or lead to permanent avoidance at distances greater than one km [0.6 mi] (Cheesman, 2016; Stenberg et al., 2015; Wahlberg & Westerberg, 2005).

Sound would not be emitted from inter-array cables when the wind farm is in operation. Impacts of increased vessel traffic during maintenance activities would be similar to those described for vessels in the construction and installation phase.

6.6.2.2.3 Electromagnetic Fields

Wind Development Area and Offshore Export Cable Corridor

Electrosensitivity has been documented in elasmobranchs (sharks, skates, and rays) and some teleost fish species (ray-finned fishes), though research on the impact of anthropogenic electromagnetic fields ("EMF") on marine fish is limited. In general, elasmobranch species are present seasonally in the Project Area with varying annual abundances (NODP, 2017). The most commonly caught elasmobranchs in the Project Area include Little Skate and Winter Skate (NEFSC, 2016). EMF would be generated by inter-array cables connecting wind turbines in the WDA and from cables along the OECC. Fish use electromagnetic sense for orientation and prey detection and therefore, the function of key ecological mechanisms may be impacted by EMF generated by the cables (Riefolo et al., 2016). Because EMF produced by cables decreases with distance, and the target burial depth for the cables is 1.5-2.5 m (5-8 ft), the magnetic field at the seabed would be expected to be weak and likely only detectable by demersal species (Normandeau et al., 2011). A study by BOEM found that although there were changes in the behavior of Little Skate, an elasmobranch, and American Lobster in the presence of energized cables, EMF from cables did not act as a barrier to movement in any way (Hutchison et al., 2018). In addition, research investigating habitat use around energized cables found no evidence that fish or invertebrates were attracted to or repelled by EMF emitted by cables (Love et al., 2017). To date, there is no evidence linking anthropogenic EMF from wind turbine cables to negative responses in fish (Baruah, 2016; Normandeau et al., 2011).

Modeling of EMF from project specific submarine cables indicated magnetic fields from both AC and DC cables would be much lower than the Earth's magnetic field and likely only able to be sensed, if at all, directly over the cable centerline (Gradient, 2017). Modeling also confirmed that EMF from cables decreases with distance and therefore, because cables in in the WDA and OECC will be buried below ~2 m (6.6 ft) of sediment, it is unlikely that demersal or benthic organisms will be impacted by EMF produced by the cables in Project Area.

6.6.2.2.4 Cable Repair

Wind Development Area and Offshore Export Cable Corridor

Cable repair, as described in Volume I, may infrequently occur along limited segments of the cables. Procedures employed to repair segments of cable in the WDA and OECC will involve bringing the cable to the surface for repair, followed by re-installation of the cable.

Impacts to fish species would be similar to those explained above, and are expected to include displacement of mobile juvenile and adult fish, injury to immobile or slower life stages or species, and temporary disturbance of benthic and pelagic habitat.

6.6.2.2.5 Avoidance, Minimization, and Mitigation Measures

The mitigation measures would be the same as discussed previously for construction and installation.

6.6.2.2.6 Summary

Impacts that may occur during operation and maintenance include alteration of habitat, increased noise, and maintenance construction. Limited habitat will be altered from non-structure to structure habitat in the WDA and may cause a change in fish assemblage in the area. Increased noise from the operation of the turbines will increase background noise and, as previous research indicates, may elicit avoidance responses in some species. Required maintenance of the turbines or cables may impact organisms in a similar manner as construction and installation.

In summary, impacts to finfish and invertebrates during operation and maintenance of the Project are expected to be localized and population level impacts are unlikely. Little to no direct mortality would occur, other than potentially during cable repair, which is expected to be rare and localized. The addition of hard structure habitat will add a complexity to the area that did not exist before and will likely attract species that prefer structured habitat. Overall, current literature indicates noise generated from the operation of wind farms is minimal and only localized avoidance behaviors are expected; acclimation to the noise over time may occur.

The addition of EMF from submarine cables will likely not have an impact on elasmobranchs or other electro-sensitive fish species, as cables will be buried in the substrate or covered with rock or concrete mattresses.

6.6.2.3 Decommissioning

6.6.2.3.1 Overall Impacts

Wind Development Area and Offshore Export Cable Corridor

Decommissioning activities would include removal of WTG and ESP foundations above the mudline. Scour protection will be removed. The offshore export cables could be retired in place or removed, subject to discussions with the appropriate regulatory agencies on the preferred approach to minimize environmental impacts. The decommissioning activities would be similar to those associated with construction. Removal of the scour protection from the WDA may result in a shift in the local finfish and invertebrate species assemblages to pre-construction, non-structure communities.

6.6.2.3.2 Avoidance, Minimization, and Mitigation Measures

The mitigation measures would be the same as discussed previously for construction and installation.

In summary, impacts will be very similar to construction and installation and are expected to be localized and short-term. Due to the long lifespan of the Project, it is also expected that technology will be enhanced by the time decommissioning occurs and impacts reduced.

6.7 Marine Mammals

6.7.1 Description of the Affected Environment

6.7.1.1 Overview

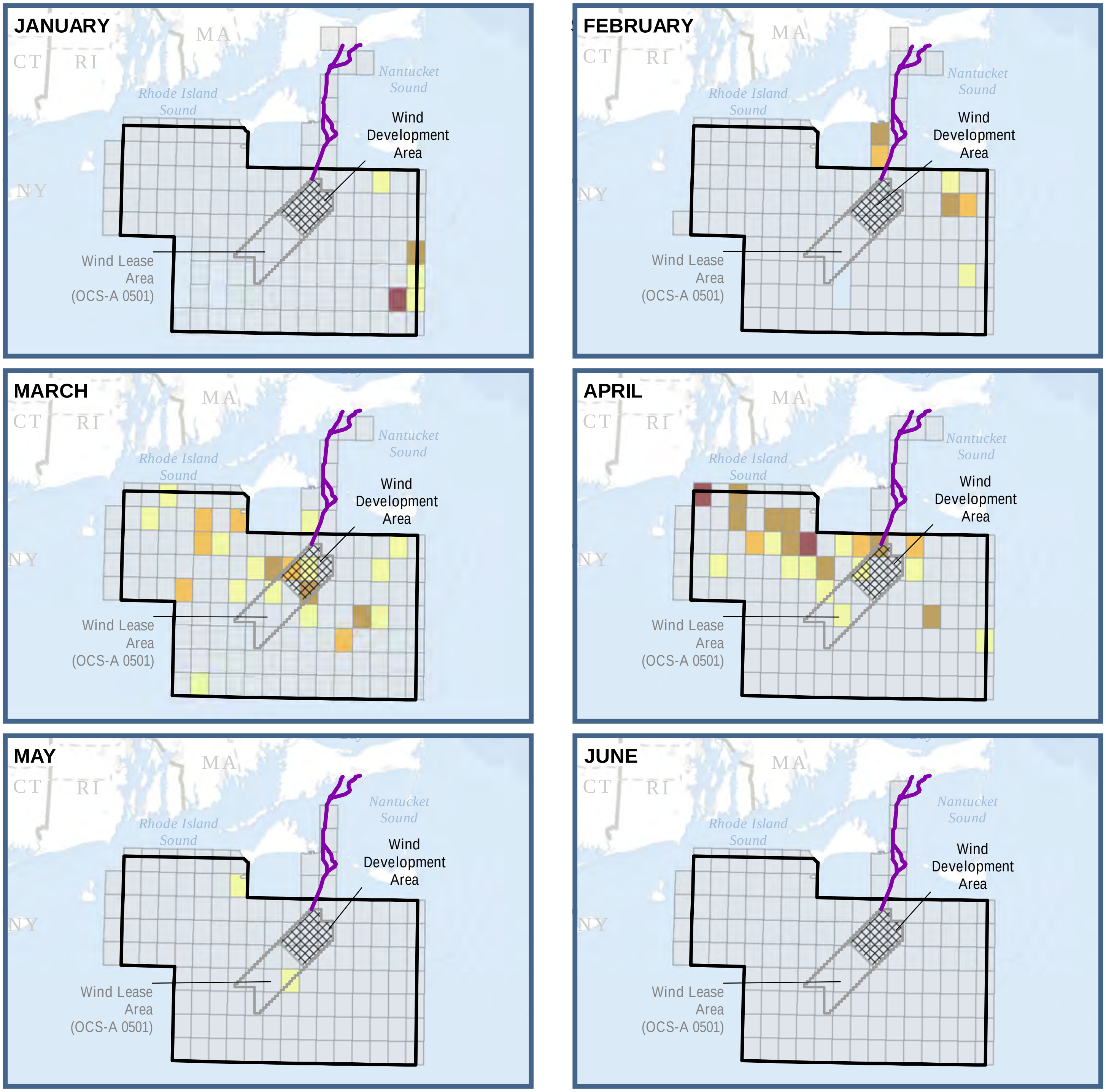
The Vineyard Wind Lease Area is south of Cape Cod and located within the Massachusetts Wind Energy Area ("MA WEA"), which was established by BOEM in 2012 through an intergovernmental renewable energy task force. More specifically, the Lease Area is located midway between Martha's Vineyard and Nantucket, just over 23 kilometers ("km") (14 miles ["mi"]) south of these islands. The Wind Development Area ("WDA"), a portion of the Vineyard Wind Lease Area and the Offshore Export Cable Corridor ("OECC") (see Figure 6.7-1[16]), is within the range of a variety of marine mammals. The description of the affected environment below reviews the distribution and use patterns of marine mammals in the WDA, OECC, and surrounding region. Species that occur within the US Atlantic (East Coast) Exclusive Economic Zone ("EEZ") are discussed generally with an evaluation of their likely occurrence in and near the Offshore Project Area (e.g., the WDA and/or the OECC). Species anticipated to potentially be affected by the Project are described in further detail.

This discussion of marine mammals is based on a review of existing literature. Existing data sources were also used to characterize the distribution, abundance, and composition of marine mammal species potentially affected by Project activities occurring within the WDA and the OECC. Some of the primary data sources for this review include the following:

<u>Northeast Large Whale Pelagic Survey</u>

The Northeast Large Whale Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles were conducted for the Massachusetts Clean Energy Center and BOEM by the Large Pelagic Survey Collaborative (comprised of the New England Aquarium, Cornell University's Bioacoustics Research Program, the University of Rhode Island and the Center for Coastal Studies) (Kraus et al., 2016). This study was designed to

[16] All figures associated with this section depict the outline of the Offshore Export Cable Corridor.



Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Kraus et al., 2016.; ESRI 2017, BOEMRE 2017; E&E 2017

Map Coordinate System: NAD 1983 UTM 19N Meters

** SPUE values are number of animals sighted per 1,000 km of survey track summarized by 5' x 5' grid cells*

N W E S

0 5 10 20 Nautical Miles

0 10 20 Kilometers

LEGEND

- State Boundary
- County Boundary
- Lease Area
- Wind Development Area
- Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles Study Area
- Offshore Export Cable Corridor

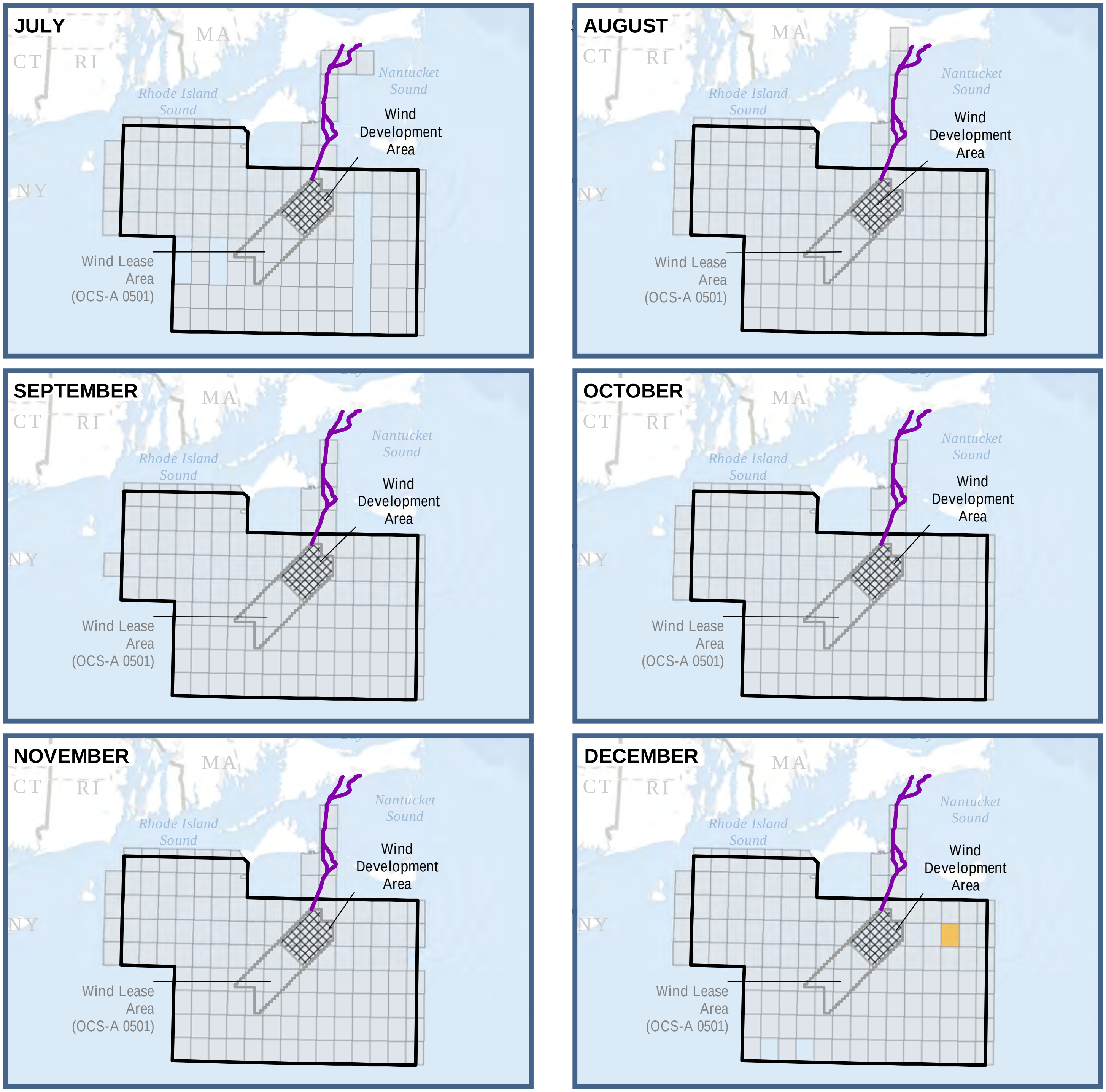
Right Whale Sightings per Unit Effort (SPUE*)
- 0
- > 1 - 30
- > 30 - 50
- > 50 - 150
- > 150 - 284

Vineyard Wind Project

VINEYARD WIND

Figure 6.7-1a

North Atlantic Right Whale Monthly Aerial Survey Sightings per Unit Effort 2011 to 2015 from Kraus et al. (2016) January to June



Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Kraus et al., 2016.; ESRI 2017, BOEMRE 2017; E&E 2017

Map Coordinate System: NAD 1983 UTM 19N Meters

** SPUE values are number of animals sighted per 1,000 km of survey track summarized by 5' x 5' grid cells*

N W E S

0 5 10 20 Nautical Miles

0 10 20 Kilometers

LEGEND

- State Boundary
- County Boundary
- Lease Area
- Wind Development Area
- Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles Study Area
- Offshore Export Cable Corridor

Right Whale

Sightings per Unit Effort (SPUE*)

- 0
- > 1 - 30
- > 30 - 50
- > 50 - 150
- > 150 - 284

Vineyard Wind Project

VINEYARD WIND

Figure 6.7-1b

North Atlantic Right Whale Monthly Aerial Survey Sightings per Unit Effort 2011 to 2015 from Kraus et al. (2016) July to December provide a comprehensive baseline characterization of the abundance, distribution, and temporal occurrence of marine mammals, with a focus on large endangered whales and sea turtles, in the Massachusetts and Rhode Island Wind Energy Areas ("MA/RI WEA") and surrounding waters. Information was collected using line-transect aerial surveys and passive acoustic monitoring ("PAM") from October 2011 to June 2015 and from December 2012 to June 2015 in in the MA/RI WEA. Seventy-six aerial surveys were conducted, and Marine Autonomous Recording Units were deployed for 1,010 calendar days, during the study period. For survey methodologies and details please refer to Kraus et al., 2016.

Atlantic Marine Assessment Program for Protected Species ("AMAPPS") Surveys

AMAPPS surveys represent the newest available survey data (NEFSC & SEFSC 2010, 2011, 2012, 2013, 2014, 2015, 2016). The data are more recent than those data used to create the cetacean habitat-based density models discussed below. Therefore, AMAPPs data was used to consider whether any deviations from predicted seasonal habitat use has occurred in recent years. Further, the abundance estimates used by National Oceanic and Atmospheric Administration ("NOAA") Fisheries for many of the marine mammals in the US Atlantic EEZ are based on the 2011 AMAPPS surveys (Hayes, Josephson, Maze-Foley, & Rosel 2017; Palka 2012). At least one survey in each survey year included the MA/RI WEA. Surveys were conducted from aerial and vessel-based platforms and in all four seasons of the year. AMAPPS surveys are ongoing.

Vineyard Wind, 2016 and 2017 Geophysical and Geotechnical ("G&G") Survey

Vineyard Wind conducted preliminary G&G surveys within the boundaries of the Lease Area in the fall of 2016 (Vineyard Wind, 2016) and late summer and fall of 2017 (Vineyard Wind, 2017). Activities occurred onboard the Research Vessel ("RV") *Shearwater*, the RV *Ocean Researcher*, and the RV *Synergy* over 54 survey days (excluding weather events) during the 2016 surveys. In 2017, activities occurred onboard the RV *Henry Hudson* and RV *Shearwater* over 47 surveys days (excluding weather events). Protected species observers ("PSOs") monitored the areas surrounding the survey boats for marine mammals and sea turtles using visual observation and PAM. The following marine mammal species were visually observed during the surveys:

- Gray Seal (Halichoerus grypus grypus)
- Unknown seal
- Unidentified dolphin or porpoise
- Short-Beaked Common Dolphin (Delphinus delphis)
- Unknown large whale

Short-Beaked Common Dolphins and unidentified dolphins were also detected acoustically. See Sections 6.7.1.2 and 6.7.1.3 for further details of visual observations and acoustic detections of marine mammals during the Vineyard Wind G&G surveys.

Marine Mammal Stock Assessment Reports (SARs)

Every year, NOAA Fisheries releases Stock Assessment Reports ("SARs") for marine mammals that occur in the US Atlantic EEZ as required under the 1994 amendments to the Marine Mammal Protection Act ("MMPA") (16 U.S.C. § 1361 et seq.). NOAA Fisheries works with regional offices to develop the technical reports by revising older SARs as new data become available (Hayes et al., 2017). Not all species' SARs are updated each year; the MMPA requires that NOAA Fisheries revise strategic stocks annually and non-strategic stock at least every three years. These reports must contain specified information such as broadly described geographic range, serious injury and mortality estimates, abundance estimates, stock status, and observed fisheries bycatch. In addition, when possible, the reports determine a minimum population estimate, maximum best productivity rate, population trend, and an estimate of the potential biological removal (i.e., maximum number of animals that may be removed from a marine mammal stock without reducing numbers below the optimum sustainable population) for each species. The number of SARs changes over time as stocks, and their definitions, shift.

Duke University Habitat-Based Cetacean Density Models

Duke University Habitat-Based Cetacean Density Models (Roberts et al., 2016) combine data from 15 aerial and shipboard surveys covering 895,000 km of trackline in the western Atlantic over 22 years from 1992 to 2014. Using data across multiple years allows for analysis of rare and cryptic species, for which there would be insufficient data for analysis in any given survey, and smooths interannual variation for a general prediction over time. This modeling assumes relatively similar population sizes and habitat preferences over time. Monthly density predictions were made in cases in which data were sufficient. If data were not sufficient to assess density by month, an average annual estimate was made. The Roberts et al., (2016) models do not include the AMAPPS data (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016) as discussed above.

In addition, this discussion relies on sources cited in the Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore Massachusetts – Revised Environmental Assessment (BOEM, 2014) and the Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf in Massachusetts, Rhode Island, New York and New Jersey Wind Energy Area Endangered Species Act Section 7 Consultation Biological Opinion (NOAA, 2013).

The term "marine mammal" is a purely descriptive term referring to mammals that carry out all or a substantial part of their foraging in marine or, in some cases, freshwater environments. Marine mammals as a group are comprised of various species from three orders (Cetacea, Carnivora, and Sirenia). Cetaceans are divided into two major suborders: Mysticeti (baleen whales) and Odontoceti (toothed whales). Toothed whales are generally smaller and have teeth that are used to capture prey. Baleen whales use baleen to filter their prey from the water. In addition to contrasting feeding methods, there are differences in the life history and social organization of these two groups (Tyack, 1986). Pinnipeds (Order Carnivora) are divided into three families: Phocidae (earless seals), Otariidae (sea lions and fur seals), and Odobenidae (walruses). Of the pinnipeds, only Earless Seals occur in and around the Offshore Project Area. The four living Sirenian species are classified into two families: Trichechidae (includes three species of manatees); and Dugongidae (only includes the Dugong).

More than 120 species of marine mammals occur worldwide (Rice, 1998), 42 of which have been documented within the US Atlantic EEZ (CeTAP, 1982; Hayes et al., 2017; Roberts et al., 2016; USFWS, 2014). Of these 42, the following 16 species are not expected to occur within the Offshore Project Area based on lack of sightings and known habitat preferences and distributions of the species (Hayes et al., 2017; Kenny & Vigness-Raposa, 2010; Kraus et al., 2016; Roberts et al., 2016; USFWS, 2014):

- West Indian Manatee (Trichechus manatus latirostris)
- Bryde's Whale (Balaenoptera edeni)
- Beluga Whale (Delphinapterus leucas)
- Northern Bottlenose Whale (Hyperoodon ampullatus)
- Killer Whale (Orcinus orca)
- Pygmy Killer Whale (Feresa attenuate)
- False Killer Whale (Pseudorca crassidens)
- Melon-headed Whale (Peponocephala electra)
- White-beaked Dolphin (Lagenorhynchus albirostris)
- Pantropical Spotted Dolphin (Stenella attenuate)
- Fraser's Dolphin (*Lagenodelphis hosei*)
- Rough-toothed Dolphin (*Steno bredanensis*)

- Clymene Dolphin (*Stenella clymene*)
- Spinner Dolphin (*Stenella longirostris*)
- Hooded Seal (*Cystophora cristata*)
- Ringed Seal (*Pusa hipsida*)

Twenty-six species occur at least occasionally within the WDA, OECC, and adjacent waters (BOEM, 2014; Hayes et al., 2017; Kenney & Vigness-Raposa, 2010; Kraus et al., 2016; Roberts et al., 2016), and are listed in Table 6.7-1. These species are discussed in Sections 6.7.1.2 and 6.7.1.3. The species noted as rare in Table 6.7-1 are unlikely to be exposed to Project activities, and are not discussed in detail. Probability of exposure to stressors from the Project is related to occurrence. Therefore, probability of exposure is low if the species has rarely been observed in the MA/RI WEA and surrounding waters, or if the primary year-round distribution of the species is elsewhere and no individuals were visually observed during the Northeast Large Whale Pelagic Survey. The species noted as rare in Table 6.7-1 are briefly addressed in the following paragraph.

The Blue Whale, listed under the Endangered Species Act ("ESA") (16 U.S.C §.1531 et seq.) (35 Fed. Reg. 8491 [June 2, 1970]), is endangered and rare in nearshore waters of Massachusetts; Hayes et al., (2017) reports that this species is considered an occasional visitor in the US Atlantic EEZ and typically occurs north of the EEZ. Blue Whales were detected acoustically during PAM but were never visually observed in the RI/MA WEA between 2011-2015 (Kraus et al., 2016). The acoustic detection radius for Blue Whales exceeded 140 km (75.5 nautical miles ["nm"]) making it difficult to specify the location of vocalizing blue whales. Blue Whales were only detected on 3.9% of days analyzed (40/1,020 days) and there was not a discernable seasonal trend (Kraus et al., 2016). Exposure probability for this species is low, and there is no anticipated loss or disturbance of individual Blue Whales. Based on sighting and distribution data, other species that are rare enough that exposure probability is low include Dwarf and Pygmy Sperm Whales (*Kogia sima and K. breviceps*), Cuvier's Beaked Whale (*Ziphius cavirostris*), Mesoplodont Beaked Whales (*Mesoplodon* spp.), Atlantic Spotted Dolphin (*Stenella frontalis*), Striped Dolphin (*Stenella coeruleoalba*), and the Western North Atlantic Northern Migratory Coastal stock of Common Bottlenose Dolphin (Hayes et al., 2017; Kraus et al., 2016; Roberts et al., 2016; Kenny & Vigness-Raposa, 2010). These species, along with Blue Whales, will not be considered further because exposure probability is low.

Species that occur in and near the Offshore Project Area, but are relatively uncommon, include Sperm Whale (*Physeter macrocephalus*), Risso's Dolphin (*Grampus griseus*), Short-finned Pilot Whale (*Globicephalus macrorhynchus*), and Harp Seal (*Pagophilus groenlandicus*). Sighting and distribution data suggest that Risso's Dolphins and Sperm

Whales typically occur in deeper waters along the continental slope and oceanic waters (Hayes et al., 2017; Roberts et al., 2016), though both species were observed during aerial surveys of MA/RI WEA from 2011-2015 (Kraus et al., 2016). Between 2011 and 2015, Kraus et al., (2016) made two sightings of individual Risso's Dolphins in spring, one sighting of one Sperm Whale in fall, and three sightings totaling eight Sperm Whales in summer. Short-finned Pilot Whales (*G. macrorhynchus*) tend to occur south of the Offshore Project Area, and are typically observed on the continental slope and in oceanic waters in the northern part of their range (Hayes et al., 2017; Roberts et al., 2016). Pilot Whales were observed during Kraus et al., (2016)'s aerial surveys of MA/RI WEAs; however, due to the difficulty in distinguishing between Long-finned and Short-finned Pilot Whales, the specific species of Pilot Whale was not clarified. However, the distribution records of Pilot Whales suggest these were likely Long-Finned Pilot Whales since these are more common (*G.melas*; Hayes et al., 2017). Harp Seals typically range north of the Offshore Project Area, though they strand annually in Massachusetts and Rhode Island (Hayes et al., 2017). Uncommon species may experience small levels of individual exposure probability and so are considered further (see Table 6.7-1).

Species that are likely to occur in the Offshore Project Area, and are considered common, include the North Atlantic Right Whale ("NARW"; *Eubalaena glacialis*), Humpback Whale (*Megaptera novaeangliae*), Fin Whale (*Balaenoptera physalus physalus*), Sei Whale (*Balaenoptera borealis*), Minke Whale (*Balaenoptera acutorostrata acutorostrata*), Long-Finned Pilot Whale, Atlantic White-Sided Dolphin (*Lagenorhynchus acutus*), Short-Beaked Common Dolphin, Bottlenose Dolphin (Western North Atlantic Offshore Stock), Harbor Porpoise (*Phocoena phocoena*), Harbor Seal (*Phoca vitulina concolor*), and Gray Seal (BOEM, 2014; Hayes et al., 2017; Kenney & Vigness-Raposa, 2010; Kraus et al., 2016; Roberts et al., 2016). Because of their common use of the WDA, OECC, and surrounding areas, these species are likely to be exposed to stressors, such as noise, increased vessel traffic, and structures in the water that may result in short-term, localized disturbance of individuals and/or long-term, localized modification of habitat. Thus, these species are considered further (see Table 6.7-1).

6.7.1.2 Threatened and Endangered Marine Mammals

All marine mammals are protected by the MMPA. Four large whale species that occur in the Offshore Project Area are listed as endangered and, therefore, are afforded additional protection under the ESA. These species are the NARW, Fin Whale, Sei Whale, and Sperm Whale (35 Fed. Reg. 8491 [June 2, 1970]).

The following section provides information on the biology, habitat use, abundance, distribution, and the existing threats to these ESA-listed marine mammals that are both in Massachusetts offshore waters and have the likelihood of occurring, at least seasonally, in the Offshore Project Area. Marine mammal hearing is discussed in Section 6.7.2.1.1.

North Atlantic Right Whale. NARWs are among the rarest of all marine mammal species in the Atlantic Ocean. They average approximately 15 meters ("m") (50 feet ["ft"]) in length (NOAA, 2016k). They have stocky, black bodies with no dorsal fin, and bumpy, coarse patches of skin on their heads called callosities. NARW feed mostly on zooplankton and copepods belonging to the *Calanus* and *Pseudocalanus* genera (Hayes et al., 2017). NARWs are slow-moving grazers that feed on dense concentrations of prey at or below the water's surface, as well as at depth (NOAA, 2016k). Research suggests that NARWs must locate and exploit extremely dense patches of zooplankton to feed efficiently (Mayo & Marx, 1990). These dense zooplankton patches are a primary characteristic of the spring, summer, and fall NARW habitats (Kenney, Hyman, Owen, Scott, & Winn, 1986; Kenney, Winn, & Macaulay, 1995).

These baleen whales are considered to be two separate stocks: the Eastern and Western Atlantic stocks. NARWs in US waters belong to the Western Atlantic stock. The Western Atlantic stock ranges primarily from calving grounds in coastal waters of the southeastern US to feeding grounds in New England waters and the Canadian Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence (Hayes et al., 2017).

Table 6.7-1 Marine Mammals that Potentially Occur in the WDA and OECC: Abundance, Status, Distribution, and Occurrence

Species	Scientific Name	Stock	Best Population Estimate in SAR[a]	Population Estimate Roberts et al., (2016)[b]	Strategic Status under MMPA[c]	Endangered Species Act Status	Occurrence within Offshore Project Area[d]
North Atlantic Right Whale	*Eubalaena glacialis*	Western North Atlantic	440[e]	535 Winter, 416 Spring, 379 Summer, 334 Fall	Strategic	Endangered	Common
Humpback Whale	*Megaptera novaeangliae*	Gulf of Maine	823[e]	205 Winter, 1,637 Summer	None	None	Common
Fin Whale	*Balaenoptera physalus physalus*	Western North Atlantic	1,618	4,633	Strategic	Endangered	Common
Sei Whale	*Balaenoptera borealis*	Nova Scotia	357	98 Winter, 627 Spring, 717 Summer, 37 Fall	Strategic	Endangered	Common (but less common than other common baleen whales)
Minke Whale	*Balaenoptera acutorostrata acutorostrata*	Canadian east coast	2,591	2,112 Summer, 740 Winter	None	None	Common
Blue Whale	*Balaenoptera musculus musculus*	Western North Atlantic	Unknown	11	Strategic	Endangered	Rare
Sperm Whale	*Physeter macrocephalus*	North Atlantic	2,288	5,353	Strategic	Endangered	Uncommon
Dwarf and Pygmy Sperm Whale	*Kogia sima* and *K. breviceps*	Western North Atlantic	2,598	3,785	None	None	Rare
Cuvier's Beaked Whale	*Ziphius cavirostris*	Western North Atlantic	6,532	14,491[f]	None	None	Rare
Mesoplodont Beaked Whales (Blainville's, Gervais', True's, Sowerby's)	*Mesoplodon* spp.	Western North Atlantic	7,092	14,491[f]	None	None	Rare
Risso's Dolphin	*Grampus griesus*	Western North Atlantic	18,250	7,732	None	None	Uncommon
Pilot Whale, Long-Finned	*Globicephalus melas*	Western North Atlantic	5,636	18,977[g]	Strategic	None	Uncommon
Pilot Whale, Short-Finned	*Globicephalus macrorhynchus*	Western North Atlantic	21,515	18,977[g]	Strategic	None	Rare
Atlantic White-Sided Dolphin	*Lagenorhynchus acutus*	Western North Atlantic	48,819	37,180	None	None	Common
Short-Beaked Common Dolphin	*Delphinus delphis*	Western North Atlantic	70,184	86,098	None	None	Common
Atlantic Spotted Dolphin	*Stenella frontalis*	Western North Atlantic	44,715	55,436	None	None	Rare
Striped Dolphin	*Stenella coeruleoalba*	Western North Atlantic	54,807	75,657	None	None	Rare
Common Bottlenose Dolphin*	*Tursiops truncatus*	Western North Atlantic, offshore	77,532	97,476h	None	None	Common
Common Bottlenose Dolphin*	*Tursiops truncatus*	Western North Atlantic, northern migratory coastal	11,548	97,476h	Strategic	None	Rare

Table 6.7-1 Marine Mammals that Potentially Occur in the WDA and OECC: Abundance, Status, Distribution, and Occurrence (Continued)

Species	Scientific Name	Stock	Best Population Estimate in SAR[a]	Population Estimate Roberts et al., (2016)[b]	Strategic Status under MMPA[c]	Endangered Species Act Status	Occurrence within Offshore Project Area[d]
Harbor Porpoise	*Phocoena phocoena*	Gulf of Maine/Bay of Fundy	79,883	17,651 Winter, 45,089 Summer	None	None	Common
Harbor Seal	*Phoca vitulina concolor*	Western North Atlantic	75,834	Not Estimated	None	None	Common
Gray Seal	*Halichoerus grypus*	Western North Atlantic	Unknown[i]	Not Estimated	None	None	Common
Harp Seal	*Pagophilus groenlandicus*	Western North Atlantic	Unknown[i]	Not Estimated	None	None	Uncommon

*Bottlenose dolphins are listed twice because there are two stocks that potentially occur within the Offshore Project Area.

Notes:

[a] Best population estimates provided in the SARs (Hayes et al., 2017) generally consider only the portion of the population found in US Atlantic EEZ waters and may not include the entire US range depending on available survey data. Most cetacean population estimates are based on 2011 AMAPPS surveys (Hayes et al., 2017; NEFSC & SEFSC, 2011; Palka, 2012), with the exceptions of the following: Humpback Whales are based on surveys in the Gulf of Maine and Bay of Fundy in 2008; North Atlantic Right Whales are based on maximum number of photo-identified individuals (in 2012); Northern Migratory Stock of Bottlenose Dolphins is based on aerial surveys in 2010 and 2011 from Florida to New Jersey; Short-Beaked Common Dolphins are based on Canadian Trans-North Atlantic Sighting Survey in 2007 and include areas outside the EEZ. The Harbor Seal population estimate is based on 2012 surveys along the Maine coast. SARs often provide information on abundance estimates from larger or different parts of stock ranges when such estimates are available, but these estimates are not provided in this table.

[b] Roberts et al., (2016) uses habitat-based density modeling of 22 years of sighting data to predict densities of cetaceans in the US Atlantic EEZ. These models are often used for evaluating marine mammal harassment estimates for Incidental Harassment Authorizations and represent integrated population abundance estimates across multiple years of surveys. Roberts et al., (2016) does not include the NEFSC & SEFSC (2011) surveys used in Palka (2012) to estimate abundance for most species in the SARs (Hayes et al. 2017).

[c] The MMPA defines a “strategic” stock as a marine mammal stock (a) for which the level of direct human-caused mortality exceeds the potential biological removal level; (b) which, based on the best available scientific information, is declining and is likely to be listed as a threatened species under the ESA within the foreseeable future; or (c) which is listed as a threatened species or endangered species under the ESA, or (d) is designated as depleted.

[d] Occurrence in the Offshore Project Area was mainly derived from sightings and information in Hayes et al., (2017), Kenney & Vigness-Raposa (2010), Kraus et al., (2016), and Roberts et al., (2016).

[e] The minimum population estimate is reported as the best population estimate in the SAR.

[f] Roberts et al., (2016) grouped the following species in their analysis: Blainsville’s Beaked Whale (*Mesoplodon densirostris*), Cuvier’s Beaked Whale, Gervais’ Beaked Whale (*M. europaeus*), Sowerby’s Beaked Whale (*M. bidens*) and True’s Beaked Whale (*M. mirus*).

[g] Roberts et al., (2016) grouped Long-Finned and Short-Finned Pilot Whales in their analysis.

[h] Roberts et al., (2016) did not differentiate the stocks of Bottlenose Dolphins, similar to how NOAA Fisheries estimates in stock assessments.

[i] Hayes et al., (2017) report the population sizes of these seal species as “unknown” because surveys have not been conducted within the US due to the northerly location of rookeries; however, they also report that estimates based on surveys at pupping areas north of the US have resulted in population estimates of 505,000 Gray Seals in 2014, and 7.1 million Harp Seals in 2012.

The size of the Western Atlantic stock is considered extremely low relative to its Optimum Sustainable Population ("OSP") in the US Atlantic EEZ (Hayes et al., 2017). The Western Atlantic NARW is classified as a strategic stock under the MMPA and is listed as endangered under the ESA. Historically, the population suffered severely from commercial overharvesting and has more recently been threatened by incidental fishery entanglement and vessel collisions (Pace, Corkeron, & Kraus, 2017; Knowlton & Kraus, 2001; Kraus et al., 2005). The minimum rate of annual human-caused mortality and serious injury to NARWs averaged 5.66 per year for the period of 2010 through 2014 (Hayes et al., 2017).

Hayes et al., (2017) reports a minimum of 440 individuals in this stock based on photo-identification recapture data from 2012. A recent estimate of 529 photographed individuals was reported in the NARW annual report card, but the best estimate of living whales was reported to be 451 (Pettis, Pace, Schick, & Hamilton, 2017) based on Pace et al., (2017), which reports a 99.99% probability of NARW population decline from 2010 to 2015. This estimate does not consider that NARWs have been experiencing an unusual mortality event since June 2017, with 16 documented deaths as of October 31, 2017 (NOAA, 2017d). This unusual mortality event appears to be driven by entanglement and trauma associated with fisheries interactions mainly in Canada. In addition to 16 deaths, five live NARWs entangled in fishing gear were recorded (Daoust, Couture, Wimmer, & Bourque, 2017; NOAA, 2017d). Cause of death findings for the unusual mortality event are based on six necropsies of the dead NARWs found in Canada in the Gulf of St. Lawrence (Daoust et al., 2017).

The NARW is a migratory species that travels from high-latitude feeding waters to low-latitude calving and breeding grounds, though this species has been observed feeding in winter in the mid-Atlantic region and was recorded off the coast of New Jersey in all months of the year (Whitt, Dudzinski, & Laliberte, 2013). These whales undertake a seasonal migration from their northeast feeding grounds (generally spring, summer, and fall habitats) south along the US East Coast to their calving grounds in the waters of the southeastern US (Kenney & Vigness-Raposa, 2010).

NARWs are usually observed in groups of less than 12 individuals, and most often as single individuals or pairs. Larger groups may be observed in feeding or breeding areas (Jefferson, Webber, & Pitman, 2008). Surveys have demonstrated the existence of seven areas where Western Atlantic NARWs congregate seasonally: the coastal waters of the southeastern US; the Great South Channel; Jordan Basin; Georges Basin along the northeastern edge of Georges Bank; Cape Cod and Massachusetts Bays; the Bay of Fundy; and the Roseway Basin on the Scotian Shelf (Hayes et al., 2017). NOAA Fisheries has designated two critical habitat areas for the NARW under the ESA: the Gulf of Maine/Georges Bank region, and the southeast calving grounds from North Carolina to Florida (81 Fed. Reg. 4837 [2016]). Two additional critical habitat areas in Canadian waters, Grand Manan Basin and Roseway Basin, were identified in Canada's final recovery strategy for the NARW (Brown et al., 2009).

NEFSC observed NARWs three times in the WDA during two AMAPPS surveys in 2014 (NEFSC & SEFSC, 2011, 2012, 2013, 2014, 2015, 2016). Two observations of NARWs in the WDA were in the winter during an aerial survey; one observation was in the spring during a shipboard survey (NEFSC & SEFSC, 2014).

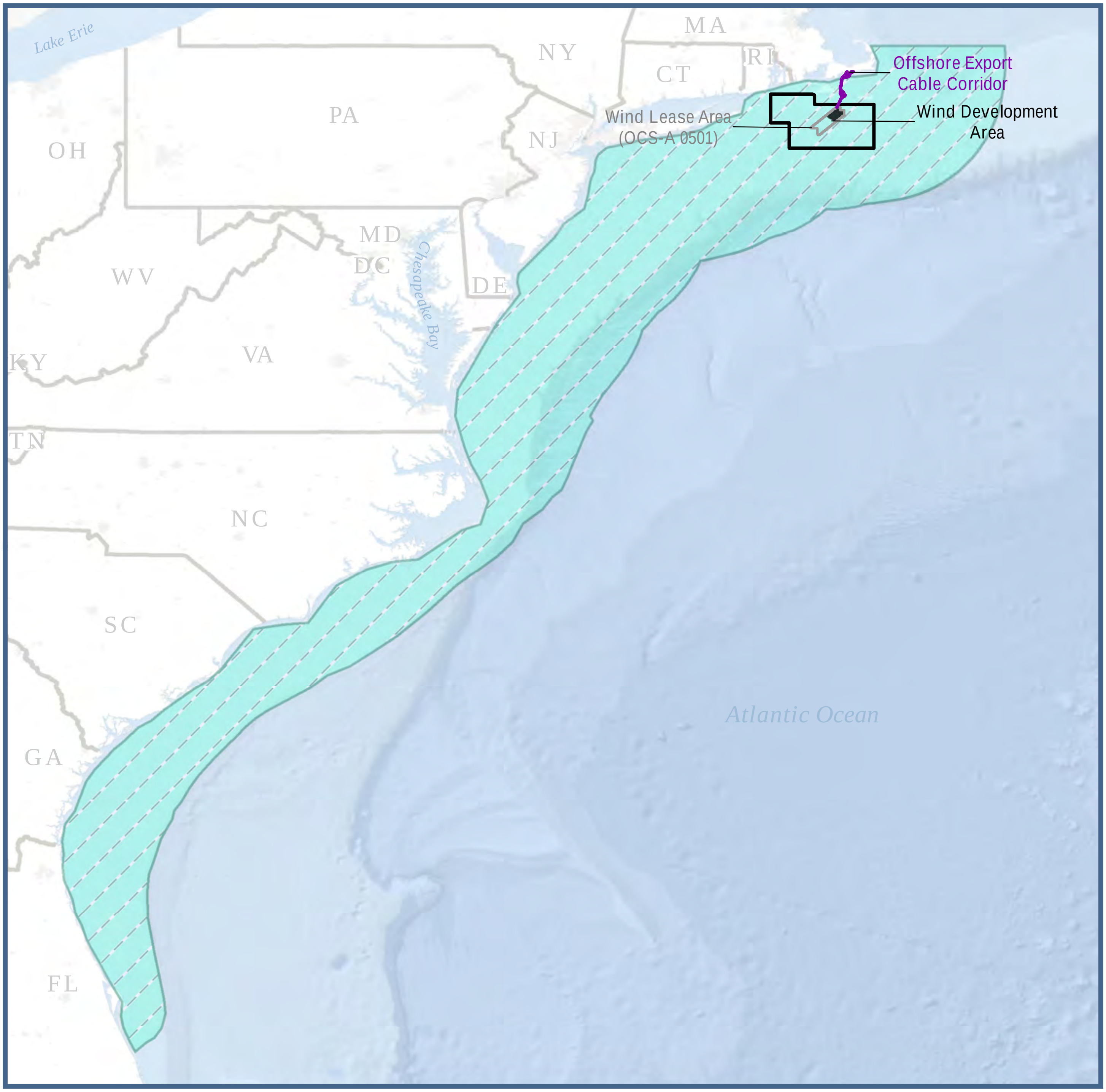
Kraus et al., (2016) observed NARWs in the MA/RI WEAs in winter and spring and observed 11 instances of courtship behavior. The greatest sightings per unit effort ("SPUE") in the MA/RI WEAs by Kraus et al., (2016) was in March, with a concentration of spring sightings in the WDA and winter sightings in the OECC. Seventy-seven unique individual NARWs were observed in the MA/RI WEAs over the duration of the Northeast Large Whale Pelagic Survey (October 2011-June 2015) (Kraus et al., 2016). Monthly SPUE for NARWs by Kraus et al., (2016) are shown in Figure 6.7-1. No calves were observed. Kraus et al., (2016) acoustically detected NARWs with PAM within the MA WEA on 43% of project days (443/1,020 days) and during all months of the year. Acoustic detections do not differentiate between individuals, so detections on multiple days could be the same or different individuals. The NARWs exhibited notable seasonal variability in acoustic presence, with maximum occurrence in the winter and spring (January through March), and minimum occurrence in summer (July, August, and September). Mean detection range for NARWs using PAM ranged from 15-24 km (49.2-78.7 ft), with a mean radius of 21 km (13 mi) (95% Confidence Interval of three kilometers [1.8 mi]) for the PAM system within the WDA. However, not all NARWs recorded by PAM in the MA WEAs were likely to be within a distance of the Project that would result in any disturbance of individuals by construction and operation. Keeping in mind that such estimates were based on a number of assumptions and are not species-specific, the maximum distance from pile driving to behavioral harassment for low frequency cetaceans such as NARWs was estimated at 7,116 m (23,346 ft) with no sound reduction technology (unweighted; 160 dB; 10.3 m monopiles; see Appendix III-M Table A-10). Vineyard Wind will use sound reduction technology, including Hydro-sound Dampers [HSD], bubble curtains, or similar technology, to achieve a target of approximately 12 dB of noise reduction, resulting in an estimated maximum behavioral harassment distance of 2,907 m (9,537 ft) (unweighted; 160 dB; 10.3 m monopiles; see Appendix III-M Table A-37). This results in a much smaller radius of disturbance than the mean detection range of the PAM system. Additionally, animals are less likely to respond to sound levels distant from a source, even when those levels elicit response at closer ranges; both proximity and received levels are important factors in behavioral response (Dunlop et al., 2017).

This species was not observed visually, or detected acoustically, in the Lease Area during the 2016 or 2017 G&G surveys for the Project (Vineyard Wind, 2016, 2017). Roberts et al., (2016) predict that the highest density of NARW in the MA WEA and adjacent waters occurs in April, and Kraus et al., (2016) reported greatest levels of SPUE of NARWs in the WDA in March (Figure 6.7-1). A NARW Biologically Important Area ("BIA") for migration occurs within the Lease Area from March to April and from November to December

(LaBrecque, Curtice, Harrison, Van Parijs, & Halpin, 2015). To determine BIAs, experts were asked to evaluate the best available information and to summarize and map areas important to cetacean species' reproduction, feeding, and migration. The purpose of identifying these areas was to help resource managers with planning and analysis. The NARW BIA for migration includes the MA/RI WEA and beyond to the continental slope, extending northward to offshore of Provincetown, MA and southward to halfway down the Florida coast. The edge seaward of the BIA shifts inshore of the continental slope off North Carolina and remains closer to shore to its southward extent. The shoreward edge remains in nearshore waters along the length of the BIA (see Figure 6.7-2) (LaBrecque et al., 2015).

Fin Whale. Fin Whales are the second-largest species of baleen whale, with a maximum length of about 22.8 m (75 ft) in the Northern Hemisphere (NOAA, 2016e). These whales have a sleek, streamlined body with a V-shaped head that makes them fast swimmers. This species has a distinctive coloration pattern: the dorsal and lateral sides of the body are black or dark brownish-gray and the ventral surface is white. Fin Whales feed on krill (Euphausiacea), small schooling fish (e.g., Herring [*Clupea harengus*], Capelin [*Mallotus villosus*], and Sand Lance [*Ammodytidae spp.*]), and squid (*Teuthida spp.*) by lunging into schools of prey with their mouths open (Kenney & Vigness-Raposa, 2010). They occur year-round in a wide range of latitudes and longitudes, but the density of individuals in any one area changes seasonally (NOAA, 2016e). Fin Whales are the most commonly observed large whales in continental shelf waters from the mid-Atlantic coast of the US to Nova Scotia (Sergeant, 1977; Sutcliffe & Brodie, 1977; CeTAP, 1982; Hain, Ratnaswamy, Kenney, & Winn, 1992).

Fin Whales off the eastern US, Nova Scotia, and the southeastern coast of Newfoundland are believed to constitute a single stock under the present International Whaling Commission scheme (Donovan, 1991), which has been called the Western North Atlantic stock. The best abundance estimate available for the Western North Atlantic Fin Whale stock in US waters is estimated at 1,618 individuals (Hayes et al., 2017). The status of this stock relative to OSP in the US Atlantic EEZ is unknown, but the North Atlantic population is listed as a strategic stock under the MMPA and is listed as endangered under the ESA. Waring, Josephson, Maze-Foley, & Rosel (2013) reported the abundance of Fin Whales estimated in Palka (2012) from 2011 NEFSC & SEFSC (2011) surveys; Lawson & Gosselin (2011) corrected estimates from Canadian surveys in 2007; and a survey by the National Marine Fisheries Service ("NMFS") in 2006 (unpublished data reported in Waring et al., 2013) that covers additional areas of the stocks range. The sum of these abundance estimates, which consider a larger portion of the Fin Whale breeding population range than Hayes et al., (2017), is 7,409. Newer estimates are being evaluated based on NEFSC & SEFSC (2016) surveys and concurrent surveys in Canadian waters. Like most other whale species along the US Atlantic EEZ, ship strikes and fisheries entanglements are perennial causes of serious injury and mortality. For the period 2010 through 2014, the minimum annual rate of human-caused mortality and serious injury to Fin Whales was 3.8 per year (Hayes et al., 2017).



Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
LaBrecque et al. 2015; ESRI 2017, BOEMRE 2017; E&E 2017

Map Coordinate System: GCS NAD83 (2011)

LEGEND

- State Boundary
- County Boundary
- Lease Area
- Wind Development Area
- Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles Study Area
- Offshore Export Cable Corridor
- North Atlantic Right Whale Biologically Important Area for migration

0 25 50 100 Nautical Miles
0 50 100 Kilometers

Vineyard Wind Project

VINEYARD WIND

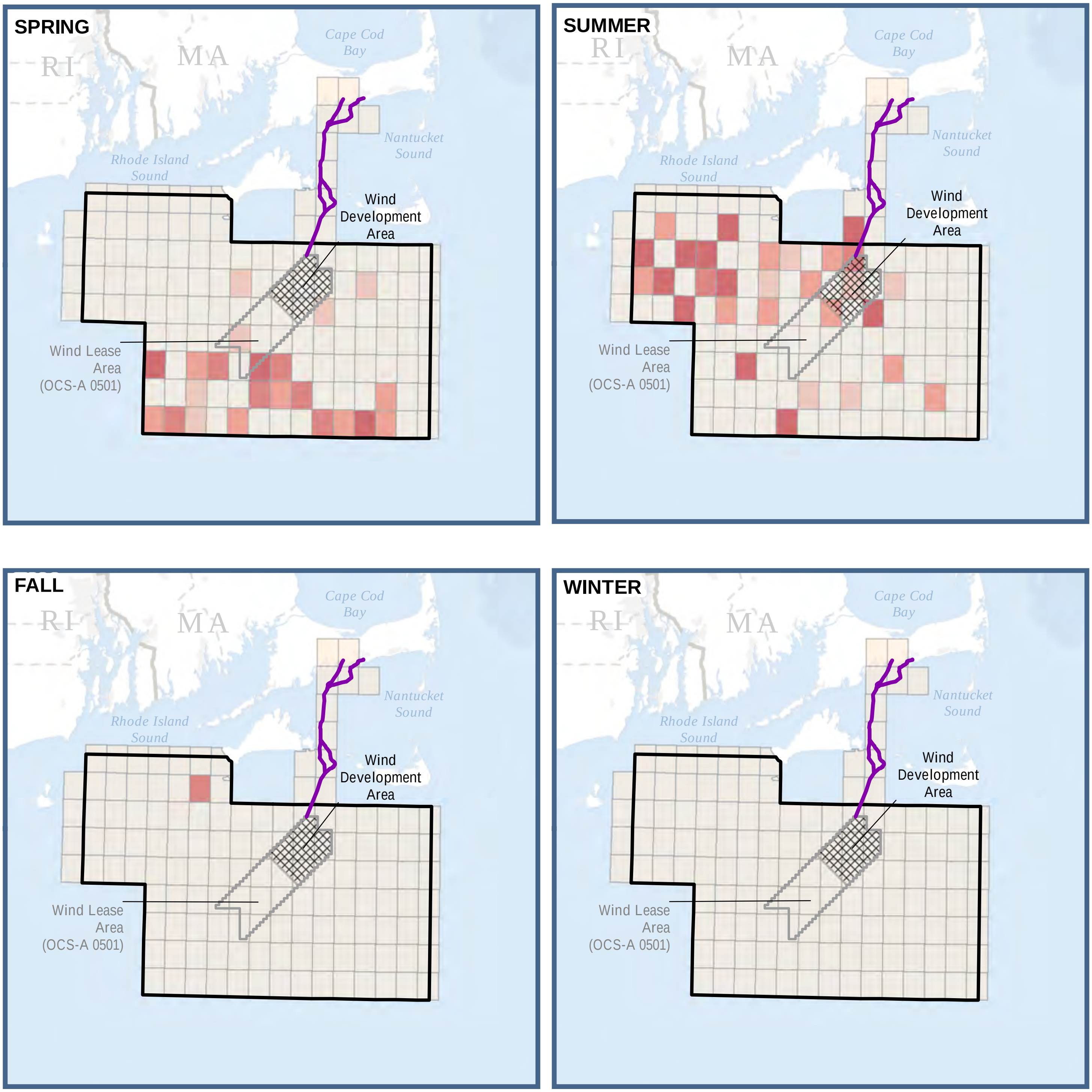
Figure 6.7-2
North Atlantic Right Whale Biologically Important Area for Migration March to April and November to December

The Fin Whale's range in the western North Atlantic extends from the Gulf of Mexico and Caribbean Sea, to the southeastern coast of Newfoundland (Hayes et al., 2017). Fin Whales are common in waters of the US Atlantic EEZ, principally from Cape Hatteras northward. While Fin Whales typically feed in the Gulf of Maine and the waters surrounding New England, mating and calving (and general wintering) areas are largely unknown (Hain et al., 1992; Hayes et al., 2017). It is likely that Fin Whales occurring in the US Atlantic EEZ undergo migrations into Canadian waters, open-ocean areas, and perhaps even subtropical or tropical regions. However, the popular notion that entire Fin Whale populations make distinct annual migrations like some other Mysticetes has questionable support (Hayes et al., 2017). Based on an analysis of neonate stranding (newborn whale beaching) data, Hain et al., (1992) suggest that calving takes place during October to January in latitudes of the US mid-Atlantic region.

Fin Whales are the dominant large cetacean species during all seasons from Cape Hatteras to Nova Scotia, having the largest standing stock, the largest food requirements, and, therefore, the largest influence on ecosystem processes of any baleen whale species (Hain et al., 1992; Kenney, Scott, Thompson, & Winn, 1997). There are currently no critical habitat areas established for the Fin Whale under the ESA.

NEFSC observed Fin Whales six times in the WDA during three AMAPPS surveys (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). One observation was in the summer of 2013 during a shipboard survey; three observations were in the summer of 2016 during a shipboard survey; and two observations were during fall of 2016 during an aerial survey (NEFSC & SEFSC, 2013, 2014, 2016).

Kraus et al., (2016) suggest that, compared to other baleen whale species, Fin Whales have a high multi-seasonal relative abundance in the MA/RI WEA and surrounding areas. Fin Whales were observed in the MA WEA in spring and summer. This species was observed primarily in the offshore (southern) regions of the BOEM MA and MA/RI WEA during spring, and found closer to shore (northern areas) during the summer months (see Figure 6.7-3) (Kraus et al., 2016). Calves were observed three times and feeding was observed nine times during the Kraus et al., (2016) study. Although Fin Whales were largely absent from visual surveys in the MA/RI WEA in the fall and winter months (Kraus et al., 2016), acoustic data indicated that this species was present in the MA/RI WEs during all months of the year. Fin Whales were acoustically detected in the MA WEA on 87% of project days (889/1,020 days). Acoustic detections do not differentiate individuals, so detections on multiple days could be the same or different individuals. Acoustic detection data indicated a lack of seasonal trends in Fin Whale abundance with slightly less detections from April to July (Kraus et al., 2016). As the detection range for Fin Whale vocalizations is in excess of 200 km (108 nm), detected signals may have originated from areas far outside of the MA/RI WEA; however, though the arrival patterns of many Fin Whale vocalizations indicated that



Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Kraus et al., 2016., ESRI 2017, BOEMRE 2017; E&E 2017

Map Coordinate System: NAD 1983 UTM 19N Meters

** SPUE values are number of animals sighted per 1,000 km of survey track summarized by 5' x 5' grid cells*

N W E S

0 5 10 20 Nautical Miles

0 10 20 Kilometers

LEGEND

State Boundary
County Boundary
Lease Area
Wind Development Area
Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles Study Area
Offshore Export Cable Corridor
Fin Whale
Sightings per Unit Effort (SPUE*)
0
<0 - 10
10 - 20
20 - 30
30 - 225

Vineyard Wind Project

VINEYARD WIND

Figure 6.7-3
Fin Whale Seasonal Aerial Survey Sightings per Unit Effort from Kraus et al. (2016) October 2011 to June 2015

received signals likely originated from within the Kraus et al., (2016) study area. This species was not observed visually, or detected acoustically, in the Lease Area during the 2016 or 2017 G&G surveys for the Project (Vineyard Wind, 2016, 2017). The Lease Area is flanked by two BIAs for feeding for Fin Whales. The area to the northeast is considered a BIA year-round, while the area off the tip of Long Island to the southwest is a BIA from March to October (LaBrecque et al., 2015).

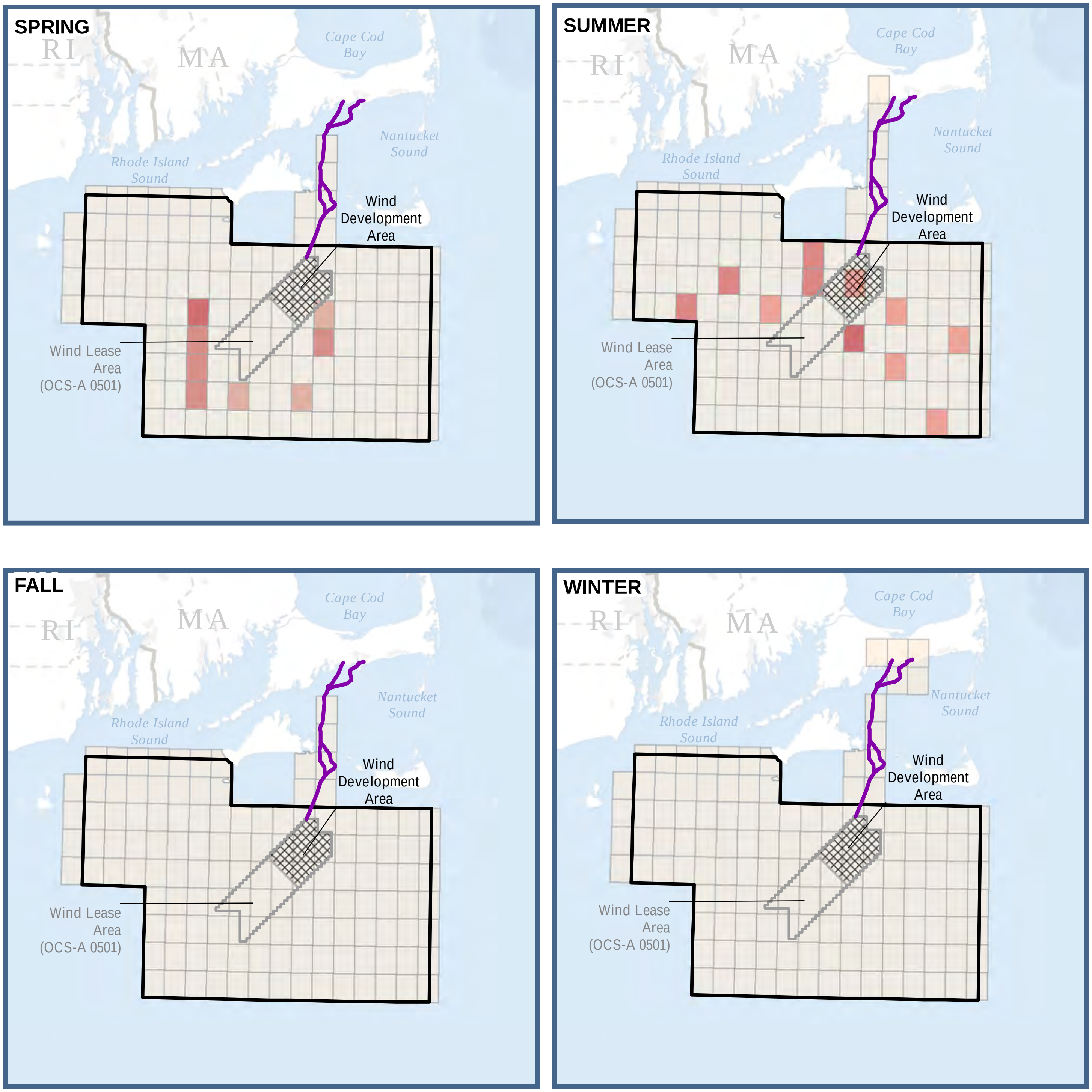
Sei Whale. Sei Whales are a baleen whale that can reach lengths of about 12-18 m (40 -60 ft) (NOAA, 2015c). This species has a long, sleek body that is dark bluish-gray to black in color and pale underneath (NOAA, 2015c). Their diet is comprised primarily of plankton, schooling fish, and cephalopods. Sei Whales generally travel in small groups (two to five individuals), but larger groups are observed on feeding grounds (NOAA, 2015c).

The stock that occurs in the US Atlantic EEZ is the Nova Scotia stock, which ranges along the continental shelf waters of the northeastern United States to Newfoundland (Hayes et al., 2017). The best abundance estimate for this stock in the US Atlantic EEZ is 357 individuals. This estimate is considered an underestimate because the full known range of the stock was not surveyed, the estimate did not include availability-bias correction for submerged animals, and there was uncertainty regarding population structure (Hayes et al., 2017). Sei Whales are listed as endangered under the ESA and the Nova Scotia stock is considered strategic under the MMPA. Between 2010 and 2014, the average annual minimum human-caused mortality and serious injury was 0.8 Sei Whales per year (Hayes et al., 2017).

Sighting data suggest Sei Whale distribution is largely centered in the waters of New England and eastern Canada (Hayes et al., 2017; Roberts et al., 2016). There appears to be a strong seasonal component to Sei Whale distribution. Sei Whales are relatively widespread and most abundant in New England waters from spring to fall (April to July). During winter, the species is predicted to be largely absent (Roberts et al., 2016). There are no critical habitat areas designated for the Sei Whale under the ESA.

NEFSC observed Sei Whales two times in the WDA during one AMAPPS survey (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). The two observations were made in the summer of 2016 during a shipboard survey (NEFSC & SEFSC, 2016).

Kraus et al., (2016) observed Sei Whales in the MA/RI WEAs and surrounding areas only between the months of March and June. The number of Sei Whale observations was less than half that of other baleen whale species in the two seasons in which Sei Whales were observed (spring and summer). This species demonstrated a distinct seasonal habitat use pattern that was consistent throughout the study (see Figure 6.7-4). Calves were observed three times and feeding was observed four times during the Kraus et al., (2016) study. Because of uncertainty associated with identifying Sei Whale vocalizations, this species was



Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Kraus et al., 2016., ESRI 2017, BOEMRE 2017; E&E 2017

Map Coordinate System: NAD 1983 UTM 19N Meters

** SPUE values are number of animals sighted per 1,000 km of survey track summarized by 5' x 5' grid cells*

N W E S

0 5 10 20 Nautical Miles

0 10 20 Kilometers

LEGEND

- State Boundary
- County Boundary
- Lease Area
- Wind Development Area
- Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles Study Area
- Offshore Export Cable Corridor

Sei Whale

Sightings per Unit Effort (SPUE*)

- <0
- >0 - 5
- 5 - 10
- 10 - 20
- 20 - 42

Vineyard Wind Project

VINEYARD WIND

Figure 6.7-4

Sei Whale Seasonal Aerial Survey Sightings per Unit Effort from Kraus et al. (2016) October 2011 to June 2015 not included in Kraus et al., (2016) PAM analyses. Sei Whales were not observed visually, or detected acoustically, in the Lease Area during the 2016 or 2017 G&G surveys for the Project (Vineyard Wind, 2016, 2017); however, the survey was conducted during October and November when Sei Whale occurrence is not anticipated due to the seasonal nature of their occurrence in this region. A BIA for feeding for Sei Whales occurs west of the Lease Area from May to November (LaBrecque et al., 2015). Sei Whales are expected to be present but much less common than Fin, Minke, Humpback, and NARWs based on Kraus et al., (2016) sighting rates.

Sperm Whale. The Sperm Whale is the largest of all toothed whales; males can reach 16 m (52 ft) in length and weigh over 40,823 kilograms ("kg"); (45 US tons), and females can attain lengths of up to 11 m (36 ft) and weigh over 13,607 kg (15 tons) (Perrin, Wursig, & Thewissen, 2002). Sperm Whales have extremely large heads, which account for 25-35% of the total length of the animal. This species tends to be uniformly dark gray in color, though lighter spots may be present on the ventral surface. Sperm Whales frequently dive to depths of 400 m (1,300 ft) in search of their prey, which includes large squid, fishes, octopus, sharks, and skates (Perrin et al., 2002). This species can remain submerged for over an hour and reach depths as great as 1,000 m (3,280 ft). Sperm Whales have a worldwide distribution in deep water and range from the equator to the edges of the polar ice packs (Whitehead, 2002). Sperm Whales form stable social groups and exhibit a geographic social structure; females and juveniles form mixed groups and primarily reside in tropical and subtropical waters, whereas males are more solitary and wide-ranging and occur at higher latitudes (Whitehead, 2002, 2003).

The International Whaling Commission recognizes only one stock of Sperm Whales for the North Atlantic, and Reeves & Whitehead (1997) and Dufault, Whitehead, & Dillon (1999) suggest that Sperm Whale populations lack clear geographic structure. Current threats to the Sperm Whale population include ship strikes, exposure to anthropogenic noise and toxic pollutants, and entanglement in fishing gear (though entanglement risk for sperm whales is relatively low compared to other, more coastal whale species) (NOAA, 2017e; Waring, Josephson, Maze-Foley, & Rosel, 2015). Though there is currently no reliable estimate of total Sperm Whale abundance in the entire western North Atlantic, the most recent population estimate for the US Atlantic EEZ is 2,288 (Waring et al., 2015). This estimate was generated from the sum of surveys conducted in 2011, and is likely an underestimate of total abundance, as these surveys were not corrected for Sperm Whale dive-time. Maximum monthly abundance in the US Atlantic EEZ was estimated to be 7,200 in density models based on 22 years of survey data (Roberts et al., 2016). Sperm Whales are listed as endangered under the ESA and the North Atlantic stock is considered strategic under the MMPA. Total annual estimated average human-caused mortality to this stock during the period from 2008 to 2012 was 0.8 Sperm Whales (Waring et al., 2015).

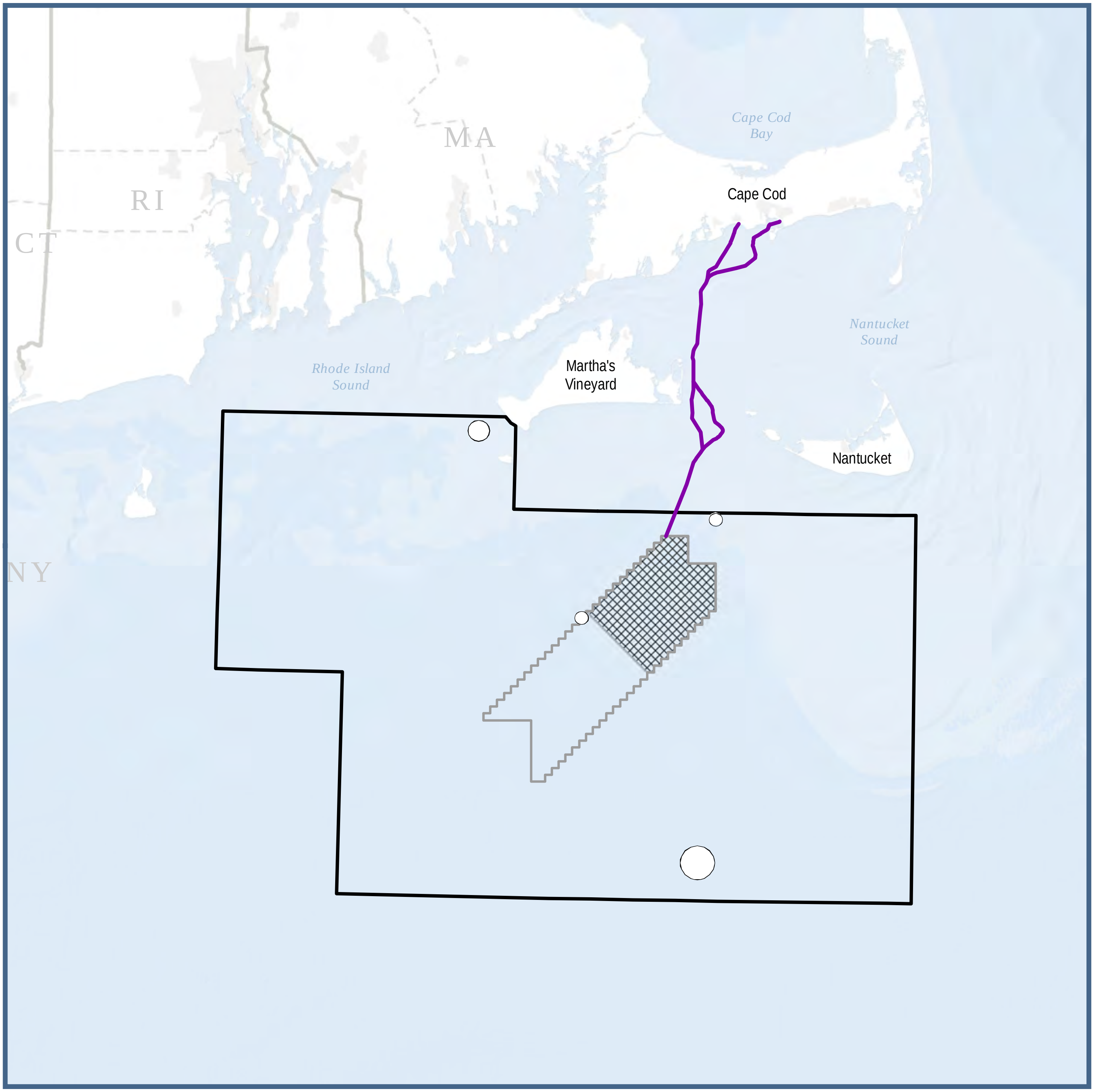
Sperm Whales mainly reside in deep-water habitats on the Outer Continental Shelf, along the shelf edge, and in mid-ocean regions (NOAA, 2010). However, this species has been observed in relatively high numbers in the shallow continental shelf areas of southern New England (Scott & Sadove, 1997). Sperm Whale migratory patterns are not well-defined, and no obvious migration patterns have been observed in certain tropical and temperate areas. However, general trends suggest that most populations move poleward during summer months (Waring et al., 2015). In US Atlantic EEZ waters, Sperm Whales appear to exhibit seasonal movement patterns (CeTAP, 1982; Scott & Sadove, 1997). During the winter, Sperm Whales are concentrated to the east and north of Cape Hatteras. This distribution shifts northward in spring, when Sperm Whales are most abundant in the central portion of the mid-Atlantic bight to the southern region of Georges Bank. In summer, this distribution continues to move northward, including the area east and north of Georges Bank and the continental shelf to the south of New England. In fall months, Sperm Whales are most abundant on the continental shelf to the south of New England and remain abundant along the continental shelf edge in the mid-Atlantic bight. There are no critical habitat areas designated for the Sperm Whale under ESA.

No Sperm Whales were observed in the WDA or OECC during AMAPPS surveys from 2010-2016 (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). Kraus et al., (2016) observed Sperm Whales four times in the MA/RI WEAs during the summer and fall from 2011 to 2015. Sperm Whales, traveling singly or in groups of three or four, were observed three times in August and September of 2012, and once in June of 2015. Effort-weighted average sighting rates could not be calculated. In the WDA, one Sperm Whale was observed on the northwestern border and in the OECC, and one was observed between the WDA and Nantucket Island (see Figure 6.7-5). The frequency of Sperm Whale clicks exceeded the maximum frequency of PAM equipment used in Kraus et al., (2016), so no acoustic data are available for this species from that study. This species was not observed visually, or detected acoustically, in the Lease Area during the 2016 or 2017 G&G surveys for the Project (Vineyard Wind, 2016, 2017). Sperm Whales are expected to be present but uncommon in the Offshore Project Area based on Kraus et al., (2016) sightings.

6.7.1.3 Non-ESA Listed Marine Mammals

The following section provides additional information on the biology, habitat use, abundance, distribution, and the existing threats to the non-endangered or threatened marine mammals that are both in Massachusetts offshore waters and have the likelihood of occurring, at least seasonally, in the Offshore Project Area. Marine mammal hearing is discussed in Section 6.7.2.1.1.

Minke Whale. Minke Whales are a baleen whale species, reaching 10 m (35 ft) in length (NOAA, 2014b). Minke Whales have a cosmopolitan distribution in temperate, tropical, and high latitude waters (Hayes et al., 2017). The Minke Whale is common and widely distributed within the US Atlantic EEZ and is the third most abundant great whale (any of



Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Kraus et al., 2016., ESRI 2017, BOEMRE 2017; E&E 2017

Map Coordinate System: NAD 1983 UTM 19N Meters

0 5 10 20 Nautical Miles

0 10 20 Kilometers

LEGEND

Number of animals
- 1
- 2 - 3
- 4

Offshore Export Cable Corridor

Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles Study Area

Lease Area

Wind Development Area

State Boundary

County Boundary

Vineyard Wind Project

VINEYARD WIND

Figure 6.7-5

Sperm Whale Aerial Survey Sightings from Kraus et al. (2016) October 2011 to June 2015 the larger marine mammals of the order Cetacea) in the EEZ (CeTAP, 1982). This species has a dark gray-to-black back and a white ventral surface (NOAA, 2014b). Its diet is comprised primarily of crustaceans, schooling fish, and copepods. Minke Whales generally travel in small groups (one to three individuals), but larger groups have been observed on feeding grounds (NOAA, 2014b).

In the North Atlantic, there are four recognized populations: Canadian East Coast, West Greenland, Central North Atlantic, and Northeastern North Atlantic (Donovan, 1991). Until better information becomes available, Minke Whales in the US Atlantic EEZ are considered part of the Canadian East Coast stock, which inhabits the area from the western half of the Davis Strait (45°W) to the Gulf of Mexico. It is also uncertain if there are separate sub-stocks within the Canadian East Coast stock. The best abundance estimate for the US Atlantic EEZ is 2,591 (Hayes et al., 2017). Lawson and Gosslin (2011) corrected estimate of abundance of this stock in Canadian waters was 20,741 in 2007. This is the estimate derived from the Canadian Trans-North Atlantic Sighting Survey ("TNASS") in July-August 2007. This survey covered more of the Minke Whale range than other surveys (Lawson & Gosselin 2009). If US estimates (2,591 Central Virginia to Lower Bay of Fundy and 3,312 South Gulf of Maine to Upper Bay of Fundy and Gulf of St. Lawrence) are added to the TNASS estimate, total abundance across that part of the Minke Whale range is estimated to be 26,644 (Waring et al., 2013). Minke Whales are not listed as threatened or endangered under the ESA and the Canadian East Coast stock is not considered strategic under the MMPA. During 2010 to 2014, the average annual minimum human-caused mortality and serious injury was 8.25 Minke Whales per year (Hayes et al., 2017).

Sighting data suggest that Minke Whale distribution is largely centered in the waters of New England and eastern Canada (Hayes et al., 2017). Risch et al., (2013) reported a decrease in Minke Whale calls north of 40°N in late fall with an increase in calls between 20° and 30°N in winter and north of 35°N during spring. Mating and calving most likely take place during the winter season in lower latitude wintering grounds (NOAA, 2014b).

NEFSC observed Minke Whales five times in the WDA during four AMAPPS surveys (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). One observation was in the fall of 2010 during an aerial survey; one observation was in the spring of 2014 during a shipboard survey; two observations were during the summer of 2016 during a shipboard survey; and one observation was in the fall of 2016 during an aerial survey (NEFSC & SEFSC, 2010, 2014, 2016).

Kraus et al., (2016) observed Minke Whales in the MA/RI WEA and surrounding areas primarily from May to June. This species demonstrated a distinct seasonal habitat usage pattern that was consistent throughout the study. Though Minke Whales were observed in spring and summer months in the MA WEA, they were only observed in the Lease Area in the spring. Minke Whales were not observed between October and February, but acoustic data indicate the presence of this species in the Offshore Project Area in winter months.

Calves were observed twice and feeding was also observed twice during the Kraus et al., (2016) study. Minke Whales were acoustically detected in the MA WEA on 28% of project days (291/1,020 days). Acoustic detections do not differentiate between individuals, so detections on multiple days could be the same or different individuals. Minke Whale acoustic presence data also exhibited a distinct seasonal pattern; acoustic presence was lowest in the months of December and January, steadily increased beginning in February, peaked in April, and exhibited a gradual decrease throughout the summer months (Kraus et al., 2016). Acoustic detection range for this species was small enough that over 99% of detections were limited to within the Kraus et al., (2016) study area. This species was not observed visually, or detected acoustically, in the Lease Area during the 2016 or 2017 surveys for the Project (Vineyard Wind, 2016, 2017). Minke Whales have a BIA for feeding west of the Lease Area from March to November (LaBrecque et al., 2015).

Humpback Whale. Humpback Whale females are larger than males and can reach lengths of up to 18 m (60 ft) (NOAA, 2016g). Humpback Whale body coloration is primarily dark gray, but individuals have a variable amount of white on their pectoral fins, belly, and flukes. These distinct coloration patterns are used by scientists to identify individuals. These baleen whales feed on small prey often found in large concentrations, including krill and fish such as Herring and Sand Lance (Kenney & Vigness-Raposa, 2010). Humpback Whales use unique behaviors, including bubble nets, bubble clouds, and flickering of their flukes and fins, to herd and capture prey (NOAA, 1991).

In the North Atlantic, six separate Humpback Whale sub-populations have been identified by their consistent maternally determined fidelity to different feeding areas (Clapham & Mayo, 1987). These populations are found in the Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, Iceland, and Norway (Hayes et al., 2017). The large majority of Humpback Whales that inhabit the waters in the US Atlantic EEZ belong to the Gulf of Maine stock. The most recent ocean-basin-wide estimate of the North Atlantic Humpback Whale population is 11,570 (Palsbøll et al., 1997). The most recent minimum population estimate for the Gulf of Maine stock is 823 individuals (Hayes et al., 2017).

The entire Humpback species was previously listed as endangered under the ESA. However, in September 2016, NMFS identified 14 DPSs of Humpback Whale and revised the ESA listing for this species. Four DPSs were listed as endangered, one as threatened, and listing was deemed not warranted for the remaining nine DPSs. All Humpback Whales in the US Atlantic EEZ belong to the West Indies DPS, which is not listed under the ESA (81 Fed. Reg. 62,269 [2016]). For the period of 2010 through 2014, the minimum annual rate of human-caused mortality and serious injury to the Gulf of Maine Humpback Whale stock averaged 9.05 animals per year (Hayes et al., 2017).

Humpback Whales in the Gulf of Maine stock typically feed in the waters between the Gulf of Maine and Newfoundland during spring, summer, and fall, but have been observed feeding in other areas, such as off the coast of New York (Sieswerrda, Spagnoli, & Rosenthal n.d.). Some Humpback Whales from most feeding areas, including the Gulf of Maine, migrate to the West Indies (including the Antilles, Dominican Republic, Virgin Islands, and Puerto Rico) in the winter, where they mate and calve their young (Palsbøll et al., 1997; Katona & Beard, 1990). However, not all Humpback Whales from the Gulf of Maine stock migrate to the West Indies every winter because significant numbers of animals are located in mid- and high-latitude regions at this time (Swingle, Barco, Pitchford, McLellan, & Pabst, 1993).

NEFSC observed Humpback Whales nine times in the WDA during three AMAPPS surveys (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). Six observations were in the summer of 2013 during a shipboard survey; one observation was in the spring of 2014 during a shipboard survey; and two observations were during fall of 2016 during an aerial survey (NEFSC & SEFSC, 2013, 2014, 2016).

Kraus et al., (2016) observed Humpback Whales in the MA/RI WEA and surrounding areas during all seasons. Humpback Whales were observed most often during spring and summer months, with a peak from April to June. Calves were observed 10 times and feeding was observed 10 times during the Kraus et al., (2016) study. Kraus et al., (2016) also observed one instance of courtship behavior. Although Humpback Whales were only rarely seen during fall and winter surveys, acoustic data indicates that this species may be present within the MA WEA year-round, the with highest rates of acoustic detections in winter and spring (Kraus et al., 2016). Humpback Whales were acoustically detected in the MA WEA on 56% of project days (566/1,020 days). Acoustic detections do not differentiate between individuals, so detections on multiple days could be the same or different individuals. Mean detection range for Humpback Whales using PAM ranged from 30-36 km (18.6-22.3 mi), with a mean radius of 36 km (22.3 mi) (95% Confidence Interval of five kilometers [3.1 mi]) for the PAM system within the WDA. However, not all Humpback Whales recorded by PAM in the MA WEA were likely to be within a distance of the Project that would result in any disturbance of individuals by construction and operation. Keeping in mind that such estimates are based on a number of assumptions and are not species-specific, the maximum distance from pile driving to behavioral harassment for low frequency cetaceans such as humpback whales has been estimated at 7,116 m (23,346 ft) with no sound reduction technology (unweighted; 160dB; 10.3 m monopiles; see Appendix III-M Table A-10). Vineyard Wind will use sound reduction technology to achieve a target of approximately 12 dB of noise reduction, resulting in an estimated maximum behavioral harassment distance of 2,907 m (9,537 ft) (unweighted; 160dB; 10.3 m monopiles; see Appendix III-M Table A-37). This results in a much smaller radius of disturbance than the mean detection range of the PAM system.

Kraus et al., (2016) estimated that 63% of acoustic detections of Humpback Whales represented whales within their study area. This species was not observed visually, or detected acoustically, in the Lease Area during the 2016 or 2017 surveys for the Project (Vineyard Wind, 2016, 2017). Humpback Whales in the Western North Atlantic have been experiencing an unusual mortality event since January 2016 that appears to be related to larger than usual numbers of vessel collisions (NOAA, 2017a). A total of 57 mortalities have been documented through October 31, 2017, as part of this event (NOAA, 2017a). Humpback Whales have a BIA for feeding west of the Lease Area from March to December (LaBrecque et al., 2015).

Pilot Whales. Two species of Pilot Whale occur within the Western North Atlantic: the Long-Finned Pilot Whale and the Short-Finned Pilot Whale. These species are difficult to differentiate at sea and cannot be reliably distinguished during most surveys (Hayes et al., 2017; Rone & Pace, 2012), so some of the descriptions below refer to both species unless otherwise stated. Pilot Whales have bulbous heads, are dark gray, brown, or black in color, and can reach approximately 7.3 m (25 ft) in length (NOAA, 2016i, 2016m). These whales form large, relatively stable aggregations that appear to be maternally determined (ACS, 2016). Pilot Whales feed primarily on squid, although they also eat small to medium-sized fish and octopus when available (NOAA, 2016i, 2016m).

Within the US Atlantic EEZ, both species are categorized into Western North Atlantic stocks. The best available population estimate in the US Atlantic EEZ for Short-Finned Pilot Whales is 21,515 and for Long-Finned Pilot Whales is 5,636 (Hayes et al., 2017). These estimates are from summer 2011 aerial and shipboard surveys covering waters from central Florida to the lower Bay of Fundy (Hayes et al., 2017). Total annual estimated average fishery-related mortality or serious injury during 2010-2014 was 38 Long-Finned Pilot Whales, and 192 Short-Finned Pilot Whales per year (Hayes et al., 2017). Neither Pilot Whale species is listed as threatened or endangered under the ESA. Both stocks are considered strategic under the MMPA (Hayes et al., 2017).

In US Atlantic waters, Pilot Whales are distributed principally along the continental shelf edge off the northeastern US coast in winter and early spring (CeTAP, 1982; Payne & Heinemann, 1993; Abend & Smith, 1999; Hamazaki, 2002). In late spring, Pilot Whales move onto Georges Bank, into the Gulf of Maine, and into more northern waters, where they remain through late fall (CeTAP, 1982; Payne & Heinemann, 1993). Short-Finned Pilot Whales are present within warm temperate to tropical waters and Long-Finned Pilot Whales occur in temperate and subpolar waters. Long-Finned and Short-Finned Pilot Whales overlap spatially along the mid-Atlantic shelf break between New Jersey and the southern flank of Georges Bank (Payne & Heinemann, 1993; Hayes et al., 2017). Long-Finned Pilot Whales have occasionally been observed stranded as far south as South Carolina, and Short-Finned Pilot Whale have stranded as far north as Massachusetts (Hayes et al., 2017). The latitudinal ranges of the two species therefore remain uncertain. However, south of Cape Hatteras, most Pilot Whale sightings are expected to be Short-Finned Pilot Whales, while north of approximately 42°N, most Pilot Whale sightings are expected to be Long-Finned Pilot Whales (Hayes et al., 2017). Based on the distributions described in Hayes et al., (2017), Pilot Whale sightings in the Offshore Project Area would most likely be Long-Finned Pilot Whales.

No Pilot Whales were observed in the WDA or OECC during AMAPPS surveys from 2010-2016 (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). Kraus et al., (2016) observed Pilot Whales infrequently in the MA/RI WEA and surrounding areas. Effort-weighted average sighting rates for Pilot Whales could not be calculated. No Pilot Whales were observed during the fall or winter, and these species were only observed 11 times in the spring and three times in the summer. Two of these sightings included calves. It is possible that the Northeast Large Whale Pelagic Survey may have underestimated the abundance of Pilot Whales, as this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species (Kraus et al., 2016). This species was not observed visually, or detected acoustically, in the Lease Area during the 2016 or 2017 G&G surveys for the Project (Vineyard Wind, 2016, 2017).

Risso's Dolphin. Risso's Dolphins are located worldwide in both tropical and temperate waters (Jefferson et al., 2008, 2014). The Risso's Dolphin attains a body length of approximately 2.6-4 m (8.5-13 ft) (NOAA, 2015b). This dolphin has a narrow tailstock and whitish or gray body. The Risso's Dolphin forms groups ranging from 10 to 30 individuals (NOAA, 2015b). Risso's Dolphins feed primarily on squid, but also fish such as anchovies (*Engraulidae*), krill, and other cephalopods (NOAA, 2015b).

Risso's Dolphins in the US Atlantic EEZ are part of the western North Atlantic Stock. The best available abundance estimate for Risso's Dolphins in the Western North Atlantic stock is 18,250, estimated from data collected during 2011 surveys (Hayes et al., 2017). Total annual estimated average fishery related mortality or serious injury to this stock during 2010 to 2014 was 53.6 per year (Hayes et al., 2017).

The Western North Atlantic stock of Risso's Dolphins inhabits waters from Florida to eastern Newfoundland (Leatherwood, Caldwell, & Winn, 1976; Baird & Stacey, 1991). During spring, summer, and fall, Risso's Dolphins are distributed along the continental shelf edge from Cape Hatteras northward to Georges Bank (CETAP, 1982; Payne, Selzer, & Knowlton, 1984). During the winter, the distribution extends outward into oceanic waters (Payne et al., 1984). The stock may contain multiple demographically independent populations that should themselves be stocks, because the current stock spans multiple eco-regions (Longhurst, 1998; Spalding et al., 2007).

NEFSC observed Risso's Dolphins two times in the WDA during one AMAPPS survey (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). The two observations were made in the summer of 2013 during a shipboard survey (NEFSC & SEFSC, 2013).

Kraus et al., (2016) results suggest that Risso's Dolphins occur infrequently in the BOEM MA and MA/RI WEAs and surrounding areas. Effort-weighted average sighting rates for Risso's Dolphins could not be calculated. No Risso's Dolphins were observed during summer, fall, or winter, and this species was only observed twice in the spring. It is possible that the Northeast Large Whale Pelagic Survey may have underestimated the abundance of Risso's Dolphins, as this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species. This species was not observed visually, or detected acoustically, in the Lease Area during the 2016 G&G survey for the Project, but 12 visual observations and 10 acoustic detections of marine mammals during the G&G survey were classified as "unidentified" dolphin or porpoise (Vineyard Wind, 2016).

Atlantic White-Sided Dolphin. Atlantic White-Sided Dolphins are located in cold temperate and subpolar waters of the North Atlantic (Cipriano, 2002). The Atlantic White-Sided Dolphin is robust and attains a body length of approximately 2.8 m (9 ft) (Jefferson et al., 2008). It is characterized by a strongly "keeled" tail stock and distinctive, white-sided color pattern (BOEM, 2014). Atlantic White-Sided Dolphins form groups of varying sizes, ranging from a few individuals to over 500 (NOAA, 2016c). Atlantic White-Sided Dolphins feed mostly on small schooling fish, shrimp, and squid, and are often observed feeding in mixed-species groups with Pilot Whales and other dolphin species (Cipriano, 2002; Jefferson et al., 2008).

Atlantic White-Sided Dolphins in the US Atlantic EEZ are part of the Western North Atlantic stock. The best available abundance estimate for White-Sided Dolphins in the Western North Atlantic stock is 48,819, estimated form data collected during a 2011 survey (Hayes et al., 2017). Total annual estimated average fishery related mortality or serious injury to this stock during 2010 to 2014 was 77 per year (Hayes et al., 2017).

The Western North Atlantic stock of White-Sided Dolphin inhabits waters from central West Greenland to North Carolina (about 35°N), primarily in continental shelf waters to the 100 m (328 ft) depth contour (Doksaeter, Olsen, Nottestad, & Ferno, 2008). Sighting data indicate seasonal shifts in distribution (Northridge, Tasker, Webb, Camphuysen, & Leopold, 1997). During January to May, low numbers of White-Sided Dolphins are located from Georges Bank to Jeffreys Ledge (off New Hampshire). During this time period, even lower numbers of White-Sided Dolphins are present south of Georges Bank, as documented by a few strandings collected on beaches from Virginia to South Carolina. From June through September, large numbers of White-Sided Dolphins occur from Georges Bank to the lower Bay of Fundy. From October to December, White-Sided Dolphins occur at intermediate densities from southern Georges Bank to the southern Gulf of Maine (Payne & Heinemann, 1990).

No Atlantic White-Sided Dolphins were observed in the WDA or OECC during AMAPPS surveys from 2010-2016 (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). Kraus et al., (2016) suggested that Atlantic White-Sided Dolphins occur infrequently in the MA/RI WEA and surrounding areas. Effort-weighted average sighting rates for White-Sided Dolphins could not be calculated. No White-Sided Dolphins were observed during the winter months, and this species was only observed twice in the fall and three times in the spring and summer. It is possible that the Northeast Large Whale Pelagic Survey may have underestimated the abundance of White-Sided Dolphins, as this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species. This species was not observed visually, or detected acoustically, in the Lease Area during the 2016 G&G survey for the Project, but 12 visual observations and 10 acoustic detections of marine mammals during the 2016 G&G survey and one visual observation in the 2017 G&G survey were classified as "unidentified" dolphin or porpoise (Vineyard Wind, 2016, 2017).

Short-Beaked Common Dolphin. The Short-Beaked Common Dolphin is one of the most widely distributed cetaceans and occurs in temperate, tropical, and subtropical regions (Jefferson et al., 2008). Short-Beaked Common Dolphins can reach 2.7 m (9 ft) in length and have a distinct color pattern with a white ventral patch, yellow or tan flank, and dark gray dorsal "cape" (NOAA, 2016l). This species feeds on squid and small fish, including species that school in proximity to surface waters as well as mesopelagic species found near the surface at night (International Union for the Conservation of Nature, 2010; NatureServe, 2010). They have been known to feed on fish escaping from fishermen's nets or fish that are discarded from boats (NOAA, 1993). These dolphins can gather in schools of hundreds or thousands, although groups generally consist of 30 or fewer individuals (NOAA, 1993).

Short-Beaked Common Dolphins in the US Atlantic EEZ belong to the Western North Atlantic stock, generally occurring from Cape Hatteras, North Carolina to the Scotian Shelf (Hayes et al., 2017). The best population estimate in the US Atlantic EEZ for the Western North Atlantic Short-Beaked Common Dolphin is 70,184 (Hayes et al., 2017). Total annual estimated average fishery-related mortality or serious injury to this stock during 2010-2014 was 409 per year (Hayes et al., 2017).

Short-Beaked Common Dolphins are a highly seasonal, migratory species. In the US Atlantic EEZ this species is distributed along the continental shelf between the 100-2,000 m (328-6,561.6 ft) isobaths and is associated with Gulf Stream features (CeTAP, 1982; Selzer & Payne, 1988; Hamazaki, 2002; Hayes et al., 2017). Common Dolphins occur from Cape Hatteras northeast to Georges Bank (35˚ to 42˚N) during mid-January to May and move as far north as the Scotian Shelf from mid-summer to fall (Selzer & Payne, 1988). Migration onto the Scotian Shelf and continental shelf off Newfoundland occurs when water temperatures exceed 11°C (51.8°F) (Sergeant, Mansfield, & Beck, 1970; Gowans & Whitehead, 1995). Breeding usually takes place between the months of June and September and females have an estimated calving interval of two to three years (Hayes et al., 2017).

NEFSC observed Short-Beaked Common Dolphins 10 times in the WDA during seven AMAPPS surveys (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). One observation was in the fall of 2010 during an aerial survey; two observations were in the fall of 2012 during an aerial survey; three observations were during the summer of 2014 during a shipboard survey; one was during the summer of 2014 during a shipboard survey; one observation was during the summer of 2016 during a shipboard survey; one observation was in the summer of 2016 during an aerial survey; and one was in the fall of 2016 during an aerial survey (NEFSC & SEFSC, 2010, 2012, 2013, 2014, 2016).

Kraus et al., (2016) suggested that Short-Beaked Common Dolphins occur year-round in the MA/RI WEA and surrounding areas. Short-Beaked Common Dolphins were the most frequently observed small cetacean species within the Kraus et al., (2016) study area. Short-Beaked Common Dolphins were observed in the MA/RI WEA in all seasons and observed in the Lease Area in spring, summer, and fall. Short-Beaked Common Dolphins were most frequently observed during the summer months; observations of this species peaked between June and August. Two sightings of Short-Beaked Common Dolphins in the Kraus et al., (2016) study included calves, two sightings involved feeding behavior, and three sightings involved mating behavior. Sighting data may indicate that Short-Beaked Common Dolphin distribution tended to be farther offshore during the winter months, than during spring, summer, and fall. It is possible that the Northeast Large Whale Pelagic Survey may have underestimated the abundance of Short-Beaked Common Dolphins, as this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species (Kraus et al., 2016). Short-Beaked Common Dolphins were the most frequently observed or detected animal during the 2016 survey in the Lease Area and one was also visually observed during the 2017 G&G survey (Vineyard Wind, 2016, 2017). During 2016 G&G survey, Short-Beaked Common Dolphins were visually observed 123 times and acoustically detected 50 times. Also, 12 visual observations and 10 acoustic detections of marine mammals during the 2016 G&G survey and one visual observation during the 2017 G&G survey were classified as "unidentified" dolphin or porpoise (Vineyard Wind, 2016, 2017).

Bottlenose Dolphin. Bottlenose Dolphins are one of the most well-known and widely distributed species of marine mammals. These dolphins reach two to four meters (6-12.5 ft) in length, and are light gray to black in color (NOAA, 2016d). Bottlenose Dolphins are commonly found in groups of two to 15 individuals, though aggregations in the hundreds are occasionally observed (NOAA, 2016d). They are considered generalist feeders and consume a wide variety of organisms, including fish, squid, and shrimp and other crustaceans (Jefferson et al., 2008).

Bottlenose Dolphins along the New England Coast belong to the Western North Atlantic Offshore stock, which ranges along the US Atlantic EEZ and into Canada (Hayes et al., 2017). The best available population estimate for this stock of Bottlenose Dolphins is 77,532 (Hayes et al., 2017). This estimate is from summer 2011 surveys covering waters from central Florida to the lower Bay of Fundy (Hayes et al., 2017). The estimated mean annual fishery-related mortality or serious injury to this stock during 2010 to 2014 was 39.4 Bottlenose Dolphins per year (Hayes et al., 2017).

The Bottlenose Dolphin is a cosmopolitan species that occurs in temperate and tropical waters worldwide. Two distinct morphotypes of Bottlenose Dolphin, coastal and offshore, occur along the eastern coast of the US (Curry & Smith, 1997; Hersh & Duffield, 1990; Mead & Potter, 1995; Rosel, Hansen, & Hohn, 2009). The offshore morphotype inhabits outer continental slope and shelf edge regions from Georges Bank to the Florida Keys, and the coastal morphotype is continuously distributed along the Atlantic Coast from south of New York to the Florida Peninsula (Hayes et al., 2017). Offshore Bottlenose Dolphin sightings occur from Cape Hatteras to the eastern end of Georges Bank (Kenney, 1990).

NEFSC observed Bottlenose Dolphins four times in the WDA during three AMAPPS surveys (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). Two observations were in the fall of 2012 during an aerial survey; one observation was in the summer of 2013 during a shipboard survey; and one observation was during the summer of 2014 during a shipboard survey (NEFSC & SEFSC 2012, 2013, 2014).

Kraus et al., (2016) observed Bottlenose Dolphins during all seasons within the MA/RI WEA. Bottlenose Dolphins were the second most commonly observed small cetacean species and exhibited little seasonal variability in abundance. Bottlenose Dolphins were observed in the MA WEA in all seasons, and observed in the Lease Area in fall and winter. One sighting of Bottlenose Dolphins in the Kraus et al., (2016) study included calves, and one sighting involved mating behavior. It is possible that the Northeast Large Whale Pelagic Survey may have underestimated the abundance of Bottlenose Dolphins, as this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species (Kraus et al., 2016). Bottlenose Dolphins were not observed visually or detected acoustically during the 2016 or 2017 surveys in the Lease Area, but 12 visual observations and 10 acoustic detections of marine mammals during the 2016 G&G survey and 1 visual observation during the 2017 G&G survey were classified as "unidentified" dolphin or porpoise (Vineyard Wind, 2016, 2017).

Harbor Porpoise. The Harbor Porpoise is the only porpoise species found in the Atlantic. It is a small, stocky cetacean with a blunt, short-beaked head, dark gray back, and white underside (NOAA, 2014a). It reaches a maximum length of 1.8 m (6 ft) and feeds on a wide variety of small fish and cephalopods (Kenney & Vigness-Raposa, 2010; Reeves & Reed, 2003). Most Harbor Porpoise groups are small, usually between five and six individuals, although they aggregate into large groups for feeding or migration (Jefferson et al., 2008).

There are four distinct populations of Harbor Porpoise in the Western Atlantic: Gulf of Maine/Bay of Fundy, Gulf of St. Lawrence, Newfoundland, and Greenland (Hayes et al., 2017). Harbor Porpoises observed in the US Atlantic EEZ are considered part of the Gulf of Maine/Bay of Fundy stock. The best current abundance estimate of the Gulf of Maine/Bay of Fundy Harbor Porpoise stock is 79,883 individuals, based upon data collected during a 2011 line-transect sighting survey (Hayes et al., 2017). The total annual estimated average human-caused mortality is 437 per year (Hayes et al., 2017). The Gulf of Maine/Bay of Fundy stock was considered strategic until 2014 because annual human-caused mortality rates exceeded the potential biological removal. In 2001, the Harbor Porpoise was removed from the candidate species list for the ESA because a review of the biological status of the stock indicated that a classification of threatened was not warranted (66 Fed. Reg. 40,176 [2011]).

The Harbor Porpoise is usually found in shallow waters of the continental shelf, although they occasionally travel over deeper offshore waters. They are commonly found in bays, estuaries, harbors, and fjords less than 200 m (650 ft) deep (NOAA, 2014a). Hayes et al., (2017) report that Harbor Porpoises are generally concentrated along the continental shelf within the northern Gulf of Maine and southern Bay of Fundy region during summer months (July through September). During fall (October through December) and spring (April through June), they are more widely dispersed from New Jersey to Maine. During winter (January through March), they range from New Brunswick, Canada, to North Carolina (Hayes et al., 2017).

NEFSC observed Harbor Porpoises four times in the WDA during two AMAPPS surveys (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). Three observations were in the spring of 2012 during an aerial survey; and one observation was in the spring of 2014 during a shipboard survey (NEFSC & SEFSC, 2012, 2014).

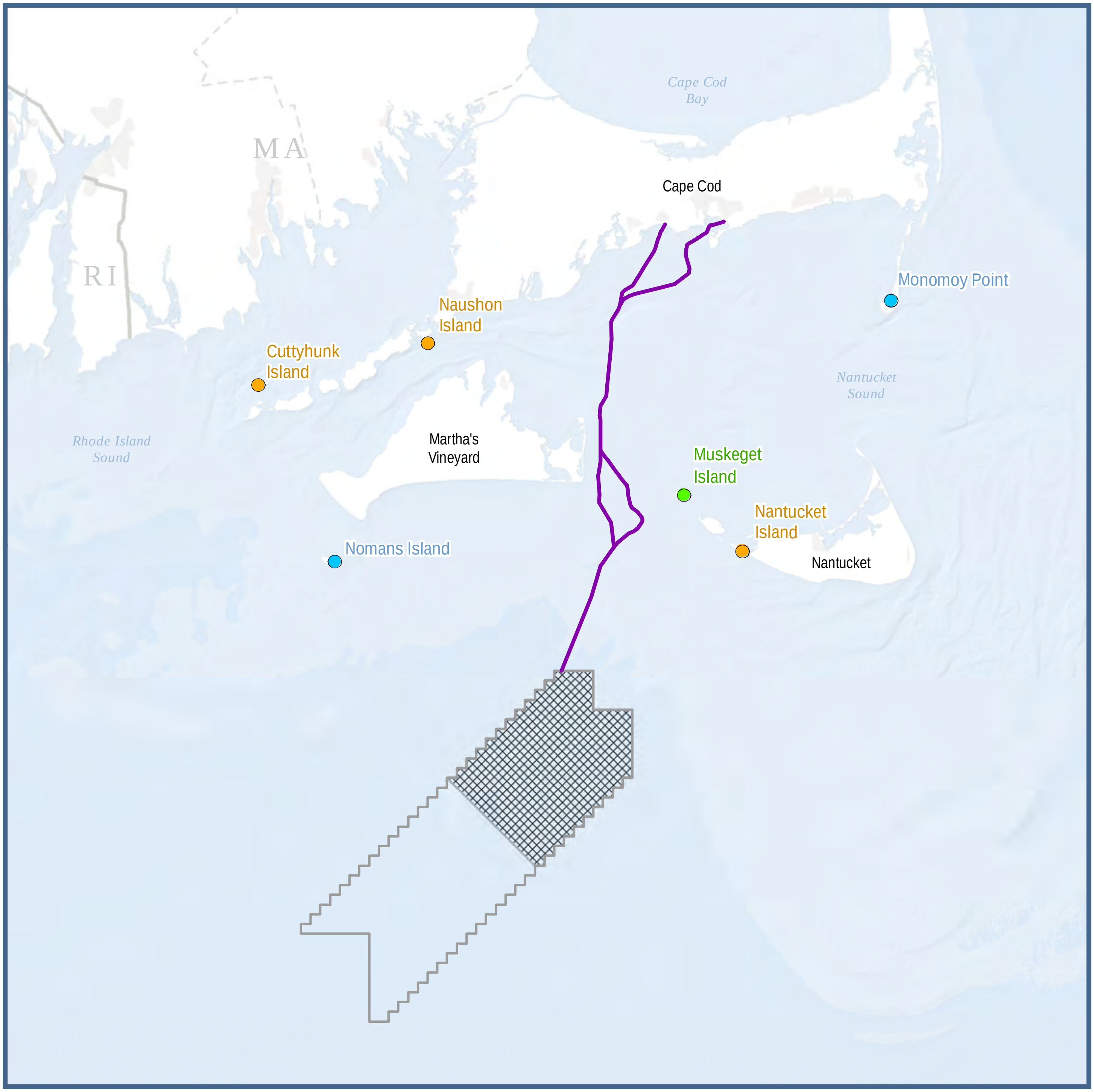
Kraus et al., (2016) indicate that Harbor Porpoises occur within the MA/RI WEA in fall, winter, and spring. Harbor Porpoises were observed in groups ranging in size from three to 15 individuals, and were primarily observed in the Kraus et al., (2016) study area from November through May, with very few sightings during June through September. It is possible that the Northeast Large Whale Pelagic Survey may have underestimated the abundance of Bottlenose Dolphins, as this survey was designed to target large cetaceans and the majority of small cetaceans were not identified to species (Kraus et al., 2016). This species was not observed visually, or detected acoustically, in the Lease Area during the 2016 or 2017 G&G surveys for the Project, but 12 visual observations and 10 acoustic detections of marine mammals during the 2016 G&G survey and one visual observation during the 2017 G&G survey were classified as "unidentified" dolphin or porpoise (Vineyard Wind, 2016).

Harbor Seal. The Harbor Seal is found throughout coastal waters of the Atlantic Ocean and adjoining seas above 30°N and is the most abundant pinniped in the US Atlantic EEZ (Hayes et al., 2017). This species is approximately two meters (6 ft) in length and has a blue-gray back with light and dark speckling (NOAA, 2016f). Harbor Seals complete both shallow and deep dives during hunting, depending on the availability of prey (Tollit, Greenstreet, & Thompson, 1997). This species consumes a variety of prey, including fish, shellfish, and crustaceans (Bigg, 1981; Burns, 2002; Jefferson et al., 2008; Reeves, Stewart, & Leatherwood, 1992). Harbor Seals commonly occur in coastal waters and on coastal islands, ledges, and sandbars (Jefferson et al., 2008).

Although the stock structure of the Western North Atlantic population is unknown, it is thought that Harbor Seals found along the eastern US and Canadian coasts represent one population that is termed the Western North Atlantic stock (Tempte, Bigg, & Wiig, 1991; Anderson & Olsen, 2010). The best estimate of abundance for Harbor Seals in the Western North Atlantic stock is 75,834 (Hayes et al., 2017). This estimate was derived from a coast-wide survey along the Maine Coast during May/June 2012. For the period of 2010-2014 the total human caused mortality and serious injury to Harbor Seals was estimated to be 389 per year (Hayes et al., 2017).

Harbor Seals are year-round inhabitants of the coastal waters of eastern Canada and Maine (Katona, Rough, & Richardson, 1993) and occur seasonally along the southern New England to New Jersey coasts from September through late May (Barlas, 1999; Schneider & Payne, 1983; Schroeder, 2000). A general southward movement from the Bay of Fundy to southern New England waters occurs in fall and early winter (Barlas, 1999; Jacobs & Terhune, 2000; Rosenfeld, George, & Terhune, 1988; Whitman & Payne, 1990). A northward movement from southern New England to Maine and eastern Canada occurs prior to the pupping season, which takes place from mid-May through June along the Maine Coast (Kenney, 1994; Richardson, 1976; Whitman & Payne, 1990; Wilson, 1978).

No Harbor Seals were observed in the WDA or OECC during AMAPPS surveys from 2010-2016 (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). Kraus et al., (2016) observed Harbor Seals in the MA/RI WEA and surrounding areas, but this survey was designed to target large cetaceans so locations and numbers of seal observations were not included in the study report (Kraus et al., 2016). Harbor Seals have five major haul-out sites in and near the MA/RI WEA: Monomoy Island, the northwestern side of Nantucket Island, Nomans Land, the north side of Gosnold Island, and the southeastern side of Naushon Island (see Figure 6.7-6) (Payne & Selzer, 1989). Payne and Selzer (1989) conducted aerial surveys and found that for haul-out sites in Massachusetts and New Hampshire, Monomoy Island had approximately twice as many seals as any of the 13 other sites in the study (maximum count of 1,672 in March of 1986). Harbor Seals were not observed visually, or detected acoustically, in the Lease Area during the 2016 or 2017 G&G surveys for the



Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Hayes et al. 2017; Payne and Selzer 1989; BOEMRE 2017; ESRI 2017; E&E 2017.

Map Coordinate System: NAD 1983 UTM 19N Meters

N W E S

0 5 10 20 Nautical Miles

0 10 20 Kilometers

LEGEND

State Boundary
County Boundary
Offshore Export Cable Corridor
Lease Area
Wind Development Area

Seal Haul Out/Pupping Location
Gray Seals
Harbor Seals
Gray Seals/Harbor Seals

Vineyard Wind Project

VINEYARD WIND

Figure 6.7-6

Major Haul-Outs of Harbor Seals and Pupping Locations of Gray Seals near WDA and OECC

Project, even though this survey overlapped with months seals would be expected to be present (October and November) (Vineyard Wind, 2016, 2017). Two seals visually observed during the 2017 G&G survey were classified as "unknown" (Vineyard Wind, 2017).

Gray Seal. Gray Seals are the second most common pinniped in the US Atlantic EEZ (Jefferson et al., 2008). This species inhabits temperate and sub-arctic waters and lives on remote, exposed islands, shoals, and unstable sandbars (Jefferson et al., 2008). Gray Seals are large, reaching two to three meters (7.5-10 ft) in length, and have a silver-gray coat with scattered dark spots (NOAA, 2016h). These seals are generally gregarious and live in loose colonies while breeding (Jefferson et al., 2008). Though they spend most of their time in coastal waters, Gray Seals can dive to depths of 300 m (984 ft), and frequently forage on the Outer Continental Shelf (Jefferson et al., 2008; Lessage & Hammill, 2001). These opportunistic feeders primarily consume fish, crustaceans, squid, and octopus (Bonner, 1971; Reeves et al., 1992; Jefferson et al., 2008).

Gray Seals form three populations in the Atlantic: Eastern Canada, Northwestern Europe, and the Baltic Sea (Katona et al., 1993). The Western North Atlantic stock is equivalent to the eastern Canada population. Available data are insufficient to estimate the size of the entire Eastern Canada Gray Seal population, but estimates are available for portions of the stock for certain time periods (Hayes et al., 2017). Gray Seal pup production for the three Canadian herds (Gulf of St Lawrence, Nova Scotia Eastern Shore, and Sable Island) totaled 93,000 animals. The total population size for these areas is estimated at 505,000 (Department of Fisheries and Oceans, 2011). For the period 2010 to 2014, the total estimated human caused mortality and serious injury to Gray Seals was 4,937 per year (Hayes et al., 2017).

The eastern Canada population ranges from New Jersey to Labrador and is centered at Sable Island, Nova Scotia (Davies, 1957; Mansfield, 1966; Katona et al., 1993; Lessage & Hammill, 2001). There are three breeding concentrations in eastern Canada: Sable Island, the Gulf of St. Lawrence, and along the east coast of Nova Scotia (Laviguer & Hammill, 1993). In US waters, Gray Seals currently pup at four established colonies from late December to mid-February: Muskeget and Monomoy Islands in Massachusetts, and Green and Seal Islands in Maine (Center for Coastal Studies, 2016; Hayes et al., 2017). Pupping was also observed in the early 1980s on small islands in Nantucket-Vineyard Sound and more recently at Nomans Land (see Figure 6.7-6) (Hayes et al., 2017). Following the breeding season, Gray Seals may spend several weeks ashore in the late spring and early summer while undergoing a yearly molt. Gray Seals are expected to occur year-round in at least the OECC, with seasonal occurrence in the WDA from September to May (Hayes et al., 2017).

No Gray Seals were observed in the WDA or OECC during AMAPPS surveys from 2010-2016 (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). Kraus et al., (2016) observed Gray Seals in the MA/RI WEA and surrounding areas, but this survey was designed to target large cetaceans so locations and numbers of seal observations were not included in the study report (Kraus et al., 2016). Gray Seals were observed on two occasions during the 2016 survey and two additional occasions in the 2017 survey in the Lease Area (Vineyard Wind, 2016, 2017).

Harp Seal. The Harp Seal is found throughout the North Atlantic and Arctic Oceans (Lavigne & Kovacs, 1988; Ronald & Healey, 1981). This species is approximately 1.7 m (5-6 ft) in length and has light gray fur with a black face and a horseshoe-shaped black saddle on its back (NOAA, 2015a). Harp Seals complete both shallower dives relative to other pinnipeds (Schreer & Kovacs, 1997). This species consumes a variety of species of finfish and invertebrates, mainly Capelin, cod (Gadidae), and krill (NOAA, 2015a).

The world's Harp Seal population is divided into three separate stocks, with the Front/Gulf stock equivalent to western North Atlantic stock (Lavigne & Kovacs, 1988; Bonner, 1990). The best estimate of abundance for Harp Seals in the Western North Atlantic stock is 7.1 million (Waring et al. 2014). This estimate was derived from a population model that was applied to 1952-2012 population estimates (Waring et al., 2014). For the period of 2007-2011, the total human caused mortality and serious injury to Harp Seals was estimated to be 306,082 (Waring et al., 2014).

Harp Seals are year-round inhabitants of the coastal waters off eastern Canada and occur seasonally in the northeastern US. Harp Seals begin their seasonal shift south toward US waters following summer feeding in the more northern Canadian waters (Sergeant, 1965; Lavigne and Kovacs, 1988). The most southerly point of observation for this species has been New Jersey, from January through May (Harris, Lelli, & Jakush, 2002). Sightings of Harp Seals this far south have been increasing since the early 1990s. The number of sightings and strandings from January to May have also increased off the east coast of the US (NOAA, 2015a).

No Harp Seals were observed during AMAPPS surveys from 2010-2016 (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, 2016). Kraus et al., (2016) did not observe Harp Seals in the BOEM MA and MA/RI WEAs and surrounding areas (Kraus et al., 2016). Harp Seals were not observed visually, or detected acoustically, in the Lease Area during the 2016 G&G survey for the Project (Vineyard Wind, 2016).

6.7.2 Potential Project Impacts

Construction and installation, operations and maintenance, and decommissioning activities associated with the Offshore Project Area have the potential to impact marine mammals through noise, changes in vessel traffic, marine debris, reductions in prey availability, habitat disturbance and modification, entanglement, electromagnetic fields ("EMF"), and sediment mobilization (see Table 6.7-2).

This section provides an initial assessment of the potential risks to populations (stocks) of marine mammals from project activities. Criteria used for this risk assessment are shown in Table 6.7-3. This assessment will be supplemented with additional information and acoustical data that will better inform the potential risks from the project and mitigation measures that may be employed. A draft version of the supplemental report can be found in Appendix III-M.

In this initial assessment, the potential risks posed by Project activities and their associated stressors are categorized as none, low, moderate, or high based on the probability of marine mammal exposure and the vulnerability of the marine mammal species to project stressors (Table 6.7-3). Occurrence of marine mammal taxa and their relationships to the established criteria were evaluated using existing literature on marine mammal distribution and habitat use in the MA and MA/RI WEA, impacts of marine construction, wind farm construction and operations in Europe, construction and operation of the Block Island offshore wind farm, and studies that provide a general understanding of hearing, vessel collision risk, noise response, and other factors that influence the potential impacts of offshore wind construction, operation, and decommissioning activities on marine mammals.

Based on this assessment, some of the impact-producing factors are not expected to pose any risk to populations of marine mammals. Therefore, further in-depth analysis was not conducted. These include impacts from marine debris, reductions in prey availability, habitat disturbance and modification, entanglement, EMF, and sediment mobilization. Each of these is briefly described below. See Table 6.7-3 for criteria for determining an impact risk level of "none." The remainder of this section focuses on impacts to marine mammals associated with noise and vessel traffic during construction and installation (see Section 6.7.2.1), operations and maintenance (see Section 6.7.2.2), and decommissioning (see Section 6.7.2.3). Avoidance, minimization and mitigation measures are provided for each of these stages of the Offshore Project.

In addition, this risk assessment considers the definitions of harassment established by NOAA under the MMPA for the purposes of evaluating noise impacts. The MMPA defines any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild as Level A Harassment. Level B Harassment is defined as any act that has the potential to disturb marine mammals or their stock in the wild by causing a disruption of behavioral patterns including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering. The Project has the potential to "harass" marine mammals, as discussed in Sections 6.7.2.1. Mitigation and best management practice ("BMP") measures, including those outlined in Table 31 of Appendix III-M, are expected to minimize impacts of noise on marine mammals and avoid vessel collision entirely.

Importantly, positive impacts to marine mammals are expected to occur from the Offshore Project Area, and these positive impacts are briefly described in the Project Summary (Section 2.0).

Table 6.7-2 Potential Impact-producing Factors for Marine Mammals

Potential Impact-producing Factor	Stressor	Wind Development Area	Export Cable Corridor	Construction and Installation	Operations and Maintenance	Decommissioning
Noise	Pile driving, construction and support vessels, wind turbines, removal of turbines	X	X	X	X	X
Vessel traffic	Construction and support vessels	X	X	X	X	X
Marine debris	Discarded material	X	X	X	X	X
Reduction in prey Abundance	Jet plow, pile driving, discharges/ withdrawals	X	X	X	X	X
Habitat disturbance and modification	Wind turbine generators, cable corridor, electrical service platform	X	X	X	X	X
Entanglement	Anchor lines, tow lines, wind turbines, fishing gear, marine debris, undersea cables	X	X	X	X	X
Electromagnetic fields (EMF)	Cable system	X	X		X	
Suspended sediments	Jet plow, pile driving, dredging	X	X	X	X	X

Table 6.7-3 Definitions of Risk, Exposure, and Vulnerability for Marine Mammals

Risk Level	Exposure	Individual Vulnerability
None	No or limited observations of the species in or near the WDA and Offshore ECC and noise exposure zones (low expected occurrence) AND/OR Species tends to occur mainly in other habitat (such as deeper water or at lower or higher latitudes) AND/OR No indication the Lease Area has regional importance	Literature and/or research suggest the affected species and timing of the stressor are not likely to overlap AND/OR Literature suggests limited sensitivity to the stressor AND/OR Little or no evidence of impacts from the stressor in the literature
Low	Few observations of the species in or near the WDA and Offshore ECC and noise exposure zones (occasional occurrence) AND/OR Seasonal pattern of occurrence in or near the WDA and Offshore ECC and noise exposure zones	Literature and/or research suggest the affected species and timing of the stressor may overlap AND/OR Literature suggests some low sensitivity to the stressor AND/OR Literature suggests impacts are typically short-term (end within days or weeks of exposure) AND Literature describes mitigation/BMPs that reduce risk

Table 6.7-3 Definitions of Risk, Exposure, and Vulnerability for Marine Mammals (Continued)

Risk Level	Exposure	Individual Vulnerability
Moderate	Moderate year-round use of the WDA and Offshore ECC and noise exposure zones AND/OR Evidence of preference for near-shore habitats and shallow waters in the literature	Literature and/or research suggest the affected species and timing of the stressor are likely to overlap. AND/OR Literature and/or research suggest a moderate susceptibility to the stressor exists in the region and/or from similar activities elsewhere. AND Literature does not describe mitigation/BMPs that reduce risk
High	Significant year-round use of the WDA and Offshore ECC and noise exposure zones	Literature and/or research suggest the affected species and timing of the stressor will overlap. AND Literature suggests significant use of WDA and Offshore ECC and noise exposure zones for feeding, breeding, or migration AND Literature does not describe mitigation/BMPs that reduce risk

Impact-producing factors not expected to pose a risk to marine mammal populations

Reductions in prey availability: As demonstrated in Sections 6.5 and 6.6, potential impacts on benthic and finfish resources from substrate (habitat) disturbance, noise, and increased turbidity will be localized and short-term; therefore, risk of declining prey availability is not anticipated. Increased substrate and reef effects are likely to increase prey availability for some species in operating wind farms (Bergström et al., 2014; Russell et al., 2014). Bergstrom et al., (2014) assessed windfarms in the North Sea and Baltic Sea and found that disturbance associated with noise during construction was lower for fish than for marine mammals, suggesting that fish would not be temporarily displaced further than marine mammals during pile driving events, allowing prey to remain available to marine mammals. Bergström et al., (2013) found increased densities of some fish species close to operating wind turbines, but no large-scale effects on fish diversity or abundance (With respect to turbidity, sediment modeling tends to be conservative and sampling conducted for the Block Island offshore wind farm did not show measurable impacts compared to modeling results (Elliott, Smith, Gallien, & Khan, 2017). Therefore, it is not expected that project activities will reduce prey availability to marine mammals.

Habitat Modification: The presence of the wind turbine generator ("WTG"), cable corridor, and electrical service platform ("ESP") foundations are not expected to modify marine mammal habitat. Marine mammals can continue to use the area after the turbines are installed, as demonstrated by the continued use of areas where other structures have been built in marine environments. For example, Delefosse, Rahbek, Roesen, & Clausen (2017) evaluated sightings of marine mammals around oil and gas installations in the North Sea. They studied an area with 25 fixed installations. Observations of Harbor Porpoises, Minke Whales, Killer Whales, White-Beaked Dolphins, Pilot Whales, Harbor Seals, and Gray Seals reflected the general expectation for marine mammal abundance and diversity in the area.

There have been some mixed results in wind farm studies in Europe. For example, a study of a wind farm in the Baltic Sea documented 89% fewer Harbor Porpoises inside the wind farm during construction and 71% fewer 10 years later compared to baseline levels (Teilmann & Carstensen, 2012). However, a similar study found a significant increase of 160% in the presence of Harbor Porpoise within an operating wind farm in the Dutch North Sea (Scheidat et al., 2011). Indeed, offshore wind energy projects may benefit fish by acting as artificial reefs, and consequently benefit marine mammals by increasing prey abundance and diversity during long-term operation (see Section 8.1 in Appendix III-M).

For the Offshore Project Area, WTGs will be placed a minimum of 1,400 m (0.8 nm) apart and a maximum of 1,850 m (1 nm) apart. These large distances between wind turbine will minimize the extent of habitat modification that could potentially impact marine mammals. Because of large distances between turbines, barriers to activities, including migration, are not anticipated from modification of the water column habitat. Entanglement: Project activities are not expected to pose an entanglement risk to marine mammals. First, marine anchored vessels will not be routinely used within the WDA. Anchors are not expected to be used for the majority of offshore export cable installation, but they may be used where needed along more challenging portions of the offshore export cable (see Section 4.2.3.3.2 of Volume I). Steel anchor cables used on construction barges are typically five to seven centimeters ("cm") (2-3 inches ["in"]) in diameter. Typically, these cables are under tension while deployed, eliminating the potential for entanglement. Similarly, tow lines for cable installation are expected to be under constant tension and should not present an entanglement risk for marine mammals. Second, as reported in Inger et al., (2009), wind turbines are unlikely to be a significant risk for entanglement of marine mammals given the large, static nature of the structures. Lost fishing gear and other marine debris could possibly catch on wind turbines and present a secondary entanglement hazard to marine mammals; however, WTG and ESP foundations have large monopile diameters (7.5-10 m [25-34 ft]) or jacket diameters (1.5-3.0 m [5-10 ft]) without the protrusions on which lost fishing gear or other marine debris would become snagged. As such, it is unlikely that entanglement of debris would be followed by a close enough approach by marine mammals to secondarily become entangled in such debris. Finally, all undersea cables have large diameters and will be buried in the seabed at depths of up to 1.5-2.5 m (5-8 ft). Where target depths cannot be achieved, the cables would be covered with concrete mattresses or similar protective measures that would preclude any risk of entanglement.

Marine Debris: The Clean Water Act (33 U.S.C §§ 1251 et seq., 1972) and other applicable federal regulations will be followed regarding any substances that could be released into the ocean during construction, operation, and decommissioning of the Offshore Project Area. Any items that could become marine debris will not be discarded in the water and will be appropriately discarded ashore. Thus, activities occurring in the Offshore Project Area are not expected to produce marine debris and therefore would not pose a risk to marine mammals.

EMF: The Offshore Project Area's offshore cable system will generate EMF. However, the intensity of any generated EMF will be minimized by cable burial into the seafloor at depths of up to 1.5-2.5 m (5-8 ft). EMF are a natural occurrence that certain marine mammals are capable of detecting (Bauer, Fuller, Pery, Dunn, & Zoeger, 1985; Czech-Damal, Dehnhardt, Manger, & Hanke, 2012; Kirschvink, Dizon, & Westphal, 1986; Kirschvink, 1990; Walker, Diebel, & Kirschvink, 2003; Walker, Kirschvink, Ahmed, & Dizon, 1992).

In general, there is a lack of research into the potential impacts of EMF on marine mammals (Slater, Schultz, Jones, & Fischer, 2011). Behavioral disturbances, such as temporary changes in swim direction or longer detours during migrations, are possible, as studies have demonstrated statistical increases in strandings near naturally occurring, slightly weakened, magnetic fields (Kirschvink, 1990). However, studies that examined the reaction of Harbor

Porpoises to operating subsea cable EMF did not detect an impact to behavior (Gill, Bloyne-Philips, Neal, & Kimber, 2005; Slater et al., 2011; Walker, 2001). In addition, it has been suggested that species that feed near the benthos are at greater risk than those that feed in the water column (Normandeau et al., 2011), and none of the common species of marine mammals in the Offshore Project Area are benthic foragers. Several reviews of existing studies have determined that, due to the lack of documented evidence of marine mammal interactions with subsea cables, cetaceans would likely not be affected by subsea cable EMF, as the area of influence would be too small to alter their behavior (Copping et al., 2016; Gill, Gloyne-Phillips, Kimber, & Sigray, 2014; Normandeau et al., 2011). Therefore, EMF associated with the offshore cable system is not expected to pose a risk to marine mammals.

Sediments: Turbidity caused by disturbance of sediment would be limited to an area near the construction or maintenance activity and be short-term. In addition, field verification of sediment plume modeling for cable installation during Block Island offshore wind farm indicated that the actual sediment plume was less than the modeled plume, without any evidence of a sediment plume in the water column resulting from use of the jet plow (Elliott et al., 2017). Sediment plumes are dependent on sediment type and mobilization of sediments and would be expected to vary from region to region. Sediments in the WDA and offshore portion of the OECC in greater than 30 m (98.4 ft) water depths are predominately fine sand with some silt, fining in the offshore direction. Heading north through Muskeget, median grain size increases, with sand and gravel dominant, along with coarser deposits (cobbles, boulders) locally. Continuing north into the main body of Nantucket Sound, sand still dominates the seabed, with coarser deposits concentrated around shoals and in high current areas and finer grained sediments occupying deeper water and/or more quiescent flow areas. These sandy sediments would be expected to settle quickly. Marine mammals are also expected to avoid areas very close to pile driving, dredging, or offshore export cable installation, thereby avoiding areas where most temporarily suspended sediments may occur before settling back to the bottom. Therefore, based on the limited mobilization of sediment into the water column, project activities are not expected to pose a risk to marine mammals.

The potential risk-producing factors that are not expected to pose a risk to marine mammal populations (reduction in prey availability, habitat disturbance and modification, marine debris, EMF, entanglement, and sediments) (see Table 6.7-2) are not addressed further in this analysis.

6.7.2.1 Construction and Installation

6.7.2.1.1 Noise from Construction and Installation

All marine mammals use sound for various components of their daily activity, such as foraging, navigating, and avoiding predators. Marine mammals also use sound to learn about their surrounding environment by gathering information from other marine mammals, prey species, phenomena such as wind, waves, and rain, or from seismic activity (Richardson, Greene, Malme, & Thomson, 1995).

Marine Mammal Hearing and NOAA Thresholds for Injury and Behavioral Harassment

High-frequency cetaceans generally possess a higher upper-frequency hearing limit and better sensitivity at high frequencies compared to the mid-frequency cetacean species (Finneran, 2016; Southall et al., 2007). Most baleen whales (low-frequency cetaceans) are most sensitive to sounds under one kiloHertz ("kHz") (Richardson et al., 1995; Southall et al., 2007). However, despite the generalization reviews (e.g., Finneran, 2016) and the NOAA (2016k) acoustic guidance, there is considerable variation in the vocal capabilities of low-frequency cetaceans, which may indicate broader hearing ranges for certain species. For example, based on their vocal capabilities, the Fin Whale's hearing range may extend as low as 10 Hertz ("Hz") to 15 Hz, while the Minke Whale can hear sounds at frequencies as low as 60 Hz and produce clicks as high as 20 kHz (Beamish & Mitchell, 1973; Richardson et al., 1995). Humpback Whales are also noted as producing vocalizations greater than one kHz, including sounds up to 1.8 kHz or even possibly 8.2 kHz (Beamish, 1979; Payne & Payne, 1985; Thompson, Cummings, & Ha, 1986). Parks, Ketten, O'Malley, & Arruda (2007) used morphometric analysis of NARW ear anatomy to estimate a hearing range of 10 Hz to 22 kHz for this species. For noises such as pile driving, mid-frequency cetaceans are less sensitive than high- and low-frequency cetaceans; therefore, it takes louder sources or a closer approach to noise sources to potentially cause hearing injury for mid-frequency cetaceans (Finneran, 2016). The generalized hearing ranges of low-, mid-, and high-frequency cetaceans and seals as established by NOAA (2016k) are shown in Table 6.7-4.

In 2016, NOAA issued new guidance for determining potential impacts of noise on marine mammals and established new injury thresholds for Level A Harassment under the MMPA (NOAA, 2016k). This guidance was reviewed per Executive Order 13795 and reissued in 2018. Thus, this guidance may change prior to the implementation of the Offshore Project Area.

Under the new guidance, NOAA Fisheries based the criteria on the potential for a sound source to result in permanent threshold shift ("PTS"). PTS occurs when exposure to noise results in a permanent loss of hearing in a portion of the frequency spectrum, which can have direct negative consequences for marine mammals. PTS can result from repeated exposures to reversible threshold shifts (temporary threshold shifts ["TTS"]), or acute exposure to an intense sound that causes immediate damage to the ear. PTS thresholds are used to determine if Level A Harassment (injury) may occur.

In addition to focusing on PTS, the criteria differentiate between five functional hearing groups and the varied susceptibility of those groups to noise from different portions of the frequency spectra (see Table 6.7-4). Consequently, different thresholds apply to each functional hearing group (see Table 6.7-5).

Table 6.7-4 Marine Mammal Hearing Groups (see Appendix III-M Section 4.3.1)

Hearing Group	Generalized Hearing Range[1]
Low-frequency Cetaceans (Baleen Whales)	7 Hz to 35 kHz
Mid-frequency Cetaceans (Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales)	150 Hz to 160 kHz
High-frequency Cetaceans (Porpoises, Dwarf and Pygmy Sperm Whales, River Dolphins, Cephalorhynchids, *Lagenorhynchus cruciger,* & *L. australis*)	275 Hz to 160 kHz
Phocid pinnipeds[2] (underwater) (Earless Seals)	50 Hz to 86 kHz

Source: NOAA, 2016k
Note:
[1] Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on a ~65 decibel (dB) threshold from normalized composite audiogram, with the exception for lower limits for low-frequency cetaceans (Southall et al., 2007) and earless seals (approximation).
[2] Because sea lions and fur seals do not occur in US Atlantic EEZ, that hearing group is not included here.

Also, NOAA Fisheries based the new criteria on different metrics than in the past. The criteria use dual metric acoustic thresholds for impulsive sounds, peak sound pressure ("Lpk") and cumulative sound exposure level ("SELcum"). For non-impulsive sources, such as vibratory pile driving, the criteria specify a single SELcum for each hearing group. All sound exposure levels for Lpk and SELcum are in decibels ("dB"), with Lpk referenced to 1 microPascal ("μPa") and SELcum referenced to 1 μPa^2 in 1 second ("μPa^2s").

Table 6.7-5 NOAA Injury Criteria for Marine Mammals

Hearing Group	Threshold Type[1]	Permanent Threshold Shift Onset Acoustic Thresholds (Received Level)	
		Impulsive	Non-impulsive
Low-Frequency Cetaceans	Lpk	219 dB	199 dB
	SELcum	183 dB	
Mid-Frequency Cetaceans	Lpk	230 dB	198 dB
	SELcum	185 dB	
High-Frequency Cetaceans	Lpk	202 dB	173 dB
	SELcum	155 dB	
Phocid Pinnipeds	Lpk	218 dB	201 dB
(Underwater)	SELcum	185 dB	

Source: NOAA, 2016k
Note: Because sea lions and fur seals do not occur in US Atlantic EEZ, that hearing group is not included here.
[1] Lpk = Peak Sound Pressure Level, SELcum = Cumulative Sound Exposure Level.

For underwater Level B (behavioral) Harassment, NOAA Fisheries defines the threshold as received level of 160 dB root mean square ("RMS") re 1 μPa for impulsive sound and 120 dB RMS re 1 μPa for continuous sound for all marine mammals. Although actual perception of underwater sound is dependent on the hearing thresholds of the species under consideration and the inherent masking effects of ambient sound levels, the NOAA-established Level B Harassment criteria do not consider species-specific hearing capabilities and are, therefore, very conservative and was not updated in the new guidance, described above (NOAA, 2016k). For airborne Level B Harassment, which can occur for pinnipeds on land, the thresholds are 100 dB RMS re 20 μPa for all pinnipeds except Harbor Seals, which have a threshold of 90 dB RMS re 20 μPa. For further discussion of acoustic thresholds for marine mammals, see Appendix III-M.

General Impacts of Noise

As noted above, marine mammals can experience TTS or PTS as a result of noise. Marine mammals' behavioral responses to noise range from no response, to mild aversion, to panic and flight (Southall et al., 2007). Short- and long-distance displacement have been observed for seals and cetaceans in response to noise. For example, studies have shown that Harbor Porpoises (Brandt, Diederichs, Betke, & Nehls, 2011; Dähne et al., 2013) and Harbor and Gray Seals (Edrén et al., 2010) may temporarily leave an area in response to pile driving noise. Displacement could cause animals to move into less suitable habitat or into areas with a higher risk from vessel collision or other anthropogenic impacts. Masking, or interference of noise with a marine mammal's ability to send and receive acoustic signals, is another potential impact. The susceptibility of a marine mammal to masking depends on the frequencies at which the marine mammal sends and receives signals and the frequencies, loudness, and other attributes of ambient noise (David, 2006). Low-frequency cetaceans such as baleen whales may be vulnerable to masking by low-frequency noise (Richardson et al., 1995), such as vessel traffic noise (Redfern et al., 2017).

Pile driving is the loudest activity expected to occur during construction of the Project. It is estimated that each monopile will typically take less than approximately three hours to install (significantly less for pin piles) and that up to two foundations could be driven per day. Assuming the maximum design scenario (100 foundations for 8 megawatt ["MW"] WTGs), there could be 100 days of pile driving activity (if only one pile were driven per day), not including weather delays; however, if larger WTGs are utilized there would be fewer WTG locations and therefore less pile driving.

There will be many days where no pile driving occurs, creating periods without noise from project construction throughout the construction period. Some habituation and/or adaptation to pile driving noise may occur. For example, Sperm Whales in the Gulf of Mexico, where seismic surveys have been conducted for decades, were found to maintain their behavior state when subjected to seismic sound sources, suggesting habituation to this relatively loud sound source (Miller et al., 2009), and similar results were found in the Arctic, including no changes in normal Sperm Whale vocal patterns during feeding dives in areas with seismic survey noise (Madsen, Møhl, Nielsen, & Wahlberg, 2002). Some cetaceans may be able to modulate their hearing to reduce the sound of loud noise (akin to putting on ear protection for humans) and physiologically reduce impacts of masking in noisy environments (Nachtigall & Supin, 2008; Nachtigall, Supin, Pacini, & Kastelein, 2017). Marine mammals in the Offshore Project Area are regularly subjected to commercial shipping noise and would potentially be habituated to vessel noise as a result of this exposure (BOEM, 2014).

Noise from Pile Driving

The Project will be the first commercial-scale wind project constructed in the US. Past construction projects in the region either involved more limited pile driving or relied on other methods of pile installation. However, the noise generated by construction-related pile driving in the Offshore Project Area would be consistent with that described for other planned wind farms (TetraTech, 2012). A description of the proposed pile driving techniques for the Project is described and used for acoustic modeling in Appendix III-M (see Sections 2.2 and Appendix A for details). Noise generated by the impact hammer would include regular, pulsed sounds of short duration (an impulsive noise source). These pulsed sounds are typically high-energy with fast rise times and sharp peaks, which can cause both behavioral changes and injury, depending on proximity to the sound source and a variety of environmental and biological conditions (Dahl, de Jong, & Popper 2015;

Nedwell et al., 2007). There is typically a decrease in sound pressure and an increase in pulse duration the greater the distance from the noise source (Bailey et al., 2010). Measurements have also indicated that the noise is broadband close to the source (two kilometers [1.2 mi]) with peak energy around 110 Hz to two kHz but with energy up to 10 kHz (Bailey et al., 2010). Noise generated by vibratory hammers would be continuous, but have lower energy without any sharp peaks and, therefore, would likely only result in behavioral impacts. For either the impact or vibratory hammer, the pile driving would last a few hours, stopping for moving equipment and other breaks.

Illingworth & Rodkin (2007) measured an unattenuated sound pressure within 10 m (33 ft) at a peak of 220 dB re 1 μPa for a 2.4 m (96 in) steel pile driven by an impact hammer. Studies of underwater pile driving indicate that most acoustic energy is below one to two kHz, with broadband sound near the source (40 Hz to >40 kHz), but only low frequencies (<400 Hz) at long ranges (Illingworth & Rodkin, 2007; Erbe, 2009). Brandt et al., (2011) found that for a pile driven in a Danish wind farm in the North Sea, the peak at 720 m (0.4 nm) from the source was 196 dB re 1 μPa. This is lower than the received levels estimated for PTS (i.e., Level A Harassment) for cetaceans and seals, which ranges from 202-230 dB Lpk re1 μPa (see Table 6.7-5). The spectral maximum was between 80 and 200 Hz, which is audible to low-frequency cetaceans (Brandt et al. 2011). These studies suggest that, although the majority of the energy in pile driving is at low frequencies, a low-frequency cetacean would need to be relatively close to the source to potentially experience PTS. Behavioral impacts may occur at farther ranges, and behavioral response may differ among individuals and relative to behavioral state and other factors (Ellison, Southall, Clark, and Frankel, 2012; Southall, Dowacek, Miller, & Tyack, 2016). To address this range of behavioral dose responses, Wood, Southall, & Tollit (2012) developed a probabilistic step function for which 10%, 50%, and 90% of individuals exposed to different dose levels of sound are expected to exhibit behavioral responses dependent on received sound levels. This approach is discussed and applied to analyses in BOEM's Programmatic Environmental Impact Statement for G&G surveys in the Gulf of Mexico (BOEM, 2017).

The risk to marine mammals from pile driving noise must also be considered in the context of existing ambient noise. Other anthropogenic noise sources can mask pile driving noise, to a certain extent. For example, during construction of a Belgian wind farm, the combined effect of the bathymetry and the noise generated by shipping was predicted to be of greater relevance to Harbor Porpoises, as the noise emitted from a single pile driving strike did not add to the soundscape for at least half of the time (EU Commission, 2016). Kraus et al., (2016) recorded ambient noise in the frequency range of 70.8-224 Hz in the MA/RI WEA from 2011 to 2015. Sound levels ranged from 96 dB re 1 μPa to 103 dB during 50% of recording time. Sound pressure levels were 95 dB re 1 μPa or less 40% of the time and greater than 104 dB re 1 μPa 10% of the time.

Noise from pile driving can cause temporary, localized displacement of marine mammals. For example, during construction of wind farms, Harbor Seals have demonstrated displacement during pile driving of up to 25 km (13.5 nm) from the center of the wind farm (Russell et al., 2016). Harbor Porpoises have also demonstrated displacement of up to 20 km (10.8 nm) from pile driving for wind farms (Dahne et al., 2013), as well as documented sensitivity to TTS from simulated pile driving sounds (Kastelein, Gransier, Marijt, & Hoek, 2015; Kastelein, Helder-Hoek, Covi, & Gransier, 2016). Zone of harassment risk to marine mammals is likely to occur from a maximum of approximately 0.5 km (0.27 nm) for potential injury to several kilometers for potential behavioral responses based on modeled and measured noise from pile driving relative to NOAA Fisheries' thresholds for injury and behavioral harassment (Chen, Guan, & Chou, 2016; Nedwell et al., 2007; TetraTech, 2012). However, field studies have indicated that distances over which injury might occur could be smaller (Bailey et al., 2010).

Species of particular concern for pile driving noise impacts include NARW, other baleen whales, Harbor Porpoises, and seals. Baleen whales and seals, as low-frequency specialists, have the potential to be particularly sensitive to the low frequencies of pile driving noise and will likely detect noise at longer distances than mid- and high-frequency cetaceans (Finneran, 2016; Kastelein, Gransier, & Jennings, 2013), though detection does not necessarily result in harassment as defined under MMPA. Generally, although low-frequency cetaceans and seals may hear pile driving noise at greater distances than high- and mid-frequency cetaceans, they are likely less sensitive to acute exposure to noise than high-frequency cetaceans because the peak energy of noise must be higher for low-frequency cetaceans to experience PTS (see Table 6.7-5; Finneran, 2016). Risk from pile driving noise to mid-frequency cetaceans is low as these species are not very sensitive to low- and high-frequency noise (Finneran, 2016); it would be expected to take more sound energy, and thus closer proximity to pile driving, to expose mid-frequency cetaceans to noise levels likely to impact behavior or cause injury.

NARWs are of particular concern because they are listed as endangered under the ESA, the population declined from 2010 to 2015 (Pace et al., 2017), the species is currently experiencing an unusual mortality event (NOAA, 2017d), and the NARW range is limited to US and Canadian east coasts, without distribution across the North Atlantic like other baleen whale species. Further, Kraus et al., (2016) identified 77 individual NARW in the MA/RI WEA and observed courtship behavior on multiple occasions. LaBrecque et al., (2015) identified the Offshore Project Area as part of a BIA for NARW migration; however, this migration BIA extends well beyond the Offshore Project Area, suggesting suitable areas for migration are extensive (see Figure 6.7-2). Mitigation will reduce risk to NARWs, and the Offshore Project is not expected to result in reductions in individual or population fitness. NARWs have been documented to modify the amplitude of their calls during periods of increased ambient noise, suggesting some flexibility in adapting to temporarily noisy environments (Parks, Johnson, Nowacek, & Tyack, 2011). NARWs may experience some chronic stress associated with relatively constant anthropogenic noise already existing in their environment (Rolland et al., 2012).

Harbor Porpoises may have sensitivity to behavioral disruptions of foraging due to energetic needs and associated foraging requirements. Although the daily feeding rate of non-lactating adult Harbor Porpoises is only about 3.5% of body weight per day, this rate can increase by as much as 80% for lactating females in summer months, resulting in about five additional hours of foraging per day at that time (Yasui & Gaskin, 2012). Tagging data suggest that Harbor Porpoises may have high metabolic demands and disruption to foraging for some individuals may be important to energy budgets and fitness (Wisniewska et al., 2016), though Hoekendijk et al., (2018) cautions that the feeding behaviors recorded by Wisniewska et al., (2016) are not representative of normal behaviors, could not be sustained over long periods to time, and may suggest resilience of Harbor Porpoises to adjust their feeding behaviors to account for disruptions in their environment. Wisniewska et al., (2018) provide some additional details and analysis regarding their original study. Interruption to feeding may occur during pile driving. Risk from pile driving noise is expected to be low for Harbor Porpoises as they are predicted to occur in the largest densities outside the MA/RI WEA (Roberts et al., 2016), suggesting better foraging habitat occurs outside the Offshore Project Area. Harbor Porpoises in proximity to pile driving may have a higher risk of injury than mid-frequency cetaceans that have less sensitivity to the frequencies of noise generated by pile driving; however, there is some evidence to suggest that several cetacean taxa may be able to modulate their hearing relative to noise, both to dampen loud noise and to improve their perception of returning echolocation sounds in noisy environments (Nachtigall & Supin, 2008; Nachtigall et al., 2017). There is also evidence to suggest that Harbor Porpoises can habituate and/or adapt to noise in their environment (Cox, Read, Solow, & Tregenza, 2001).

Distribution can also play a role in marine mammal exposure to pile driving noise. Gray Seals are present year-round in the Offshore Project Area. Gray Seals spend periods of time on land at haul-outs and breeding sites where they will not be subject to noise from the Offshore Project Area. Likewise, Harbor Seals are not subject to exposure to underwater noise while on land. Risk to Gray Seals and Harbor Seals is low as both species mainly occur farther north than the Offshore Project Area (Hayes et al., 2017), thereby limiting the number of individuals available for exposure to pile driving relative to their populations.

The risk of behavioral disturbances are difficult to quantify, but sufficient disturbances may result in temporary displacement and/or some decline in foraging activity in the Offshore Project Area. Species ranges for Gray Seals, Harbor Seals, and Harbor Porpoises described above extend well beyond the Offshore Project Area, and predictions of the density of cetaceans (Roberts et al., 2016) suggest that densities of baleen whales are low in the Offshore Project Area, with preferred foraging habitats outside the Offshore Project Area (LaBrecque et al., 2015).

With respect to airborne sound that could potentially impact seals hauled-out near pile driving activities, Van Renterghem, Botteldooren, & Dekoninck (2014) evaluated airborne sound propagation over the Belgian North Sea during wind farm pile driving activities. Though airborne sound is expected to propagate differently depending on variables such as type of equipment, wind speed, sea state, etc., this study is informative for considering how far sound that meets behavioral disturbance criteria may travel from offshore pile driving locations. Van Renterghem et al., (2014) found that, at distances over 10 km (5.4 nm), noise impact was expected to be very low. The closest major seal haul-out site to the WDA where pile driving would take place is on the northwestern side of Nantucket Island. This haul-out is 23 km (12.4 nm) from the WDA. Given this distance, risk from airborne noise from pile driving would be low and would not reach NOAA thresholds for Level B disturbance of seals at major haul-out sites. Thus, airborne noise will not be considered further.

Concerns of acoustic impacts of pile driving on prey availability have been raised by McCauley et al. (2017) who argued that seismic survey air gun operations negatively impact zooplankton. However, the study design of McCauley et al. (2017) had weaknesses. There was considerable variability in plankton in the control (decreased abundance by 91% in the control) and differences in tide height between the two days studied, suggesting natural fluctuations in plankton may have caused the study results. Richardson et al. (2017) evaluated the impact on ocean ecosystem dynamics and zooplankton and found that even if effects such as those in conclusions by McCauley et al. (2017) did exist, extensive movements of water masses and rapid reproductive cycle of these organisms would result in no effects to population dynamics.

Noise from Vessel Traffic

Ship engines and vessel hulls emit broadband, continuous sound, generally ranging from 150 to 180 dB re 1 μPa/m, at low frequencies below 1,000 Hz, which overlaps with the hearing frequency range for all marine mammals (NSF & USGS, 2011). Researchers have reported a change in the distribution and behavior of marine mammals in areas experiencing increased vessel traffic, particularly associated with whale watching, likely due to increases in ambient noise from concentrated vessel activity (Erbe, 2002; Jelinski, Krueger, & Duffus, 2002; Nowacek, 2004). Kraus et al., (2016) recorded ambient noise in the BOEM MA/RI WEAs from November 2011 to March 2015. Kraus et al., (2016) reported that sound levels in the 70.8 to 224 Hz frequency band for all PAM sites varied between 96 dB and 103 dB re 1 μPa during 50% of the recording time.

Vessel traffic associated with the Offshore Project Area would potentially originate from Rhode Island and/or Massachusetts (see Section 2.0). However, depending on the pace and timing of the Project's construction efforts, Vineyard Wind may stage certain activities from other North Atlantic ports. Potential acoustic impacts would consist of vessel noise produced during transit to and from multiple ports as well as the vessel noise produced during construction at the WDA. DP thrusters would likely be used; however, these thrusters are commonly used by the shipping traffic in the area and would be consistent with existing ambient vessel noise. Because marine mammals rely on sound for communication, navigation, and predator/prey detection, increased vessel traffic in the Offshore Project Area may potentially impact these species (Clark et al., 2009; Southall, 2005; Kraus et al., 2013). Possible effects from vessel noise are variable and would depend on the species of marine mammal, the marine mammal's location and activity, the novelty of the noise, vessel behavior, and habitat. As noise from vessel traffic associated with construction is likely to be similar to background vessel traffic noise additional vessel noise risk to marine mammals would be low relative to pile driving noise.

Vessel traffic throughout the MA/RI WEA is relatively high (see Appendix III-M Section 8.2); marine mammals in the area are presumably habituated to vessel noise (BOEM, 2014). Although received levels of noise may, at times, be above the continuous sound threshold for Level B Harassment (120 dB), NARWs are known to continue to feed in Cape Cod Bay despite disturbance from passing vessels (Brown & Marx, 2000). In addition, construction vessels would be stationary on site for significant periods of time and the large vessels would travel to and from the site at low speeds, which would produce lower noise levels than vessel transit at higher speeds. Cable installation is described in detail in Section 4.2.3 of Volume I. Potential noise risk is predicted to be low, and noise generated from vessels installing the offshore export cables is comparable to potential vessel noise from vessels traveling to and within the WDA (see above).

Noise from Cable Installation

Cable installation is described in detail in Section 4.2.3 of Volume I; noise impacts within the OECC due to cable installation are comparable to vessel noise impacts expected in the WDA for construction and installation. Risk is low that cable installation noise will have an effect on marine mammal behavior.

Noise from Survey Operations

High frequency (>200 kHz) and low frequency acoustic surveys (<200 kHz) could be conducted during construction activities to map and document temporary physical conditions for informing the installation process. Examples could include checking cable burial, mapping trench depth after dredging prior to laying cable within, or imaging the areal extent of scour protection around the base of WTGs. These surveys would include the appropriate PSO monitoring and mitigation procedures. Refer to Section 1.7 of Volume I and Section 6.7.2.1.3 below for a summary of these BMPs. Accordingly, the risk to marine mammals from noise from survey operations would be low.

6.7.2.1.2 Vessel Traffic

Vessel collisions with cetaceans (whales, dolphins, and porpoises) that result in serious injury or death can occur. Vessel collisions are more of a threat to baleen whales than any other marine species (Wiley, Asmutis, Pitchford, & Gannon, 1995). Research indicates that most vessel collisions with whales resulting in serious injury or death occur when a ship is traveling over speeds of 7.2 meters per second (14 knots) (Laist, Knowlton, Mead, Collet, & Podesta, 2001). Thus, the highest risk for vessel strike would most likely occur during transit to and from the WDA, if vessels travel at increased speeds. However, construction vessels are large and travel at relatively low speeds. Laist et al., (2001) reviewed 407 stranding deaths of seven large whale species from 1975 to 1996 along the US East Coast (Maine to Florida). The review indicated that 67% of Sei Whale, 33% of Fin Whale, 33% of NARW, 8% of Humpback Whale, 5% of Minke Whale, and zero Sperm and Bryde's Whale stranding deaths included signs of vessel collision (Laist et al., 2001). In 2016 and through October 31, 2017, there were 57 Humpback Whale strandings on the US Atlantic coast; of the 20 cases examined, 10 had injuries consistent with vessel collision (NOAA, 2017e). As such, vessel collision risk for individuals would be highest for Sei Whales, Fin Whales, NARWs, and Humpback Whales; however, guidance to avoid such collisions has been produced by NOAA NMFS (2008) and will be followed to reduce risk.

Several studies have reported a shift in the distribution and behavior of marine mammals in high traffic areas (Erbe, 2002; Jelinski et al., 2002; Nowacek et al., 2004). Therefore, increased vessel activity associated with construction could result in marine mammals avoiding the area, which would reduce the risk of collision with oncoming vessels, but the potential for vessel collision may increase if whales are displaced into higher shipping traffic areas (such as commercial shipping corridors) by pile driving noise. Given the distance (at least 40 km [22 nm]) to the nearest shipping lane and project activities, risks resulting from marine species moving into the shipping lane are low and will be further evaluated in the context of mitigation and Project-specific BMPs. Also, existing marine vessels in the area adhere to vessel collision avoidance measures. Reductions in vessel speed have been shown to reduce the risk of collision-related mortality for NARWs (Conn & Silber, 2013) and is also inherently protective of other marine mammals. Risk of collision within the vessels in the OECC is expected to be similar to the risk experienced with construction activities in the WDA. However, since the OECC is closer to shore, vessel transit times would decrease, reducing the risk of vessel collision.

6.7.2.1.3 Avoidance, Minimization, and Mitigation Options

Working collaboratively with BOEM and NOAA, Vineyard Wind will develop mitigation that will effectively minimize and avoid the risk of impacts to marine mammals from construction, operation, and decommissioning. Vineyard Wind will continue to use acoustic modeling as a tool to inform approaches to mitigation and address sensitive variables relative to potential risks of Project-related noise on marine mammals. Modeling, as part of permitting and regulatory processes, will continue to be used to evaluate potential risks and specific mitigation and BMP options. A draft of the acoustic modeling report can be found in Appendix III-M.

Mitigation and BMPs must consider both practicability for a large-scale project and effectiveness at avoiding and minimizing impacts to marine mammals. Practicability includes safety, logistical ability, project integrity, environmental impacts, and the potential to increase the Project construction duration, which may have secondary impacts on other Project resources. Options will be modeled and weighed against biological value and effectiveness relative to practicability. NOAA and BOEM will be engaged in this iterative and adaptive process that will also incorporate lessons learned from Block Island offshore wind farm's five-turbine demonstration project in the MA/RI WEA.

Thus, it is premature to discuss all potential mitigation measures based solely on this qualitative assessment. However, at this stage, a number of potential measures and initiatives have been identified. Measures such as the establishment of exclusion and monitoring zones, pile driving soft-start procedures, vessel speed restrictions and avoidance measures, noise reduction technology, and the use of PSOs are expected to be part of the final mitigation plan (and are described below).

Importantly, pending successful award of a power contract in 2018, Vineyard Wind has established a $3 million fund to develop and demonstrate innovative methods and technologies to enhance protections for marine mammals during offshore wind development. Investments by the fund will be guided by a steering committee that will include representatives of environmental advocacy groups and others with expertise in the field of marine mammal protection. The fund may be directed toward such things as enhanced monitoring techniques and pile driving technologies.

Mitigation and BMP options to be considered include, but are not limited to, the following menu. A more detailed list of the acoustic and non-acoustic monitoring and mitigation measures currently proposed for the Project can be found in Table 31 of Appendix III-M.

Siting

The Massachusetts Request for Interest Area was determined by BOEM in collaboration with the Massachusetts Renewable Energy Task Force. Based on public input on the Request for Interest Area, BOEM selected a MA WEA. BOEM then modified the planning area and published a Call for Information and Nominations to identify areas where there was interest in commercial leases. After considering comments on the Call for Information and Nominations, BOEM further modified the WEA to exclude some areas of important habitat and fisheries value. BOEM conducted an Environmental Assessment of Commercial Wind Leasing and Site Assessment Activities (BOEM, 2014), which resulted in a Finding of No Significant Impact. Siting choices associated with these processes were the first step to minimize and avoid impacts to marine mammals and other resources and habitats.

Establishment of Monitoring and Exclusion Zones

As practicable, monitoring and exclusion zones could be established to minimize and avoid potential noise impacts on marine mammals during pile driving. An exclusion zone is a shutdown or power-down area surrounding construction activities that may be defined relative to Level A Harassment zones (as defined in NOAA, 2016) or based on other criteria as appropriate. The size of Level A Harassment zones may differ relative to different environmental conditions and different marine mammal hearing types (NOAA, 2016), and biologically appropriate and practicable zones may vary by species and situation. During pile driving, safety and project integrity issues may affect practicability of shutdown or power-down timing and duration.

In addition, a monitoring zone could be established during impact pile driving to monitor and record marine mammal occurrence and behavior. Monitoring zones are monitored for marine mammals, but marine mammal presence does not necessarily trigger shutdown or other actions. These monitoring zones are useful for observing potential approach by marine mammals to exclusion zones and can inform understanding of and adaptive management for potential behavioral disturbance.

Monitoring of exclusion and monitoring zones during pile driving will be conducted by NOAA Fisheries-approved PSOs and the final requirements and data sharing will be determined in collaboration with BOEM and NOAA Fisheries.

Establishment of Clearance Zones

As practicable, clearance zones could be established. Clearance zones are typically zones in which observations for marine mammals are made prior to starting pile driving. Commencement of pile driving may be delayed if marine mammals are observed in such a zone. As with exclusion and monitoring zones, biologically appropriate and practicable clearance zones may differ by species and circumstance. Specific requirements for clearance will be determined through collaboration with BOEM and NOAA Fisheries.

Pile Driving Ramp-up/Soft-start Procedures

As practicable, a ramp-up or soft-start could be used at the start of pile driving to provide additional protection to marine mammals located near the construction effort. A soft-start potentially allows marine mammals to become aware of noise at low levels and move away from the area prior to the commencement of full pile driving activities. Alternatively, other low noise sources could be used to alert animals. A soft-start utilizes an initial set of very low energy strikes from the impact hammer, followed by a waiting period. Additional strike sets gradually increase energy to what is needed to install the pile (usually less than hammer capability).

Equipment and Technology

Vineyard Wind will consider the best available equipment and technology for minimizing and avoiding impacts to marine mammals during construction and installation. Examples of potential technology include passive acoustic monitoring recorders, thermal cameras, and sound dampening devices. As described in Section 9 of Appendix III-M, Vineyard will use sound reduction technology, including Hydro-sound Dampers [HSD], bubble curtains, or similar technology, to reduce sound levels by a target of approximately 12 dB. Vineyard Wind will collaborate with BOEM and NOAA to integrate practicable technology choices in equipment, mitigation, and monitoring to meet the necessary standards for permitting and successful consultations.

Vessel Speed/Avoidance Procedures

Vineyard Wind will adhere to legally mandated speed, approach, and other requirements for NARW in the Offshore Project Area. As safe and practicable, NOAA's vessel strike guidance will also be implemented (NOAA NMFS, 2008). This guidance includes the following:

1. Vessel operators and crews shall maintain a vigilant watch for marine mammals to avoid striking sighted protected species.
2. When whales are sighted, maintain a distance of 91.4m (100 yards) or greater between the whale and the vessel.
3. When small cetaceans are sighted, attempt to maintain a distance of 50 yards or greater between the animal and the vessel whenever possible.
4. When small cetaceans are sighted while a vessel is underway (e.g., bow-riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until the cetacean has left the area.

5. Reduce vessel speed to 18.5 km/hr (10 kt) or less when mother/calf pairs, groups, or large assemblages of cetaceans are observed near an underway vessel, when safety permits. A single cetacean at the surface may indicate the presence of submerged animals in the vicinity; therefore, prudent precautionary measures should always be exercised. The vessel shall attempt to route around the animals, maintaining a minimum distance of 91.4 m (100 yards) whenever possible.

6. When an animal is sighted in the vessel's path or in proximity to a moving vessel, and when safety permits, reduce speed and shift the engine to neutral. Do not engage the engines until the animals are clear of the area.

In addition, environmental training of construction personnel will stress individual responsibility for marine mammal awareness and reporting.

Reporting of Marine Mammal Impacts

Vineyard Wind will report impacts on marine mammals to jurisdictional/interested agencies, as required. These agencies include, but are not limited to, NOAA Fisheries and BOEM. Vineyard Wind will provide notification of commencement and completion of construction activities and provide all required documentation and reports for permitted activities to the jurisdictional agencies.

BMPs and mitigation will be integrated and applied to construction and installation to meet the required standards of applicable statutes, regulations, and policies in collaboration with implementing agencies. Mitigation and BMPs that may be individually practicable may not be practicable in concert. Thus, a suite of mitigation will be developed as part of permitting processes to ensure efficacy and practicability of the mitigation as an integrated whole.

6.7.2.2 Operations and Maintenance

6.7.2.2.1 Noise from Operations and Maintenance

There is a low risk that the Project's operations and maintenance activities, as discussed in Section 2.3, have a likelihood of causing acoustic impacts to marine mammal populations. A comparison of studies on ambient noise and turbine operational noise (e.g. Kraus et al. 2016; Tougaard et. al 2009) in Section 7.2 of Appendix III-M concluded that the operational noise is predicted to have minimal impact. Vineyard Wind has used the best available data to determine that noise levels generated by the Project's WTGs are expected to be low risk to marine mammals. See Section 6.7.2.1.1 for a general description of potential impacts of noise on marine mammals and NOAA guidance associated with injury and behavioral harassment of marine mammals. In addition, Vineyard Wind is developing a framework for a post-construction monitoring program for protected resources. Using a standardized protocol, the Project will document any observed impact to marine mammals and sea turtles during construction, operations and decommissioning. The standardized protocol will be developed with BOEM and NMFS.

Noise from Wind Turbine Operation

Noise from WTG operation is expected to be much lower and with different characteristics than noise generated during construction activities. Modeling indicates that operational noise from turbines might be audible to marine mammals up to several kilometers away (EU Commission, 2016); however, no evidence exists of any behavioral impacts on marine mammals from WTG operational noise. Injury to marine mammals would only occur if individuals remained in close proximity to WTGs over long periods of time (EU Commission, 2016). Tougaard, Henriksen, & Miller (2009) found that noise from three different wind turbine types in European waters was only measurable above ambient noise levels at frequencies below 500 Hz. Low-frequency cetaceans within a few kilometers of a wind farm may hear noise associated with operation at low levels depending on sound-propagation conditions and ambient noise levels (Madsen, Whalberg, Tougaard, Lucke, & Tyack, 2006). Studies of Harbor Porpoises in European offshore wind farm areas have found temporary displacement during pile driving, with resumption of activities in the area during operation (with operational noise) (e.g., Brandt et al., 2011), and Scheidat et al., (2011) reported increased use by Harbor Porpoise in an area of the North Sea after construction of a wind farm. Such results suggest the risk of operational noise generated by the Project to displace or negatively impact marine mammals is low.

Noise from Vessel Traffic

As described in Section 6.7.2.1.1, all cetaceans and seals use underwater sound for various components of daily survival, such as foraging, navigating, and predator avoidance. Consequently, increased vessel traffic in the Offshore Project Area may affect these species. However, ambient noise due to commercial shipping and other vessel traffic is expected to overwhelm any noise associated with ships conducting operations and maintenance activities during the Project. Therefore, the risk to marine mammals from Project-related vessel traffic noise would be low.

Noise from Survey Operations

High frequency (>200 kHz) and low frequency acoustic surveys (<200 kHz) could be conducted during post-construction activities to map and document changes in seafloor and subsurface conditions that could impact Project components. Examples could include checking cable burial depth for suitable overburden in mobile sediment areas or monitoring various types of scour around the WTGs and ESPs. These surveys would include the appropriate PSO monitoring and mitigation procedures. Refer to Section 1.7 of Volume I and Section 6.7.2.1.3 for a summary of these BMPs. Accordingly, the risk to marine mammals from noise from survey operations would be low.

6.7.2.2.2 Vessel Traffic

As discussed in Section 6.7.2.1.2, collisions between marine mammals and ships that result in serious injury or death can occur. Reductions in vessel speed have been shown to reduce the risk of collision-related mortality for NARW (Conn & Silber, 2013); and is also inherently protective of other marine mammals. Sei Whales are less common in the Offshore Project Area than Fin, Humpback, and NARWs. Through the incorporation of BMPs for vessels in the area, individual and population level collision risk from vessel traffic associated with the Project would be low for Sei Whales, Fin, Humpback, and NARWs.

6.7.2.2.3 Avoidance, Minimization, and Mitigation Options

During operations and maintenance activities, Vineyard Wind will use BMPs and mitigation to avoid vessel collisions as described in Section 6.7.2.1.3 and Table 31 of Appendix III-M.

6.7.2.3 Decommissioning

Decommissioning is expected to have similar levels of vessel traffic as construction and installation; however, pile driving is not part of the decommissioning process; therefore, noise is not expected to be a primary risk during decommissioning.

6.7.2.3.1 Noise from Decommissioning

The Project's operations and maintenance activities, as discussed in Section 2.3, are unlikely to cause acoustic impacts on marine mammals. See Section 6.7.2.1.1 for a general description of potential risks of noise on marine mammals and NOAA guidance associated with injury and behavioral harassment of marine mammals.

Noise from Removal of Wind Turbines

To decommission the Project, the wind turbines and towers will be removed and the steel foundation components (transition piece and pile) will be decommissioned. Sediments inside the piles will be suctioned out and temporarily stored on a barge to allow access for cutting. In accordance with BOEM's removal standards (30 C.F.R. 250.913), the pile and transition piece assembly will be cut below the seabed; the portion of the pile below the cut will remain in place. Depending upon the capacity of the available crane, the foundation assembly above the cut may be further cut into more manageable sections in order to facilitate handling. The cut piece(s) will then be hoisted out of the water and placed on a barge for transport to a suitable port area for recycling.

Cutting of the steel piles below the mudline would likely be completed using one or a combination of underwater acetylene cutting torches, mechanical cutting, or high pressure water jet. Noise produced by such equipment is not similar to pile driving and would not be expected to disturb marine mammals more than general vessel traffic noise (Molvaer & Gjestland, 1981; Pangerc, Robinson, Theobald, & Galley, 2016; Reine, Clarke, & Dickerson, 2012). The sediments previously removed from the inner space of the pile would be returned to the depression left when the pile is removed. A vacuum pump and diver or remotely operated vehicle-assisted hoses would likely be used in order to minimize sediment disturbance and turbidity. See Section 4.4 of Volume I for more details on decommissioning procedures.

Noise from Vessel Traffic

As described in Section 6.7.2.1.1, all cetaceans and seals use underwater sound for various components of daily survival, such as foraging, navigating, and predator avoidance. Consequently, increased vessel traffic in the Offshore Project Area may pose a risk for these species. However, ambient noise due to commercial shipping and other vessel traffic is expected to overwhelm any noise associated with ships conducting operations and maintenance activities during the Project. Anticipated risk from vessel noise associated with the Project would be low.

Noise from Offshore Export Cable Removal

The offshore export cables may be abandoned in place to minimize environmental impact; in this instance, there would be no impacts from its decommissioning. If removal of the cables is required, the cables would be removed from their embedded position in the seabed. Where necessary, the cable trench will be jet plowed to fluidize the sandy sediments covering the cables, and the cables will then be reeled up onto barges. Impacts from removing the cables would be short-term, localized to the Project Area, and similar to those experienced during cable installation (see Section 6.7.2.1.1).

Noise from Survey Operations

High frequency (>200 kHz) and low frequency acoustic surveys (<200 kHz) could be conducted during decommissioning activities to map and document the proper removal or onsite stabilization of Project components. Examples could include mapping scour protection materials over cables and around WTGs, checking cable burial depth, or monitoring seafloor conditions around Project components. These surveys would include the appropriate PSO monitoring and mitigation procedures. Refer to Section 1.7 of Volume I and Section 6.7.2.1.3 for a summary of these BMPs. Accordingly, the risk to marine mammals from noise from survey operations would be low.

6.7.2.3.2 Vessel Traffic

Vessel traffic rates during decommissioning are expected to be similar to traffic rates during the construction phase (see Section 6.7.2.1.2). Consequently, the risk from vessel collisions on marine mammals during decommissioning are anticipated to be similar to those during construction. The offshore export cables may be left in place to minimize environmental impact; in this instance, there would be no vessels, so there would be no risk of vessel collision from cable decommissioning. If removal of the cables is required, the cables would be removed from their embedded position in the seabed and reeled up onto barges. Collision risk from removing the cables would be short-term, localized to the Project Area, and similar to those experienced during cable installation, described in Section 6.8.2.1.2.

6.7.2.3.3 Avoidance, Minimization, and Mitigation Options

During decommissioning, Vineyard Wind will use BMPs and mitigation to avoid vessel collisions. BMP and mitigation options that can reduce the risk of vessel collision are described in Section 6.7.2.1.3.

6.7.2.4 Conclusions

There are 16 species likely to have some individuals exposed to stressors from the Offshore Project Area. Four of these species (Risso's Dolphin, Long-Finned Pilot Whale, Sperm Whale, and Harp Seal) are not common and, thus, have low exposure probability. Sperm Whales are listed as endangered under the ESA and may have vulnerability to noise via masking or displacement close to noise sources, but noise as loud as seismic surveys has been shown to have no effect on Sperm Whale behavior (Miller et al., 2009) or vocalizations (Madsen et al., 2002).

No population level impacts are anticipated, and all potential risks to marine mammal populations are localized in and near the Offshore Project Area, which comprises only a small portion of the ranges of these species. Although there is potential for vessel collision, mitigation and implementation of BMPs will make the risk of this occurring very low, and no loss of individuals is expected as a result of the Offshore Project.

Because of their common use of the WDA, the OECC, and surrounding areas, common species (see Table 6.7-1) are likely to have individuals exposed to noise and increased vessel traffic. Species vulnerability to these stressors varies, but it is unlikely that population level impacts will occur for ESA and non-ESA listed species. Mid-frequency cetaceans (Bottlenose Dolphins, Short-beaked Common Dolphins, and Atlantic White-sided Dolphins) have low sensitivity to pile driving and similar low-frequency dominated noise sources such as vessels (Finneran, 2016). The additional Project-related vessel traffic is not anticipated to significantly disrupt normal traffic patterns to which these species may already be habituated (see Section 8.2 of Appendix III-M). Thus, behavioral vulnerability of these species is low.

For Sei Whales, Fin Whales, and NARWs, which are listed as endangered under the ESA, there are no anticipated losses of individuals, but disturbance of individuals is anticipated. Behavioral responses for these species are likely limited to short-term disruption of behavior or displacement related to construction noise (i.e., pile driving). Similar responses would be anticipated for Humpback and Minke Whales. BIAs for feeding occur near but not within the Offshore Project Area for all of the large baleen whale species, and a NARW BIA for migration includes the Offshore Project Area and extends well beyond that area (see Figure 6.7-2) (LaBrecque et al., 2015). Thus, proximity of some important biological activities creates the potential for some exposure during these activities.

NARWs are endangered under the ESA and are declining (Pace et al., 2017); therefore, they are potentially more vulnerable to population level impacts than other marine mammals in the region. NARWs are also experiencing an unusual mortality event (NOAA, 2017d), and the Offshore Project Area is part of their migratory habitat (LaBrecque et al., 2015). NARWs can potentially adapt to noise by modifying their calls in noisy environments (Parks et al., 2011). NARWs may experience some chronic stress associated with relatively constant anthropogenic noise in their environment (Rolland et al., 2012). Additional noise may increase stress levels; however, unlike commercial vessel traffic noise, pile driving noise from the Offshore Project Area will be limited to a small fraction of the NARW range, allowing NARWs to avoid Project-generated noise. Pile driving noise will also only typically occur in less than approximately three-hour increments with hours or days in between, providing recovery time for cumulative sound exposure and returning noise to baseline levels for most of the construction period (only one to two piles could be driven per day). At least 77 individual NARWs were present in the MA/RI WEA from 2011 to 2015 (Kraus et al., 2016). This suggests that at least 15% of the NARW population may use the MA/RI over a five-year period; however, this area is not considered a BIA for feeding (LaBrecque et al., 2015) and, despite several observations of courtship behavior by Kraus et al., (2016), calving and most breeding takes place south of the MA/RI WEA (Hayes et al., 2017). The migratory BIA includes a much larger area in the region than the MA/RI WEA (LaBrecque et al., 2015). Thus, displacement of individuals is unlikely to significantly affect important activities like foraging, migrating, and mating. In addition, mitigation, which will include MMPA permit requirements that result in negligible impacts and small numbers findings, will keep risk of population level impacts low.

Baleen whales migrate through the area MA/RI that includes the WDA, and the WDA is part of a BIA for NARW migration; however, this BIA is extensive (see Figure 6.7-2). Therefore, some avoidance of noise in the WDA would not appreciably affect available habitat for migration. After construction is complete, turbines would have sufficient distance between them (approximately 1.9 km [1 nm]) so that NARWs and other species would not be impeded from using the habitat. Masking and displacement are potential results of pile driving noise, but the duration and intensity would be short-term and localized, and habituation will likely reduce behavioral response over time. Further, mitigation would reduce Project associated risk. Mitigation can be individualized for species such as NARWs. NARWs are vulnerable to vessel collisions (Laist et al., 2001), but mitigation, such as laws governing vessel speeds, PSOs watching for whales, and vessel collision guidance recommendations (NOAA NMFS, 2008), are expected to result in avoidance of vessel collision.

In addition to NARWs, Harbor Porpoise are high-frequency cetaceans, which make them susceptible to injury from high-frequency components of pile driving noise. Although high-frequency noise attenuates quickly in marine environments, high-frequency cetaceans, such as Harbor Porpoises, are sensitive to this noise (Finneran, 2016) and occur in areas of the WDA near pile driving locations. Feeding disruption of Harbor Porpoise could be an important response to noise, due to the energetic requirements of lactating females, in particular (Yasui & Gaskin, 2012). Given the use of this habitat for foraging, the installation of in-water structures may cause a decline in Harbor Porpoise foraging activity in the area. However, feeding can occur in nearby areas if Harbor Porpoises are temporarily displaced. Predictions of occurrence (Roberts et al., 2016) suggest nearby habitat is suitable and potentially preferred relative to the Offshore Project Area. Further, as with NARWs, mitigation measures will minimize risk to Harbor Porpoises.

As phocid seals, Harbor and Gray Seals are considered low-frequency specialists (Kastak & Schusterman, 1999; Kastelein, Wensveen, Hoek, & Terhune, 2009; Reichmuth, Holt, Mulsow, Sills, & Southall, 2013; Sills, Southall, & Reichmuth 2014; and Sills, Southall, & Reichmuth, 2015). Gray Seals are present year-round in the Offshore Project Area and spend periods of time on land at haul-outs and breeding sites where they would not be subject to stressors from the Offshore Project Area. Likewise, Harbor Seals are not subject to exposure to underwater noise while on land. Both Harbor Seals and Gray Seals primarily occur farther north than the Offshore Project Area (Hayes et al., 2017), limiting the numbers of individuals available for exposure to pile driving relative to their populations. Implications of behavioral disturbance are similar to those described above, and impacts can be minimized or offset through similar mitigation.

Baleen whales, Harbor Porpoises, and Harbor Seals all have a seasonal component to their occurrence in the WDA and Offshore EEC. Based on Kraus et al., (2016), AMAPPS surveys (NESFC & SESFC, 2010, 2011, 2012, 2013, 2014, 2015, 2016), and predictions by Roberts et al., (2016), NARWs are mainly present in the Offshore Project Area in the spring, with another smaller peak in the winter, and range elsewhere for their main feeding and breeding/calving activities as a species. Humpback, Fin, and Minke Whales are mainly present in the spring and summer. Sei Whales are also mainly present in the spring and summer but are less common than the other baleen whales. Harbor Porpoises and Harbor Seals tend to move out of the Offshore Project Area in the summer. There will be a risk of short-term, localized, behavioral disturbance to these species during some seasons. The implications of behavioral disturbance are hard to quantify, but sufficient disturbance may result in temporary displacement. Risk can be minimized or offset through mitigation consisting of vessel collision guidance and noise reduction through technology and real-time observation and mitigation actions.

In summary, the type of impact expected for common species in the Offshore Project Area is disturbance of individuals, mainly from pile driving noise. Exposure probability is low for uncommon species but probable for individuals of common species in seasons during which they are present. The duration of the impact is expected to be short-term, though it may extend through short periods during approximately a year of installation and construction activities, likely leading to some habituation and adaptation to the noise source. Impacts would be localized in the WDA and nearby waters, which make up only a small portion of the full ranges of the marine mammal species potentially affected. Risk is low to have population level consequences, and there is no anticipated loss of individuals of ESA-listed species. The two most vulnerable species are NARWs and Harbor Porpoises for the reasons described above. Both species are seasonal in the Offshore Project Area, allowing individuals to spend parts of the year away from noise. Further, both species are predicted to occur in higher densities outside of the WDA, suggesting suitable habitat is available for any displaced individuals. Mitigation and BMPs will be implemented to reduce risk to levels that meet regulatory requirements under ESA, MMPA, and other applicable laws. Further, benefits of the Project to marine mammals include the potential for increased prey availability after turbines are installed due to reef effects and fish aggregation, and decreased impacts to species from climate change as greenhouse gas production is reduced by use of offshore wind power (see Section 2.0 of Volume III for Project Benefits).

6.7.2.5 Mitigation/BMPs

It is anticipated that authorization for pile driving activities will be requested from NOAA (and later for decommissioning as necessary). A marine mammal experiencing NOAA's acoustic thresholds is not necessarily taken, by definition in the MMPA (e.g., behavior may not change when an animal enters a Level B Harassment radius calculated using NOAA thresholds), but, for practical reasons, thresholds are applied as levels that represent presumed take. NOAA recommends that a Level A take be requested for projects with noise exceeding Level A thresholds at distances of more than a few tens of meters from sound sources, and such projects must make its findings of negligible impacts and small numbers relative to the Level A take that NOAA Fisheries permits; however, Vineyard Wind will employ mitigation and BMPs with the goal of avoiding a Level A take, regardless of permitted take numbers. Mitigation and BMPs will be applied to reduce noise impacts. As such, risk to marine mammals from construction, installation, and decommissioning activities are ultimately expected to be low. Operations and maintenance activities are not expected to result in Level A or Level B Harassment of marine mammals.

Individual mitigation actions may be practicable, but a suite of individually practicable mitigation actions may become impracticable in concert. Thus, care must be taken in evaluating both the benefits to marine mammals and the practicability of final combined mitigation decisions to ensure that mitigation can be practically implemented to meet the goal of avoiding a Level A take. Mitigation can also be individualized to address concerns about particular species, such as NARWs.

6.8 Sea Turtles

The Lease Area is south of Cape Cod and located within the Massachusetts Wind Energy Area ("MA WEA"), which is approximately 22 kilometers ("km") (13.7 miles [mi]) south of Martha's Vineyard. The Vineyard Wind Lease Area, within the MA WEA, is just over 23 km (14 mi) from Martha's Vineyard and Nantucket. The Wind Development Area ("WDA"), a portion of the Vineyard Wind Lease Area, and/or Offshore Export Cable Corridor ("OECC") (see Figure 6.8-1[17]) overlaps with the range of several sea turtle species. The description of the affected environment below reviews the distribution and use patterns of sea turtles in the Offshore Project Area and surrounding region. Species that occur within the US Atlantic (East Coast) Exclusive Economic Zone are listed generally with evaluation of their likely occurrence in and near the Offshore Project Area. Species potentially affected by the Project are described in further detail.

Sea turtles are reptiles that use marine habitats throughout the tropical and temperate regions of the world's oceans, in addition to adjacent terrestrial habitats (i.e., sandy beaches) for nesting. Seven species of sea turtles occur worldwide (Pritchard, 1996).

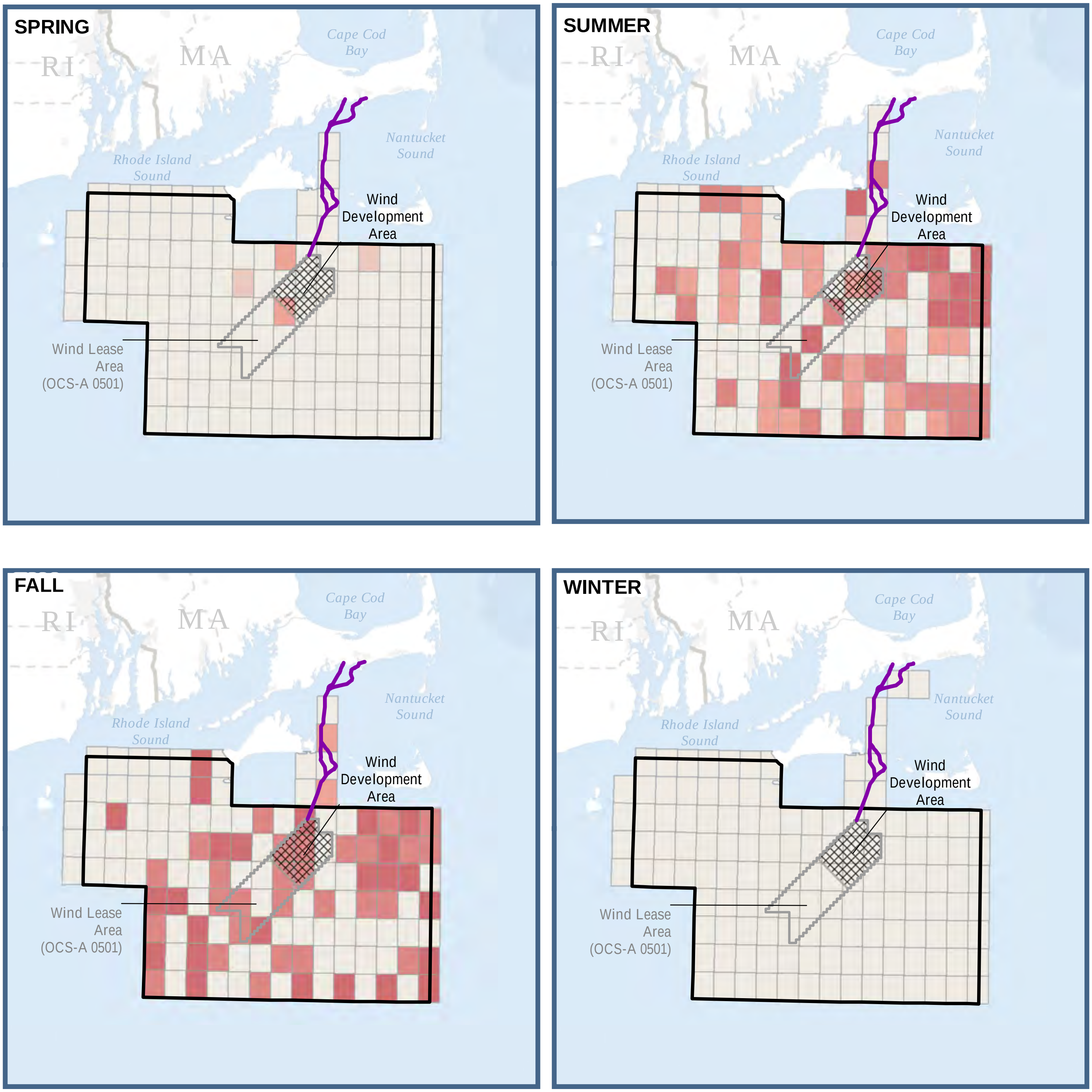
Four species of sea turtles may occur in the Offshore Project Area: Loggerhead Sea Turtle (*Caretta Caretta*), Kemp's Ridley Sea Turtle (*Lepidochelys kempii*), Green Sea Turtle (*Chelonia mydas*), and Leatherback Sea Turtle (*Dermochelys coriacea*). The abundance, distribution, and sighting data for these species were primarily derived from the following sources, and data specific to the Offshore Project Area were used, where available.

Primary Data Sources

Northeast Large Pelagic Survey

The Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles were conducted for the Massachusetts Clean Energy Center and BOEM by the Large Pelagic Survey Collaborative (comprised of the New England Aquarium, Cornell University's Bioacoustics Research Program, the University of Rhode Island, and the Center for Coastal Studies) (Kraus et al., 2016). This study was designed to provide a comprehensive baseline characterization of the abundance, distribution, and

[17] All figures associated with this section depict the outline of the Offshore Export Cable Corridor.



Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Kraus et al., 2016., ESRI 2017, BOEMRE 2017; E&E 2017

Map Coordinate System: NAD 1983 UTM 19N Meters

** SPUE values are number of animals sighted per 1,000 km of survey track summarized by 5' x 5' grid cells*

0 5 10 20 Nautical Miles

0 10 20 Kilometers

LEGEND

- State Boundary
- County Boundary
- Lease Area
- Wind Development Area
- Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles Study Area
- Offshore Export Cable Corridor

All Sea Turtles

Sightings per Unit Effort (SPUE*)

- 0
- <0 - 5
- 5 - 10
- 10 - 20
- 20 - 127.4

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Figure 6.8-1

All SeaTurtles Seasonal Aerial Survey Sightings per Unit Effort from Kraus et al. (2016) October 2011 to June 2015 temporal occurrence of marine life, with a focus on large endangered whales and sea turtles, in the Massachusetts and Rhode Island Wind Energy Areas ("MA/RI WEA") and surrounding waters. Information was collected using line-transect aerial surveys and passive acoustic monitoring from October 2011 to June 2015 in the MA WEA, and from December 2012 to June 2015 in the MA/RI WEA. Seventy-six aerial surveys were conducted, and Marine Autonomous Recording Units were deployed for 1,010 calendar days during the study period. For survey methodologies and details, please refer to Kraus et al., (2016).

<u>Vineyard Wind, 2016 & 2017 Geotechnical and Geophysical (G&G) Surveys</u>

Vineyard Wind conducted preliminary geotechnical and geophysical ("G&G") surveys within the boundaries of the Lease Area and potential OECCs to shore in the fall of 2016. Activities occurred onboard the Research Vessel ("RV") Shearwater and the RV Ocean Researcher over 54 survey days (excluding weather events). In 2017, Vineyard Wind conducted surveys in late summer and fall aboard the RV Henry Hudson and the RV Shearwater. Protected species observers ("PSOs") monitored the area surrounding the survey boats for marine mammals and sea turtles using visual observation and passive acoustic monitoring. All opportunistic sightings were recorded (Vineyard Wind, 2016).

<u>The National Oceanic and Atmospheric Administration's ("NOAA") Fisheries Sea Turtle Stranding and Salvage Network ("STSSN")</u>

NOAA established the Sea Turtle Stranding and Salvage Network ("STSSN") in response to the need to better understand threats faced by sea turtles in the marine environment, to provide aid to stranded sea turtles, and to salvage deceased sea turtles for scientific and educational purposes (SEFSC, 2017). In the northeast region, there is an active network of organizations that support and participate in the STSSN, and collected data are stored in the national STSSN database, which is maintained by NOAA's Southeast Fisheries Science Center ("SEFSC").

<u>North Atlantic Right Whale Consortium ("NARWC") Database</u>

Since the late 1970s, the NARWC has archived much of the existing aerial and shipboard survey data for marine mammals and sea turtles in southern New England waters. The NARWC database is managed and continually updated at the University of Rhode Island's Graduate School of Oceanography. Kenney & Vigness-Raposa (2010) have modeled the relative seasonal abundance of sea turtles from data gathered from 1974 to 2008.

Atlantic Marine Assessment Program for Protected Species ("AMAPPS") Sightings Data within the WDA

AMAPPS aggregates seasonality, spatial distribution, abundance, and density data for marine mammals, sea turtles, and seabirds from the collection efforts of the Northeast Fisheries Science Center ("NEFSC"), SEFSC, and the US Fish and Wildlife Service ("USFWS") Division of Migratory Birds for the years 2010 to 2016. The survey techniques for data collection include aerial and shipboard visual and acoustic practices. Each survey listed below contained at least one completed track line (i.e., aerial or ship line-transect) intersecting the WDA.

- NEFSC 17 August - 26 September 2010 Aerial Survey
- NEFSC 28 January - 15 March 2011 Aerial Survey
- NEFSC 1 - 31 August 2011 Aerial Survey
- NEFSC 28 March - 3 May 2012 Aerial Survey
- NEFSC 17 October - 16 November 2012 Aerial Survey
- NEFSC 1 July - 18 August 2013 Shipboard Survey
- NEFSC 17 February - 27 March 2014 Aerial Survey
- NEFSC 11 March - 1 May 2014 Shipboard Survey
- NEFSC 25 - 30 July 2014 Shipboard Survey
- NEFSC 5 December 2014 - 14 January 2015 Aerial Survey
- NEFSC 27 June - 25 August 2016 Shipboard Survey
- NEFSC 14 August - 28 September 2016 Aerial Survey
- NEFSC 15 October - 18 November 2016 Aerial Survey

Navy Operations Area (OPAREA) Density Estimates (NODEs)

OPAREA's NODEs for the Northeast OPAREA-Boston, Narragansett Bay, and Atlantic City-provide area-specific marine mammal and sea turtle density information estimates (Navy, 2007). These data were prepared for the US Navy Fleet Forces Command to meet its requirements established through the National Environmental Policy Act, Marine Mammal

Protection Act, and Endangered Species Act ("ESA") (16 U.S.C §.1531 et seq., 1973) compliance processes. Though these data have been superseded by more up-to-date abundance information for most species, this report provides general distribution information for sea turtles.

Northeast Ocean Data

In response to the U.S. National Ocean Policy call for regional ocean planning supported by a robust data management system, the Northeast Ocean Data Portal (NortheastOceanData.org) was created to bring together key data types. Data products are developed in association with the Northeast Regional Planning Body and the Northeast Regional Ocean Council. Currently, the portal contains information on loggerhead and leatherback sea turtle sightings in the Northeast for spring and summer.

OBIS-SEAMAP

The Ocean Biogeographic Information System Spatial Ecological Analysis of Megavetrebrate Populations (OBIS-SEAMAP; seamap.env.duke.edu) is an effort lead by Duke University aimed to augment our understanding of the distribution and ecology of marine mammals, sea turtles, seabirds, and rays & sharks. Data are collected from various providers world-wide and archived online in a spatially and temporally interactive format for distribution, abundance and modeling efforts.

6.8.1 Description of the Affected Environment

All sea turtles are protected by the ESA. However, only four species of sea turtles are likely to occur within the region of the WDA and/or OECC (see Table 6.8-1 and Figure 6.8-1). The official range of a fifth species, the Hawksbill Sea Turtle (*Eretmochelys imbricata*), extends into the Offshore Project Area; however, there are no recorded sightings of Hawksbill Sea Turtles in the area. Rather, the Hawksbill Sea Turtle is known in this region from an historical stranding record in Massachusetts in 1968 (Lazell, 1980; McAlpine, James, Lien, & Orchard, 2007) and an historical stranding record in New York in 1938 (Morreale, Meylan, Sadove, & Standora, 1992). Because the potential presence of this species is low, no impacts to the species are expected, and Hawksbill Sea Turtles will not be considered further in this analysis.

The presence of sea turtles in the Offshore Project Area is primarily limited to summer and fall months (see Figure 6.8-1) due to seasonal habitat use whereby sea turtles use warmer water habitats in the winter months (Milton & Lutz, 2003; Hawkes, Broderick, Coyne, Godfrey, & Godley, 2007; Dodge, Galaurdi, Miller, & Lutcavage, 2014, U.S. DON, 2017). No nesting sites are expected near landfall areas for the Project (NMFS & USFWS 1991, 1992a,b, 1993, 2008); evaluation of impacts to sea turtles will only be described and assessed based on their offshore distributions. Vineyard Wind consulted the STSSN database for strandings within this zone over the past 10 years (2007 to 2017) as a relative indication of each species' presence in the area (see Table 6.8-1), seasonal relative abundance patterns of sea turtles in the region (see Table 6.8-1) (Kenney & Vigness-Raposa, 2010), and sighting per unit effort ("SPUE") results from the Northeast Large Pelagic Survey (see Figure 6.8-1)(Kraus et al., 2016) to confirm the presence/absence of sea turtle species in the Offshore Project Area (see Figure 6.8-1). Sightings information from surveys reported in BOEM (2014) have also been integrated into the species-specific discussions below.

Threatened and Endangered Sea Turtles within the WDA and OECC

This section discusses the four sea turtle species known to occur within or near the Offshore Project Area, including a description of the species' biology, habitat use, abundance, and distribution, as well as the known threats to these populations.

Loggerhead Sea Turtle. Loggerheads are among the largest of the hard-shelled Chelonidae sea turtles, with carapace (i.e., shell) lengths ("CL") reaching 120 centimeters ("cm" (47 inches ["in"]) (TEWG, 2009). They have a reddish-brown carapace, with a dull brown integument (outer protective layer) dorsally and a light-to-medium yellow integument ventrally (Conant et al., 2009). When in the pelagic habitats, juvenile Loggerheads feed on invertebrates associated with *Sargassum* (a brown seaweed that can form large floating masses) as well as salps and jellyfish (Bjorndal, 1997). Once they reach a size of 40-60 cm (16 -24 in) CL, they recruit to coastal inshore and waters of the continental shelf throughout the US Atlantic to feed on a wide range of benthic and suspended animals including crabs, mollusks, jellyfish, and vegetation at or near the surface (NMFS, 2002).

Loggerhead Sea Turtles were listed as threatened in 1978 (43 Fed. Reg. 32,800 [1978]). In 2011, the National Marine Fisheries Services ("NMFS") and the USFWS issued a final rule concluding that, globally, the Loggerhead Sea Turtle is comprised of nine distinct population segments ("DPSs"), identifying four as threatened and five as endangered (76 Fed. Reg. 58,868 [2011]). Only the Northwest Atlantic DPS is likely to occur in the Offshore Project Area (see Table 6.8-1). Globally, Loggerheads occur throughout the temperate and tropical regions of all ocean basins (Dodd, 1988). The range of the Northwest Atlantic DPS is within the Atlantic Ocean, north of the equator, south of 60° N. and west of 40° W. Nesting for this DPS is concentrated along the Florida coast, with lower levels of nesting occurring into the Gulf of Mexico and up the Atlantic coast as far north as Virginia. Thus, there is no concern for nesting at the potential Landfall Sites.

Table 6.8-1 Sea Turtles in the Wind Development Area and Offshore Export Cable Corridor: Status and Occurrence

Species	Scientific Name	DPS/Stock	ESA Status	Average Strandings/Year (2007-2017)[1]	Combined Sighting, Stranding, and Bycatch Records for the Region (1974-2008; Kenney & Vigness-Raposa 2010)[3]	Relative Occurrence within the Offshore Project Area
Loggerhead	*Caretta caretta*	Northwest Atlantic DPS	Threatened	15.6	233	Common (summer and fall)
Kemp's Ridley	*Lepidochelys kempii*	N/A	Endangered	47.4[2]	14	Regular[1,4] (summer and fall)
Green	*Chelonia mydas*	North Atlantic DPS	Threatened	6.7	1	Rare
Hawksbill	*Eretmochelys imbricata*	Atlantic	Endangered	0	0	Hypothetical
Leatherback	*Dermochelys coriacea*	Atlantic	Endangered	13.5	142	Common (summer and fall)

Notes:

1 From the STSSN (https://www.sefsc.noaa.gov/species/turtles/strandings.htm).

2 Includes Kemp's Ridley Sea Turtles from large cold-stun events, likely inflating the number in relation to other species.

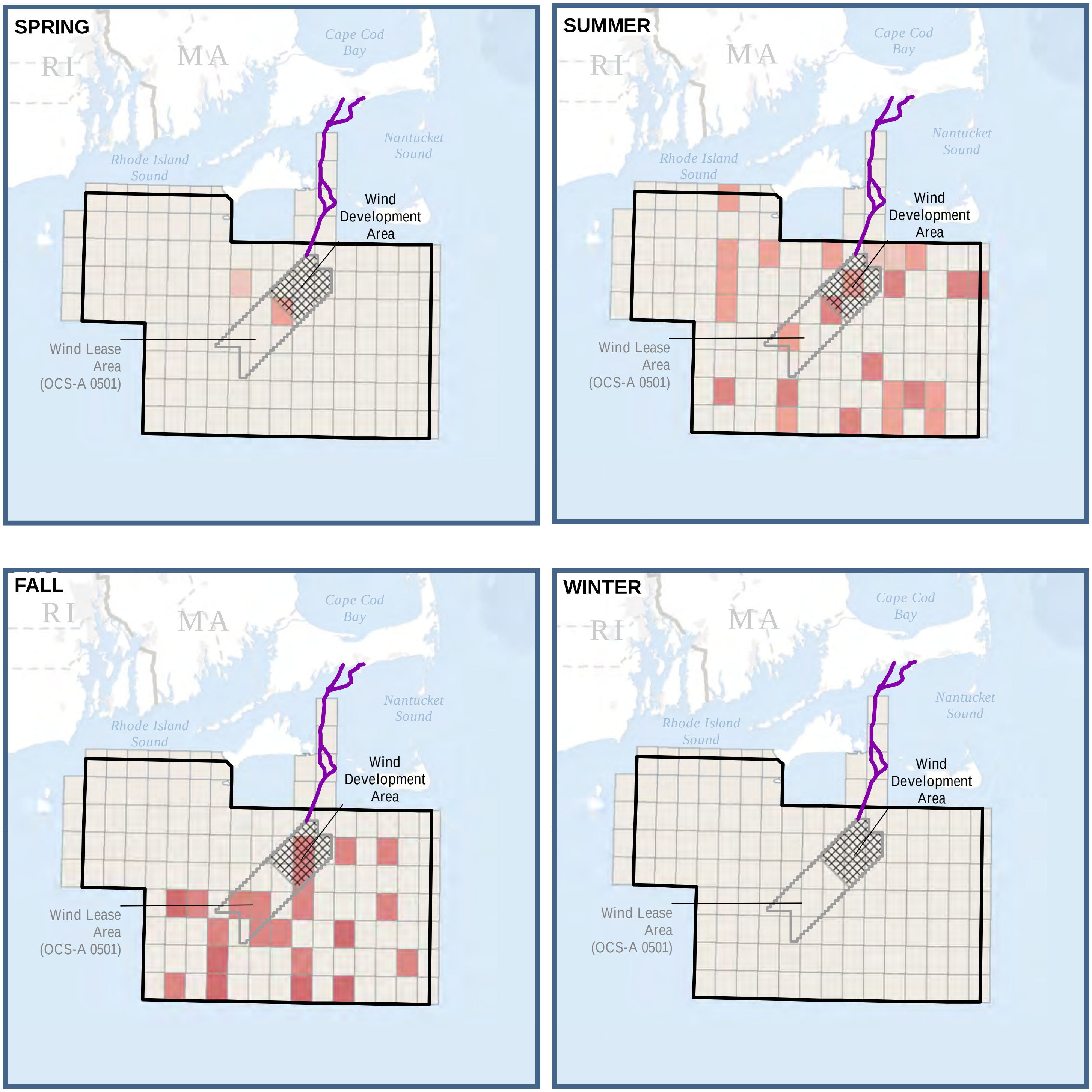
3 Summarizes occurrence records from four data sources: (1) aerial and shipboard surveys conducted by various agencies and archived by the NARWC; (2) opportunistic sightings records with no associate survey, also archived by the NARWC; (3) strandings records from 1993-2005; and (4) fisheries bycatch records. Records for Loggerhead Sea Turtles from 1979-2002, Kemp's Ridley Sea Turtles from 1979-2002, Leatherback Sea Turtles from 1974-2008, Green Sea Turtles in 2005 only. Includes Kemp's Ridley Sea Turtles from large cold-stun events, likely inflating the number in relation to other species.

4 While stranding records suggest Kemp's Ridleys may be common in the Project Area, the species is listed as regular due to the lack of survey-based sightings (Kenney & Vigness-Raposa, 2010).

The most common way to census sea turtle populations is to count nests on nesting beaches. In 2016, the Loggerhead nest count for Florida index beaches was 65,807 (FFWCC, 2017), which is the highest count since recording began in 1989. This value represents approximately 70% of all nesting that occurs in Florida. Females will lay three to four nests in a year, but will not nest every year; therefore, converting the nest count to a population count requires assumptions, and thus nest trends are typically used as a proxy for population trends. Overall, nesting trends for this DPS have been increasing since 2008.

Kraus et al., (2016) surveys of the MA/RI WEAs found that Loggerhead Sea Turtles occur throughout the region, with the most sightings occurring during the summer and fall months (over 92% of sightings occurred in August and September) (see Figure 6.8-2). Vineyard Wind also identified one Loggerhead Sea Turtle in the Lease Area during the 2016 G&G surveys (Vineyard Wind, 2016); four unknown species were sighted in 2017. Loggerheads tend to be absent during the winter months and are rare during the spring months, although sightings in spring were found within the Lease Area (Kraus et al., 2016). These findings of Loggerhead Sea Turtle spatial and temporal distributions are consistent with prior studies in the region; AMAPPS surveys have also spotted Loggerheads near the Project Area in the summer and fall months during surveys in 2010, 2012, 2013, and 2016 (NEFSC & SEFSC, 2010, 2012, 2013, & 2016). Data from the NARWC database report a majority of Loggerhead sightings in the region (99.6%) during the summer and fall months and are less likely to occur in nearshore waters (e.g., the OECC) (Kenney & Vigness-Raposa, 2010). However, nearshore areas should not be discounted, as juveniles present in more coastal areas or embayments may be too small to be detected during surveys (Kenney & Vigness-Raposa, 2010). STSSN data also indicate that Loggerhead Sea Turtles are relatively common within the region during the summer and fall. Additional studies consistent with Loggerhead Sea Turtle distributions reported here include the Cetacean and Turtle Assessment Program (CETAP, 1982) and Shoop & Kenney (1992) Loggerhead Sea Turtles spend approximately 3.8% of the time (or 2.3 minutes per hour) at the surface and are otherwise submerged, foraging, or resting (Thompson, 1988).

Historically, the primary threat to Loggerheads was the harvest of both eggs and turtles. Current threats include incidental capture in fishing gear (primarily longline and gill nets, trawls, traps, and dredges), and destruction and modification of nesting habitat from coastal construction, coastal erosion, and placement of erosion control structures (Conant et al., 2009).



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Kraus et al., 2016., ESRI 2017, BOEMRE 2017; E&E 2017

Map Coordinate System: NAD 1983 UTM 19N Meters

** SPUE values are number of animals sighted per 1,000 km of survey track summarized by 5' x 5' grid cells*

N S E W

0 5 10 20 Nautical Miles

0 10 20 Kilometers

LEGEND

- State Boundary
- County Boundary
- Lease Area
- Wind Development Area
- Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles Study Area
- Offshore Export Cable Corridor

Loggerhead Turtle Sightings per Unit Effort (SPUE*)

- 0
- <0 - 5
- 5 - 10
- 10 - 30
- 30 - 72

Vineyard Wind Project

VINEYARD WIND

Figure 6.8-2

Loggerhead Turtle Seasonal Aerial Survey Sightings per Unit Effort from Kraus et al. (2016) October 2011 to June 2015

Kemp's Ridley Sea Turtle. Kemp's Ridleys are the smallest of the Chelonidae Sea Turtles, with CLs reaching 65 cm (25.6 in). Their nearly circular-shaped carapace is almost as wide as it is long and is olive-gray in color. Integument coloration is olive-gray dorsally and light yellow ventrally. The plastron (bottom shell) is a light cream-white (NMFS, USFWS, & SEMARNAT, 2011). When in pelagic habitats, juvenile Kemp's Ridleys feed on small invertebrates associated with *Sargassum*, such as mollusks and crabs (Bjorndal, 1996). Once they recruit to nearshore habitats, their diet is primarily composed of crabs. Kemp's Ridleys spend approximately 11% of their time at the surface and are otherwise submerged, foraging, or resting (Renaud, 1995).

The Kemp's Ridley Sea Turtle was listed as endangered in 1970 (35 Fed. Reg. 18,319 [1970]). There is only one population of Kemp's Ridleys, and all nesting occurs in the western Gulf of Mexico. Nesting primarily occurs at Rancho Nuevo, Mexico, but nesting within the US (primarily on South Padre Island in Texas) has been increasing. Kemp's Ridley Sea Turtles and the closely related Olive Ridley Sea Turtles are the only turtles to exhibit a synchronized nesting behavior; large numbers of females gather offshore and then come ashore as a group to nest in an arribada (mass nesting behavior). Primarily due to harvest, the Kemp's Ridley population suffered severe declines over the latter half of the 20th century. Estimations from a 1947 video of an arribada suggest that approximately 45,760 females nested over a four-hour period (Bevan et al., 2016). By 1985, it was estimated that only 250 females nested during the entire year. Currently, the population appears to be recovering, with annual nest counts exceeding 20,000 in recent years (Bevan et al., 2016).

Kemp's Ridleys are distributed throughout the Gulf of Mexico and along the US Atlantic seaboard as far north as Nova Scotia; their range encompasses the Offshore Project Area. Although Kemp's Ridley's are expected to regularly occur within the Offshore Project Area, their abundance may be biased due to several factors: (1) most individuals are too small to be detected during surveys; (2) historically, shallow bays and estuaries utilized by Kemp's Ridleys in the region have been excluded from survey designs (including Kraus et al., 2016); and (3) Kemp's Ridleys may be overrepresented in stranding reports due to cold-stun events (i.e., a hypothermic reaction that occurs from prolonged exposure to cold water temperatures) (Kenney & Vigness-Raposa, 2010).

In the Kraus et al., (2016) surveys of the MA/RI WEAs, the only confirmed sightings of Kemp's Ridley Sea Turtles occurred within a four-week span in 2012 (one on August 23, four on September 12, and one on September 17, 2012). Modeling from the NARWC database show that Kemp's Ridley Sea Turtles are present in the MA/RI WEA, with over 85% of records in summer months; however, this species is sighted at much lower numbers than other species (Kenney & Vigness-Raposa, 2010). The AMAPPS surveys did not detect Kemp's Ridleys near the Project Area (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, & 2016). The STSSN records indicate that Kemp's Ridleys are the most common species to be found stranded within or near the Offshore Project Area (see Table 6.8-1); however, this does not necessarily indicate that they are the most common species, as noted above for their overrepresentation in stranding data. Cold stun events are relatively common in Cape Cod (Dodge, Prescott, Lewis, Murley, & Merigo, 2007), and 50 to 200 turtles are expected to be found cold-stunned each year and reported as strandings in the STSSN. Kemp's Ridleys are the most common cold-stunned stranding turtle species to be recovered (Dodge et al., 2007).

Historically, the primary threat to Kemp's Ridleys was the harvest of both eggs and turtles. Small levels of harvest still occur on nesting beaches in Mexico, but it has decreased dramatically from historical levels (NMFS, USFWS, & SEMARNAT, 2011). Current threats include vehicles on beaches and coastal development in terrestrial habitats, oils spills (e.g., the 2010 Deepwater Horizon spill), and bycatch in fisheries, especially the shrimp trawl fishery (NMFS, USFWS, & SEMARNAT, 2011).

Green Sea Turtle. Also in the family Chelonidae, Green Sea Turtles are similar in size to Loggerheads, reaching CLs of 100 cm (39 in) or greater at maturity (Seminoff et al., 2015). They are differentiated from Loggerheads by a heart-shaped carapace, small head, and single-clawed flippers. The carapace ranges from light to dark brown, can be olive-shaded, and contains radiating markings of darker color; the name "Green" refers to the color of their subdermal fat deposits and not to their external coloring. When in pelagic habitats, Green Sea Turtles are likely associated with *Sargassum* and feed on associated plants and animals. At 20-25 cm (8-10 in) CL, they recruit to nearshore habitats where they shift to a primarily herbivorous diet of seagrass and algae, occupying a unique feeding niche among sea turtles (Bjorndal, 1996).

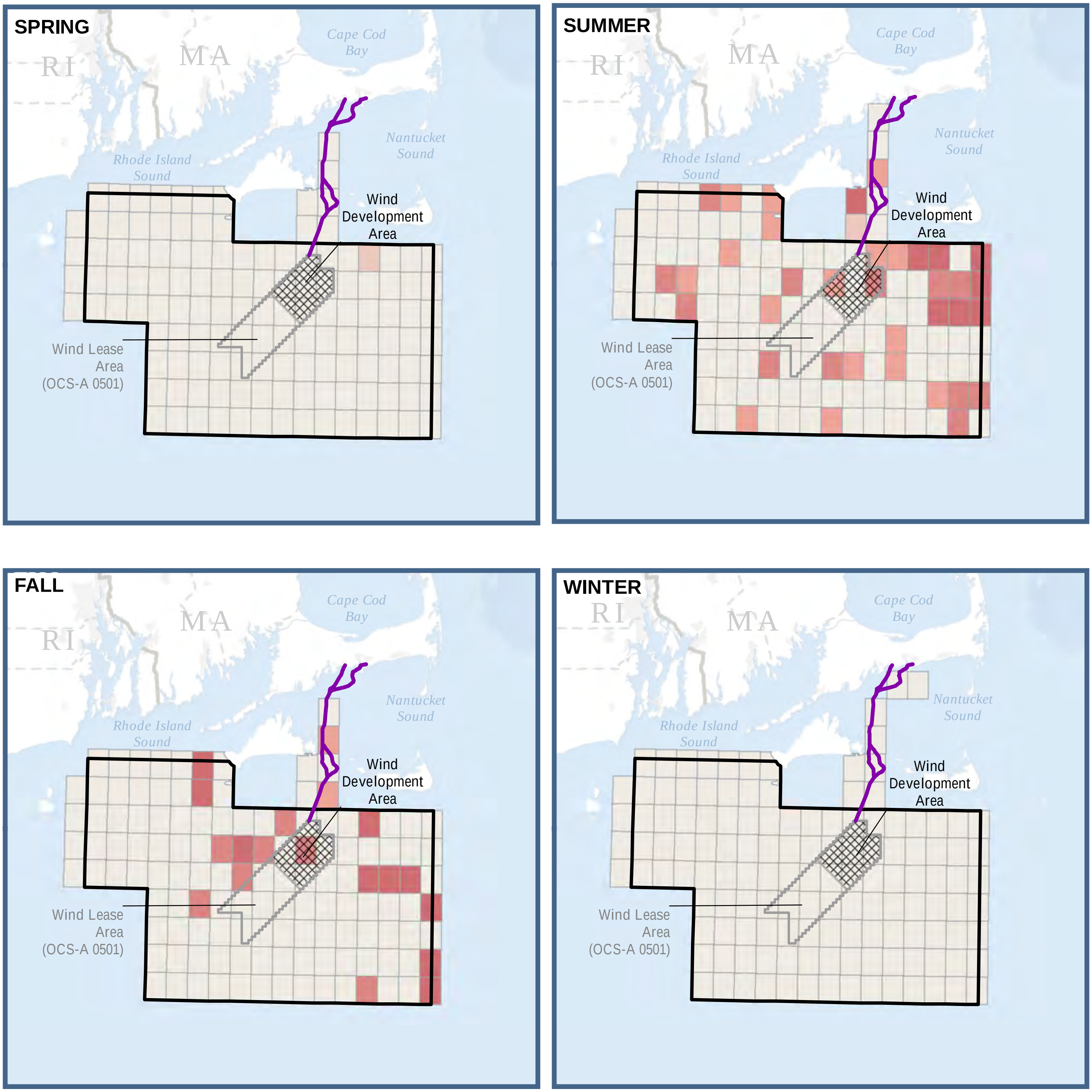
The Green Sea Turtle was listed as threatened in 1978 (43 Fed. Reg. 32,800 [1978]), except for breeding populations in Florida and the Pacific coast of Mexico, which were listed as endangered. In 2016, the NMFS and USFWS issued a final rule concluding that the Green Sea Turtle population is comprised of 11 DPSs and identified eight as threatened and three as endangered. Only the North Atlantic DPS is likely to occur in the Offshore Project Area (see Table 6.8-1). Globally, Green Sea Turtles typically occur along continental coasts and islands in tropical and subtropical waters between 30° N and 30° S. The range of the North Atlantic DPS is bounded east to west by the western coasts of Europe and Africa and the eastern coasts of the Americas. From north to south, the boundaries are 48° N and 14° N. Although nesting occurs throughout the US coastline south of North Carolina, Mexico, Central America, and areas of the Caribbean, the primary nesting beaches for the North Atlantic DPS are Costa Rica (Tortuguero; representing approximately 79% of the nesting for the DPS), Mexico (Campeche and Quintana Roo), US (Florida), and Cuba (Seminoff et al., 2015). Nesting trends are generally increasing for this DPS.

Given their preference for tropical and sub-tropical habitats, Green Sea Turtles are anticipated to be rare in the Offshore Project Area. Small, juvenile Green Sea Turtles do occur in the stranding records, and Kenney & Vigness-Raposa (2010) have reported one sighting in the region (March 25, 2005) south of Long Island, New York. Kraus et al., (2016) report no sightings of Green Sea Turtles in the MA/RI WEA during aerial surveys. The AMAPPS surveys did not detect Green Sea Turtles near the Project Area (NEFSC & SEFSC, 2010, 2011, 2012, 2013, 2014, 2015, & 2016). This may be in part due to their size; much like Kemp's Ridleys, many Green Sea Turtles are too small to be sighted during aerial surveys (Kenney & Vigness-Raposa, 2010). However, the STSSN does report strandings of Green Sea Turtles in the region and supports the research that Green Sea Turtles are known to be present in shallow waters around eastern Long Island, New York, and Cape Cod, and may transit through the offshore waters (Kenney & Vigness-Raposa, 2010). Green Sea Turtles spend approximately 5% time at the surface, with the remainder of the time spent submerged foraging or resting (Hays et al., 2000).

In many parts of the world, Green Sea Turtles are harvested, both for meat and for eggs, which remains a threat to the population (Seminoff et al., 2015). Terrestrial threats to nesting habitats are similar to those of other sea turtle species and include coastal development, erosion, erosion control, and recreation activities. Additional threats include bycatch in coastal artisanal and industrial fishing gear, including drift nets, set nets, pound nets, and trawls. Disease, especially tumor-forming fibropapilloma, and harmful algal blooms also pose a threat to the North Atlantic DPS (Seminoff et al., 2015).

Leatherback Sea Turtles. Leatherback Sea Turtles are the only remaining species of the family Dermochelyidae and are characterized by an extreme reduction of the bones of the carapace and plastron and a lack of scutes (i.e., bony plates) (Pritchard, 1997). They are the largest of the sea turtles, reaching over 180 cm (71 in) CL. They are black in coloration on their dorsal surfaces with varying patterns of white spotting; ventrally they are mottled pinkish-white and black (NMFS & USFWS, 1992). The carapace has seven longitudinal ridges that taper to a blunt point. Their diet primarily consists of jellyfish and salps.

The Leatherback Sea Turtle was listed as endangered in 1970 (35 Fed. Reg. 8,491 [1970]). Leatherbacks primarily use pelagic habitats, except when nesting. Leatherback Sea Turtles have thermoregulatory adaptations, including counter-current heat exchange systems, a high oil content, and large body size that allow them to have the widest geographical distribution of all sea turtles (Spotila, O'Connor, & Paladino, 1996). While primarily found in tropical and temperate waters, they occur as far north as British Columbia, Newfoundland, and the British Isles in the Northern Hemisphere. Primary nesting beaches for Atlantic Leatherbacks are Gabon, Africa, and French Guiana, though substantial nesting also occurs in the US, Puerto Rico, and US Virgin Islands. Nesting trends for these areas are generally stable or increasing (TEWG, 2007).



Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Kraus et al., 2016., ESRI 2017, BOEMRE 2017; E&E 2017

Map Coordinate System: NAD 1983 UTM 19N Meters

** SPUE values are number of animals sighted per 1,000 km of survey track summarized by 5' x 5' grid cells*

N S W E

0 5 10 20 Nautical Miles

0 10 20 Kilometers

LEGEND

State Boundary

County Boundary

Lease Area

Wind Development Area

Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles Study Area

Offshore Export Cable Corridor

LeatherbackTurtle

Sightings per Unit Effort (SPUE*)

- 0
- <0 - 5
- 5 - 10
- 10 - 20
- 20 - 112

Vineyard Wind Project

VINEYARD WIND

Figure 6.8-3

LeatherbackTurtle Seasonal Aerial Survey Sightings per Unit Effort from Kraus et al. (2016) October 2011 to June 2015

Modeled seasonal abundance patterns of Leatherback Sea Turtles suggest that Leatherbacks are present in the Offshore Project Area during the fall months and remain south of the Offshore Project Area during the summer months (Kenney & Vigness-Raposa, 2010). A recent survey of the MA/RI WEA differed from this conclusion and reported that Leatherbacks were widespread throughout the region during both summer and fall months (98.7% of sightings), with the highest abundances located within the OECC and to the east of the WDA (see Figure 6.8-3) (Kraus et al., 2016). Three Leatherback Sea Turtles (one live sighting and two deceased animals) were identified in October 2016 in the Lease Area during the 2016 G&G surveys conducted by Vineyard Wind (Vineyard Wind, 2016); and 14 Leatherbacks and four unknown species were identified during 2017 surveys conducted by Vineyard Wind. Only two Leatherback Sea Turtles were detected outside of the summer and winter months for MA/RI WEA surveys (both in the spring), and these sightings occurred south and southeast of the Offshore Project Area (Kraus et al., 2016). AMAPPS surveys sighted Leatherback Sea Turtles only during summer surveys (shipboard and aerial) in 2011 and 2016 (NEFSC & SEFSC, 2011, 2016). A lack of spring and winter survey sightings are consistent with previous modeling efforts that suggest Leatherback Sea Turtles are not expected to be present during these seasons (Kenney & Vigness-Raposa, 2010). Data from the STSSN also support the conclusion that Leatherback Sea Turtles are relatively common within the Offshore Project Area during the summer and fall months. Mean dive duration for Leatherback Sea Turtles is approximately 10 minutes with mean surface interval time of 5 minutes, suggesting they spend about a third of the time at the surface (Eckert, Eckert, Ponganis, & Kooyman, 1989).

Harvesting of eggs and meat continues to be a threat throughout parts of the Leatherback's nesting range. Terrestrial threats to nesting habitats are similar to those of other sea turtle species and include coastal development, erosion, erosion control, and recreational activities. Leatherbacks are also vulnerable to bycatch in fishing gear, such as longline, gillnets, trawls, traps, and dredges.

6.8.2 Potential Impacts of the Project

Construction and installation, operations and maintenance, and decommissioning activities associated with the Project have the potential to affect sea turtles through enhanced noise, changes in vessel traffic, marine debris, reductions in prey availability, habitat disturbance and modification, and entanglement (see Table 6.8-2). Criteria used for this risk assessment are shown in Table 6.8-3.

This section provides an initial assessment of the potential risks to populations of sea turtles from Project activities. This assessment will be supplemented with additional information and acoustical data that will better inform the potential risks from the Project and mitigation measures that may be employed. A draft version of the supplemental report can be found in Appendix III-M.

In this initial assessment, the potential risks posed by Project activities and their associated stressors are categorized as none, low, moderate, or high based on the probability of sea turtle exposure and the vulnerability of the sea turtle species to Project stressors (Table 6.8-3). Occurrence of sea turtle taxa and their relationships to the established criteria were evaluated using existing literature on sea turtle distribution and habitat use in the MA and MA/RI WEA, impacts of marine construction, wind farm construction and operations in Europe, construction and operation of the Block Island offshore wind farm, and studies that provide a general understanding of hearing, vessel collision risk, noise response, and other factors that influence the potential impacts of offshore wind construction, operation, and decommissioning activities on sea turtles.

Based on this assessment, some of the impact-producing factors are not expected to pose any risk to populations of sea turtles. Therefore, further in-depth analysis was not conducted. These include impacts from marine debris, reductions in prey availability, entanglement, and sediment mobilization. Each of these is briefly described below. See Table 6.8-3 for criteria for determining an impact risk level of "none." The remainder of this section focuses on impacts to sea turtles associated with noise, vessel traffic, EMF, and habitat disturbance and modification during construction and installation (see Section 6.8.2.1), operations and maintenance (see Section 6.8.2.2), and decommissioning (see Section 6.8.2.3). Avoidance, minimization and mitigation measures are provided for each of these stages of the Offshore Project.

Importantly, positive impacts to sea turtles are expected to occur from the Offshore Project Area, and these positive impacts are briefly described in the Project Summary (Section 2.0).

Table 6.8-2 Potential Impact-producing Factors for Sea Turtles

Impact-producing Factor	Stressor	Wind Development Area	Offshore Export Cable Corridor	Construction and Installation	Operations and Maintenance	Decommiss-ioning
Noise	Pile driving, construction and support vessels, wind turbines, removal of turbines	X	X	X	X	X
Vessel traffic	Construction and support vessels	X	X	X	X	X
Marine debris	Discarded material	X	X	X	X	X
Reduction in prey Abundance	Jet plow, pile driving, discharges/ withdrawals	X	X	X	X	X
Habitat disturbance and modification	Wind turbine generators, cable corridor, electrical service platform	X	X	X	X	X
Entanglement	Anchor lines, tow lines, wind turbines, fishing gear, marine debris, undersea cables	X	X	X	X	X
Electromagnetic fields (EMF)	Cable system	X	X		X	
Suspended sediments	Jet plow, pile driving, dredging	X	X	X	X	X

Table 6.8-3 Definitions of Risk, Exposure, and Vulnerability for Sea Turtles

Risk Level	Exposure	Individual Vulnerability
None	No or limited observations of the species in or near the WDA and Offshore ECC and noise exposure zones (low expected occurrence) AND/OR Species tends to occur mainly in other habitat (such as deeper water or at lower or higher latitudes) AND/OR No indication the Lease Area has regional importance	Literature and/or research suggest the affected species and timing of the stressor are not likely to overlap AND/OR Literature suggests limited sensitivity to the stressor AND/OR Little or no evidence of impacts from the stressor in the literature
Low	Few observations of the species in or near the WDA and Offshore ECC and noise exposure zones (occasional occurrence) AND/OR Seasonal pattern of occurrence in or near the WDA and Offshore ECC and noise exposure zones	Literature and/or research suggest the affected species and timing of the stressor may overlap AND/OR Literature suggests some low sensitivity to the stressor AND/OR Literature suggests impacts are typically short-term (end within days or weeks of exposure) AND Literature describes mitigation/BMPs that reduce risk

Table 6.8-3 Definitions of Risk, Exposure, and Vulnerability for Sea Turtles (Continued)

Risk Level	Exposure	Individual Vulnerability
Moderate	Moderate year-round use of the WDA and Offshore ECC and noise exposure zones AND/OR Evidence of preference for near-shore habitats and shallow waters in the literature	Literature and/or research suggest the affected species and timing of the stressor are likely to overlap. AND/OR Literature and/or research suggest a moderate susceptibility to the stressor exists in the region and/or from similar activities elsewhere. AND Literature does not describe mitigation/BMPs that reduce risk
High	Significant year-round use of the WDA and Offshore ECC and noise exposure zones	Literature and/or research suggest the affected species and timing of the stressor will overlap. AND Literature suggests significant use of WDA and Offshore ECC and noise exposure zones for feeding, breeding, or migration AND Literature does not describe mitigation/BMPs that reduce risk

Impact-producing factors not expected to pose a risk to sea turtles

Reductions in prey availability: Risk of impacts to sea turtle prey availability, including crabs and whelks, from benthic disturbance during construction would be localized and short-term; therefore, risk of declining prey availability is not anticipated. During all phases of the Project, the loss of prey habitat would be localized, and the presence of the electrical service platform ("ESP") and wind turbine generator ("WTG") foundations and associated scour protection would result in a small loss of benthic habitat (less than one percent of the total WDA; see Section 6.5). During the operations and maintenance phase, the WTG foundations can be expected to create habitat and increase prey availability through the creation of artificial reef (Petersen & Malm, 2006; Friedlander, Ballesteros, Fay, & Sala, 2014; Sammarco et al., 2014), which would result in a long-term positive impact on sea turtles.

Entanglement: As with marine mammals, the direct risk of entanglement from construction and operation is extremely low. First, marine anchored vessels will not be routinely used within the WDA. Anchors are not expected to be used for the majority of offshore export cable installation, but they may be used where needed along more challenging portions of the offshore export cable (see Section 4.2.3.3.2 of Volume I). Steel anchor cables used on construction barges are typically five to seven centimeters (2-3 in) in diameter. Typically, these cables are under tension while deployed, eliminating the potential for entanglement. Similarly, tow lines for cable installation are expected to be under constant tension and should not present an entanglement risk for sea turtles. Lost fishing gear and other marine debris could possibly catch on wind turbines and present a secondary entanglement hazard to sea turtles; however, WTG and ESP foundations have large monopile diameters (7.5-10.3 m [25-34 ft]) or jacket diameters (1.5-3.0 m [5-10 ft]) without the protrusions on which lost fishing gear or other marine debris would become snagged. As such, it is unlikely that entanglement of debris would be followed by a close enough approach by sea turtles to secondarily become entangled in such debris.

Marine Debris: The Clean Water Act (33 U.S.C §§ 1251 et seq., 1972) and other applicable federal regulations will be followed regarding any substances that could be released into the ocean during construction, operation, and decommissioning of the Offshore Project Area. Any items that could become marine debris will not be discarded in the water and will be appropriately discarded ashore. Thus, activities occurring in the Offshore Project Area are not expected to produce marine debris and therefore would not pose a risk to sea turtles.

Sediments: Turbidity caused by disturbance of sediment would be limited to an area near the construction or maintenance activity and be short-term. In addition, field verification of sediment plume modeling for cable installation during Block Island offshore wind farm indicated that the actual sediment plume was less than the modeled plume, without any evidence of a sediment plume in the water column resulting from use of the jet plow (Elliott et al., 2017). Sediment plumes are dependent on sediment type and mobilization of sediments and would be expected to vary from region to region. Sediments in the WDA and offshore portion of the OECC in greater than 30 m (98.4 ft) water depths are predominately fine sand with some silt, fining in the offshore direction. Heading north through Muskeget, median grain size increases, with sand and gravel dominant, along with coarser deposits (cobbles, boulders) locally. Continuing north into the main body of Nantucket Sound, sand still dominates the seabed, with coarser deposits concentrated around shoals and in high current areas and finer grained sediments occupying deeper water and/or more quiescent flow areas. These sandy sediments would be expected to settle quickly. Sea turtles are also expected to avoid areas very close to pile driving, dredging, or offshore cable export installation, thereby avoiding areas where most temporarily suspended sediments may occur before settling back to the bottom. Therefore, based on the limited mobilization of sediment into the water column, project activities are not expected to pose a risk to marine mammals.

The potential risk-producing factors that are not expected to pose a risk to sea turtle populations (reduction in prey availability, marine debris, entanglement, and sediments) (see Table 6.8-2) are not addressed further in this analysis.

6.8.2.1 Construction and Installation

6.8.2.1.1 Noise from Construction and Installation

Very little is known about sea turtle vocalization and hearing (Cook & Forrest, 2005; McKenna, 2016). Most of what is understood about hearing in sea turtles is from studies of Green and Loggerhead Sea Turtles; however, limited studies have also been conducted for juvenile Kemp's Ridley and hatchling Leatherback Sea Turtles (see Table 6.8-4). The upper limit of sea turtle hearing is estimated to be approximately 1 kiloHertz ("kHz"), with the greatest sensitivity at approximately 100-400 Hertz ("Hz"). Piniak, Mann, Harms, Jones, & Eckert (2016) found that Green Sea Turtles detect underwater stimuli between 50 and 1,600 Hz, with maximum sensitivity between 200 and 400 Hz. Ridgway, Wever, McCormick, Palin, & Anderson (1969) suggest that the maximum sensitivity for Green Sea Turtles was between 300 and 400 Hz, with an upper limit of 1,000 Hz. Bartol, Musick, & Lenhardt (1999) found that the Loggerhead Sea Turtle's range of effective hearing was between 250 and 750 Hz, with the greatest sensitivity at the low end of that range; however, Lavender, Bartol, & Bartol (2014) estimate the range to be 50 to 1,100 Hz for post-hatchling and juvenile Loggerheads, with the greatest sensitivity between 100 and 400 Hz. In support of this, Martin et al., (2012) also found the greatest sensitivity to sound occurs between 100 and 400 Hz in an adult Loggerhead Sea Turtle.

Table 6.8-4 Hearing Ranges for Sea Turtles (all values are frequencies in Hz)

Species	Sound Production	Total Hearing	Most Sensitive Hearing Range	Reference
Loggerhead	NA	250-1,000; 50-1,000; 1,000-1,131	250 juvenile; 100-400 juvenile; 100-400 adult	Bartol et al., (1999); Lavender et al., (2014); Martin et al., (2015)
Kemp's Ridley	NA	100-500	100-200 juvenile	Bartol & Ketten (2006)
Green	NA	100-500, 100-800; 500-1,600	200-400 subadult; 600-700 juvenile; 200-400 juvenile	Bartol & Ketten (2006); Piniak et al., (2016)
Leatherback	300-4,000 adult/terrestrial	50-1,200	100-400	Cook & Forrest (2005); Dow Piniak, Eckert, Harms, & Stringer (2012)

NOAA has not established formal acoustic guidelines for sea turtles, and the impacts of noise on sea turtles are poorly understood, partly because of limited studies addressing their auditory ability; it is believed that sea turtles are far less sensitive to sounds than marine mammals. A working group that convened to determine sound exposure guidelines for fish and sea turtles made the following recommendations for sound exposure due to pile driving: 210 decibels cumulative sound exposure level ("dB SEL_{cum}") or >207 decibels peak sound level ("dB Peak") (see Table 6.8-5; Popper et al., 2014). In the absence of official guidance, these sound levels will be used to gauge the risk impacts of acoustic noise from the construction and installation phase of the Offshore Project. For further discussion of acoustic thresholds for sea turtles, see Appendix III-M.

Table 6.8-5 Pile Driving Mortality and Recoverable Injury Thresholds for Sea Turtles

Relative Risk (Distance to Sound Source)	Mortality and Potential Mortal Injury	Impairment			Behavior
		Recoverable Injury	TTS	Masking	
Near	210 dB SEL_{cum} or >207 dB peak	High	High	High	High
Intermediate		Low	Low	Moderate	Moderate
Far		Low	Low	Low	Low

Source: Adapted from Popper et al., (2014). Adopts the levels for fish that do not hear well since it is likely these would be conservative for sea turtles.
Note: the same peak levels are used both for mortality and recoverable injury since the same single strike exposure level (SEL_{ss}) was used throughout the pile driving studies. Thus, the same peak level was derived (Halvorsen, Casper, Woodley, Carlson, & Popper, 2011). Data on mortality and recoverable injury are from Halvorsen et al., (2011), Halvorsen, Casper, Matthews, Carlson, & Popper (2012), and Halvorsen, Casper, Woodley, Carlson, & Popper (2012), based on 960 sound events at 1.2 s intervals.

General Impacts of Noise

Hearing damage is usually categorized as either a temporary or a permanent injury. Temporary threshold shifts ("TTS") are recoverable injuries to the hearing structure. These injuries can vary in intensity and duration. Normal hearing abilities return over time; however, animals may lack the ability to detect prey and/or predators and assess conditions in the local environment during recovery. Permanent threshold shifts ("PTS") result in the permanent loss of hearing through loss of sensory hair cells (Clark, 1991). Few studies have researched hair cell damage in reptiles; it remains unknown if sea turtles are able to regenerate damaged hair cells (Warchol, 2011).

Offshore Project noise has the potential to mask relevant sounds for sea turtles in the environment. Acoustic masking is considered to be one of the main effects of noise pollution on marine animals (Peng, Zhao, & Liu, 2015; Vasconcelos, Amorim, & Ladich, 2007). Masking can interfere with the acquisition of prey or a mate, the avoidance of predators, and, in the case of sea turtles, identification of an appropriate nesting site (Nunny, Graham, & Bass, 2008). Sea turtles appear to be low-frequency specialists (see Table 6.8-3), thus, potential masking noises would likely fall within 50-1,000 Hz. Masking sounds within this range could have diverse origins, ranging from natural to anthropogenic sounds (e.g., wind, waves, shipping traffic, military sonar operations, and pile driving) (CBD, 2014; Hildebrand, 2005).

Behavioral changes that can occur due to masking could have ecological and biological consequences for sea turtles. There is also evidence that sea turtles may use sound to communicate; the few vocalizations described for sea turtles are restricted to the "grunts" of nesting females and the chirps, grunts, and "complex hybrid tones" of eggs and hatchlings (Cook & Forrest, 2005; Ferrara, et al., 2014; Mrosovsky, 1972). However, there is a lack of data on masking of biologically important signals in sea turtles by manmade sounds (Dow Piniak et al., 2012; Popper et al., 2014).

Pile Driving

Sea turtles have been recorded to adjust their behavior in response to low-frequency, impulsive sounds (DeRuiter & Doukara, 2012). Although data on the effects of pile driving on sea turtles are lacking (Popper et al., 2014), it can be inferred that pile driving of the ESP and WTG foundations has the potential to impact sea turtles within the Offshore Project Area (see Table 6.8-4). Information on predicted takes of sea turtles and potential range of zones of influence can be found in Sections 5, 10.2, and A.5.1.2 of Appendix III-M. The maximum distance to behavioral disturbance is predicted to be 4,328 m (14,199 ft) based on a 10.3 m monopile (see Table A-17 in Appendix III-M).

The lack of data on the impacts of intense sounds on sea turtles makes it difficult to predict the potential impact on hearing structures from pile driving and construction activities. Pile driving activities are short-term, and one investigation suggested that, while sea turtles may avoid an area of active pile driving, they will return to the area upon completion (USCG, 2006). In addition, it is possible that sea turtles are highly protected from impulsive sound effects due to their rigid external anatomy (Popper et al., 2014). Sea turtles have displayed avoidance reactions to seismic signals at levels between 166-179 dB re 1μPa (Moein et al., 1995; McCauley et al., 2000); however, due to the experimental conditions, the extent of avoidance could not be monitored. Moein et al., (1995) have also observed a habituation response from sea turtles to seismic airguns; animals stopped responding to the signal after three presentations. It is unknown if the lack of behavioral response was a result of habituation, TTS, or PTS.

The risk to sea turtles from pile driving noise must also be considered in the context of existing ambient noise. Other anthropogenic noise sources can mask pile driving noise, to a certain extent. For example, during construction of a Belgian wind farm, the combined effect of the bathymetry and the noise generated by shipping was predicted to be of greater relevance to Harbor Porpoises, as the noise emitted from a single pile driving strike did not add to the soundscape for at least half of the time (EU Commission, 2016). This study did not include sea turtles, but illustrates that ambient noise can mask some noise associated with wind farm construction in some cases. Further description of noise measured during wind farm pile driving can be found in Section 6.7.2.1.1. Kraus et al., (2016) recorded ambient noise in the frequency range of 70.8-224 Hz in the MA/RI WEA from 2011 to 2015. Sound levels ranged from 96 dB re 1 μPa to 103 dB during 50% of recording time. Sound pressure levels were 95 dB re 1 μPa or less 40% of the time and greater than 104 dB re 1 μPa 10% of the time.

Data are limited regarding sea turtle behavioral responses to sound levels below those expected to cause injury, and some research has demonstrated sea turtles have limited capacity to detect sound (McCauley et al., 2000; Ridgway et al., 1969). Sea turtle behavioral response is further described in Section 11.2 of Appendix III-M including startle response and area avoidance. Sea turtles that experience disturbing sound levels are likely to exhibit a behavioral response (see Table 6.8-4) and avoid and/or leave these regions during the short periods of time pile driving would occur; these impact risks are also only expected during the seasons sea turtles are present (i.e., primarily summer and fall). With the implementation of mitigation and BMPs, the risk to sea turtles due to pile driving are low, with 1 or fewer individuals per species predicted to undergo injury or behavioral modification (see Sections 5 and 10.2 of Appendix III-M). Pile driving activities are unlikely to result in long-term behavioral modification, impact risks are expected to be seasonal, short-term, and localized, and risk of impacts will be minimized or offset through BMPs and/or mitigation (see Section 6.8.2.1.3). These mitigation measures would not be materially different from those employed for marine mammals, and will provide protection for both marine mammals and sea turtles (see Section 6.7.2.1.3).

Noise from Vessel Traffic

Vessels emit more cumulative sound energy into the ocean than any other man-made source (Weilgart, 2007). Ship engines and vessel hulls emit broadband, continuous sound, generally ranging from 150-80 dB re 1 μPa/m at low frequencies below 1,000 Hz, which overlaps with the hearing frequency range for sea turtles (NSF & USGS, 2011).

Vessel traffic associated with the Offshore Project would potentially originate from Rhode Island and/or Massachusetts (see Section 2.0). However, depending on the pace and timing of the Project's construction efforts, Vineyard Wind may stage certain activities from other North Atlantic ports. Potential acoustic impacts would consist of vessel noise produced during transit to and from multiple ports as well as the vessel noise produced during construction at the WDA. Dynamic positioning ("DP") thrusters would likely be used; however, these thrusters are commonly used by the shipping traffic in the area would be consistent with existing ambient vessel noise.

The impact of vessel traffic noise on sea turtles is largely unknown (Williams et al., 2015), although Tyson et al., (2017) found preliminary evidence of behavioral changes during vessel passes in a juvenile Green Sea Turtle. Popper et al., (2014) suggest that sound levels from vessel traffic are unlikely to cause mortality or injury, but masking and behavioral changes could occur in sea turtles. Given that vessel traffic throughout the MA WEA is relatively high (BOEM, 2014), sea turtles in the area are presumably habituated to vessel noise (Hazel et al., 2007) and vessels associated with the Offshore Project would not add substantive vessel noise to the existing soundscape (see Sections 7.1 and 8.2 of Appendix III-M). Risk to sea turtles from vessel traffic noise is low as it is unlikely the additional vessel traffic resulting from the Project will result in injury, displacement, or have an effect on sea turtle behavior due to possible habituation.

Noise from Cable Installation

Cable installation is described in detail in Section 4.2.3 of Volume I; noise risk within the OECC due to cable installation are comparable to vessel noise risk expected in the WDA for construction and installation. Risk is low that cable installation noise will have an effect on sea turtle behavior.

6.8.2.1.2 Vessel Traffic

Sections 7.1 and 8.2 of Appendix III-M describe the vessel traffic anticipated for the Project. Collisions with vessels involved in fisheries that result in serious injury or death occur for sea turtles (Barco et al., 2016; Love et al., 2017). However, while the literature suggests that sea turtles spend substantial amount of time near the ocean surface (Shimada, Limpus, Jones, & Hamann, 2017; Smolowitz, Patel, Haas, & Miller, 2015), they spend the majority of the time submerged. Hardshell sea turtles spend 89 to 96 % of the time submerged, while leatherbacks spend about 66% of the time submerged (Thompson, 1988; Eckert et al., 1989, Renaud, 1995; Hays et al., 2000). Sea turtles will not be vulnerable to vessel collisions during these long periods of submergence. Furthermore, there is likely a correlation between vessel speed and the potential for a collision (Hazel, Lawler, Marsh, & Robson, 2007, Shimada et al., 2017). Specifically, Hazel et al., (2007) found that sea turtles' avoidance response to vessels decreased with increased vessel speed, making them more vulnerable to vessel collision from vessels traveling in excess of 4 $kmhr^{-1}$. Therefore, the highest risk for vessel collision most likely occurs during the transit to and from the Offshore Project Area because of increased vessel speeds. Vessel speed is likely to be low during actual construction activities, except for the smaller crew/supply boats that can travel at higher speeds during transit.

While the presence of vessel traffic may alter sea turtle behavior in terms of dive patterns (Tyson et al., 2017) and avoidance response (Hazel et al., 2007), sea turtles do continue to use key forage habitat under conditions of increased vessel traffic (Denkinger et al., 2013).Furthermore, sea turtles likely rely more on visual than auditory cues to detect danger and therefore may habituate to vessel sounds as background noise, especially when submerged (Hazel et al. 2007).

Risk of collision within the vessels in the OECC is expected to be similar to the risk experienced with construction activities in the WDA. However, since the OECC is closer to shore, vessel transit times would decrease, reducing the risk of vessel collision.

Sea turtles' seasonal use of the region, low percent of time that they are at the surface and vulnerable to vessel strikes, and mitigation measures/BMPs designed to avoid collisions result in a low risk of vessel collision for sea turtles.

6.8.2.1.3 Avoidance, Minimization, and Mitigation Measures

Working collaboratively with BOEM and NOAA, Vineyard Wind will develop mitigation that will effectively minimize and avoid risks to sea turtles from construction, operation, and decommissioning. Vineyard Wind will continue to use acoustic modeling as a tool to inform approaches to mitigation and address sensitive variables relative to potential risks of noise. Modeling, as part of permitting and regulatory processes, will continue to be used to evaluate potential risks, specific mitigation, and best management practice ("BMP") options during construction and installation. A draft of the acoustic modeling report can be found in Appendix III-M.

Proposed avoidance, minimization, and mitigation measures for threatened and endangered sea turtle species would not be materially different from those employed for marine mammals (TetraTech, 2012). In many cases, measures put in place to minimize impacts for marine mammals are more stringent than those required for sea turtles (e.g., pile driving soft-start procedures and use of noise reduction technology). Mitigation and BMPs must consider both practicability for a large-scale project and effectiveness at avoiding and minimizing impacts to sea turtles. Practicability includes safety, logistical ability, project integrity, environmental impacts, and the potential to increase the Project construction duration, which may have secondary impacts on other Project resources. Options will be modeled and weighed against effectiveness relative to impact to the species and project practicability. NOAA and BOEM will be engaged in this iterative and adaptive process that will also incorporate lessons learned from Block Island Wind Farm's five-turbine demonstration project in the MA/RI WEA.

Thus, it is premature to discuss all potential mitigation measures based solely on this qualitative assessment. However, at this stage, a number of measures and initiatives have been identified. See Section 6.7.2.1.3 and Table 31 of Appendix III-M for descriptions of mitigation/BMP options associated with Construction and Installation.

Importantly, pending successful award of a power contract in 2018, Vineyard Wind has established a $3 million fund to develop and demonstrate innovative methods and technologies to enhance protections during offshore wind development. Investments by the fund will be guided by a steering committee that will include representatives of environmental advocacy groups and others with expertise in the field of marine mammal protection. The fund may be directed towards such things as enhanced monitoring techniques and pile driving technologies. Although the fund will be prioritized around the protection of marine mammals, benefits of the fund will likely also be shared with sea turtles, as previously described. In addition, measures such as the establishment of exclusion and monitoring zones, pile driving soft-start procedures, vessel speed restrictions and avoidance measures, and the use of PSOs are expected to be part of the final mitigation plan.

6.8.2.2 Operations and Maintenance

6.8.2.2.1 Noise from Operations and Maintenance

There is a low risk that the Project's operations and maintenance activities, as discussed in Section 2.3, have a likelihood of causing acoustic impacts to sea turtle populations. See Section 6.8.2.1.1 for a general description of potential impacts of noise on sea turtles. Vineyard Wind is developing a framework for a post-construction monitoring program for protected resources. Using a standardized protocol, the Project will document any observed impact to marine mammals and sea turtles during construction, operations and decommissioning. The standardized protocol will be developed with BOEM and NMFS.

Noise from Wind Turbine Operation

Underwater noise radiated from operating wind turbines is low-energy and low-frequency (Nedwell & Howell, 2004). Low-frequency noise is of concern for sea turtles, as their most sensitive hearing range is confined to low frequencies (Bartol et al., 1999; Ridgway et al., 1969;), and sea turtles have shown behavioral avoidance to low frequency sound (Dow Piniak, 2012; O'Hara and Wilcox, 1990). Tougaard, Henriksen, & Miller (2009) found that noise from three different wind turbine types in European waters was only measurable above ambient noise levels at frequencies below 500 Hz, and Thomsen et al., (2015) suggest that at approximately 500 meters ("m") (1,640 feet ["ft"]) from operating turbines, sound levels are expected to approach ambient levels. In New York waters, average noise pressure ranged from 80 dB to 110 dB re 1 μPa, depending on levels of human activity, suggesting sea turtles are already exposed to high levels of underwater noise during much of the season when they are actively foraging in that region, which is relatively close to the MA/RI WEAs (Samuel, Morreale, Clark, Greene, & Richmond, 2005). Kraus et al., (2016) recorded ambient noise in the frequency range of 70.8-224 Hz in the MA/RI WEA from 2011 to 2015. Sound levels ranged from 96 dB re 1 μPa to 103 dB during 50% of recording time. Sound pressure levels were 95 dB re 1 μPa or less 40% of the time and greater than 104 dB re 1 μPa 10% of the time. Visual review of NOAA modeling of noise due to shipping traffic also suggest ambient noise levels of approximately 70 dB to 100 dB re 1 μPa (NOAA, 2012). Due to ambient noise, sea turtles are unlikely to be able to detect sounds generated by turbines at large distances away from the Project, but may exhibit avoidance behavior close to the turbines. Sea turtle risk to turbine noise is low; due to the high levels of ambient noise in the Project Area, any behavioral changes from exposure to turbine noise are expected to be short-term and localized to areas near the turbine field.

Noise from Vessel Traffic

Ambient noise due to commercial shipping and other vessel traffic is expected to overwhelm any noise associated with ships conducting operations and maintenance activities during the Project. Therefore, the risk to sea turtles from Project related vessel traffic noise would be low.

6.8.2.2.2 Vessel Traffic

It is anticipated that vessel traffic will be less at any given time during the operations and maintenance phase of the Project than during the construction phase. Risk of vessel collision during the construction phase is low (see Section 6.8.2.1.2). For the same reasons, the risk of vessel collisions for sea turtles is low for the operations and maintenance phase.

6.8.2.2.3 Electromagnetic Fields (EMF)

The Project's offshore cable system will generate EMF that could have a risk of impacting sea turtle activities. However, the intensity of any generated EMF will be minimized by cable sheathing and burial into the seafloor at depths of up to 1.5-2.5 m (5-8 ft), reducing this to low risk for sea turtles. Sea turtles can be affected by EMF because they form a "magnetic map" that allows them to derive positional information from the Earth's magnetic field (Lohmann, Lohmann, & Putman, 2007). Hatchling turtles can orient to the Earth's magnetic field and can use magnetic field intensities to derive positional information in the world's oceans (Lohmann, 1991; Lohmann & Lohmann, 1994; Lohmann & Lohmann, 1996).

Cable EMFs are likely less intense than the Earth's geomagnetic field and, it is generally assumed that marine animals will not be affected by these EMFs (Copping et al., 2016). The New Jersey Department of Environmental Protection (NJDEP, 2010) has reported that EMF during the operation of a wind farm would not be expected to impact sea turtles in the region. Copping et al., (2016) suggests that EMF has the potential to impact navigation, attraction behavior, and avoidance behavior in sea turtles. The literature suggests that sea turtles spend most of their time near (though not at) the surface rather than near the benthos where a cable would be buried (Smolowitz et al., 2015). However, in coastal, neritic habitats less than 200 m depth, hardshell sea turtles forage on benthic invertebrates (Burke, Morreale, & Standora, 1993). While foraging they may come in close proximity to EMF generated from Project cables. Based on EMF intensity, sheathing and burial of cables, and minimal sea turtle time spent at the seafloor in proximity to cables, the risk to sea turtles from EMF is expected to be low.

6.8.2.2.4 Habitat modification

Submerged wind turbine and oil and gas platform foundations create artificial reef habitat (Petersen & Malm, 2006; Friedlander et al., 2014; Sammarco et al., 2014). Sea turtles are known to be attracted to reefs associated with artificial structures, likely because they are a source of both shelter and forage habitat (Stoneburner, 1982; Gitschlag, Herczeg, & Barcak, 1997). For these reasons wind turbine foundations may have a long-term, positive impact on sea turtles.

Fish are also attracted to artificial habitat created by these submerged structures (Gallaway, Szedlmayer, & Gazey, 2012; Lowe, Anthony, Jarvis, Bellquist, & Love, 2009; Friedlander et al., 2014), which in turn attract both commercial and recreational fishing activities (Stanley & Wilson, 1989; Hooper, Ashley, & Austen, 2015). Both active and derelict fishing gear are known to cause injury or death to sea turtles due to hook ingestion and entanglement (Chaloupka, Work, Balazs, Murakawa, & Morris, 2008; Casale et al., 2010). Hence, artificial habitat created by wind turbine foundations may create a low risk of fisheries interaction to sea turtles that are attracted to them due to potential increase in the use of these reefs for fishing. Implementation of mitigation and BMPs would avoid impacts to sea turtles.

6.8.2.2.5 Avoidance, Minimization, and Mitigation Measures

During operations and maintenance activities, Vineyard Wind will use BMPs and mitigation to avoid vessel collisions as described in Section 6.8.2.1.3. Section 6.7.2.2.3 and Table 31 of Appendix III-M for descriptions of mitigation/BMP options associated with Operations and Maintenance.

6.8.2.3 Decommissioning

Decommissioning is expected to have similar levels of vessel traffic as construction and installation; however, pile driving is not part of the decommissioning process; therefore, noise is not expected to be a primary risk during decommissioning.

6.8.2.3.1 Noise from Decommissioning

Noise from Removal of Wind Turbines

To decommission the Project, the wind turbines and towers will be removed and the steel foundation components (transition piece and pile) will be decommissioned. Sediments inside the piles will be suctioned out and temporarily stored on a barge to allow access for cutting. In accordance with BOEM's removal standards (30 C.F.R. 250.913), the pile and transition piece assembly will be cut below the seabed; the portion of the pile below the cut will remain in place. Depending upon the capacity of the available crane, the foundation assembly above the cut may be further cut into more manageable sections in order to facilitate handling. The cut piece(s) will then be hoisted out of the water and placed on a barge for transport to a suitable port area for recycling.

Cutting of the steel piles below the mudline would likely be completed using one or a combination of underwater acetylene cutting torches, mechanical cutting, or high pressure water jet. Noise produced by such equipment is not similar to pile driving and would not be expected to disturb sea turtles more than general vessel traffic noise (Molvaer & Gjestland, 1981; Pangerc, Robinson, Theobald, & Galley, 2016; Reine, Clarke, & Dickerson, 2012). The sediments previously removed from the inner space of the pile would be returned to the depression left when the pile is removed. A vacuum pump and diver or remotely operated vehicle-assisted hoses would likely be used in order to minimize sediment disturbance and turbidity. See Section 4.4 of Volume I for more details on decommissioning procedures.

The offshore export cables may be abandoned in place to minimize environmental impact; in this instance, there would be no risk from its decommissioning. If removal of the cables is required, the cables would be removed from their embedded position in the seabed. Where necessary, the cable trench would be jet plowed to fluidize the sandy sediments covering the cables, and the cables would then be reeled up onto barges. Risks from removing the cables would be short-term, localized to the Project Area, and similar to those experienced during cable installation (see Section 6.8.2.2.1).

Noise from Vessel Traffic

Vessel traffic rates during decommissioning are expected to be similar to traffic rates during the construction phase (see Section 6.8.2.1.2). Consequently, the risk from vessel collisions sea turtles during decommissioning are anticipated to be similar to those during construction.

Noise from Offshore Export Cable Removal

The offshore export cables may be abandoned in place to minimize environmental impact; in this instance, there would be no impacts from its decommissioning. If removal of the cables is required, the cables would be removed from their embedded position in the seabed. Where necessary, the cable trench will be jet plowed to fluidize the sandy sediments covering the cables, and the cables will then be reeled up onto barges. Risk of impacts from removing the cables would be short-term, localized to the Project Area, and similar to those experienced during cable installation (see Section 6.8.2.1.1).

6.8.2.3.2 Vessel Traffic

Vessel traffic rates during decommissioning are expected to be similar to traffic rates during the construction phase (see Section 6.7.2.1.2). Consequently, the risk from vessel collisions on marine mammals during decommissioning are anticipated to be similar to those during construction. The offshore export cables may be left in place to minimize environmental impact; in this instance, there would be no vessels, so there would be no risk of vessel collision from cable decommissioning. If removal of the cables is required, the cables would be removed from their embedded position in the seabed and reeled up onto barges. Collision risk from removing the cables would be short-term, localized to the Project Area, and similar to those experienced during cable installation, described in Section 6.8.2.1.2.

6.8.2.3.3 Avoidance, Minimization, and Mitigation Measures

During decommissioning, Vineyard Wind will use BMPs and mitigation to avoid vessel collisions. BMP and mitigation options that can reduce the risk of vessel collision are described in Section 6.8.2.1.3. Section 6.7.2.3.3 for descriptions of mitigation/BMP options associated with decommissioning.

6.8.2.4 Conclusions

There are four species likely to have some individuals exposed to stressors from the Offshore Project Area. A fifth species, Hawksbill Sea Turtles, are only hypothetical and have not been documented near the RI/MA WEAs. One of the four species, Green Sea Turtles are rare and, thus, have very low exposure probability. Kemp's Ridley Sea Turtles are not rare but are not as common as Loggerhead and Leatherback Sea Turtles. All of the sea turtles found in the RI/MA WEAs are listed as under the ESA

No population level impacts are anticipated, and all potential risks to sea turtle populations are localized in and near the Offshore Project Area, which comprises only a small portion of the ranges of these species. Although there is potential for vessel collision, mitigation and implementation of BMPs will make the risk of this occurring very low, and no loss of individuals is expected as a result of the Offshore Project.

The main risk of impacts to sea turtles are expected to be short-term and localized. Impacts could include localized noise and vessel traffic, short-term disturbance of local habitat, and long-term modification (though not loss) of habitat. Because of their common use of the Offshore Project Area and surrounding areas, the more common species (i.e., Loggerheads and Leatherbacks) have a higher risk of being exposed to stressors such as noise, increased vessel traffic, and structures in the water that may result in the short-term, localized disturbance of individuals. Species vulnerability to stressors varies, but risk to these species generally remains low due to their seasonal use of the Project Area and planned implementation of mitigation measures to avoid impact. Behavioral vulnerability for turtles is likely limited to short-term disturbance.

6.8.2.5 Mitigation/BMPs

It is anticipated that ESA consultation for construction activities will be conducted by NOAA as part of permitting processes (and later for decommissioning as necessary). Mitigation and BMPs will be applied to reduce potential impacts. As such, risk to sea turtles from construction, installation, and decommissioning activities are ultimately expected to be low. Operations and maintenance activities are also expected to have low risk of impacts on sea turtles.

Individual mitigation actions may be practicable, but a suite of individually practicable mitigation actions may become impracticable in concert. Thus, care must be taken in evaluating both the benefits to sea turtles and the practicability of final combined mitigation decisions to ensure that mitigation can be practically implemented to meet the goal of avoiding and minimizing impacts.

Section 7.0

Socioeconomic Resources

7.0 SOCIOECONOMIC RESOURCES

7.1 Demographics and Employment, and Economics

The Project Region is the geographic area that could be affected by Project-related activities. The principal construction and installation activities will be concentrated at New Bedford, Massachusetts in Bristol County and offshore in the Wind Development Area ("WDA"). Ports located in Rhode Island and Connecticut may potentially serve as staging areas for some Project components (see Section 3.2.5 of Volume I). Onshore construction activities will occur in Barnstable County, Massachusetts. During the operations and maintenance phase, activities are expected to be concentrated in Dukes and Bristol Counties and offshore in the WDA. Thus, for purposes of this analysis, the Project Region consists of the communities in Barnstable County, Bristol County, Dukes County, and Nantucket County, Massachusetts; the communities in Providence County and Washington County, Rhode Island; and the communities in Fairfield County and New London County, Connecticut.

Additional details on Project-related activities are provided in Sections 7.1.2.1, 7.1.2.2, and 7.1.2.3.

7.1.1 Description of the Affected Environment

Demographic, employment, and economic baselines, including existing socioeconomic activities and resources in the onshore and coastal environment that may be affected by the Project are described in the sections that follow. It should be noted that many of the coastal and ocean amenities that attract visitors to these regions are free for public access, thereby generating no direct employment, wages, or gross domestic product. Nonetheless, these nonmarket features function as key drivers for many coastal businesses, particularly those within the recreation and tourism sectors.

7.1.1.1 Massachusetts

Population and economic statistics for Barnstable, Bristol, Dukes, Nantucket Counties, and the Commonwealth of Massachusetts are provided in Table 7.1-1, below.

Table 7.1-1 Existing Economic Conditions in the Vicinity of Vineyard Wind

Location	Population (2017)[1]	Population Density[2] (persons per sq. mile)	Per Capita Income (2016)[3]	Annual Total Employment (2017)[4]	Annual Unemployment Rate (2017)[4]
Massachusetts	6,859,819	879.5	$38,069	3,521,482	3.7%
Barnstable County	213,444	542.1	$39,104	107,254	4.7%
Bristol County	561,483	1,015.2	$30,525	278,472	4.7%
Dukes County	17,325	167.8	$40,051	9,007	4.9%
Nantucket County	11,229	249.7	$46,009	6,810	4.4%

[1]US Census Bureau, Population Estimates Program ("PEP"), Updated annually; [2] US Census Bureau, Census of Population and Housing. Land area is based on current information in the TIGER® data base, calculated for use with Census 2010; population from PEP V2017 [3] US Census Bureau, American Community Survey ("ACS") 5-Year Estimates (2016); [4] Quarterly Census of Employment and Wage Program of the Bureau of Labor Statistics, accessed July 2018, not seasonally adjusted.

7.1.1.1.1 Barnstable County

Demographics

Barnstable County consists of the 15 municipalities on the Cape Cod peninsula extending from the southeast coast of Massachusetts (Figure 7.1-1).

The Census Bureau's Population Estimates Program ("PEP") data for 2016 counts 214,276 residents of Barnstable County. The Towns of Barnstable and Falmouth are the largest population centers of the Barnstable County with estimated populations of 44,498 and 31,544, respectively, as estimated in 2016 by the Census Bureau's American Community Survey ("ACS").

Barnstable County's population density, per capita income, total employment, and unemployment rate are provided in Table 7.1-4. Based on ACS estimates for 2016, Barnstable County's median household income is $65,382, which is less than the statewide median of $70,954.

As occurs in certain other coastal communities, towns in Barnstable County experience significant seasonal population growth. The Cape Cod Commission ("CCC") estimates that the average annual seasonal population growth on Cape Cod was equivalent to 68,856 full-time residents in 2010 (CCC, 2012). Seasonal population growth is estimated to occur during the summer months, between June and August. CCC's Regional Policy Plan (2012) notes that seasonal population continues to grow even as the number of Cape Cod's year-round residents decreased by 0.7% since 2010.

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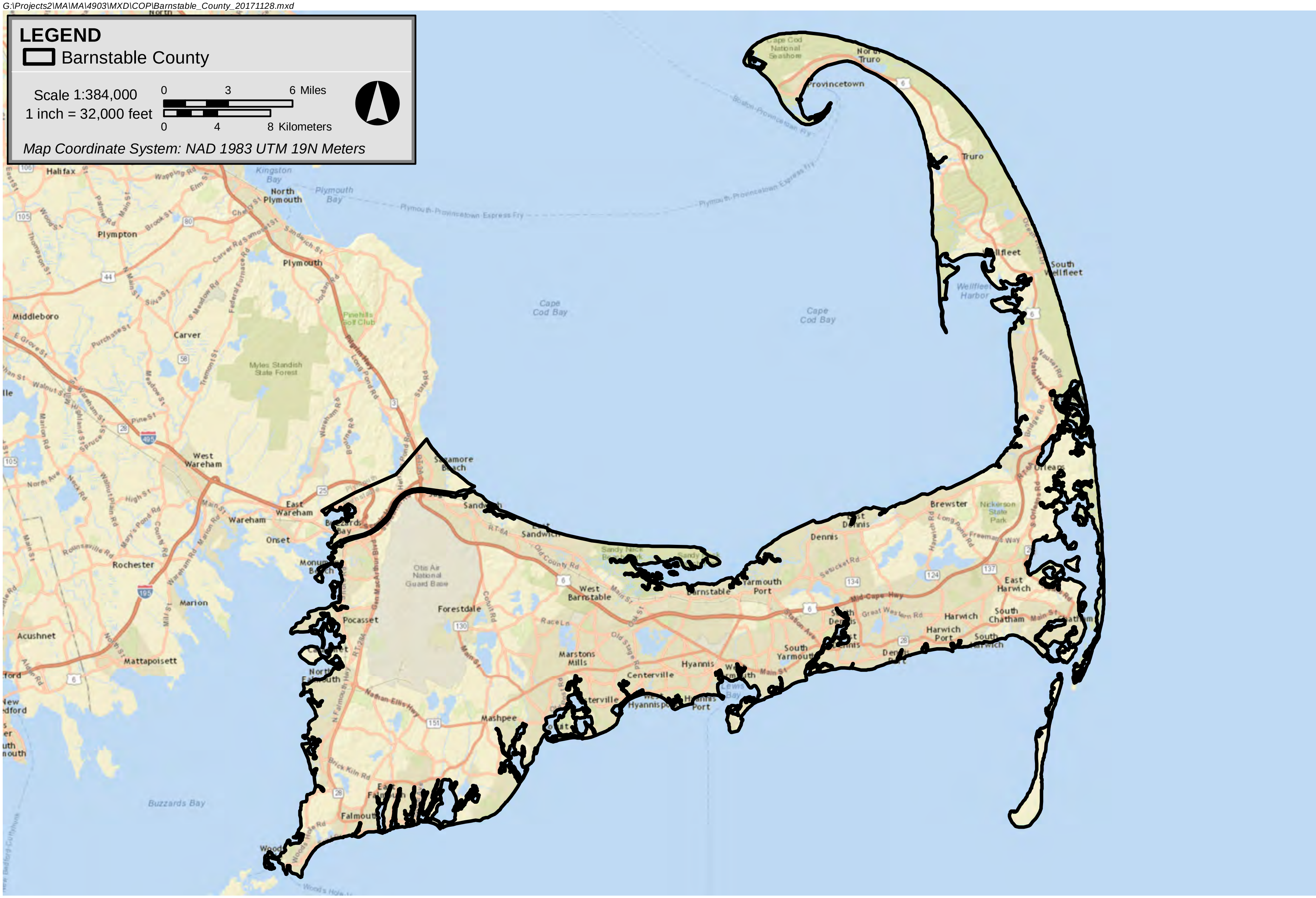

Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong

Vineyard Wind Project

VINEYARD WIND

Figure 7.1-1

Barnstable County

Barnstable County's population density, when calculated with only year-round population, is less than the statewide average. When seasonal residents are included in population density calculations, Barnstable County's population density increases to approximately 719 people per square mile ("people/mi^2").

Economy and Employment

Although Barnstable County's employment opportunities are influenced by its seasonally oriented, visitor-based economy, Barnstable County also hosts substantial health, social service, and professional, management, and administrative employment opportunities.

According to the Bureau of Labor Statistics ("BLS") data, in 2016 Barnstable County's average annual labor force included approximately 110,749 individuals and Barnstable County's unemployment rate was 4.7% in 2016.

In 2016, BLS data show Barnstable County's 9,371 private-sector employer establishments, which are each physical locations at which business is conducted or where services or industrial operations are performed, employed 96,271 individuals. In 2016, the most recent year for which data are available, Barnstable County's workforce was comprised of 66.1% of Barnstable County residents and 33.9 % non-residents.

The largest employment sectors by North American Industry Classification System ("NAICS") Sector, according to County Business Patterns ("CBP") data for 2015, are the Health Care and Social Assistance, Retail Trade, and Accommodation and Food Services sectors. According to the Massachusetts Executive Office of Labor and Workforce Development, the five largest employers in Barnstable County are: Cape Cod Hospital, Steamship Authority, Woods Hole Oceanographic Institute, Air National Guard, and Arris Group, Inc. Census Bureau data indicate that Barnstable County's highest concentrations of jobs are in the Falmouth and West Yarmouth communities.

The National Oceanic and Atmospheric Administration's ("NOAA") Office for Coastal Management provides data on "Ocean Economy" activities. These categories of activities are based on NAICS codes that depend on the ocean for input. They include: Living Resources, Marine Construction and Marine Transportation, Offshore Mineral Resources, Ship and Boat Building, and Tourism and Recreation. In 2014, the most recent year for which data is available, the Ocean Economy accounted for 10.3% of Barnstable County's total Gross Domestic Product ("GDP"), and Ocean Economy activities employed approximately 16,554 individuals, including self-employed individuals. Ocean Economy jobs include fishing, seafood processing, marine passenger transportation, boat dealers, and tourism and recreation, amongst other jobs.

Over the preceding ten-year period, as a percentage of GDP, Barnstable County's Ocean Economy expanded by 1.7% and added approximately 1,048 jobs. In 2014, the largest Ocean Economy sector by dollar value was recreation and tourism, which accounts for 88.8% of the total Ocean Economy; 1.4% of the Barnstable County's Ocean Economy is attributed to commercial fishing, aquaculture, and seafood processing.

Housing

Housing data for Barnstable County are presented in Table 7.1-2, below.

Table 7.1-2 Barnstable County Housing[1]

Location	Housing Units	Vacant Units	Median Value of Owner-Occupied Units	Median Gross Rent
Barnstable County	161,632	41.6%	$367,300	$1,137

[1] US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates

Census Bureau data for 2015 counts 161,311 total housing units in Barnstable County, of which 66,894 (41.5%) are categorized as vacant. Of the County's 94,417 occupied housing units, 78.8% are owner-occupied. The high vacancy rate reflects the intensity of seasonal use and seasonal population growth noted above. In 2010, the most recent year housing vacancy status is categorized as "seasonal, recreational, or occasional," 88.1% of those vacant units were for seasonal, recreational, or occasional uses.

It is estimated that Barnstable County is the county most heavily influenced by seasonal tourism within the Project Region, suggesting that Project-related housing impacts during the peak tourism season, if any, would be most acute in Barnstable County. Hotel room occupancy statistics made available by the Cape Cod Chamber of Commerce indicate that between 2010 and 2017, the peak hotel room occupancy rate in Barnstable County was 85%, which occurred in August of 2013. As noted in Section 7.5.1.2, Barnstable County's recreation and tourism sectors are supported by an estimated 274 facilities offering accommodations. During winter months, the lodging demand in Barnstable County declines by 50,000 to 100,000 rooms per month. (Barrow, et al., 2000). When lodging demand declines, the Project may provide additional economic benefits to the local communities. The small number of personnel that may relocate to the Project Region, particularly within Barnstable County, are not anticipated to affect the availability of accommodations at any point of a given year.

7.1.1.1.2 Bristol County

Demographics

Bristol County consists of 20 cities and towns located in the southeast coastal region of Massachusetts (Figure 7.1-2). The Census Bureau's PEP data for 2016 counts 558,324 residents of Bristol County. The estimated population of Bristol County's largest cities, New Bedford and Fall River, is 95,032 and 89,220 residents, respectively.

Bristol County's population density, per capita income, total employment, and unemployment rate are shown in Table 7.1-1. Bristol County is more densely population than the statewide average. At $59,343, median household income in Bristol County in 2016 falls below the statewide median of $70,954, while the unemployment rate is higher than the statewide average.

In recent years, Bristol County and surrounding areas in the southeast coastal region of Massachusetts have experienced population gain because of international migration. These gains, however, are offset by domestic out-migration, notably among the college-age population (Renski, 2015).

Economy and Employment

In 2016, according to the BLS, Bristol County's average annual labor force included approximately 287,648 individuals and the unemployment rate was 4.7%.

In 2016, Bristol County's 17,322 private-sector employer establishments, employed 223,466 individuals (BLS, 2017). In 2015, the most recent year for which data are available, Barnstable County's workforce was comprised of 57.7% of County residents and 42.3% non-residents, with the largest concentration of jobs in the Attleboro, Fall River, New Bedford, and Taunton communities. According to BLS data, in 2016, the largest employers by NAICS, are Health Care and Social Assistance, Retail Trade, and Manufacturing sectors. The five largest employers in Bristol County are: Bristol County Community College, DePuy Spine, Inc., General Dynamics, Hormel Foods, and Medtronic, Inc. (EOLWD, 2017).

According to NOAA, Ocean Economy activities accounted for 2.1% of Bristol County's total GDP in 2014 and employed approximately 6,096 individuals, including self-employed individuals. The largest Ocean Economy sectors by dollar value were commercial fishing, aquaculture, and seafood processing, which accounted for 58% of Bristol County's total Ocean Economy value.

Bristol County's Port of New Bedford is a full service port with well-established fishing and cargo handling industries. The Port of New Bedford's operations and facilities include warehouses, ice houses, boatyards and ship repair yards, construction, engineering, tug

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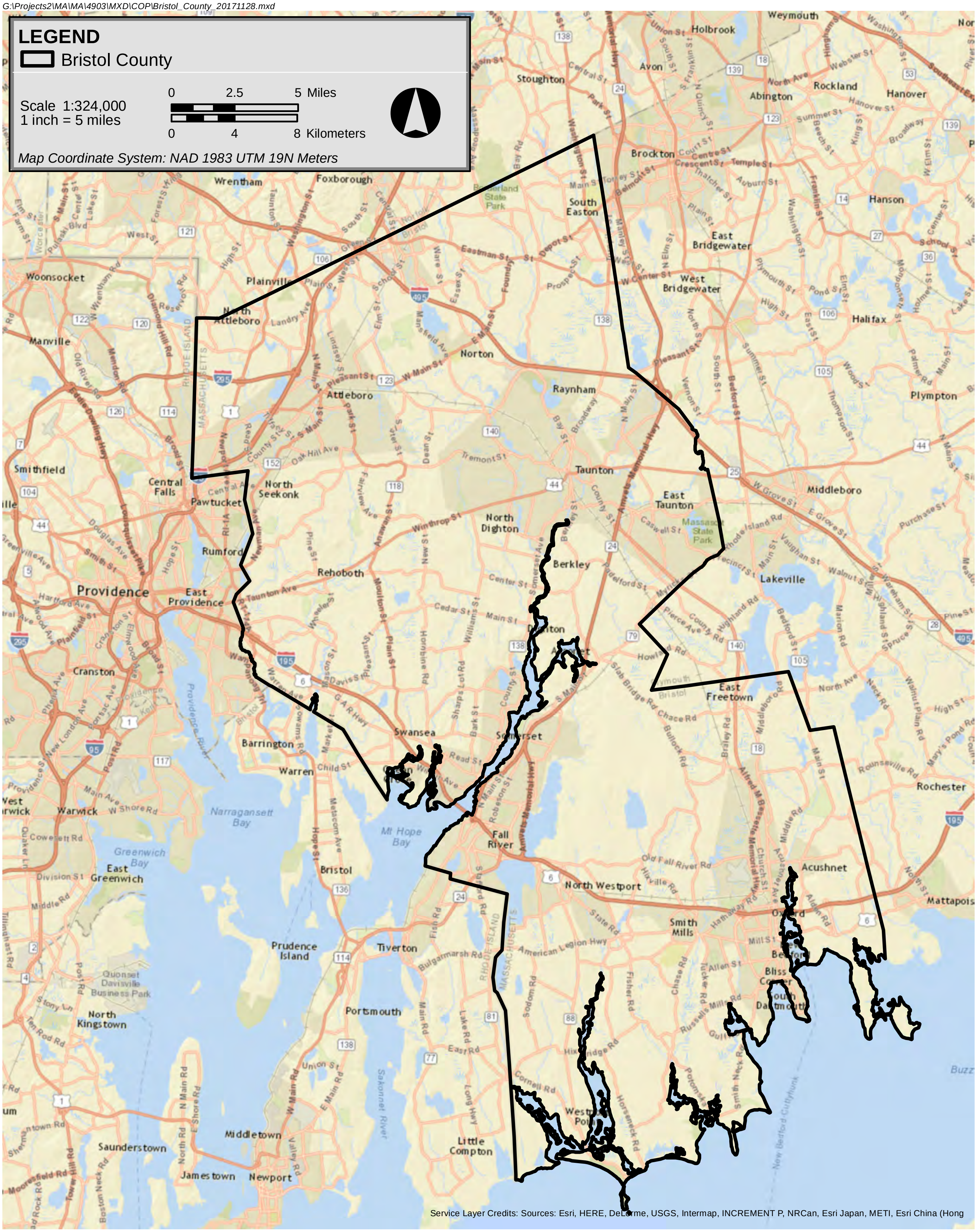

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Figure 7.1-2
Bristol County

assists, pilots and other maritime services (NBHDC, 2016). In 2015, 36,578 jobs were generated by Port of New Bedford activities (NBHDC, 2016). Recreational boating facilities are also located within and surrounding the Port.

Brayton Point, located on the Taunton River in Somerset, Massachusetts, is the site of the former Brayton Point Power Plant. The power plant was shutdown in 2017 and is being decommissioned. The Commonwealth of Massachusetts' Clean Energy Center ("CEC") has identified Brayton Point, with its existing port facilities, as a potential site for marine industrial and other uses, including offshore wind energy projects. Vineyard Wind is evaluating the potential of Brayton Point to host construction and installation activities. Additionally, Brayton Point's recent history of industrial uses suggests a skilled workforce consistent with Project needs is located in proximity to the site.

The former Montaup Power Plant site, also located on the Taunton River in Somerset, Massachusetts, is the former site of a coal-fired electric generation facility which ceased operation on January 1, 2010. The Montaup Power Plant site has working quayside facilities with deep water access and a large turning basin. The CEC has evaluated several redevelopment scenarios in which the site could host marine industrial uses consistent with Vineyard Wind's requirements for staging construction and installation activities.

Housing

Housing data for Bristol County are presented in Table 7.1-3, below.

Table 7.1-3 Bristol County Housing[1]

Location	Housing Units	Vacant Units	Median Value of Owner-Occupied Units	Median Gross Rent
Bristol County	231,247	7.9%	$273,700	$829

[1] US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates.

Census Bureau data for 2016 counts 231,247 total housing units in Bristol County, of which 18,314 are categorized as vacant. Of the County's 212,993, occupied housing units, 62.1% are owner-occupied. In 2010, the most recent year vacancy status is categorized as "seasonal, recreational, or occasional," 15.2% of those vacant units were for seasonal, recreational, or occasional uses.

7.1.1.1.3 Dukes County

Demographics

Dukes County consists of 11 islands off the southeast coast of Massachusetts, including Martha's Vineyard, Dukes County's largest and most populous island (Figure 7.1-3). Dukes County's population, according to the Census Bureau's PEP, is 17,246 year-round residents. Dukes County's population density, per capita income, total employment, and unemployment rate are shown in Table 7.1-1. The Towns of Oak Bluffs and Edgartown are the largest population centers of Dukes County with 4,647 and 4,247 residents, respectively.

The Martha's Vineyard Commission (2004) estimates that seasonal residents account for more than a tripling of the Martha Vineyard's population during the in-season months of June, July, and August, suggesting approximately 60,000 seasonal residents locate to the Martha's Vineyard. Such significant population fluctuations dramatically alter Dukes County characteristics, including population density which, when not including seasonal residents, remains well below the statewide average of 839.4 people/m2. Estimated seasonal population growth increases density to approximately 639.2 people/m2. Dukes County's estimated median household income for 2016 is $63,534, below the statewide median of $70,954.

Economy and Employment

According to BLS data, in 2016 Dukes County's average annual labor force included approximately 9,350 individuals. Dukes County's unemployment rate in 2016 was 5.0%. Unemployment rates, not seasonally adjusted, speak to the influence of recreation and tourism on the County's employment patterns. The unemployment rate during July of 2016 was 3.5% but during the offseason, in January of 2017, it had risen to 8.3%.

The economy of Dukes County is dominated by seasonal activities related to recreation and tourism. With the exception of the commercial fishing industry, which employs a limited number of people, there are no significant exports of goods or services. Dukes County's economic base is largely supported by visitors, particularly second homeowners, who purchase goods and services during their stay (Martha's Vineyard Commission, 2008; NOAA, 2012).

A total 1,248 private-sector employer establishments in Dukes County employ 8,843 individuals (BLS, 2017). In 2015, the most recent year for which data are available, Dukes County's workforce was comprised of 64.9% of County residents and 35.1% non-residents. The highest percentage of employment, by NAICS Sector, according to CBP data for 2015, is provided by the Retail Trade, Construction, Health Care and Social Assistance sectors. The highest concentration of jobs is in the Vineyard Haven, Oaks Bluffs, and Edgartown

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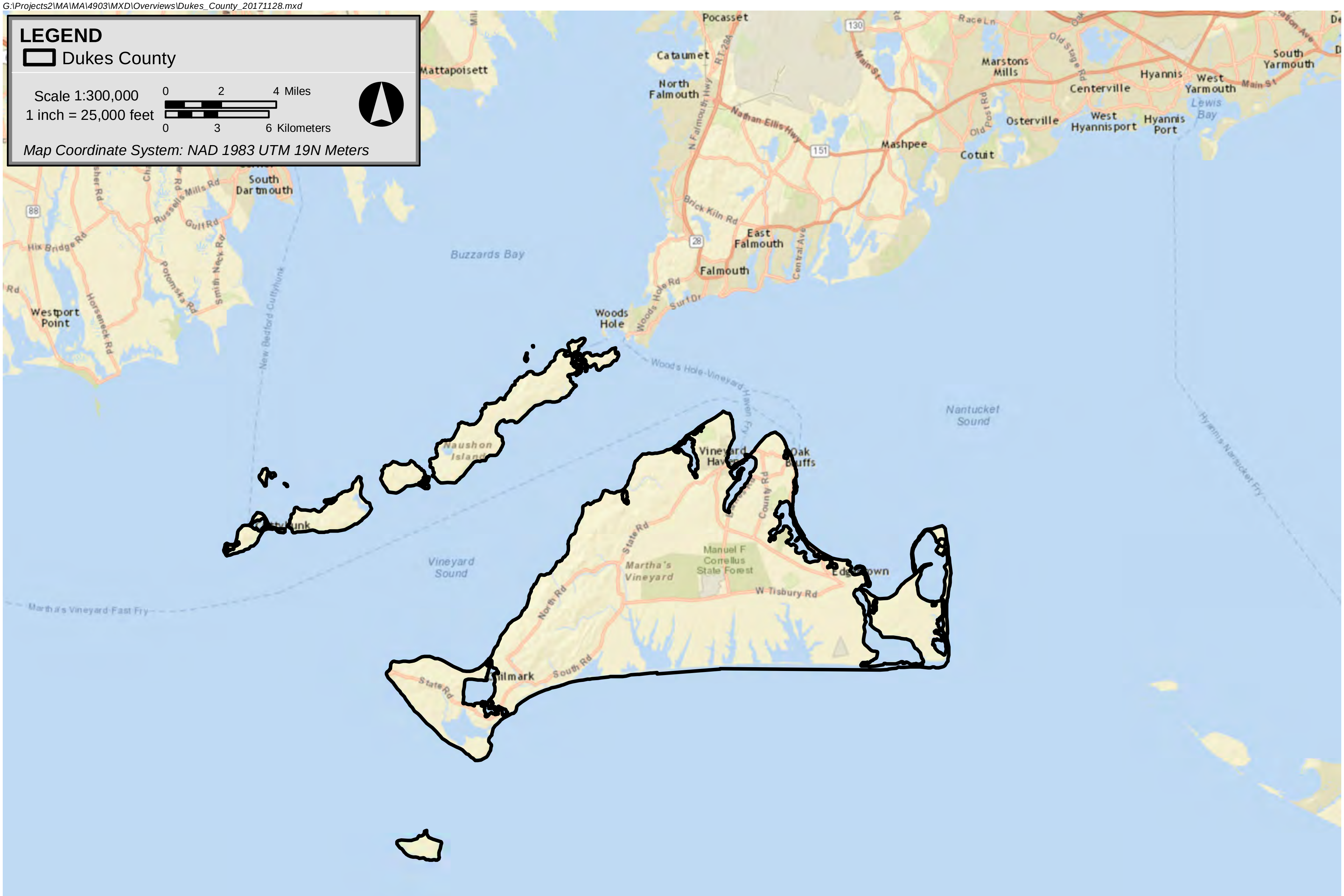

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Figure 7.1-3
Dukes County

communities. The five largest employers in Dukes County are Martha's Vineyard Hospital, Harbor View Hotel, Martha's Vineyard Community Services, Martha's Vineyard Regional High School, and Martha's Vineyard Taxi Company (EOLWD, 2017).

According to NOAA, Ocean Economy activities account for 19% percent of the County's total GDP and those activities employ approximately 1,717 individuals, including self-employed individuals. The largest Ocean Economy sector by dollar value is recreation and tourism, which accounts for 96.2% of total Ocean Economy value. 3.8% of the Ocean Economy is attributed to commercial fishing, aquaculture, and seafood processing.

Housing

Housing statistics for Dukes County are presented in Table 7.1-4, below.

Table 7.1-4 Dukes County Housing[1]

Location	Housing Units[1]	Vacancy Rate	Median Value of Owner-Occupied Units	Median Gross Rent
Dukes County	17,536	65.0%	$656,000	$1,448

[1] US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates.

Census Bureau data for 2016 counts 17,536 total housing units in Dukes County, of which 65.6% are categorized as vacant. Again, the high vacancy rate reflects the intensity of seasonal use and population growth noted above. Of Dukes County's 6,134 occupied housing units, 76.5% are owner-occupied. In 2010, the most recent year vacancy status is categorized as "seasonal, recreational, or occasional," 94.2% of vacant units were for seasonal, recreational, or occasional uses.

7.1.1.1.4 Nantucket County

Demographics

Nantucket County comprises the Island of Nantucket (Figure 7.1-4) and, according to the Census Bureau's PEP, has 11,008 year-round residents. The Nantucket Planning Board estimates approximately 40,000-50,000 seasonal residents, an estimate that excludes short-term visitors of one week or less, locate to Nantucket County during the summer months (Nantucket Planning Board, 2009).

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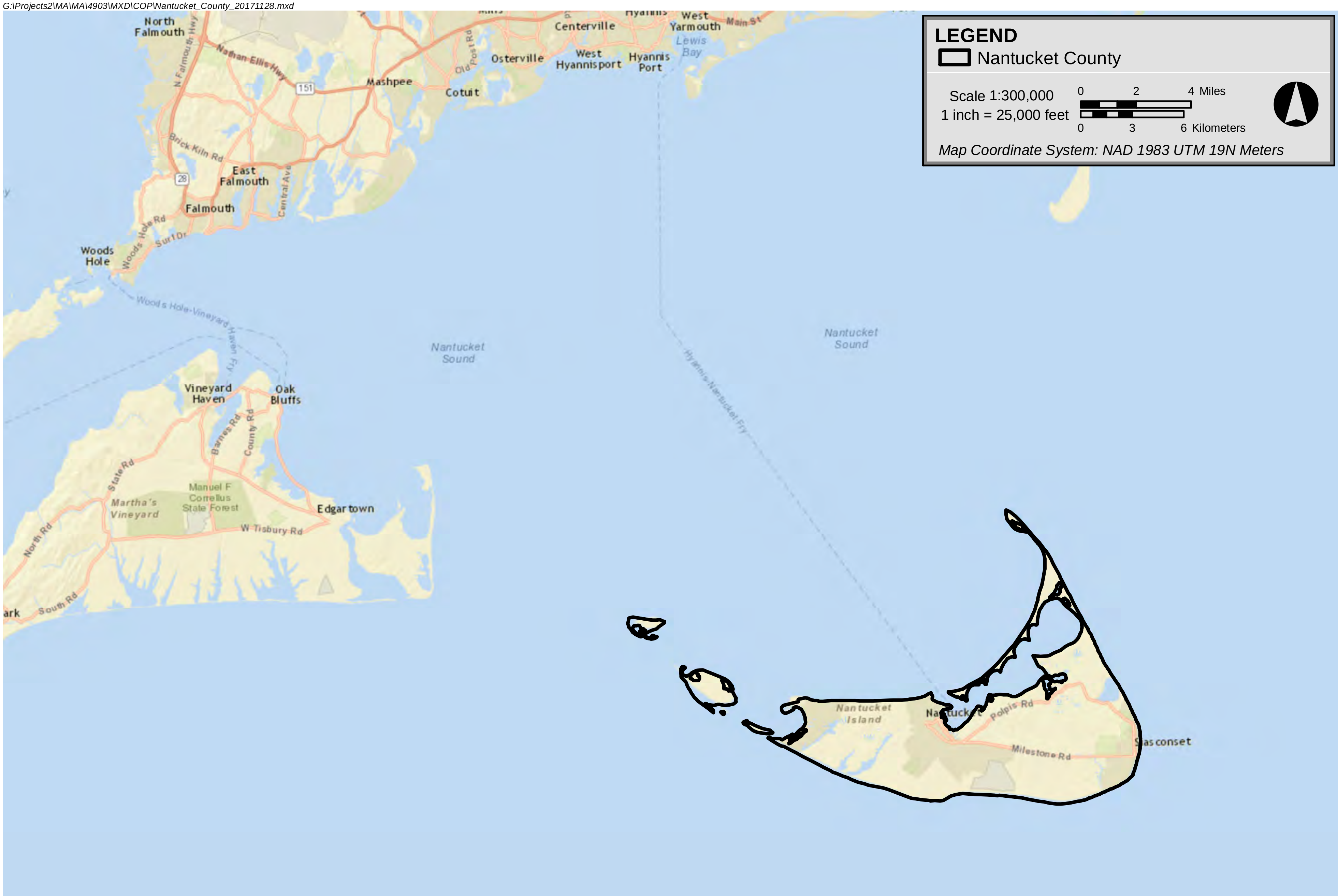

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Figure 7.1-4
Nantucket County

As with the other counties in the Project Region, seasonal population fluctuations dramatically alter Nantucket County's population density which, when not accounting for seasonal residents, remains well below the statewide average of 839.4 people/m2. Estimated seasonal population growth potentially increases density to over 1,000 people/m2, exceeding the statewide average. The County's population density, per capita income, total employment, and unemployment rate are shown in Table 7.1-1. Nantucket County's estimated median household income in 2016 was $89,428.

Economy and Employment

Nantucket County's economy is dominated by seasonal activities related to recreation and tourism, as reflected in unemployment patterns. The unemployment rate, not seasonally adjusted, for July of 2016 was 1.8% and increased to 9.8% in January of 2017. With some variation, this pattern is repeated annually. In 2016, the most recent year for which data are available, Nantucket County's workforce was comprised of 77.3% of County residents and 22.7% non-residents.

Accommodation and Food Service, Retail Trade, and Construction are the three largest employment sectors on the Island. The five largest employers in Nantucket County are Martha's Vineyard Hospital, Harbor View Hotel, Martha's Vineyard Community Services, Martha's Vineyard Regional High School, and Martha's Vineyard Taxi Company (EOLWD, 2017).

According to NOAA, in 2014 Ocean Economy businesses provided 22.0% of the total jobs in Nantucket. 99.5% of these jobs are in tourism and recreation related sectors, producing an estimated $112.6 million in goods and services. The remaining 0.5% of the ocean-related jobs are in fishing, seafood processing and related trades, which produce an estimated $0.6 million in goods and services.

Housing

Housing data for Nantucket County are presented in Table 7.1-5, below.

Table 7.1-5 Nantucket County Housing[1]

Location	Housing Units[1]	Vacancy Rate	Median Value of Owner-Occupied Units	Median Gross Rent
Nantucket County	11,844	67.6%	$966,600	$1,615

[1] US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates.

Census Bureau data for 2016 counts 11,844 total housing units in Nantucket County, of which 67.6% are categorized as vacant. Of the County's 3,836 occupied housing units, 63.9% are owner-occupied. Again, the high vacancy rate reflects the intensity of seasonal use and population growth noted above. In 2010, the most recent year vacancy status is categorized as "seasonal, recreational, or occasional," 91.0% of those vacant units were for seasonal, recreational, or occasional uses.

7.1.1.2 Rhode Island

Population and economic statistics for Providence and Washington Counties, and the State of Rhode Island are provided in Table 7.1-6, below.

Table 7.1-6 Existing Economic Conditions in the Vicinity of Vineyard Wind

Location	Population (2016)[1]	Population Density[2] (persons per sq. mile)	Per Capita Income (2016)[3]	Annual Average Total Employment (2017)[4]	Annual Average Unemployment Rate (22017)[4]
Rhode Island	1,059,639	1,025.0	$31,904	554,658	4.5%
Providence County	637,357	1,556.4	$27,809	308,436	4.8%
Washington County	126,150	383.2	$37,692	66,369	4.0%

[1]US Census Bureau, Population Estimates Program ("PEP"), Updated annually; [2] US Census Bureau, Census of Population and Housing. Land area is based on current information in the TIGER® data base, calculated for use with Census 2010; population from PEP V2017 [3] US Census Bureau, American Community Survey ("ACS") 5-Year Estimates (2016); [4] Quarterly Census of Employment and Wage Program of the Bureau of Labor Statistics, accessed July 2018, not seasonally adjusted.

7.1.1.2.1 Providence County

Demographics

Providence County consists of 16 cities and towns located in the northernmost region of Rhode Island (Figure 7.1-5). The Census Bureau's PEP data for 2016 counts 631,344 residents of Providence County. The estimated population of the County's largest city and the state capital, Providence, is 178,042.

Providence County's population density, per capita income, total employment, and unemployment rate are shown in Table 7.1-6. Providence County is the most populous county in Rhode Island and is more densely populated than the statewide average. At $50,637, median household incomes in Bristol County in 2016, falls below the statewide median of $75,655.

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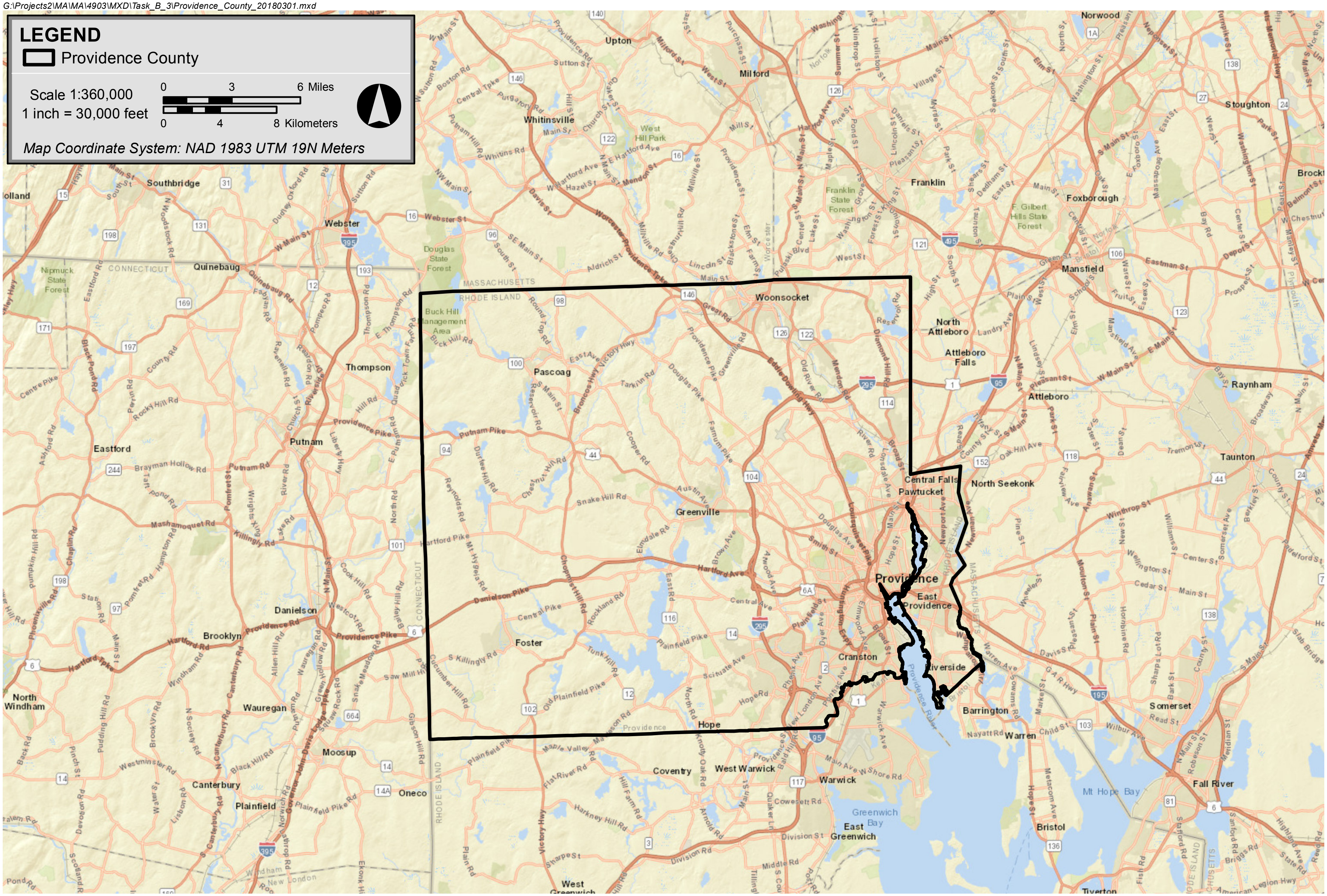

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Figure 7.1-5

Providence County, Rhode Island

Economy and Employment

According to the BLS, Providence County's average annual labor force included approximately 304,086 individuals in 2016 and Bristol County's unemployment rate was 5.7% in 2016.

In 2016, Providence County's 17,507 private-sector employer establishments, employ 249,874 individuals (BLS, 2018). In 2015, the most recent year for which data are available, Providence County's workforce was comprised of 62.6% Providence County residents and 37.4% non-residents, with the largest concentration of jobs in the greater Providence-Pawtucket area. According to BLS data, in 2016, the largest employers by NAICS, are Health Care and Social Assistance, Education Services, and Retail Trade.

According to NOAA, in 2014, Ocean Economy activities accounted for 1.8% of the County's total GDP and employed approximately 15,385 individuals, including self-employed individuals. The largest Ocean Economy sector by dollar value was tourism and recreation which accounted for 85.1% of Providence County's total Ocean Economy value.

The Port of Providence ("ProvPort") is a privately owned marine terminal located within the City of Providence and occupies approximately 105 acres along the Providence River. According to ProvPort, terminal services have resulted in economic output of approximately $164 million for the City of Providence and $211 million for the State of Rhode Island since 1994. The indirect impact of the port has generated approximately $2.8 billion in economic output for the state since 1994, with $1 billion of that occurring within the City of Providence. (ProvPort, 2018)

Housing

Housing data for Providence County are presented in Table 7.1-7, below.

Table 7.1-7 Providence County Housing[1]

Location	Housing Units	Vacant Units	Median Value of Owner-Occupied Units	Median Gross Rent
Providence County	263,549	9.9%	$209,800	$900
[1] US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates.				

Census Bureau data for 2016 counts 263,549 total housing units in Bristol County, of which 26,090 are categorized as vacant. Of the County's 237,459, occupied housing units, 53.9% are owner-occupied. In 2010, the most recent year vacancy status is categorized as "seasonal, recreational, or occasional," 6.5% of those vacant units were for seasonal, recreational, or occasional uses.

7.1.1.2.2 Washington County

Demographics

Washington County consists of nine towns located in the southwestern region of Rhode Island (Figure 7.1-6). The Census Bureau's PEP data for 2016 counts 126,319 residents of Washington County. The estimated population of the County's largest city, South Kingstown, is 30,651.

Washington County's population density, per capita income, total employment, and unemployment rate are shown in Table 7.1-9. At $74,302, median household incomes in Washington County in 2016, is just below the statewide median of $75,655.

Economy and Employment

According to the BLS, Washington County's average annual labor force included approximately 65,803 individuals in 2016 and Bristol County's unemployment rate was 4.8% in 2016.

In 2016, Washington County's 4,209 private-sector employer establishments, employ 43,674 individuals (BLS, 2018). In 2015, the most recent year for which data are available, Washington County's workforce was comprised of 49.3% of County residents and 50.7% non-residents, with the largest concentration of jobs in the Westerly and Wakefield areas.

According to BLS data, in 2016, the largest employers by NAICS Sector are Manufacturing, Education Services, and Health Care and Social Assistance.

According to NOAA, Ocean Economy activities accounted for 12.9% of the County's total GDP in 2014 and employed approximately 10,413 individuals, including self-employed individuals. The largest Ocean Economy sector by dollar value was tourism and recreation which accounted for 59.5% of Providence County's total Ocean Economy value.

The Port of Davisville, known locally as "Quonset," including Quonset Business Park, is home to more than 200 companies and nearly 11,000 workers. (Quonset Development Corp., 2018). According to the State of Rhode Island, the Port of Davisville accounts for approximately $333 million in business output within the State of Rhode Island, over 1,500 direct and indirect jobs, and over $97 million in household income in 2014. (RI, 2016)

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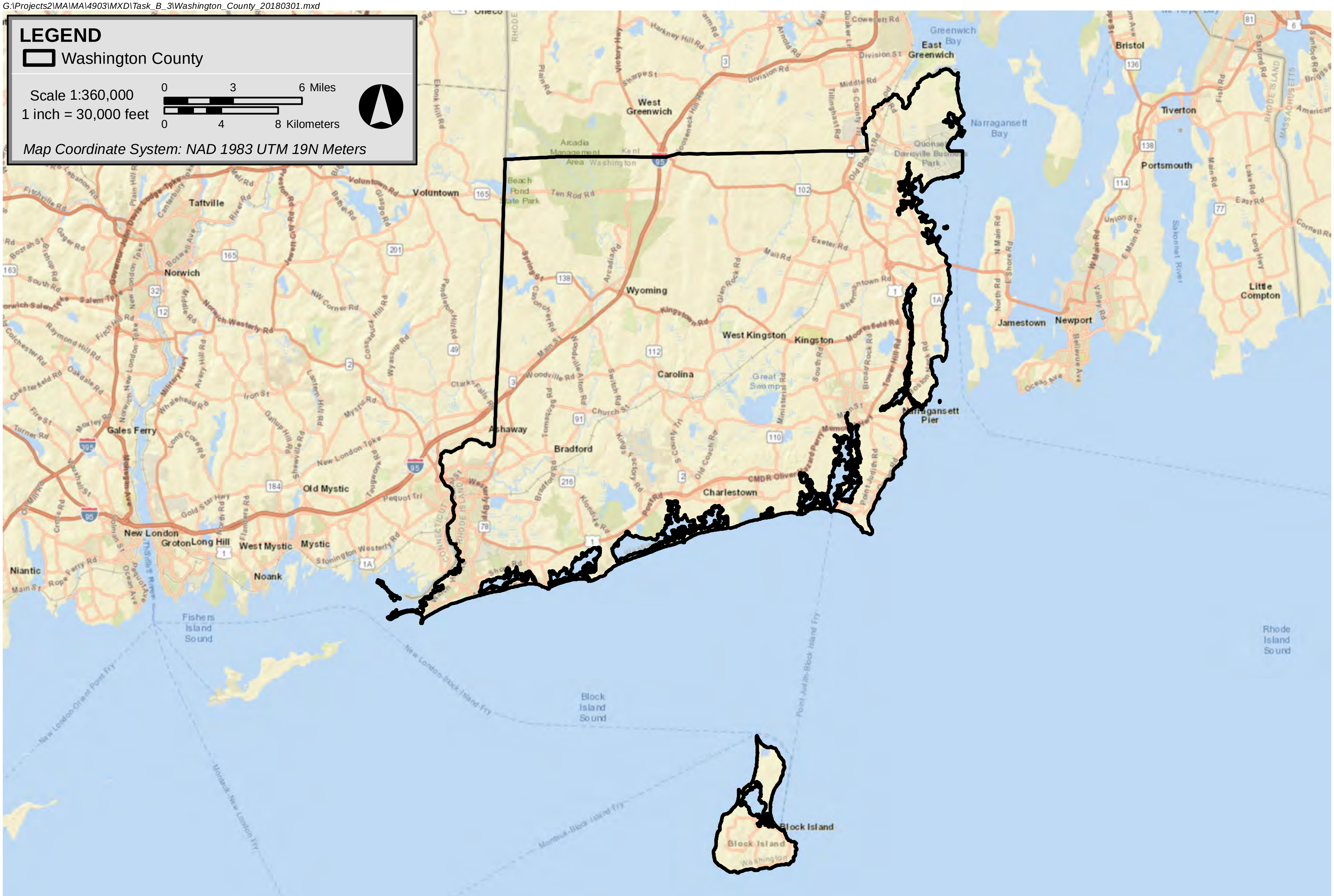

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Figure 7.1-6

Washington County, Rhode Island

Housing

Housing data for Washington County are presented in Table 7.1-8, below.

Table 7.1-8 Washington County Housing[1]

Location	Housing Units	Vacant Units	Median Value of Owner-Occupied Units	Median Gross Rent
Washington County	62,854	21.2%	$315,100	$1,062

[1] US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates.

Census Bureau data for 2016 counts 62,854 total housing units in Washington County, of which 13,301 are categorized as vacant. Of the County's 49,553, occupied housing units, 72.4% are owner-occupied. In 2010, the most recent year vacancy status is categorized as "seasonal, recreational, or occasional," 76.6% of those vacant units were for seasonal, recreational, or occasional uses.

7.1.1.3 Connecticut

Connecticut has three deep-water commercial ports, any one of which could serve as a staging area for project components, such as the turbine blades. Because of the potential use of Connecticut ports, population and economic statistics for Fairfield and New London Counties, and the State of Connecticut are provided in Table 7.1-9, below.

Table 7.1-9 Existing Economic Conditions in the Vicinity of Vineyard Wind

Location	Population (2016)[1]	Population Density[2] (persons per sq. mile)	Per Capita Income (2016)[3]	Total Employment (2016)[4]	Unemployment Rate (2016)[4]
Connecticut	3,588,184	741.0	$39,906	1,828,858	4.7%
Fairfield County	949,921	1,520.1	$51,719	463,484	4.5%
New London County	269,033	404.6	$35,531	133,191	4.5%

[1]US Census Bureau, Population Estimates Program ("PEP"), Updated annually; [2] US Census Bureau, Census of Population and Housing. Land area is based on current information in the TIGER® data base, calculated for use with Census 2010; population from PEP V2017 [3] US Census Bureau, American Community Survey ("ACS") 5-Year Estimates (2016); [4] Quarterly Census of Employment and Wage Program of the Bureau of Labor Statistics, accessed July 2018, not seasonally adjusted.

7.1.1.3.1 Fairfield County

Demographics

Fairfield County consists of 24 municipalities of the southwestern region of Connecticut (Figure 7.1-7).

The Census Bureau's Population Estimates Program ("PEP") data for 2016 counts 944,177 residents of Fairfield County, in 2016 it was Connecticut's most populous county. In 2016, as estimated by the American Community Survey ("ACS"). The City of Bridgeport, with a population of 147,022 residents, had the largest population in both Fairfield County and the State of Connecticut.

Fairfield County's population density, per capita income, total employment, and unemployment rate are provided in Table 7.1-9. Based on ACS estimates from 2016, Fairfield County's median household income is $86,670, which is higher than the statewide median of $71,755.

Economy and Employment

According to the BLS, Fairfield County's average annual labor force included approximately 482,418 individuals in 2016 and Fairfield County's unemployment rate was 4.8% in 2016

In 2016, Fairfield County's 32,408 private-sector employer establishments employed 378,174 individuals (BLS, 2018). In 2015, the most recent year for which data are available, Fairfied County's workforce was comprised of 63.2% of County residents and 36.8% non-residents, with the largest concentration of jobs along the Interstate 95 corridor from Bridgeport to Greenwich. According to BLS data, in 2015, the largest employers by NAICS Sector, are Health Care and Social Assistance, Retail Trade, and Finance and Insurance sectors. The five largest employers in Fairfield County are: Immucor, Sikorsky Aircraft Corp., Ceci Brothers Inc., Boehringer Ingelheim Corp., and Trefz Corp. CDL, 2017).

In 2014, the most recent year for which data is available, the Ocean Economy accounted for 1.5% of Fairfield County's total Gross Domestic Product ("GDP"), and Ocean Economy activities employed approximately 18,574 individuals, including self-employed individuals.

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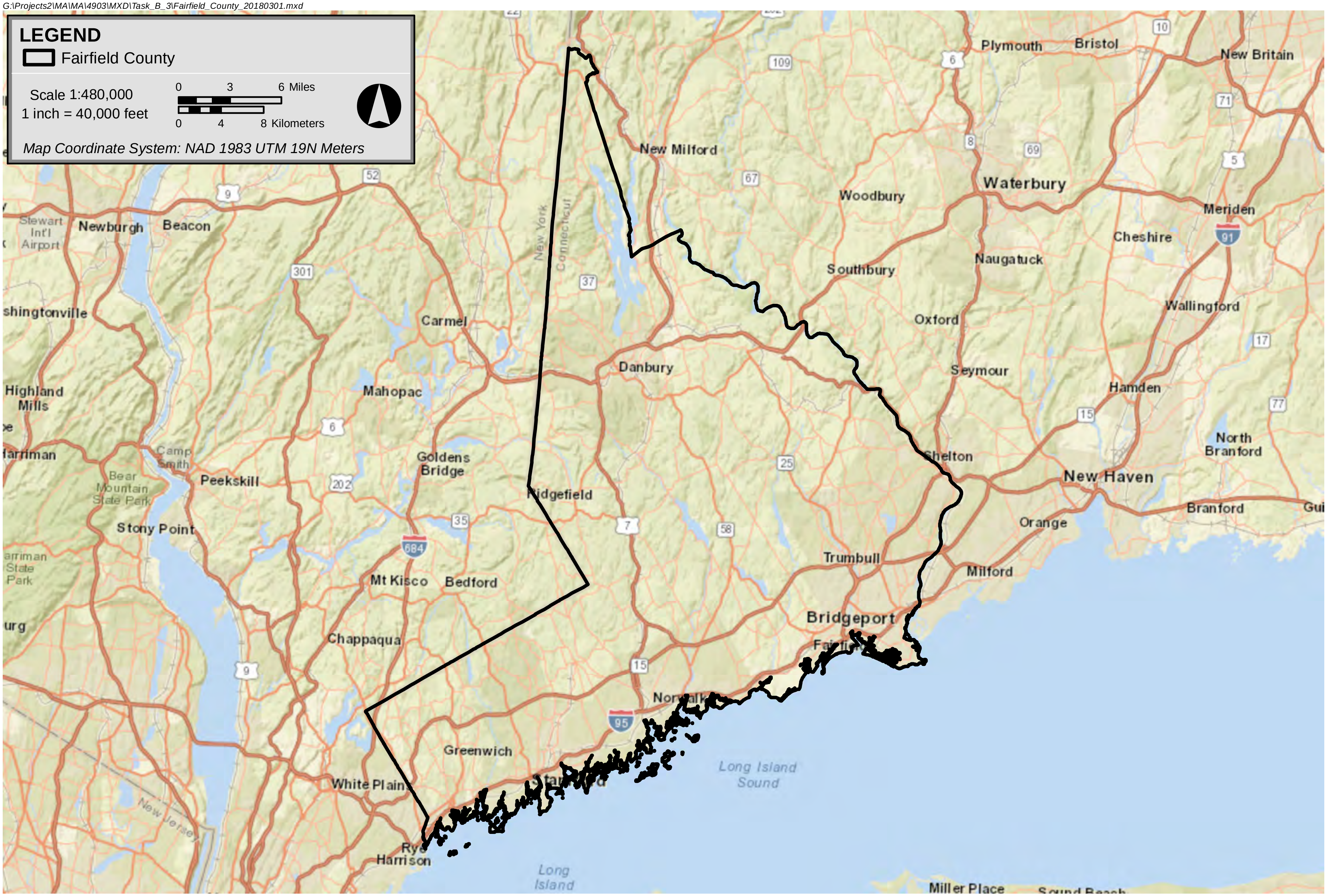

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Figure 7.1-7

Fairfield County, Connecticut

These jobs include fishing, seafood processing, marine passenger transportation, boat dealers, and tourism and recreation, amongst other jobs.

Over the preceding 10 year period, as a percentage of GDP, Barnstable County's Ocean Economy expanded by 3.3% and added approximately 4,695 jobs. In 2014, the largest Ocean Economy sector by dollar value was recreation and tourism, which accounted for 77.3% of the total Ocean Economy; 0.3% of the Ocean Economy was attributed to commercial fishing, aquaculture, and seafood processing.

Fairfield County's Port of Bridgeport is one of three deepwater ports in Connecticut and currently contains a mix of industrial, commercial, and recreational uses. The Port of Bridgeport has established berthing facilities, cargo handling, and vessel servicing facilities. (Apex, 2010)

Housing

Housing data for Fairfield County are presented in Table 7.1-10, below.

Table 7.1-10 Fairfield County Housing[1]

Location	Housing Units	Vacant Units	Median Value of Owner-Occupied Units	Median Gross Rent
Fairfield County	364,737	8.1%	$413,400	$1,385

[1] US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates

Census Bureau data for 2016 counts 364,737 total housing units in Fairfield County, of which 29,528 (8.1%) are categorized as vacant. Of the County's 335,209 occupied housing units, 67.6% are owner-occupied. In 2010, the most recent year vacancy status is categorized as "seasonal, recreational, or occasional," 21.2% of those vacant units were for seasonal, recreational, or occasional uses.

7.1.1.3.2 New London County

New London County consists of 24 municipalities of the southeastern region of Connecticut (Figure 7.1-8).

The Census Bureau's PEP data for 2016 counts 274,055 residents of New London County. In 2016, as estimated by the ACS, The City of Norwich had the largest population in the New London County, with a population of 40,057 residents.

New London County's population density, per capita income, total employment, and unemployment rate are provided in Table 7.1-9. Based on ACS estimates from 2016, New London County's median household income is $83,925.

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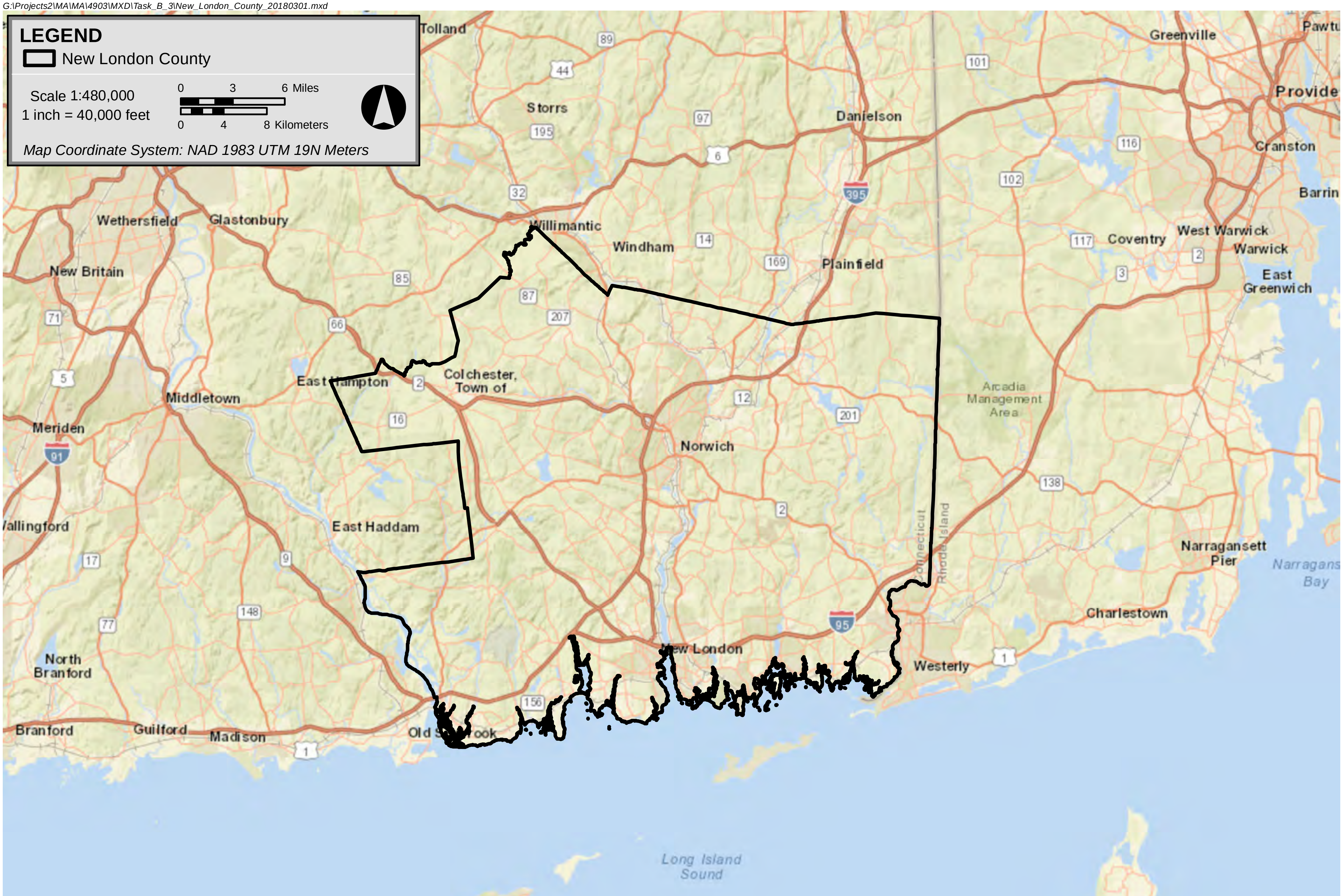

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Figure 7.1-8

New London County, Connecticut

Economy and Employment

According to the BLS, in 2016, New London County's average annual labor force included approximately 136,592 individuals with an unemployment rate of 5.0%.

In 2016, New London County's 6,895 private-sector employer establishments, employ 91,779 individuals (BLS, 2018). In 2015, the most recent year for which data are available, Fairfield County's workforce was comprised of 66.7% of County residents and 33.3% non-residents, with the largest concentration of jobs near the City of New London. According to BLS data, in 2015, the largest employers by NAICS Sector, are Manufacturing, Health Care and Social Assistance, and Arts, Entertainment, and Recreation. The five largest employers in New London County are: Foxwoods Resort Casino, General Dynamics Electric Boat, Mohegan Sun, Electric Boat Corp., and L+m Healthcare. (CDL, 2017).

NOAA's Office for Coastal Management provides data on "Ocean Economy" activities. These categories of activities are based on NAICS sectors that depend on the ocean for input. In 2014, the most recent year for which data is available, the Ocean Economy accounted for 12.6% of New London County's total Gross Domestic Product ("GDP"), and Ocean Economy activities employed approximately 17,071 individuals, including self-employed individuals.

Over the preceding 10 year period, as a percentage of GDP, New London County's Ocean Economy expanded by 2.8% and added approximately 1,805 jobs. In 2014, the largest Ocean Economy sector by dollar value was "suppressed", meaning certain data cannot be published without violating the confidentiality of one or more businesses. The "suppressed" sector accounted for 73.4% of the total Ocean Economy.

The Port of New London/Groton is one of three deepwater ports in Connecticut. According to the Southeastern Connecticut Enterprise Region (2017), 13% of regional employment is attributed to the region's military and shipbuilding sectors, including the US Naval Submarine Base in Groton, and General Dynamics Electric Boat. Other major employers are the Theater Aviation Sustainment Maintenance Group (TASMG) in Groton - an arm of the Connecticut National Guard and the US Coast Guard Academy and the Coast Guard's research and development centers in New London. Defense represents over $3.3 Billion annually in economic impact in Southeastern Connecticut. (SCER, 2017).

Housing

Housing data for New London County are presented in Table 7.1-11, below.

Table 7.1-11 New London County Housing[1]

Location	Housing Units	Vacant Units	Median Value of Owner-Occupied Units	Median Gross Rent
New London County	121,426	12.6%	$241,500	$1,039
[1] US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates				

Census Bureau data for 2016 counts 121,426 total housing units in New London County, of which 15,256 (12.6%) are categorized as vacant. Of the County's 106.170 occupied housing units, 66.1% are owner-occupied. In 2010, the most recent year vacancy status is categorized as "seasonal, recreational, or occasional," 41.2% of those vacant units were for seasonal, recreational, or occasional uses.

7.1.2 Potential Impacts of the Project

The potential impact-producing factors as they relate to specific Project elements are presented in Table 7.1-12, below.

As noted in Section 7.1, although Project activities may occur in one or more counties within the Project Region, these activities and their socioeconomic impacts, where applicable, are anticipated to occur in proximity to the port(s) hosting Project-related activities.

Table 7.1-12 Impact-producing Factors for Employment and Economics

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommissioning
Workforce hiring	X	X	X	X	X
Procurement of certain construction or maintenance materials	X	X	x	X	
Procurement of non-construction materials	X	X	X	X	X
Vessel charters	X	X	X	X	X
Port Use	X	X	X	X	x
Workforce Training Programs	X			X	
Housing			X	X	X
Temporary Accommodations			X		X

7.1.2.1 Construction and Installation

As described in Volume I, Project components will be installed in the onshore and offshore environments. In the onshore environment, new utility duct bank will be installed beneath and along public rights-of-way from the offshore export cable Landfall Site to the general vicinity of the Barnstable Switching Station. A section of existing rail right-of-way ("ROW") and a segment of existing utility ROW may be used for a portion of the route as well. Horizontal directional drilling ("HDD") operations and other construction activity will also occur at the Landfall Site.

In the WDA, which is located well offshore, WTGs, inter-array and inter-link cables, and up to four electrical service platforms ("ESPs") will be installed as part of the ~800 megawatt Project. Construction and installation activities will also occur offshore along the Offshore Export Cable Corridor ("OECC").

The New Bedford Marine Commerce Terminal ("New Bedford Terminal"), described in Section 7.1.1.2.2, will host shore-side WTG construction and fabrication, laydown, and Project management activities. Vessels delivering WTG components to the New Bedford Terminal, construction and installation vessels, and crew transport vessels will likely operate within New Bedford Harbor. Shore-side activities and vessel operations will be most intensive during the construction and installation, and decommissioning phases, though delivery of replacement WTG components may occur at the New Bedford Terminal during the Project's operations and maintenance phase. Construction and installation activities may also occur at the ports described in Sections 7.1.1.1, 7.1.1.2, and 7.1.1.3. The vessels, equipment, and personnel active at those ports will likely be less than those active at the New Bedford Terminal, but for purposes of this analysis they are considered comparable.

Construction and installation activities occurring at the New Bedford Terminal, or at any of the other ports being evaluated are compatible with surrounding and active port uses. Though the offshore wind sector may be new to these ports, ship-to-shore transfers, shore-side fabrication, and other Project-related activities described in Volume I, are consistent with on-going or historic activities at these ports.

Construction and installation activities along the OECC, including at the Landfall Site, may occur in the Towns of Barnstable and Yarmouth. Cable installation procedures, including vessel and equipment types, are described in Volume I.

Construction and installation activities may affect the Project Region as described below.

7.1.2.1.1 Workforce Impacts

During the construction and installation phase, Vineyard Wind anticipates directly hiring a workforce spanning a diverse range of professions for fabrication, construction, and/or assembly of components. The University of Massachusetts, Dartmouth, Public Policy Center (PPC) analyzed the economic contributions to employment and economic output that the Project can be expected to have on the Commonwealth of Massachusetts and the regional economy of Southeastern Massachusetts (SEMA). (Borges, Goodman, Korejwa, McCarthy, 2017). The PPC estimates that the Project will support an estimated 3,180 to 3,658 direct FTE job years across all phases of the project.[18] This total includes job years over the entire 25-year Operations phase. In terms of the actual number of workers (not FTEs), the project is expected to directly employ 1,706 to 2,120 workers across all the project phases. The PPC analysis is attached as Appendix III-L.

During the construction phase, the PPC estimates that the Project will generate 1,100 to 1,552 FTE job years. (Borges, et al., 2017). Vineyard Wind expects that most of these jobs will be located in Southeastern Massachusetts as this is where most of the construction activities will occur. A small number of other personnel may temporarily relocate to the Project Region, including vessel crew and those with specialized technical skills or project-specific management experience. Vineyard Wind has already staffed a New Bedford office and engaged a number of Massachusetts-based environmental consultants, engineers and attorneys to support elements of the design effort, licensing, and permitting. It is anticipated that the share of local supply chain jobs will vary over each phase of the Project as regional investments in supply chain materialize.

As noted, Vineyard Wind may use other ports within the Project Region for staging certain project activities. These ports offer well-established industrial and commercial port facilities and affiliated workforces. The other ports being evaluated include: Brayton Point and Montaup in Somerset, Massachusetts; ProvPort and Port of Davisville (Quonset) in Rhode Island; and Port of New London/Groton and Port of Bridgeport in Connecticut. No additional workforce impacts are expected due to the use of these ports.

Alternate locations within the industrial waterfront areas of New Bedford Harbor, and in proximity to the New Bedford Terminal are being evaluated to determine the feasibility of hosting construction and installation related activities at these locations. Due to the proximity of the alternate locations to the New Bedford Terminal, it is anticipated that that no additional workforce impacts would occur if they were used for Project-related activities.

To the extent feasible, construction materials and other supplies, including vessel provisioning and servicing, and certain fabrication work will be sourced from within the Project Region. Impacts associated with materials sourcing are anticipated to have a stimulating effect of the Project Region's economy.

[18] One FTE is the equivalent of one person working full time for 1 year (2,080 hours).

In sum, the Project is expected to provide steady, well-paying jobs that will have a direct positive and stabilizing impact of the Southeastern Massachusetts workforce.

In addition to the direct jobs created during construction, the Project is expected to create 373 indirect jobs during the construction and installation phase. Indirect job creation is expected to be in the areas of transport and support services, as well as professional services such as legal and accounting. The Project is expected to induce an additional 898 jobs during the construction and installation phase. This is because induced impacts (the jobs created by the expenditure of wages) are driven by wage amounts, both of workers directly working on the project and supply chain workers.

7.1.2.1.2 Economic Impacts

Most Project-related activities are anticipated to have location-specific effects, largely dependent on the magnitude of changes relative to existing local conditions. The Project, however, will create opportunities for market growth in sectors servicing the offshore wind industry along the Atlantic coast. Overall, the Project will provide benefits to local coastal economies and industries supporting the construction and installation phase. Construction and installation activities will provide a number of job opportunities within the marine trades and affiliated industries, and will have a positive impact on those sectors, particularly those heavily influenced by seasonal hiring. Opportunities for marine trades industries include: tug and other vessel charters, dockage, fueling, inspection/repairs, provisioning, and crew work. In addition, the Project will source certain materials within the Project Region whenever feasible.

Vineyard Wind estimates that it will spend $177.4 to $196.3 million procuring materials and services from Massachusetts suppliers to support the development and construction of the Project. (Borges, et al., 2017). These expenditures will support a variety of Massachusetts and southeastern Massachusetts-based businesses, from tool suppliers and crane companies to transportation companies and component suppliers. In turn, these expenditures support further job impacts through business-to-business transactions along the Project's supply chain, as well as from the wages that Project suppliers' employees spend in the local economy on goods and services such as gas, rent, food, and childcare. The PCC estimates that the Project will contribute nearly $98 million in added value to the Massachusetts economy during the construction and installation phase. The Project's induced impacts are estimated to support $156.8 million in new economic output during construction. (Borges, et al., 2017)

It is estimated that the Project will generate $14.7 to $17.0 million in state and local taxes as a result of the development, construction, and first year of operations of the ~800 MW Project. This includes an estimated $4.7 to $5.3 million increase in Massachusetts personal income and other personal tax payments, a $3.0 to $3.5 million increase in sales taxes, a

$5.2 to $6.1 million increase in property taxes, a $1.3 to $1.5 million increase in corporate taxes and payroll taxes, and a $0.5 to $0.6 million increase in fees, fines, and other taxes. (Borges, et al., 2017) Although these tax benefits are based on a single year of expenditures during the operations and maintenance phase, tax benefits will continue annually over the Project's lifetime. In addition, Vineyard Wind is in the process of negotiating Host Community Agreements with the towns of Barnstable and Yarmouth. It is anticipated that the Host Community Agreements will stipulate payments from Vineyard Wind to the local towns in addition the Projects usual annual tax payments.

Finally, Vineyard Wind is committing to invest up to $10.0 million in projects and initiatives to accelerate the development of the offshore wind supply chain, businesses, and infrastructure in Massachusetts when a power contract is awarded. This fund will be used to attract investments to upgrade or create new facilities or infrastructure needed to develop the offshore wind industry in Massachusetts. Examples of possible investments by the fund include expanding and improvement of ports to support offshore wind construction and enabling the establishment of offshore wind manufacturing facilities in Massachusetts.

7.1.2.1.3 Avoidance, Minimization, and Mitigation Measures

The construction and installation phase is anticipated to increase in employment and income within the Project Region, including growth in sectors servicing the offshore wind industry and are, therefore beneficial to the Project Region.

Additional coordination with federal, state, and local authorities and other stakeholders will be pursued in advance of the construction and installation process. The Project will continue to work cooperatively with southeastern Massachusetts educational institutions, such as the Massachusetts Maritime Academy, University of Massachusetts Dartmouth, Bristol Community College and others to help create training and educational opportunities for their students and faculty throughout each phase of the Project. One such partnership, Vineyard Wind's "Windward Workforce" initiative, will support workforce training in the offshore wind sector and will be implemented when Vineyard Wind is awarded a power contract. The Windward Workforce initiative is a set of programs, with Vineyard Wind providing $2 million in underlying support, which will recruit, mentor, and train residents of Massachusetts, particularly southeast Massachusetts, for careers in the Commonwealth's new offshore wind industry. The ultimate objective of the Wind Workforce initiate is to create in Massachusetts the best trained, most experienced offshore wind workforce in the US. The Windward Workforce program will be undertaken in partnership with vocational schools, community colleges, the Fishing Partnership Support Services, and others. Vineyard Wind has already initiated conversations with potential partners including the Bristol Community College, Martha's Vineyard Regional High School, Cape Cod Community College, and Cape and Islands Self-Reliance.

7.1.2.2 Operations and Maintenance

Vineyard Wind plans to locate the Project's O&M Facilities in Vineyard Haven on Martha's Vineyard. The O&M Facilities will function for the operational life of the Project, which is anticipated to extend up to 30 years after construction and installation. Construction of the O&M Facilities may require additional engineering, construction, and trades personnel. Impacts to surrounding communities during the construction of the O&M Facilities will be comparable to other construction projects of similar use and scale. Improvements to Vineyard Haven may be necessary to accommodate Vineyard Wind's operational needs, such as improvements to existing marine infrastructure (e.g., dock space for Crew Transport Vessels ("CTVs"), access, etc.) and to structures (office and warehouse space). Any such improvements are not anticipated to have substantial workforce or economic impacts.

Once operational, the O&M Facilities will operate with a staff of technicians and engineers responsible for long-term operation and maintenance of the Project. The use of machinery and equipment will be necessary for the planned office and training space, shop space, warehouse space. Additional workforce may be required for planned periodic maintenance of the Onshore Project Area, including the Onshore Export Cable Route, and periodic maintenance and repairs to in-water and other Project assets.

Vineyard Wind intends to use port facilities at both Vineyard Haven and the New Bedford Terminal to support O&M activities (see Section 3.2.6 of Volume I). Smaller vessels (e.g. CTVs or SOVs) used for O&M activities will be based out of Vineyard Haven. Larger vessels used for major repairs during O&M (e.g. jack-up vessels, heavy cargo vessels, etc.) would likely use the New Bedford Terminal. Helicopters may be used for fast response visual inspections and repair activities, as needed and are typically used in conjunction with CTVs.7.1.2.2.1 Workforce Impacts

The O&M Facilities, as described in Section 7.1.2.2, will operate with a staff of technicians and engineers responsible for long-term operation and maintenance of the Project.

Operations and maintenance of the Project will create an estimated 81 direct, FTE jobs annually, for a total of 2,025 FTEs. (Borges, et al., 2017). Vineyard Wind estimates that about 90% of these positions will be based on Martha's Vineyard. Vineyard Wind expects that all of these jobs will be held by Martha's Vineyard's year-round residents within five years of the Project's operation. These jobs will help diversify and stabilize Martha's Vineyard's economy, which is otherwise highly dependent on tourism and related seasonal employment opportunities.

Additional service providers will be necessary during planned inspection, maintenance, and repair of the in-water facilities. Maintenance, repairs, and upgrades to the Onshore Project Area will also be required during the Project's operation and maintenance phase.

The operations and maintenance phase will create a number of job opportunities within the marine trades and affiliated industries, and will have a positive impact on those sectors throughout the anticipated life of the Project by creating job market opportunities and increased employment stability, particularly within those sectors heavily influenced by seasonal hiring. It is estimated that the Project will create 26 indirect jobs annually and induce 63 jobs annually.

7.1.2.2.1 Economic Impacts

Overall economic impacts from the Project are expected to yield benefits in the Project Region for the duration of the operations and maintenance phase. Vineyard Wind anticipates opportunities for area marine trades industries including: tug and other vessel charters, dockage, fueling, inspection/repairs, provisioning, and other port and harbor services.

A number of ancillary services will also be required during the operations and maintenance phase. These functions include day-to-day workflow management, facilities monitoring, data analysis, and performance optimization services. Logistics management, including maintenance vessel and crew operations, materials storage and handling, tooling, and engineering and fabrication services will be required during the operations and management phase.

In other locations where offshore wind has been developed, vessel and sightseeing operators have expressed interest in providing excursions to the in-water facilities. Vineyard Wind anticipates that similar operations may occur in the WDA.

Finally, the Project anticipates sourcing many goods and services throughout the multi-decade operations and maintenance phase from local and regional providers. The induced jobs effect of the Project during the operations and maintenance phase is anticipated to create 69 FTE positions each year during the operational phase.

7.1.2.2.2 Avoidance, Minimization, and Mitigation Measures

Vineyard Wind is committed to working with the Bureau of Ocean Energy Management ("BOEM"), the Commonwealth of Massachusetts, local and regional officials, and other stakeholders to maximize this unique and timely opportunity to establish Massachusetts as the center of the offshore wind industry in the US.

7.1.2.3 Decommissioning

As currently envisioned, decommissioning the Project is largely the reverse of the construction and installation process as described in Volume I. Impacts associated with decommissioning are similar to those described in Section 7.1.2.1.

7.1.2.3.1 Workforce Impacts

Vineyard Wind anticipates that the workforce necessary for decommissioning will be approximately the same composition and size of the construction and installation workforce. Personnel may temporarily relocate to the Project Region, including vessel crew and those with specialized technical skills or project-specific management experience, though, because regional growth of the offshore wind sector is anticipated, a larger local share of decommissioning labor may be used.

Impacts associated with decommission activities are anticipated to have a minor stimulating effect of the Project Area economy.

7.1.2.3.2 Economic Impacts

Economic impacts of the decommissioning phase are anticipated to be consistent with the construction and installation impacts described in Section 7.1.2.1.

7.1.2.3.3 Mitigation Measures

Any impacts associated with the decommissioning phase will largely be beneficial to the Project Region. Temporary impacts will be mitigated through best management practices, where practicable. Individual monitoring, outreach, and communication plans are expected to be implemented, as necessary, to assess and address impacts resulting from the decommissioning process. Additional coordination with federal, state, and local authorities and other stakeholders will be pursued in advance of the decommissioning process.

7.2 Environmental Justice / Minority and Lower Income Groups/Subsistence Resources

This section assesses the Project's effects on Environmental Justice ("EJ") populations, which are primarily minority and low-income populations. Socioeconomic characteristics of the Project Region have been examined to determine whether the proposed activities would disproportionately impact any EJ populations. The construction, operation and maintenance, and decommissioning of the Project are not anticipated to create disproportionately high and adverse health or environmental effects of federal actions on EJ populations.

EJ is defined by the Environment Protection Agency ("EPA") as,

> *"The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial,*

ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies." (EPA, 2017)

Executive Order ("E.O.") No. 12898 (1994) requires federal agencies to take appropriate steps to identify and address disproportionately high and adverse health or environmental effects of federal actions on minority and low-income populations. An EJ assessment considers the following:

(1) The areas in which a proposed project may result in significant adverse environmental effects;

(2) The presence and characteristics of potentially affected minority and/or low-income populations (i.e., "communities of concern") residing in these study areas; and

(3) The extent to which these communities are disproportionately affected in comparison to the effects experienced by the population of the greater geographic area within which the affected area is located is determined.

The Council on Environmental Quality ("CEQ") EJ guidance under the National Environmental Policy Act (CEQ, 1997) defines "minorities" as including American Indian or Alaskan natives, Asian or Pacific Islanders, Black, or Hispanic persons. For the purposes of this analysis, a community may be considered to have a minority population when the percentage of minorities in a study area is "meaningfully greater" than the minority percentage of the general population. The composition of the affected area population is therefore compared to the characteristics of the population in the next larger geographic area or political jurisdiction.

A community of concern may also be identified by the presence of low-income populations within the study area. Low-income populations are identified using the poverty thresholds available from the Census Bureau, and a comparison to the general population sets the context for the assessment. Poverty level is defined by the Census Bureau, which considers a variety of factors including family size, number of children, and the age of the householder. To determine a person's poverty status, total family income over a 12-month period is compared against the poverty threshold appropriate for that person's family size and composition. Since poverty status is defined at the family level and not the household level, the poverty status of a household is determined by the poverty status of the householder. Households are classified as below the poverty level when the total income in a 12-month period is below the appropriate poverty threshold. Income thresholds are not adjusted for regional or local variations in the cost of living.

For race and ethnicity, the tables below include a breakdown of the Asian, Black, Hispanic, and white populations in the Project Region. The "other" category includes respondents to US Census surveys who did not identify with any listed racial groups (e.g., white, Black, Asian), or who indicated that they are of more than one race. The US Census Bureau defines persons of Hispanic origin as those respondents who classified themselves in one of the specific Hispanic origin categories in the census questionnaire, such as "Mexican," "Cuban" or "Puerto Rican," as well as those who indicated that they were of "Other Spanish/Hispanic/Latino" origin. These respondents include those whose origins are from Spain, the Spanish-speaking countries of Central and South American or the Dominican Republic, or who are persons of Hispanic origin who identify themselves generally as Spanish, Spanish-American, Hispanic, or Latino. Persons of Hispanic origin may be of any race.

Because the minority populations in the communities within the Project Region do not exceed 50%, and the percentage of minorities and people with income below the poverty level is not significantly higher than the state-wide levels, there are no EJ communities, as defined by the EPA, affected by the Project.

However, as discussed in greater detail below, some areas within the Project Region do meet criteria for EJ populations as established by their respective state authorities.

7.2.1 Description of the Affected Environment

The study area for the EJ analysis encompasses the Project Region and focuses on locations where potential impacts resulting from construction and installation, operations and maintenance, and decommissioning activities may occur. Relevant characteristics of county-level populations in the Project Region are compared to their respective State characteristics as the context for the assessment. Population and demographic data used in this analysis was obtained from the Census Bureau and the EPA's Environmental Justice Screening and Mapping Tool (v2017), as well as information provided by State authorities. As noted above, county-level statistics indicate, based on EPA criteria, that the Project does not affect EJ communities.

7.2.1.1 Massachusetts

Table 7.2-1 summarizes state and county populations in the Commonwealth of Massachusetts.

Table 7.2-1 Minority and Low Income Populations, Massachusetts

Location	Total Population[1]	Race and Hispanic Origin (Percent of Population)[1]					Total Minority (Percent)	Below the Poverty Level (Percent)[2]
		Asian (alone)	Black or African American (alone)	Hispanic or Latino	White (alone)	Other		
Massachusetts	**6,859,819**	**6.9%**	**8.8%**	**11.9%**	**81.3**	**3.0%**	**18.7%**	**10.5%**
Barnstable County	213,444	1.5%	3.2%	3.0%	90.2%	5.1%	9.8%	7.6%
Bristol County	561,483	2.4%	5.4%	8.0%	89.2%	3.0%	10.8%	10.7%
Dukes County	17,325	1.0%	4.5%	3.5%	90.1%	4.4%	9.9%	7.6%
Nantucket County	11,229	1.5%	10.6%	14.4%	85.6%	2.3%	14.4%	6.4%

[1]County Level - US Census Bureau, Population Estimates Program ("PEP"), Updated annually; v2017 [2] County level - The Small Area Income and Poverty Estimates ("SAIPE").

Although, under the EPA's criteria, the socioeconomic statistics for each of the counties indicate they are not EJ communities, EJ populations, as defined by criteria established under the Commonwealth of Massachusetts' Environmental Justice Policy ("EJ Policy") (Executive Order No. 552, 1994), exist within the Project Region.

An Environmental Justice population includes any area that:

(1) Has one or more Census block groups where 25% of households have an annual median household income equal to or less than 65% of the statewide median ($68,563 in 2015), which equates to $44,657; or

(2) Has one or more Census block groups where 25% or more of the residents identify as minority; or

(3) Has one or more Census block groups where 25% or more of households have no one over the age of fourteen who speaks English only or very well (i.e., Limited English Proficiency).

The Massachusetts EJ data layer from 2010, provided by the Massachusetts Bureau of Geographic Information ("MassGIS"), identifies certain census block groups in the Project Region as EJ populations. These populations are located in proximity to the New Bedford Marine Commerce Terminal ("New Bedford Terminal"), onshore facilities in Barnstable and Yarmouth, and the Operations and Maintenance Facilities ("O&M") in Vineyard Haven.

As shown on Figure 7.2-1, MassGIS identifies 12 block groups within one mile of the Project's onshore facilities in Barnstable County. Figure 7.2-2, MassGIS identifies 19 block groups within one mile of the New Bedford Terminal in Bristol County. Figure 7.2-3, MassGIS identifies two block groups within one mile of the site under consideration for an Operations and Maintenance Facility in Dukes County.

7.2.1.2 Rhode Island

Table 7.2-2 summarizes state and county populations in the State of Rhode Island.

Table 7.2-2 Minority and Low Income Populations, Rhode Island

Location	Total Population[1]	Race and Hispanic Origin(Percent of Population)[1]					Total Minority (Percent)	Persons Below the Poverty Level (Percent)[2]
		Asian (alone)	Black or African American (alone)	Hispanic or Latino	White(alone)	Other		
Rhode Island	**1,059,639**	**3.7%**	**8.2%**	**15.5%**	**84.1%**	**4.0%**	**15.9%**	**12.8%**
Providence County	637,710	4.6%	12.2%	22.8%	78.4%	4.8%	21.6%	15.8%
Washington County	126,150	2.1%	1.4%	3.2%	93.5%	3.0%	6.5%	9.8%

[1]County Level - US Census Bureau, Population Estimates Program ("PEP"), Updated annually, v2017; [2] County level - The Small Area Income and Poverty Estimates ("SAIPE"), 2016.

Although socioeconomic statistics for each of the counties indicate they are not EJ communities under the EPA criteria, the State of Rhode Island has identified geographic areas in proximity to the Port of Davisville as potential Environmental Justice areas (Figure 7.2-4)

The Rhode Island Department of Environmental Management (DEM) considers the effects that site remediation activities would have on the Environmental Justice populations surrounding the subject site consider the issues of environmental equity for low income and racial minority populations. Vineyard Wind is not proposing any site remediation activities.

7.2.1.3 Connecticut

Table 7.2-3 summarizes state and county populations in the State of Connecticut.

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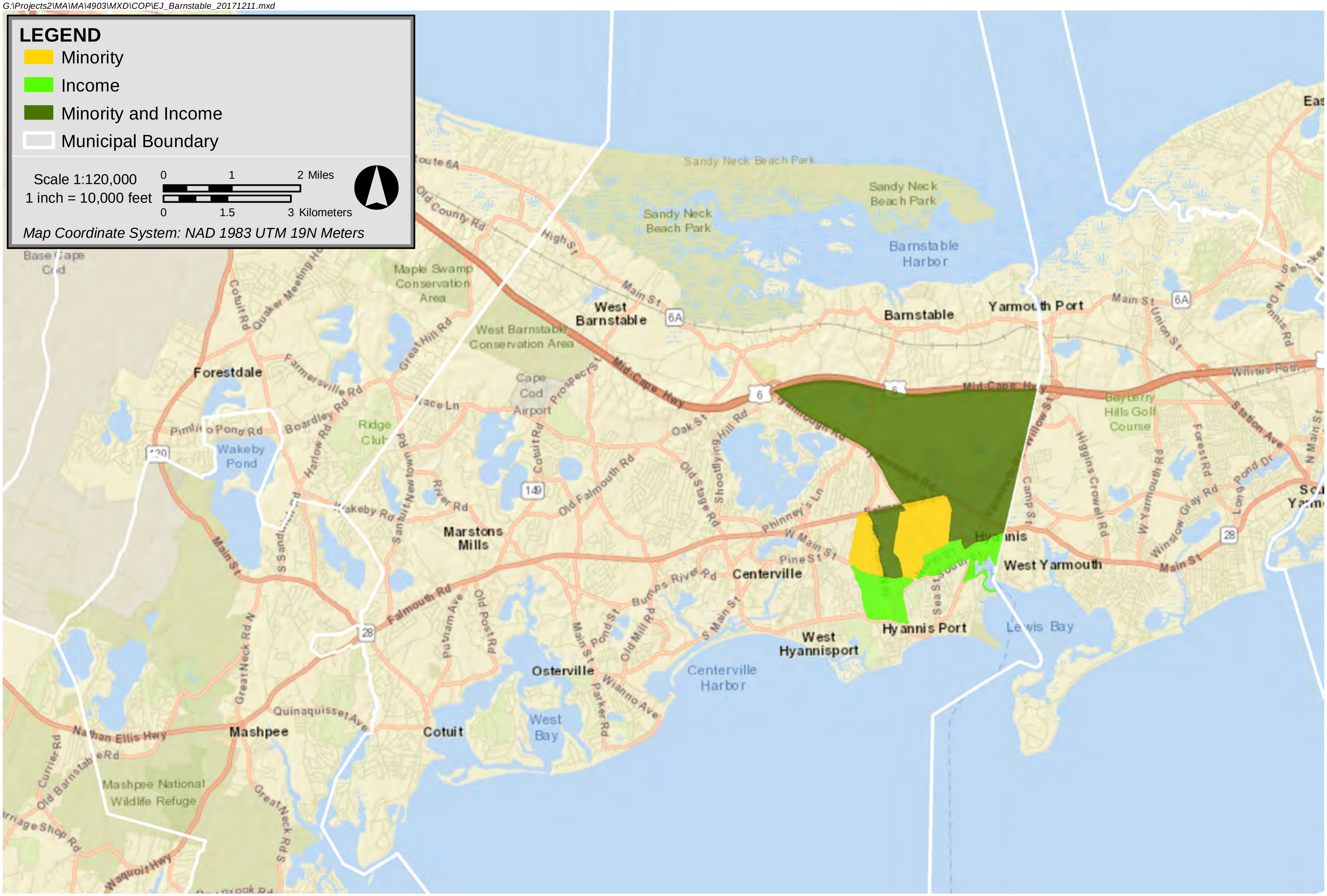


Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong

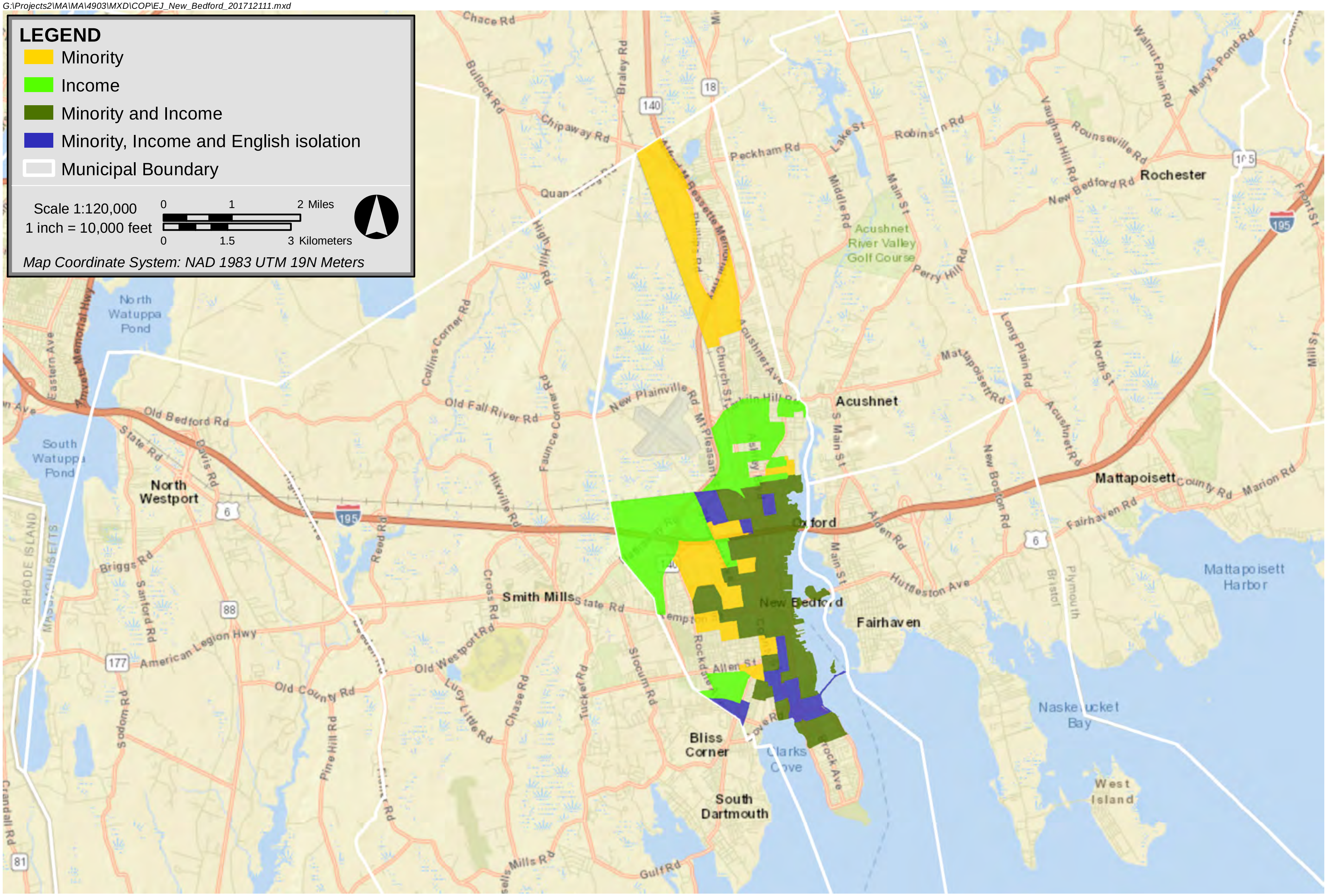
Vineyard Wind Project

VINEYARD WIND

Figure 7.2-1

Environmental Justice Communities, Barnstable

G:\Projects2\MA\MA\4903\MXD\COP\EJ_New_Bedford_201712111.mxd



Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong

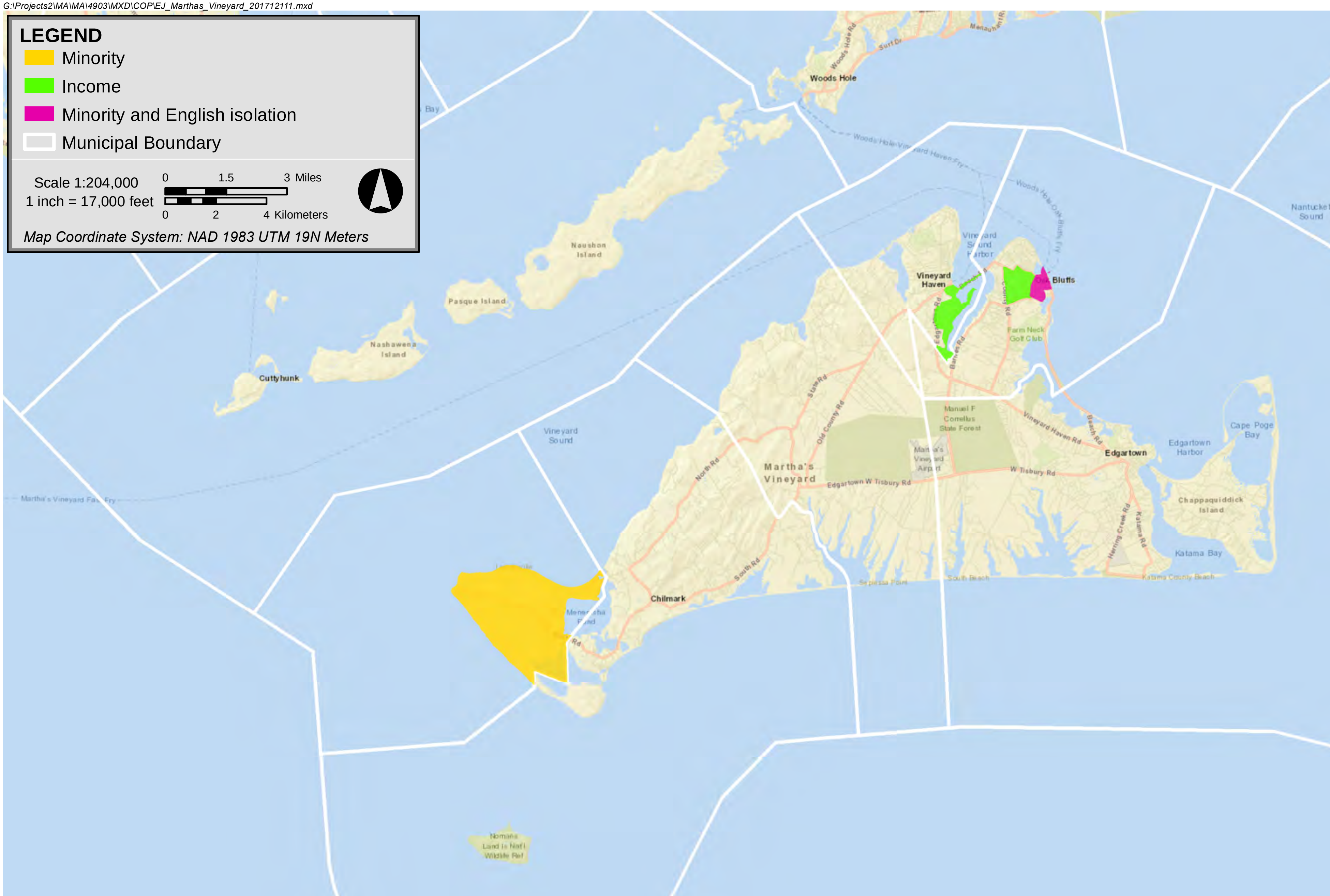
Vineyard Wind Project

VINEYARD WIND

Figure 7.2-2

Environmental Justice Communities, New Bedford

G:\Projects2\MA\MA\4903\MXD\COP\EJ_Marthas_Vineyard_201712111.mxd



Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong

Vineyard Wind Project

VINEYARD WIND

Figure 7.2-3

Environmental Justice Communities, Martha's Vineyard

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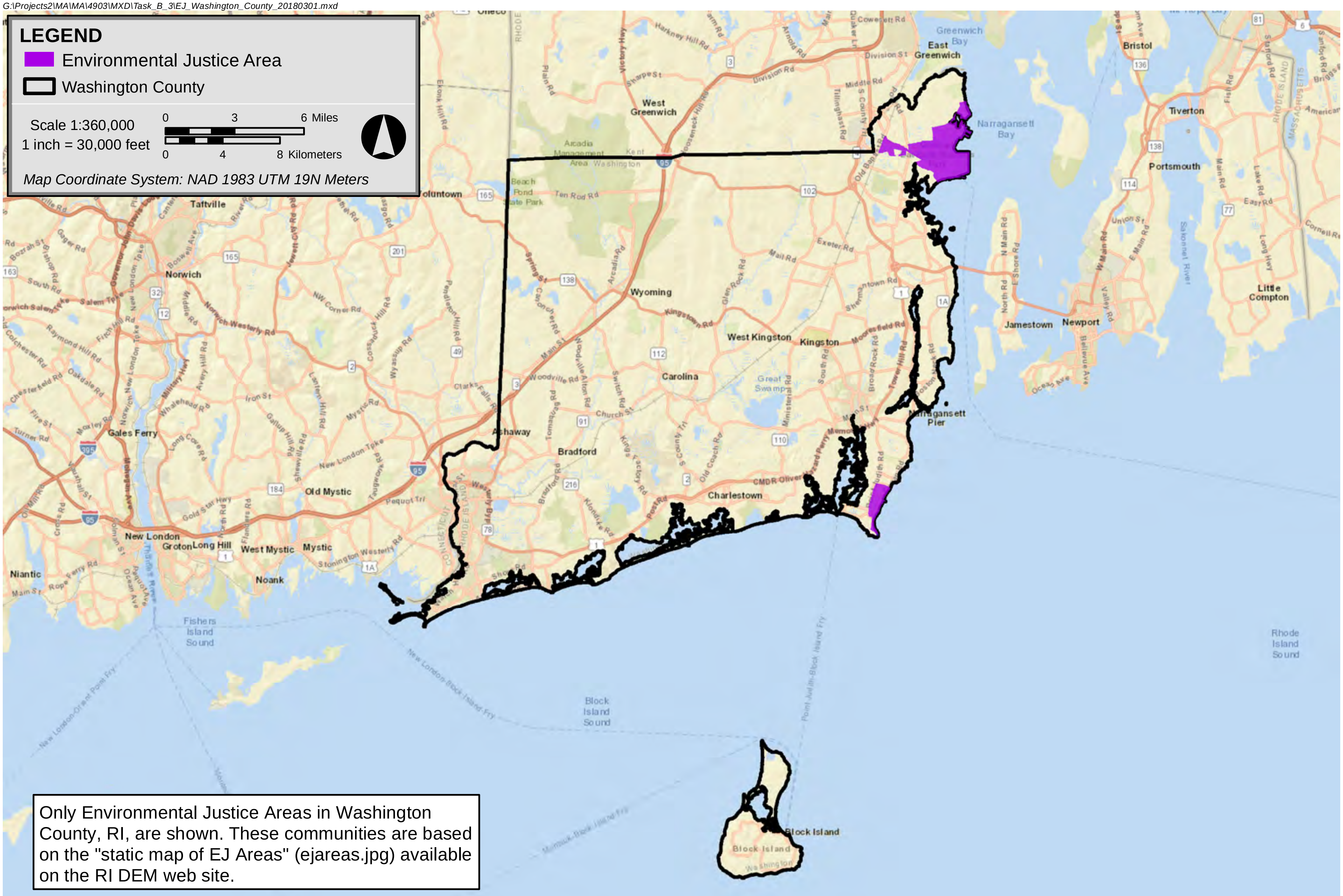

Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong

Vineyard Wind Project

VINEYARD WIND

Figure 7.2-4

Environmental Justice Communities, Washington County, Rhode Island

Table 7.2-3 Minority and Low Income Populations, Connecticut

Location	Total Population[1]	Race (Percent of Population)[1]					Total Minority (Percent)	Below the Poverty Level (Percent)[2]
		Asian	Black or African American	Hispanic or Latino	White	Other		
Connecticut	**3,588,184**	**4.8%**	**11.9%**	**16.1%**	**80.3%**	**3.0%**	**19.7%**	**9.8%**
Fairfield County	949,921	5.8%	12.6%	19.9%	78.9%	2.7%	21.1%	8.6%
New London County	269,033	4.6%	6.9%	10.6%	83.6%	4.9%	16.4%	9.3%

[1]County Level - US Census Bureau, Population Estimates Program ("PEP"), Updated annually, v2017; [2] County level - The Small Area Income and Poverty Estimates ("SAIPE"),, 2016.

Although socioeconomic statistics for each of the counties indicate they are not EJ communities under the EPA criteria, the City of Bridgeport is considered a "distressed community," as defined by criteria established under Connecticut General Statutes (CGS), section 22a-20a (Public Act 08-94). The State of Connecticut's Environmental Justice Policy is only applicable to "affecting facilities" defined under CGS section 22a-20a. Vineyard Wind facilities are not anticipated to meet those criteria.

7.2.2 Potential Impacts of the Project

The Project, including each phase, is not anticipated to cause disproportionately high and adverse effects on any minority or low-income populations and is in consistent with the provisions of Massachusetts' EJ Policy.

Table 7.2-4 Impact-producing Factors for Environmental Justice Communities

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommissioning
Workforce hiring	X	X	X	X	X
Cable Installation		X	X	X	X
Port Use	X	X	X	X	x
Local Vehicle Traffic		X	X		
Workforce Training Programs	X			X	
Housing			X	X	X

7.2.2.1 Construction and Installation

See Section 7.1.2.1 for a description of activities during the construction and installation phase of the Project.

7.2.2.1.1 Impacts to Environmental Justice Populations

New Bedford Terminal will be the most active Port facility used for Project-related activities. It is anticipated, however, that construction and installation activities at the New Bedford Terminal will not cause disproportionately high and adverse effects on any minority or low-income populations in accordance with the provisions of E.O. No. 12898 (1994). Other port facilities were selected, in part, because of their extant workforce and capacity to host Project-related activities. These ports are actively engaged in water-dependent marine industrial activities and the introduction of the Project to those ports is anticipated to have exceptionally limited impacts to areas of concern to EJ and other communities.

Additional vehicle and vessel traffic will occur at the New Bedford Terminal, though the facility is well-served by vehicle access roadways and, therefore, the Project is not anticipated to adversely affect those roadways and abutting communities. Traffic and its related impacts are not anticipated to disrupt the normal and routine functions of the nearby communities. Additional information regarding air quality impacts from these activities is provided in Section 5.1.

Construction and installation activities along the Onshore Export Cable Route may also cause traffic and related impacts within the immediate vicinity these activities, though any disruption to normal and routine functions will be eliminated upon conclusion of the construction and installation activity. From a traffic management perspective, there are no road segments of the Onshore Export Cable Route that are considered unique or unusual for this type of construction.

The Project's construction and installation activities are expected to increase employment opportunities, job training, and economic activity within the Project Region.

The Project is consistent with the Massachusetts' EJ Policy. This consistency is based on Vineyard Wind's community engagement and public information process, which will facilitate the opportunities for all interested parties to participate, and is also based on the fact that the Project does not exceed any environmental impact thresholds that would necessitate enhanced analysis or enhanced public participation under the Policy.

7.2.2.1.2 Avoidance, Minimization and Mitigation Measures

The Project is not anticipated to cause disproportionately high or adverse effects on minority or low-income populations. In accordance with the provisions of E.O. No. 12898 (1994), no mitigation measures are necessary.

However, in accordance with Massachusetts' EJ Policy, Project stakeholder engagement plans will include outreach to the communities of the block groups identified in Section 7.2.1. Additional, a Traffic Management Plan will be developed so as to minimize disruptions to residences and commercial establishments in the vicinity of construction and installation activities.

Prior to construction, Vineyard Wind will work closely with the municipalities to develop a Traffic Management Plan (TMP) for construction and installation activities along the Onshore Export Cable Route. The TMP will be submitted for review and approval by appropriate municipal authorities (typically Department of Public Works/Town Engineer and Police). As part of a Host Community Agreement, Vineyard Wind proposes to pay for the town to hire a construction monitor to ensure compliance with the TMP and communicate with the town and address any resident concerns during construction. Additional outreach to EJ communities, as necessary, will be coordinated by Vineyard Wind and/or its contractors.

7.2.2.2 Operations and Maintenance

Section 7.1.2.2 provides detailed descriptions of the Project's operations and maintenance phase.

7.2.2.2.1 Impacts to Environmental Justice Populations

Operations and maintenance ("O&M") activities are not anticipated to cause disproportionately high and adverse effects on any minority or low-income populations in accordance with the provisions of E.O. No. 12898 (1994).

Minor, temporary and short-term impacts associated with the construction of the O&M Facilities may occur. Construction impacts will be comparable to projects of a similar size and may include increased vehicle traffic, disruptions to existing traffic patterns, noise, dust, and lighting. These impacts will be minor, temporary and short-term.

Following the completion of construction and Project commissioning, only negligible impacts are anticipated from the O&M Facilities, which will provide employment opportunities within the Project Region. During the operations and maintenance phase of the Project, goods, services, and other items will be sourced from the surrounding community.

Periodic planned and unplanned maintenance of Project facilities may cause minor, temporary, short-term impacts to communities in the immediate vicinity of these activities. Such activities may include the clearing of vegetation along rights-of-way, planned replacement of equipment and materials, and the operation of maintenance equipment. Any disruption to normal and routine functions of the project area will be eliminated upon conclusion of the construction and installation activity.

7.2.2.2.2 Avoidance, Minimization, and Mitigation Measures

Based on the foregoing discussion, the Project is not anticipated to cause disproportionately high and adverse effects on minority or low-income populations in accordance with the provisions of E.O. No. 12898 (1994). Therefore, no mitigation measures are necessary.

7.2.2.3 Decommissioning

As currently envisioned, decommissioning the Project is largely the reverse of the construction and installation process as described in Volume I. Impacts associated with decommissioning are similar to those described in Section 7.2.2.1.

7.2.2.3.1 Impacts to Environmental Justice Communities

Impacts associated with decommissioning will be consistent with impacts anticipated during the construction and installation phase described in Section 7.2.2.1.1

7.2.2.3.2 Avoidance, Minimization, and Mitigation Measures

Based on the foregoing discussion, the Project is not anticipated to cause disproportionately high and adverse effects on minority or low-income populations in accordance with the provisions of E.O. No. 12898 (1994). Therefore, no mitigation measures are necessary.

7.3 Cultural, Historical, and Archaeological Resources

In support of the assessment of cultural, historical, and archaeological resources that have the potential to occur in the Project Area, comprehensive analyses were developed based on desktop research and field reconnaissance surveys. These comprehensive analyses include "Archaeological Due Diligence Report" and "Archaeological Permit Application" (both of which are included in Appendix III-G), and "Marine Archaeological Services Report" (Volume II-C). This section provides a brief summary of the noted reports, for additional information refer to Volume II-C and Appendix III-G.

Public Archaeology Laboratory ("PAL") completed an archaeological due diligence review of potential Onshore Export Cable Routes as well as the archaeological permit application that are included as Appendix III-G. The desktop archaeological due diligence review was conducted to provide information about known archaeological sites within one-half mile of the potential routes, provide a sensitivity assessment for archaeological resources with the Project Area, and make recommendations regarding the need for consultation with the Massachusetts Historical Commission ("MHC") and additional cultural resource management investigations. The desktop due diligence review consisted of a search of the MHC's Inventory of the Historic and Archaeological Assets of the Commonwealth ("MHC Inventory") and the Massachusetts Cultural Resource Information System to identify previously recorded archaeological sites within the vicinity of the Project and analyze current environmental conditions to determine archaeological sensitivity.

[redacted]

PAL has conducted a reconnaissance level archaeology survey for terrestrial areas, including completion of background research and a walkover survey. The survey included the two proposed Onshore Export Cable Routes with their variants as well as the proposed onshore substation site, and assessed their potential to affect archaeological resources. The reconnaissance survey identified known archaeological sites, previous disturbance, and addressed potential effects to archaeological sites as outlined in the archaeological permit application included in Appendix III-G. The survey was completed in cooperation with local historical commissions and Tribal Historic Preservation Offices. The survey report ranked areas for low, moderate and high archaeological sensitivity and gave recommendations for potential excavations as part of a potential intensive level survey. The survey report is presently under review at the MHC. Additional archaeological surveys will only be undertaken with the approval of the MHC. Curation arrangements for cultural records and materials have been made as Vineyard Wind is required under the State Archaeologist's Permit to house artifacts at PAL's office unless another approved facility is found and deaccession approved by the State Archaeologist.

To facilitate an assessment of marine archeological resources, Gray & Pape, Inc. provided a "Marine Archaeological Services Report" (Volume II) including a high-resolution geophysical ("HRG") and geotechnical marine survey of the Wind Development Area ("WDA") and Offshore Export Cable Corridor ("OECC") to a number of potential Landfall Sites on Cape Cod. This research was conducted over the 2016 and 2017 seasons in conjunction with Alpine Ocean Seismic Surveys, Inc. and Fugro Marine Geoservices, Inc., in order to satisfy the BOEM's offshore wind energy lease requirements for Vineyard Wind. The goal of this study was to assist Vineyard Wind and BOEM in determining whether or not there are potentially significant cultural resources in the potential Project Area.

[redacted]

The HRG surveys utilized a magnetometer, side scan sonar, shallow and medium penetration subbottom profilers, and multibeam sonar. Data collected were analyzed for both potential materials of pre-contact and historic origin that might be affected by Project activities. The Project Area extends over numerous environments from the Outer Continental Shelf to Nantucket Sound and the nearshore. [redacted]

Surveys planned for the 2018 field campaign in support of the Construction and Operations Plan will extend seafloor and subsurface coverage in all areas where bottom disturbance could occur during construction activities. Survey line spacing, coverage, geophysical system parameters, and methodologies will comply with BOEM geophysical and geotechnical as well as archaeological guidelines applicable to this Project.

It is anticipated that an additional assessment of potential Project-related impacts will be developed through the planned future surveys. Avoidance, minimization, and mitigation measures for terrestrial and submarine historical and archaeological resources within the Project Area will be determined in consultation with MHC and Massachusetts Board of Underwater Archaeological Resources through the Section 106 process.

7.4 Visual Resources

The Visual Impact Assessment provided as Appendix III-H.a determined that the Project would result in change to landscape conditions for viewers along the Martha's Vineyard and Nantucket coastline. The Assessment utlilized windshield surveys, photography, and similations for potential impact determinations. Based upon the results of the Assessment, viewers on the islands will have limited visibility of the WTGs when weather conditions allow. However, at distances greater than 23 km (14 mi), and viewed within the context of the ocean that includes the vast expanse of water, extended beach views and dunes, as well as the sights and sounds of breaking surf and wind, the Project would likely be considered visually subordinate to the wider landscape. The Project will be indiscernible from Cape Cod.

All offshore and onshore cables will be subsurface/buried and will not be visible. The power grid connection will be constructed adjacent to an existing onshore substation. The proposed improvements for the onshore substation will be consistent in scale and visual character with the existing electric substation.

The Historic Properties Visual Impact Assessment, provided as Appendix III-H.b, identified a variety of historic properties, including historic buildings and structures, within the proposed Area of Potential Effect ("APE") for the Project. These resources are listed as National Historic Landmarks, on the National Register of Historic Places, the Massachusetts State Register of Historic Places, and included within the Inventory of Historic and Archaeological Assets of the Commonwealth.

As described in Appendix III-H.b, a file review and a windshield survey was conducted to investigate the potential visual impact of the Project on historic properties, determine the area of potential visibility and identify any previously undocumented historic properties. Based upon the historic properties identified within the APE, the potential visual impact varies by location. The Project may affect the viewshed of limited historic properties situated along the southern coast of Martha's Vineyard, the southwestern coast of Nantucket and their minor outlying islands. The effect will be mitigated by distance and weather conditions. No effect to properties on Cape Cod or Cuttyhunk Island is anticipated due to extreme distance from the WDA. See Appendix III-H.b for details.

7.5 Recreation and Tourism (including recreational fishing)

This section describes the general characteristics of recreation and tourism activities, including recreational fishing, in the Project Region and assesses potential effects of Project-related activities on these recreation and tourism within the Project Region.

The Project Region is the geographic area that could be affected by Project-related activities. For the purposes of recreation and tourism, it consists of the communities in Barnstable County, Bristol County, Dukes County and Nantucket County. As described in Sections 7.1 and 7.2, and in Section 7.5.1 below, this area, especially Cape Cod and the Islands, contains a wealth of recreational resources and attracts large numbers of seasonal residents and visitors. As a general matter, major Project-related activities will occur well offshore and at one or more of the industrial ports selected. Accordingly, project effects on recreation and tourism, if any, are expected to be highly localized and largely temporary in nature.

7.5.1 Description of the Affected Environment

Construction and installation activities will be staged principally from New Bedford. The Wind Development Area ("WDA") is located south of the Islands of Nantucket and Martha's Vineyard and the OECC will pass through Muskeget Channel and traverse Nantucket Sound. The Onshore Export Cable Route will be installed primarily beneath existing roads in Barnstable and a new onshore substation will be built on an industrial parcel in Barnstable. As noted above, many of the communities in the Project Region are popular tourist destinations and depend on the tourism and recreation industries for significant revenues. For example, an estimated 44% of Cape Cod's economic base is derived from seasonal tourism; this represents approximately one billion dollars in annual spending by tourists (CCC, 2012).

On the water, recreational boating, including paddle sports, sport fishing, and diving are seasonally important recreational activities. Offshore whale watching, deep-sea fishing, and other vessel charters are common seasonal activities. In the Project Region, several wildlife sanctuaries and the Cape Cod National Seashore are important destinations for onshore wildlife viewing.

Recreational boating activity varies seasonally, with peak boating season occurring between May and September. Other boat-based recreational activities, including canoeing, kayaking, and paddle boarding take place close to shore, in sheltered waters, and predominantly within one mile of the coastline. These activities are likely only occur along the OECC, in areas close to shore, and not within the WDA.

Recreational fishing vessels operate from nearly every harbor in the Project Region; in addition, ramp-launched vessels are brought to the Project Region from other parts of New England. Although recreational fishing occurs on a year-round basis throughout the Project Region, the intensity of recreational fishing increases substantially as the weather warms. The timing of migratory species' "run" through the Project Region often dictates the intensity of recreational fishing activity, although offshore fishing is much less variable than surfcasting and nearshore fishing from small boats.

BOEM estimates that, of the nearly two million angler trips occurring in Massachusetts in between 2007 and 2012, approximately 4.4% of those angler trips occurred within one mile of the Massachusetts Wind Energy Area ("MA WEA") (Kirkpatrick et al., 2017). Substantially fewer numbers of angler trips originating in New York and Rhode Islands occurred within one mile of the MA WEA. During that same time period, recreational angler trips occurring within one mile of the MA WEA most frequently originated from Tisbury, Nantucket, and Falmouth Harbors; while fewer than 600 angler trips originated from Rhode Island (Kirkpatrick et al., 2017).

Saltwater fishing tournaments are also frequently held during the summer months in waters throughout the Project Region. Rhode Island and Massachusetts-based organizations sponsor upward of 60 fishing tournaments each year. The tournaments target a variety of different species (e.g., cod, Black Sea Bass [*Centropristis* striata], Bluefish [*Pomatomus saltatrix*], Striped Bass [*Morone saxatilis*], Haddock [*Melanogrammus aeglefinus*], tuna, and fluke) (RI Ocean SAMP 2011; NROC 2015).

The following sections describe with additional detail, recreational activities occurring within the Project Region.

7.5.1.1 Massachusetts

Barnstable County (Cape Cod)

Detailed descriptions of Barnstable County can be found in Sections 7.1.1.2.1. For convenience, this section briefly summarizes some of the relevant tourism and recreational information.

Barnstable County, located in southeastern Massachusetts, is comprised of the entirety of Cape Cod. Much of Barnstable County's 885 kilometer ("km") (550 mile ["mi"]) coastline is sandy beach that is ideal for beach going, walking, snorkeling, windsurfing, and at certain beaches, surfing. The County has more than 150 public beaches, several more private beaches, and limited access coastal areas. There are approximately 30 harbors, 40 marinas and boatyards, and approximately two dozen private boating and yacht clubs in the County (USFWS, 2011; NPS, 2011).

Based on the most recent Census Bureau data available, Barnstable County's recreation and tourism sectors are supported by an estimated 274 facilities offering accommodations. In 2012, these facilities collectively generated nearly $300 million in annual revenue. The County has approximately 869 food and drink establishments generating over $700 million in annual sales. Approximately 31.9% of all residential units in Barnstable County are for seasonal, occupational, or occasional use (US Census Bureau, 2010).

Bristol County ("mainland" county, centered around New Bedford)

Detailed descriptions of Bristol County can be found in Sections 7.1.1.2.2. For convenience, this section briefly summarizes some of the relevant tourism and recreational information.

Bristol County is located on the mainland of southeastern Massachusetts, to the west of Cape Cod. Bristol County's coastline is comprised largely of two bays: Mount Hope Bay, in the upper reaches of Narragansett Bay and extending into the Taunton River, and Buzzard's Bay. The County has five public beaches, two harbors, approximately 20 marinas/boatyards, and five yacht clubs. The County has approximately 12 public boat launch facilities providing access to coastal waters. There are no nationally protected refuges in the County, although the New Bedford Whaling National Historical Park encompasses 34 acres over 14 city blocks in the vicinity of the New Bedford Terminal (USFWS, 2012; NPS, 2012).

Bristol County's recreation and tourism sectors are supported by an estimated 48 lodging facilities offering short-term accommodations. In 2015, these facilities collectively generated over $60 million in annual revenue. The County has approximately 1,193 food and drink establishments generating over $908 million in annual sales. (US Census Bureau, 2016).

Dukes County (Martha's Vineyard and adjoining small islands)

Detailed descriptions of Dukes County can be found in Sections 7.1.1.2.3. For convenience, this section briefly summarizes some of the relevant tourism and recreational information.

Dukes County, off the south coast of Massachusetts has approximately 241 km (150 mi) of coastline consisting almost entirely remote, sandy beaches. Dukes County has approximately 15 large public beaches, but on the Dukes County's largest island, Martha's Vineyard, much of the coast is private access only. There are five harbors, two marinas, and three yacht clubs in Dukes County. The County also has six public boat launch facilities providing access to coastal waters. Dukes County's only nationally protected land is on Noman's Land Island National Wildlife Refuge (ICF Incorporated, 2012). However, nearly a quarter, or approximately 81 square kilometers (20,000 acres), of Martha's Vineyard, is conserved open space, which includes substantial recreational area.

Dukes County's recreation and tourism sectors are supported by an estimated 31 facilities offering lodging, including hotels, motels, inns, and bed and breakfast establishments. In 2015, these facilities collectively generated over $36 million in annual revenue. The County has approximately 107 food and drink establishments generating nearly $84 million in annual sales. Approximately 53.4% of all residential in Dukes County are for seasonal, occupational, or occasional use (US Census Bureau, 2010).

Nantucket County

Detailed descriptions of Nantucket County can be found in Sections 7.1.1.2.4. For convenience, this section briefly summarizes some of the relevant tourism and recreational information.

The island of Nantucket has approximately 177 km (110 mi) of shoreline, of which approximately 129 km (80 mi) is sandy beach open to the public. The Nantucket Wildlife Refuge accounts for 24 acres of nationally-protected land and is the only national refuge on the island. Nantucket's two main harbors, Nantucket Harbor and Madaket Harbor, are both popular seasonal destinations for recreational vessels. The Island of Nantucket has two yacht clubs and multiple marinas. (ICF Incorporated, 2012.) Nantucket also offers two public access boat ramps in Madaket Harbor.

Nantucket County's recreation and tourism sectors are supported by an estimated 28 facilities offering lodging. In 2015, these facilities collectively generated over $31 million in annual revenue. The County has approximately 83 food and drink establishments generating over $88 million in annual sales. Approximately 56% of all residential units in Nantucket County are for seasonal, occupational, or occasional use (US Census Bureau, 2010).

7.5.1.2 Rhode Island

Providence County

Detailed descriptions of Providence County can be found in Sections 7.1.1.3.1 For convenience, this section briefly summarizes some of the relevant tourism and recreational information.

Based on the most recent Census Bureau data available, Providence County's recreation and tourism sectors are supported by an estimated 36 facilities offering accommodations. In 2012, these facilities collectively generated in excess of $126 million in revenue. Providence County has approximately 1,527 food and drink establishments generating over $1.1 billion in sales. Approximately 0.4% of all residential units in Providence County are for seasonal, occupational, or occasional use (US Census Bureau, 2016).

Washington County

Detailed descriptions of Washington County can be found in Sections 7.1.1.3.2. For convenience, this section briefly summarizes some of the relevant tourism and recreational information.

Based on the most recent Census Bureau data available, Washington County's recreation and tourism sectors are supported by an estimated 80 facilities offering accommodations. Washington County has approximately 381 food and drink establishments. Collectively, Washington County accommodation facilities and food and drink establishments generated $342 million in sales in 2012. Approximately 14.3% of all residential units in Washington County are for seasonal, occupational, or occasional use (US Census Bureau, 2016).

7.5.2 Potential Impacts of the Project

The potential impact-producing factors as they relate to specific Project elements are presented in Table 7.5-1, below. The majority of impact-producing factors identified in Table 7.5-1 will occur in the Massachusetts communities of Dukes County, Nantucket County, and Barnstable County. These impacts are largely associated with the siting of WTGs well offshore of those coastal counties and with the temporary impacts in proximity to the Export Cable Corridor and other onshore facilities. Local expenditures by Vineyard Wind's workforce, include housing and accommodations by the limited number of non-local workers, and other impacts may occur in the vicinity of the port(s) selected for construction and installation activities.

Table 7.5-1 Impact-producing Factors for Recreation and Tourism

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommissioning
Cable installation	X	X	x		
Dredging		X	x		
Increased vessel traffic	X	X	X	X	x
HDD		X	X		
Utility Duct Construction			x		
WTGs (Visual)	X		X	X	
Local Expenditures by Vineyard Wind Workforce			X	X	X
Housing & Accommodations			X	X	
Equipment Operations		X	X	X	X

7.5.2.1 Construction and Installation

As described in Volume I, Project components will be installed in the onshore and offshore environments. In the onshore environment, there will be installation of new utility duct bank located beneath and along public rights-of-way from the offshore export cable Landfall Site to the general vicinity of the Barnstable Switching Station. A section of existing rail right-of-way ("ROW") and a segment of existing utility ROW may be used for a portion of the route as well. Horizontal directional drilling ("HDD") operations and other construction activity will also occur at the Landfall Site.

In the WDA, located well offshore, wind turbine generators ("WTGs"), inter-array and inter-link cables, and up to four electrical service platforms ("ESPs") will be installed as part of an ~800 megawatt Project. Construction and installation activities will also occur along the OECC.

7.5.2.1.1 Impacts to Recreational Resources

As described in Section 1.5.3 of Volume I, Vineyard Wind will not conduct activities along the onshore transmission route within public roadway layouts from Memorial Day through Labor Day unless authorized by the host town; such work could extend through June 15 subject to consent from the local Department of Public Works (DPW). A Traffic Management Plan will be developed so as to minimize disruptions to residences and commercial establishments in the vicinity of construction and installation activities.

At each potential Landfall Site, the proposed HDD operations, which are described in Section 4.2.3.8 of Volume I, may cause temporary conflicts with pedestrian access to limited areas of the Landfall Site, though any such conflicts would be limited to the very short period of HDD activities.

The Project will also establish Operations and Maintenance Facilities ("O&M Facilities") in Vineyard Haven on Martha's Vineyard. Any impacts to recreational resources associated with the O&M Facilities are anticipated to be negligible, consistent with other marine construction activities, and limited to the construction period of that facility. As noted in Section 3.2.6 of Volume I, site-specific modifications will likely be performed by the site owner/lessor in order to meet Vineyard Wind's requirements for its O&M Facilities.

7.5.2.1.2 Impacts to Recreational Boating and Fishing

The majority of recreational boating in the Project Region occurs within 5.5 km (3 nautical miles ["nm"]) of shore and within state waters (NROC, 2012). Although recreational boaters may transit the WDA, there are no known concentrated navigational routes of any significance in proximity to the WDA. Potential routes of offshore long-distance sailboat races could transit the WDA; however, the preferred vessel routing during those events varies based on weather, tide, and other variables. Navigation and vessel traffic are further discussed in Section 7.8 and Appendix III-I.

The entire near-coastal region and numerous offshore locations within the Project Region may host species targeted by recreational fishermen. Recreational fishing activities have been reported to occur in portions the MA WEA, notably at "The Dump," the approximately 259 km^2 (100 mi^2) Dumping Area identified on National Oceanic and Atmospheric Administration charts near the southerly end of the MAWEA. The Dump, along with "The Owl" and other areas along the 20 fathom line, as well as "The Star" and "Gordon's Gully" along the 30 fathom line, are popular locations for vessels targeting highly migratory and other recreational species. Both the 20 and 30 fathom lines cross the WDA from west to east. Along the OECC, numerous shoals and other structure provide productive fishing grounds for the recreational fishing industry.

Construction activities may affect recreational fishing activities. Potential water quality, noise, and other impacts as they may relate to species targeted by recreational fishing vessels are described in Section 6.6. The proximity of the WDA and OECC to numerous productive recreational fishing areas suggests that the highly localized impacts of construction and installation activities will have only minimal impacts to recreational species. Shore-based fishing activities at the Landfall Site may be temporarily displaced during the construction and installation phase.

Vessel traffic associated with the Project is not anticipated to represent a significant increase over the current levels of vessel traffic within the Project Region. Large draft vessels delivering components to the Project Region and installation vessels servicing the WDA and along the OECC may cause navigation impacts around confined navigation channels and turning basins, particularly at the entrance to the New Bedford Harbor and at the Hurricane Barrier, for example. Increased vessel traffic may occur through inshore traffic zones and any traffic separation scheme along the selected route to the WDA. Accordingly, the construction and installation phase may result in temporary, minimal impacts to recreational boating activities in the Offshore Project Area. Similarly, increased vessel traffic to and from the WDA may cause negligible impacts to recreational boating activities during the construction and installation phase.

When construction and installation vessels are on station in the WDA and along the OECC, temporary impacts to recreational boating and fishing activities in the immediate vicinity of those vessels may occur. Cable installation within or near areas of restricted navigation, or in close proximity to obstructions, may require additional temporary safety measures.

Noise from construction and installation activities, including pile driving, and low-intensity noise from drilling, dredging, or increased vessel traffic may lead to recreationally targeted species being temporarily displaced from the immediate vicinity of the construction and installation activities (Kirkpatrick et al., 2017). Any species affected by construction and installation activities are anticipated to return to the area soon after construction and installation noises cease (Bergstrom, 2014).

7.5.2.1.3 Avoidance, Minimization, and Mitigation Measures

Vineyard Wind's onshore construction schedule minimizes impacts to recreational uses and tourism-related activities during peak summer months and other times when demands on these resources are elevated.

To minimize hazards to navigation, all Project-related vessels, equipment, and appurtenances will display the required navigation lighting and day shapes. Notices to mariners will be distributed by Vineyard Wind to notify recreational and commercial vessels of their intended operations to/from and within the WDA.

Mitigation of potential water quality and other impacts as they may relate to species targeted by recreational fishing vessels are described in Section 6.6.

Finally, as noted in Section 7.1.2.1.3 above, and elsewhere, Vineyard Wind will implement a comprehensive communications plan to keep the relevant parties informed throughout this phase of the Project. A draft of the Fisheries Communication Plan is included as Appendix III-E.

7.5.2.2 Operations and Maintenance

Following the completion of construction and Project commissioning, impacts from operation and maintenance of the Project on recreational resources will be negligible. The Project's onshore and offshore cable system, onshore substation, WTGs and ESPs in the WDA will be monitored and controlled remotely from the Project's O&M Facilities, which will be staffed by the necessary personnel, including managers, engineers, technicians, and support personnel. In the event that monitors determine a repair is necessary, a crew would be dispatched to the identified location to complete repairs and restore normal operations.

7.5.2.2.1 Impacts to Recreational Resources

Vineyard Wind is not proposing any vessel exclusions around the WTGs or other areas of the Project during the operations and maintenance phase. As noted in Section 7.5.2.1.2, impacts to recreational boating, including offshore sailboat races, are anticipated to be negligible. The WTGs will also provide additional aids to navigation.

The WDA may provide additional recreational opportunities, as a study of Delaware beachgoers found that 45% of respondents would likely take a tour boat to see an offshore wind facility (Lilley et al., 2010). Hy-Line Cruises, based in Hyannis, had expressed interest in operating sightseeing vessels to other offshore projects with the expectation that such facilities will be popular tourist destinations (Cape Cod Times, 2011). As noted in Section 7.1.2.2.2, vessel and sightseeing operators may provide excursions to the WDA.

The operations and maintenance phase would involve the new infrastructure in the WDA as well as onshore facilities. As noted above, however, Vineyard Wind is not proposing to limit access to the WDA, and recreational and tourism activities in the WDA should not be affected.

Alterations to local aesthetics, important factors in attracting tourists to a coastal area, will not be altered by the operations and maintenance of the Project (BOEM, 2012). WTGs, particularly during the summer months, will be difficult to see from the shoreline of coastal communities in the Project Region, and are expected to not impact onshore and near shore recreational resources.

7.5.2.2.2 Impacts to Recreational Boating and Fisheries

Operations and maintenance of the Project may provide modest, positive impacts to recreational fisheries. By providing additional structure for species that prefer hard, complex bottoms, the WTGs may function as fish aggregating devices (BOEM, 2012) and provide additional habitat for certain species. Based on the intensity of recreational fishing within the WDA and its geographic scale, neither congestion effects nor gear conflicts are expected, in the event that WTGs aggregate recreationally targeted species.

Navigation through the WDA, particularly for smaller vessels, should not be impacted.

7.5.2.2.3 Avoidance, Minimization, and Mitigation Measures

Impacts associated with scheduled, periodic maintenance activities during the operations and maintenance phase will be adequately minimized or mitigated through the implementation of best management practices ("BMP") when practicable.

To aid mariners navigating the WDA, WTGs and ESP will be lit, marked, and maintained as Private Aids to Navigation in accordance with International Association of Lighthouse Authorities ("IALA") Guidance for the marking of man-made offshore structures (IALA Recommendation O-139, edition 2, 2013), and US Coast Guard approval.

During the operations and maintenance phase, WTG and ESP foundations may become popular fishing locations, and recreational fishing activities may increase. Anglers' interest in visiting the WDA may also lead to an increased number of fishing trips out of nearby ports which could support an increase in angler expenditures at local bait shops, gas stations, and other shore side dependents (Kirkpatrick et al., 2017).

7.5.2.3 Decommissioning

As described in Section 4.4.3 of Volume I, no decommissioning work is planned for the Project's onshore facilities, although removal of Project cables via existing manholes may occur if required. The splice vaults, duct bank, and onshore substation will likely remain as valuable infrastructure that would be available for future offshore wind projects developed within the Vineyard Wind Lease Area or elsewhere.

Decommissioning of the offshore components, described in Section 4.4 of Volume I, include removal of WTG and ESP pile foundations and cables within the WDA and OECC. Impacts from these activities will be similar to those associated with construction.

The O&M Facilities can be easily repurposed for continued use by Vineyard Wind or another site operator. Decommissioning of the offshore components is described in Section 4.4 of Volume I.

7.5.2.3.1 Impacts to Recreational Resources

During the decommissioning phase, vessel operations will increase in the area surrounding the New Bedford Terminal, navigational channels, inshore traffic zones and any traffic separation scheme along the selected route to the WDA.

7.5.2.3.2 Impacts to Recreational Fisheries

During the decommissioning phase, vessel operations will increase in the WDA and along the selected route to and from the WDA.

Potential water quality impacts as they may relate to species targeted by recreational fishing vessels are described in Section 6.6.

7.5.2.3.3 Avoidance, Minimization, and Mitigation Measures

As noted in Section 7.1.2.1.3 above, and elsewhere, Vineyard Wind will implement a comprehensive communications plan to keep the relevant parties informed throughout this phase of the Project. All Project-related vessels, equipment, and appurtenances will display the required navigation lighting and day shapes. A Notice to Mariners will be distributed by Vineyard Wind to notify recreational and commercial vessels of their intended operations to/from and within the WDA.

Mitigation of potential water quality and other impacts as they may relate to species targeted by recreational fishing vessels are described in Section 6.6.

7.6 Commercial Fisheries and For Hire Recreational Fishing

Commercial and for-hire recreational fishing are vital economic activities that take place in state and federal waters off the south coast of Massachusetts, Cape Cod and the Islands; and off the coast of Rhode Island, Connecticut, and the eastern Long Island region of New York. For purposes of describing commercial and for-hire regional fisheries and assessing potential fishery-related economic impacts of the Project, this area is referred to as the "Project Region." The Project Region also includes an important and growing aquaculture industry which is focused primarily on shellfish, and is currently located along the south coast of Massachusetts.

This section describes commercial and for-hire recreational fishing activities within the Project Region, within the MA-WEA, and within the WDA. It also develops estimates of potential economic impacts on these fisheries from Project activities during construction and installation, operation and maintenance, and decommissioning. These estimates of economic impacts are based primarily on how the Project is expected to impact fish resources, as described in Section 6.5 (benthic resources) and Section 6.6 (finfish and invertebrates), and how it is expected to impact fishing activity, as described in Section 4.1.7 of the Vineyard Wind Navigational Risk Assessment (Appendix III-I). Economic impact estimates were also based on Vineyard Wind's extensive outreach and engagement with the commercial fishing industry, which includes interviews with fishermen and meetings with groups of fishermen who operate in and near the Project Region, and supplemental fishing data and fishing information provided by fishermen.

This section has five main parts.

- Section 7.6.1 provides an overview of fishing fleets, fishing ports, fishing activity, and the value of fish harvested in the project area, and outlines how state and federal regulations affect fishing in the project area.

- Section 7.6.2 presents baseline "without project" estimates of the economic value of fishing activity in the project region, within the MA WEA and within the WDA. These values represent the economic "exposure" or potential economic impact of development in these areas.

  It also describes sources of data that were used to develop baseline economic values. These include maps of fishing activity based on Vessel Monitoring System (VMS), Vessel Trip Reports (VTRs), and landings databases maintained by the Northeast Regional Ocean Council (NROC) and the Mid-Atlantic Council on the Ocean (MARCO); estimates of the baseline economic value of commercial fisheries in the MA-WEA presented in a recent study by BOEM (Kirkpatrick, et. al. 2017); and baseline economic values of commercial fishing in the Vineyard Wind Lease Area that were presented in a recent study by the Rhode Island Department of Environmental Management (DEM [Livermore, 2017]). Baseline estimates of fishing values were modified and refined based on individual interviews and group meetings with commercial fishers and supplemental fishing data provided by them.

- Section 7.6.3 describes the approach that was used to estimate "with project" economic values associated with fishing activities within the WDA and to determine potential fishery-related impacts of the WDA. The approach used was a conventional application of fishery economic methods which aims to trace two separate pathways by which changes in fishing conditions affect fishing trip performance and generate economic impacts. The first pathway involves changes in fish resources which, for purposes of fishery economic analysis, are best characterized in terms of changes in the abundance, availability, and catchability of various fish species. Section 6.5, Benthic Resources, and Section 6.6, Finfish and Invertebrates, provided the basis for this analysis. The second impact pathway involves Project-related activities within the WDA that may change the level or allocation of fishing effort; in particular, changes that increase steaming, searching, or idle time or otherwise reduce fishing time, or require more time fishing in less productive or less familiar waters. Section 4.1.7 of Appendix III-I and interviews with fishermen provided the basis for assessing this pathway of potential economic impacts.

- Section 7.6.4 summarizes results of the analysis and presents "sensitivity" tests which show how fishery-related economic impact estimates respond to worst-case assumptions (e.g., higher than average fish abundance in the WDA when it is closed to fishing) as opposed to assumptions based on expected conditions (e.g., typical fish abundance in the WDA which is not closed to fishing). This section also presents information to help interpret the extent of potential economic impacts associated with disruptions in certain fishing conventions within the WDA that were identified by fishermen, such as the need for vessels to make straight east-west tows when trawling for squid and "gentlemen's agreements" between mobile and fixed gear fishers which are used to prevent space/use conflicts and gear loss.

- Section 7.6.5 discusses for-hire recreational fishing within the Offshore Project Area.

To provide context for interpreting results of the analysis presented in Section 7.6.2 through 7.6.4, it is useful to consider the relative size of the WDA with respect to the MA WEA, and the proximity of the WDA to important fishing ports and fishing areas. The Vineyard Wind Lease Area occupies 22.5 percent of the MA WEA and the WDA, which represents 45.3 percent of the Lease Area, accounts for 10.2 percent of the MA WEA. This is relevant because the BOEM fisheries study (Kirkpatrick, 2017) estimated the average annual value of fish taken in the MA WEA during 2007-2012 to be $3.03 million and the DEM fisheries study (Livermore, 2017) estimated the average annual value of fish taken in the Lease Area during 2011-2016 to be $0.858 million. That is 28.3 percent of Kirkpatrick's (2017) harvest value estimate for the MA WEA which was based on data for a few years earlier. Accounting for differences in the sample years the results of the two studies validate one another and indicate that the economic value of fishing is fairly uniformly distributed across the MA WEA at $1,000 to $1,200 per km^2 with the average value of annual catches from the WDA during 2011-2016 estimated to total $348,450.

Additionally, the estimated value of fishery exposure within the MA WEA and/or WDA does not reflect fishermen income from fishing in the WDA because estimated exposure does not account for fishing costs. By some estimates, including that of NOAA's Fisherman's Contingency Fund Program, fishing costs may be approximately 50 percent of landed value. Applying such an estimate to aid in valuing potential income from landings harvested in the WDA suggests that approximately half of estimated fishery exposure described below might be considered loss of income should vessels elect to not fish within the WDA.

7.6.1 Description of the Affected Environment

This section provides an overview of fishing fleets, fishing ports, fishing activity, and the value of fish harvested in the project area, and outlines how state and federal regulations affect fishing in the project area. Landings data is largely sourced from NOAA's Fisheries Statistics Division and the Atlantic Coastal Cooperative Statistics Program's (ACCSP) "data warehouse."

7.6.1.1 Massachusetts Commercial Fishing Ports

Data from the NMFS Fisheries Statistics Division identify several important commercial fishing ports within the Project Region, including ports in Massachusetts, as some of the most valuable in the US. Although the highest revenue producing fishery in the Project Region is the scallop fishery, largely landed at the Port of New Bedford, other species are important to Massachusetts's commercial fishing fleets. Prominent among the Massachusetts fisheries are sea scallop, lobster, oyster, surf clam, haddock, and monkfish; each of these fisheries consistently exceed ten million dollars in landed value each year. Massachusetts' Jonah crab fishery exceeded $10 million in landed value for the first time in 2017.

According to NMFS data, the two most valuable Massachusetts fisheries are the sea scallop and lobster fisheries. Each year since 2007, the sea scallop fishery has landed an average of 28.9 million pounds, worth an annual average of approximately $276 million. Over the same period of time, the state's second most valuable fishery, the lobster fishery, landed an annual average of approximately $61 million.

Port of New Bedford

The Port of New Bedford is home to a commercial fleet of an estimated 500 commercial fishing vessels, including approximately 238 federally permitted vessels in 2017. New Bedford has a well-established shore side economy serving the commercial fishing industry; including approximately 44 fish wholesale companies, 75 seafood processors, and another 200 related shore side industries. Maritime International, which operates in New Bedford, has one of the largest US Department of Agriculture-approved cold treatment centers on the East Coast. American Seafoods, one of the largest seafood companies in the US, has a large processing facility in New Bedford where they process primarily scallops. Northern Pelagic Group, LLC ("Norpel"), also in New Bedford, is one of the largest pelagic processing companies in the US, catching and processing both mackerel and herring with a dedicated fleet of mid-water trawlers. Eastern Fisheries, Inc. is the New Bedford-based owner and operator of the largest scallop fleet in the industry. New Bedford's auction house, Whaling City Seafood Display Auction, opened in 1994, allowing fishermen to get fair prices for their catch and providing buyers with a more predictable supply of seafood (Colburn et al., 2010).

Much of New Bedford's commercial fishing revenue comes from the sale of scallops. Commercial fishermen landed 22.8 million pounds of sea scallops in Massachusetts worth over $280 million in 2016, and the majority of this catch was landed in New Bedford. In addition to scallops, other top species landed in New Bedford include: Monkfish (Lophius americanus), Atlantic Surf Clams, Ocean Quahog, American Lobster (Homarus americanus), Skate, Mackerel, Atlantic Butterfish (Peprilus triacanthus), Summer Flounder (Paralichthys dentatus), Scup (Stenotomus chrysops), Black Sea Bass (Centropristis striata) (NOAA, 2018). In total, commercial fishermen operating from New Bedford landed over 106.6 million pounds of fish in 2016, worth an estimated $326.5 million dollars. New Bedford has consistently been the highest value-producing fishing port in the US.

Provincetown and Chatham

Combined, the commercial fishermen in the communities of Provincetown and Chatham landed over 26.5 million pounds of fish in 2016, worth an estimated $32.8 million dollars. Top species landed in Provincetown and Chatham include: American Lobster, Scallops, Skate, Monkfish, Dogfish, Summer Flounder, Scup, Black Sea Bass, Atlantic Surf Clams, and Ocean Quahog (Colburn et al., 2010).

Martha's Vineyard and Nantucket

Martha's Vineyard, and to a lesser extent, Nantucket have commercial fishing and for-hire recreational fishing fleets active in the Project Region. Traps, pot, and gillnet fishermen from the Martha's Vineyard Fishermen's Preservation Trust, and other active fishermen on Martha's Vineyard, have identified a number of active fishing locations in the Project Region.

7.6.1.1.1 Near-Shore Commercial Shellfish Resources

As noted in Section 7.6.1.1, Massachusetts cities and towns manage the shellfisheries in all waters within their boundaries that are not closed by the DMF for public health or other reasons, with the exception of the commercial harvest of Surf Clams and Ocean Quahogs that remain under state control. The OECC includes two potential Landfall Sites that may affect near-shore commercial shellfishing activities in the Towns of Yarmouth and Barnstable.

Town of Yarmouth

There are a total of seven aquaculture grants within Lewis Bay in Yarmouth. As shown on Figure 7.6-1, three aquaculture grants are located in a close group near Pine Island, and four others are located within Uncle Roberts Cove off Great Island. The Town of Yarmouth also operates two "upweller" facilities for the propagation of shellfish seed.

Lewis Bay is reportedly one of the best remaining areas where bay scallops can be effectively targeted for commercial harvest in the Project Region. There are approximately 20 licensed vessels participating in the fishery, and approximately ten of those are actively harvesting from Lewis Bay on a daily basis. The vessels participating in this fishery are typically small boats that are often launched from trailers at either Englewood Beach or the Hospital Ramp.

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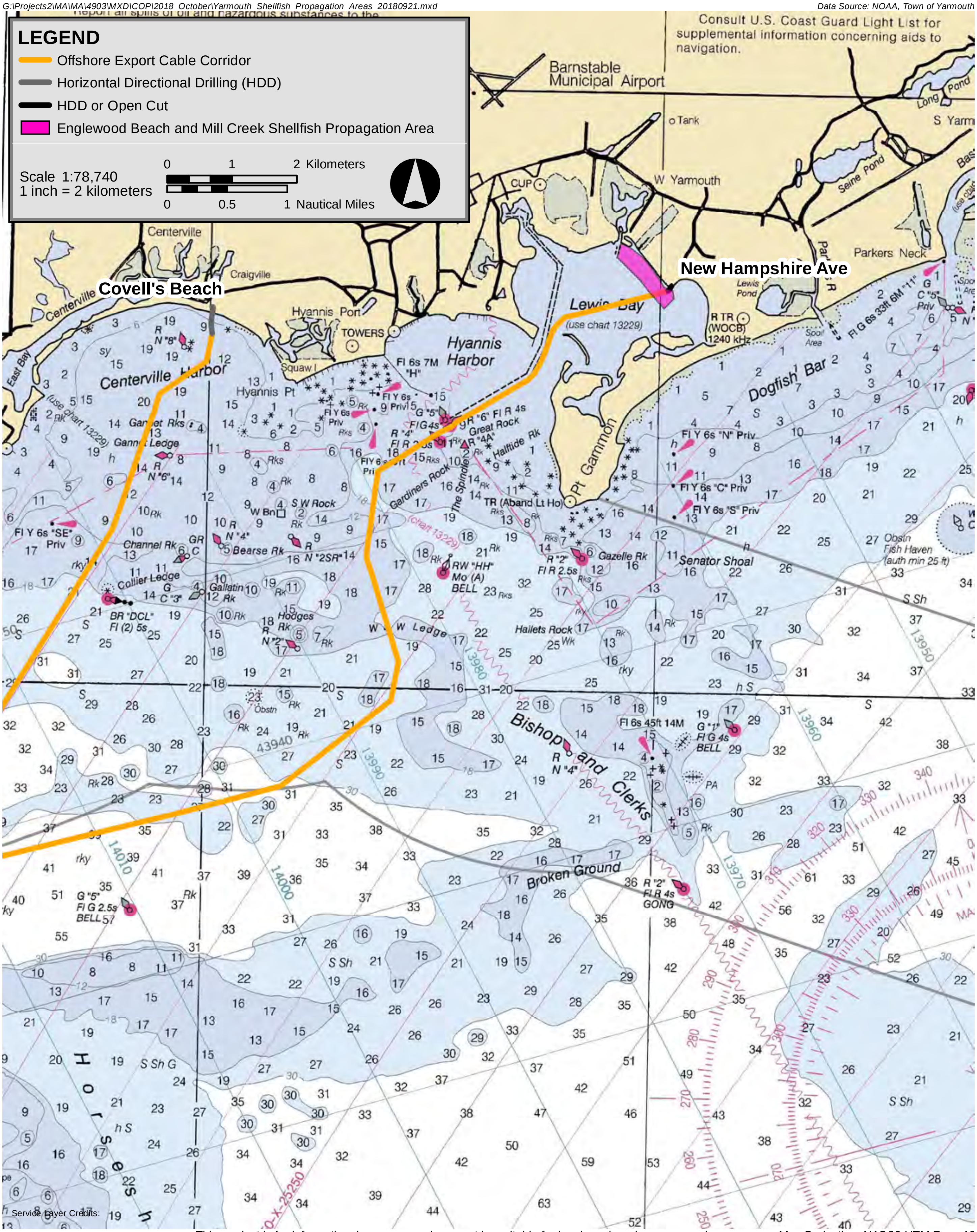
Data Source: NOAA, Town of Yarmouth



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-1

Yarmouth Shellfish Propagation Areas

The Town of Yarmouth stocks quahogs in the area located between Englewood Beach and Mill Creek to a distance of approximately 365 meters ("m") (400 yards ["yds"]) offshore, in the area of the New Hampshire Avenue Landfall Site, as shown on Figure 7.6-1. This is a put-and-take relay program whereby contaminated Quahogs from the Taunton River are transplanted to Lewis Bay and, after a sufficient depuration period, are made available for commercial and recreational harvest.

Town of Barnstable

The Town of Barnstable has an active shellfish propagation program for Quahogs, Oysters, Soft Shell Clams, and Bay Scallops. The Town's propagation programs, including the in-town and out-of-town shellfish relay programs, Quahog upwelling facility and the Oyster propagation program are credited with helping to replenish shellfish resources throughout the study area, which includes the Three Bays and the Centerville River estuarine systems and adjacent waterfront. The in-town relays take contaminated Quahogs from the Centerville River and East Bay, and relay them to West Bay, and most recently to Bay Street, Osterville. For the out-of-town relay, mildly contaminated Quahog stock from off Cape Cod locations is purchased by the Town and transplanted into the designated shellfish relay areas.

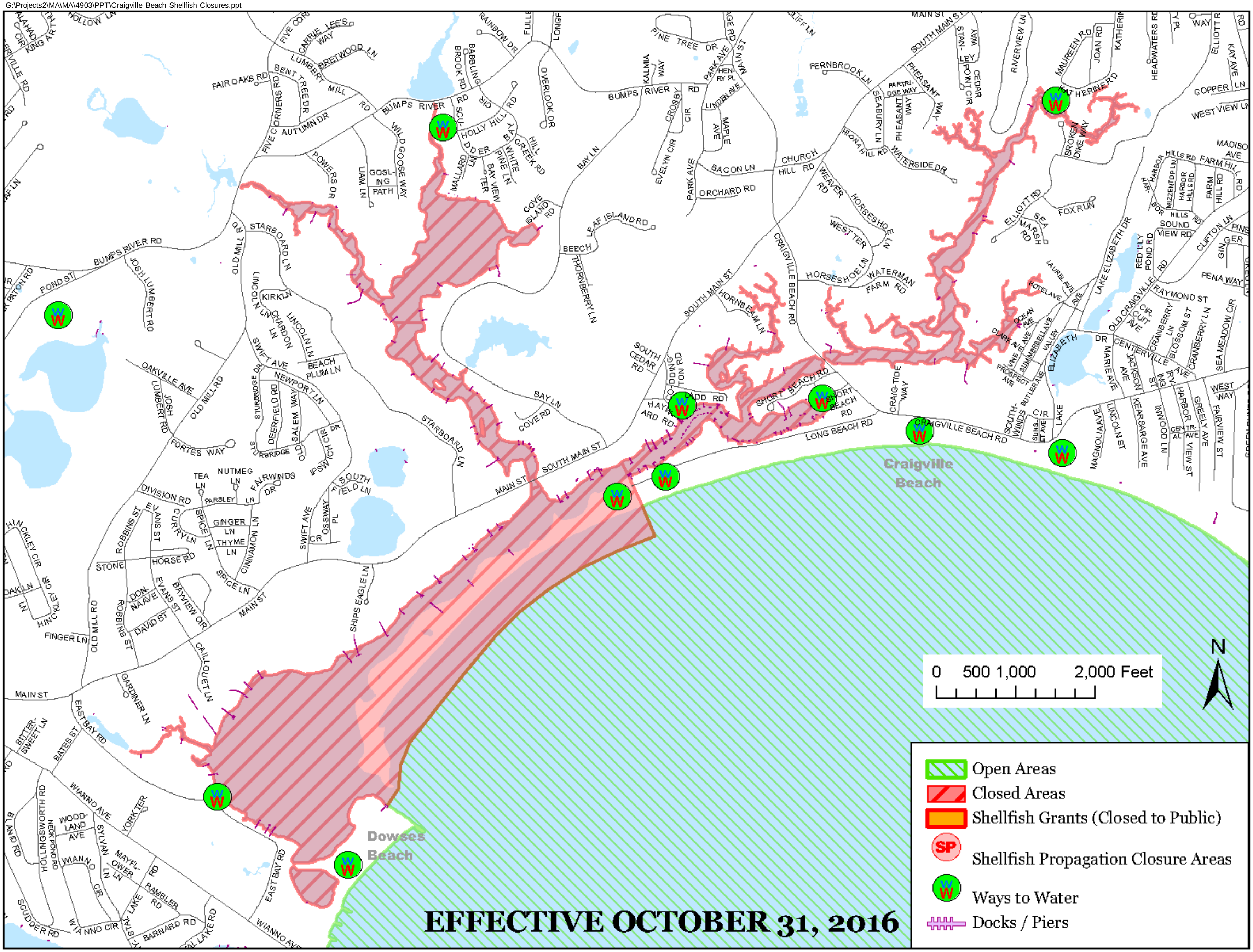
As shown on Figure 7.6-2, as of 2016, Hyannis Inner Harbor and west of the terminus of Long Beach Road along Craigville Beach, in proximity to the Covell's Beach Landfall Site, are closed to shellfishing.

7.6.1.2 Rhode Island Commercial Fishing Ports

Commercial fishermen operating in the MA WEA may also be homeported in Rhode Island. The MA WEA is relied on primarily by pot, gillnet, bottom trawl, and midwater trawl fishermen operating from Rhode Island ports. Landings from these vessels consist mainly of small mesh species (Hake, Squid, Mackerel and Butterfish), Ocean Quahogs, Skates, Monkfish, and Jonah Crab (*Cancer borealis*) (Kirkpatrick, et al., 2017). Fishermen active in the MA WEA may be operating from harbors in addition to those described below.

Point Judith and Narragansett

The Port of Galilee in Point Judith is the most active fishing port in Rhode Island, and is supported by bait shops, commercial marine suppliers, and vessel repair shops. In 2017, there were 120 federally permitted vessels with their home port in the Point Judith, 92 of which possess a federal permit in the Squid, Mackerel, Butterfish Fishery Management Plan. The Port has a number of fish processing companies that do business locally, nationally, and internationally. Point Judith's largest fish processors are the Town Dock Company, G:\Projects2\MA\MA\4903\PPT\Craigville Beach Shellfish Closures.ppt



Vineyard Wind Project

VINEYARD WIND

Figure 7.6-2

Craigville Beach Shellfish Closures

Handrigan's Seafood, and Seafreeze Shoreside. Several smaller processors are also located in the Point Judith area: Ocean State Lobster Co., Narragansett Bay Lobster Co., Fox Seafood, Osprey Seafood, Sea Fresh America, and The Local Catch Inc., a Community Supported Fishery (Colburn et al., 2010).

In 2016, Point Judith ranked 18th in landed weight, with 53.4 million pounds, and 15th, in terms of dollars landed out of all major ports in the US. In the New England Region, Point Judith ranked third in both pounds and dollar value landed (NOEP, 2017). Most of Point Judith fishing revenue comes from the sale of squid, American Lobster, Summer Flounder, Sea Scallop (*Placopecten magellanicus*), Scup, Monkfish, Silver Hake (*Merluccius bilinearis*), Jonah Crab, Atlantic Herring (*Clupea harengus*) and Yellowtail Flounder (*Limanda ferruginea*). A seasonal longline fishery for Tuna also operates out of the port (Colburn et al., 2010).

North Kingstown

The North Kingstown fishing fleet lands a wide variety of species groupings and the port has a number of commercial operations and associations involved in commercial fishing industry. Located in North Kingstown are American Mussel Harvesters, one of the Rhode Island's largest purchasers and suppliers of clams and mussels, and SeaFreeze, Ltd., which is the largest producer of sea-frozen fish on the east coast of the US and berths the two largest fishing vessels in the state, F/V Relentless and F/V Persistence. Top species harvested in port: squid, mackerel, butterfish, herring. (Colburn et al., 2010).

7.6.1.3 Connecticut Commercial Fishing Ports

Commercial fishermen operating in the MA WEA may also be homeported in Connecticut. According to Kirkpatrick, et al. (2017), the MA WEA is relied on by vessels operating from Stonington, Connecticut. However, Connecticut ports were not among the commercial fishing ports most exposed to development in the MA WEA. Kirkpatrick (2017) indicates that the less than 0.5% of Connecticut's total commercial fishing revenue, if any, would be sourced from the MA WEA. Fishermen active in the MA WEA may be operating from harbors in addition to those described below.

Stonington

Stonington is the largest fishing port in the state of Connecticut, both by pounds and value landed. Stonington vessels landed 9.0 million pounds of catch in 2016 worth $5.1 million, making Stonington the 111th most valuable port in the US. The limited data available on Stonington's commercial fishing fleet suggests it is small but diversified, and includes gillnetters, draggers, and lobster fishermen. (Colburn et al., 2010; Hall-Arbor, et al., 2001). Stonington's most valuable landings in 2014, as reported by NOAA, are Fluke, Scup, Black Sea Bass, Butterfish, Mackerel, and Squid. The commercial fishing fleet is supported by local processing facilities.

Port of New London

The New London fishing fleet is the second most productive in the State of Connecticut. New London vessels landed 2.1 million pounds of catch in 2016 worth $5.1 million, making New London the 116th most valuable port in the US. New London's most valuable landings in 2014, as reported by NOAA, are Scallops, Whiting, Butterfish, Mackerel, and Squid,

7.6.1.4 New York Commercial Fishing Ports

Commercial fishermen operating in the MA WEA may also be homeported in New York. According to Kirkpatrick (2017), the MA WEA is relied on by hand gear, longline and bottom trawl fishermen operating from New York ports, though dredge fishermen have been reported to also operate in the MA WEA. Fishermen active in the MA WEA may be operating from harbors in addition to those described below.

Montauk

The village of Montauk is the largest fishing port in the state of New York, both by pounds and value landed. Montauk landed 11.8 million pounds of catch in 2016 worth $16.3 million, making Montauk the 68rd most valuable port in the US. Kirkpatrick's (2017) analysis of the MA WEA estimated that 1.3% of Montauk's commercial fishing revenue was sourced from within the MA WEA.

Hampton Bays and Shinnecock

Hampton Bays and Shinnecock, here considered to be the same community, is New York's second largest fishing port. Shinnecock is the fishing port located in Hampton Bays, and fishermen use either port name in reporting their catch (NOAA, 2005). Combined, the Hampton Bay and Shinnecock commercial fishing fleet landed 5.2 million pounds of catch in 2016, worth $8 million. Fifty-four commercial vessels were homeported in Hampton Bays in 2006, the most recent year data available (Colburn et al., 2010). No estimate of Hampton Bays' commercial fishing revenue sourced from within the MA WEA is available, though vessels from Hampton Bays operate in the area, according to BOEM data (Kirkpatrick, 2017).

7.6.1.5 New Jersey Commercial Fishing Ports

Commercial fishermen operating in the MA WEA may also be homeported in New Jersey. According to BOEM (Kirkpatrick, 2017), the MA WEA is relied on by longline and dredge fishermen operating from Cape May and Barnegat Light, New Jersey. Fishermen active in the MA WEA may be operating from harbors in addition to those described below.

Cape May/Wildwood

The Port of Cape May/Wildwood is the largest commercial fishing port in New Jersey. The Port serves as the center of fish processing and freezing in New Jersey and has numerous shore side support and supply services. Cape May has an active trawler fleet in addition to Scallop and Sea Clam dredgers, pot boats, handliners and purse seiners (NJDA, n.d.).

In 2016, the Cape May/Wildwood commercial fishing industry landed 46.6 million pounds of fish, worth an estimated $84.7 million. Cape May's fishing industry currently generates most of its revenue from the sale of Sea Scallops, Squid, Mackerel, and Butterfish.

Top species harvested in port: Sea Scallops, Butterfish, Summer Flounder, Scup, Black Sea Bass, Atlantic Surf Clams, Ocean Quahog, American Lobster, Atlantic Herring, Monkfish (Colburn et al., 2010).

Barnegat Light

Barnegat Light is the primary commercial sea port on Long Beach Island with approximately 36 commercial boats, working year-round, as well as recreational vessels and transient vessels. Barnegat Light's two commercial docks are home to several scallop vessels, longliners, and a fleet of smaller, inshore gillnetters

The Barnegat Light commercial fishing fleet landed 7.2 million pounds of catch in 2016, worth $24.0 million. The top species harvested in Barnegate Light include: Sea Scallop, Monkfish, Swordfish (*Xiphias gladius*), Golden Tilefish (Lopholatilus chamaeleonticeps), Bluefish (*Pomatomus saltatrix*), Summer Flounder, Scup, and Black Sea Bass (Colburn et al., 2010).

7.6.1.6 Fisheries Management

Under the Magnuson-Stevens Fishery Conservation and Management Act, 16 USC. § 1801 et seq., which is the primary mechanism governing fishing in US federal waters, including the WDA, certain fish species are managed through species-specific management plans developed by eight Regional Councils. The Regional Council system allows regional, participatory governance of different fisheries by knowledgeable stakeholders. These councils develop fishery management plans ("FMPs"), which include fishing seasons, quotas, and closed areas. The Regional Councils propose rules for fishermen operating in federal waters and also address habitat issues across multiple plans. The FMPs and other measures are implemented by the National Marine Fisheries Service ("NMFS").

Within the Project Region, the New England Fisheries Management Council ("NEFMC"), the Atlantic States Marine Fisheries Commission ("ASMFC"), the Mid-Atlantic Fisheries Management Council ("MAFMC"), and the National Oceanic and Atmospheric Administration's ("NOAA") Highly Migratory Species Office manage the various fisheries.

The NEFMC is the primary council in the Project Region, and is charged with conserving and managing the fishery resources of Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut, including the Gulf of Maine and Georges Bank. The NEFMC overlaps with the Mid-Atlantic Council for some species harvested in the New England Region.

The ASMFC has coordinated interstate management of the lobster fishery from zero to three miles offshore since 1996. The management unit includes all coastal migratory stocks between Maine and Virginia. American Lobster is currently managed under Amendment 3 and Addenda I-XXIV to the Fishery Management Plan. Three separate stocks of lobsters are managed: the Gulf of Maine, Georges Bank, and Southern New England, with each stock further divided into seven management areas. The WDA is within Area 2 of the Southern New England Stock.

The Massachusetts Division of Marine Fisheries ("DMF") and the Rhode Island Department of Environmental Management ("DEM") oversee commercial fishing within their respective state waters. DMF maintains the sole authority for the opening and closing of areas for the taking of any and all types of fish in state waters. In the Massachusetts Ocean Management Plan (2015), areas of "high commercial fishing effort and value" within state waters were identified, including portions of the Project Region; notably, within Nantucket and Vineyard Sounds, as shown on Figure 7.6-3.

In Massachusetts, cities and towns manage the shellfisheries in all waters within their boundaries that are not closed by the DMF for public health or other reasons, with the exception of the commercial harvest of Atlantic Surf Clams (*Spisula solidissima*) and Ocean Quahogs (*Artica islandica*) that remain under state control.

7.6.2 Baseline "Without Project" Economic Value of Fishing Activity

Following sections present baseline "without project" estimates of the economic value of fishing activity in the Project Region, within the MA WEA, and within the WDA. These values represent the economic "exposure" or potential economic impact of WDA development in these areas.

7.6.2.1 Commercial Fishing Data Sources

Several data sources and reports provide information on commercial fishing activities within the Project Region, the MA WEA, and the WDA. The following section describes the different data sources and reports compiled for the COP, the sources of that data, and the geographic area for which the data is available.

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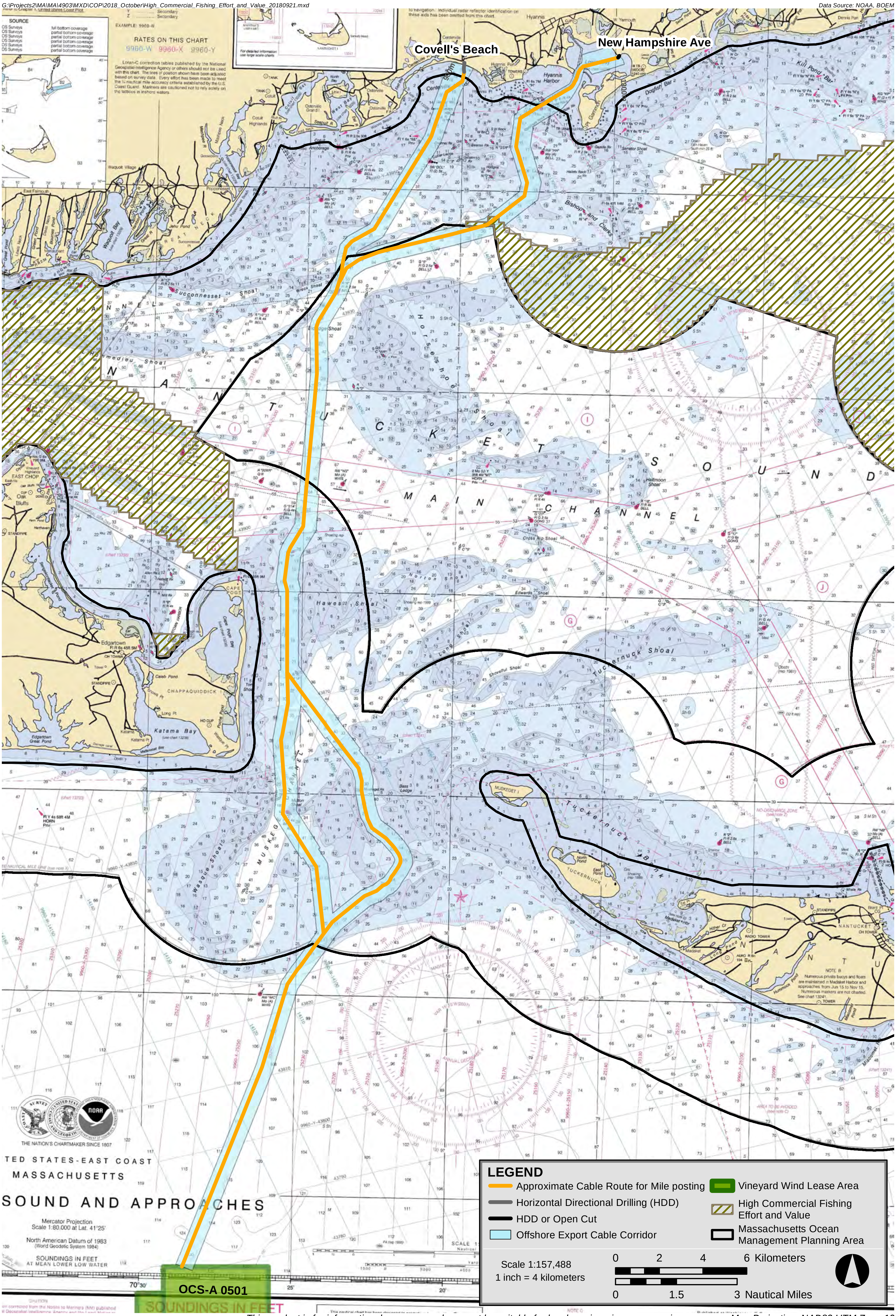
Data Source: NOAA, BOEM



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-3

Massachusetts Ocean Management Plan, High Commercial Fishing Effort and Value

Vessel Monitoring Systems (VMS) Data

Both the Northeast Regional Ocean Council (NROC) and the Mid-Atlantic Regional Council on the Ocean (MARCO) maintain a suite of databases and maps of the ocean ecosystem and ocean-related human activities, including commercial fishing.

The NROC and MARCO commercial fishing datasets and associated mapping of those datasets characterize the density of commercial fishing vessel activity for seven fisheries[19] in the northeast and mid-Atlantic regions of the US based on VMS data for the years 2006 to 2016. MARCO makes available NROC's VMS-based mapping products through their Mid-Atlantic Ocean Data Port, where the VMS data is provided by NMFS. NMFS describes VMS as a satellite-based system primarily used to monitor the location and movement of commercial fishing vessels active in certain fisheries in the Project Region.

VMS data provided to NROC by NMFS contains the day, month, and year; the geographic coordinates of the vessel at the time of transmission; speed over ground; and the vessel's declaration code, which may signify fishery plan, program within that plan, and associated area identifier or gear-type information. VMS data are subject to strict confidentiality restrictions. Therefore, the maps produced by NROC[20] depict the density of vessel locations following the removal of individually identifiable vessel positions. The process of removing confidential vessel locations follow the "rule of three" mandated by NMFS Office of Law Enforcement (OLE) by using a screening grid to identify which grid cells contained three or more VMS records. Per the rule of three, any record within a cell that contain fewer than three VMS records has been eliminated from the analysis.

In order to more likely identify active fishing rather than fishing vessels transiting the WDA, certain figures below characterize VMS data from vessels operating at or below a vessel speed consistent with gear deployment for that fishery. According to NROC, the speed thresholds were vetted through engagement with fishermen in each fishery. Although transformation of the VMS data expands the fine scale footprint of the more precise VMS data points, it provides visually informative results (Shmookler, 2015). The resulting density grids represent a "heat map" of the vessel activity which indicate a relative level of vessel presence and spatially represent specific fisheries over specific timespans.

Characterizing fishing effort with VMS data is also complicated by the fact that VMS is not required for all fishermen in some fisheries. For example, the Monkfish fishery has different requirements for vessels operating in the Southern Fishery Management area than for those vessels operating in the Northern Fishery Management Area. Moreover, fisheries oversight

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19 The fisheries include Multispecies, Monkfish, Herring, Scallop, Surfclam/Ocean Quahog, Pelagics (Herring/Squid/Mackerel), and Squid.

20 Analysis of the VMS data was performed by Applied Science Associates, Inc. ("RPS ASA") on behalf of NROC.

and management measures that affect the characterization of commercial fishing density are not static and are anticipated to be altered over time. Changes to fisheries as a result of oversight and management, fish distribution patterns, or environmental factors should be anticipated (Battista, et. al, 2013).

Vessel Trip Report (VTR) Data

MARCO[21] also produces a commercial fishing data visualization product using VTRs. Operators of NOAA Fisheries Greater Atlantic Region permitted vessels are required to submit a VTR for every fishing trip regardless of where the fishing occurs or what species are targeted, with the exception of those vessels that possess only a lobster permit. VTRs provide information on when and where catch occurred and each report includes the trip date, number of crew on board the vessel, species and quantities caught, and the trip location. Vessel permit data additionally includes a vessel's "principal port" as well as other variables describing the vessel itself (e.g. length, horsepower, and age).

VTR, however, only requires that fishermen report a single geographic position (point location) each fishing trip unless they switch to a new gear type or move into a new statistical reporting area. As a result, mapping of fixed gear fishing activity may be more accurate than mapping of mobile fishing gear, and mapping of single day trips may be more accurate than mapping of multi-day trips. VTR reporting requires that fishermen record the position where the majority of fishing occurred but because a new VTR is necessary only when gear type changes or fishing occurs in a new statistical areas, multiple tows within the same statistical area using the same gear will likely be assigned only a single point location, which may not necessarily represent the actual location of fishing activity.

MARCO's VTR-based maps characterize both fixed and mobile gear fisheries within the Project Region using trip location point data as inputs to create density polygons representing vessel visitation frequency. The VTR-based maps depict total labor including crew time and the time spent in transit to and from fishing locations. According to MARCO, VTR data were aggregated to the "community" level and none of the resultant maps represent a fishing area of any individual fisherman or fishing vessel.

When accessed through MARCO's Mid-Atlantic Ocean Data Portal, querying any single location on the VTR maps will display, for example, the various port communities that have recorded a significant level of fishing activity at that location. According to MARCO, drafts of the maps were reviewed with diverse fishermen and fishing industry managers throughout the Mid-Atlantic and New England states, including at Mid-Atlantic Fishery

[21] MARCO obtained VTR data from NOAA NMFS Northeast Fisheries Science Center, with methodology, data processing, and cartography provided by staff at the Center for Remote Sensing and Spatial Analysis (CRSSA) at Rutgers University.

Management Council and New England Fishery Management Council meetings. MARCO also notes that overlay comparison of their VTR based maps with VMS based maps reveals substantial agreement between the two, and the VMS maps provide additional useful precision for fisheries where both VTR and VMS data are available.

Landings Data

The NOAA Fisheries Statistics Division maintains a publicly accessible automated data summary program of US commercial fisheries landings. The data summary program can be queried for commercial landings in several formats, including pounds and dollar value of commercial landings by years, months, states and species for the years 1990 onwards.

The ACCSP also maintains a publicly accessible data warehouse of Atlantic coast fishery-dependent data supplied by the ACCSP's program partners. ACCSP's data warehouse includes commercial landings data which include state and federal landings submitted by both dealers and fishermen.

Vessels with Massachusetts Commercial Permits are required to submit monthly "Trip-level" reports for commercial landings. Permits with federal reporting requirements are exempt from reporting to DMF. Certain non-confidential landings data reported to DMF for landings within state designated Statistical Reporting Areas (SRAs) were provided to Vineyard Wind. Landings data, reported below, are for those SRAs where Project-related activities may occur and are the cumulative total of federal and state landing reports. Only the OECC is within the SRAs; WTGs, ESPs, and inter-array cables are not located within SRAs or the waters of Massachusetts.

Automatic Identification System

The Automated Identification System (AIS) is, in part, a shipborne mobile equipment system that typically consists of integrated Very High Frequency (VHF) radio and Global Positioning Systems (GPS) which broadcast a vessel's name, dimensions, course, speed and position, as well as destination and estimated time of arrival, amongst other vessel characteristics. The primary use of AIS systems is to allow vessels to monitor marine traffic in their area and to broadcast their location to other vessels with AIS equipment onboard. Broad categories of vessel type, including fishing vessels, can also be identified using the information contained in a vessel's AIS transmissions. Federal regulations require self-propelled commercial fishing vessels greater than 20 m (65 ft) in length to operate an AIS Class B device to broadcast vessel information. (33 C.F.R. § 164.46; USCG NAVCEN, 2017a).

Because of the autonomous and continuous nature of AIS data, it can also be compiled to establish a record of a vessel's operating history. Vineyard Wind obtained AIS data for portions of the Project Region that include the WDA and OECC. The AIS datasets were used to evaluate vessel traffic in the vicinity of the Project, including commercial fishing vessel traffic counts within the Lease Area, the WDA, and along the OECC.

7.6.2.2 Baseline Fishing Activity in the Offshore Project Area

Portions of the WDA are utilized by commercial fishermen. Vineyard Wind's extensive outreach and conversations with over 100 fishery stakeholders has aided in identifying commercial fishing effort in the WDA. Based on feedback from the fishing community during that outreach, the following fisheries likely fish within the WDA and along to the OECC and therefore are potentially impacted by the Project:[22]

- Static gear fisheries (gill nets, traps/pots)
- Groundfish/Bottom trawl mobile gear (Squid/Fluke/Atlantic Mackerel, Whiting, Butterfish)
- Atlantic Surfclam/Ocean Quahog dredge fishery

AIS data was queried to establish estimates of commercial fishing vessel traffic within the WDA and along the OECC. These vessel counts are believed to capture larger commercial fishing vessels which are required to operate an AIS Class B device, such as the bottom trawl vessels over 65 feet in length characterized by MARCO's analysis of VTR data. The bottom trawl vessels that appear active in proximity to the WDA, likely representing small mesh gear mobile trawl vessels that are understood to be targeting squid in the Project Region. Thus, the AIS data provides additional clarity on the types and numbers of vessels that may operate near the WDA and OECC.

Table 7.6-1 identifies the number of commercial fishing vessels operating within the WDA in 2016 and 2017 based on AIS data. Vessel counts were tabulated individually; therefore, vessels may be counted more than once if present in the WDA across multiple months.

[22] Vineyard Wind's on-going assessment of fishing effort in the Project Region will continue to be a collaborative effort among fishermen, Vineyard Wind, regulatory authorities, and other stakeholders and will inform the Project's best management practices ("BMPs") during construction.

Table 7.6-1 Number of fishing vessels in the WDA per month (AIS 2016/17 data)[23]

Number of Fishing Vessels per Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	3	7	14	7	15	37	45	64	68	22	16	11
2017	11	15	26	56	60	67	53	44	26	18	9	6

Vessel speed reported by AIS data may also indicate whether a vessel is fishing or transiting. Commercial fishing vessels are assumed to operate at vessels speeds up to four knots when mobile gear is deployed. When these vessels are transiting an open water area such as the WDA, they are assumed to operate at speeds in excess of seven knots. To estimate the number of the vessels that were potentially fishing within the WDA, the AIS data was queried to identify which of these vessels were operating at or below four knots. Based on this analysis, it is estimated that in 2017 approximately 54 percent of AIS–equipped commercial fishing may have deployed fishing gear within the WDA. This suggests, for example, that approximately 36 AIS-equipped commercial fishing vessels may have been fishing within the WDA the months with the highest count of AIS-equipped fishing vessels (June, 2017; September, 2016).

As described above, VMS data from commercial vessels has been used to characterize commercial fishing effort in the Project Region, including within the MA WEA and the WDA. The VMS datasets and associated mapping by NROC and MARCO qualitatively characterize the density of commercial fishing vessel activity for seven fisheries in the northeast and mid-Atlantic regions (Shmookler, 2015).

Maps of commercial fishing effort using VTR data were also created by MARCO and made available on their Mid-Atlantic Ocean Data Portal. Using VTR data to create density polygons that represent the visitation frequency of fishing vessels, MARCO's maps can be interpreted as an indicator of "community presence," in this case, the type of gear deployed in the WDA and the ports from which these vessels are operating.

23 For more details on the AIS data, see Appendix III-I.

Each of the aforementioned datasets produced qualitative representations of vessel activity within the Multispecies,[24] Monkfish, Herring, Scallop, Atlantic Surf Clam/Ocean Quahog, Mackerel, and squid fisheries, and within the bottom trawl, dredge, gillnet, longline, and pots and traps fisheries.

Figures 7.6-4 through 7.6-10 depict a standardized density of commercial fishing vessel activity within the Multispecies, Monkfish, Herring, Scallop, Atlantic Surf Clam/Ocean Quahog, Mackerel, and squid fisheries in the northeast and mid-Atlantic regions of the US based on NROC's VMS data for the years 2006 to 2016.

NROC's VMS-based analysis indicates the density of multispecies vessel activity can be characterized largely as "Medium-Low" throughout the WDA with some areas characterized as "Medium-High" (see Figure 7.6-4). Little to no multispecies vessel activity is shown in the southerly portions of the WDA during the years analyzed. NROC does not define the terms "Medium-Low" or "Medium-High" other than to note they are relative to the density of vessel traffic estimated by their model. The highest relative vessel density is to the north, outside of the WDA. Along the OECC south of Martha's Vineyard and Nantucket, NROC identifies multispecies vessels active to the east and west of Muskeget Channel.

Some vessels targeting Monkfish (see Figure 7.6-5) appear to be deploying gear in portions of the WDA during the years analyzed. Vessel density increases to the north of the WDA, in the areas on either side of Muskeget Channel.

Scallop vessel density during the years analyzed is Medium-Low, with a small section characterized as "Medium-High" within limited areas of the WDA and along a section of the OECC near Muskeget Channel (see Figure 7.6-6).

Vessels targeting Surfclam/Ocean Quahogs appear to have a limited presence in the WDA during the years analyzed. Areas of Medium-High to High density occur to the northwest of the WDA (see Figure 7.6-7).

Squid vessels appear active in the WDA and along portions of the OECC through Nantucket Sound (see Figure 7.6-8) during the years analyzed. However, the highest level of squid activity occurs outside and to the north of the WDA. Fishermen indicate that squid activity primarily occurs near the WDA, offshore in federal waters, from approximately May/June to August, and areas within Nantucket Sound and Massachusetts coastal waters are active from April to June. This is consistent with the AIS data presented in Table 7.6-1.

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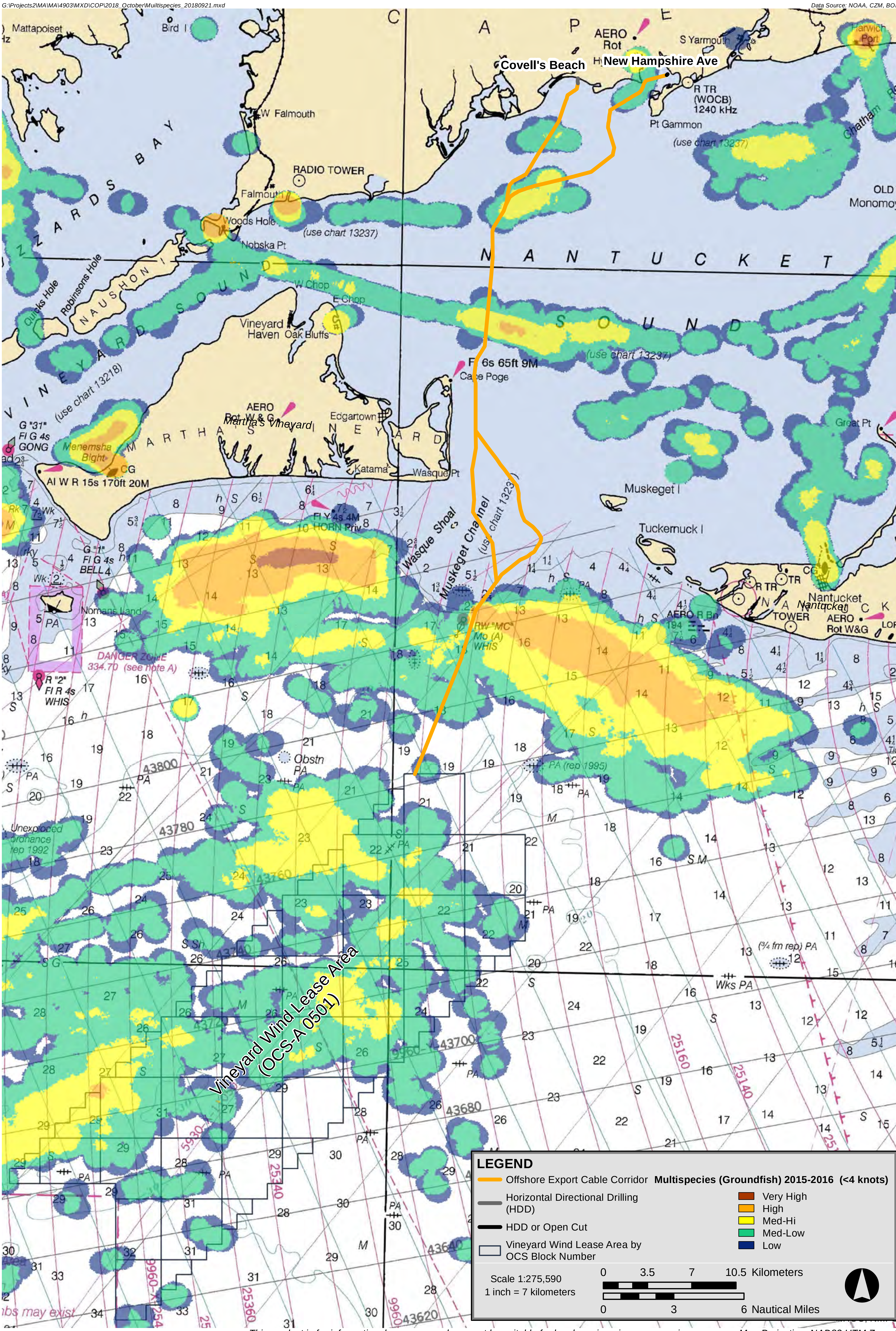
[24] The multispecies data includes the following species: Cod, Haddock (*Melanogrammus aeglefinus*), Yellowtail Flounder, Pollock (*Pollachius pollachius*), Plaice, Witch Flounder (*Glyptocephalus cynoglossus*), White Hake (Urophycis *tenuis*), Windowpane Flounder (*Scopthalmus aquosus*), Atlantic Halibut (*Hippoglossus hippoglossus*), Winter Flounder, Redfish, Atlantic Wolffish (*Anarhichas lupus*), and Ocean Pout (*Macrozoarces americanus*).

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\Muiltispecies_20180921.mxd

Data Source: NOAA, CZM, BOEM



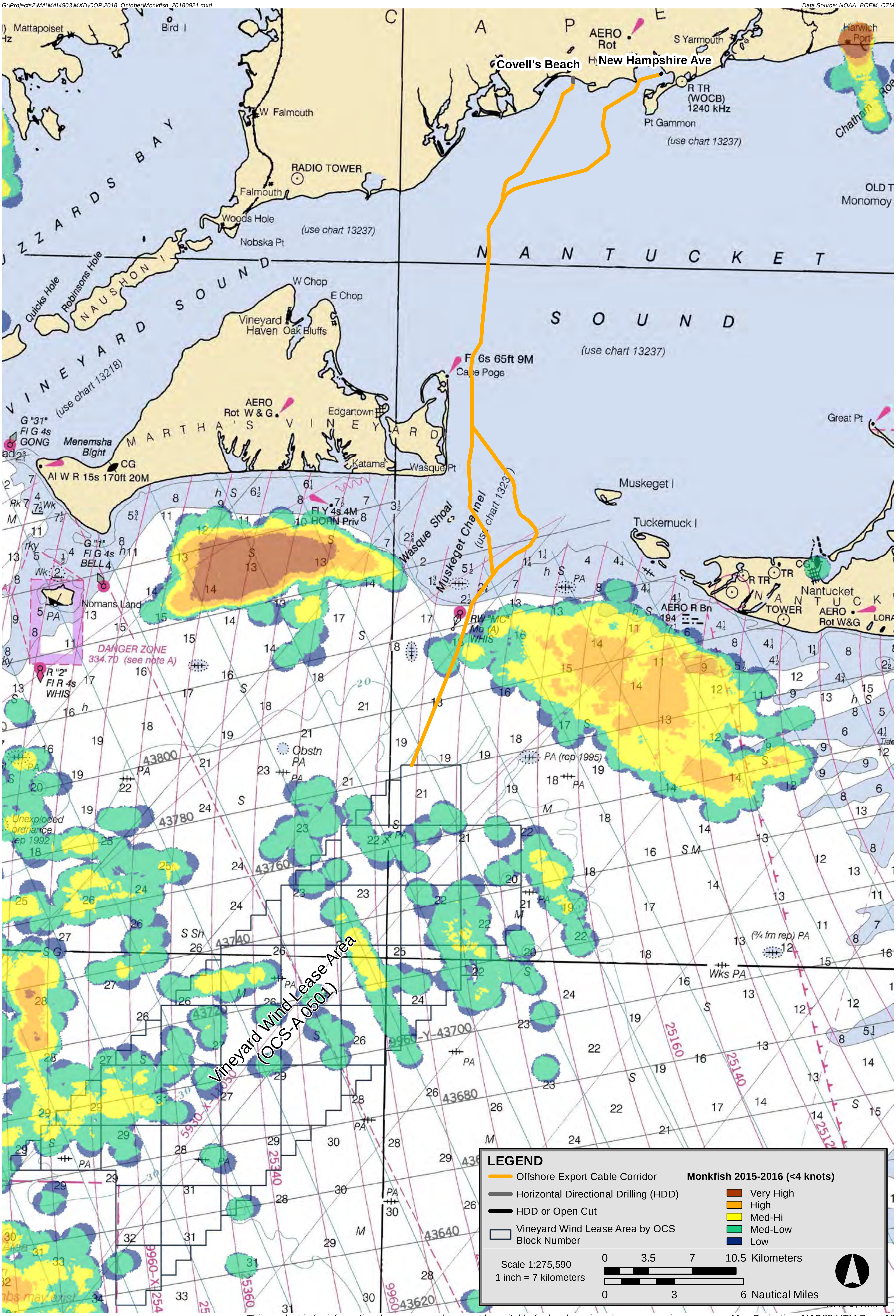
This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Figure 7.6-4

Northeast Multispecies 2015-2016 (<4 knots) Commercial Fishing Density

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\Monkfish_20180921.mxd

Data Source: NOAA, BOEM, CZM



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

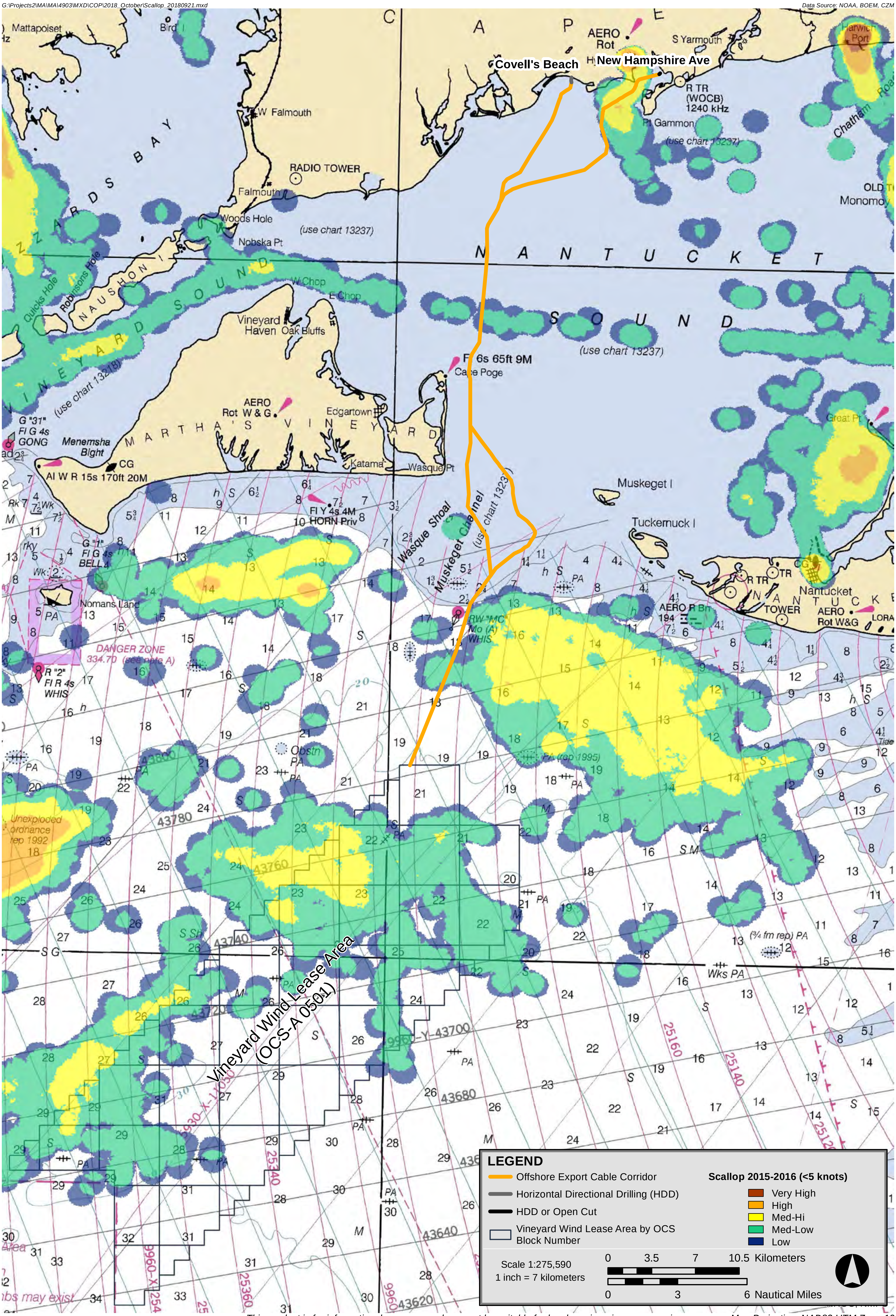
VINEYARD WIND

Figure 7.6-5

Monkfish 2015-2016 (<4 knots) Commercial Fishing Density

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\Scallop_20180921.mxd

Data Source: NOAA, BOEM, CZM



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-6

Scallop 2015-2016 (<5 knots) Commercial Fishing Density

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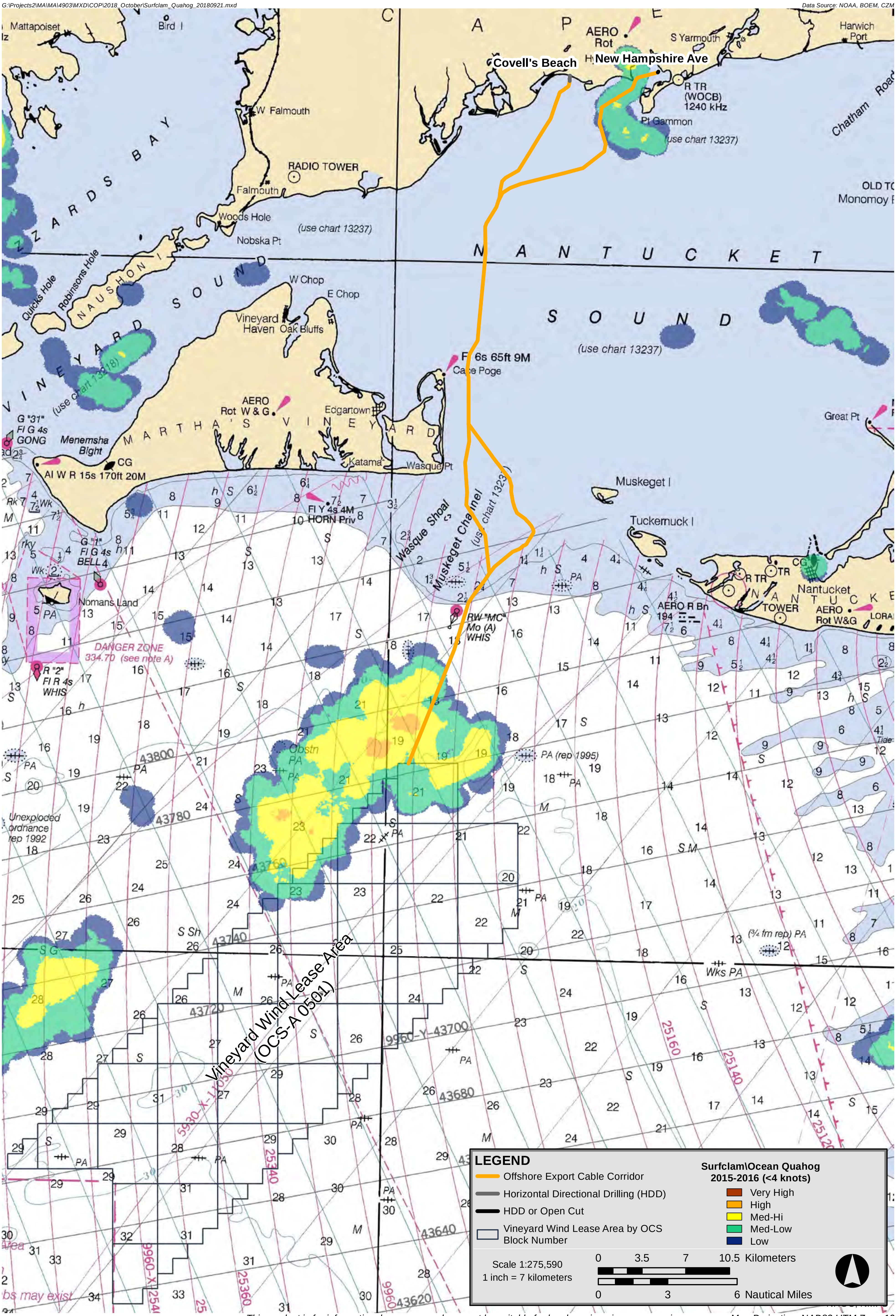
Data Source: NOAA, BOEM, CZM



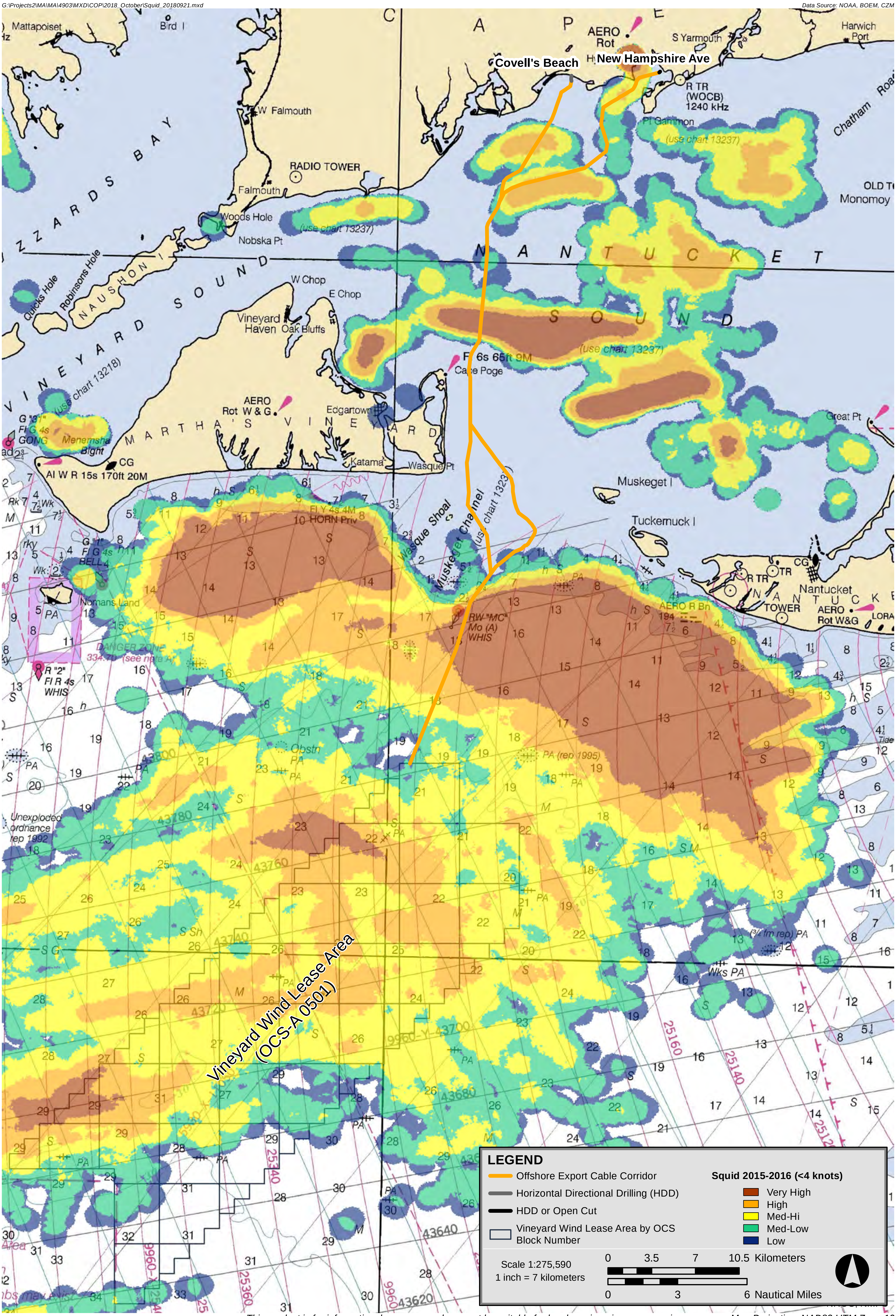
This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-7

Surfclam/Ocean Quahog 2015-2016 (<4 knots) Commercial Fishing Density



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Figure 7.6-8

Squid 2015-2016 (<4 knots) Commercial Fishing Density

During the years analyzed, vessels targeting Mackerel and Herring do not appear to deploy gear in the WDA (see Figures 7.6-9 and 7.6-10).

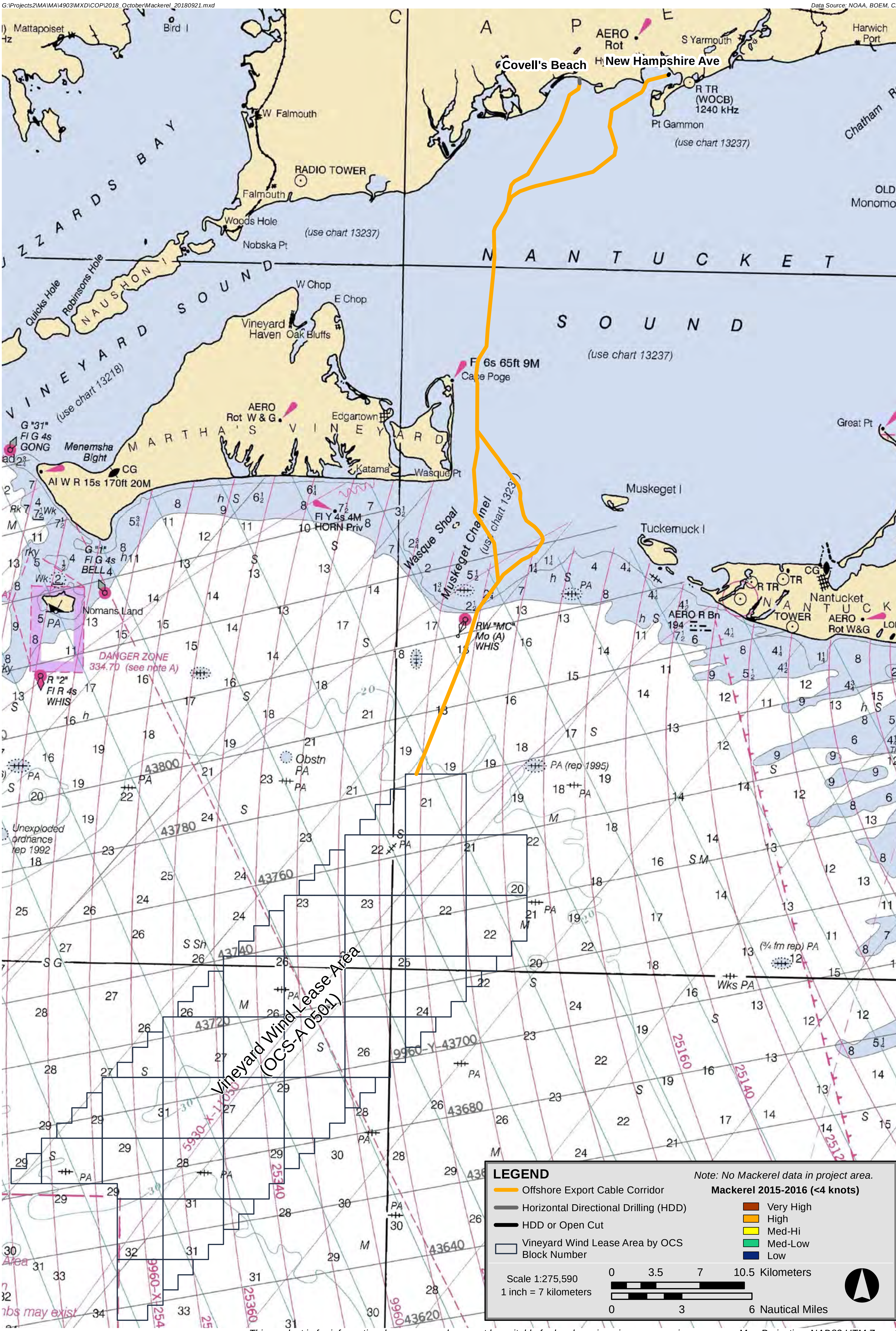
Fisheries representatives have also indicated that vessels targeting Whiting (*Merluccius bilinearis*) and Scup, may be active in the WDA throughout the year and vessels targeting Yellowtail and Winter Flounder (*Pseudopleuronectes americanus*) are active south of the WDA, in proximity to the northwest corner of The Dump. The Whiting fishery is not represented in VMS heat map data since regulations allow vessels to "Declare Out of Fishery" or "DOF" when targeting Whiting. Vineyard Wind is working with Whiting fishermen to obtain data on vessel activity in the WDA to better understand the fishery.

As noted above, the American Lobster fishery is active in the Project Region, which is located in Area 2 of the Southern New England Lobster Management area. The American lobster resource and fishery are cooperatively managed by the states and NMFS under the framework of the Atlantic States Marine Fisheries Commission. According to the Greater Atlantic Regional Fisheries Office, 172 Federal lobster permits were issued for Area 2 in 2017. Based on review of the Federal Permit dataset for 2017, approximately 68 of these vessels were homeported in Rhode Island, and 63 vessels were homeported in Massachusetts. NMFS published a "final rule" in 1999 that establishes a moratorium on any new entrants into the Federal lobster fishery. Existing permits, when associated with a vessel, however, may be sold to another entity.

Vineyard Wind has had limited success verifying lobster activity within the Lease Area. Due to NOAA regulations, lobster fishing vessels are not required to have installed operational VMS units on their vessels. The Greater Atlantic Regional Fisheries Office requires permitted vessels to submit a VTR for every fishing trip regardless of where the fishing occurs or what species are targeted, with the exception of those vessels that possess only a lobster permit. Without VTR or VMS data, lobster catch data relevant to the Lease Area has been difficult to verify.

Based on outreach to fishermen that hold Area 2 lobster permits who are currently actively fishing, Vineyard Wind understands that there may be only five to six lobstermen who actively fish in the Lease Area. Lobstermen have also indicated to Vineyard Wind that the scour protection placed at the base of the WTGs will attract lobster and other fish species and could improve lobster fishing within the WDA.

As described above, portions of the OECC are within the state waters of Massachusetts. Harvesting of lobster in Massachusetts also requires a commercial lobster permit issued by the Massachusetts Department of Marine Fisheries ("DMF"), and landings must be sold only to licensed Massachusetts dealers. In 2017, DMF reports 1,088 coastal and 407 offshore lobster permits were issued. A Coastal Lobster Permit allows the taking and landing of lobster from within the coastal waters of the Massachusetts, and the sale of those lobsters to



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

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Figure 7.6-9

Mackerel 2015-2016 (<4 knots) Commercial Fishing Density

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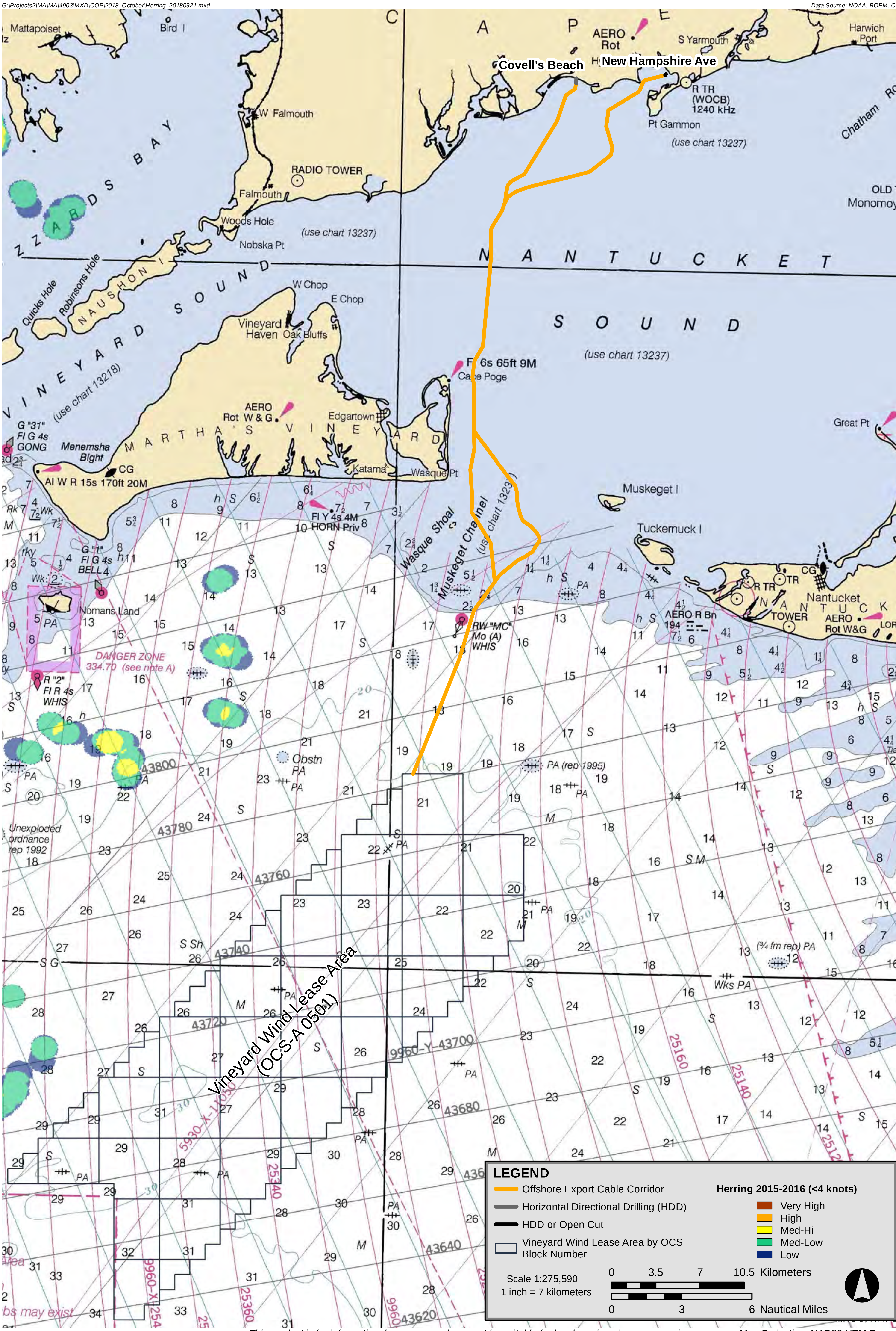
Data Source: NOAA, BOEM, CZM



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-10

Herring 2015-2016 (<4 knots) Commercial Fishing Density a licensed dealer. An Offshore Lobster Permit allows the landing and sale of lobster to a licensed dealer taken outside of the coastal waters of the Commonwealth, pursuant to the appropriate federal permit(s).

Figures 7.6-11 through 7.6-22 are MARCO's VTR-based maps depicting the bottom trawl, dredge, gillnet, longline, and pots and traps fisheries. It is important to note that the NROC figures depict relative vessel density between 2015 and 2016, while VTR data from MARCO's Data Portal, as referenced herein, has been aggregated, separately, for 2006 to 2010 and 2011 to 2015.

MARCO's VTR-based analysis of the bottom trawl fishery is further divided into two categories: vessels less than 65 feet in length (Figures 7.6-11 and 7.6-12) and vessels greater than 65 feet in length (Figures 7.6-13 and 7.6-14). During the years analyzed, smaller bottom trawl vessels appear to operate largely within Nantucket Sound and in areas outside the WDA, south of Nantucket and Martha's Vineyard. Figures 7.6-11 and 7.6-12 depict areas of low to moderate fishing effort by these vessels. During the years analyzed, low fishing effort by vessels greater than 65 feet in length appears distributed throughout the WDA and along the portions of the OECC within Nantucket Sound, as shown on Figures 7.6-13 and 7.6-14. Elevated fishing effort, likely reflecting vessels targeting squid, occurs outside and to the north of the WDA (just south of Martha's Vineyard and Nantucket).

During the years analyzed, limited areas of low fishing effort by vessels deploying dredge gear occur along the OECC (Figures 7.6-15 and 7.6-16). Though Figure 7.6-16 identifies nearly no fishing effort by dredge vessels between 2011 and 2015. Fishing effort by dredge vessels is not reflected within the WDA during the years analyzed.

During the years analyzed, only limited areas of low fishing effort by gillnet vessels is reflected in the WDA and along the OECC (Figures 7.6-17 and 7.6-18).

During the years analyzed, no fishing effort by longline vessels occur within the WDA or along the OECC (Figures 7.6-19 and 7.6-20).

During the years analyzed, deployment of pots and traps occurs predominantly within Nantucket Sound and no pots and traps fishing effort is reflected within the WDA or along the OECC south of Muskeget Channel (Figures 7.6-21 and 7.6-22).

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Data Source: NOAA, BOEM, CZM

This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-11

MARCO – Bottom Trawl (Vessels <65 ft.) 2006 - 2010

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Data Source: NOAA, BOEM, CZM

This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

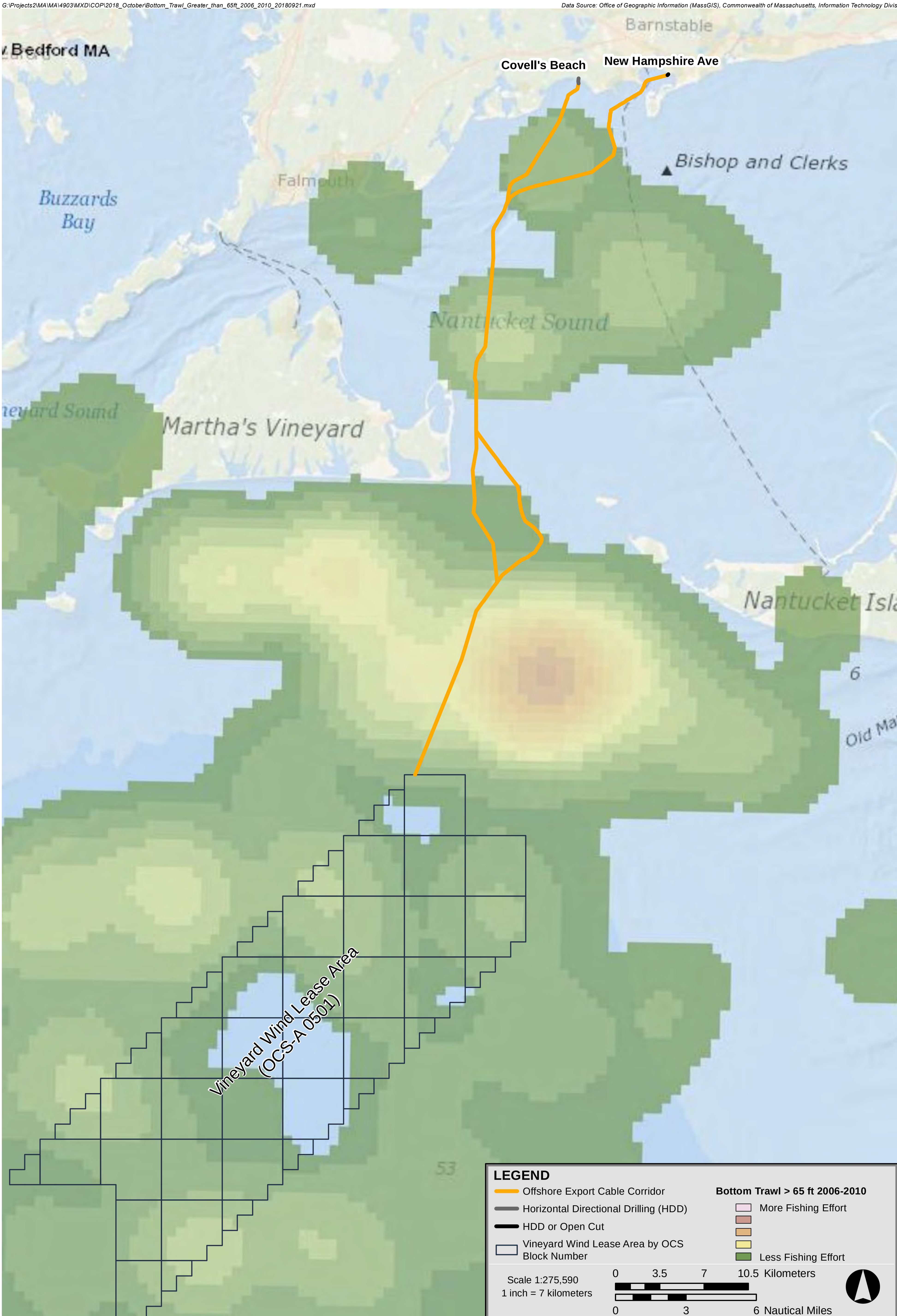
VINEYARD WIND

Figure 7.6-12

MARCO – Bottom Trawl (Vessels <65 ft.) 2011 - 2015

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\Bottom_Trawl_Greater_than_65ft_2006_2010_20180921.mxd

Data Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division



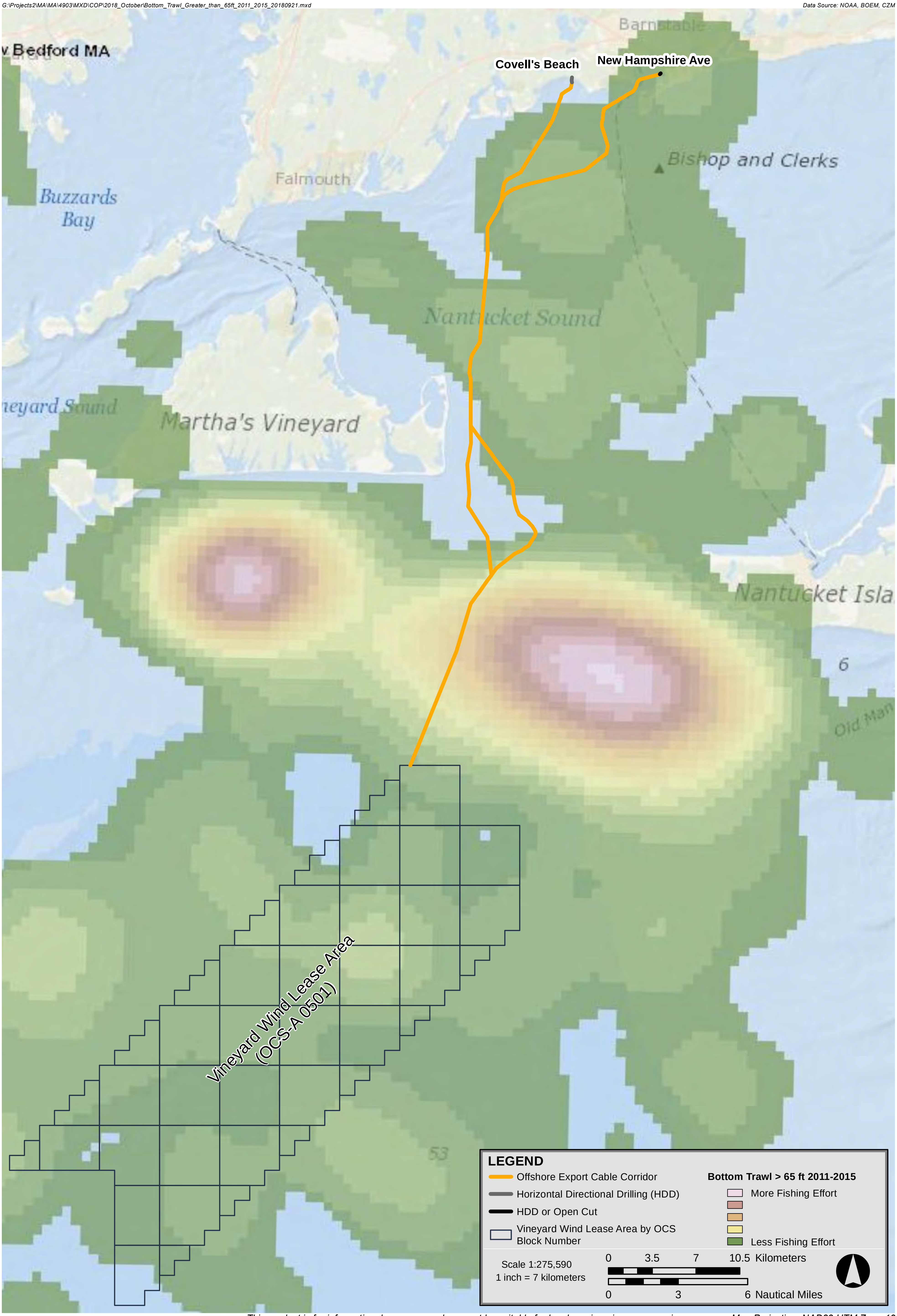
This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-13

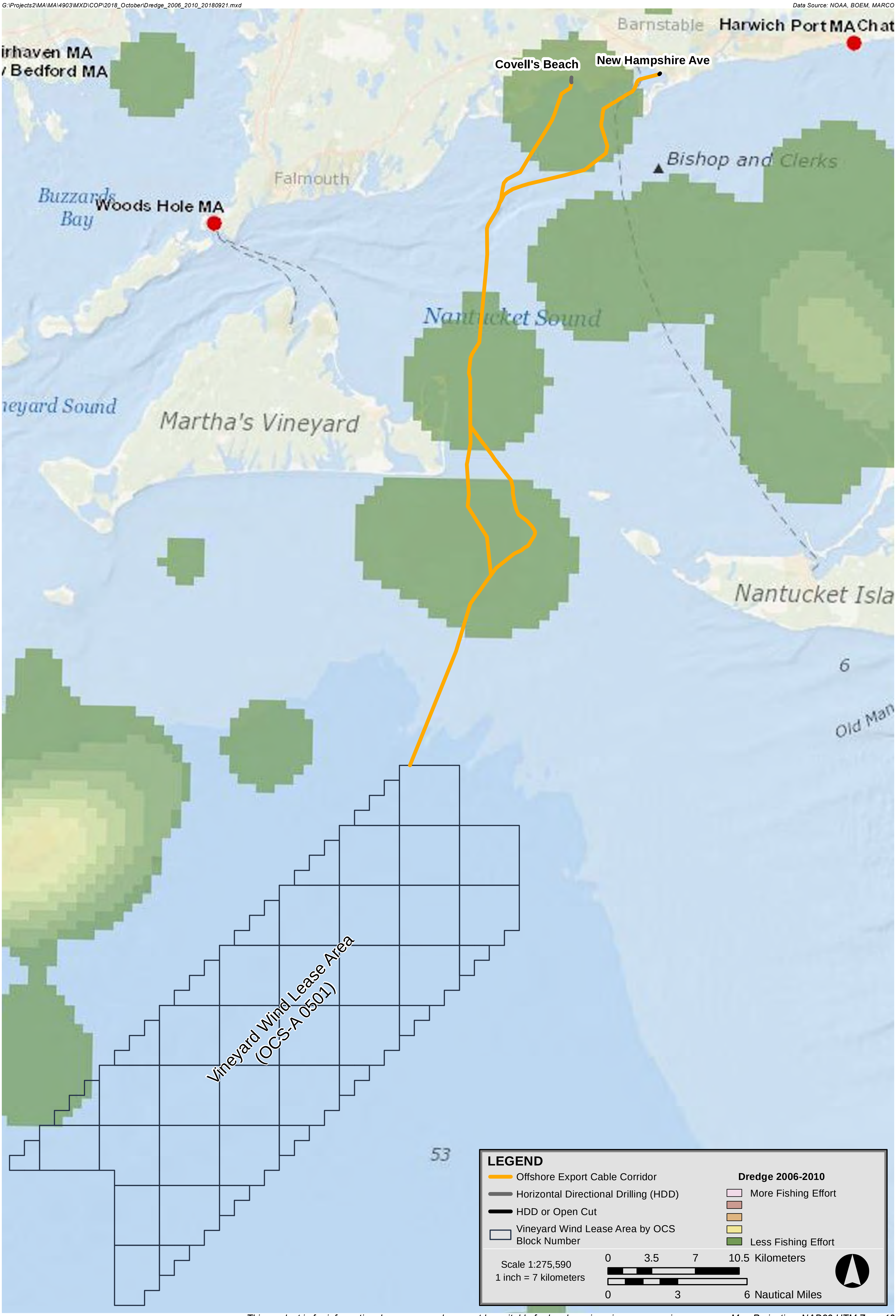
MARCO – Bottom Trawl (Vessel >65 ft.) 2006 - 2010



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Figure 7.6-14

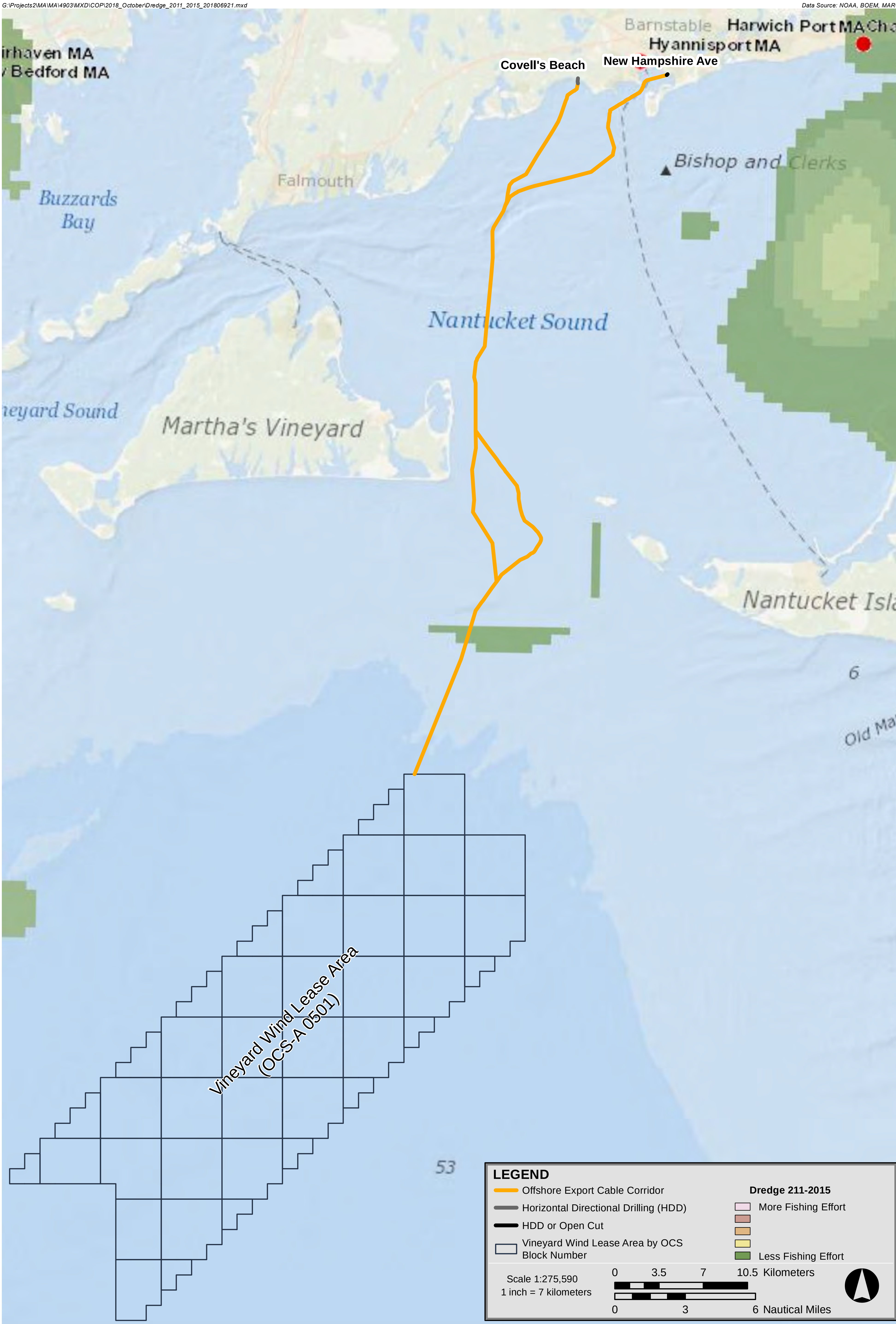
MARCO – Bottom Trawl (Vessel >65 ft.) 2011 - 2015



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\Dredge_2011_2015_20180692 1.mxd

Data Source: NOAA, BOEM, MARCO



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-16

MARCO – Dredge 2011 - 2015

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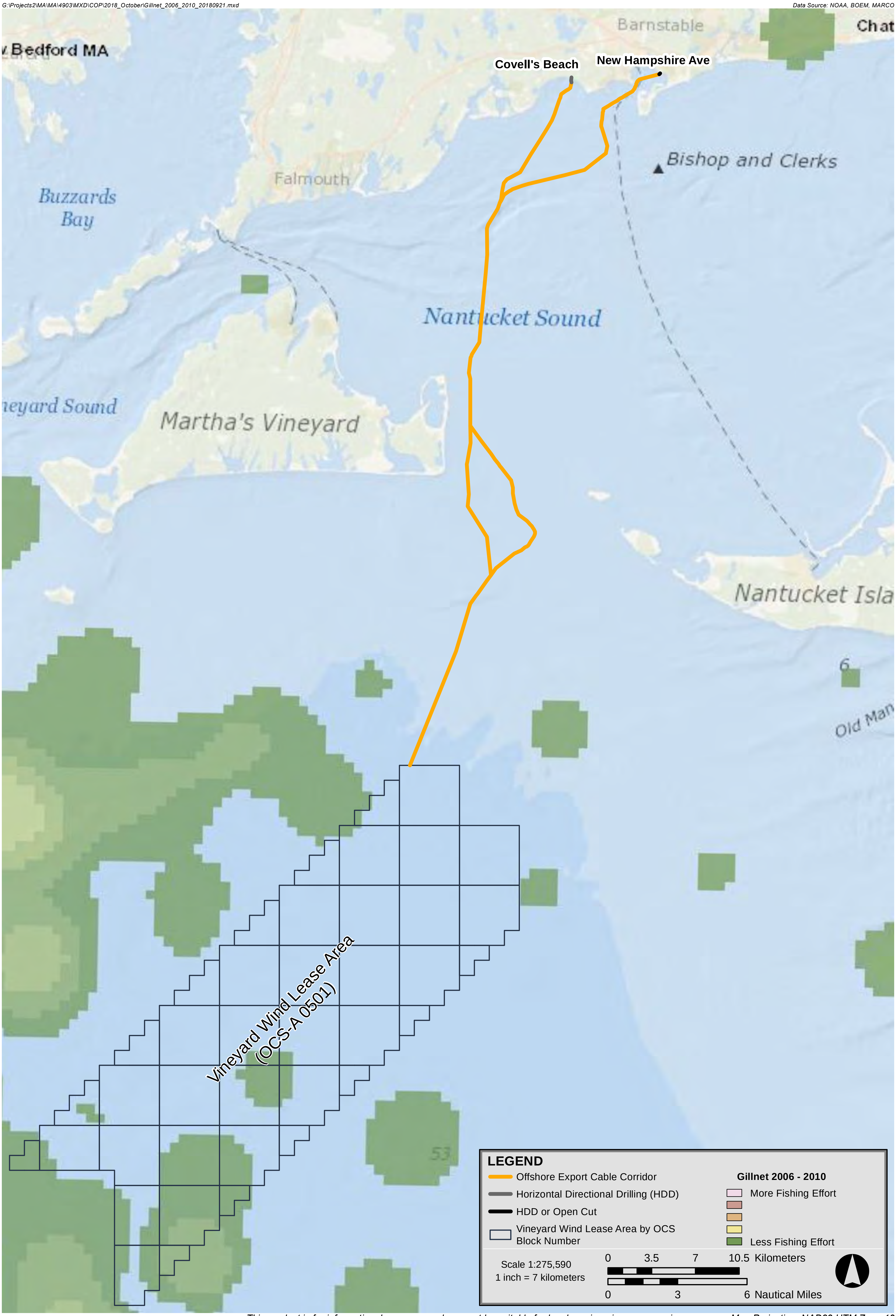
Data Source: NOAA, BOEM, MARCO



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-17

MARCO – Gillnet 2006 - 2010

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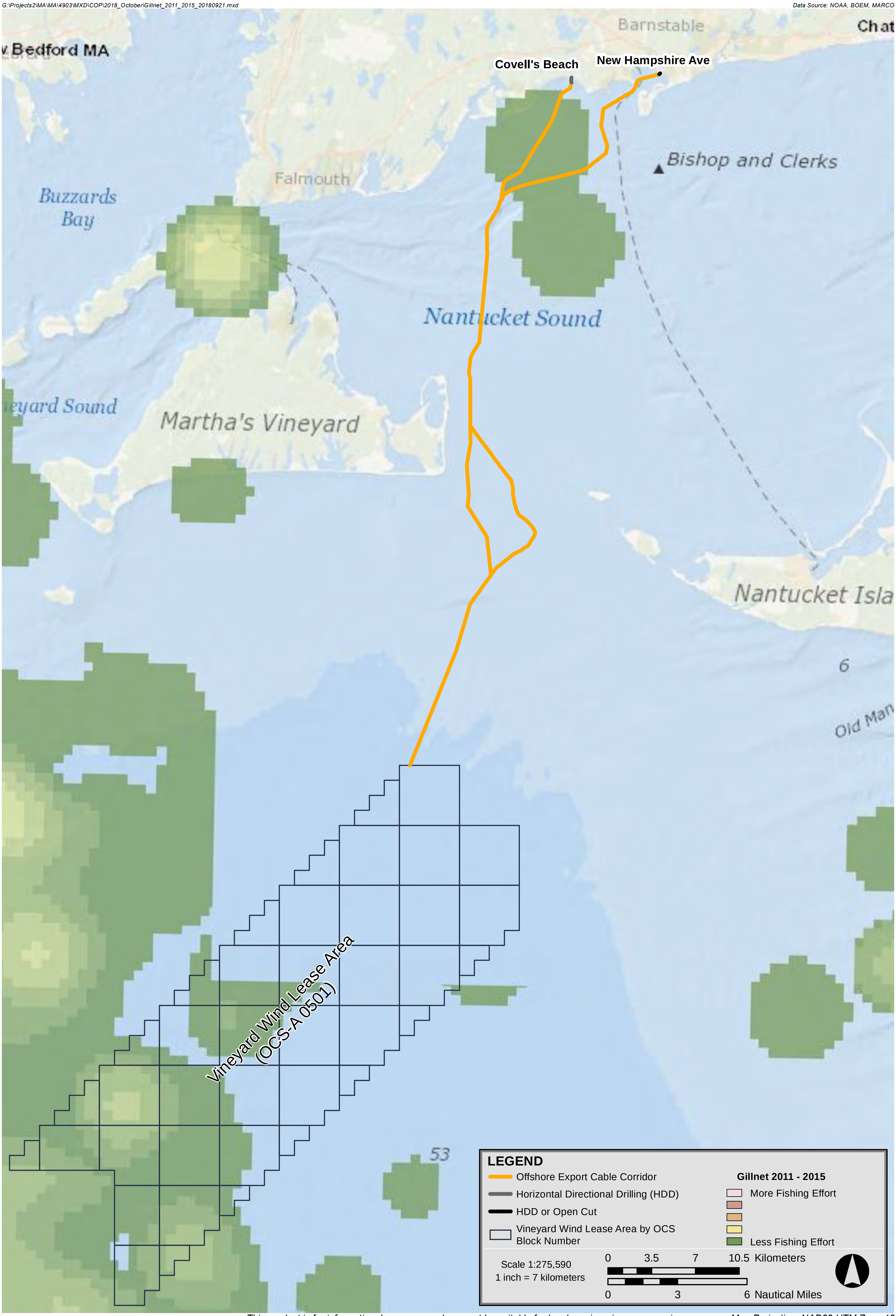
Data Source: NOAA, BOEM, MARCO



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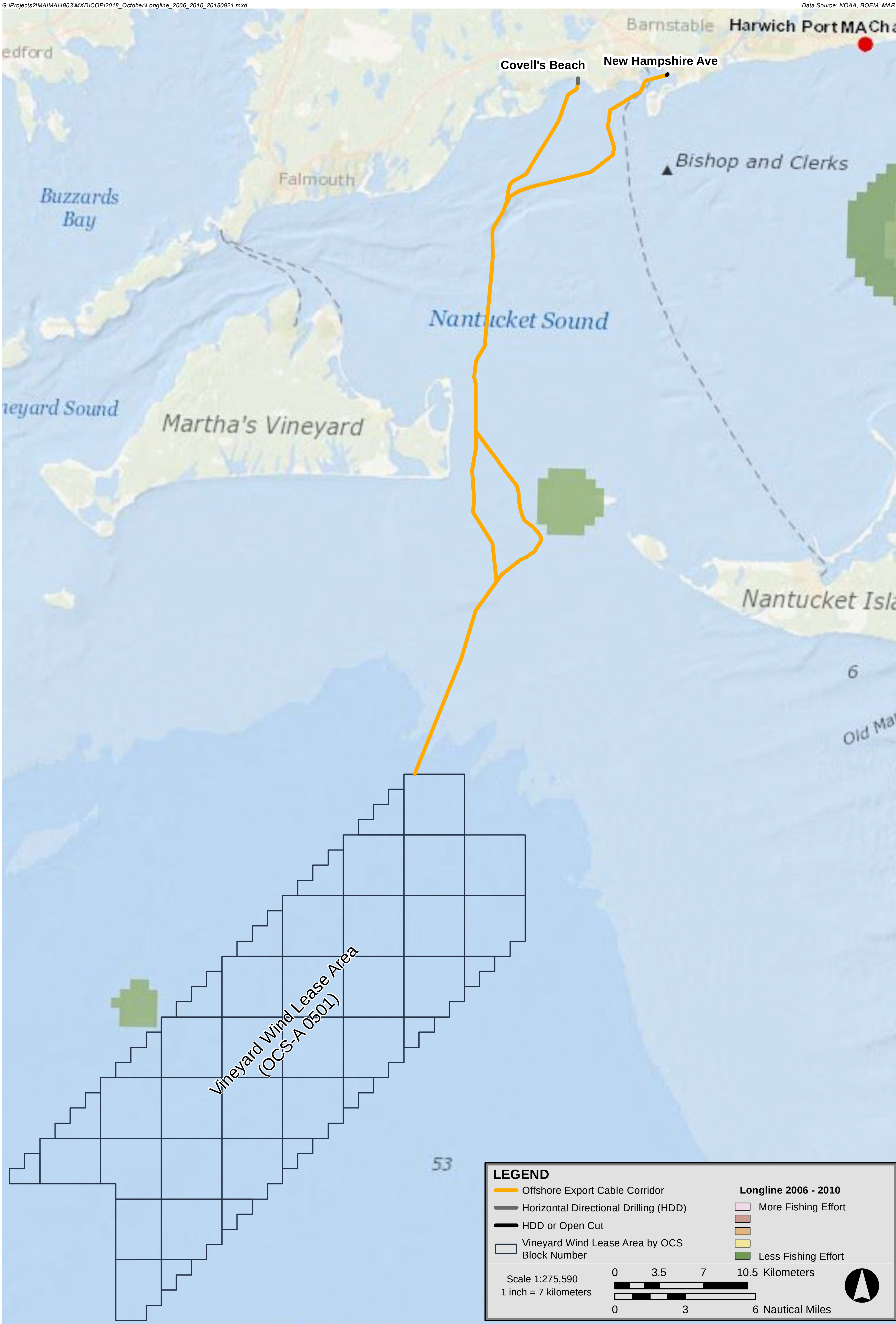
Vineyard Wind Project

VINEYARD WIND

Figure 7.6-18

MARCO – Gillnet 2011 - 2015



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Figure 7.6-19

MARCO – Longline 2006 - 2010

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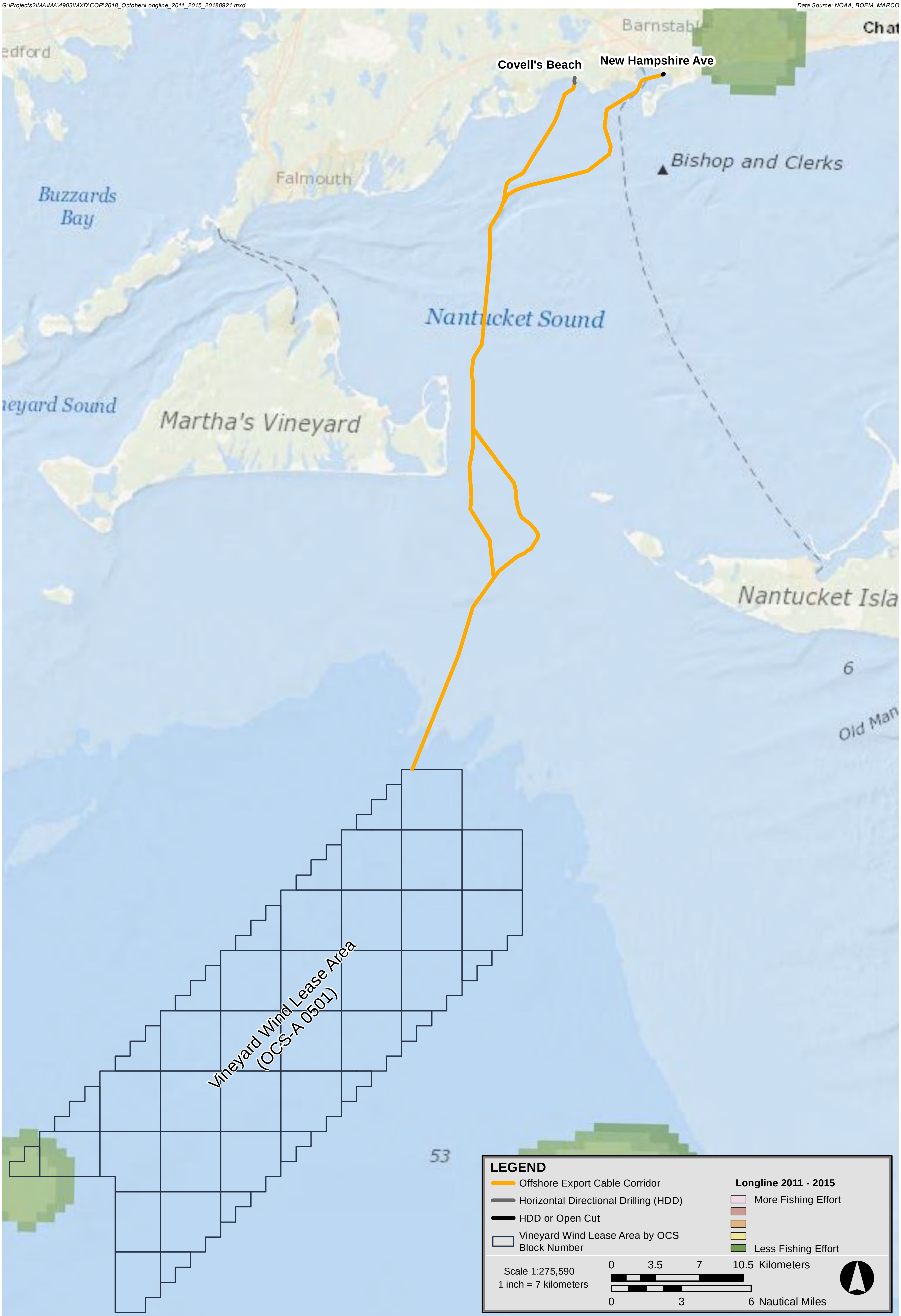
Data Source: NOAA, BOEM, MARCO



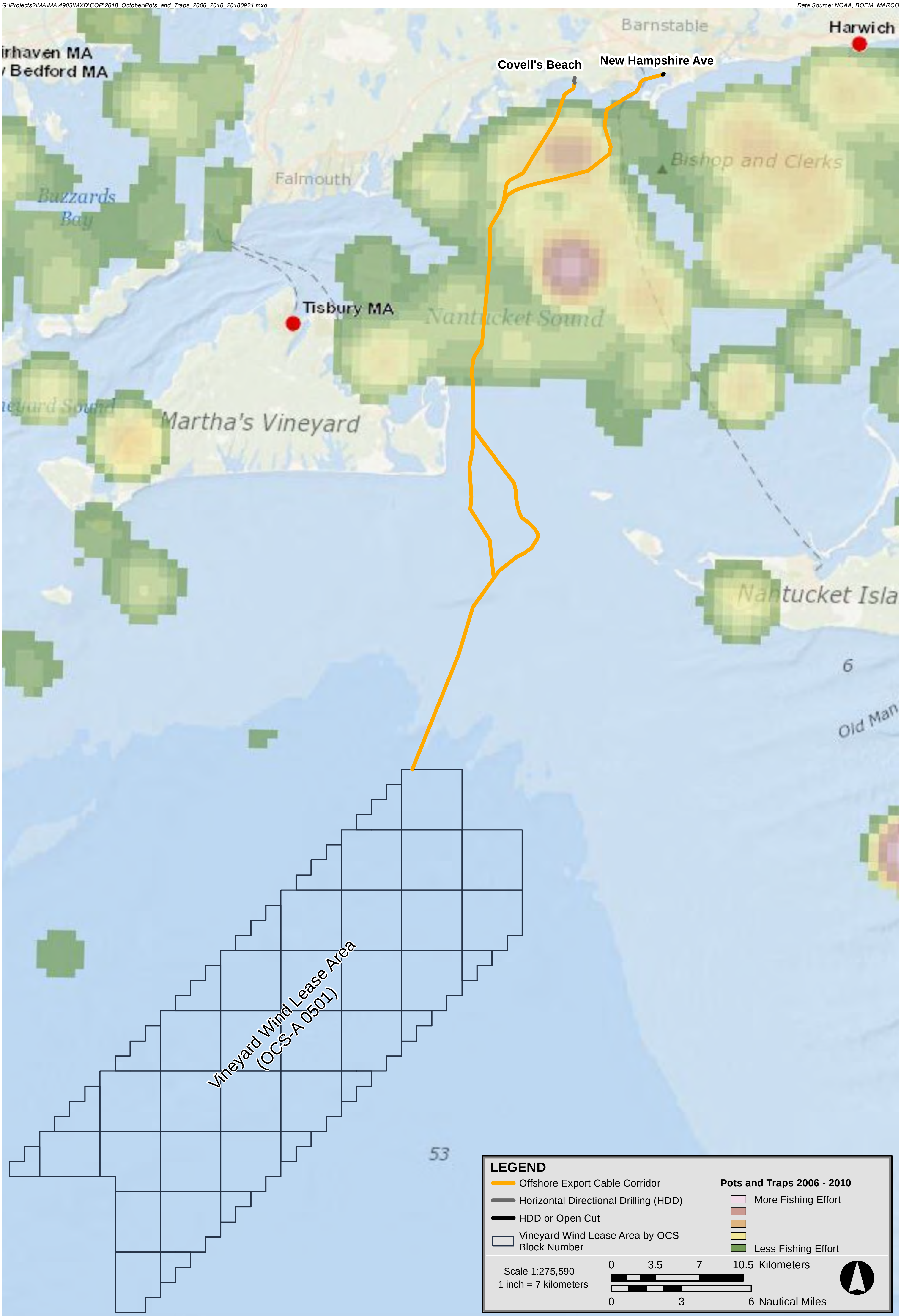
This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

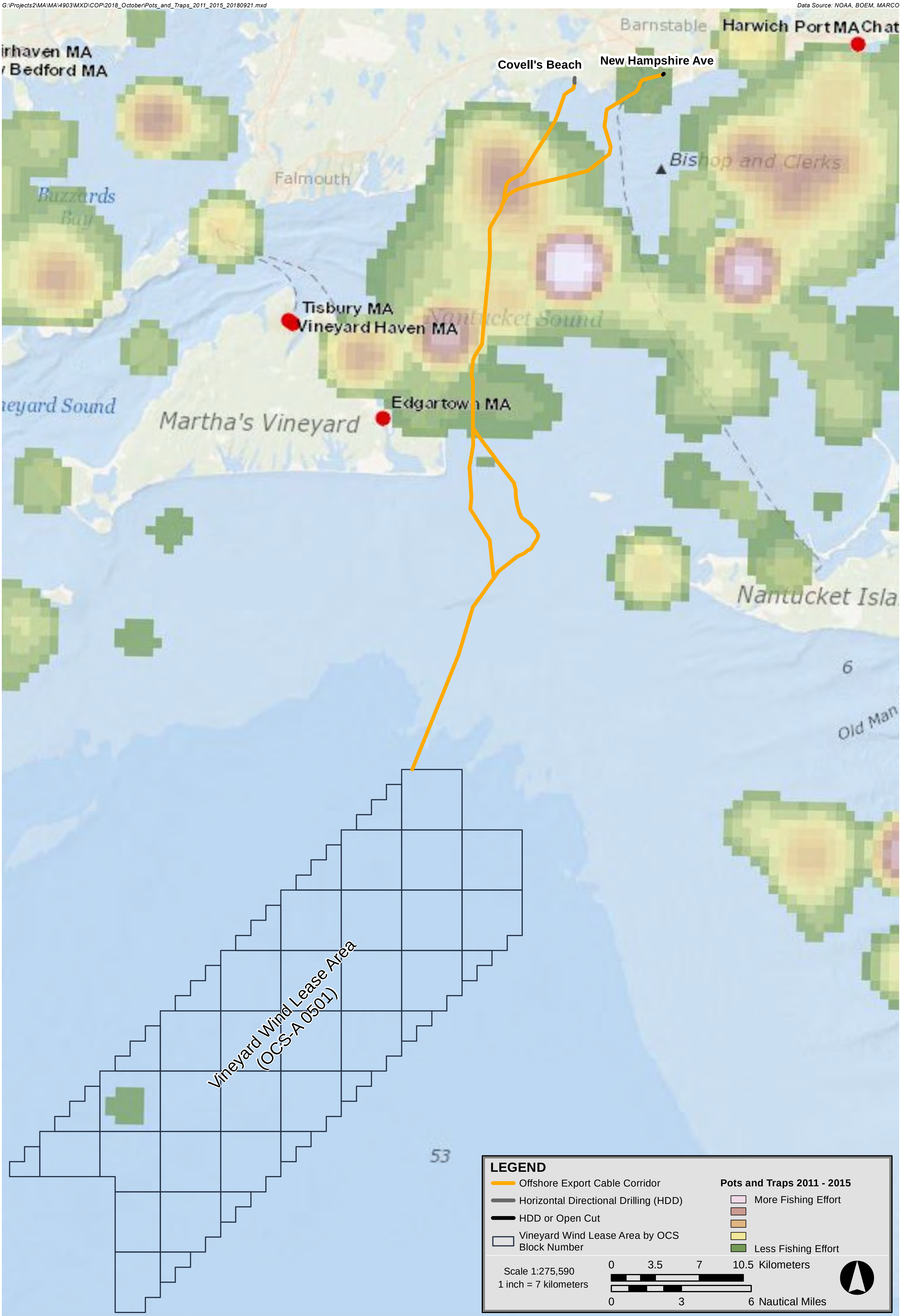
VINEYARD WIND

Figure 7.6-20

MARCO – Longline 2011 - 2015



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Figure 7.6-22

MARCO – Pots and Traps 2011 - 2015

Cable installation work along the OECC and Project-related vessel traffic will occur within a limited geographic area of two DMF Statistical Reporting Areas: Statistical Reporting Area 10 (SRA 10) and Statistical Reporting Area 12 (SRA 12), shown on Figure 7.6-23. These Statistical Reporting Areas are within the waters of Massachusetts and the federal waters of Nantucket Sound; they partially overlap the OECC. Only a very short segment of the OECC, in the vicinity of Muskeget Channel, traverses SRA 12. The WDA is not within either reporting area.

Certain non-confidential landings data reported by the DMF for those Statistical Areas were made available to Vineyard Wind. Landings reported to DMF within SRA 10 are shown in Table 7.6-2 and landings reported to DMF within SRA 12 are shown in Table 7.6-3.

Table 7.6–2 Massachusetts Annual Landings (live pounds) by Species in Statistical Reporting Area 10 (DMF)

SPECIES	2010	2011	2012	2013	2014	2015	2016
BLUEFISH	90,002	187,726	167,410	230,235	179,905	200,223	81,329
BUTTERFISH	24,451	6,388	13,982	2,371	8,215	28,283	15,113
CLAM, NORTHERN QUAHOG	2,486,062	1,622,147	1,505,640	1,464,435	1,499,151	1,435,501	1,505,251
CLAM, OCEAN QUAHOG / CLAM, SURF	4,887,623	2,039,872	175,253	1,149,764	81,335	321,553	249,524
CLAM, RAZOR, ATLANTIC	C	C	23,866	234,019	20,556	794	4,307
CLAM, SOFT	244,115	472,253	1,567,163	505,958	183,372	436,526	451,337
CRAB, HORSESHOE	244,175	246,705	287,587	414,784	325,824	327,566	345,405
DOGFISH, SPINY	29,503	113,957	205,508	187,788	33,977	25,156	109,795
FINFISH-OTHER	26,959	13,009	485,410	8,270	33,663	6,595	564,600
FLOUNDER, WINTER	16,402	1,558	1,201	4,732	1,489	877	241
MONKFISH	9,500	1,262	4,499	874	C	811	10,157
GROUNDFISH-OTHER	66,070	48,615	6,103	5,821	0	3,092	2,157
INTERTIDAL SHELLFISH-OTHER	3,488	C	C	C	1,882	4,128	9,301
INVERTEBRATES-OTHER	19,805	157	49,068	1,792	18,815	393	61,317
LOBSTER, AMERICAN	22,668	29,537	21,163	23,689	16,497	5,983	8,323
MACKEREL, ATLANTIC	336	1,093	2,806	533	55,259	7,253	21,782
MUSSEL, BLUE	52,529	63,215	492,391	1,761,182	C	C	1,046,261
OFFSHORE SHELLFISH-OTHER	C	2,587	C	8,382	13,854	17,445	21,105
SCALLOP, SEA	C	71,434	647,799	56,573	19,492	47,881	C
SCUP	508,787	179,618	221,308	145,862	213,255	125,555	367,974
SEA BASS, BLACK	90,764	94,712	74,404	90,525	105,622	100,945	94,511
SKATES	15,873	34,994	14,937	142,641	3,006	12,158	34,062
SQUID, LONG FINNED (LOLIGO)	601,296	353,590	1,771,748	60,305	1,125,117	356,793	1,004,261

Table 7.6–2 Massachusetts Annual Landings (live pounds) by Species in Statistical Reporting Area 10 (DMF) (Continued)

SPECIES	2010	2011	2012	2013	2014	2015	2016
STRIPED BASS	83,026	85,772	97,776	102,115	203,500	39,126	49,756
TAUTOG	2,170	5,377	3,802	7,863	7,699	807	2,565
WHELK, CHANNELED	1,757,666	2,331,299	2,165,836	1,757,928	1,349,020	1,158,208	1,052,329
WHELK, KNOBBED	118,938	211,222	256,366	427,062	421,941	302,924	212,402

SOURCE: MATL Reports, NMFS VTRs
C = Confidential Data

Table 7.6-3 Massachusetts Annual Landings (live pounds) by Species in Statistical Reporting Area 12 (DMF)

SPECIES	2010	2011	2012	2013	2014	2015	2016
BLUEFISH	3,591	6,524	9,743	25,412	9,599	7,571	5,943
CLAM, SOFT	7,960	C	14,902	21,570	20,683	30,342	23,024
FINFISH-OTHER	23,465	61,527	82,043	47,166	6,360	15,616	1,737
FLOUNDER, SUMMER (FLUKE)	52,919	76,750	89,501	51,587	50,721	64,665	24,178
FLOUNDER, WINTER	1,368	3,179	3,739	2,986	3,279	1,559	248
GOOSEFISH	16,826	46,247	53,805	23,214	1,515	6,894	5,728
GROUNDFISH-OTHER	51,285	10,698	3,960	88	399	444	1,439
INTERTIDAL SHELLFISH-OTHER	C	C	C	C	C	C	C
INVERTEBRATES-OTHER[1]	4,355	3,815	142,480	7,345	68,730	111,469	283,172
LOBSTER, AMERICAN	65,640	62,328	86,310	99,966	65,630	109,772	150,408
OFFSHORE SHELLFISH-OTHER	437,553	482,269	21,451	4,687	2,202	C	27,778
OYSTER, EASTERN	2,495	6,529	11,167	35,491	50,185	250,850	40,254
SCALLOP, BAY	396	15,221	25,119	56,740	26,715	C	C
SCUP	100,692	124,950	246,814	262,032	146,774	140,483	173,868
SEA BASS, BLACK	5,320	8,801	4,183	26,501	30,777	55,252	57,299
SKATES	441,577	424,667	378,647	150,208	65,741	65,037	2,508
STRIPED BASS	45,389	24,348	20,161	21,387	32,136	12,272	14,137
TAUTOG	C	1,229	1,565	4,354	2,901	4,971	3,245
WHELK, CHANNELED	14,157	113,462	44,468	37,007	67,754	1,172	8,950

SOURCE: MATL Reports, NMFS VTRs

C= Confidential Data

1 Squid may be included in this category by the state to preserve confidentiality of data.

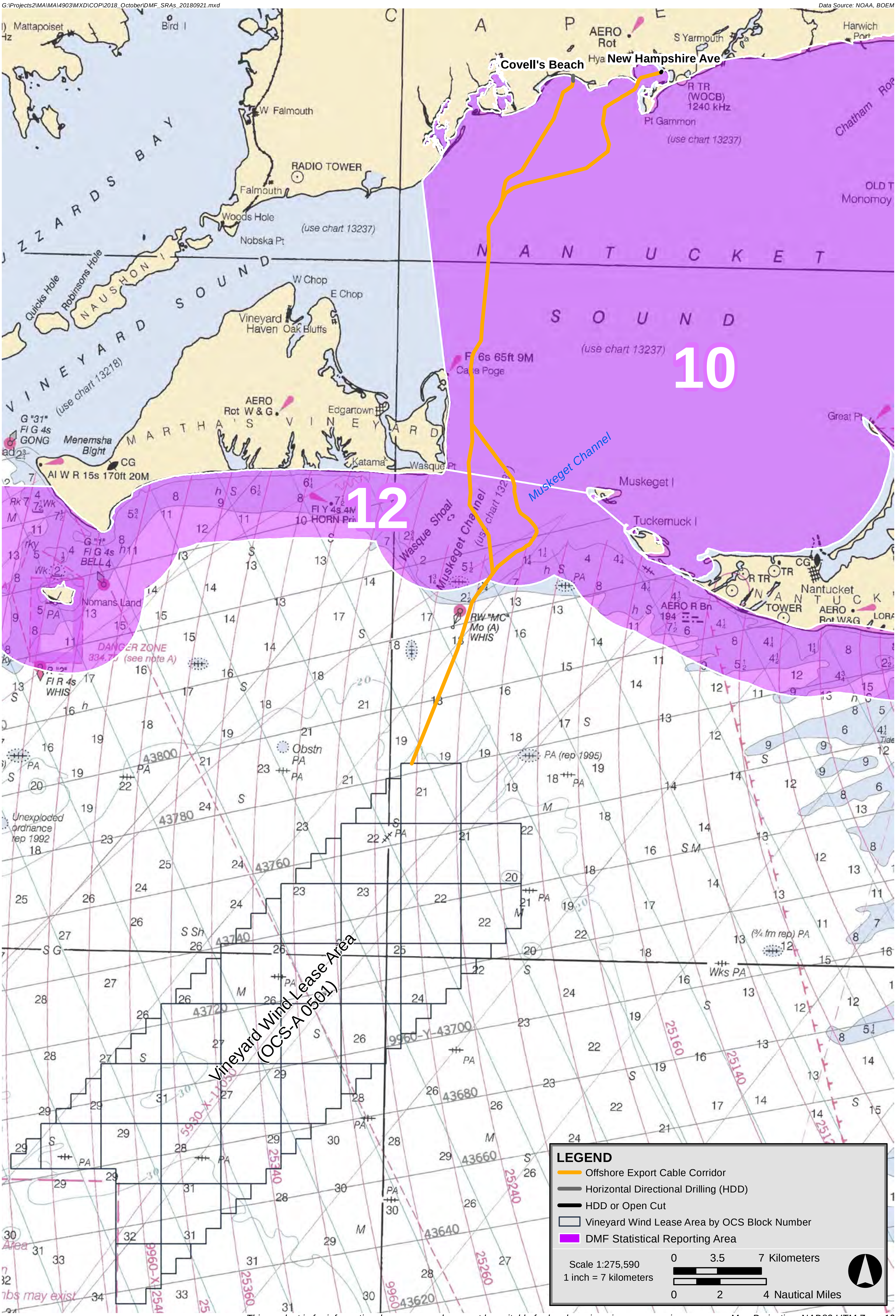


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Figure 7.6-23

Massachusetts Division of Marine Fisheries Statistical Reporting Areas

It has been reported that species of large gastropod whelks (Busycon carica and Busycotypus canaliculatum) are present within SRA 10 and SRA 12, which is confirmed by the landings of those species shown in Tables 7.6-1 and 7.6-2. Similarly, the Massachusetts Ocean Management Plan's (2015) identification of areas of commercially and recreationally important species with high abundance in the vicinity of the Project, based on MA DMF trawl survey data, included both channeled whelk and knobbed whelk. DMF reports that in 2016 the Massachusetts channeled whelk fishery landed, in total, approximately 1.9 million pounds valued in excess of $4.8 million. Based on DMF's 2016 landings data, approximately 54 percent of channeled whelk harvested in Massachusetts was sourced from SRA 10 and SRA 12, though largely from SRA 10. In 2017 the Massachusetts channeled whelk fishery landed, in total, approximately 1.1 million pounds valued in excess of $3.1 million, a substantial decrease from 2016 though; species management could be a factor in the decrease. 2017 landings data for SRA 10 and SRA 12 have not yet been made available to Vineyard Wind

DMF also reports that recent stock assessments indicate that the whelk stock in Nantucket Sound is over fished, and overfishing is still occurring. The biomass index based on the DMF trawl survey has declined by over 70% since the early 1980s. Indeed, DMF biologists conducting sampling trips aboard commercial vessels fishing targeting channeled whelk in Nantucket Sound and Buzzards Bay since 2003 have identified a ⅜-inch decrease in the average size of channeled whelk observed. And, despite minimum legal size increases that occurred in 2014, 2015, and 2017, the average size has decreased and there are fewer whelk above the size at which females reach maturity than in previous years (DMF, 2017).

Vineyard Wind has consulted with shellfish constables in Yarmouth and Barnstable, DMF, and members of the commercial bay scallop and whelk fishing communities. These consultations will continue and will be useful for determining the extent of commercial fishing effort for these species. Project-related impacts along the OECC as they may impact the whelk fishery will be limited both in spatial extent and duration, and the Project will continue to avoid and minimize disturbance in coordination with DMF.

7.6.2.3 Baseline Economic Value of Fishing Activity in the Massachusetts Wind Energy Area

BOEM funded a study conducted by NOAA's Northeast Fisheries Center that characterizes commercial fishing from Maine to North Carolina and provides insight into revenue generated by federally permitted fishermen. (Kirkpatrick (2017), *Socio-Economic Impact of Outer Continental Shelf Wind Energy Development on Fisheries in the U.S. Atlantic*). The report details the average value of fish harvested over the six-year period between 2007 and 2012 and identifies the ports and fishery sectors (e.g., gear, species) supporting that activity. NOAA also developed a model to estimate the socio-economic impact of wind energy development on commercial fishermen. Making use of VTR data, spatial data from the Northeast Fisheries Observer Program database (NEFOP), and VMS data[25], the study provides information on commercial harvest by location, species caught, gear type, and port group. Using haul locations recorded by observers from 2004-2012, Kirkpatrick was able to model the area associated with the reported VTR point, and identify the proportion of catch that are sourced from within the MA WEA from any VTR record, or groups of VTR records. This methodology, ultimately, produced an estimate of revenue "exposure" within discrete geographic areas, including the MA WEA.

The following section describes commercial fisheries within the entire MA WEA based on Kirkpatrick's modelling of revenue exposure. The 306.01 km^2 (118.15 mi^2) WDA is only a small subset of the MA WEA; the WDA encompasses 45.3 percent of the entire Vineyard Wind Lease Area and only 10.2 percent of MA WEA. Fishery revenue exposure within the WDA, therefore, is expected to be a fraction of fishery revenue exposed within the MA WEA reported by Kirkpatrick (2017). As Kirkpatick notes, economic impacts depend upon many factors, including the ability of a given vessel to fish within the MA WEA as currently permitted by regulation. Vessels will not be precluded from operating within the WDA, with the exception of when temporary safety zones in the immediate vicinity of construction and installation vessels are imposed by the Coast Guard. Therefore, commercial fishing vessels may continue operations within the WDA as currently permitted. If commercial fishing vessels elect to avoid the WDA or OECC, alternative nearby fishing grounds are available. If alternative fishing grounds are accessed at no additional cost to vessels electing to operate outside the WDA or OECC, revenue may not be affected (Kirkpatrick, 2017).

Table 7.6-4 shows the percentage of each fishery management plan's revenue derived from the MA WEA between 2007 and 2012. According to Kirkpatrick (2017), between 2007 and 2012, the fisheries producing the most revenue from the MA WEA, as a percentage of the fishery's total revenue, are the Small Mesh Multispecies, Skate, Monkfish, Atlantic Surf Clam/Ocean Quahog fisheries. For other fisheries during those same years, revenue derived from the MA WEA, as a percentage of the fishery's total revenue, represented less than one percent of their respective total average annual revenue (Kirkpatrick, 2017).

[25] "Because the VMS is used to generate high resolution vessel-specific spatial data, VMS data were used only to analyze specific impacts where appropriate." (Kirkpatrick, 2017).

Table 7.6-4 Average Annual Revenue from the MA Wind Energy Area by Fishery Management Plan (2007-2012, Kirkpatrick et al. 2017)

Fisheries Management Plan	Average Annual Revenue from BOEM's Wind Energy Area	Average Total Revenue of Fishery	Percent of Fishery Revenue from BOEM's Wind Energy Area
Small Mesh Multispecies	$368,710	$10,675,728	3.5
Skate	$199,021	$7,796,915	2.6
Monkfish	$340,775	$19,759,447	1.7
Surf Clam/Ocean Quahog	$854,205	$64,967,095	1.3
Squid, Mackerel, Butterfish	$357,115	$40,849,295	.09
Atlantic Herring	$138,193	$21,241,713	0.6
Summer Flounder, Scup, Black Sea Bass	$158,752	$33,166,172	0.5

Kirkpatrick (2017) identified which species, as a percentage of the total average revenue generated from that species, were most exposed within the MA WEA. Table 7.6-5 identifies those species. As noted above, the WDA encompasses 10.2 percent of the geographic area of the MA WEA, and any estimate of a fishery's revenue from the WDA should be reduced accordingly.

Table 7.6-5 Average Annual Revenue from the MA Wind Energy Area by Species (2007-2012, Kirkpatrick et al. 2017)

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

Within the MA WEA, bottom trawl gear is used primarily for targeting species from the Small Mesh Multispecies Fisheries Management Plan. Silver Hake was the most abundant landing of the small mesh species sourced from the MA WEA (Kirkpatrick et al., 2017). Commercial fishermen have reported to Vineyard Wind representatives that Mackerel, Whiting, and, more recently, Butterfish are also targeted in the MA WEA; though Squid are the predominant landing from the Squid, Mackerel, Butterfish Fishery Management Plan.

Gillnet vessels in the MA WEA land primarily Monkfish, skates, and Spiny Dogfish (*Squalus acanthias*), as well as some species from the Summer Flounder, Scup and Black Sea Bass fisheries. Commercial fishermen have reported to Vineyard Wind that pot fisheries are active in MA WEA, however, landings and revenue from activity within MA WEA is characterized as low. For example, of the annual average revenue of over $212 million for Lobster harvested between 2007 and 2012, approximately $175,000 per year was harvested from the MA WEA (Kirkpatrick 2017). As mentioned before however, the data for the location of the lobster fishery is lacking.

Table 7.6-6 identifies the number of permits and revenue, by gear type, potentially exposed to development of the MA WEA. According to Kirkpatrick (2017), gear categories presented below are not mutually exclusive and an individual fisherman can be represented in multiple gear categories. The "unmanaged" category indicates revenue generated from species that are not included in a NMFS Fisheries Management Plan. The primary commercial fishing gear used in the MA WEA, by average annual revenue, are gillnet, bottom trawl, and dredge. Dredge gear is generally either scraping or hydraulic dredges and are most often used to harvest bivalves; in the Project Region dredge fishermen typically target Scallops, Atlantic Surf Clam, and Ocean Quahog. Most dredge revenue is landed in either Massachusetts or Rhode Island, while most bottom trawl revenue is landed in Rhode Island (Kirkpatrick et al., 2017).

Table 7.6-6 Number of Permits and Revenue, by Gear, Exposed to Development of the MA Wind Energy Area, 2007–2012 (Kirkpatrick et al. 2017)

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

Table 7.6-6 Number of Permits and Revenue, by Gear, Exposed to Development of the MA Wind Energy Area, 2007–2012 (Kirkpatrick et al. 2017) (Continued)

Gear	Permits	Average Annual Revenue	Average Annual Revenue from MA WEA	Percent Revenue from MA WEA	Top 4 FMPs	Top 5 Port Groups
Lobster Pot	114	$213,321,675	$282,692	0.1	Unmanaged;[d] Summer Flounder, Scup, Black Sea Bass;[c] Small Mesh Multispecies;[b] Large Mesh Multispecies[b]	New Bedford, MA; Newport, RI; Narragansett, RI; Sandwich, MA; Westport, MA
Bottom Trawl	234	$174,094,198	$1,032,021	0.6	Small Mesh Multispecies;[b] Squid, Mackerel, Butterfish;[a] Summer Flounder, Scup, Black Sea Bass;[a] Large Mesh Multispecies[b]	Narragansett, RI; Montauk, NY; New Bedford, MA; Tiverton, RI; Newport, RI
Mid-water Trawl	21	$21,384,152	$182,118	0.9	Atlantic Herring;[b] Squid, Mackerel, Butterfish;[a] Unmanaged;[d] Small Mesh Multispecies[b]	New Bedford, MA; Gloucester, MA; Fall River, MA; Narragansett, RI; North Kingstown, RI

[a] MAFMC; [b] NEFMC; [c] Joint NEFMC and MAFMC management; [d] Unmanaged species; [e] Atlantic Highly Migratory Species management

7.6.2.4 Baseline Economic Value of Fishing Activity in the Vineyard Wind Lease Area

As noted above, the 306.01 km^2 (118.15 mi^2) WDA encompasses only 45.3 percent of the entire Lease Area. Determining a precise allocation of fishery revenue exposure within the WDA can be reasonably estimated and is anticipated to be a fraction of the value estimated for the Lease Area.

DEM conducted a study in response to concerns by the Rhode Island fishing industry that the economic values of the fisheries were underestimated by BOEM, particularly as they related to the New York Call Area, because the data used to describe commercial fishing activity were said to be inadequate. DEM conducted a separate analysis of the New York Wind Energy Area (NY WEA) and further refined the methodology of that analysis to produce a more comprehensive analysis referred herein as the Livermore (2017) study.

The Livermore study made use of VMS data for a larger portion of the North Atlantic, as well as VTRs and landings data for New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, and New Jersey for the years of 2011 through 2016. Livermore (2017), acknowledging certain limitations of VTR-based analysis of fishing effort, notably the potential for imprecise location attributes, conducted the analysis of the MA WEA such that VMS, VTR, and commercial landings datasets were linked. The combined data were additionally subsetted by fishery (species, gear, state and port landings) and mapped as a raster of fishing density by year. In addition to providing more robust locational information through the incorporation of the VMS dataset, Livermore (2017) was able to scale the landings based on the density of fishing activity within the MA WEA during a given year, thereby providing a unique estimate of fishery revenue within specific geographic areas of the MA WEA, including the Vineyard Wind Lease Area.

Livermore (2017), assuming all fishing activity is not equal and by using the fishing density maps described above, was able to scale commercial landings by the amount of fishing activity within the Lease Area per trip. Each individual fishing location point within a trip was weighted by the fishing density map for that fishery that year, placing higher weights on points where the fishing density was higher. According to Livermore (2017), this strategy makes the assumption that fishermen target areas that are most profitable (i.e. where species abundances are higher).

Table 7.6-7 Estimated Annual Landings from Lease Area by State (2011-2016; Livermore [2017])

State	2011	2012	2013	2014	2015	2016	Non-Confidential Total in Lease Area
Connecticut	$35,943.23	$23,679.76	$36,764.79	$19,297.48	-	$51,530.60	$167,215.86
Massachusetts	$112,425.43	$987,431.20	$551,972.38	$199,069.54	$247,676.22	$675,235.18	$2,773,809.95
New Jersey	-	$3.64	-	$498.63	$19,335.96	$49,531.51	$69,369.74
New York	$3,439.51	$13,965.63	$26,489.39	$673.67	$10,819.09	$166,145.53	$221,532.81
Rhode Island	$56,401.42	$53,035.97	$159,040.67	$257,132.80	$245,168.64	$1,142,581.23	$1,913,360.73

Notes: (-) = no landings.

Livermore identified 24 ports with landings from the Lease Area, though only four of those ports had non-confidential landings from the Lease Area. Those ports and the associated landings are identified in Table 7.6-8, below. Livermore found that between 2011 and 2016, fishing activity in the Lease Area results in landings primarily in New Bedford, Massachusetts and Point Judith, Rhode Island. For the six years of data analyzed, vessels landed an estimated annual average value of $407,160 in New Bedford and $313,847 in Point Judith from the Lease Area. Estimated annual landings, by state, from the Lease Area are presented in Table 7.6-7. Again, the WDA encompasses less than half of the Lease Area and estimates of landings from the WDA should be reduced accordingly.

Table 7.6-8 Estimated Annual Landings by Port (2011-2016; Livermore [2017])

Port	2011	2012	2013	2014	2015	2016	Non-Confidential Total in Lease Area
Chatham, MA	$65,332.05	$97,471.16	$37,237.08	$21,321.88	C	C	$221,362.17
Montauk, NY	C	C	$24,372.87	C	$9,067.00	$118,652.10	$152,091.97
New Bedford, MA	$37,705.15	$884,492.00	$513,661.67	$177,570.24	$215,194.22	$615,985.94	$2,444,609.22
Point Judith, RI	$54,172.29	$52,724.30	$150,418.90	$257,070.74	$245,168.64	$1,111,489.95	$1,871,044.82

Notes: (C) = confidential landings. The 69 reports of confidential landings for all 24 ports during the years studied are $451,152.08.

Recognizing the importance of certain species and/or Fisheries Management Plans to specific ports within the Project Region, namely Squid and Sea Scallops, Table 7.6-9 identifies the estimated annual landings of those species from the Lease Area. Livermore, however, identifies landings from a total of 21 species and/or Fishery Management Plans from within the Lease Area.

Table 7.6-9 Estimated Annual Landings by Fishery Management Plan (2011-2016; Livermore [2017])

Fishery Management Plan	2011	2012	2013	2014	2015	2016	Non-Confidential Total in Lease Area
Sea Scallop	$486,967	$42,904	C	$860,827	$123,921	$3,768	1,518,405
Squid, Mackerel, Butterfish	$111,097	$132,054	$19,930	$21,504	$65,001	$1,371,305	1,720,891

Notes: (C) = confidential landings. The 38 reports of confidential landings for all 21 species/Fisheries Management Plans during the years studied total less than $66,626.23.

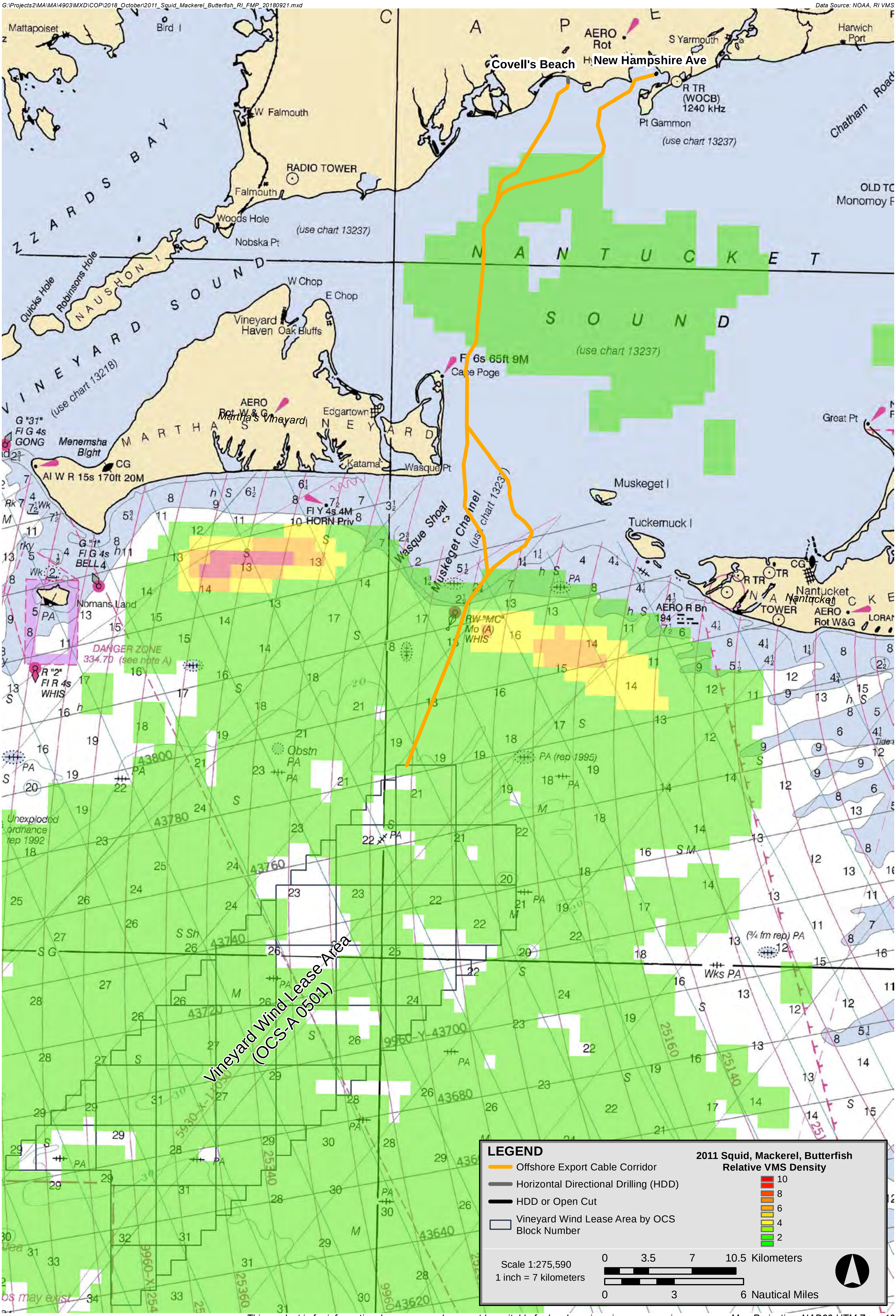
Finally, Livermore identified six different gear types with landings from within the Lease Area. Only three of those gear types had non-confidential landings, which are shown in Table 7.6-10, below.

Table 7.6-10 Estimated Annual Landings by Gear Type (2011-2016; Livermore [2017])

Fishery Management Plan	2011	2012	2013	2014	2015	2016	Non-Confidential Total in Lease Area
DREDGE, SCALLOP	C	$860,813.02	$487,985.38	$123,480.82	$42,929.62	C	$1,515,208.84
GILL NET, SINK	$72,630.77	$105,557.14	$48,131.90	$21,447.60	$41,888.11	$67,574.28	$357,229.80
OTTER TRAWL, BOTTOM, FISH	$114,166.51	$109,599.42	$226,370.35	$331,493.73	$438,182.18	$1,981,018.41	$3,200,830.60

Notes: (C) = confidential landings. The 9 reports of confidential landings for all gear types during the years studied total $72,019.83.

Relative annual fishing vessel density, as calculated by DEM, for the Squid, Mackerel, Butterfish Fishery Management Plan between 2011 and 2016 are provided as Figures 7.6-24 to 7.6-30. Figure 7.6-30 depicts the cumulative density of fishing vessels for the same years within that Fishery Management Plan. Consistent with the NROC and MARCO data, relative vessel density within the Lease Area for each year analyzed was low, with the highest densities occurring outside and to the north of the WDA. Portions of the OECC south traversed areas of medium and high vessel density in 2013 and 2014 south of Muskeget Channel.



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Figure 7.6-24

DEM – Squid, Mackerel, Butterfish 2011 Commercial Fishing Density

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Data Source: NOAA, RI VMS

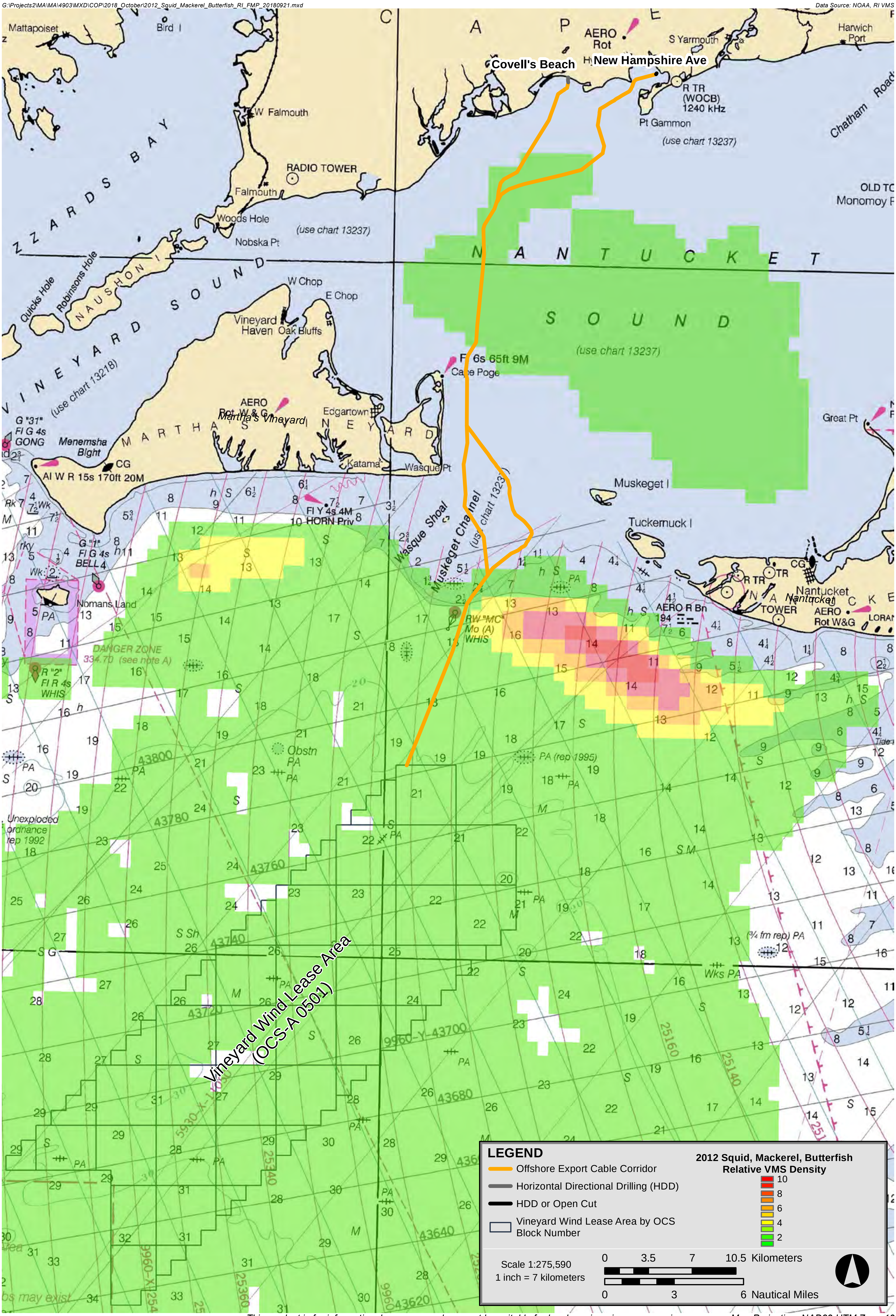

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Figure 7.6-25

DEM – Squid, Mackerel, Butterfish 2012 Commercial Fishing Density

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Data Source: BOEM, RI VMS

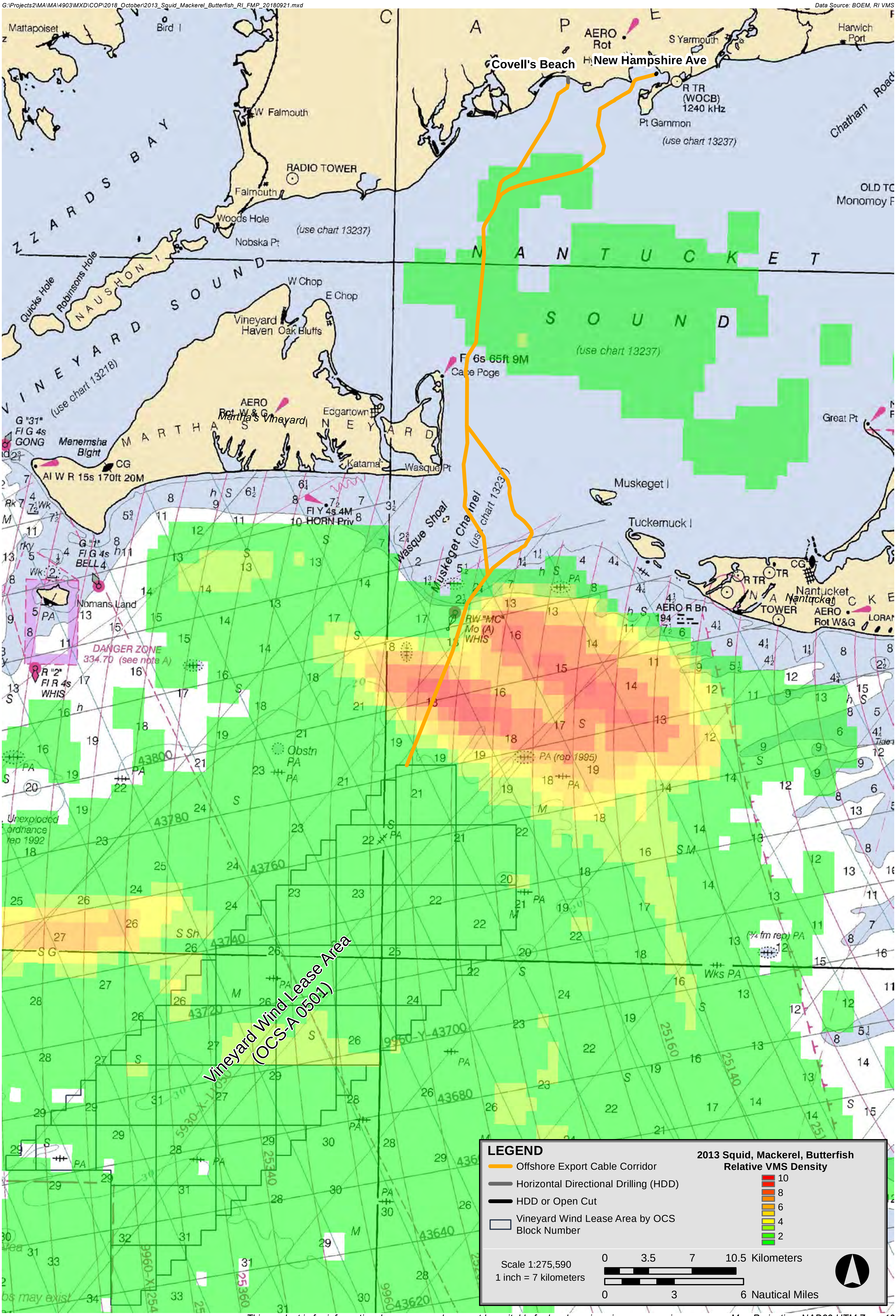

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Figure 7.6-26

DEM – Squid, Mackerel, Butterfish 2013 Commercial Fishing Density

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Data Source: BOEM, RI VMS

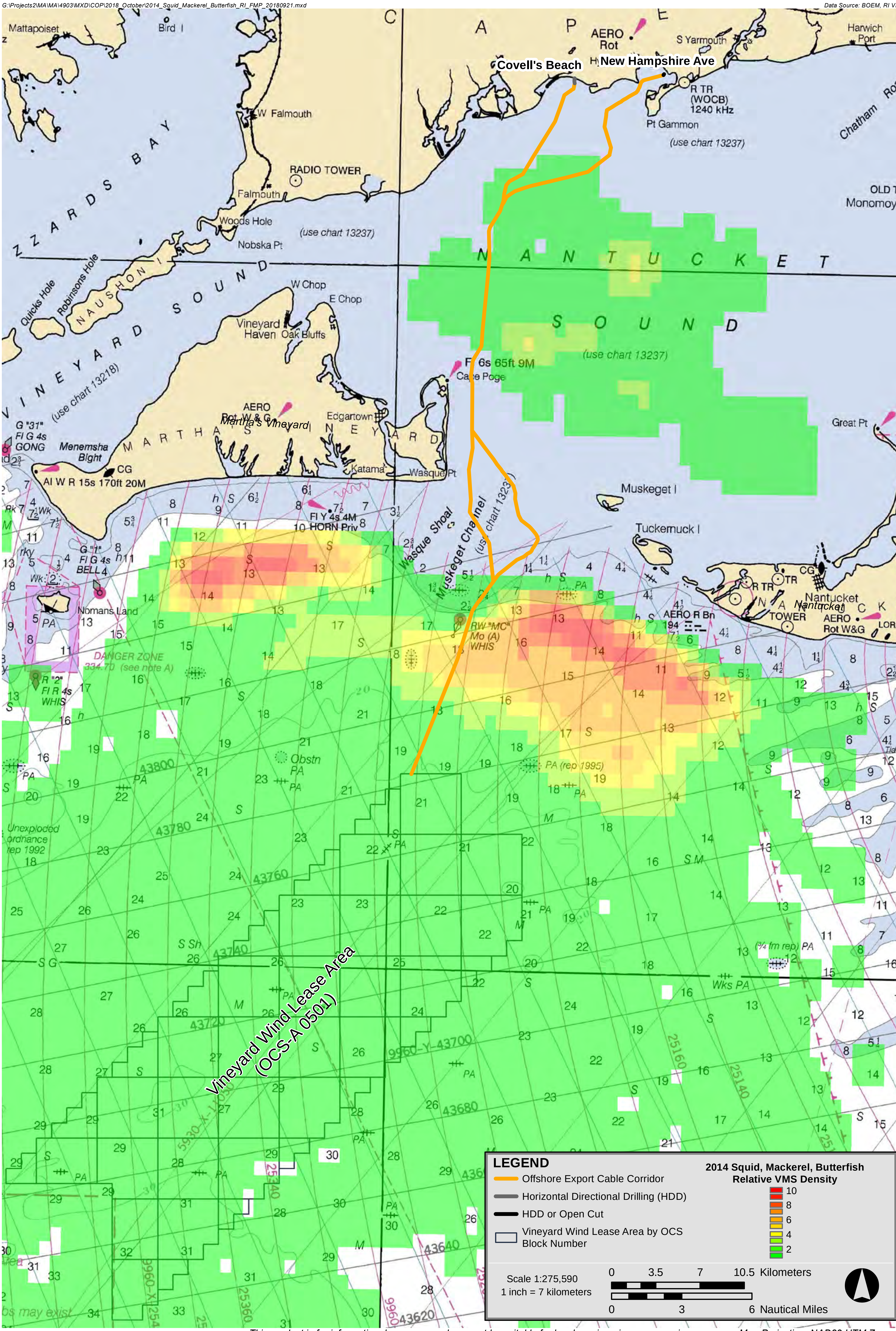

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Figure 7.6-27

DEM – Squid, Mackerel, Butterfish 2014 Commercial Fishing Density

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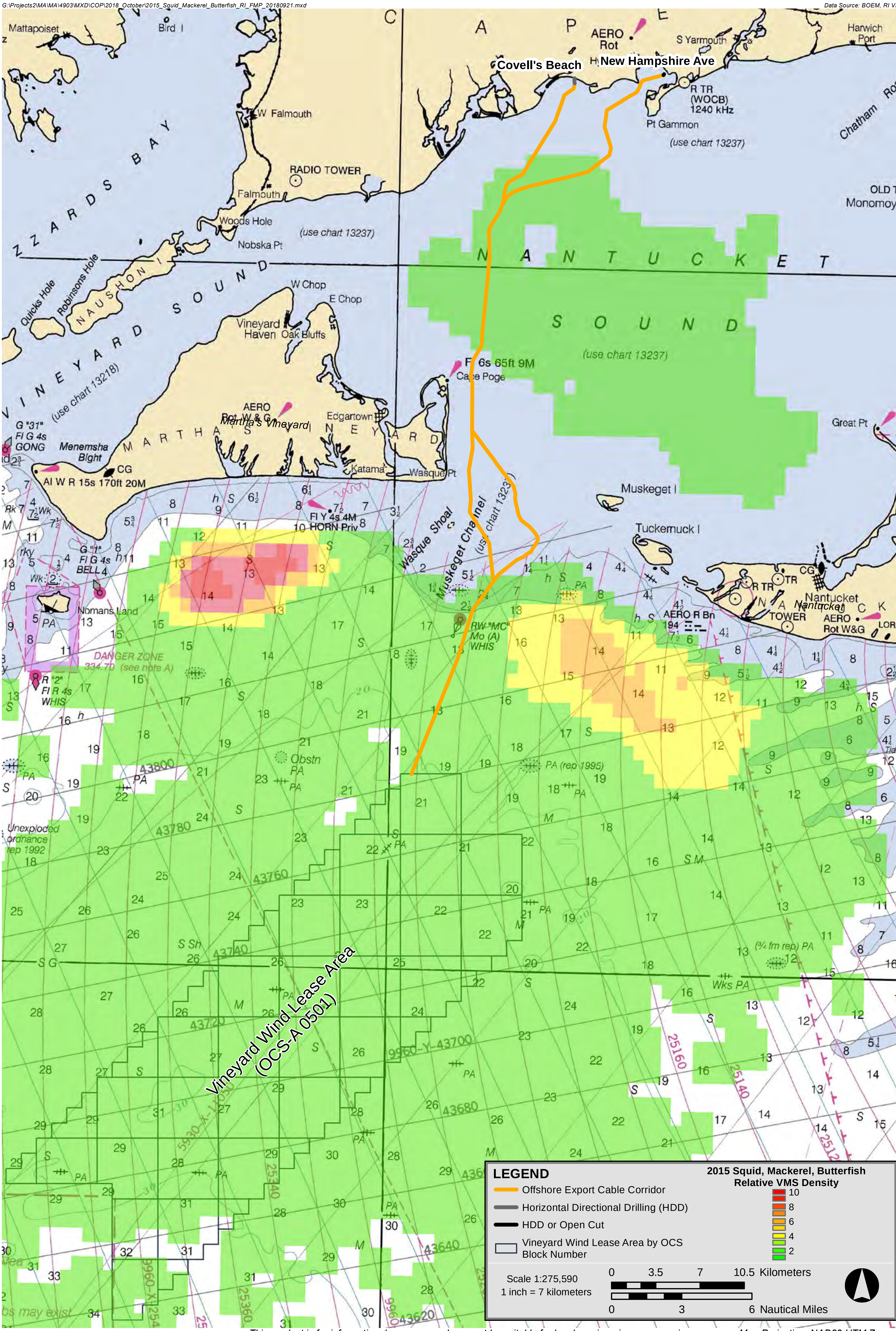
Data Source: BOEM, RI VMS



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Vineyard Wind Project

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Figure 7.6-28

DEM – Squid, Mackerel, Butterfish 2015 Commercial Fishing Density

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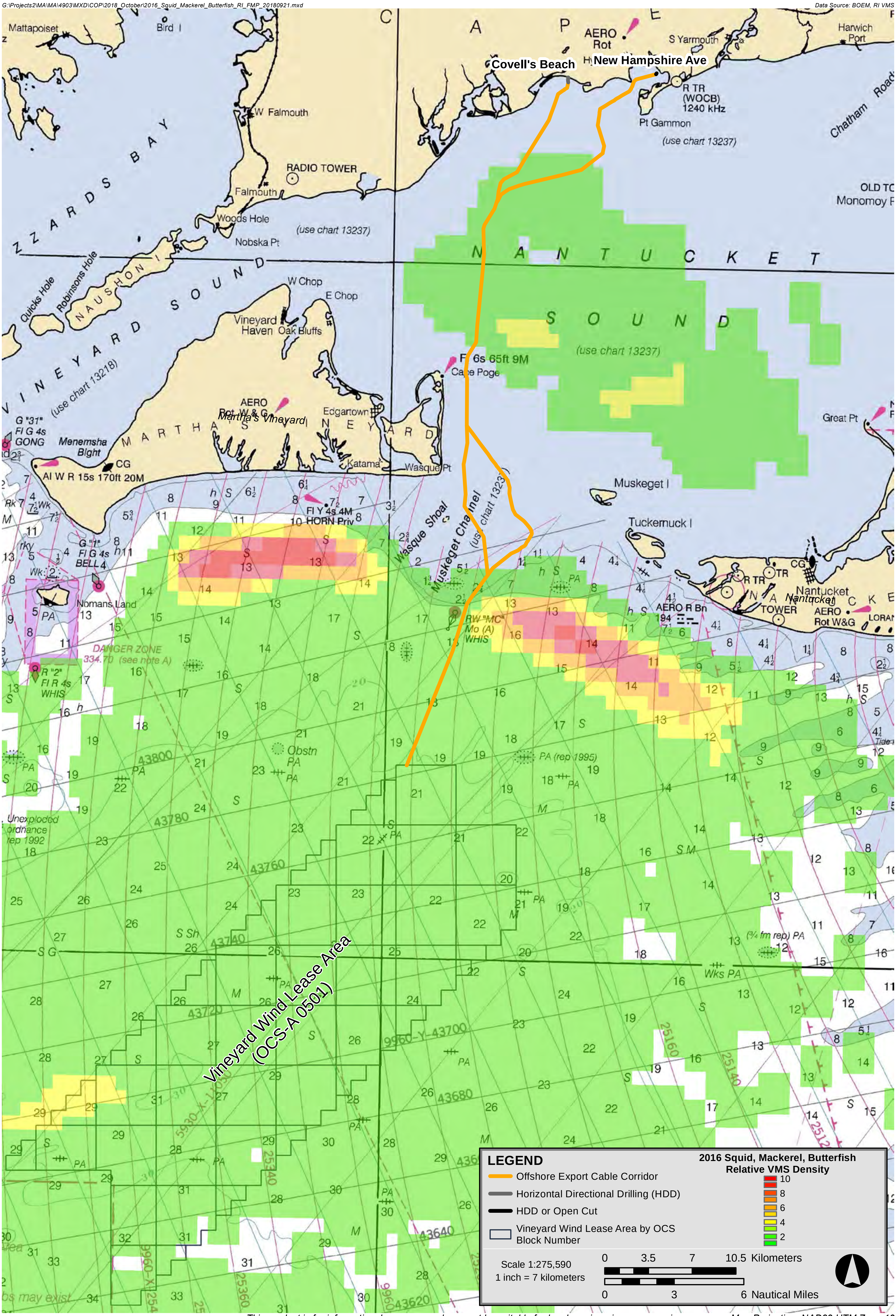
Data Source: BOEM, RI VMS



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Vineyard Wind Project

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Figure 7.6-29

DEM – Squid, Mackerel, Butterfish 2016 Commercial Fishing Density

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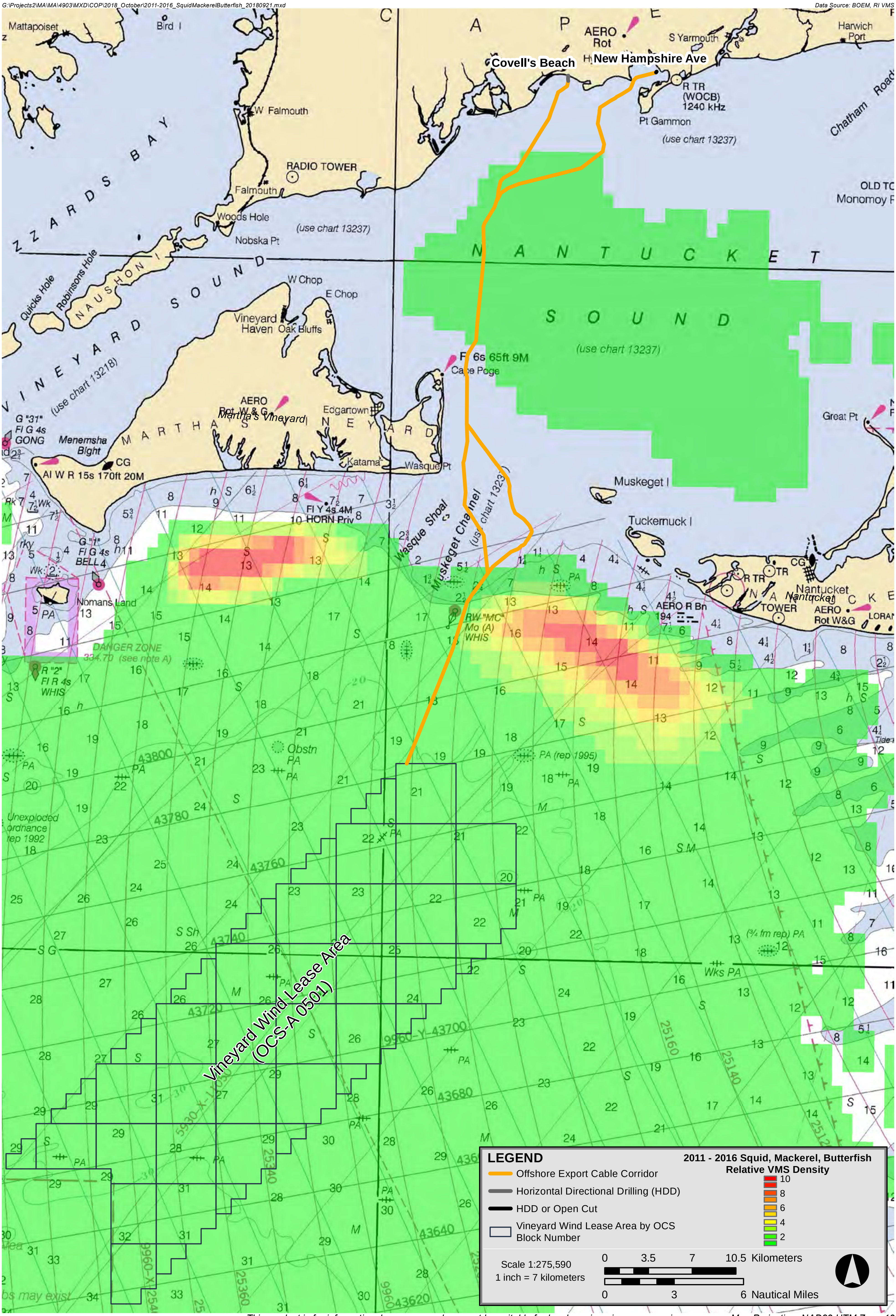
Data Source: BOEM, RI VMS



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

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Figure 7.6-30

DEM – Squid, Mackerel, Butterfish 2011-2016 Commercial Fishing Density

Relative annual fishing vessel density, as calculated by DEM, for vessels operating within the Sea Scallop Fishery Management Plan between 2011 and 2016 are provided as Figure 7.6-31 to figure 7.6-37. Figure 7.6-37 depicts the cumulative fishing vessel density for the same years within that Fishery Management Plan. In each year analyzed, limited areas of low relative vessel density in this fishery were identified within the WDA and along the OECC. Based on the parameters of this analysis, certain portions of the WDA and OECC did not register vessel density in this fishery.

Relative annual fishing vessel density, as calculated by DEM, for vessels operating within the Northeast Multispecies Fishery Management Plan between 2011 and 2016 are provided as Figure 7.6-38 to figure 7.6-44. Figure 7.6-44 depicts the cumulative fishing vessel density for the same years within that Fishery Management Plan. In each year analyzed, limited areas of low relative vessel density in this fishery were identified within the WDA and along the OECC. Based on the parameters of this analysis, certain portions of the WDA and OECC did not register vessel density in this fishery.

Relative annual fishing vessel density, as calculated by DEM, for vessels operating within the Monkfish Fishery Management Plan between 2011 and 2016 are provided as Figure 7.6-45 to figure 7.6-51. Figure 7.6-51 depicts the cumulative fishing vessel density for the same years within that Fishery Management Plan. With the exception of 2016, limited areas of low relative vessel density in this fishery were identified within the WDA and along the OECC. In 2013, a small area of elevated vessel density was reported along the OECC south of Muskeget Channel.

7.6.3 Fishery Impacts In and Around the Wind Development Area

As described in Section 6.6.2, impacts to finfish and invertebrates, including those species targeted by commercial fishermen within the WDA, are expected to be short-term and localized during the construction and installation phase of the Project. Given that construction and installation activities will occur within very limited and well-defined areas of the WDA and no vessel restrictions are proposed other than those imposed by the US Coast Guard (USCG) in the immediate vicinity of the construction and installation vessels, the majority of the WDA will remain accessible to commercial fishing vessels throughout the construction and installation process and, indeed, throughout the anticipated lifespan of the Project.

It should be noted that the existing low total fish biomass within the WDA, coupled with the high species richness in the Offshore Project Area reduces the relative impact of the Project on commercially harvested species within the WDA. Low biomass within the WDA, suggesting decreased efficiencies within certain fisheries, may preclude productive harvesting from within the WDA even before construction and installation activities commence. Nonetheless, the species that may be impacted by construction and installation

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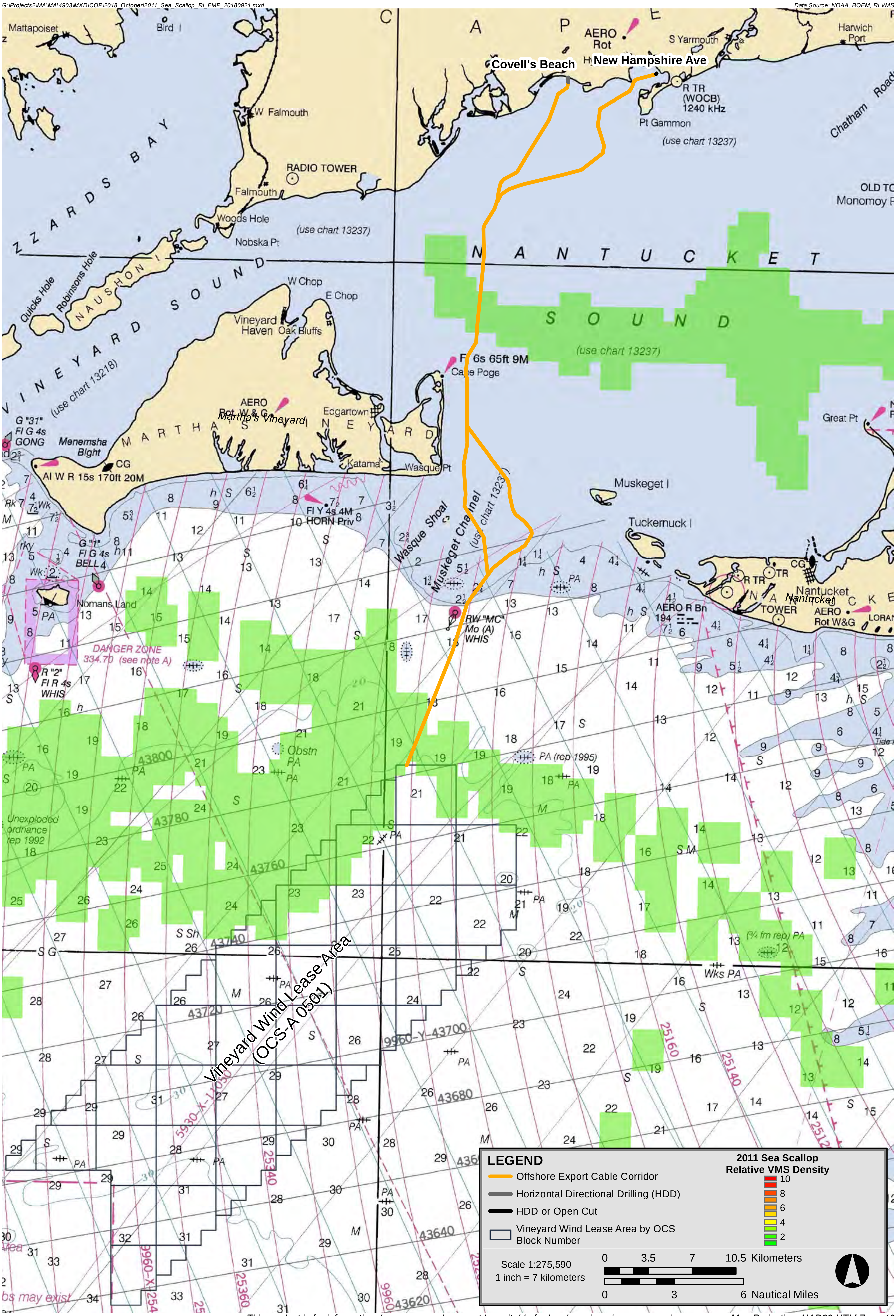
Data Source: NOAA, BOEM, RI VMS



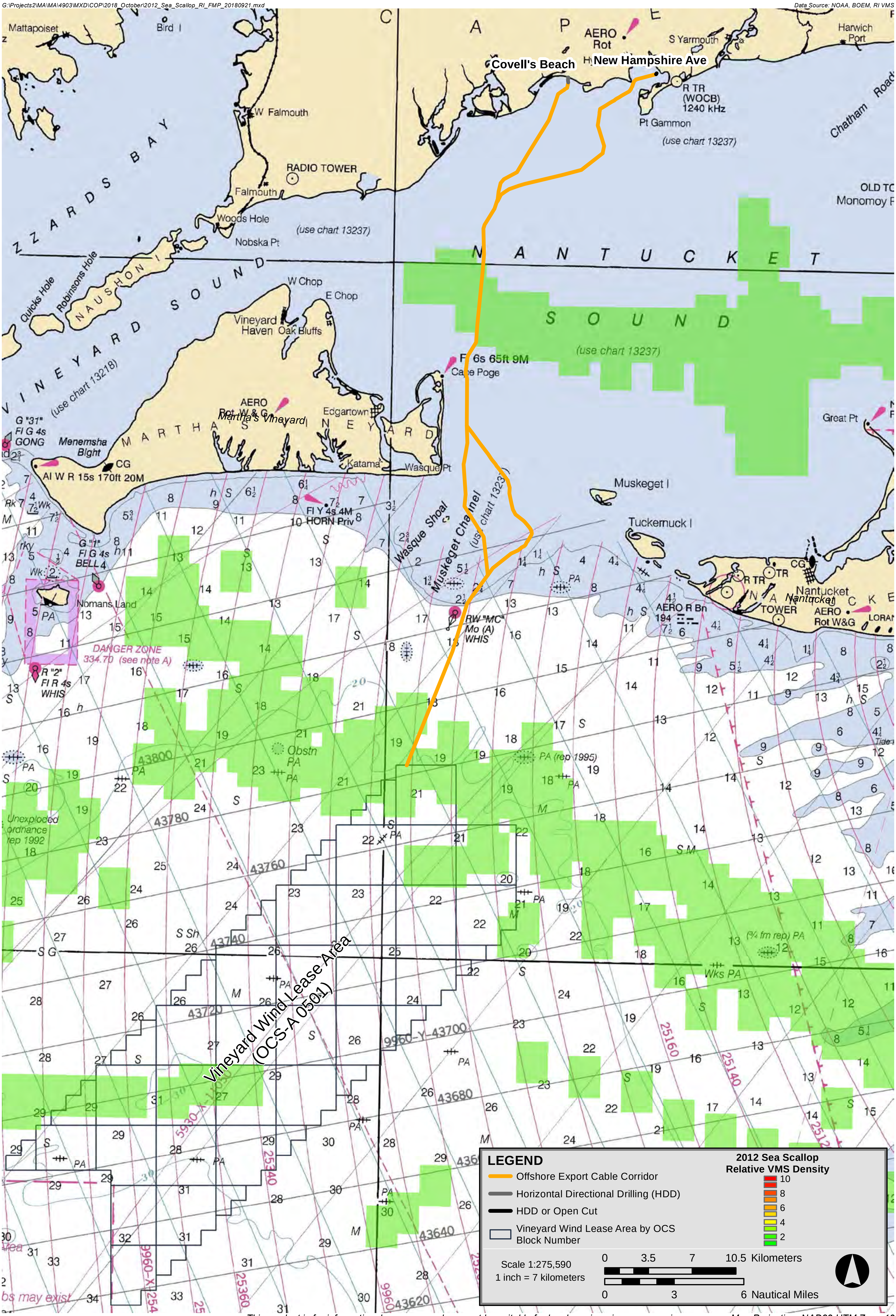
This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-31

DEM – Sea Scallop 2011 Commercial Fishing Density



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-32

DEM – Sea Scallop 2012 Commercial Fishing Density

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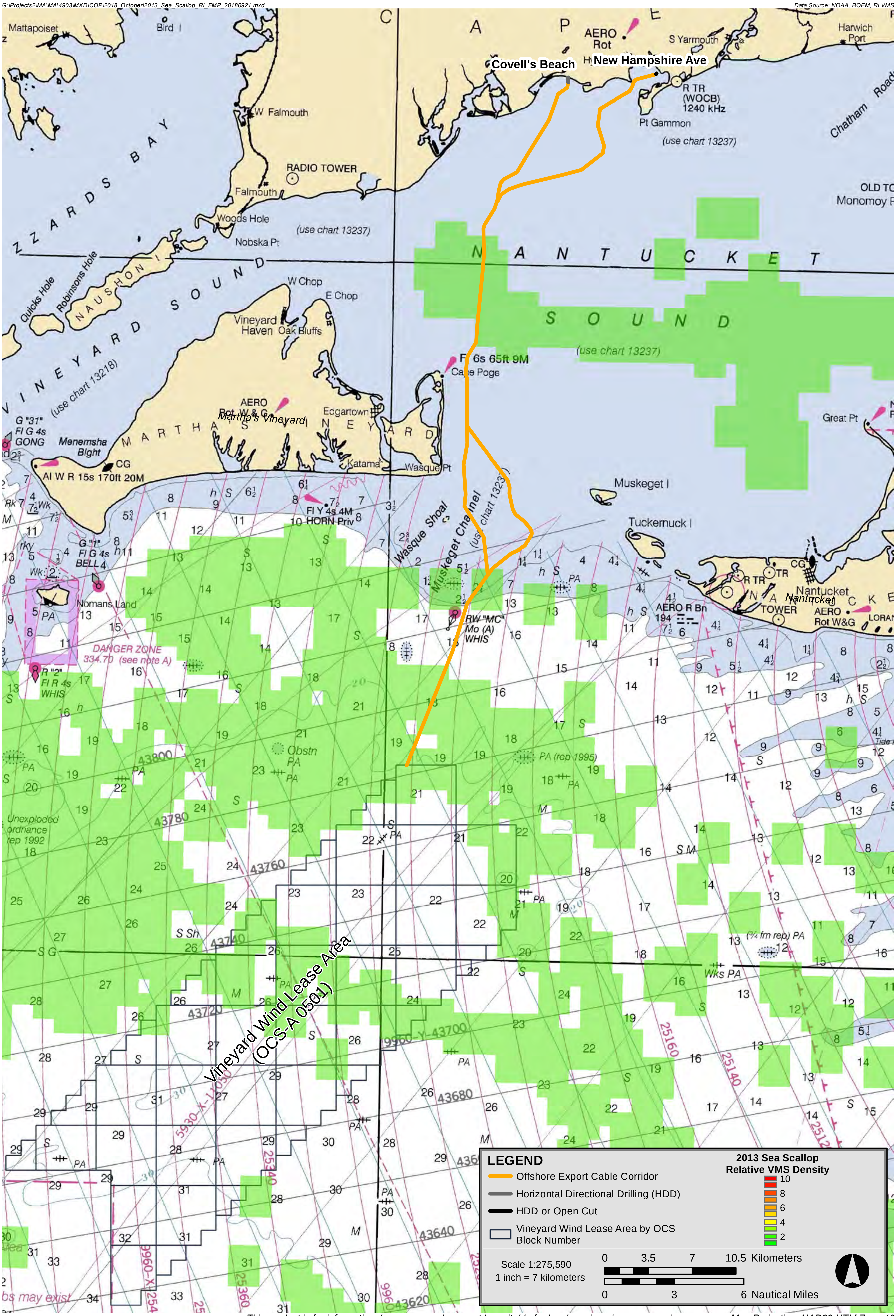
Data Source: NOAA, BOEM, RI VMS



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

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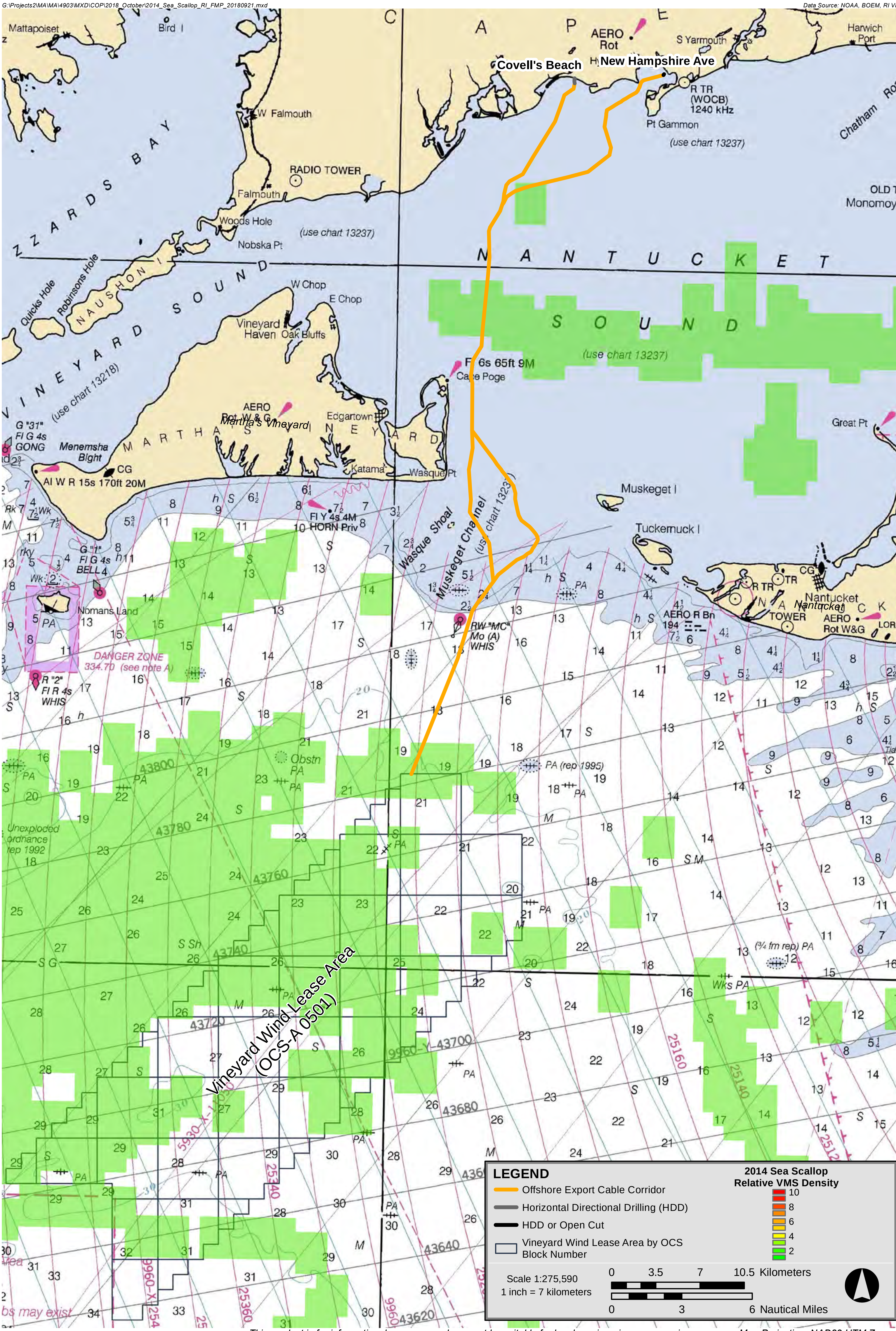
Figure 7.6-33

DEM – Sea Scallop 2013 Commercial Fishing Density



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Vineyard Wind Project

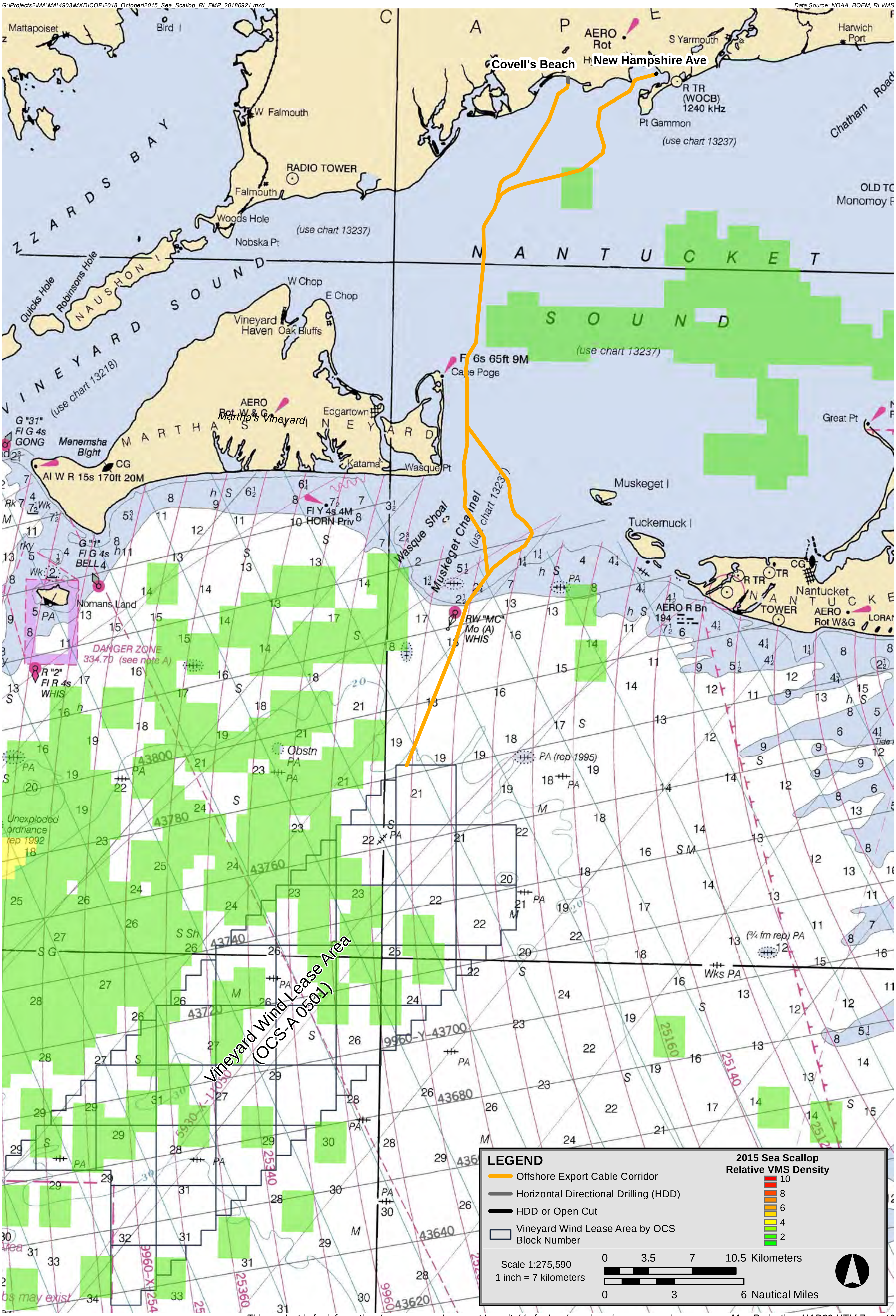
VINEYARD WIND

Figure 7.6-34

DEM – Sea Scallop 2014 Commercial Fishing Density

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\2015_Sea_Scallop_RI_FMP_20180921.mxd

Data Source: NOAA, BOEM, RI VMS



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Vineyard Wind Project

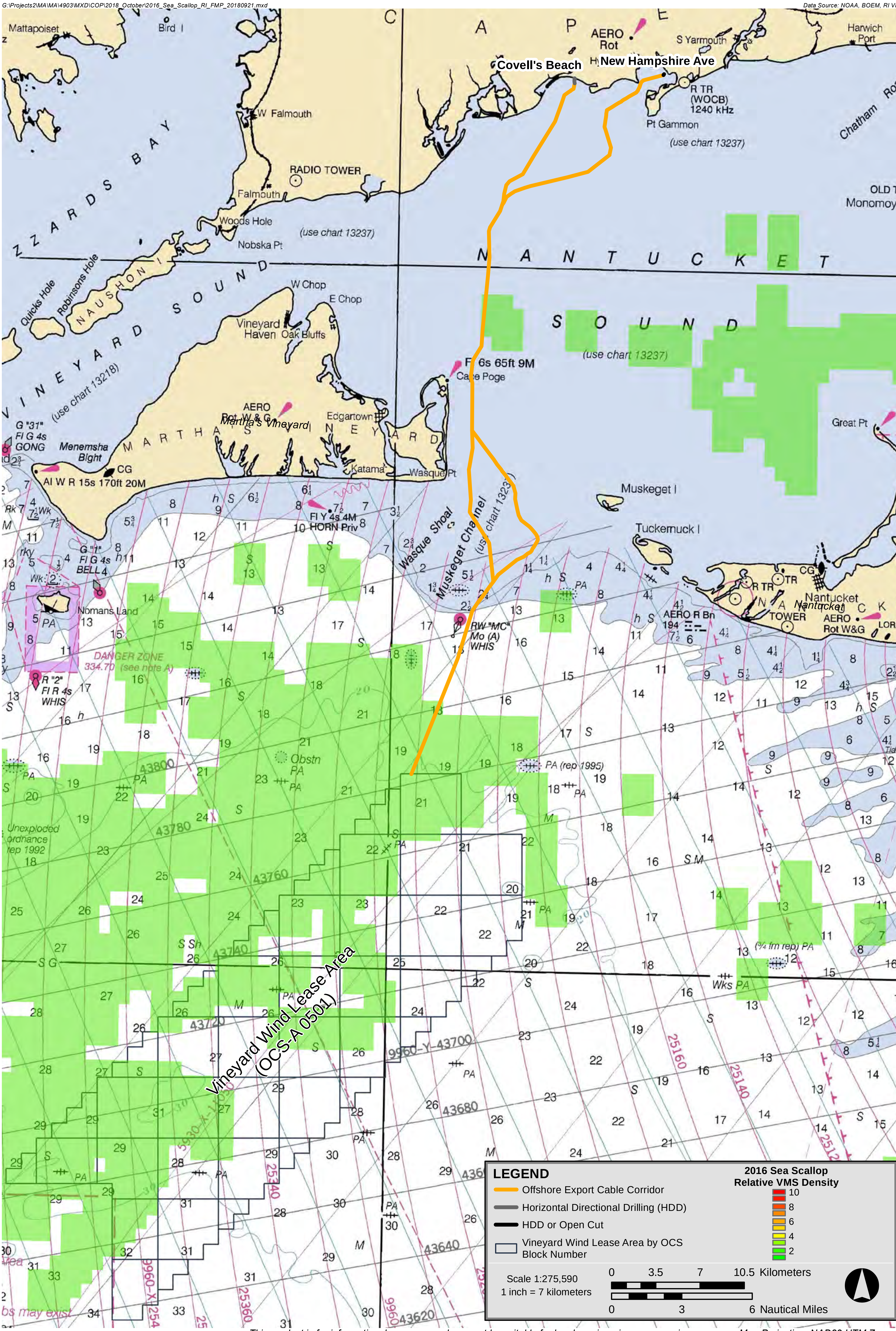
VINEYARD WIND

Figure 7.6-35

DEM – Sea Scallop 2015 Commercial Fishing Density

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\2016_Sea_Scallop_RI_FMP_20180921.mxd

Data Source: NOAA, BOEM, RI VMS



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Vineyard Wind Project

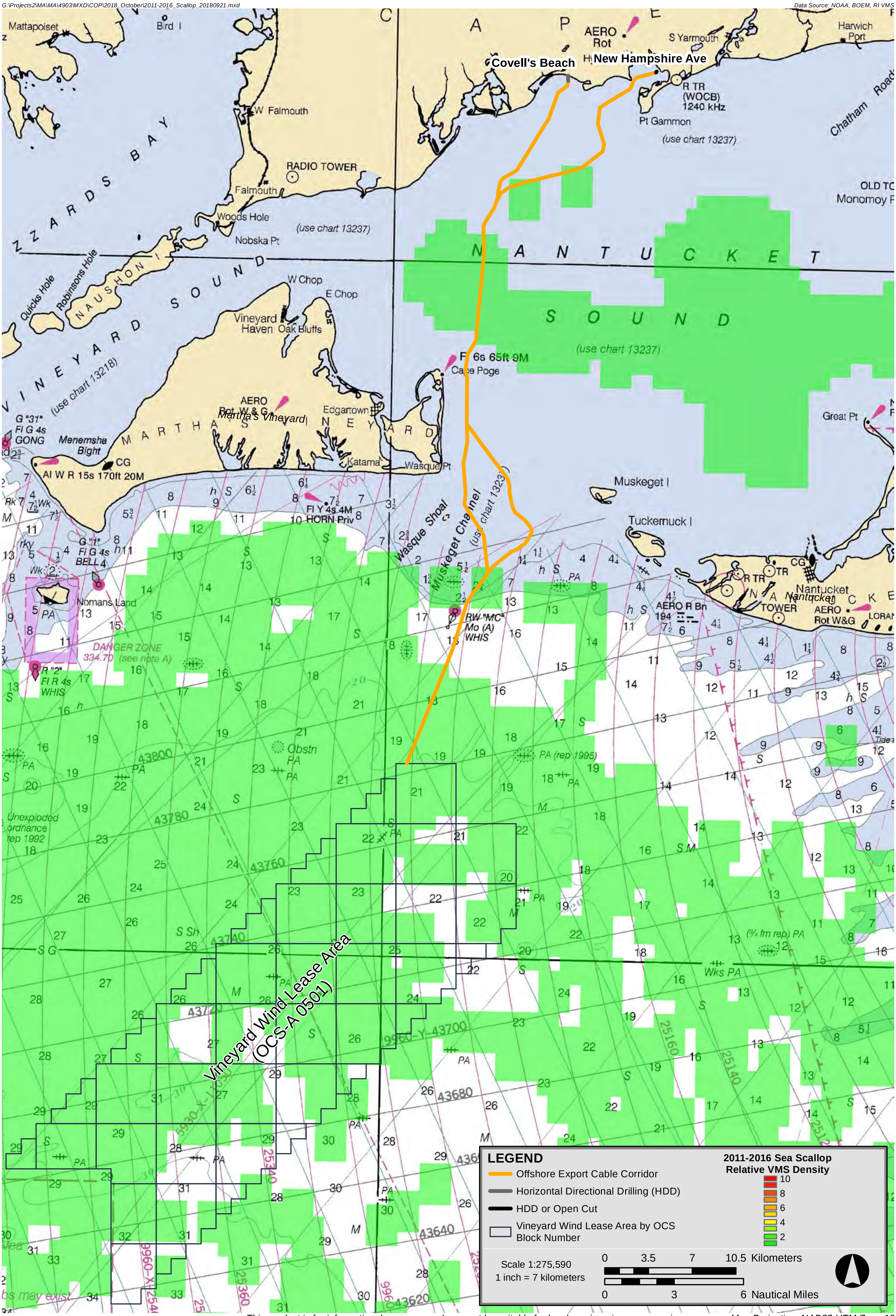
VINEYARD WIND

Figure 7.6-36

DEM – Sea Scallop 2016 Commercial Fishing Density

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\2011-2016_Scallop_20180921.mxd

Data Source: NOAA, BOEM, RI VMS



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Vineyard Wind Project

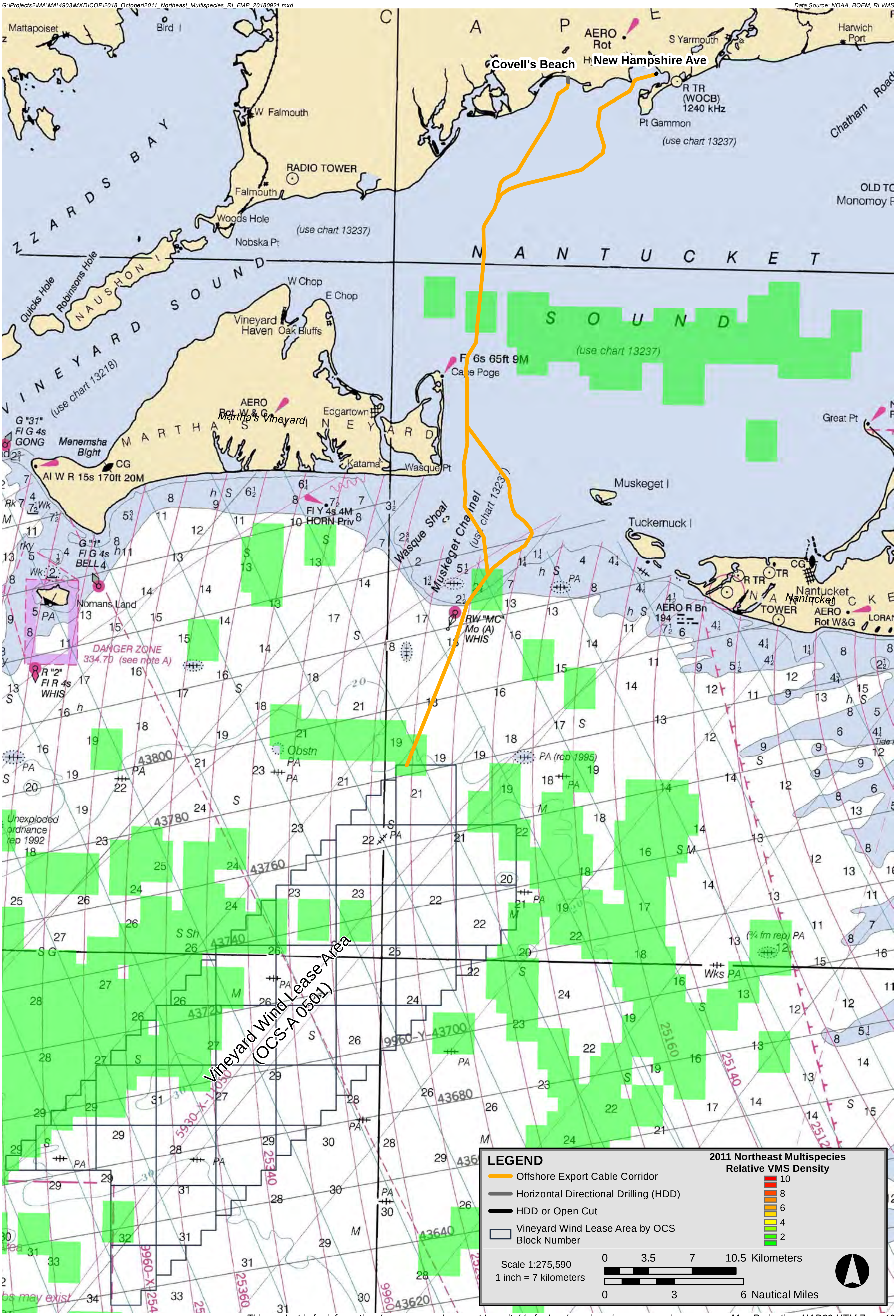
VINEYARD WIND

Figure 7.6-37

DEM - Scallop 2011-2016 Commercial Fishing Density

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\2011_Northeast_Multispecies_RI_FMP_20180921.mxd

Data Source: NOAA, BOEM, RI VMS



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Vineyard Wind Project

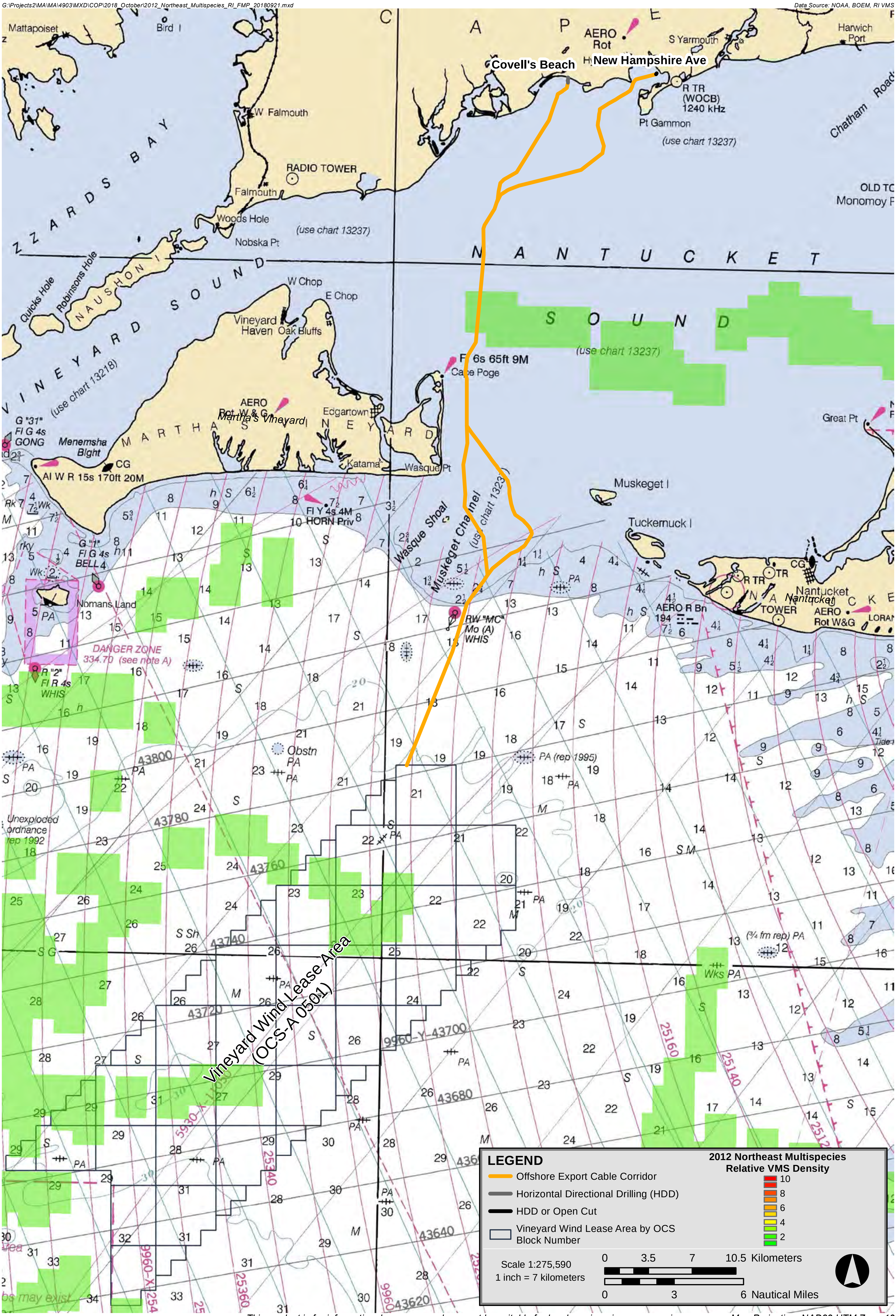
VINEYARD WIND

Figure 7.6-38

DEM – Northeast Multispecies 2011 Commercial Fishing Density

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\2012_Northeast_Multispecies_RI_FMP_20180921.mxd

Data Source: NOAA, BOEM, RI VMS



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Vineyard Wind Project

VINEYARD WIND

Figure 7.6-39

DEM – Northeast Multispecies 2012 Commercial Fishing Density

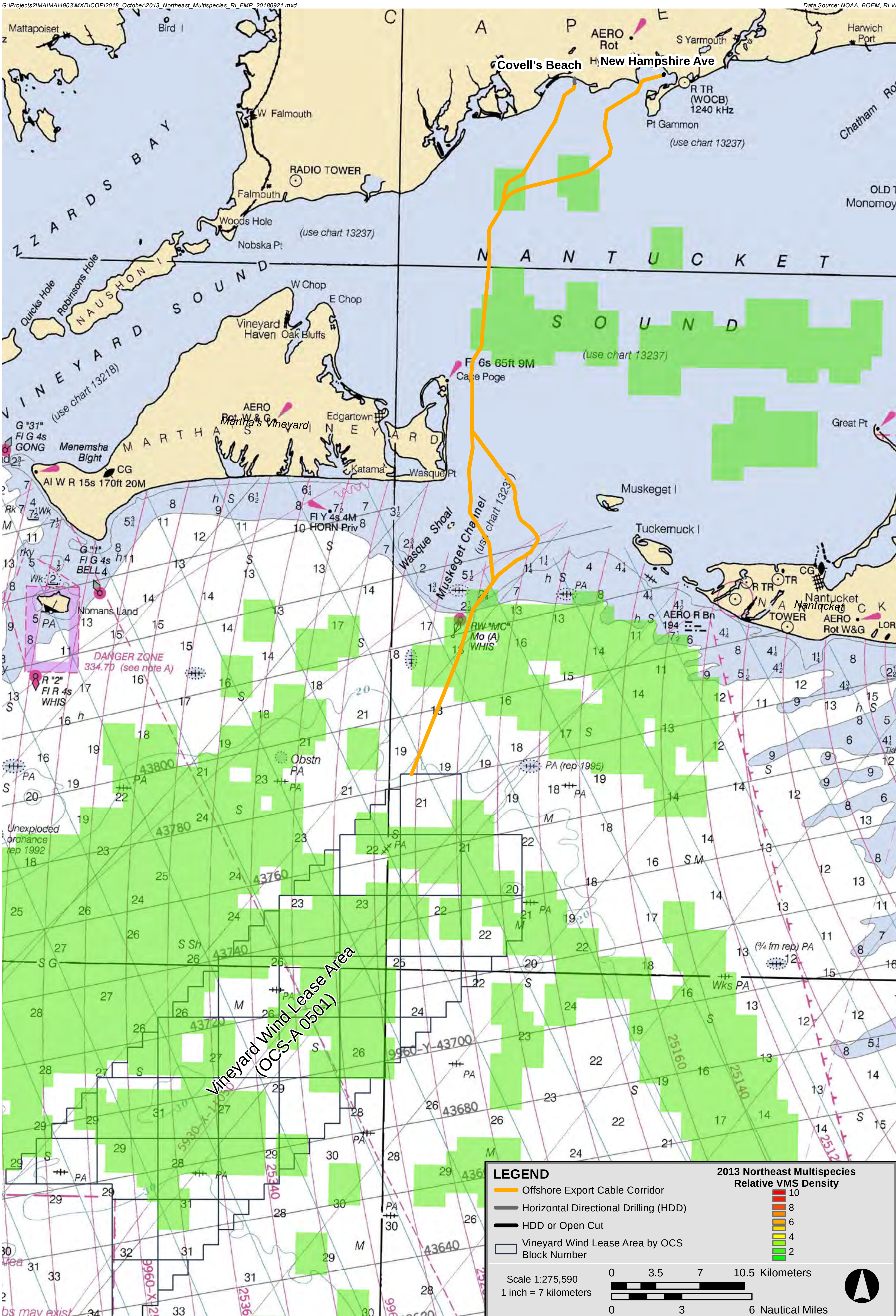

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Figure 7.6-40

DEM – Northeast Multispecies 2013 Commercial Fishing Density

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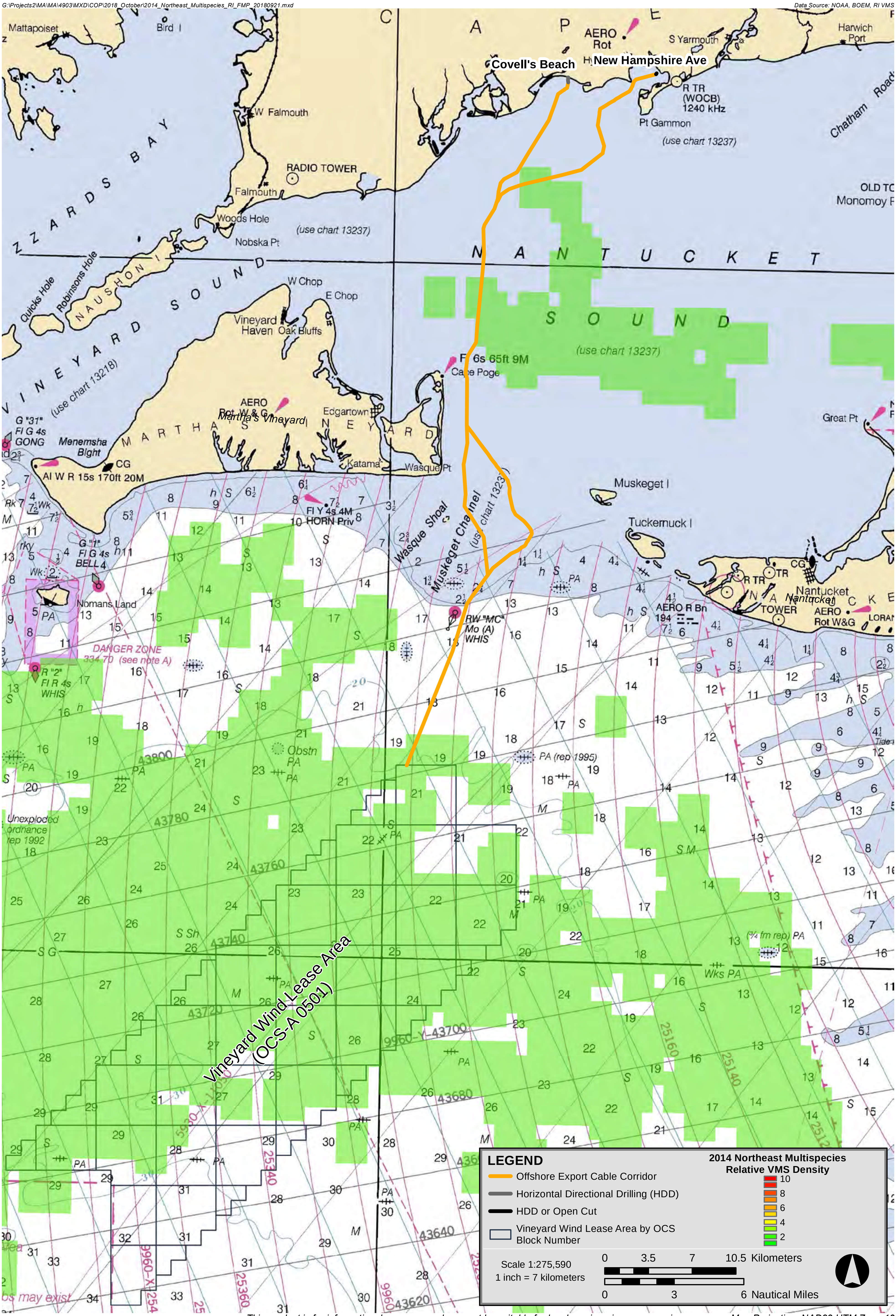
Data Source: NOAA, BOEM, RI VMS



This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

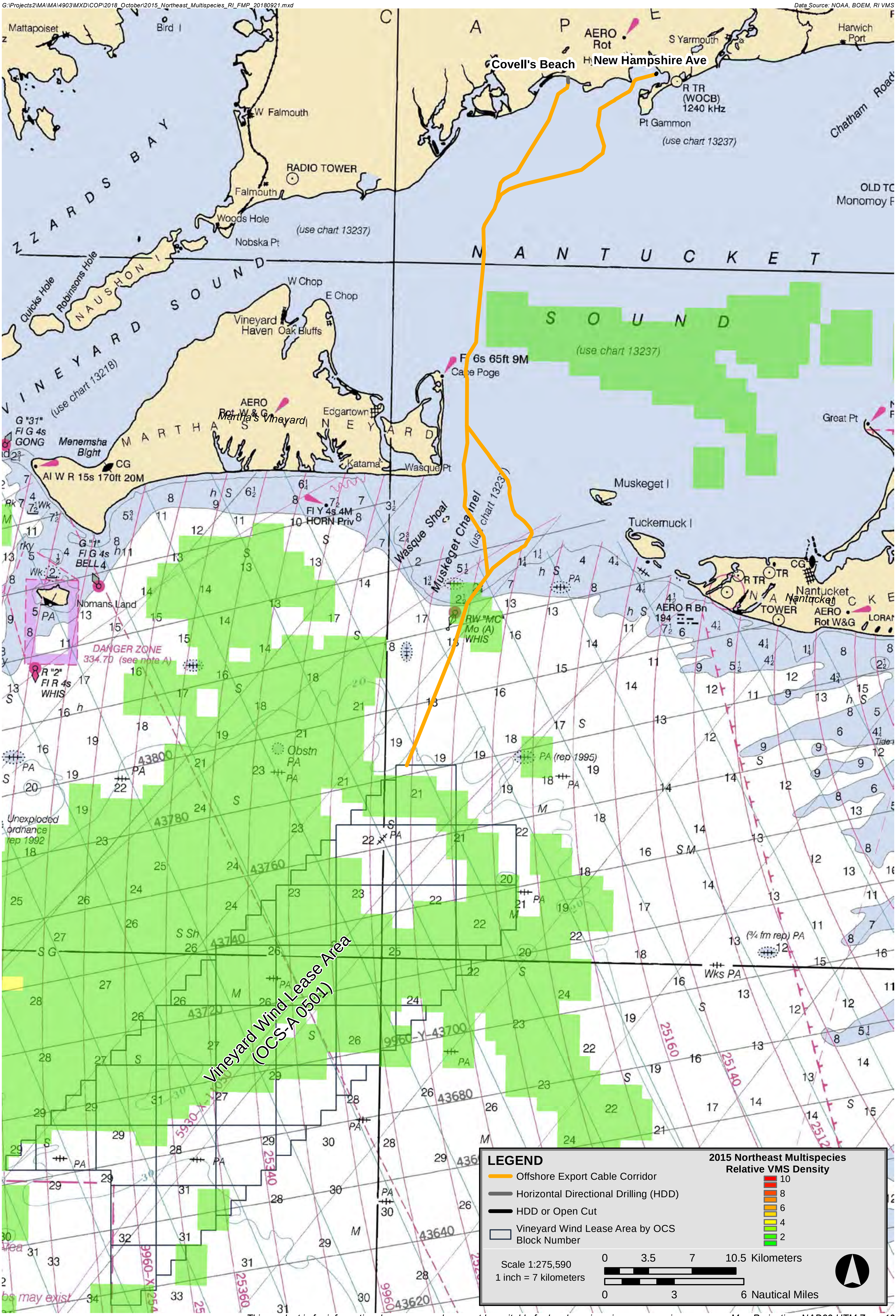
VINEYARD WIND

Figure 7.6-41

DEM – Northeast Multispecies 2014 Commercial Fishing Density

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\2015_Northeast_Multispecies_RI_FMP_20180921.mxd

Data Source: NOAA, BOEM, RI VMS



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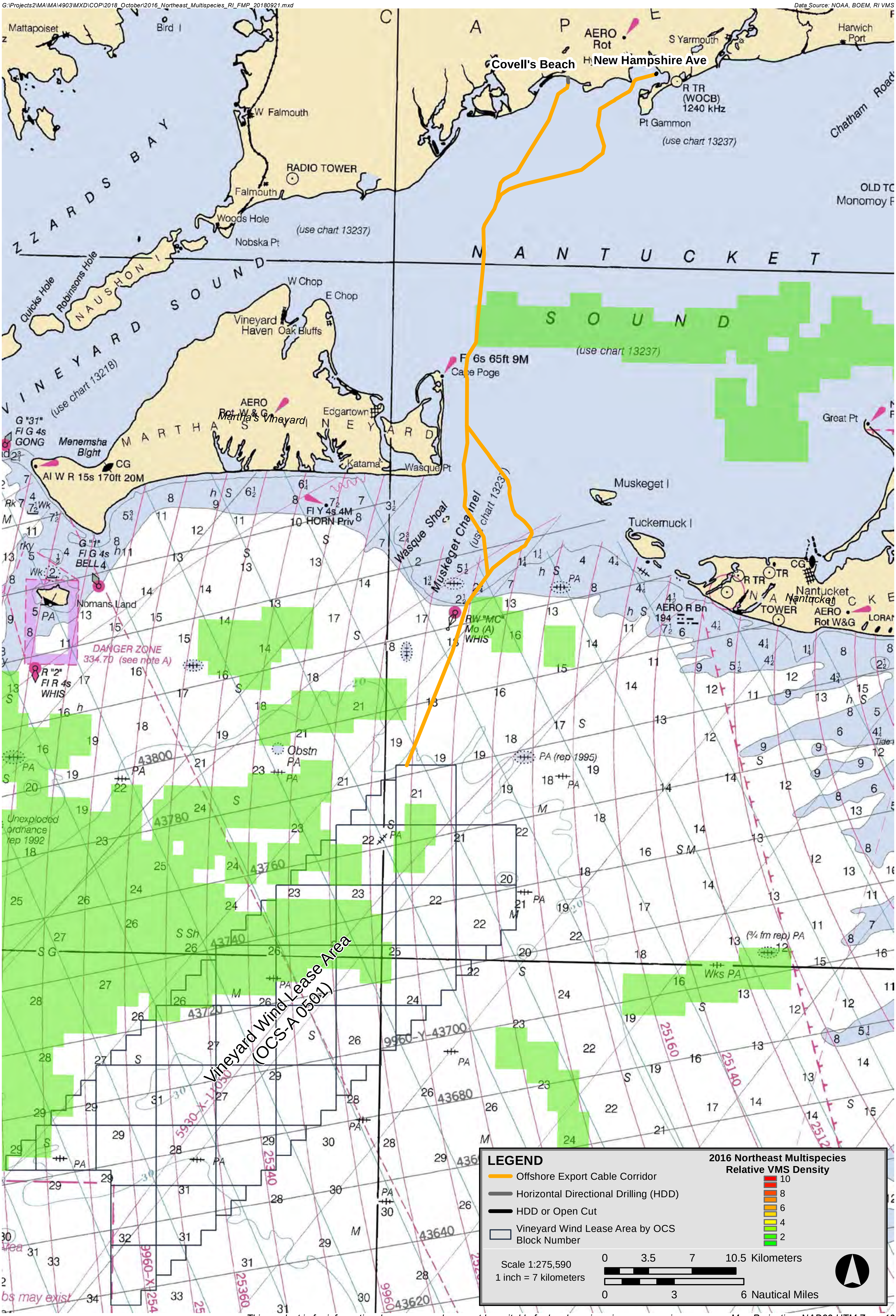
Vineyard Wind Project

VINEYARD WIND

Figure 7.6-42

DEM – Northeast Multispecies 2015 Commercial Fishing Density



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Vineyard Wind Project

VINEYARD WIND

Figure 7.6-43

DEM – Northeast Multispecies 2016 Commercial Fishing Density

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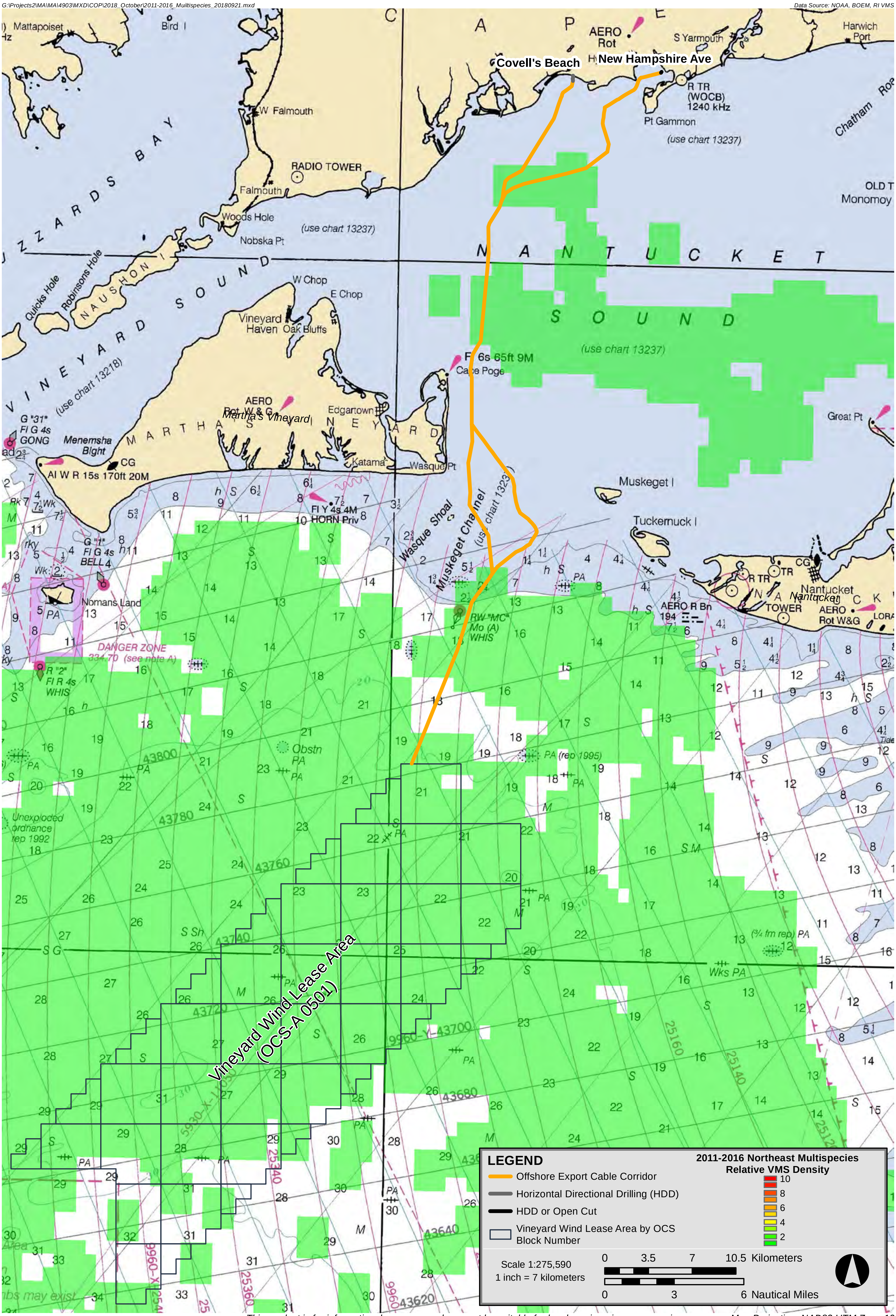
Data Source: NOAA, BOEM, RI VMS



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Vineyard Wind Project

VINEYARD WIND

Figure 7.6-44

DEM - Northeast Multispecies 2011-2016 Commercial Fishing Density

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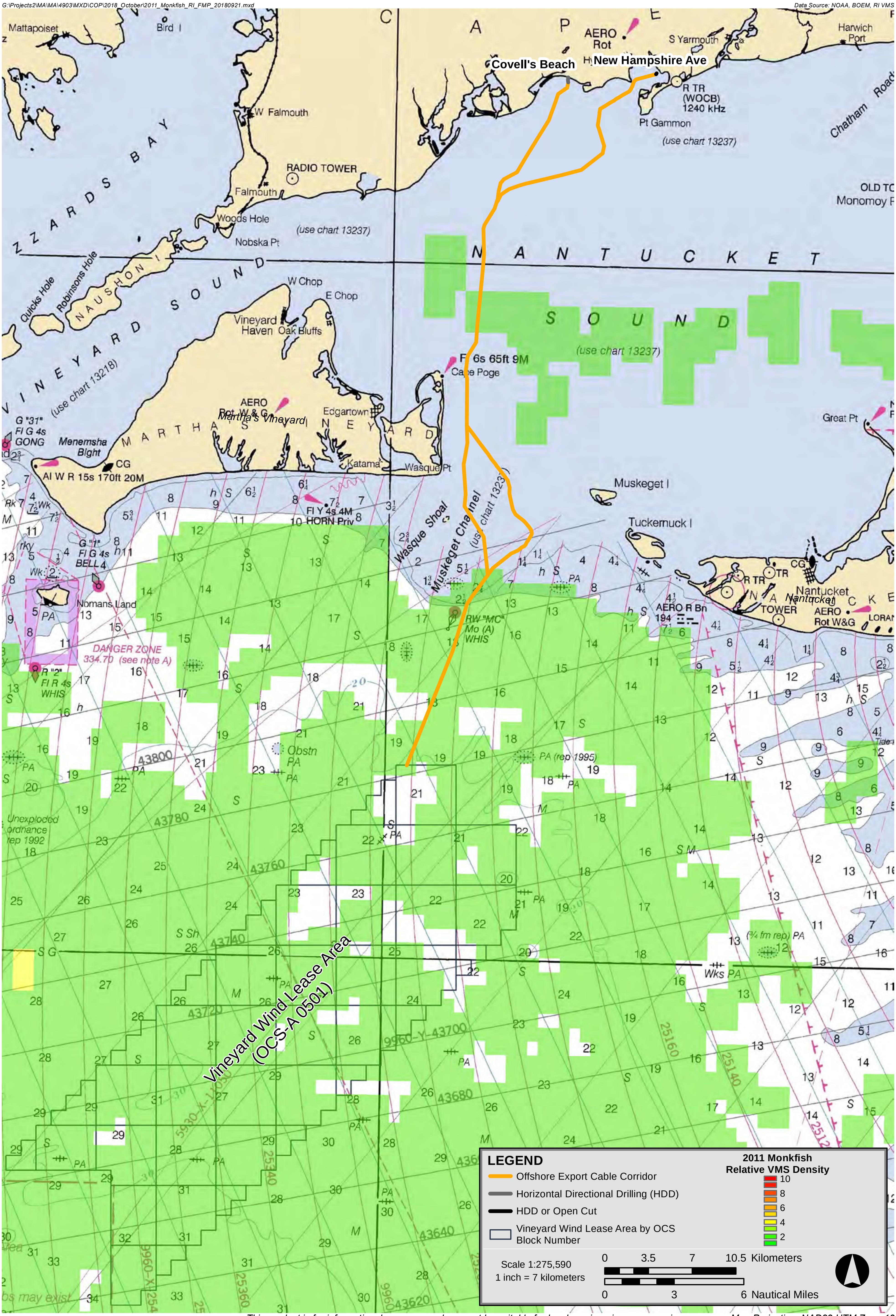
Data Source: NOAA, BOEM, RI VMS



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Vineyard Wind Project

VINEYARD WIND

Figure 7.6-45

DEM – Monkfish 2011 Commercial Fishing Density

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Data Source: NOAA, BOEM, RI VMS

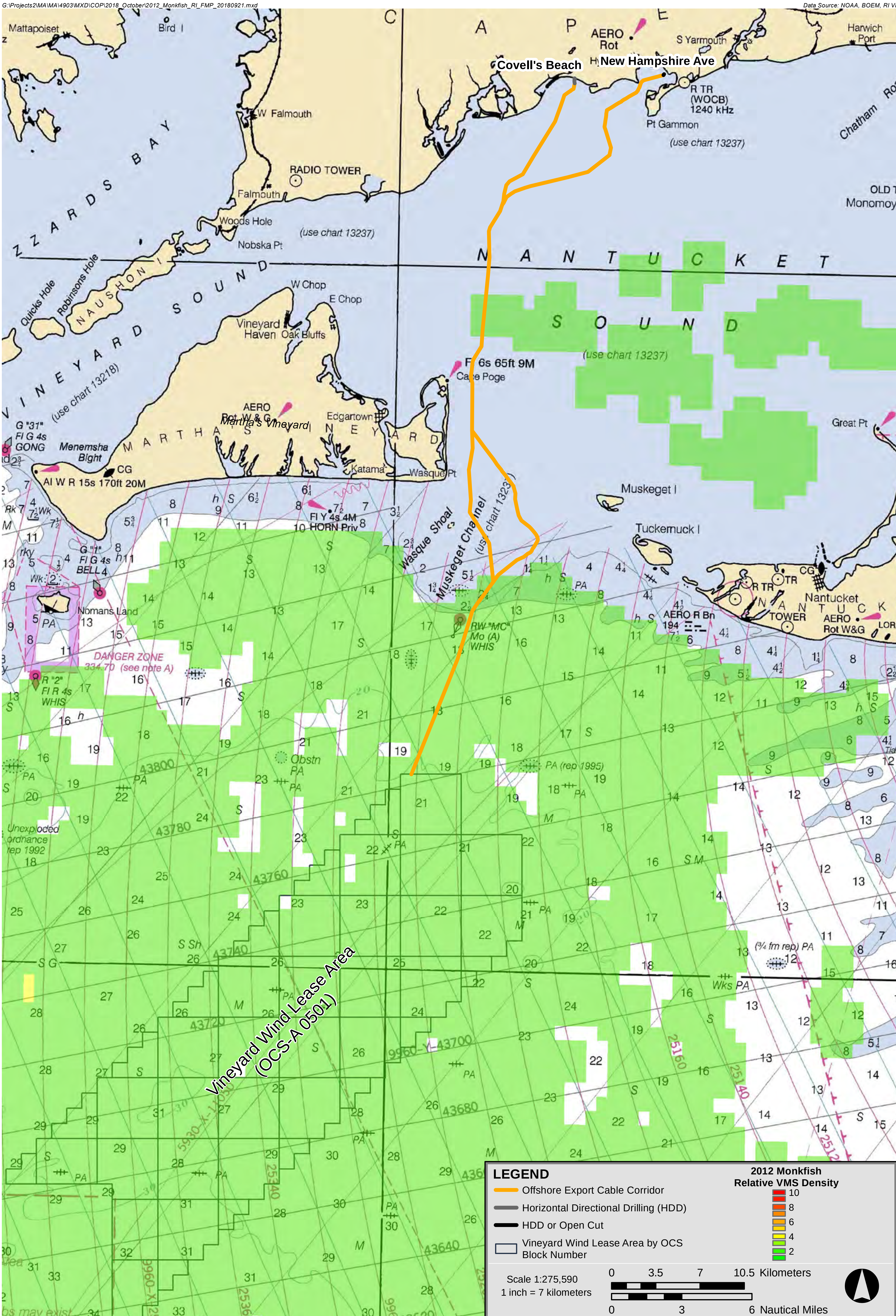

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Figure 7.6-46

DEM – Monkfish 2012 Commercial Fishing Density

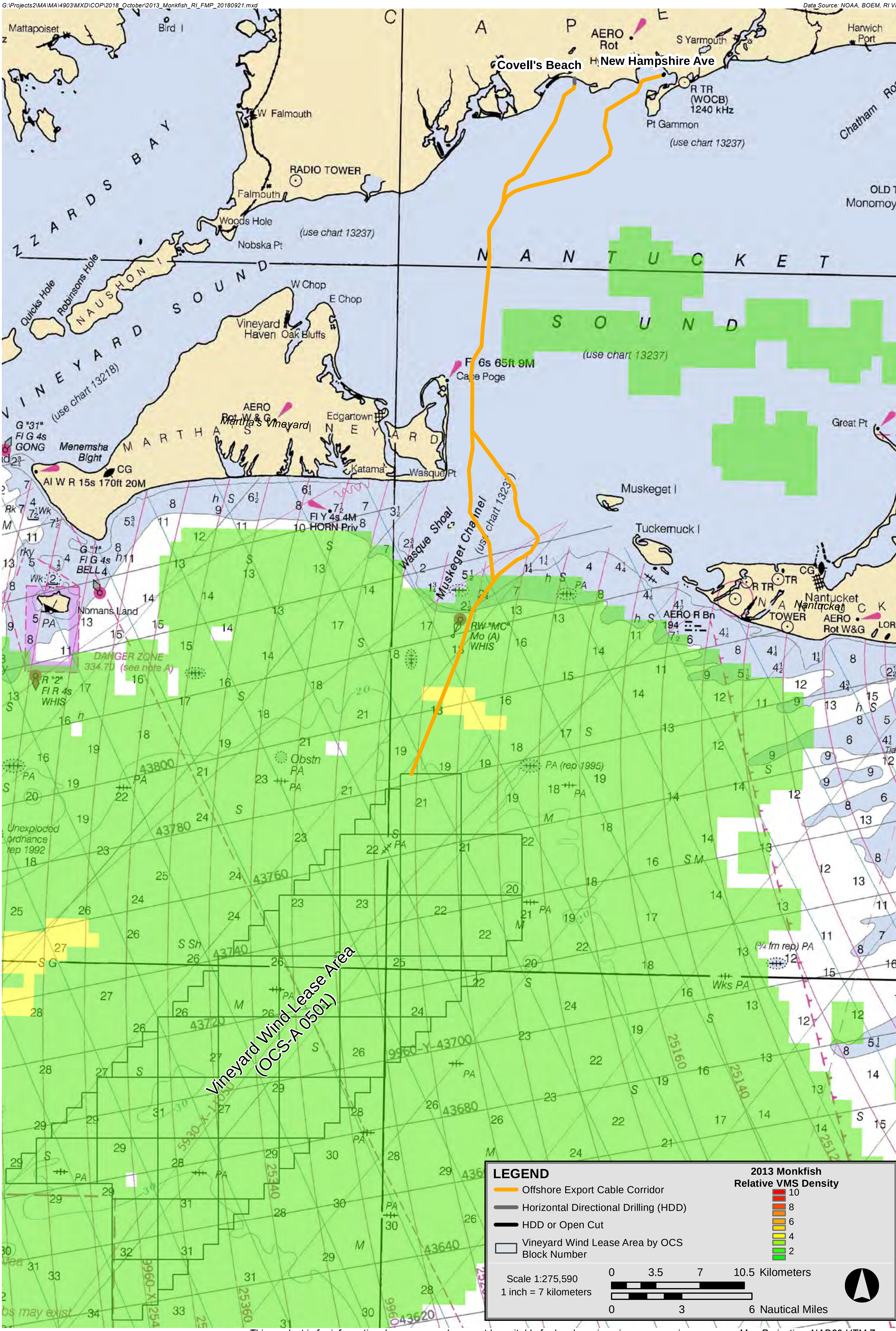

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Figure 7.6-47

DEM – Monkfish 2013 Commercial Fishing Density

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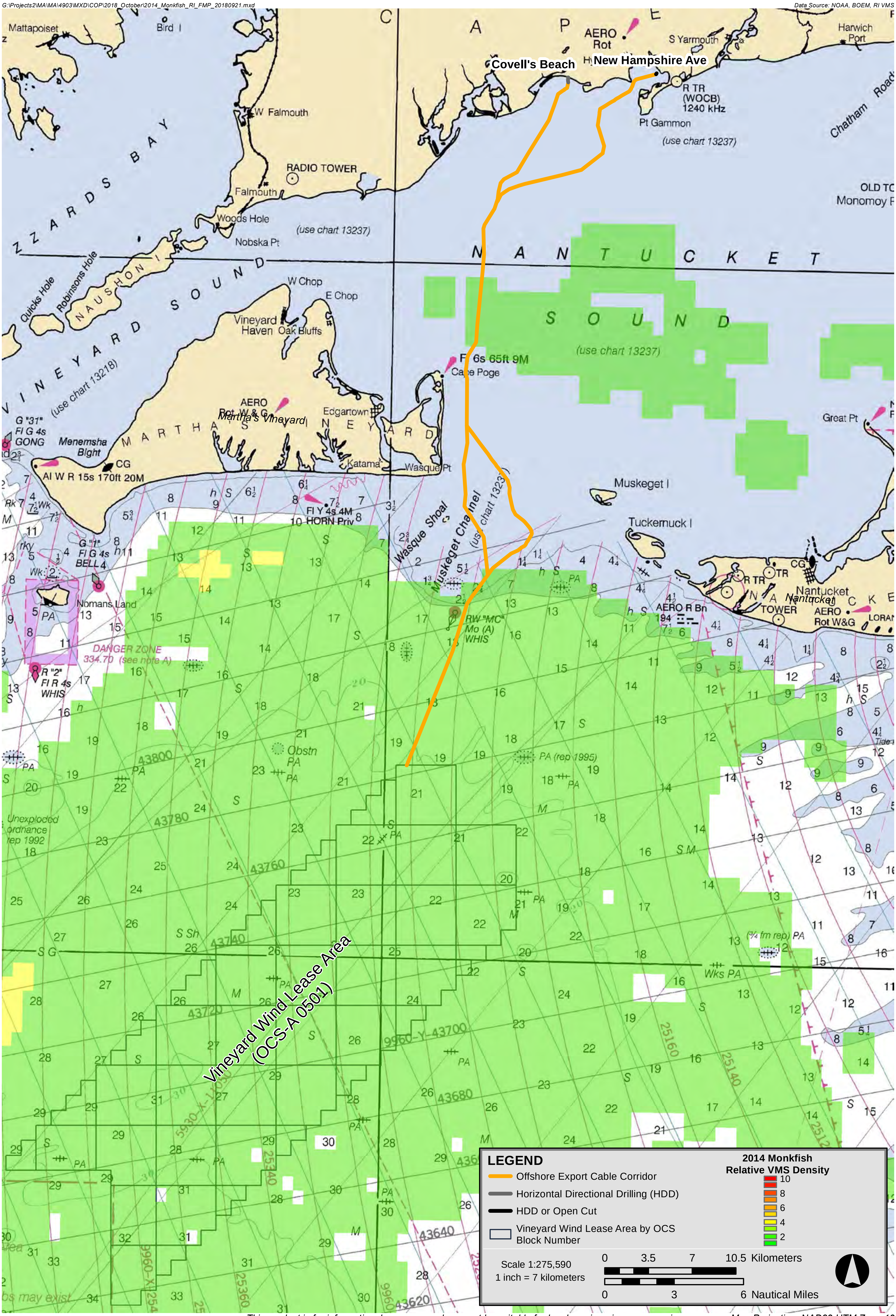
Data Source: NOAA, BOEM, RI VMS



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Vineyard Wind Project

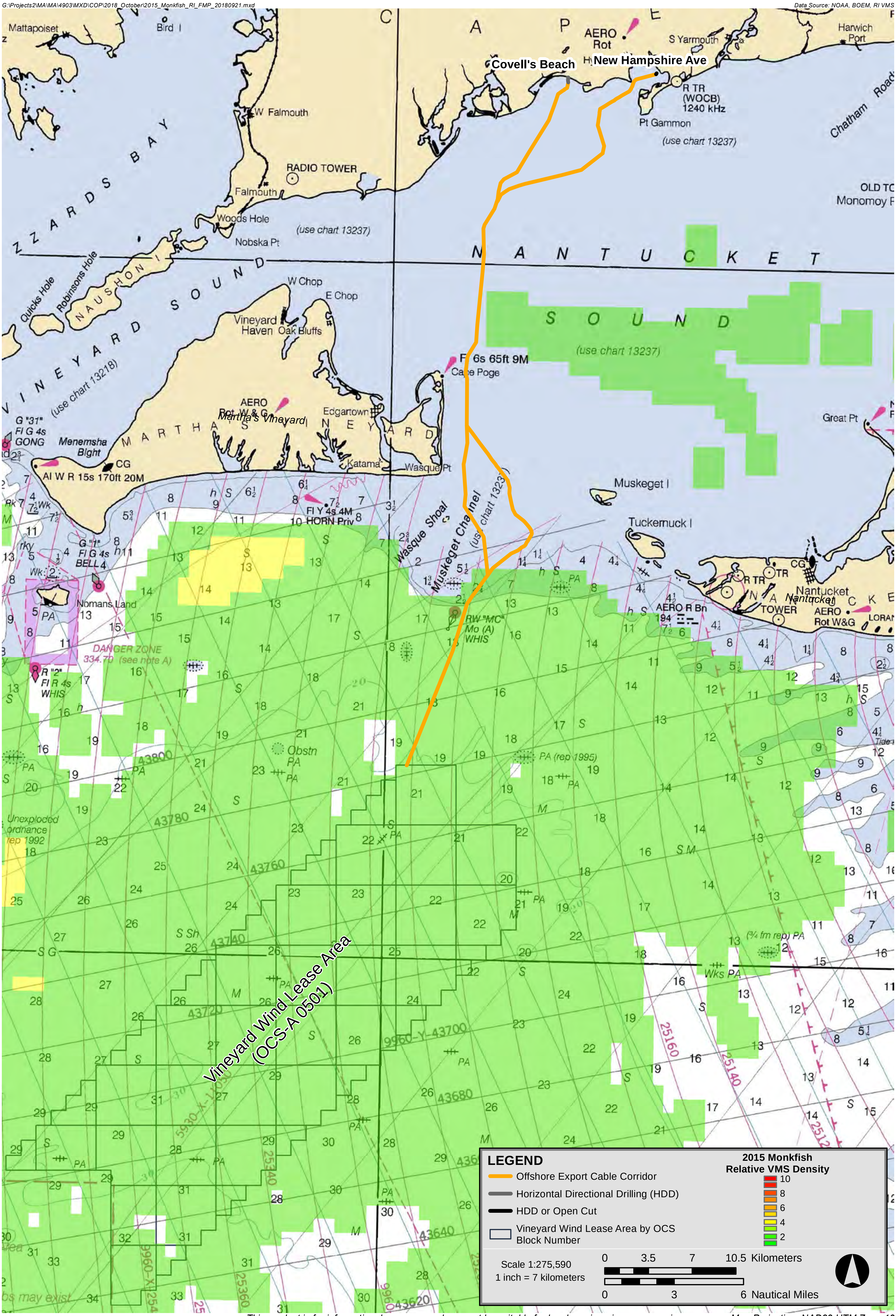
VINEYARD WIND

Figure 7.6-48

DEM – Monkfish 2014 Commercial Fishing Density

G:\Projects2\MA\MA\4903\MXD\COP\2018_October\2015_Monkfish_RI_FMP_20180921.mxd

Data Source: NOAA, BOEM, RI VMS



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Vineyard Wind Project

VINEYARD WIND

Figure 7.6-49

DEM – Monkfish 2015 Commercial Fishing Density

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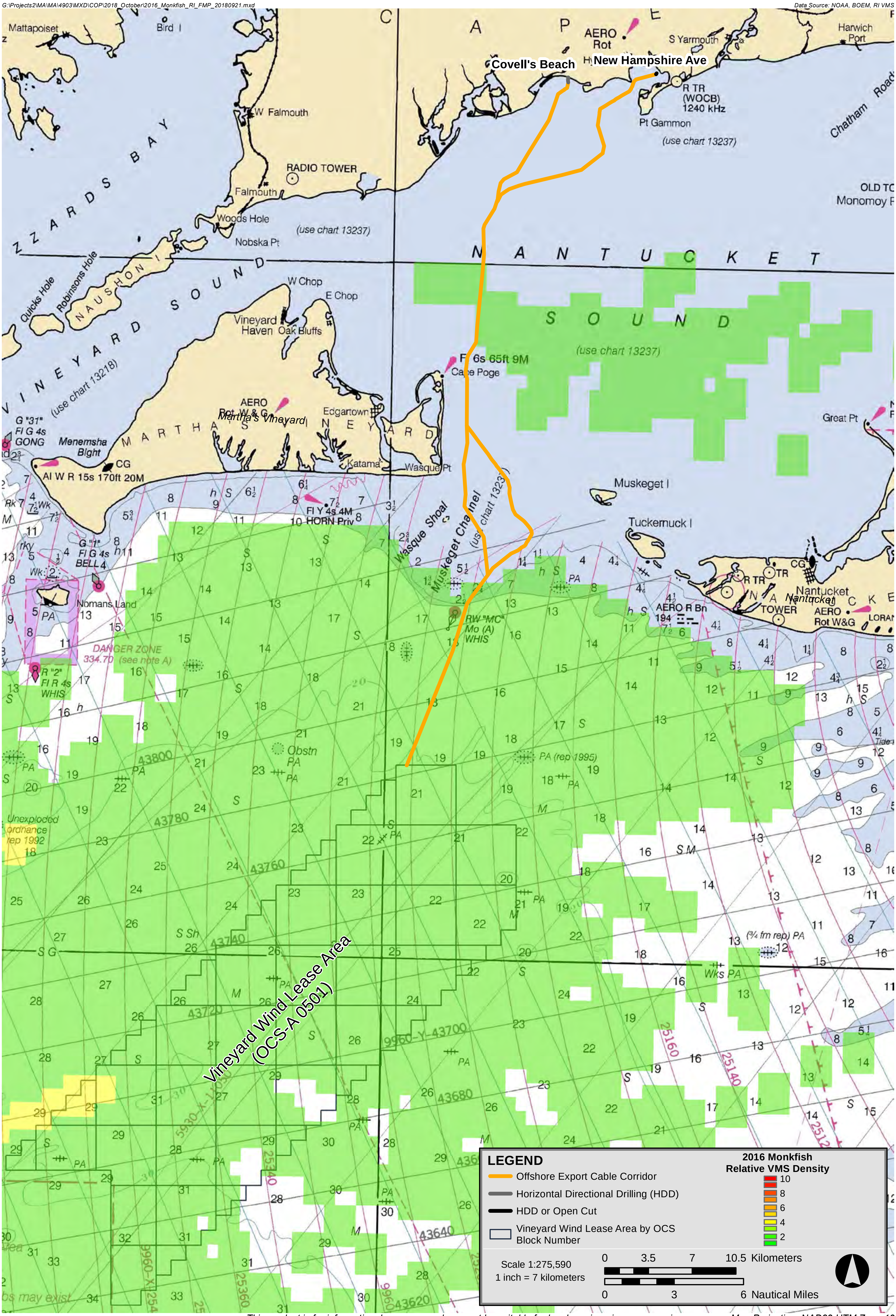
Data Source: NOAA, BOEM, RI VMS



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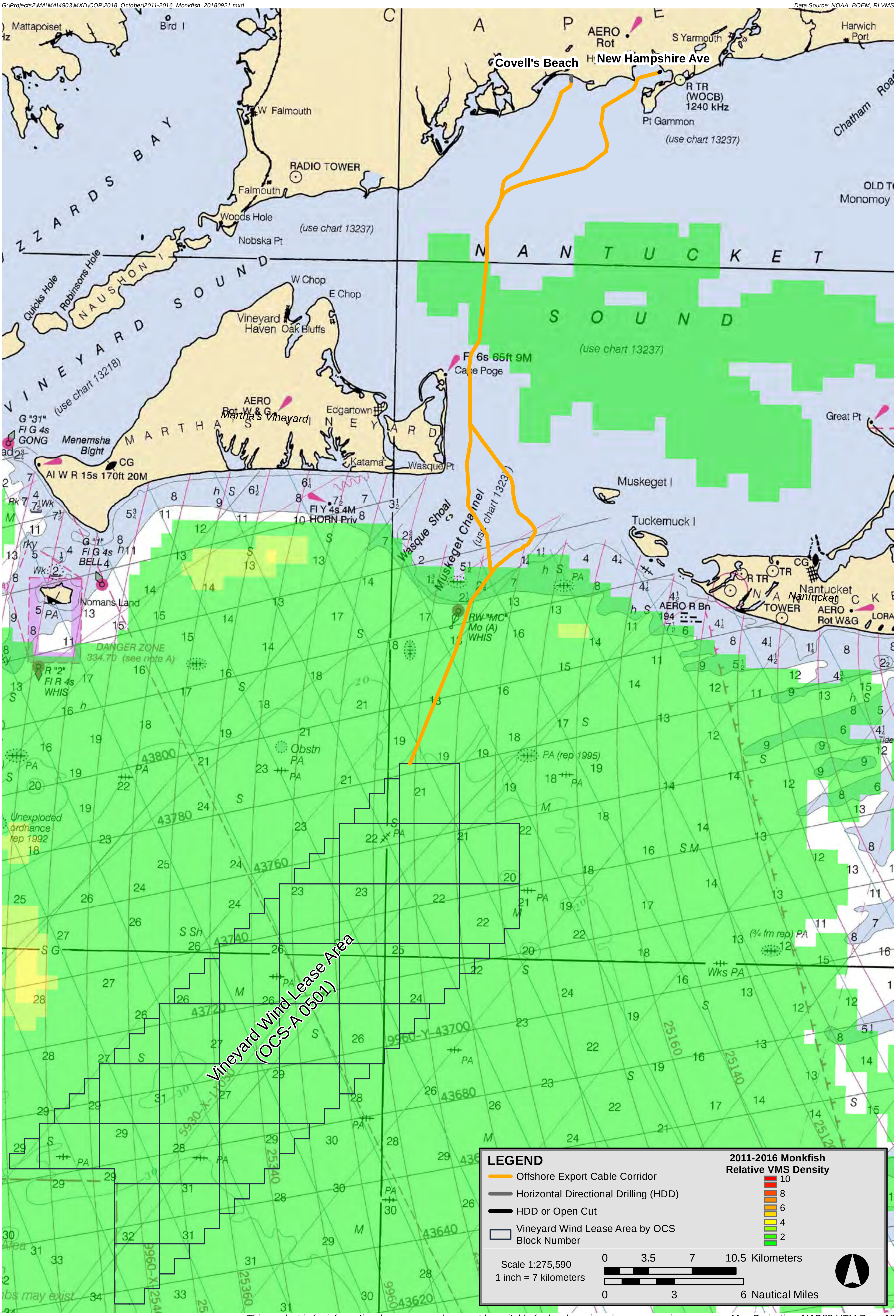
Vineyard Wind Project

VINEYARD WIND

Figure 7.6-50

DEM – Monkfish 2016 Commercial Fishing Density



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Vineyard Wind Project

VINEYARD WIND

Figure 7.6-51

DEM - Monkfish 2011-2016 Commercial Fishing Density activities are anticipated to quickly recover following any potential disturbances, as described in Section 6.6.2. Additionally, the Project's efforts to limit habitat disturbance further minimizes impacts to commercial fishing activities. For those species that may be impacted by habitat alteration, the total area of alteration within the WDA due to foundation and scour protection installation, jack-up vessel use, inter-array and inter-link cable installation, and potential cable protection installation, as those activities may relate to fisheries impacts, is 1.59 km^2 (393 acres), only 0.5% of the entire WDA.

Impacts to mobile pelagic fish and invertebrate species may include localized and short-term avoidance behavior. Mobile pelagic and invertebrate species targeted by commercial fishing vessels, and known to overlap with the WDA, include herring, mackerel, butterfish, whiting, and squid. These species will be able to avoid construction areas and are not expected to be substantially impacted by construction and installation. Abundance of mobile pelagic and invertebrate species, therefore, would not be affected. However, availability of these species in proximity to construction and installation activities may decrease, potentially resulting in increased catch per unit effort outside the WDA.

As described in Section 6.6.2.1., burial and mortality of some demersal eggs (fish [e.g., Atlantic Herring], squid [e.g., Longfin Inshore Squid (*Doryteuthis pealeii*)]), and whelk species) may occur during cable installation activities. Such impacts are confined to small, localized areas in the WDA and OECC where sediment deposition from dredging and cable installation may be greater than one millimeter. Since the impacted area is only a small portion of the available habitat in the area and because most of these species produce millions of eggs each year, population level impacts are highly unlikely. Notwithstanding potential construction and installation impacts, availability of these species is consistently elevated in fishing grounds outside the WDA, as described in Section 7.6.2, and validated by Livermore (2017) and Kirkpatrick (2017). Increases in commercially important species, such as Atlantic Cod and whiting have been observed near deep water wind farms (Hille Ris Lambers & Ter Hofstede, 2009; Løkkeborg et al., 2002) and abundance and availability of these species could increase within the WDA.

Characterization of vessels targeting sea scallop and surf clam in Section 7.6.2, and presumably all dredge gear vessel, suggests that relative fishing effort for this gear type is quite low within the WDA. Nonetheless, construction and installation related impacts may result in direct and indirect mortality events for sea scallop and surf clam, resulting in their decreased availability within the WDA. Habitat conversion, though limited, may also decrease availability of these species within the WDA and along the OECC over the expected life of the Project.

Mobile benthic invertebrates, such as lobsters and crabs, would be temporarily displaced by construction and installation activities, but are likely able to avoid the associated sediment deposition areas. Conversion of soft bottom habitat associated with installation of WTGs and scour protection may increase abundance and availability of those species upon completion of construction and installation activities.

Electromagnetic fields ("EMF") would be generated by inter-array cables connecting WTGs in the WDA and from cables along the OECC. As described in Section 6.6.2.2.3, although electrosensitivity has been documented in elasmobranchs (sharks, skates, and rays) and some teleost fish species (ray-finned fishes), research investigating habitat use around energized cables found no evidence that fish or invertebrates were attracted to or repelled by EMF emitted by cables (Love et al., 2017).

7.6.3.1 Impacts on Fishing Activity Within the WDA

This section presents information to help interpret the extent of potential economic impacts associated with disruptions in certain fishing conventions during the operational phase of the Project that were identified by fishermen, such as "gentlemen agreements" between mobile and fixed gear fishers which are used to prevent space/use conflicts and risks of gear loss. As noted above, construction and installation activities will occur within very limited and well-defined areas of the WDA and no vessel restrictions are proposed other than in the immediate vicinity of the construction and installation vessels. Meaning, the majority of the WDA will remain accessible to commercial fishing vessel operations throughout the construction and installation process and, indeed, during the entire anticipated lifespan of the Project.

Current agreements regarding the placement of mobile and fixed gear within the WDA, as they may be observed, could remain in effect once WTGs are in place should vessel operators so desire. If the proposed WTG layout presents inefficiencies that make such arrangements undesirable, the grid pattern of the WTG provides opportunity for adjustments to extant gear placement protocol. The largely uniform spacing of WTGs creates "lanes" oriented in the northwest-southeast direction. This is intended, in part, to facilitate the deployment mixed gear-types in several different potential arrangements. Under one such arrangement, fixed gear and mobile gear could be deployed in alternating lanes. Such arrangements may, in the short-term, modestly increase idle and/or steaming time for those vessels that operate within the WDA.

Separately, vessels towing mobile gear in the WDA may choose to exit the WDA before retrieving gear or reversing course for a subsequent tow through the WDA, thereby extending the amount of time fishing gear is deployed and/or more frequent retrieval and deployment if gear. It is possible that vessels electing to exit the WDA in these scenarios may incur additional costs or downtime associated with additional gear handling and increased steaming distances. In certain situations, longer periods of gear deployment may result in increased landings. Nonetheless, as noted in Appendix III-I, based on International Maritime Organization (IMO) resolution MSC.137(76) Standards for ship maneuverability, and (Maritime Safety Council (MSC) Circ.1053, explanatory notes for the standards for ship maneuverability, the largest fishing vessels known to operate in proximity to the WDA are expected to have sufficient room to maneuver, including a complete round-turn, within the proposed 1 nm navigation corridor.

Should vessels elect to fish outside the WDA, they may spend additional time either steaming to alternate fishing areas or search for target species. Suitable fishing areas in proximity to the WDA, however, suggests these choices would have only modest impacts to cost and revenue.

The use of pots and traps, predominantly deployed along the OECC within Nantucket Sound, is not expected to be impacted by the Project. Although bottom trawl gear typically interacts with the sea floor, target burial depths of inter-array and offshore cables will allow for safe deployment of such gear. Should cable protection be required, it will be designed to minimize impacts to fishing gear and fishermen will be informed of the areas where protection is used. Fixed gear fishermen have suggested the use of consistent transit lanes for construction vessels during the installation phase to reduce conflicts and minimize or eliminate loss of gear. Vineyard Wind will implement such an approach with the Marine Coordinator and Fisheries Liaison.

7.6.3.2 Impacts to Fishing Activities Outside the Wind Development Area (WDA)

The previous section described the exposure of commercial fishing values within the WDA to impacts from WDA activities and the likely range of those impacts. The WDA could also affect the economic value of fishing outside the WDA if the fishing vessels don't use the most direct routes between ports and fishing grounds or between fishing grounds.

Figure 7.6-52 and Table 7.6-11 illustrate the likely range of these potential steaming cost impacts. Figure 7.6-52 shows the proximity of the WDA to fishing ports and fishing areas. Table 7.6-11 identifies the steaming distances between port and fishing area, and distances between fishing areas using two alternative vessel routes; the most direct route and a route around the WDA. (No values are shown in Table 7.6-11 if the most direct route does not cross through the WDA.)

Figure 7.6-52 and Table 7.6-11 represent only a few combinations of fishing ports and fishing areas that could be affected by the WDA, but they are representative of likely transit routes to fishing areas from the selected ports. The analysis shows, for example, that in situations where the WDA is located on the most direct route, as may be the case with vessels transiting from Montauk, New York to Asia Rip. For a vessel electing to transit around the WDA, in this scenario, steaming distance increases by 0.6 nm. At a steaming speed of 10 knots this would add approximately 3.6 minutes per direction of travel, which means the trip might be very slightly longer, but there would be no expected losses in available fishing time. For a fishing vessel that burns 50 gallons per hour at 10 knots, this would result in 3.0 additional gallons of diesel fuel burned in transit (one way) which, at a dockside price of $3.00 per gallon, would increase round trip costs by an average of $18.00. A more detailed assessment of fishing vessel characteristics and fishing activity in the vicinity of the WDA would be required to determine potential fleet-wide steaming cost impacts.

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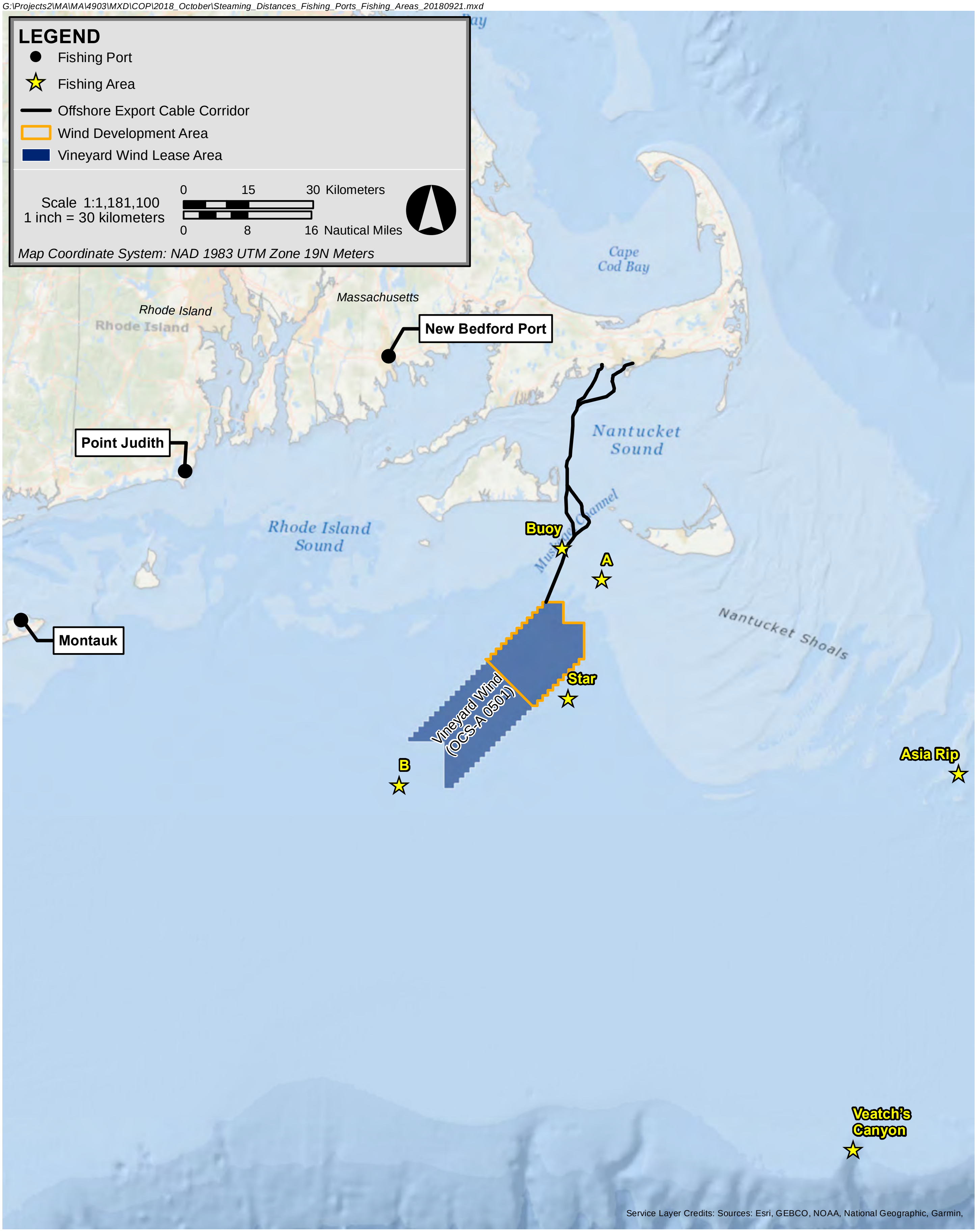

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Vineyard Wind Project

VINEYARD WIND

Figure 7.6-52

Steaming Distances and Time from Fishing Ports to Fishing Areas

Table 7.6-11 Estimated Transit Route Distances for Select Fishing Ports

Port	Direct Route (nm)	Route Around WDA (nm)	Difference (nm)
Fishing Area A			
New Bedford, Massachusetts	52	NA	-
Point Judith, Rhode Island	54	NA	-
Montauk, New York	73	NA	-
Fishing Area B			
Port	Direct Route (nm)	Route Around WDA (nm)	Difference(nm)
New Bedford, Massachusetts	55	NA	-
Point Judith, Rhode Island	48	NA	-
Montauk, New York	52	NA	-
Veatch's Canyon			
Port	Direct Route (nm)	Route Around WDA (nm)	Difference (nm)
New Bedford, Massachusetts	119	NA	-
Point Judith, Rhode Island	119	NA	-
Montauk, New York	123	NA	-
Asia Rip			
Port	Direct Route (nm)	Route Around WDA (nm)	Difference (nm)
New Bedford, Massachusetts	99.3	NA	-
Point Judith, Rhode Island	103.37	103.42	0.05
Montauk, New York	119.2	119.8	0.6
Fishing Area A to Fishing Area B			
	Direct Route (nm)	Route Around WDA (nm)	Difference (nm)
	18.9	**19.6**	**0.7**
Buoy to Star			
	Direct Route (nm)	Route Around WDA (nm)	Difference (nm)
	36	**38.5**	**2.5**

7.6.3.3 Potential Impacts to Port Facilities

Project-related vessel traffic during the construction and installation phase of the Project is not anticipated to cause impacts to either commercial or for-hire recreational fisheries as they operate in each of the ports described in Section 7.1.1.1, Section 7.1.1.2, and Section 7.1.1.3. Modest increases in vessel traffic in these ports may occur. Potential impacts to navigation as they relate to commercial fishing are evaluated in Appendix III-I.

7.6.3.4 Avoidance, Minimization, and Mitigation Measures

The original siting of the MA WEA by BOEM included a significant public engagement process. Through this process, and in response to stakeholder concerns, the MA WEA was extensively modified. BOEM excluded areas of high fisheries value to reduce potential conflict with commercial and recreational fishing activities. This careful siting of MA WEA, which includes the WDA, will avoid many impacts to commercial and for-hire recreational fisheries. In addition, WTG layout is a result of input from numerous stakeholders, including the USCG and fishermen who use or transit the Project area. The original WTG layout was designed to optimize energy development, which requires that the WTGs be scattered and closer together, not aligned in a grid pattern with large separation distances. Understanding the need for transit corridors and separation distances that allow the area to be fished, the Project layout was modified to address competing fishing interests. Of particular concern was the potential impact of the Project on the scallop fishery out of New Bedford, which according to NOAA data, has an annual average value of over $281 million. The orientation of the transit corridor through the Project was specifically designed to allow passage through the Project to fishing areas, and the wide distances between the turbines allows for mobile and fixed gear fishing to coexist within the Project area.

In addition, as discussed in Section 3.1.1.1 of Volume I, Vineyard Wind intends to adopt a 2 nm (3.7 km) wide transit lane that was developed through discussion among fishing stakeholders and state agencies and presented during the September 20th, 2018 Massachusetts Fisheries Working Group (FWG) on Offshore Wind meeting. This transit lane layout, provided by MA Coastal Zone Management (CZM) is shown in Figure 7.6-53 and Figure 2.1-2 of Volume I. Federal and state agencies worked to synthesize input from fishing stakeholders and arrive at this layout, which represents a compromise of the various desired transit directions and corridor widths to/from priority areas identified by various fishing sectors and ports. From a navigation safety perspective, this corridor provides options for vessels transiting through the adjacent MA and RI lease areas (see Figure 1.1-1 of Volume I) to maintain a single heading. Scallopers, fixed gear, squid, and whiting/scup fishermen from MA, NY, and RI ports all agreed this was a workable compromise at the meeting. As stated in a letter from MA CZM regarding Vineyard Wind's SDEIR dated October 5th, 2018, "CZM believes that the working group consensus alternative is a balanced and feasible option that while perhaps optimal to none, is acceptable from a

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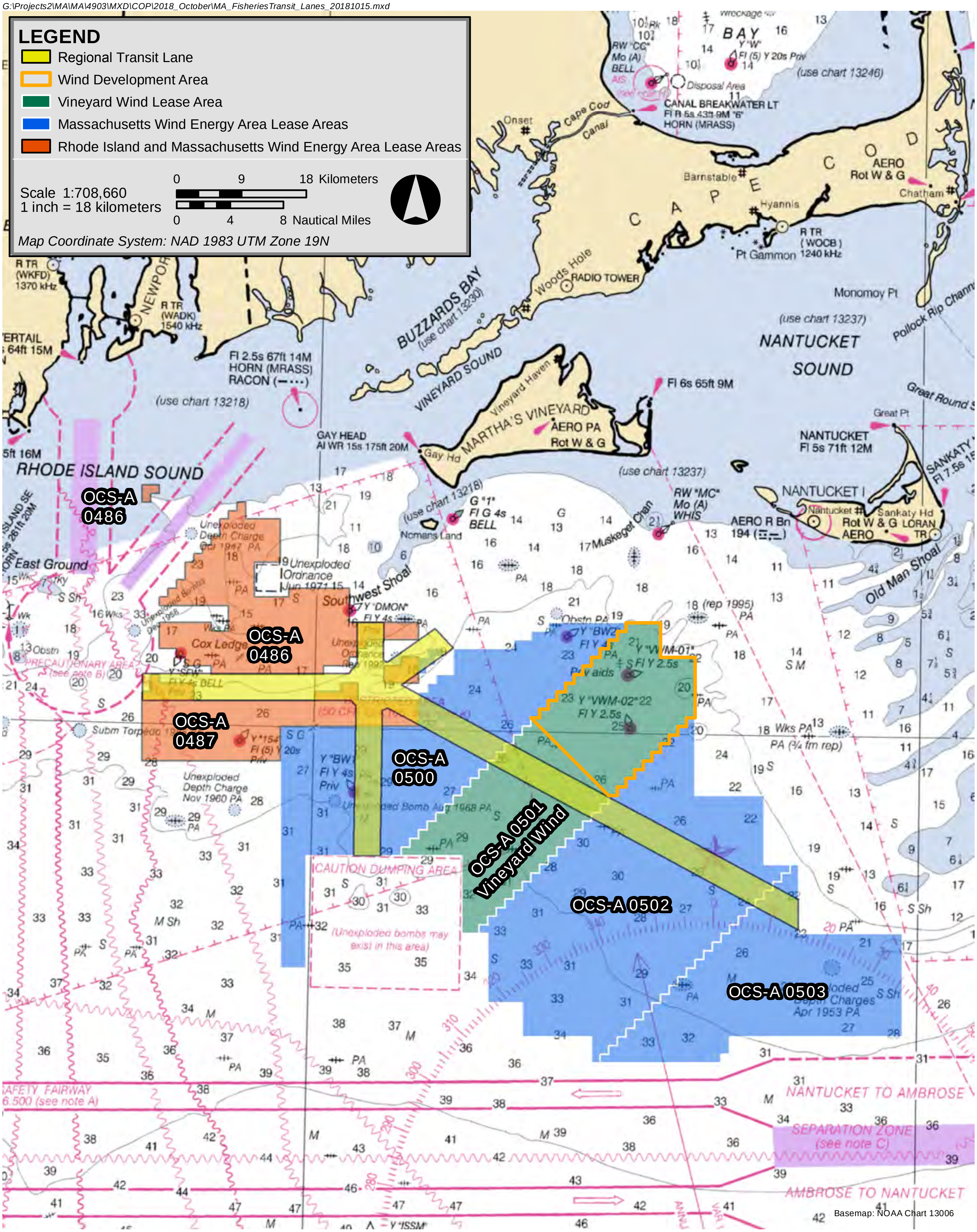

Vineyard Wind Project

VINEYARD WIND

Figure 7.6-53
Regional Transit Lanes

navigational safety perspective and represents a compromise approach to a very difficult issue." At the FWG meeting and at a follow-up meeting in Rhode Island organized by Coastal Resources Management Council (CRMC) on October 11th, 2018, the USCG expressed support of these lanes, as did RI fisheries stakeholders. The September 20th and October 11th meetings resulted in an unprecedented level of agreement among fishermen. For all these reasons, the consensus transit corridor plans that resulted from those discussions will be incorporated in to the Vineyard Wind Project. Vineyard Wind also supports adopting a north/south transit lane directly to the east of the WDA to allow passage for fisheries travelling between squid and whiting fishing grounds.

Finally, Vineyard Wind is proposing a mitigation option for the layout that eliminates spare WTG positions to create requested east-west fishing passage. This option is further described in Appendix III-R.

To further minimize impacts, Vineyard Wind will implement a comprehensive communications plan with the various port authorities; federal, state, and local authorities; and other key stakeholders, including recreational fishermen and boaters, commercial fishermen, harbormasters, the Northeast Marine Pilots Association, and other port operators. The current version of the Fisheries Communication Plan is included as Appendix III-E. As described in the Fisheries Communication Plan, both Fisheries Liaisons (FL) and Fisheries Representatives (FR) are already engaged to ensure effective communication between the Project and the fishermen. More information on the FL and FR roles can be found in Appendix III-E. In addition, based on feedback from stakeholders, including commercial fishing interests, Vineyard Wind is developing a program to manage fishing-specific communications regarding Project activities and impacts. It is anticipated that the program will provide a single point-of-contact for fishermen to report problems and concerns with construction and installation activities and to report gear loss or damage from project components and activities. Vineyard Wind is committed to developing an easy-to-use, accessible, and responsive protocol that equitably addresses impacts to fishing activities and gear as they may arise from construction and installation activities. The various fishing communities will be invited to participate in the development of this program.

Vineyard Wind is developing a framework for a pre- and post-construction fisheries monitoring program to measure the Project's effect on fisheries resources. Vineyard Wind is working with the Massachusetts School for Marine Science and Technology (SMAST) and local stakeholders to inform that effort and design the study. The duration of monitoring will be determined as part of the initial effort to determine the scope of the study, but it is anticipated to include the pre-construction period and at least one year of post-construction monitoring. In addition, post-construction monitoring will be conducted to document habitat disturbance and recovery (see Benthic Habitat Monitoring Plan in Appendix III-D).

To minimize hazards to navigation, all Project-related vessels, equipment, and appurtenances will display the required navigation lighting and day shapes. Notices to Mariners (NTMs) will be distributed by Vineyard Wind and the USCG to notify recreational and commercial vessels of their intended operations to/from and within the WDA. WTGs will be widely-spaced in the WDA so that the foundations and associated scour protection, along with the ESPs, inter-link cables, and inter-array cables, only occupy a minimal portion of the WDA. Ultimately, a large portion of the WDA will remain undisturbed, thereby minimizing impacts to commercial and for-hire recreational fisheries and improving navigational ability throughout the WDA.

Temporary safety zones may be established around work areas during the construction and installation phase to improve safety in the vicinity of active work areas. This proposed safety zone would be adjusted as construction work areas change within the WDA, allowing fishermen and other stakeholders to make use of the portions of the WDA not being used for construction and installation activities. It is anticipated that the majority of the WDA will remain open to non-Project related vessels throughout the construction and installation phase.

In an effort to provide fishermen with the most accurate and precise information on work within the WDA and along the OECC, Vineyard Wind is currently providing and will continue to provide portable digital media with electronic charts depicting locations of Project-related work activities and Project-related information to fishermen.

Impacts associated with scheduled, periodic maintenance activities during the operations and maintenance phase will be adequately mitigated through the implementation of BMPs where feasible. To aid mariners navigating the WDA, WTGs and ESPs will be lit, painted, and marked with high-visibility paint, reflecting panels, and unique identification lettering and numbering. The WTGs will also be maintained as Private Aids to Navigation. Additional details on proposed aids to navigation within and in proximity to the WDA are provided in the Navigational Risk Assessment (see Appendix III-I).

7.6.4 Summary

The following section summarizes results of the analysis and presents “sensitivity” tests which suggest how fishery-related economic impact estimates respond to worst-case assumptions (e.g., higher than average fish abundance in the WDA when it is closed to fishing) as opposed to assumptions based on expected conditions (e.g., typical fish abundance in the WDA which is not closed to fishing).

As noted above, the relative size of the WDA with respect to the MA WEA, and the proximity of the WDA to important fishing ports and fishing areas is a significant consideration when estimating potential effects on commercial fishing operations that may occur near the WDA. The BOEM fisheries study (Kirkpatrick, 2017) estimated the average annual value of fish taken in the MA WEA between 2007 and 2012 to be $3.03 million, and the DEM fisheries study (Livermore, 2017) estimated the average annual value of fish taken in the Lease Area between 2011 and 2016 to be $0.858 million. DEM's estimate is 28.3 percent of BOEM's estimated value for the entire MA WEA, which was based on data for a few years earlier. Geographically scaled to the WDA, the 2017 BOEM fisheries study indicates that the average annual revenue exposed within the WDA during the years studied is approximately $308,450. Accounting for differences in the sample years, the results of the two studies validate one another and suggest that the economic value of fishing could be uniformly distributed across the MA WEA at $1,000 to $1,200 per km^2, with the average value of annual catches from the WDA between 2007 and 2016 estimated to be approximately $348,450.

An estimate of landings from the WDA is presented in Table 7.6-12. Assuming fishing could be uniformly distributed across the MA WEA, as above, Table 7.6-12 presents Livermore's (2017) estimated annual revenue by state from the Lease Area proportionally scaled to the smaller geographic area of the WDA (i.e., the value for the WDA is 45.3% of the value for the Lease Area).

Table 7.6-12 Estimated Annual Landings from Wind Development Area by State (2011-2016)

State	2011	2012	2013	2014	2015	2016	Estimated Annual Average in Wind Development Area
Connecticut	$16,174.44	$10,655.89	$16,544.16	$8,683.87	-	$23,188.77	$15,049.43
Massachusetts	$50,591.44	$444,344.04	$248,398.57	$49,571.29	$111,454.30	$303,855.83	$208,035.75
New Jersey	-	$1.64	-	$244.38	$8,701.18	$22,289.18	$7,804.10
New York	$1,547.78	$6,284.53	$11,920.23	$303.15	$4,868.59	$74,765.493	$16,614.96
Rhode Island	$24,930.64	$23,867.54	$71,568.30	$115,709.76	$110,325.89	$514,161.55	$143,502.06

Many factors, both environmental and regulatory, contribute to productive commercial fishing areas, and as a result, the location of commercial fishing effort, and to a lesser extent for-hire recreational fishing activities, are variable. Vineyard Wind will continue to meet with fishermen to solicit additional information on fishing effort in the WDA, and to ensure that the most accurate and relevant information regarding each of the fisheries in the Project Region is incorporated into the Project's operations plans.[26]

During the construction/installation of the Project, temporary and permanent habitat alteration or loss is expected in limited areas for several commercially valuable species, and some alteration of non-structured habitat to structured habitat in the WDA may change species assemblages in that area by attracting more structure-oriented species. Pelagic and invertebrate species identified within the WDA which may also be targeted by commercial fishing interests have been represented to include squid, mackerel, and butterfish. NROC and MARCO's characterization of relative fishing vessel density and estimates of revenue exposure by BOEM and DEM within those fisheries, as described in Section 7.6.2, suggest that commercial fishing effort and revenue for those species within the WDA is, in fact, quite modest. Though, in certain years increased commercial fishing vessel density may occur within the WDA, an increase likely associated with the squid fishery. Landings from the Squid, Mackerel, Butterfish Fishery Management Plan from the entire Lease Area, for example, as reported by Livermore (2017) over the six years of the analysis, averaged $292,235.64 per year. Again, assuming the economic value of this fishery is uniformly distributed throughout the Lease Area, approximately $132,383 of revenue from that Fishery Management Plan is sourced from the WDA.

In a worst-case scenario, if commercial vessels targeting squid or another species from that management plan elect not to fish within the WDA during the entire construction and installation phase, those commercial vessels could forgo revenue for up to two seasons. Worst case estimates of fishery-related economic impacts based on scenarios in which abundance of certain species within the WDA exceed average landings, suggest modest impacts to commercial fishing revenue, even if landings from within the WDA were to double or triple under some hypothetical scenario. Given the proximity of the WDA to known, productive fishing grounds, any forgone revenue is likely to be offset by additional fishing effort in adjacent water and/or through potential vessel operating cost reductions.

[26] Vineyard Wind has received and seen various data and representations of activity from fishermen directly that include, but are not limited to, thumb drives with Wind Plot data, printouts of vessel tracks, and hand drawn maps of preferred fishing areas. We are working to analyze the information as it comes in, as well as confirm that it is representative of the broad fishing interests within the region. However, our preliminary review suggests the information is consistent with the analysis herein.

As noted elsewhere, post-construction monitoring through the Project's Benthic Habitat Monitoring Plan and partnerships with research and other organizations will also be conducted to document habitat disturbance and recovery. To further avoid and minimize impacts to commercial fishing activities, Vineyard Wind will implement a comprehensive communications plan with the various port authorities, federal, state, and local authorities, and other key stakeholders, including recreational fishermen and boaters, commercial fishermen, harbormasters, the Northeast Marine Pilots Association, and other port operators.

Vineyard Wind has developed and implemented a Fisheries Communication Plan and the Project management team will continue to develop and utilize communications plans to ensure relevant and accurate information regarding the Project is disseminated to the various commercial fishing communities during each stage of the Project. As additional information on commercial and for-hire recreational fishing are made available, Vineyard Wind may make adjustments to operating procedures and other practices in an effort to avoid, minimize, and mitigate Project-related impacts to these fishing communities.

7.6.5 For-Hire Recreational Fishing

For-hire recreational fishing is an important activity throughout the Project Region. An estimated 601 vessels based out of ports in Connecticut, Rhode Island, and Massachusetts provide for-hire recreational fishing opportunities in the Project Region. Of these vessels, approximately 430 were home ported in Massachusetts (Steinback & Brinson, 2013). In 2016, 49,969 angler trips were estimated to occur in state and federal waters off the coast of Massachusetts (NOAA MRIP, 2017).

The entire near-coastal region and numerous offshore locations within the Project Region may host species targeted by for-hire recreational fishing operations. For-hire recreational fishing activities have been reported to occur in portions of the MA WEA or nearby, notably at "The Dump," the approximately 260 square meter (100 square mile) Dumping Area identified on NOAA charts near the southerly end of the MA WEA, abutting the WDA. Other notable recreational fishing areas as identified by Captain Seagull's Nautical Sportfishing Chart, "Offshore: Canyon chart off MA, RI, CT, NY" include "The Owl" along the 20 fathom line, and "The Star" and "Gordon's Gully" along the 25 fathom line are within the WDA. The "FM Hole" is another popular spot in the Vineyard Wind Lease Area but outside of the WDA. These are popular locations for vessels targeting highly migratory and other recreational species. According to the Salty Cape website (www.saltycape.com), a popular regional website for recreational fishermen, "Gordon's Gully" and "the Owl" are best known for late June/early July bluefin tuna, mako and thresher sharks. White marlin can be found at both locations as well. "The Star" has historically be a spot for yellow fin tuna. "The Dump" is best known for catching yellowfin tuna, albacore tuna and mahi mahi. Both the 20 and 30 fathom lines cross the WDA from west to east. Along the Offshore Export Cable Corridor ("OECC"), shoals and other structure may provide productive fishing grounds for the for-hire recreational fishing industry. Notable recreational fishing areas along the OECC as identified by Captain Seagull's Nautical Sportfishing Chart, "Offshore: Nantucket Shoals and Georges Bank, MA" include "The Hooter", which is location named for the fairway buoy, that makes a "hooting" sound, and is a marker for the end of Muskeget Channel south west of Martha's Vineyard. The Salty Cape website categorizes this area as a shoal that attracts striped bass and blue fish in mid-May as well as bonito and false albacore. Bluefin tuna is also "fairly common" in this area. Other popular areas, according to Captain Seagull's, along or close to the OECC include "Mutton Shoal" in Muskeget Channel, "Hawes Shoal", north of Muskeget Channel, and "Eldridge Shoal" "Wreck Shoal" and "Colliers Ledge", the last three being located in Nantucket Sound. It is common knowledge amongst for-hire recreational charter fishing captains with whom Vineyard Wind spoke that the most popular species to catch in these areas would be striped bass, bluefish, false albacore and bonito as well as summer flounder, black sea bass and scup.

NOAA's Marine Recreation Information Program data for 2016 indicate that Cod and Hake, Striped Bass (*Morone saxatilis*), and Mackerel were the most caught species within the Massachusetts for-hire recreational fishery. Black Sea Bass, Scup, and Summer Flounder were the most caught species within the Rhode Island for-hire recreational fishery.

The for-hire recreational fishing fleets contribute to the overall economy in the Northeast, not just through direct employment, income, and gross revenues of the for-hire businesses, but also through spending on products and services to maintain and operate their vessels, triggering further indirect multiplier effects that are dependent upon the initial demands of the for-hire fleet (Steinback & Brinson, 2013).

7.6.5.1 Impacts to For-Hire Recreational Fisheries

Impacts to species targeted by for-hire recreational fishermen during construction will be similar to those described for commercial fishing resources in Section 7.6.2, above. The proximity of the WDA to numerous other productive fishing areas utilized by for-hire recreational fishermen suggests that the localized impacts of construction and installation activities will have only minor impacts to recreational species.

Operation and maintenance of the Project may have positive impacts to for-hire fisheries though temporary, short-term restricted navigation areas around crew support vessels and WTGs undergoing maintenance may be necessary to ensure the safety of maintenance personnel and mariners.

WTGs may become fishing locations, and for-hire recreational fishing activities may increase in the WDA. Anglers' interest in visiting the WDA may also lead to an increased number of fishing trips out of nearby ports which could support an increase in angler expenditures at local bait shops, gas stations, and other shoreside dependents (Kirkpatrick et al., 2017).

The Project management team will continue to develop and utilize their communications plans to ensure relevant and accurate information regarding the Project is disseminated to the recreational fishing and boating communities throughout the construction and installation process. As additional data on commercial and for-hire recreational fishing are made available, Vineyard Wind may make adjustments to operating procedures and other practices in an effort to avoid, minimize, and mitigate Project-related impacts to these fishing communities.

7.7 Land Use and Coastal Infrastructure

The following sections describe the existing land uses and coastal infrastructure in the Project Region. Vineyard Wind anticipates that each phase of the Project will generate few impacts on extant land use patterns and coastal infrastructure.

7.7.1 Description of the Affected Environment

Attributes of county land use and coastal infrastructure for each county are provided below. Because of the highly localized nature of Project-related impacts, additional detail of town-level land use patterns and coastal infrastructure are also provided.

7.7.1.1 Massachusetts

Onshore facilities may be located in the City of New Bedford in Bristol County; the Towns of Barnstable and Yarmouth in Barnstable County; and Vineyard Haven in Dukes County. Land use and coastal infrastructure are described as they exist in those communities

7.7.1.1.1 Barnstable County

Barnstable County comprises approximately 1,020 square kilometers ("km^2") (394 square miles ["mi^2"]) of land and approximately 2,362 km^2 (912 mi^2) of watersheet. The county encompasses all of Cape Cod, the geographic cape extending into the Atlantic Ocean from the southeastern corner of mainland Massachusetts, just west of the Cape Cod Canal. Barnstable County borders Plymouth County, located to the northwest. Located off Barnstable County's southern shore are Dukes County and Nantucket County.

Major overland transportation arteries in Barnstable County include US Route 6, and State Routes 28 and 6A. Both Route 28 and Route 6 are considered major arteries in the Towns of Barnstable and Yarmouth. US Route 6 continues eastward through Cape Cod, from Bourne to Orleans, as a freeway. North of Orleans to its terminus in Provincetown, US Route 6 is a surface road. Combined, these three major arteries comprise less than 6% of Cape Cod's roads by mileage. Over 80% of the roadways on Cape Cod are local roadways (CCC, 2015).

Barnstable County has a number of public transportation options. The Cape Cod Regional Transportation Authority ("RTA") operates the Hyannis Transportation Center which serves as a bus terminal, a maintenance facility, and the RTA office. Regional and intercity bus services, the Cape Cod Rail Line, commercial service airports, and ferry routes provide connections from Falmouth (Falmouth Harbor and Woods Hole), Hyannis (Hyannis Harbor), Provincetown (Fisherman's Wharf), and Harwich Port (Squatucket Harbor) to Martha's Vineyard, Nantucket, Boston, and Plymouth, all serve Barnstable County.

Barnstable County has substantial open space resources. The CCC (2012) estimates that 42% of the County's land is considered developed, while 29% is protected, 13% is wetlands, and the remaining 16% of land is eligible for development. The County includes approximately 209 km^2 (51,758 acres) of protected conservation and recreation lands. The Cape Cod National Seashore, alone, contains more than 109 km^2 (27,000 acres) of natural, scenic, and recreational resources spread across six Barnstable County towns. The Commonwealth of Massachusetts also holds in trust large areas of protected open space including Nickerson State Park in Brewster, Hawksnest State Park in Harwich, Crane Wildlife Management Area in Falmouth, and the Hyannis Ponds in Barnstable. Through the use of land banks, conservation easements, and other land preservation mechanisms, towns throughout the County have established more than 16 km^2 (4,000 acres) of open space (CCC, 2012).

As described above, seasonal use of the County's open space resources, particularly the area's beaches, play a significant factor in the County's economic productivity. For example, approximately 4.5 million people visit the Cape Cod National Seashore each year (Chamber of Commerce, 2017). The Association to Preserve Cape Cod (2014) estimates 17 km^2 (4,250 acres) of Barnstable County are categorized as farm lands and an additional 2.4 km^2 (600 acres) of shellfish cultivation occurs on aquaculture grants. There are approximately 235 aquaculture license holders throughout the County, though 70% of the aquaculture acreage is in the coastal waters of Wellfleet and Barnstable (Beauchamp & Geist, 2011).

The Association to Preserve Cape Cod estimates that approximately 40% of the land-based agriculture is cranberry bogs, while another 35% percent is general farming activity. The remaining 25% of land-based agriculture consists of wood lots, tree farms, garden centers and greenhouses.

Joint Base Cape Cod, a military installation encompassing approximately 78 km^2 (30 mi^2) of land, is located adjacent to the Cape Cod Canal in the towns of Bourne, Mashpee, and Sandwich. The installation hosts the Massachusetts Air National Guard's Otis Air National Guard Base, the US Coast Guard's Air Station Cape Cod, the Veterans Administration Cemetery, the US Air Force's Cape Cod Air Force Station, and the Massachusetts Army National Guard's Camp Edwards. Barnstable County hosts three prominent research and education institutions; Barnstable Community College, the Massachusetts Maritime Academy, and the Woods Hole Oceanographic Institution.

Town of Barnstable

The Town of Barnstable is the largest community on Cape Cod both in land area and population, and also serves as the County seat. Most of the Town's residential development has occurred in the last 40 years. During this period of substantial residential growth, wastewater, water supply, transportation improvements, recreational amenities, schools and other government services were developed (Barnstable, 2010). Figure 7.7-1 depicts land uses in the Town of Barnstable.

The Town of Barnstable land use policy directs growth to the downtown Hyannis area, a major seasonal tourist destination and an active recreational boating harbor. Hyannis is also the second largest commercial fishing port on Cape Cod. Hyannis contains important regional assets, including two ferry terminals with service to Nantucket and Martha's Vineyard, the region's largest commercial airport, the Cape Cod Mall and other commercial areas on Route 132, and the region's primary medical facility, Cape Cod Hospital (Utile, 2010). Barnstable's road network consists of three major regional east-west roads – Route 6A, Route 6 and Route 28, and four regional roads that connect to the east-west roads - Willow Street, Route 132, Phinney's Lane and Route 149.

Barnstable consists largely of open space, including inland and coastal wetlands, forest, and freshwater features. Substantial areas of low- to medium-density residential development surround corridors of commercial and industrial uses. Barnstable has 3 km^2 (49 acres), approximately 2% of its land area, that claim Massachusetts General Laws Chapter 61A current use tax status as active agricultural or forest use.

Working waterfronts are a signature feature of Barnstable County, and long-established water-dependent uses have activated deep-water harbors in support of traditional fishing activities and the recreational boating public.

The Town of Barnstable has approximately 160 kilometers ("km") (100 miles ["mi"]) of coastline, more coastline than any other town in Massachusetts. The Town of Barnstable also has extensive salt-water wetland areas which, including Great Marsh south of Sandy Neck, accounts for approximately 27% of the County's salt marsh (Barnstable Comprehensive Plan, 2010). No Project-related actives will occur proximate to Barnstable's northerly coastline fronting Cape Cod Bay. The following section, therefore, focuses on coastal infrastructure along the Town's southerly coastline; primarily the 95 km (59 mi) of coastline from the Osterville and Three Bays area to the Hyannis and Hyannis Port area of the western portions of Lewis Bay.

Hyannis Harbor consists of an Outer Harbor, a Middle Harbor (known as Lewis Bay), and an Inner Harbor. The Inner Harbor, typical of working waterfronts, is developed with timber and steel sheetpile bulkheads to the extent of filled tidelands. Piers, wharves, docks, and other facilities are located along the perimeter of the Inner Harbor.

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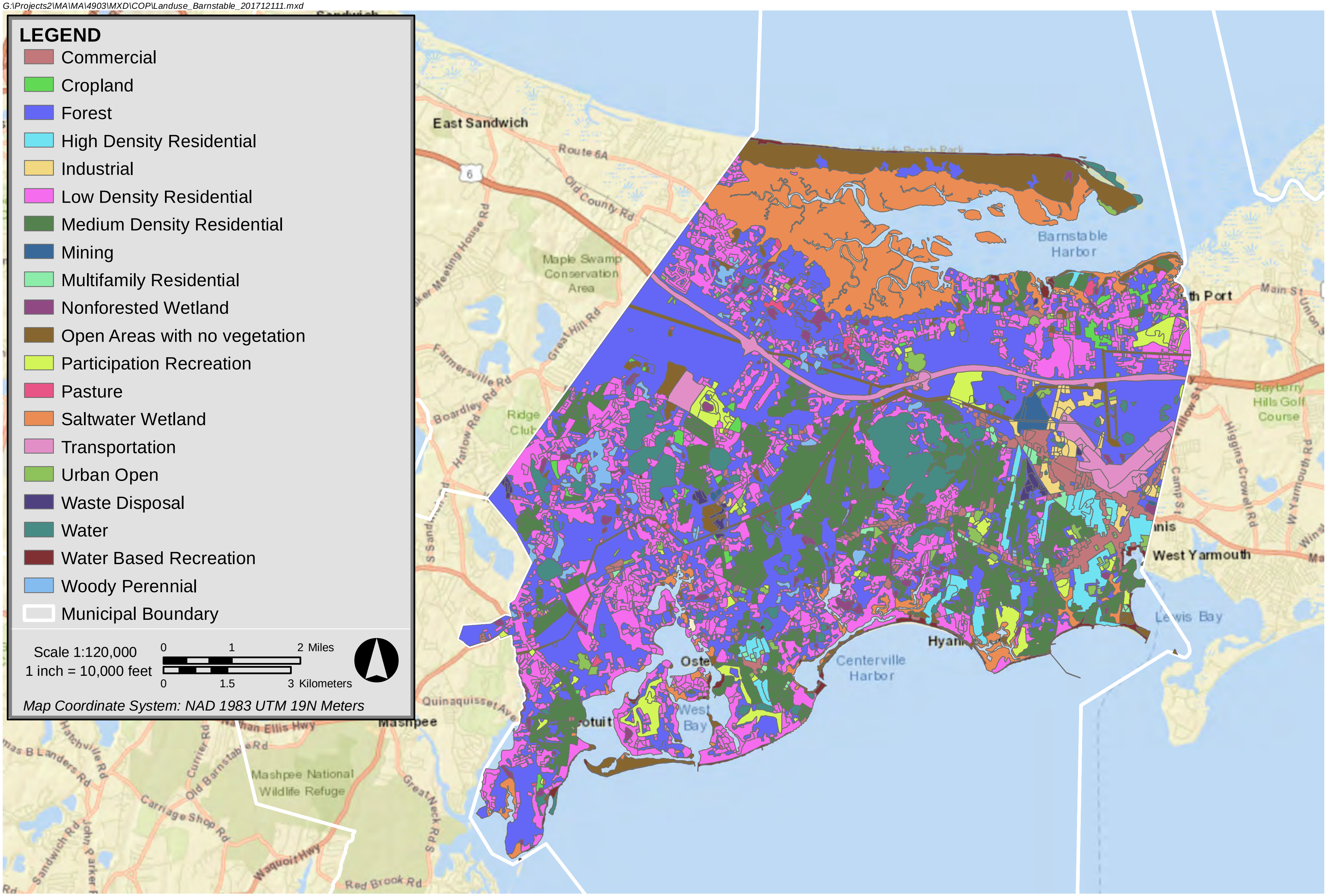

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Figure 7.7-1

Land Use, Barnstable

The Town of Barnstable operates two marinas in Hyannis Harbor; the Bismore Park Marina and the Gateway Marina and boat ramp. These facilities also provide dockage for the commercial fishing vessels. The Town's facilities provide dockage for tourist day boats and other recreational vessels. The Town of Barnstable manages an estimated 2,460 mooring permits issued to individual mooring permit holders. The Barnstable Harbormaster also operates land-based, semi self-service pump-out facilities and a pump-out vessel. Several private marina operators offer dockage, fuel, and servicing within the Harbor. Hy-Line Cruises and The Nantucket Steamship Authority, both passenger vessel and ferry service operators, have facilities located within the Inner Harbor.

The USACE maintains a FNP within Lewis Bay. The FNP provides for: a 357 m (1,170 ft]) long stone breakwater lying approximately 1.1 km (0.7 mi) offshore; an anchorage area dredged to -4.7 m (15.5 ft) MLLW in a protected area behind the breakwater; an entrance channel dredged to -3.9 m (-13.0 ft) MLLW from deep water in Nantucket Sound to the entrance of the inner harbor area; a -3.9 m (-13.0 ft) MLLW and 4.5 m (15 ft) wide channel and a -3.9 m (-13.0 ft) MLLW deep turning basin in the inner harbor area; and a 45 m (150 ft) wide channel dredged to -3.7 m (12.0 ft) MLLW and adjoining the -3.9 m (13.0 ft) MLLW deep entrance channel in the outer harbor area. The FNP provides for two additional anchorage areas, 3.7 m (12.0 ft) MLLW anchorage adjacent to the inner harbor turning basin. The FNP also includes a 305 m (1,000 ft) long riprap jetty extending south from Dunbar Point. The US Coast Guard maintains a series of aids to navigation delineating the Harbor approach, channel, and obstructions.

A Confined Aquatic Disposal ("CAD") cell was created outside of Hyannis Harbor in 1998. The Hyannis CAD cell is located beneath the former harbor entrance channel adjacent to the outer Harbor anchorage area southwest of the Lewis Bay. The suitable material removed during cell construction was placed on the beaches at Great Island and within the dikes built the previous year on Dunbar Point behind Kalmus Beach. Approximately 57,600 cubic meters ("m^3") (2.03 million cubic feet ["ft^3"]) of silty material from the Inner Harbor basin was disposed in the CAD cell from December 1998 to March 1999. The cell was capped with clean sand from a prior Lewis Bay channel deepening project in March 1999. The OECC does not interact with the Hyannis CAD cell.

Four marinas and five marine services businesses are located to the west of Lewis Bay, including Prince Cove Marina, a facility owned and operated by the Town of Barnstable.

The relatively shallow depth of water throughout much of this area limits navigational capacity. Navigable depths appear to be maintained in marked channels; however, shoaling is often reported and the Town of Barnstable has sponsored periodic maintenance dredging activities in these areas (CRMP, 2009). Much of this area is characterized by small villages, marinas, and mooring areas set in coves and along marsh and beaches areas. Public access facilities, including parking, pedestrian access, and boat ramps, launch areas and mooring access points are extremely limited and in heavy demand during the summer boating season, a common issue in the State's coastal communities. The Town of Barnstable operates 16 boat launch ramps and associated facilities, seven of these are coastal facilities located in the area west of Lewis Bay.

The Town of Barnstable maintains and operates four public beaches within proximity to Lewis Bay. Craigville Beach and Covell's Beach, in Centerville Harbor; Sea Street – Keyes Beach and Kalmus Beach in the Outer Harbor; and Veterans Beach in the Middle Harbor/Lewis Bay. These facilities also include public amenities and may be staffed on a seasonal basis.

The Town of Barnstable also hosts electric transmission and distribution infrastructure necessary to accommodate the Project. This infrastructure includes the West Barnstable Substation and the Barnstable Switching Station. The Project is evaluating these locations as points of interconnection with the Cape Cod bulk power grid.

Town of Yarmouth

The Town of Yarmouth is comprised three villages: South Yarmouth, West Yarmouth and Yarmouth Port. Barnstable County's three major east-west transportation corridors, Route 6A, Route 6, and Route 28 bisect the Town.

The Town of Yarmouth is substantially built-up, though development is largely low- to medium-density residential with commercial corridors built along Route 6 and Route 28. Retail, industrial, institutional, and commercial uses comprised the largest square footage of development (Local Comprehensive Plan, 1997). Of the approximately 18.6 km^2 (4,600 acres) of land in the Town of Yarmouth, 6.9 km^2 (1,700 acres) are devoted to conservation, including land for the protection of public water supplies. An additional 6 km^2 (1,500 acres) are considered protected from development due to various ownership and conservation restrictions. Figure 7.7-2 depicts land uses in the Town of Yarmouth

Freight rail service through the Town of Yarmouth is operated by the Massachusetts Coastal Railroad from the Barnstable town line to just west of Station Avenue south of US Route 6. A trash transfer station is located along the rail line and provides Cape area refuse and transfer services to Covanta's Southeastern Massachusetts Resource Recovery Facility, a waste-to-energy facility in Rochester, MA.

No Project-related actives will occur proximate to Town of Yarmouth's northerly coastline fronting Cape Cod Bay. The following section, therefore, focuses on the limited coastal infrastructure along the Town of Yarmouth's southerly coastline. Large sections of the Town of Yarmouth's coastline fronts Lewis Bay, Great Island, and the Parker River estuary. This coastline is characterized by low- to medium-density residential development and recreational and conservation open space

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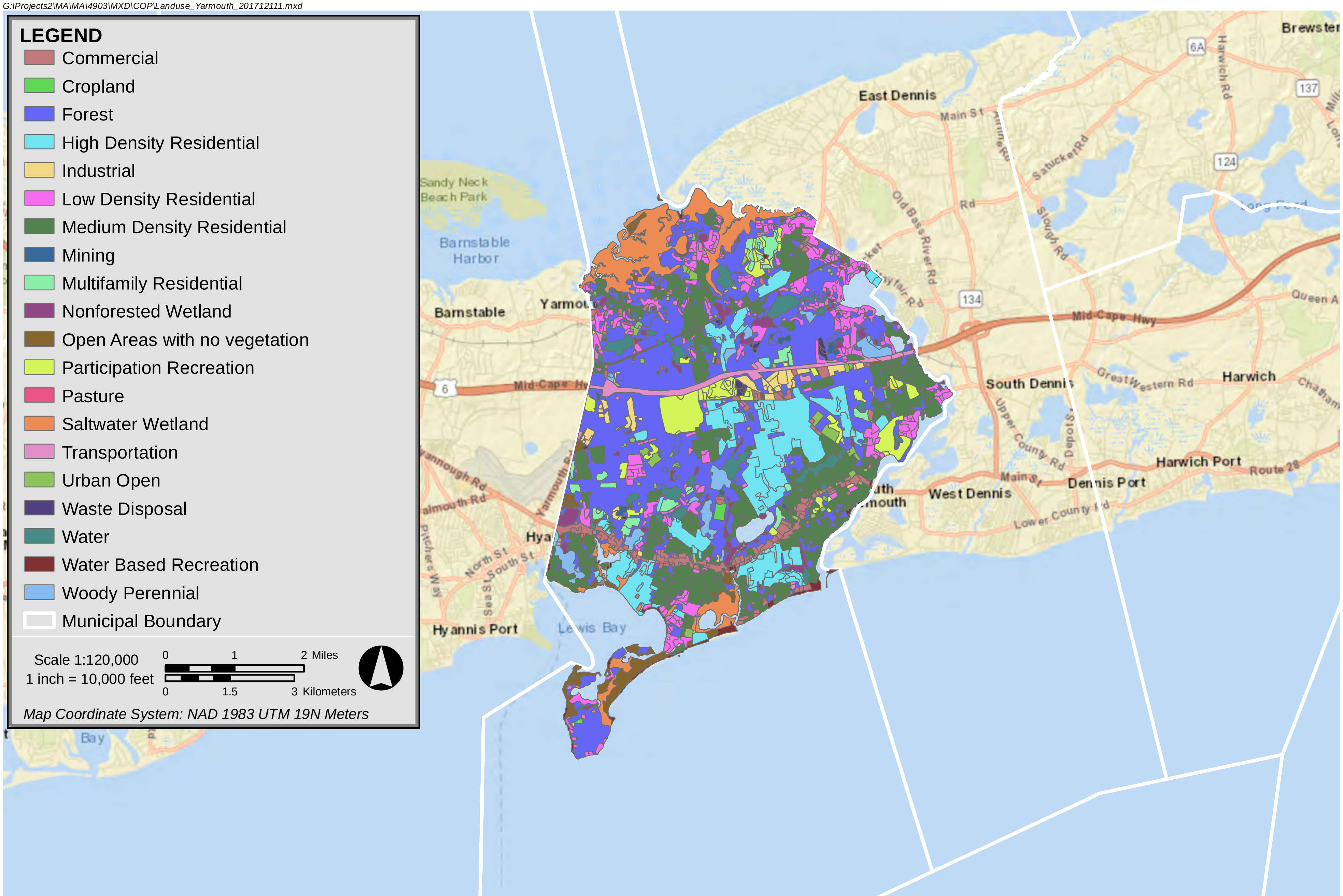

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Figure 7.7-2

Land Use, Yarmouth

The Town of Yarmouth operates four marina facilities: Packet Landing, Colonial Acres, Englewood Beach, and Bass Hole providing slips for recreational and commercial vessels.

The Town of Yarmouth Harbormaster Department currently maintains and monitors 60 navigational markers in Bass River, Lewis Bay, and Nantucket Sound. Channel markers, swim buoys, and hazard markers are set seasonally by the Town of Yarmouth Harbormaster and Natural Resource staff.

The Town of Yarmouth is proposing to construct a "marine park" on a 22-acre site on Parker's River that was acquired with the intention of developing a marina and other recreational uses. The site currently hosts the Town of Yarmouth's shellfish propagation upweller facility.

The Town of Yarmouth maintains and operates eleven public beaches. Beaches along the Town of Yarmouth's southerly coast are: Colonial Acres Beach and Englewood Beach in Lewis Bay and Sea View Beach, South Middle Beach, Seagull Beach, Parker River Beach, and Bass River Beach on Nantucket Sound. Some of these beaches are staffed on a seasonal basis and offer additional public amenities, including boat launch facilities.

7.7.1.1.2 Bristol County

Bristol County comprises approximately 1,432 km^2 (553 mi^2) of land and approximately 357 km^2 (138 mi^2) of watersheet in the southeast region of the state. The County borders Norfolk County to the north, Plymouth County to the east, and Bristol County and the State of Rhode Island to the west. Bristol County is included in the South Coast region of the state which includes older industrial cities, and in some locations sprawling development. The South Coast communities of Fall River, New Bedford and Taunton are the only cities within 80 km (50 mi) of Boston not served by commuter rail.

The Interstates 95, 195, and 495 corridors, which frame Bristol County, exhibit high levels of development in the areas surrounding the larger cities, including New Bedford. Agriculture in the southeast region of the state, including Bristol County, however, remains a major industry.

With the exception of New Bedford, Fairhaven, and Fall River, Bristol County's coastline is characterized by low density residential development. The coastal regions of the Bristol County also have significant recreation resources such as beaches, harbors, and conservation land.

City of New Bedford

The City of New Bedford comprises 52 km^2 (20 mi^2) of land, including a bit less than one square kilometer (217 acres) of conservation land and 3.7 km^2 (921 acres) of recreational land. The City has 16.5 km (10.3 mi) of coastline and approximately four square miles of watersheet. The City has 15 neighborhood parks, more than 3.2 km (12 mi) of trails and bikeways, 26 acres of beaches, and numerous public and private athletic fields and facilities.

Figure 7.7-3 depicts the land use types in the City of New Bedford.

The City of New Bedford regulates land use through zoning regulations or ordinances that largely classify land uses as residential, commercial, or industrial. The City of New Bedford's Planning Department administers the local and state regulations affecting land use and land reuse. The Planning Department also provides staff support to the Planning Board, Historical Commission, Zoning Board of Appeals, the City Council, and other city departments, boards and commissions as needed. Waterfront development, infrastructure upgrades, dredging and other construction and repair projects on or over and adjacent to the Port of New Bedford watersheet are reviewed by the Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs and their Office of Coastal Zone Management, the Department of Environmental Protection, the Massachusetts Department of Marine Fisheries, the Environmental Protection Agency ("EPA"), USACE, the New Bedford Harbor Development Commission, and local municipal conservation commissions, zoning and waterways management boards, and a variety of other federal, state and city officials.

New Bedford has significant transportation assets including an interstate highway, a regional airport, water ferry service, freight rail, and regional and interstate bus service.

Coastal infrastructure in New Bedford, particularly within the New Bedford/Fairhaven Harbor, is substantial. According to the New Bedford/Fairhaven Municipal Harbor Plan, roughly 70% of the approximately 3.8 km^2 (938 acres) of harbor land area is on the New Bedford side of the Harbor, with the remaining 30% in Fairhaven. Including coastal infrastructure on the Fairhaven side of the Harbor, and inland areas with direct or indirect ties to the waterfront, approximately 1.2 km^2 (304 acres) of the harbor land area is currently used for industrial and seafood processing activities. Approximately 16% of harbor land is owned or directly control by municipal, county, state or federal government entities. Many of these holdings are leased for marine industrial uses. About 7% of harbor land is used by commercial businesses that indirectly support the marine industry and the remainder is open space, residential, parking and transportation services, and other businesses. Approximately 4% of harbor land was vacant in 2010. Generally, commercial and industrial activities are more densely clustered on the New Bedford side of the harbor, accounting for approximately 70% of harbor land uses (MHP, 2010).

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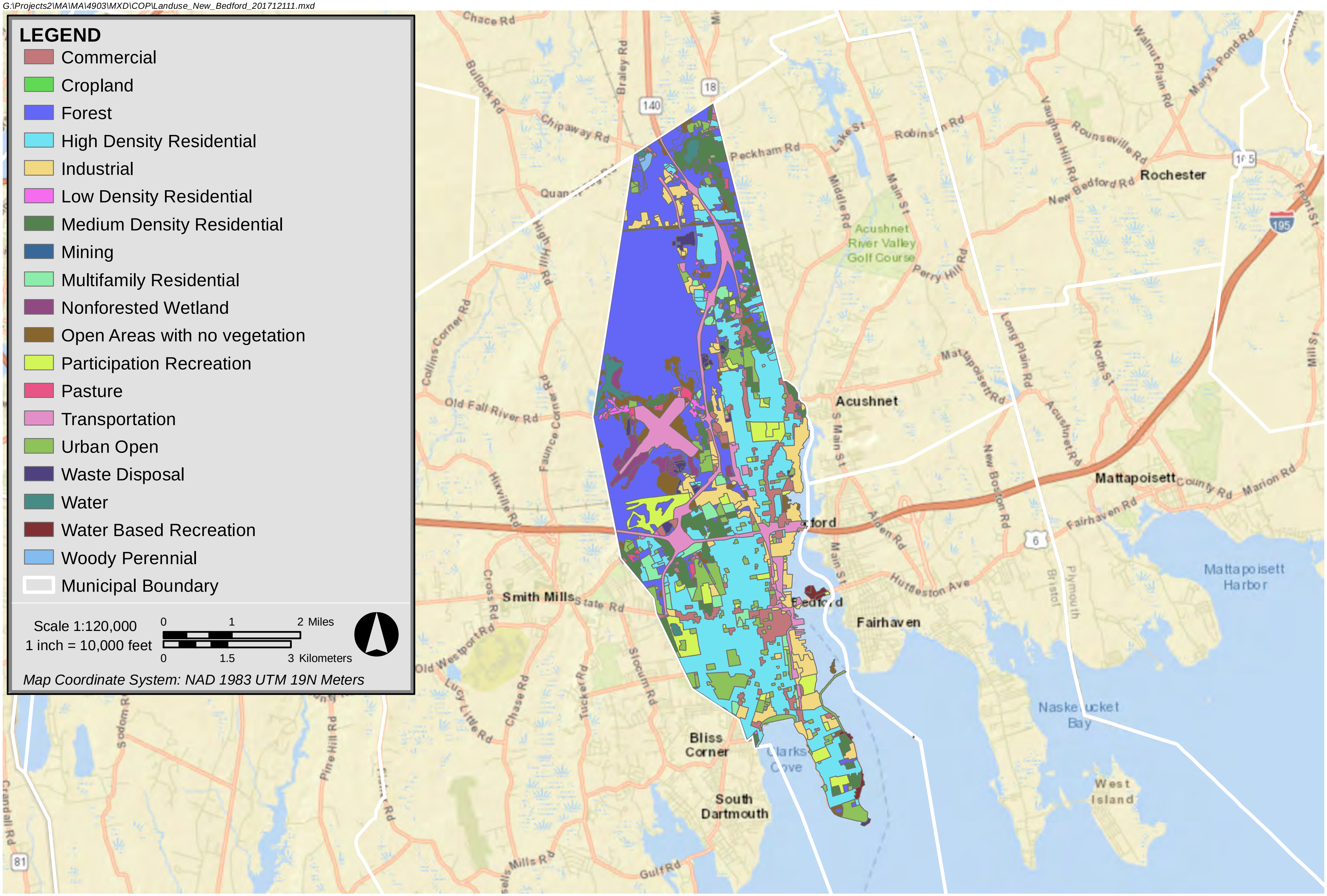

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Figure 7.7-3

Land Use, New Bedford

The Port of New Bedford is a significant regional economic and cultural asset. It's a deep-water commercial port with direct access to important maritime corridors leading from the Massachusetts coast. The Port of New Bedford ("Port") is approximately 17 km (9 nm) from the Cape Cod Canal, 133.5 km (83 mi) south of Boston Harbor, and 267 km (166 mi) north of New York (HDC, 2017). By landed value, the Port is the primary fishing port in the nation; commercial fishing operations generate economic activity in excess of $9.8 billion and related employment of more than 36,000 people (NBHDC, 2016). The fishing fleet of approximately 500 vessels lands over 122 million pounds of product, annually leveraging $322 million in direct sales (HDC, 2017).

The USACE's New Bedford Hurricane Protection Barrier lies across entrance to the New Bedford and Fairhaven Harbor. The Hurricane Protection Barrier protects approximately 5.6 km^2 (1,400 acres) of land in New Bedford, Fairhaven, and nearby communities from tidal flooding associated with coastal storms. The Hurricane Protection Barrier is a 1.4 km (4,500 ft) long earthen fill dike with stone slope protection. It has a maximum elevation of 6 m (20 ft) above mean sea level and a 46 m (150 ft) wide gated opening to accommodate commercial and recreational navigation.

The USACE also manages and maintains the New Bedford and Fairhaven FNP. The FNP consists of a 350-foot wide navigation channel, dredged to -30.0 ft MLLW extending eight kilometers (5 mi) from Buzzards Bay to a point above the New Bedford-Fairhaven Bridge (i.e., US Route 6). Northwest of Palmer Island (along the New Bedford main waterfront) and above the New Bedford-Fairhaven bridge, the navigation channel has areas of increased widths for anchorage and maneuvering purposes. A second channel is dredged to -7.6 m (-25.0 ft) MLLW and from 61-76 m (200-250 ft) wide extending 320 m (1,050 ft) from the lower maneuvering area along the New Bedford waterfront to the vicinity of Fish Island and the swing bridge.

A separate channel along the Fairhaven waterfront extends approximately 1,128 m (3,700 ft) northward from Pierce and Kilburn. From Pierce and Kilburn Wharf to Old South Wharf, the channel is dredged to -4.5 m (-15.0 ft) MLLW and ranges from 45-122 m (150-400 ft) wide. From Old South Wharf to a point 304 m (1,000 ft) south of the old causeway pier, the channel is -3 m (-10.0 ft) MLLW and 46 m (150 ft) wide. The US Army Corps also maintains a 0.66 km^2 (165 acre), triangular-shaped anchorage, dredged to -7.6 m (-25.0 ft) MLLW along the east side of the main channel and north of Palmer Island.

New Bedford's inner harbor and the main working port extends north from the Hurricane Barrier to a fixed highway bridge on Interstate-195. New Bedford harbor is up to 1,150 m (3,800 ft) wide and 3.62 km (2.25 mi) long, and is bisected by the Route 6 causeway and its three bridges. Two of the causeway bridges are fixed spans with vertical clearances of 1.8 m (6 ft) at Mean High Water. The third bridge is a swing span that crosses the main shipping channel. When the span is in the open position, the bridge provides access to the northern half of the inner harbor through two openings, each slightly less than 29 m (95 ft) in width. These openings restrict the size of vessels that can reach the Harbor's northern-most facilities.

Passenger ferry operations serving over 100,000 passengers each year operate from New Bedford Harbor. The Port of New Bedford supports a growing tourism sector; the Harbor is a port of call for American Cruise Lines and other locally owned harbor tour operators. A number of marine service operators are located in the Harbor. These facilities offer Travelift and marine rail launch/haul services for vessels up to 850-tons, along with comprehensive maintenance, repair, and refit services. The Harbor is a significant intermodal shipping center for the northern US market and offers Roll-on/Roll-off, including ship-to-rail; bulk, break-bulk, and containerized cargo facilities. The Harbor also has immediate access to approximately 127,400 m^3 (4.5 million ft^3) of cold storage, Foreign Trade Zone ("FTZ") #28, and direct links to the Interstate Highway System, and regional air and rail networks.

Six marinas in New Bedford Harbor are located in Fairhaven, and provide more than 580 boat slips for recreational vessels. The Fairhaven Harbormaster permits approximately 70 public and private moorings. The Town of Fairhaven also operates and maintains public boat ramp and dinghy dock a Pease Park.

7.7.1.1.3 Dukes County

Dukes County comprises approximately 267 km^2 (103 mi^2) of land and approximately 1005 km^2 (388 mi^2) of watersheet. Although the County consists of the island of Martha's Vineyard, including Chappaquiddick Island, the Elizabeth Islands (including Cuttyhunk), the island of Nomans Land, and other associated islets, the following section describes land uses and coastal infrastructure on the island of Martha's Vineyard. As described above, Vineyard Wind intends to use Vineyard Haven Harbor in Tisbury as a location for the Project's O&M Facilities.

According to the Martha's Vineyard Commission ("MVC"), Martha's Vineyard went through its biggest development surge in the 1980s. Conservation efforts, notably the establishment of the Land Bank Commission, resulted in more than 40% of the Island being conserved from development. Commercial activity has historically, and remains centered on the traditional town and village centers, while residential development is more dispersed. Vineyard Haven, Oak Bluffs, and Edgartown are, in general terms, the commercial centers of the island. Community character and historic resources are significant factors influencing land use and development and development patterns on the island. Figure 7.7-4 depicts land uses on Martha's Vineyard.

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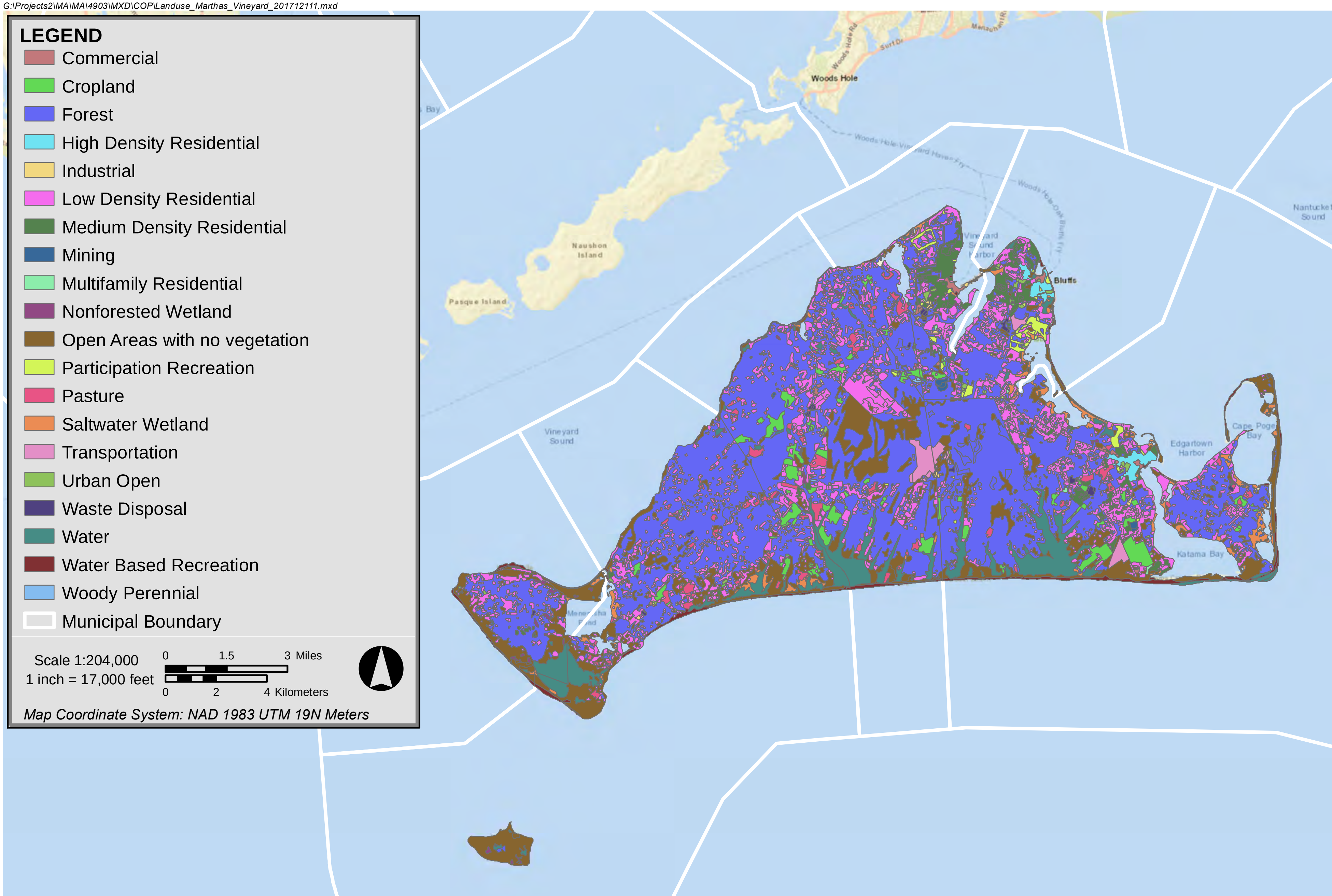

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Vineyard Wind Project

VINEYARD WIND

Figure 7.7-4

Land Use, Martha's Vineyard

The Steamship Authority carries more than two million passengers and almost 500,000 vehicles to and from Martha's Vineyard each year on ferries operating from Woods Hole to Vineyard Haven and Oak Bluffs. There are also close to 300,000 passenger trips on private passenger ferries linking Martha's Vineyard and Gosnold to various mainland ports.

There are two airfields on the Island. The Martha's Vineyard Airport (MVY) handles about 250,000 passenger trips and more than 25,000 aircraft operations in 2015 (FAA, 2017) while the Katama Airpark (1B2) handles an average of 7,200 aircraft operations in 2010 (MassDOT, 2010).

The Martha's Vineyard Transit Authority ("VTA") provides year-round public transit service to the six towns of Martha's Vineyard: Aquinnah, Chilmark, Edgartown, Oak Bluffs, Tisbury and West Tisbury. The VTA's transportation services consist of both fixed route and paratransit services. VTA fixed route service varies throughout the year, depending on the seasonal travel demand, but typically operates with 14 Island-wide routes during the peak season (VTA, 2017).

The waterfront communities of Edgartown and Oak Bluffs, and to a lesser extent Tisbury, are primarily comprised of tourism-oriented establishments, many of which close in the off-season. Year-round retail and office activities have begun to locate away from the historical commercial centers, most notably along and near Upper Main Street in Edgartown and Upper State Road in Tisbury (MVC, 2006). Other retail and office activities are located in smaller village centers including West Tisbury, Menemsha, and Chilmark's Beetlebung Corner. Industrial activities occur in various in-town and rural locations, though clustering of these activities occurs at the Airport Business Park alongside other commercial activities.

Martha's Vineyard has four primary harbors: Vineyard Haven Harbor, Menemsha Basin, Edgartown, and Oak Bluffs. The harbors are home to the Island's fishing fleet and commercial vessels that handle passenger and cargo services from the mainland. These harbors are important destination for tourists and recreational boaters, alike, and offer full-service facilities for recreation boaters.

As noted above, Vineyard Wind intends to use Vineyard Haven Harbor as a location for the Project's O&M Facilities. Vineyard Haven Harbor is considered the year-round working port and is home to most of the Martha's Vineyard boatyards. Vineyard Haven Harbor is located approximately four miles southeast of Woods Hole and 35 km (22 mi) southeast of New Bedford. Vineyard Haven Harbor is used regularly by small coastal tankers and ferries transporting freight, vehicles, and passengers.

The USACE maintains an FNP in Vineyard Haven Harbor. The FNP includes a navigation fairway at the head of the Harbor between Steamboat Wharf and a breakwater built and maintained by the Commonwealth of Massachusetts. This triangular-shaped area is dredged to -5 m (-17.0 ft) MLLW, is approximately 46-84 m (150-275 ft) wide, and 304 m (1,000 ft) long. The FNP also includes a -3.7 m (-12.0 ft) MLLW- anchorage behind the breakwater, immediately north of the fairway area, which hosts a mooring field operated by the Town of Tisbury. Areas of the inner harbor, to the south of the fairway have dockage at pile supported piers. Much of the inner Harbor, however, remains coastal beach and limited wharfing space is currently available. Additional marine services are available within Lagoon Pond, south of the inner harbor and the Beach Road causeway.

7.7.1.2 Rhode Island

Onshore facilities may be located in the City of Providence in Providence County, and in the Town of North Kingstown, in Washington County. Land use and coastal infrastructure are described as they exist in those communities.

7.7.1.2.1 Providence County

Providence County, encompassing the northern portion of the State of Rhode Island, consists of 1,062 km^2 (436 mi^2) of land and 67 km^2 (26 mi^2) of watersheet. Providence County borders the Commonwealth of Massachusetts to the north and east, the state of Connecticut to the west, Kent County to the south, and Bristol County to the southeast. With an estimated population of 631,344 residents in 16 cities and towns, Providence County is the most populous in the State of Rhode Island.

The southeasterly portions of Prividence County are the most densly developed, particularly the communities located within the Interstate 295 corridor that bisects the County to the east and north of the City of Providence, the State capital. Interstate 95 also serves Providence County, along with regional rail, bus, and ferry services.

City of Providence

The City of Providence comprises 48 km^2 (18.5 mi^2) of land including 5 km^2 (2.1 mi^2) of watersheet spread over 25 distinct neighborhoods. The City of Providence is the most populous in the State of Rhode Island with an estimated population of 178,851. The City of Providence is also home to numerous top hospitals, colleges and universities, which are key factors in the city's economy. (Providence Tomorrow, 2014)

Figure 7.7-5 depicts the land use types in the City of Providence.

The City of Providence has a fixed land area of 46.6 km^2 (18 mi^2) and is characterized by it's compact footprint. The City has limited land area available for new development, approximately a third of which is located existing residential neighborhoods. (Providence Tomorrow, 2014). Remnants of the City of Providence's industrial past remain in the form of underutilized mill building, though many of these vacant and underutilized parcels must be remediated to make the land safe for redevelopment. (Providence Tomorrow, 2014)

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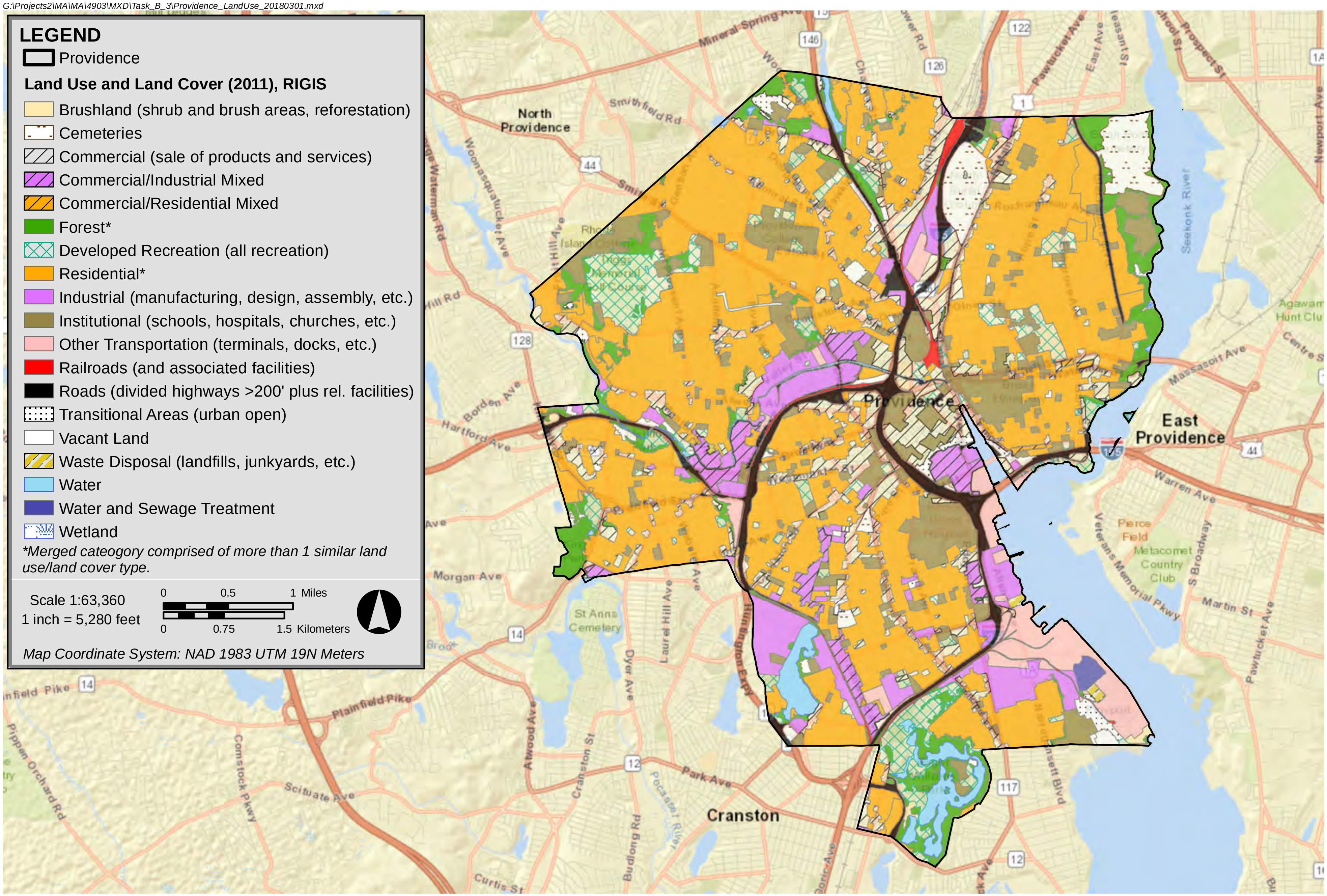

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Vineyard Wind Project

Figure 7.7-5

Land Use - City of Providence, Rhode Island

Providence has a diversified public park and recreation system that has continued to grow in size. Public amenities, such as Waterplace Park and the city's "riverwalks" are critical to the tourism and providing settings for events and destinations for visitors. (Providence Tomorrow, 2014)

As the State of Rhode Island's commercial and industrial center, the City of Providence also has areas of intense commercial and industrial activity, including areas of Providence River and the Port of Providence.

The Port of Providence is Rhode Island's principal commercial port, handling over 70 percent of the cargo entering Narragansett Bay. The Port of Providence is an intermodal port that offers interstate highway access as well as rail service that reaches inland to major connections throughout the US and is of particular importance, both locally and regionally, for its role in supplying energy products to southern New England.

Shipping operations into the Port of Providence make use of port facilities located in both Providence and East Providence. Most of the port's maritime activity is concentrated in ProvPort (a private port facility located in Providence), though these industries depend on support services provided by tugboat, shipyard, and other services located throughout Providence Harbor. (SAMP, 2011). ProvPort is a 115-acre facility that provide 1,280 m (4,200 ft) of berthing space, 12,077 m^2 (130,000 ft^2) of covered storage, and more than 20 acres of open lay down area. ProvPort also has on-dock rail service and quayside water depth to -12.2 m (-40 ft) MLW. (ProvPort, 2018)

Marine transportation into the Port of Providence is facilitated by a federally maintained navigational channel, which was recently dredged in 2005 to a -12.2 m (-40 ft) MLW, allowing the Port of Providence to accommodate deep-draft vessels. The deep draft channel—as well as its intermodal capabilities, connecting water, rail, and land transportation—together make the Port of Providence attractive to both domestic and international vessels (ProvPort 2009). Providence is also one of the few New England ports that can accommodate deep draft vessel while offering direct access to the interstate highway system (FXM Associates 2008).

7.7.1.2.2 Washington County

Washington County, locally referred to as "South County," has 126,319 residents in its nine towns: North Kingstown, South Kingstown, Exeter, Narragansett, Charlestown, Hopkinton, Richmond, Westerly, and New Shoreham. Washington County is largely undeveloped with communities ranging from rural farming enclaves to seasonal beach communities, and more typical New England village centers and low density residential development. With approximately 30,651 residents, South Kingstown is the Washington County's largest town by population. Washington County is comprised of 852 km^2 (329 mi^2) of land and 606 km^2 (234 mi^2) of watersheet.

Washington County encompasses all of southwestern Rhode Island, from the Connecticut border to Narragansset Bay, including Block Island located approximately 16 km (10 mi) south of mainland Rhode Island, in Block Island Sound. Washington County's southerly shoreline is comprised largely of coastal beaches which provide numerous recreational and public access opportunities. The easterly shoreline, along Narragansset Bay, is comprised of rocky intertidal habitat though areas of sandy beach do exist.

Interstate 95 passes through the northwestern portion of the Washington County and US Route 1 largely follows the County's coastline. Regional passenger rail service is provided by Amtrak which makes stops in West Kingston and Westerly. Privately-owned Richmond Airport (08R), and the state-owned airports: Westerly (KWST), Block Island (KBID), and Quonset State Airports are located in Washington County. Ferry service to Block Island is operated from Point Judith in Galilee.

Town of North Kingstown

North Kingstown's town center, Wickford village, is the County's center of government and recreation-based maritime activities and the Towns more rural areas are comprised of preserved farmland and open space, residential and commercial development, and village centers.

Figure 7.7-6 depicts the land use types in the Town of North Kingstown.

Quonset Business Park (QBP), formerly known as the Quonset/Davisville Port and Commerce Park, is a 3,000-acre complex located on Narragansett Bay north of Wickford. QBP is the former location of the Quonset Naval Air Station which was deactivated in 1974, and the Davisville Naval Construction Battalion Center which, until its recommended closure under the Defense Base Closure and Realignment Act of 1990, as amended, was operational until 1994. The QBP, operated by Quonset Development Corporation (QDC), a quasi-public agency, hosts industrial, office, research and development, retail, transportation, manufacturing, tourist, open space, and recreational uses. 500 acres of QBP are dedicated to the Quonset State Airport. Approximately 700 of the 2,500 acres of the business park remain available for development.

To the north of QBP is the Port of Davisville (Quonset), which currently provides 1,372 linear meters (4,500 linear feet) of berthing space at two 366 m (1200 ft) piers, a bulkhead, --9.74 m (-32 ft) controlling depth MLW, on-dock rail, and 58 acres of laydown and terminal storage. The Port of Davisville also has heavy lift capacity, including a 150 metric ton (MT) mobile harbor crane. Vessels access the Port of Davisville through a shipping channel with a 29-foot controlling depth that is not maintained by the U.S. Army Corps of Engineers.

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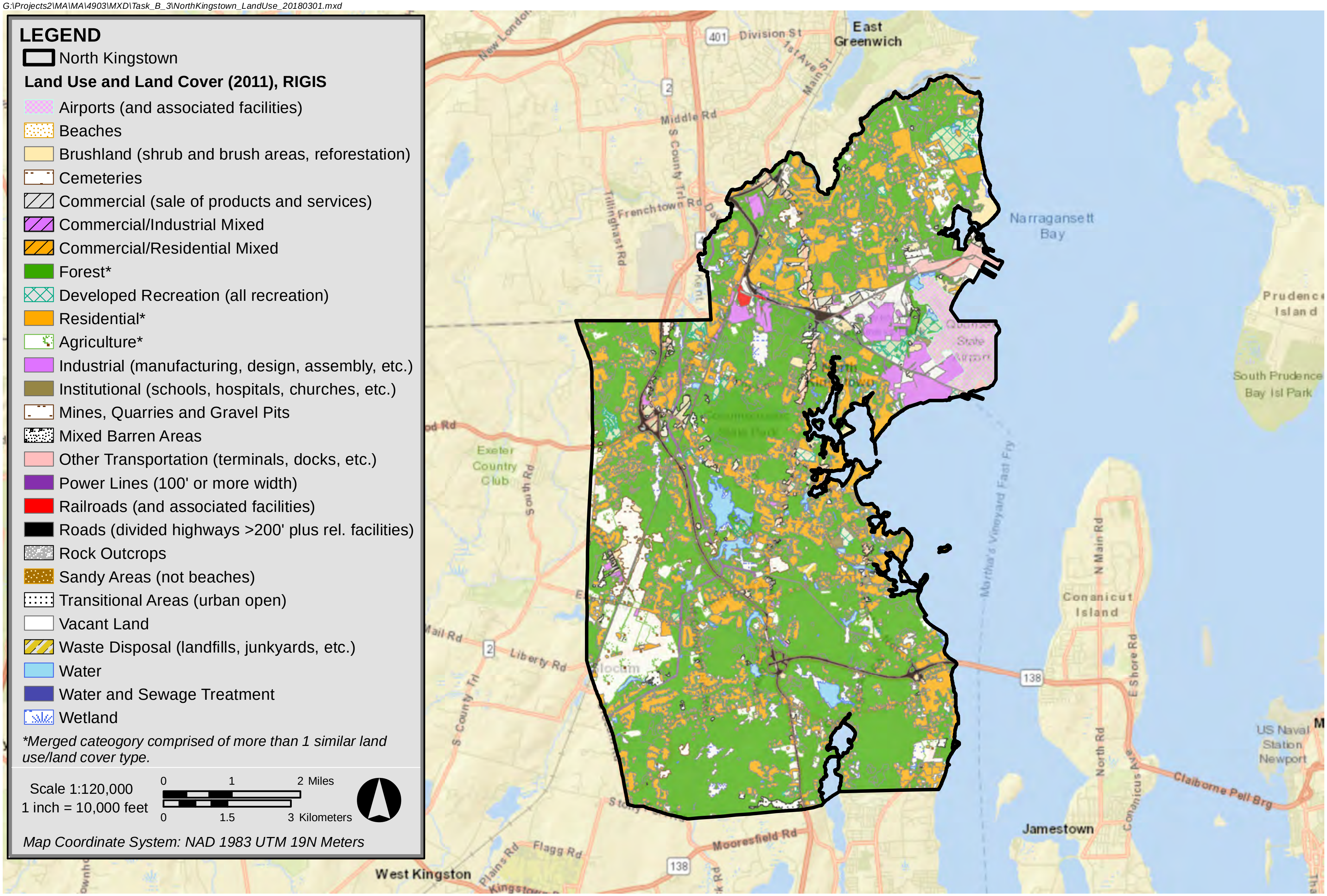

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Vineyard Wind Project

VINEYARD WIND

Figure 7.7-6

Land Use - Town of North Kingstown, Rhode Island

Vineyard Fast Ferry, which operates a seasonal ferry between Quonset Point and Martha's Vineyard, operates a small ferry terminal in the Quonset Business Park. Other current marine transportation-related uses at the Quonset Business Park include businesses such as Senesco Marine, a barge-building company, and General Dynamics Electric Boat, which builds components for the US Navy. (SAMP, 2011)

7.7.1.3 Connecticut

Onshore facilities may be located in the City of Bridgeport in Fairfield County, and in the City of New London, in New London County. Land use and coastal infrastructure are described as they exist in those communities.

7.7.1.3.1 Fairfield County (Southwestern Connecticut)

Fairfield County, the most populous county in the State, is located in southwestern Connecticut, along the Long Island Sound and approximately 80.5 km (50 mi) east of New York City. Fairfield County comprises approximately 1619 square kilometers (km2))(625 square miles [mi2]) and approximately 549 km2 (212 mi2) of watersheet.

Fairfield County land use consists, broadly, of low density residential (47.8%), medium density residential (19.0%), and parks and open space (19.9%). (Metropolitan Council of Governments, 2015). Institutional, mixed-use, commercial, and light industrial uses comprise the remaining percentages of land uses. Fairfield County's urban centers, including the City of Bridgeport, are the most intensely developed and integrated mix of uses (MCOG, 2015).

Fairfield County is served by commuter rail, ferry, the train, and the local bus systems. The region's freeways, I-95 and State Routes 8 and 25, also serve Fairfield County. Sikorsky Memorial Airport in Stratford is owned by the City of Bridgeport and provides general aviation services primarily for private and corporate aircraft.

Fairfield County and, more generally, southwestern Connecticut has more than 4,000 acres of municipally operated parks that provide recreational opportunities. (GBRPA, 2003). The coastal communities of Fairfield, Stratford, and Bridgeport all have public beaches, in addition to municipal beaches on inland lakes and ponds throughout Fairfield County.

City of Bridgeport

The City of New London occupies 41.4 km^2 (16 mi^2) of land situated along the Long Island Sound. The City of Bridgeport has the largest population in Connecticut and is also the state's most densely populated city. According to the Greater Bridgeport Regional Planning Agency (2003), the City of Bridgeport is comprised of 79% of the region's high density residential land-uses, the largest land-use category within Bridgeport, which constitutes

25% of the City of Bridgeport's land area. 22% of the city is medium density residential, 8% is commercial, nearly 7% is industrial and 8% is institutional. Vacant property, which may be in any category, is estimated to be 8.5% of land area. Geographic Information System ("GIS") data for land uses are not publically available for the City of Bridgeport.

The City of Bridgeport is served by state and interstate highway systems, including Interstate 95. Regional and local rail service, passenger and vehicle ferry services, local bus service, and air transport services are available to the City of Bridgeport.

Bridgeport Harbor is one of Connecticut's three deep-water ports, though the Port of Bridgeport is comprised o two natural harbors, Bridgeport Harbor and Black Rock Harbor. The City of Bridgeport has a long history of industrial manufacturing and water-dependent uses along its waterfront.

Bridgeport Harbor's FNP includes entrance, main and branch tributary channels, anchorages, a turning basin, and two stone breakwaters at the entrance to the harbor. The main channel has an authorized depth of -10.7 m (-35 ft) MLLW. A lack of maintenance dredging, resulting in shoaling and a reduction in the controlling depth, as reported by the USACE to be 30 feet in its 2008 Bridgeport Dredge Material Management Plan (DMMP), Similar reductions in the controlling depth of the channels in various tributaries has also been reported. (Moffatt & Nichol, 2012). The Port of Bridgeport has several private cargo facilities that handle a range of goods, including petroleum products, break bulk, and sand, gravel, and coal. The Bridgeport Port Authority owns Bridgeport Regional Marine Complext, a 43-acre industrial site dedoicated for water-dependent uses.

7.7.1.3.2 New London County (Southeastern Connecticut)

New London County comprises approximately 1,722 km^2 (665 mi^2) of land and approximately 277 km^2 (107 mi^2) of watersheet. The county encompasses the southeastern corner of Connecticut and borders the State of Rhode Island, located to the east.

New London County and, more generally, southeastern Connecticut transportation systems includes roads and highways, public and private bus services, commuter and long-distance rail, freight rail, ferries, and airports. Major overland transportation arteries in New London County include Interstates 95 and 395. The southeastern Connecticut region contains over 2,000 miles of local and state-owned roads, with 27% of roads in urban areas, 51% in suburbs, and 22% in rural areas. (SCCG, 2017). Amtrak passenger rail service is available several New London County communities and provides transporation connectivity between Boston and New York City, and beyond. Freight rail services the New London County and connects regionally with Rhode Island and Massachusetts freight rail corridors, including connections to New London's State Pier. Publicly-owned general aviation airports include Groton-New London Airport (KGON) and Windham Airport (KIJD). Groton-New London primarily serves corporate shuttles, military, recreational, and student flights. (SCCG, 2017)

According SCCG (2017), 24,490 acres of southeastern Connecticut's land are currently used for agricultural purposes and conservation programs that protect agricultural land from being developed for other uses protect another 11,000 acres. In 2011, 40% of the Southeastern Connecticut land was reported as undeveloped, and 35% of the region's land area was considered developed. (SCCG, 2017). According to SCCG (2017) the majority of residential development is low-density, defined as less than one housing unit per acre; while higher-density residential is found in urban centers, suburban and rural village centers, and in isolated pockets throughout New London County. Residential uses are the predominant land use is southeastern Connecticut, residential acreage is more than triple the combined amount of acreage used for commercial, industrial, or institutional uses (SCCG, 2017). Geographic Information System ("GIS") data for land uses are not publically available for the City of New London.

Southeastern Connecticut contains a variety of parks and other opportunities for outdoor recreation at public beaches, state parks, hiking and multi-use trails, and water access points for motorized and non-motorized boating.

Several institutions are located in New London County, including: Connecticut College, the United States Coast Guard Academy, Naval Submarine Base New London, and Coast Guard Station New London.

City of New London

The City of New London occupies 14.24 km^2 (5.5 mi^2) of land situate along the Thames River and Long Island Sound. New London Harbor, separating the City of New London from the Town of Groton to the east, is one of Connecticut's three deep-water ports. New London is one of the smallest cities in Connecticut by land area and has an estimated population of 27,212. (US Census, 2016)

Interstate 95 passes through the New London and the city is served by Amtrak's Northeast Regional and Acela Express regional rail services and Shore Line East (SLE) commuter rail service. Regional and interstate bus services operate within New London as does the Cross Sound Ferry to Long Island, the Fishers Island Ferry District, and the Block Island Express ferry. As noted in Section 7.1.1.1.2, The Groton-New London Airport is located in Groton, Connecticut.

The City of New London has approximately 30.5 km (19 mi.) of coastline along Long Island Sound and the Thames River. The City of New London's coastline features tidal and freshwater wetlands, beaches, and rocky shorefronts. (City of New London, 2017). The majority of the New London's downtown waterfront is developed and consists of water-dependent uses including piers, docks, marinas, port facilities, shipyards, and ferry terminals. The City of New London owns and leases facilities to passenger ferry service operators on the New London side of the port.

The US Army Corps of Engineers maintains a Federal Navigation Project ("FNP") in New London Harbor as well as the Thames River Navigation Project upstream of the Harbor. The Thames River Navigation Project consists of a channel dredged to -7.5 meter ("m") (-25.0 feet [ft.]) mean lower low water (MLLW) extending about 16.9 km (10.5 mi) from the area east of Mamacoke Cove in New London to the Town of Norwich, Connecticut at the mouth of the Shetucket River. The channel is 76.2 m (250 ft) wide from Mamacoke Cove to Bartlett Crossover, approximately 6.4 km (4 mi) upstream of the New London Highway Bridge. The channel narrows to 61.0 m (200 ft) wide from Bartlett Crossover to Norwich, Connecticut. In 1980, the Department of the Navy deepened to -36.0 MLLW the channel north of the Interstate 95 bridge to U.S. Naval Submarine Base in Groton. The USACE maintains the channel to a depth of 36 feet and a width of 250 feet if required by military and commercial vessel traffic.

Within New London Harbor the USACE maintain a 152.4 m (500 ft) wide channel dredged to -12.2m. (40 ft.) MLLW extending approximately 4.8 km (3 mi.) from the New London Ledge Light in Long Island Sound to a widened approach at the State Pier. A 122 m (400 ft) wide channel, dredged to -7.0 m (-23.0 ft) MLLW provides access from the main navigation channel to Shaw's Cove, the downtown New London waterfront, and the westerly portions of the State Pier watersheet. The United States Coast Guard Academy, General Dynamics Electric Boat shipyard and the U.S. Navy's submarine base in Groton have facilities along the Thames River at New London and utilize the same navigation channels as commercial vessels and ferries.

The Port of New London includes two 305 m (1000 ft) long cargo piers, the Admiral Harold E. Shear State Pier ("State Pier") and the Central Vermont Railroad (CVRR) Pier which are located approximately 6.1 km (3.8 mi) from Long Island Sound via the main navigational channel. The Admiral Harold E. Shear State Pier at the Connecticut State Pier facilities is owned and managed by the Connecticut Department of Transportation's Bureau of Aviation and Ports. In addition to easy access to I-95, the piers have the advantage of a railroad connection and track. (Connecticut Maritime Coalition, 2010). Many of New London's port facilities are owned by the State of Connecticut and managed by the Connecticut Department of Transportation.

7.7.2 Potential Impacts of the Project

The potential impact-producing factors as they relate to specific Project elements are presented in Table 7.7-1, below.

Table 7.7-1 Impact-producing Factors for Land Use and Coastal Infrastructure

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommissioning
Vessel Traffic	X		X		
Cable installation	X	X	x		
Dredging		X	x		
O&M Facilities			X	X	x
HDD		X	X		
Utility Duct Construction			x		

7.7.2.1 Construction and Installation

As described in Volume I, Project components will be installed in the onshore and offshore environments. Existing land uses and coastal infrastructure may experience temporary and short-term impacts during the construction and installation phase of the Project.

Each port facility in the Project Region is located within an existing industrial waterfront area and was selected for further evaluation, in part, based on the port's existing infrastructure and capacity to host construction and installation activities, including an extant skilled labor force. The use of one or more of these facilities may be contingent upon the site owner/lessor implementing site-specific improvements based on Vineyard Wind's fit-out requirements (see Section 3.2.5 of Volume I). The construction and installation phase requires port facilities with very high load bearing ground or deck capacity, adequate vessel berthing parameters, and suitable laydown and fabrication space. Site-specific modifications performed by the site owner/lessor may be required to meet those requirements.

Vineyard Wind has signed a letter of intent to the use the New Bedford Terminal to support Project construction and installation activities. The 26-acre New Bedford Terminal is located in the Port of New Bedford on the industrial waterfront. The New Bedford Terminal serves as a multi-purpose, heavy-lift cargo facility designed to support the construction, assembly, and deployment of offshore wind projects. It is also designed to handle bulk, break-bulk, container shipping, and large specialty marine cargo. The New Bedford Terminal provides easy access to open water for both domestic and international shipping routes as well as interstate transportation networks for land-based logistics. Vineyard Wind plans to use the New Bedford Terminal to offload shipments of components, prepare them for installation, and then load components onto jack-up barges or other suitable vessels for delivery to the lease area for installation.

7.7.2.1.1 Impacts to Land Use

In the onshore environment, new utility duct bank located beneath and along public rights-of-way from the offshore export cable Landfall Site to the general vicinity of the Barnstable Switching Station. A section of existing rail right-of-way ("ROW") and a segment of existing utility ROW may be used for a portion of the route as well. HDD operations and other construction activity will also occur at the Landfall Site.

As noted above, during the construction and installation phase, the Project plans to establish O&M Facilities in Vineyard Haven. Vineyard Wind intends to use port facilities at both Vineyard Haven and the New Bedford Terminal to support O&M activities (see Section 3.2.6 of Volume I). Temporary construction-related impacts typical of the type of facility under consideration are anticipated.

The construction and installation process will make use of existing port facilities and modifications to those facilities are not anticipated to be necessary. Construction and installation activities in the WDA require the use of specialized construction and crew vessels, potentially aided by tug and barge services. These vessels will operate from existing port facilities, though, frequency of these vessels operating from the New Bedford Marine Commerce Terminal ("New Bedford Terminal") and the O&M Facilities will increase.

Installation of duct bank beneath paved roadways will require only minimal disturbance to the adjacent road shoulder and is expected to be completed without significant alteration to any land or infrastructure. Land uses are not anticipated to be impacted or altered upon completion of the construction and installation phase. At the Landfall Site, HDD operations, which are described in Section 4.2.3.8 of Volume I may result in minor, temporary impacts to seawalls, and/or parking and access facilities in the immediate vicinity of the Landfall Site.

Establishment of the Project's O&M Facilities may cause minor, temporary and short-term impacts in the immediate vicinity of the Facility. The Project's intended O&M Facilities and ports used for O&M activities are within areas of compatible water-dependent uses, ranging from commercial and retail marine operations to heavy marine-industrial uses.

7.7.2.1.2 Impacts to Coastal Infrastructure

Vessel operations will increase in the area surrounding the New Bedford Terminal, navigational channels, inshore traffic zones and any traffic separation scheme along the selected route to the WDA.

7.7.2.1.3 Avoidance, Minimization, and Mitigation Measures

Installation of the in-road underground cabling will be done so as to minimize traffic disruption and construction and installation activities will be adequately mitigated through the implementation of BMPs when practicable. Vineyard Wind's onshore construction schedule minimizes impacts to land uses and coastal infrastructure to the greatest extent practical during peak summer months and other times when demands on these resources are elevated.

See Section 7.1.2.1.3 for a description of additional measures that are expected to be implemented during this phase of the Project.

7.7.2.2 Operations and Maintenance

Upon stabilization, impacts associated with operations and maintenance of the Project are not anticipated to have adverse effects on the surrounding communities and will not disrupt the communities' routine functions. Most of the Project's systems will be monitored from the O&M Facilities. Planned and unplanned maintenance and repairs will largely be staged from this location and, in the event that a repair is necessary, a crew would be dispatched to the identified location to complete repairs and/or restore normal operations.

7.7.2.2.1 Impacts to Land Use

Periodic maintenance, repair, or improvements to O&M Facilities, the Onshore Export Cable Route, and other onshore facilities may be necessary over the anticipated life of the Project.

Operations and maintenance of the onshore facilities are not expected to impact land use and coastal infrastructure.

7.7.2.2.2 Impacts to Coastal Infrastructure

System repairs typically involve work on transmission cables which are accessed through manholes at the installed splice vaults, or within the fenced perimeter of the substation, thus they can be completed within the installed transmission infrastructure without impacts to surrounding land uses or coastal infrastructure.

7.7.2.2.3 Avoidance, Minimization, and Mitigation Measures

Impacts associated with scheduled period maintenance activities during the operations and maintenance phase will be adequately mitigated through the implementation of BMPs when practicable.

7.7.2.3 Decommissioning

As currently envisioned, decommissioning of the Project is largely the reverse of the construction and installation process as described in Volume I. Vineyard Wind expects to implement a decommissioning plan that removes and recycles equipment and associated materials, thereby substantially returning the WDA and Onshore Project Area to pre-existing conditions

7.7.2.3.1 Impacts to Land Use

It is anticipated that equipment, vessel, and personal requirements for decommissioning will be similar to those utilized during construction and installation. The transition vaults and duct bank may be valuable infrastructure that could be available for future infrastructure projects. The O&M Facilities can be easily repurposed for continued use by Vineyard Wind or another site operator.

7.7.2.3.2 Impacts to Coastal Infrastructure

During the decommissioning phase, vessel operations will increase in the area surrounding the New Bedford Terminal, navigational channels, inshore traffic zones and any traffic separation scheme along the selected route to the Wind Energy Area.

7.7.2.3.3 Avoidance, Minimization, and Mitigation Measures

As noted in Section 7.1.2.1.4 above, and elsewhere, Vineyard Wind will implement a comprehensive communications plan to keep the relevant parties informed throughout this phase of the Project.

7.8 Navigation and Vessel Traffic

This section describes Project activities that may affect navigation and vessel traffic within the Project Region, including within the Wind Development Area ("WDA"), the New Bedford Harbor and New Bedford Marine Commerce Terminal ("New Bedford Terminal") and other port facilities, and the Operation & Maintenance ("O&M") Facilities.

A detailed Navigational Risk Assessment ("NRA"), included as Appendix III-I, has also been conducted for the Project. The NRA conforms to the US Coast Guard ("USCG") guidance for Offshore Renewable Energy Installations contained in Navigation Vessel Inspection Circular 02-07, and incorporates information gained through consultation with the USCG and numerous marine trades and maritime transportation stakeholders.

7.8.1 Description of the Affected Environment

The following sections describe the maritime navigation and vessel traffic characteristics of the Project Region. Project-related activities that may impact navigation capacity and vessels operating to and from ports along the south coast of Massachusetts, Cape Cod and the Islands, and Rhode Island (this area is referred to as the "Project Region").

7.8.1.1 Navigation

Private aids to navigation ("PATONs"), federal aids to navigation ("ATONs"), and radar transponders are located throughout the Project Region. These aids to navigation consist of lights, sound horns, buoys, and onshore lighthouses. Most are marked on National Oceanic and Atmospheric Administration ("NOAA") nautical charts, and are intended to serve as a visual reference to support safe maritime navigation.

ATONs are developed, established, operated, and maintained by the USCG in order to assist navigators in determining their position, help navigators identify a safe course, and warn navigators of dangers and obstructions. Likewise, ATONs are used to facilitate the safe and economic movement of commercial vessel traffic.

The Project Region also includes several precautionary areas, which are defined areas within which ships must use particular caution and should follow the recommended direction of traffic flow. Precautionary areas may include a Traffic Separation Scheme ("TSS"), one of several routing measures adopted by the International Maritime Organization to facilitate safe navigation in areas where dense, congested, and/or converging vessel traffic may occur, or where navigation, particularly for deep-draft vessels, is constrained. A TSS creates separate traffic lanes reserved for unidirectional traffic, and are typically used by deep-draft vessels. A TSS is not necessarily marked by an ATON, but it is marked on NOAA nautical charts. Cargo vessels, tankers, cruise ships, and other deep-draft vessels approaching and departing New York, Boston, and ports in the Project Region are expected to use recommended vessel routes, including the TSS (NOAA, 2017f), although the use of a TSS is not mandated by federal regulations.

To the east of the island of Nantucket, the *Nantucket to Boston Harbor* TSS follows the deep bathymetry of the Great South Channel, a deep-water passage between Nantucket and Georges Bank. This TSS enables deep-draft vessels to safely travel south from Boston Harbor and northern waterways past Cape Cod and the dangerously shallow waters of the Nantucket Shoals. The *Nantucket to Boston Harbor* TSS inbound and outbound lanes, each 1.6 kilometers ("km") (0.8 ["nm"]) wide, are separated by a 3.2 km (1.7 nm) wide separation zone to enable vessels to safely enter and exit the TSS (NOAA, 2017f), although most vessels enter a TSS at its terminus.

A precautionary area with a radius of 25 km (1.5 nm) southeast of the Nantucket Shoals, at the southerly end of the Great South Channel, connects the *Nantucket to Boston Harbor* TSS with the *Nantucket to Ambrose* TSS, an east-west approach to Narragansett Bay, Buzzards Bay, and Long Island, New York coastal areas. An additional TSS services the approaches to Narragansett Bay and Buzzards Bay, and consists of four parts: two precautionary areas and two approaches- a Narragansett approach and a Buzzards Bay approach. The precautionary areas have radii of 8.7 km (4.7 nm) and 5.8 km (3.1 nm), and are located at the southerly ends of Narragansett Bay and Buzzards Bay, respectively (NOAA, 2017f).

7.8.1.2 Commercial Vessel Traffic

Commercial vessel traffic in the Project Region makes use of waterways, ports, and other coastal infrastructure to move goods and passengers, and is essential for the Project Region's economy and security. Commercial vessel traffic may include a variety of vessel types ranging from passenger cruise ships to articulated tug barges moving liquid petroleum. Each of these vessel types operate differently and may have operational and navigational requirements that present unique needs based on other uses and activities in the Project Region.

Vessel traffic within the Project Region was assessed by the NRA using Automatic Identification System ("AIS") data from 2016 and 2017, and through outreach to vessel operators and other stakeholders. Based on the NRA, commercial vessel traffic in the Project Region includes research, tug/barge, liquid tankers, cargo, military and search-and-rescue vessels, and commercial fishing vessels. AIS data for the Project Region was also queried for vessel activity within the WDA in order to establish a representative profile of seasonal and year-round activity within the WDA and along the Offshore Export Cable Corridor ("OECC"). Based on this assessment, the NRA established that the most common type of vessels transiting in the WDA are commercial fishing vessels. Detailed descriptions of commercial vessel traffic within the WDA is provided in Appendix III-I.

As described in Appendix III-I, commercial vessel traffic in the vicinity of the WDA is heaviest in four primary areas: 1) vessels approaching, entering, and exiting Narragansett Bay; 2) vessels entering and exiting Buzzards Bay; 3) vessels traveling from Hyannis to Nantucket; and 4), vessels traveling from Woods Hole to Vineyard Haven. A high volume of passenger ferry traffic occurs between Cape Cod and Nantucket and Martha's Vineyard. These vessels typically stay within 9.6 km (6 mi) of the shoreline while transporting passengers throughout Rhode Island and Massachusetts, but must cross Nantucket Sound and the OECC when transporting passengers to Martha's Vineyard and Nantucket. Both seasonal and year-round service is provided by several ferry companies, with more than twenty-four daily trips between Hyannis and Nantucket during the peak of the summer season.

Commercial vessel traffic in the Project Region has also been characterized by the Northeast Regional Ocean Council ("NROC") as part of their regional ocean planning efforts. Their dataset is a series of maps created by using vessel density products from the NOAA Office for Coastal Management and raw AIS data provided by the USCG. The dataset provides vessel traffic density by general vessel type for each year between 2011 and 2013. Vessel types include cargo, passenger, tug-tow, and tanker. These maps do not identify the number of transits, but rather the relative density of vessels in a particular area over a year-long period. According to the Northeast Regional Planning Body, these data have been reviewed and validated by the USCG and by vessel owners, pilots, and port authorities in the region (Northeast Regional Planning Body, 2016).

NROC's analysis is particularly helpful in identifying major vessel routes within the Project Region, especially as each vessel type mapped by NROC may have different operating requirements within the Project Region. The Northeast Regional Planning Body (2016) notes that these routes are expected to stay relatively static in the foreseeable future. Nonetheless, future development of and changes to coastal infrastructure, operating parameters, equipment, and market demand are likely to affect the intensity of traffic traversing these routes (Northeast Regional Planning Body, 2016).

NROCs commercial vessel density maps for the Project Region are included as Figure 7.8-1, Cargo Vessel Density; Figure 7.8-2, Passenger Vessel Density; Figure 7.8-3, Tug-Tow Vessel Density; and Figure 7.8-4, Tanker Vessel Density.

7.8.2 Potential Impacts of the Project

7.8.2.1 Construction and Installation

The construction and installation phase of the Project will make use of both construction and support vessels to complete tasks in the WDA and along the OECC. Construction vessels will transit between the WDA and the New Bedford Terminal, however, vessels may operate from other port facilities in the Project Region, as needed.

During construction and installation of the ~800 MW Project, it is anticipated that an average of approximately 25 vessels will operate during a typical work day in the WDA and along the OECC. Many of these vessels will remain in the WDA or OECC for days or weeks at a time, potentially making only infrequent trips to port for bunkering and provisioning, if needed. Therefore, although an average of ~25 vessels will be involved in construction activities on any given day, fewer vessels will transit to and from New Bedford Harbor or secondary port each day. During the most active period of construction, it is estimated that a maximum of approximately 46 vessels could be involved in the Project at one time; however, the maximum number of vessels involved in the Project at one time is highly dependent on the Project's final schedule, the final design of the Project's components, and the logistics solution used to achieve compliance with the Jones Act.

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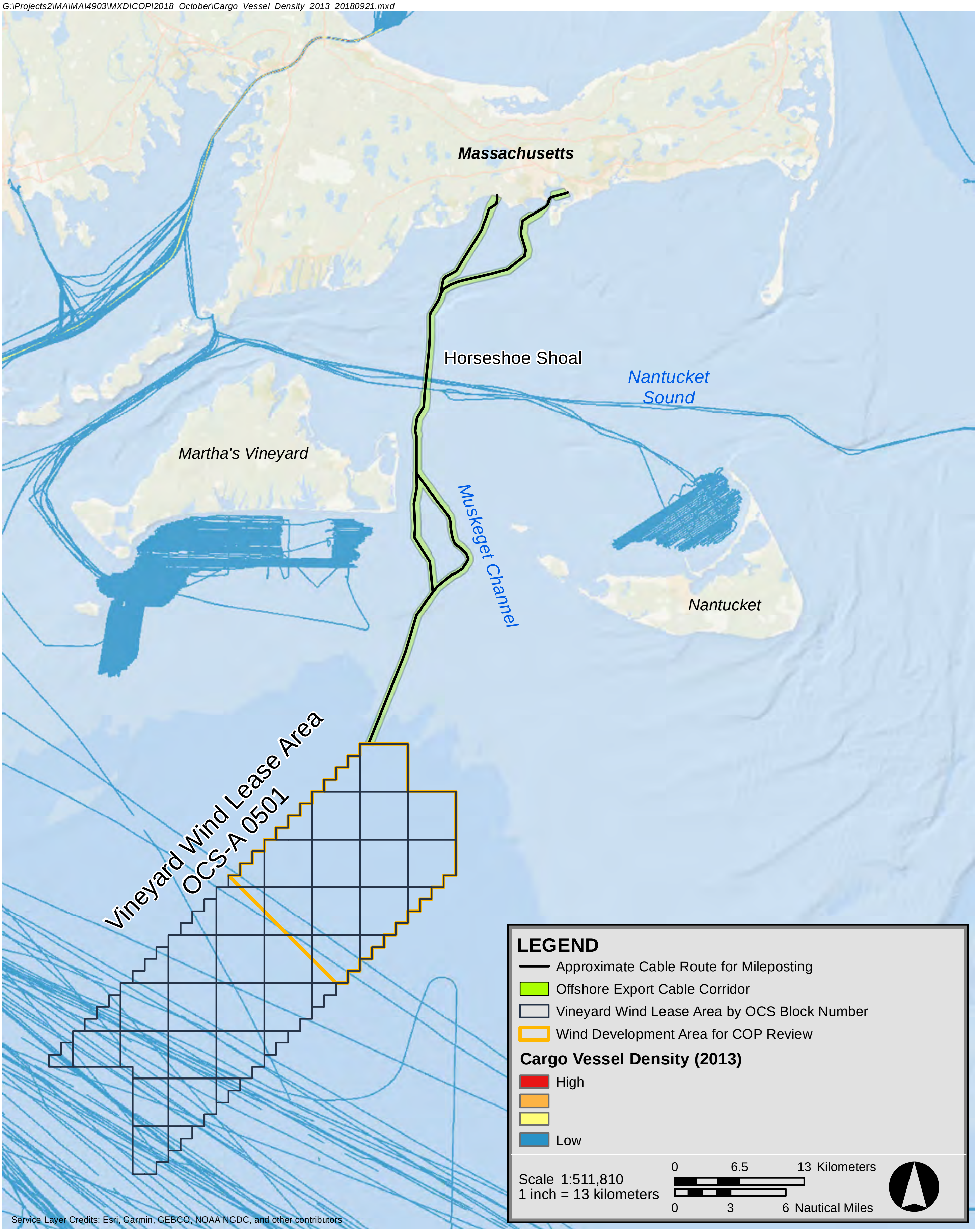

This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes. Map Projection: NAD83 UTM Zone 19

Vineyard Wind Project

VINEYARD WIND

Figure 7.8-1

2013 Cargo Vessel Density

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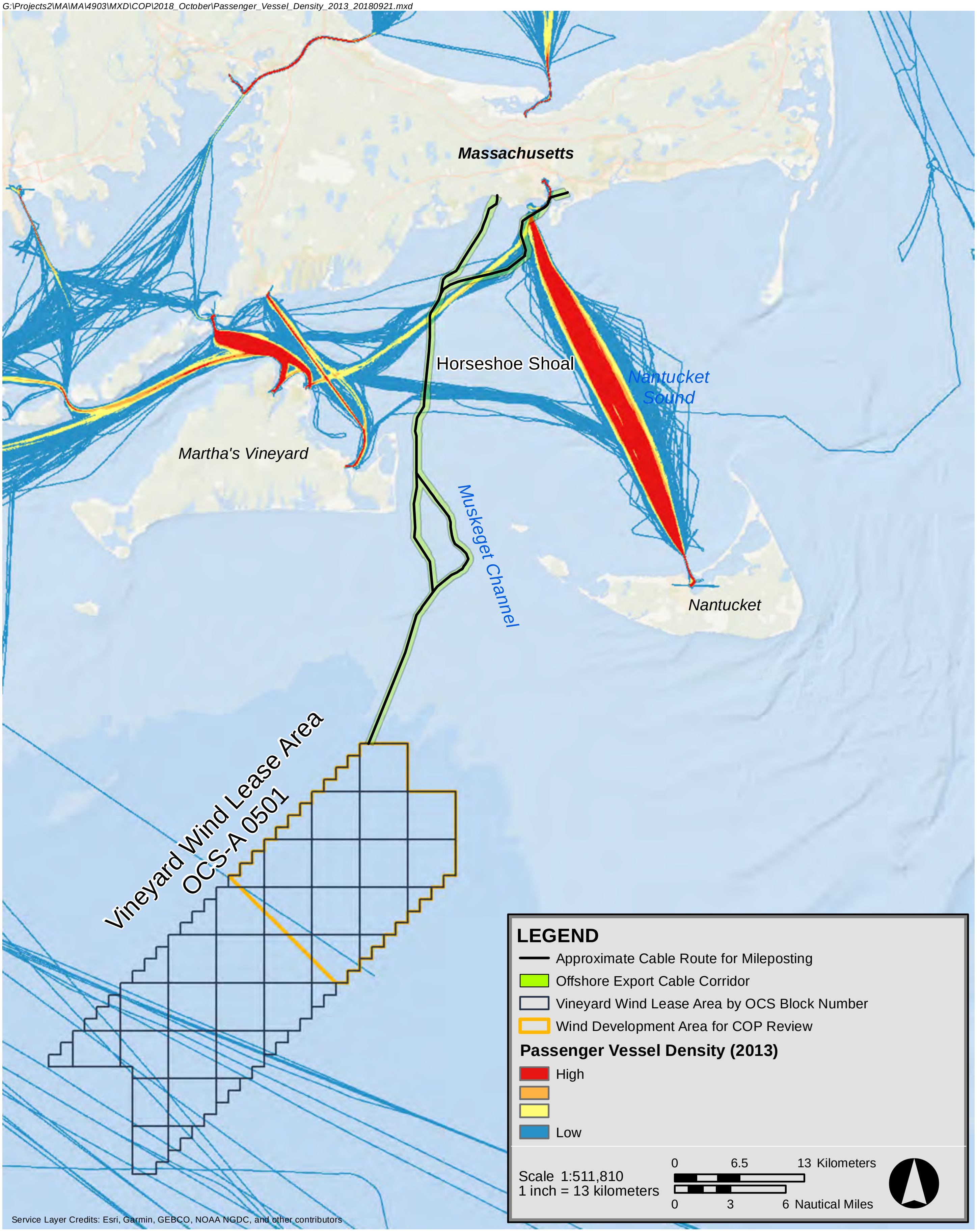

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Vineyard Wind Project

VINEYARD WIND

Figure 7.8-2

2013 Passenger Vessel Density

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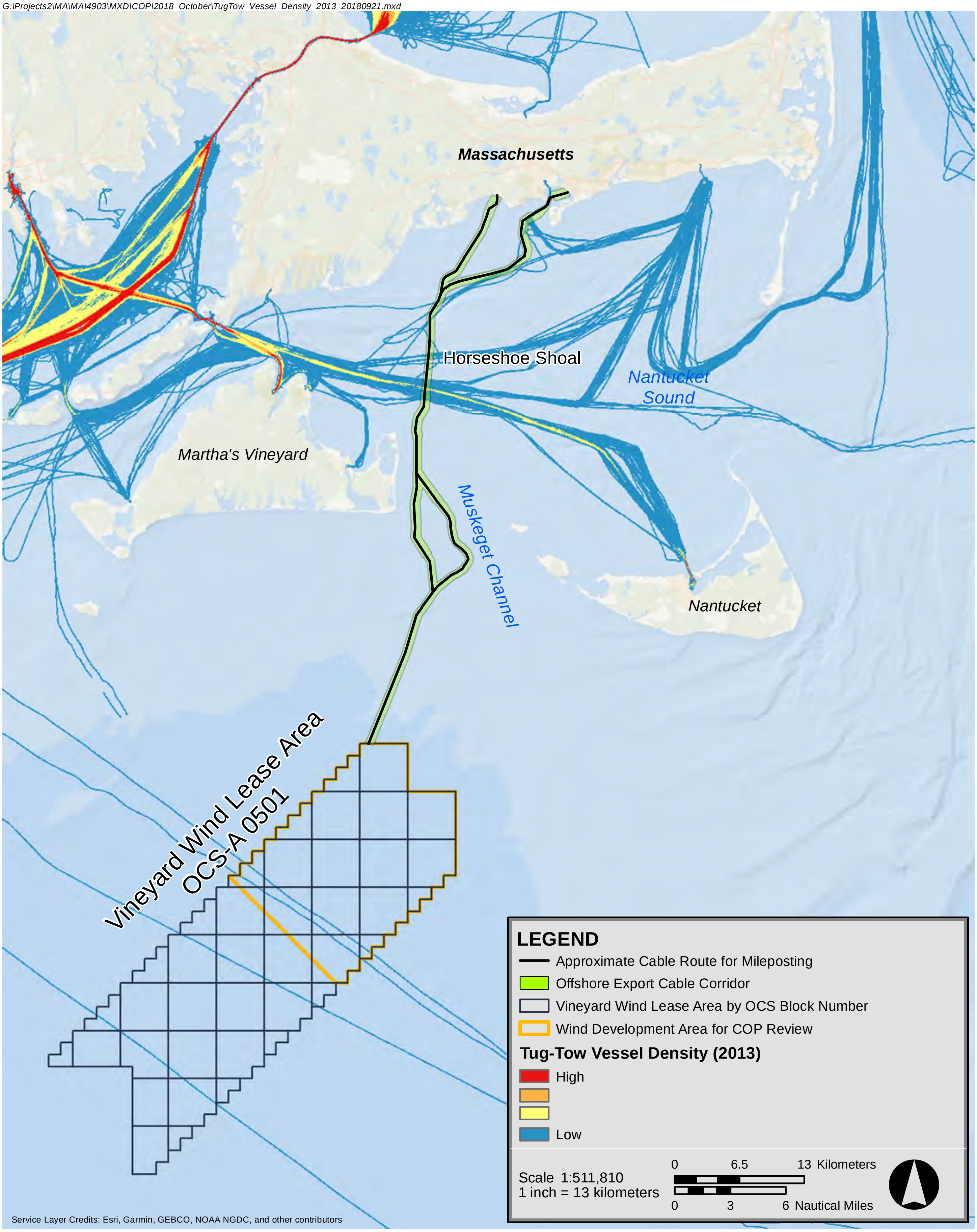

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Vineyard Wind Project

VINEYARD WIND

Figure 7.8-3

2013 Tug-Tow Vessel Density

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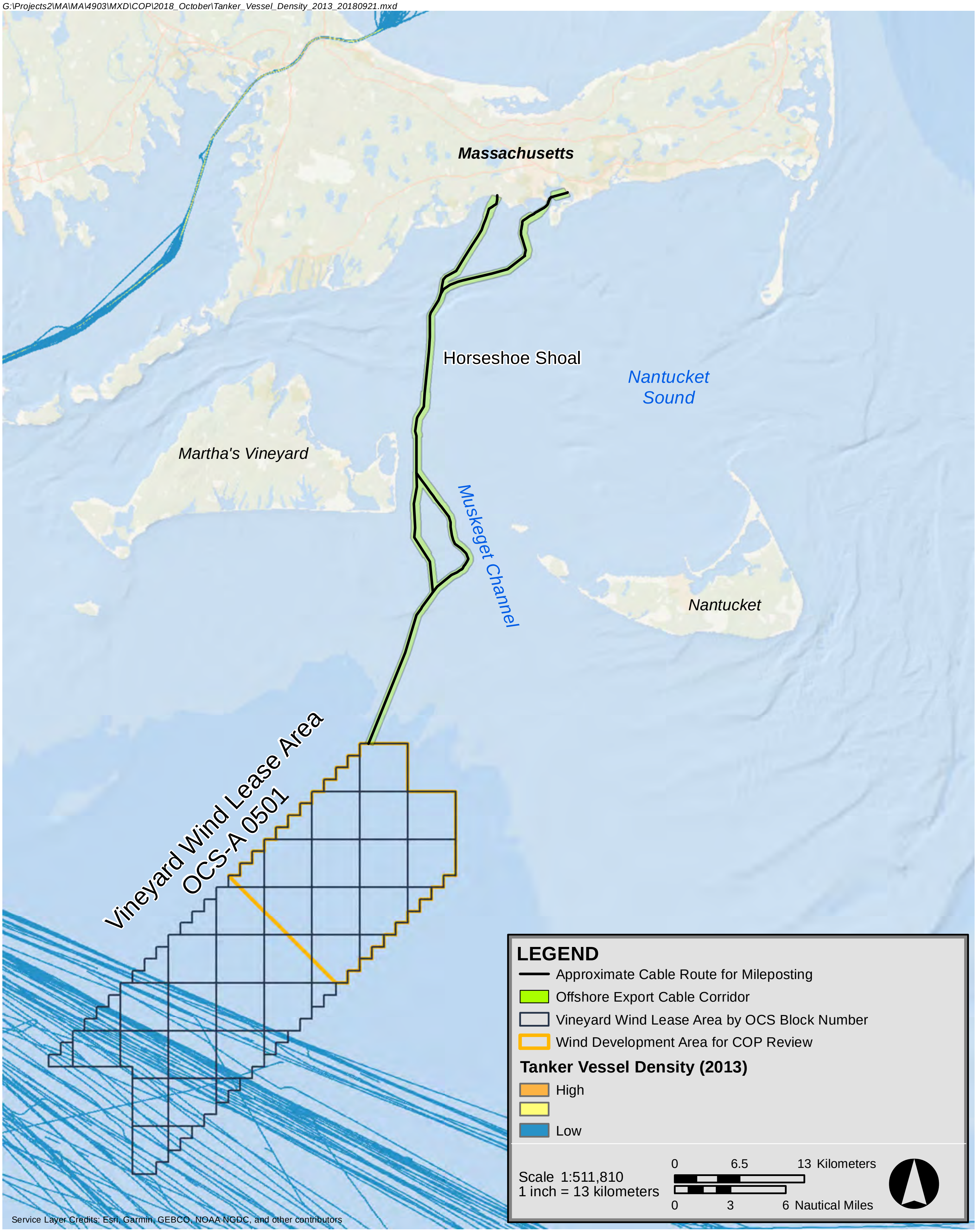

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Vineyard Wind Project

VINEYARD WIND

Figure 7.8-4

2013 Tanker Vessel Density

Vessels making round-trips from port facilities are primarily smaller Crew Transport Vessels (CTVs), tugboats, and smaller jack-up vessels. Over the course of construction, Vineyard Wind anticipates an average of approximately seven daily trips between both the primary and secondary ports and the WDA or OECC. During the most active month of construction, it is anticipated that an average of approximately 18 daily vessel trips will occur. The Navigational Risk Assessment (see Appendix III-I) conservatively assesses the unlikely scenario that the maximum number of vessels are working in the WDA or along the OECC and all must return to port on the same day, resulting in a maximum of approximately 46 vessel trips in one day. However, as with the total number of vessels involved in the Project, the number of daily vessel trips to each of the Project's ports is highly dependent on the Project's final schedule, design, and logistics.

Specific to offshore export cable installation, on average, approximately six vessels will be used for cable laying activities along the OECC in any given month, although as many as approximately nine vessels may be used for cable laying activities in any one month. Vessels used for cable installation may include a cable laying vessel, up to three anchor handling tug supply vessels, a CTV, a pre-lay grapnel run vessel, a tug boat, a pre-construction survey boat, a trenching vessel, a dredging vessel, a boulder clearance vessel (if required), and a vessel used to install cable protection (if required). Many of the cable installation activities are sequential; therefore, these vessels would not all operate along the Offshore Export Cable Corridor simultaneously.

Detailed descriptions of the vessel types generally used for offshore wind energy development are provided in the NRA.

7.8.2.1.1 Impacts to Navigation

Each of the vessels being evaluated for construction and installation have operational and navigation constraints similar to the commercial vessels typically seen in the Project Region and are not anticipated to affect navigation in the WDA, largely because the WDA is not heavily trafficked (as described in Appendix III-I). Temporary safety zones may be established around work areas during the construction and installation phase. Temporary safety zones are expected to improve safety in the vicinity of active work areas, and would not affect the entire WDA or OECC. Temporary safety zones may be marked with temporary buoys placed at four corners of the safety zone within an approximately 500 m (1,640 ft) distance of the construction and installation activity, which may include WTG and/or ESP installation within the WDA, or cable installation along the OECC.

Construction and installation activities will cause a modest increase in vessel traffic when foundations, WTGs, and inter-array cable are installed in parallel, including within the TSS approaches to and from ports in Rhode Island, Massachusetts, and Connecticut.

Although a modest increase in vessel traffic is anticipated due to construction and installation activities, port facilities and adjacent waterways, particularly with regard to the New Bedford harbor, are capable of accommodating this small increase with limited to no disruption to ongoing port operations. As reported to the US Army Corps of Engineers by all commercial freight and passenger vessel operators, on average there were 2,426 commercial and passenger vessel movements from Buzzards Bay through New Bedford Harbor annually between 2012 and 2016 (excluding commercial fishing vessels). In addition to these vessel movements, the approximately 219 federally permitted commercial fishing vessels and an estimated 500 recreational vessels homeported in New Bedford Harbor add to the vessel traffic in and around New Bedford Harbor. As described in the Appendix III-I, the New Bedford Port Director communicated that 150 to 200 vessels transit the New Bedford hurricane protection barrier each day. This suggests that the incremental increase in vessels that will use Massachusetts ports during the Project's construction and installation phase can be accommodated without creating conflicts with existing uses.

Nonetheless, vessels entering New Bedford Harbor are limited by the 45 m (150 ft) wide opening in the hurricane barrier. Larger beam construction and installation vessels transiting the hurricane barrier may pose temporary navigational obstructions to other vessels also transiting the hurricane barrier.

When construction and installation vessels are on-station along the OECC or in the WDA, within areas of confined navigation or in close proximity to obstructions, temporary navigational impacts in the immediate vicinity of those vessels may occur. Other vessels transiting these areas may need to make adjustments to planned routes or transit times to avoid construction and installation vessels.

Radar systems are commonly used in maritime applications to detect and monitor other vessels' positions and movements near a radar-equipped vessel. Radar systems also provide information regarding vessel position relative to fixed objects such as AToNs. Construction and installation activities are expected to have little effect on marine radar systems. Increased vessel traffic, as noted above, will have no impact on the operation of marine radar systems. As WTGs are installed during the construction and installation phase, they will produce new radar signals.

An evaluation of the effects of WTGs on marine radar systems operated near the UK Kentish Flat Offshore Wind Farm (BWEA, 2007) indicates that the expected impacts of offshore WTGs on marine radar systems depends on a number of variables, including vessel size, a vessel's proximity to the WTGs, a vessel's angle of travel in relation to the wind farm, and the position of the radar systems onboard a vessel. Additional information on marine radar systems is provided in Section 7.8.2.2.1, below, and in Section 7.2 of Appendix III-I.

Aside from temporary safety zones and the potential for increased vessel traffic, no significant disruption of the Project Region's established navigation patterns or aids to navigation is anticipated during the construction and installation phase.

7.8.2.1.2 Impacts to Commercial Vessel Traffic

Additional vessel traffic associated with construction and installation activities is not anticipated to affect commercial vessel traffic in the Project Region. Certain vessels transiting confined navigation channels will have limited maneuverability within the bounds of the navigation channel or at the New Bedford Harbor hurricane barrier, as noted above. These vessels may therefore require other vessels transiting navigation channels or the hurricane barrier to adjust course, where possible, or adjust their departure/arrival times to avoid navigational conflicts. However, navigational conflicts are not anticipated to be a common occurrence, and Vineyard Wind will provide Notices to Mariners ("NTMs") advising other vessel operators of construction and installation activities. Vineyard Wind will also coordinate arrival and departure of Project vessels with the New Bedford Harbormaster, the USCG, local pilots, and other port operators.

On average, four cable-laying, support, and crew vessels may be deployed along sections of the OECC during the construction and installation phase. As described in Appendix III-I, Section 4.1.3, ferry services operating along the OECC do not anticipate a significant impact to their route so long as they are provided with adequate notice of construction and installation activities. As such, Vineyard Wind will continue to work with ferry operators, harbor pilots, and other vessel operators to ensure any impacts to commercial vessel traffic are minimized to the greatest extent practicable.

AIS data suggests that commercial vessel traffic through the WDA is infrequent, and construction and installation activities are not anticipated to affect such vessel traffic. Construction and installation impacts to commercial fishing vessels are addressed in Section 7.6.2.1.

Given the scale of the Project and the possibility that one or more other offshore wind projects may be using portions of the New Bedford Terminal at the same time, Vineyard Wind may make use of one or more port facilities described in Section 7.1.1.1, Section 7.1.1.2, and Section 7.1.1.3. Vineyard Wind plans to use port facilities in the Project Region to offload shipments of components, prepare them for installation, and then load components onto jack-up barges or other suitable vessels for delivery to the lease area for installation. Some component fabrication and fit-up may take place at one or more of these port facilities. It is also possible that other North Atlantic commercial seaports may be used. At this juncture, the Project may use a port facility in nearby Rhode Island to offload, store, and stage the turbine blades or other components for delivery to the offshore WDA, as needed. These port facilities were selected, in part, based on the port's existing infrastructure and capacity to host construction and installation vessels with few impacts to existing uses and users. Additional vessel traffic may occur within those ports as a result of construction and installation activities. Vessels will also be delivering materials and wind turbine generators ("WTGs") from outside the Project Region. With mitigation measures described in Section 7.8.2.1.3, the increased vessel traffic is not anticipated to result in significant disruption of commercial vessel traffic is anticipated during the construction and installation phase.

7.8.2.1.3 Avoidance, Minimization, and Mitigation Measures

Coordination among the New Bedford Harbor Development Commission, the New Bedford Harbor Master, USCG, local pilots, and other entities will be necessary to ensure that impacts from construction and installation vessels are minimized. Vineyard Wind is committed to working with each stakeholder to address navigation and other concerns during each phase of the Project. As part of this effort, Vineyard Wind will develop and implement a communication plan to engage these stakeholders. Vineyard Wind will work to coordinate a vessel traffic management plan, as necessary, to align construction and installation vessel operations with established port operations.

During the construction and installation phase, Vineyard Wind will employ a Marine Coordinator to manage all construction vessel logistics and act as a liaison with the USCG, port authorities, state and local law enforcement, marine patrol, and port operators. As specified in the Project's Draft Safety Management System (COP Volume I Appendix I-B), the Marine Coordinator will keep informed of all planned vessel deployment and will manage the Project's marine logistics and vessel traffic coordination between the staging ports and the WDA.

NTMs will be distributed by Vineyard Wind to notify recreational and commercial vessels of their intended operations to/from and within the WDA. Local port communities and local media will be notified and kept informed as the construction progresses. Updated navigational charts (paper and electronic) with the location of the Project will be issued to stakeholders. The Project's website will be updated regularly to provide information on the construction zone, scheduled activities, and specific Project information.

To minimize hazards to navigation, all Project-related vessels, equipment, and appurtenances will display the required navigation lighting and day shapes. PATONs will also be installed by the Project during the construction and installation process to further assist navigators in determining their position and best safe course of navigation through and around the WDA. As the components for the WTGs are being installed, temporary PATONs will be added to vertical foundation/transition piece structures and WTGs, as required. Permanent PATONs will be installed on the fully constructed WTGs in accordance with International Association of Lighthouse Authorities ("IALA") Guidance for the marking of man-made offshore structures (IALA Recommendation O-139, edition 2, 2013), and USCG approval. WTGs and ESPs will be equipped with Automatic Identification System ("AIS") transponders, day marks, painted markings, and lighting, as required. High-visibility yellow paint will cover WTG foundations from the waterline (at all tidal conditions) to a height of at least 15 m (50 ft) above the water line. Selected WTGs will also be equipped with sound signals. See Appendix III-I for further discussion of marking and lighting requirements.

Vineyard Wind is committed to working with the USCG to mitigate safety concerns during construction. This may include a temporary safety zone around construction activities. This proposed safety zone would be adjusted as construction work areas change within the WDA, allowing fishermen and other stakeholders to make use of the WDA areas not under construction. When feasible, Vineyard Wind will deploy one or more safety vessels to monitor vessel traffic approaching construction operations. Additional resources (e.g., safety vessels, personnel) will be in close proximity to construction and installation activities to respond to safety or environmental concerns, as they may arise.

Vineyard Wind has also engaged with the marine pilots to coordinate construction and installation vessel approaches to the Project Region, as required by state and federal law, and to minimize impacts to commercial vessel traffic and navigation.

7.8.2.2 Operations and Maintenance

As described in Section 1.5, the Project is being permitted using an Envelope concept. Up to 106 turbine locations are being permitted to allow for spare positions (in the event of environmental or engineering challenges). Although the Project is including 106 WTG positions in the Project Envelope, only up to 100 positions will be occupied by a WTG. The site layout for up to 106 turbine locations is shown on Figure 3.1-2 of Volume I. The WTGs are laid out in a grid-like pattern with spacing of 0.76-1.0 nm between turbines. In consultation with local fishermen and the USCG, corridors in a northwest/southeast and northeast/southwest direction have been maintained. Additionally, for the ~800 MW Project, there will be one conventional 800 MW ESP or two conventional 400 MW ESPs.

Vineyard Wind plans to locate the Project's O&M Facilities in Vineyard Haven on Martha's Vineyard. The O&M Facilities will function for the operational life of the Project, which is anticipated to extend up to 30 years after construction and installation. Once operational, the O&M Facilities will operate with a staff of technicians and engineers responsible for long-term operation and maintenance of the Project. The O&M Facilities, including the vessels necessary for the long-term maintenance of the WDA, will be of a scale compatible with on-going water-dependent industrial uses and existing infrastructure of the surrounding port. Operations and maintenance functions may be co-located with the port facility and/or with existing Project offices on the mainland. The O&M facility will require deep-water access and quayside facilities. The O&M facility will also include berths for crew transport vessels CTVs and other support vessels. These siting requirements are consistent with existing conditions at many working ports. Because an average of fewer than three vessels O&M vessels will transit to and/or from the O&M facility on any given day, vessel activities at the O&M facility are not expected to adversely affect other commercial or recreational vessel traffic.

During the operations and maintenance phase, the number of Project-related vessels operating in the Project Region will vary depending on several factors, including: manufacturer-specified WTG maintenance schedules, WTG and cable inspections and/or troubleshooting, emergency repairs, or replacement of damaged or inefficient parts. Vineyard Wind intends to use port facilities at both Vineyard Haven and the New Bedford Terminal to support O&M activities (see Section 3.2.6 of Volume I). Crew Transport Vessels ("CTVs") and other support vessels will operate from the O&M Facilities. Larger vessels used for major repairs during O&M (e.g. jack-up vessels, heavy cargo vessels, etc.) would likely use the New Bedford Terminal. For regularly scheduled maintenance and inspections, it is anticipated that on average one CTV or survey/inspection vessel will operate in the WDA per day. In other maintenance or repair scenarios, additional vessels may be required, which could result in a maximum of three to four vessels per day operating within the WDA.

During the operations and maintenance phase, both inter-array and export cables will be inspected on a regular basis. Cable inspection may involve the use of survey vessels and other vessel-based systems for subsurface inspections. These inspections will occur on a regularly scheduled maintenance timetable, but are generally expected to occur less than once each year. The vessels used for such inspections are similar in size and operational requirements as other vessels frequently operating in the Project Region.

Typical marine and aerial radar systems rely on measurement of return signals in response to an output of electromagnetic energy. Radar systems work by transmitting a signal generated by an antenna in a particular direction and detecting the return of the electromagnetic signal reflected off of objects in the path of the signal. Several studies have assessed the impact of European wind farms on radar signals, including at the Horns Rev and North Hoyle Wind Farms in Denmark the UK, respectively (Howard & Brown, 2004). Additional studies were conducted at the Kentish Flat Offshore Wind Farm in the UK in 2005 (MARICO, 2007). To-date, the most comprehensive study concerning the possible effects of wind farms on radar was conducted by the British Wind Energy Association ("BWEA") in 2005 at the Kentish Flat Offshore Wind Farm (BWEA, 2007). The Kentish Flat studies gathered field data on marine radar systems in proximity to an operating offshore wind farm. Data was sourced from marine radar systems installed in various vessel types, including the types of vessels and radar systems currently operating in the Project Region. The study was designed to determine if particular types of vessels, radar, or antennae are more susceptible to effects from wind farms. The data collected were intended to facilitate the preparation of more informed navigational risk assessments and to assist in the development of appropriate mitigation measures.

During the study, marine radar systems were observed as the vessel was passing in proximity to the wind farm. Approximately one-third of the vessels participating in the study experienced no discernable effects on their radar system when passing near the wind farm (BWEA, 2007). Of those radar systems that were affected, a proportion of the interference observed was related to false or multiple echoes of the vessel's superstructure (i.e., radar signals bouncing back and forth between the transmitting vessel and WTGs, causing weak false echoes of the transmitting vessel to appear on the radar screen as a series of faint targets). These false or multiple echeos appeared when the vessel was near the wind farm and disappeared as the vessel moved past the wind farm and the angle of the radar signal to the wind farm changed.[27] BWEA (2007) noted that while unwanted effects were recorded on vessel radar systems, the radar operators were able to readily identify the false echoes and could safely navigate in and around the wind farm.

In 2009, the USCG considered the potential impacts to radar navigation from WTGs (USCG, 2009). The USCG concluded that the WTGs would not adversely impact a mariner's ability to effectively use radar as a navigation tool even though certain WTGs may impact radar systems, in part because most mariners were experienced at interpreting radar signals under a variety of circumstances.

The proposed WTG layout is likely to have similar effects on marine radar systems as those described in the above referenced studies. False or multiple echoes, for example, may be identified on marine radar systems operated in proximity to the WDA. However, as noted above, the effectiveness of radar systems and any impacts from WTGs will vary from vessel to vessel based on several factors, including radar equipment settings and installation. In order to mitigate potential effects on marine radar systems, WTGs will be equipped with AIS transponders. AIS transponders are based on VHF mobile bands, which have not shown any impacts from WTGs.

Vineyard Wind will continue to work with the USCG and BOEM to maintain safe navigation within the area of the WDA. As noted in the USCG (2009) assessment, impacts to radar should not negatively impact a mariner's ability to safely navigate in the WDA; even so, Vineyard Wind will work with stakeholders to identify potential mitigation measures, as necessary.

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27 Radar system settings and the location of the radome onboard the vessels are among the factors that influence radar signals.

7.8.2.2.1 Impacts to Navigation

During the operations and maintenance phase, increased risks to navigation may result from the presence of WTGs and ESPs, which are fixed structures in open water, in the WDA. To aid navigation in proximity to the WDA, markings, reflectors, and lighting on or near the WTGs and ESPs will be installed.

Vineyard Wind plans to locate the O&M Facilities in Vineyard Haven on Martha's Vineyard. Improvements to Vineyard Haven may be needed to accommodate Vineyard Wind's needs, such as improvements to existing marine infrastructure (e.g., dock space for CTVs, access, etc.) and to structures (office and warehouse space). Any such improvements are not anticipated to impact ongoing port operations and would be completed at the direction of the site owner/lessor, as described in Section 7.7.2.1.

Based on the anticipated vessel type and activity, no significant disruption of the Project Region's established navigation patterns or aids to navigation is anticipated during the operations and maintenance phase. As noted in Appendix III-I, vessels may select routes that avoid the WDA or may travel at reduced speeds through the WDA which could result in extended travel time through or around the WDA.

7.8.2.2.2 Impacts to Commercial Vessel Traffic

Section 4.0 of the NRA provides a summary of vessel types, characteristics, operating areas and routes, traffic density, and seasonal traffic variability within the Offshore Project Area.

As noted in Section 7.8.1.1, commercial vessel traffic in the WDA is characterized as low, and therefore few impacts to commercial vessel traffic are anticipated. Commercial vessels may select alternate routes around the WDA rather than navigating through the WDA.

Operations and maintenance vessels will be operating between the O&M Facilities and the WDA. The O&M Facilities will require deep-water access and quayside facilities. However, because these siting requirements are consistent with existing working ports, the O&M Facilities are not expected to affect commercial vessel traffic. Operations and maintenance vessels will rarely be operating along the OECC unless a vessel is merely transiting area. Therefore, few impacts to passenger vessel routes along the OECC from operations and maintenance activities are anticipated.

Upon installation of the offshore export cable system, anchoring of vessels in proximity to the OECC is not recommended. However, any anchoring limitations along the OECC are not anticipated to affect commercial vessel traffic.

Most operations and maintenance activities in the WDA will only require the use of a CTV, which is anticipated to have no effect on commercial vessel traffic. Larger multipurpose vessels will only be deployed in the event of major maintenance issues or when larger equipment requires replacement; these are expected to be infrequent events. These larger vessels would likely operate from the New Bedford Terminal.

7.8.2.2.3 Avoidance, Minimization, and Mitigation Measures

Vineyard Wind will coordinate with the appropriate entities to minimize impacts to commercial vessel traffic and work with the USCG to ensure NTMs are distributed. The Project's website will be regularly updated to provide information on the O&M activities occurring in the area.

To aid mariners navigating the WDA, WTGs and ESP will be lit, marked, and maintained as PATONs in reference to International Association of Lighthouse Authorities ("IALA") Guidance for the marking of man-made offshore structures (IALA Recommendation O-139, edition 2, 2013), and US Coast Guard approval. As noted in Section 7.8.2.1.3, AIS transponders will be installed on WTGs to further aid mariners in identifying the location of WTGs and to mitigate the effects, if any, of the WTGs on marine radar systems. The number and location of AIS transponders to be located on WTGs is being evaluated. Additional details regarding proposed aids to navigation are provided in Appendix III-I. To minimize hazards to navigation, all Project-related vessels, equipment, and appurtenances will display the required navigation lighting and day shapes.

As described in the NRA, the proposed symmetry and alignment of WTGs is aligned with typical vessel travel patterns.WTGs are separated by a distance of 1.85 km (1.0 nm) to create the lineal corridors that provide an optional route for vessels traversing the WDA along its southeast-northwests axis and the northeast-southwest axis. Additionally, as described in Section 7.6.3, Vineyard Wind intends to adopt a 2 nm (3.7 km) wide transit lane that was developed through discussion among fishing stakeholders and state agencies. This transit lane, which was presented during the September 20th, 2018 Massachusetts Fisheries Working Group (FWG) on Offshore Wind meeting, is shown in Figure 7.6-53 and Figure 2.1-2 of Volume I. This transit lane layout represents a compromise of the various desired transit directions and corridor widths to/from priority areas identified by various fishing sectors and ports. Scallopers, fixed gear, squid, and whiting/scup fishermen from MA, NY, and RI ports all agreed this was a workable compromise at the meeting. MA Coastal Zone Management and the USCG have also expressed support of these transit lanes. Vineyard Wind also supports adopting a north/south transit lane directly to the east of the WDA to allow passage for fisheries travelling between squid and whiting fishing grounds.

Vineyard Wind will work with the USCG to develop a communication plan for search and rescue evacuations and other emergency response situations. To mitigate potential impacts to search and rescue aircraft operating in the WDA, the Project will have a strict operational protocol with the USCG that requires the Project to secure the WTG (stop the blades from rotating) within a specified time (e.g. 2-minutes) upon request from the USCG.

7.8.2.3 Decommissioning

Decommissioning of the offshore components, described in Section 4.0 of Volume I, includes removal of WTG and ESP pile foundations and possibly cables within the WDA and OECC.

Impacts from these activities will be similar to those associated with construction as described in Section 7.8.2.1.1.

7.8.2.3.1 Impacts to Navigation

Impacts from decommissioning activities are anticipated be similar to those associated with construction and installation, as described in Section 7.8.2.1.1.

As part of the decommissioning process, all PATONs will be removed from the WDA.

7.8.2.3.2 Impacts to Commercial Vessel Traffic

Impacts from decommissioning activities are anticipated to be similar to those associated with construction and installation, as described in Section 7.8.2.1.2

7.8.2.3.3 Avoidance, Minimization, and Mitigation Measures

Impacts associated with decommissioning activities will be adequately mitigated through the implementation of best management practices, where practicable. Avoidance, minimization, and mitigation measures are anticipated to be similar to those described above in Section 7.8.2.1.3.

7.9 Other Uses (Marine Minerals, Military Use, Aviation, Offshore Energy)

The Project Region hosts multiple uses and activities, including national security and military uses, cables and pipelines, aviation, marine mineral extraction, offshore energy projects, and radar systems. When developing new infrastructure, careful planning and consideration of other uses is required to minimize risk to these competing uses.

7.9.1 Description of the Affected Environment

The following sections describe other uses within the Project Region that may be affected by the Project. The Project Region is the geographic area that could be affected by Project-related activities, and consists of the communities in Barnstable County, Bristol County, Dukes County, Nantucket County in Massachusetts, and Newport County, Rhode Island. Collectively, this area is referred to as the "Project Region".

7.9.1.1 National Security

United States Navy

Newport, Rhode Island hosts Naval Station Newport, which is home to 50 Navy, Marine Corps, Coast Guard, and US Army Reserve commands and activities. Approximately 5,800 employees work at the various Naval Station commands, and an additional 17,000 students annually pass through one of the many schools on base. Naval Station Newport is home to the Navy Supply Corps School, the Center for Service Support, the US Marine Corps Aviation Logistics School, and the Navy's most prestigious educational institution, the Naval War College.

Naval Station Newport is also home to the Naval Undersea Warfare Center ("NUWC"), one of the corporate laboratories of the Naval Sea Systems Command. The NUWC is the Navy's research, development, test and evaluation, engineering, and fleet support center for submarines, autonomous underwater systems, and offensive and defensive weapons systems associated with undersea warfare.

New London and Groton, Connecticut, host equipment and personnel at Naval Submarine Base New London. Submarine Transit Lanes, which are transit corridors where submarines may navigate underwater, are located within the Project Region.

The Navy maintains three range complexes located along the mid-Atlantic and northeastern seaboard of the US. A range complex is a designated set of specifically bounded geographic areas that encompass a water component (above and below the surface), airspace, and may encompass a land component and is where training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occur. Range complexes include established Operating Areas ("OPAREAs") and special use airspace, which may be further divided to provide better control of the area and events being conducted for safety reasons.

Combined, these areas are the principal locations for some of Navy's major training and testing events and infrastructure. Three separate range complexes; the Boston Range Complex, the Narragansett Bay Range Complex, and the Atlantic City Range Complex, are collectively referred to as the Northeast Range Complex. These range complexes span 1,224 kilometers ("km") (761 mi) along the coast from Maine to New Jersey. The Northeast Range Complex includes special use airspace with associated warning areas and surface and subsurface sea space.

The Northeast Range Complex is further subdivided into three OPAREAs: Boston OPAREA, Narragansett Bay OPAREA, and Atlantic City OPAREA. The Wind Development Area ("WDA") is located within the Narragansett Bay OPAREA. This OPAREA is a surface and subsurface exercise/operating area, extending approximately 185 km (100 nautical miles ["nm"]) south and 407 km (220 nm) east of the coasts of Massachusetts, Rhode Island, and New York. OPAREA training exercises generally occur in deeper offshore waters, southeast of the WDA (SAMP, 2010; J. Casey, personal communication, November 30, 2017). Navy vessels may, however, remain in shallower portions of the Narragansett Bay OPAREA in preparation for formal voyages. (J. Casey, personal communication, November 30, 2017)

United States Coast Guard

The United States Coast Guard ("USCG") 1st District is headquartered in Boston, Massachusetts and is responsible for USCG activities in Northern New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, Vermont, and Maine.

The 1st District maintains two "ashore" units in the vicinity of the WDA. Sector Southeastern New England, located in Woods Hole, Massachusetts and its affiliated USCG Stations throughout the Project Region cover over 777 square kilometers ("km^2") (3,000 square miles ["mi^2"] of offshore waters and 1,930 km (1,200 mi) of coastline in Rhode Island and southeastern Massachusetts, including Cape Cod and the Islands. Air Station Cape Cod, the USCG's only Coast Guard Aviation Facility in the northeast, is located at Joint Base Cape Cod. Air Station Cape Cod provides search and rescue, maritime law enforcement, international ice patrol, aids to navigation support, and marine environmental protection. USCG Base Cape Cod, the single point for Deputy Commandant for Mission Support in support of USCG operations within the 1st Coast Guard District, is also located at Joint Base Cape Cod.

The 1st District also maintains three "afloat" units in the vicinity of the WDA: the USCG Cutter ("USCGC") Ida Lewis, a "Keeper" class coastal buoy tender, and USCGC Juniper and USCGC Oak, both "Juniper" class seagoing buoy tenders.

7.9.1.2 Aviation and Air Traffic

Various segments of airspace overlie the Project Region, including: US territorial airspace, different levels of controlled airspace, and special-use airspace.

Territorial airspace is the airspace over the US, its territories and possessions, and over US territorial waters out to 22 km (12 nm) from the coast. Limited areas of the WDA are located within territorial airspace. The WDA is also within the limits of the Air Defense Identification Zone, into which all international flights entering the US domestic airspace must provide the appropriate documentation.

Project-related activities may occur within three different controlled airspace classifications: Class E, East Coast Low Area, and the Atlantic Low Area. These classifications of airspace define the volumes of airspace within which air traffic control services are provided and often dictate different operating requirements that are imposed upon pilots, including weather, communication, and equipment minimums.

A portion of the WDA is also within Warning Area "W-105A," which is a block of airspace ranging from 0-15,240 meters ("m") (0-50,000 feet ["ft"]) Above Mean Sea Level ("AMSL"). Warning Area airspace, such as W-105A, is designated for aircraft operations of a nature such that limitations may be imposed on other aircraft not participating in those operations. The Department of Defense ("DoD") uses domestic and international airspace for readiness training and exercises. To make pilots aware of military operations, the Federal Aviation Administration ("FAA") designates sectors of airspace as warning areas and charts these areas on aeronautical charts with an identifying number. The Navy and, occasionally, other DoD organizations use the airspace over and adjacent to the WDA.

7.9.1.3 Offshore Energy

The Energy Policy Act of 2005, Public Law No. 109-58, added Section 8(p)(1)(C) to the Outer Continental Shelf Lands Act ("OCSLA"), which authorizes the Secretary of the Interior to issue leases, easements, or rights-of-way on the Outer Continental Shelf ("OCS") for the purpose of wind energy development. See 43 U.S.C. § 1337(p)(1)(C).

To that end, BOEM and its partners have identified the most appropriate areas for commercial wind energy leasing on the OCS off the Atlantic Coast. To date, BOEM has identified six Wind Energy Areas ("WEAs") on the OCS that are considered appropriate for commercial offshore wind energy development. The WEAs were selected after an exhaustive process with a goal of minimizing conflicts among existing uses and the environment. The Project is located in the Massachusetts WEA ("MA WEA"), in proximity to the Rhode Island/Massachusetts Wind Energy Area ("RI/MA WEA"). Vineyard Wind anticipates the development of additional offshore energy projects in lease areas within both the MA WEA and RI/MA WEA.

In conformance with Section 7(a) of the Project's Commercial Lease of Submerged Lands for Renewable Energy Development on the OCS, the Project does not propose activities that will unreasonably interfere with or endanger activities or operations carried out under any lease or grant issued or maintained pursuant to the OCSLA.

It should be noted that a marine hydrokinetic facility being evaluated for the Muskeget Channel has been discontinued and the project is no longer pursuing deployment of tidal energy turbines with the Muskeget Channel.

7.9.1.4 Sand and Marine Mineral Extraction

Sand resources on the OCS managed by BOEM provide, in certain situations, material to support costal resilience projects and plans designed with federal, state, and local partners. Chronic shoreline erosion and damage caused by coastal storms, and a growing awareness of the risks associated with sea level rise from climate change, have increased the demand for sand suitable for beach and other nourishment efforts along the Atlantic coast. In order to help coastal communities recover from coastal storms and promote resilient coastal systems, BOEM funded offshore surveys in 2015, 2016, and 2017 to identify new sources of sand in federal waters. BOEM's geological and geophysical research program, the Atlantic Sand Assessment Project, identifies and assesses new potential sand.

There are no federal OCS sand and mineral lease areas within the Offshore Project Area. No significant sand resource blocks have been identified in the Offshore Project Area.

7.9.1.5 Cable and Pipelines

There are currently four submarine transmission cable systems located in Nantucket Sound that service Nantucket and Martha's Vineyard. These cables are identified on NOAA Raster Navigational Charts (RNCs). Service to Martha's Vineyard is provided by two cables interconnecting the Town of Falmouth, on Cape Cod, with Vineyard Haven and Tisbury through the easterly side of Vineyard Sound. Two cables also service Nantucket. Cables from Dennis Port and Hyannis Port interconnect through Nantucket Sound to a landfall at Jetties Beach. The Hyannis Port cable makes landfall at Kalmus Beach in Outer Lewis Bay. If the New Hampshire Avenue landing site is selected for the Offshore Export Cable Corridor ("OECC"), a cable crossing will occur over an existing National Grid submarine power cable that connects the south shore of Cape Cod to Nantucket (see Section 4.2.3.3 of Volume I). The cable crossing will occur south of Dunbar Point outside of Lewis Bay as shown on Figure 4.2-2. The specifics of this crossing will be developed with National Grid as Project planning continues.

Other than the Project's offshore cable system, no publicly noticed plans for additional submarine cables in the Offshore Project Area have been made available.

No pipelines service Martha's Vineyard or Nantucket.

7.9.1.6 Radar Systems

Commercial air traffic control ("ATC") radar systems, national defense radar systems, and weather radar systems are operating in the Project Region. A number of commercial ATC radar systems are deployed to service the Project Region, as noted below. National defense radar systems operating within the Project Region include the Precision Acquisition Vehicle Entry/Phased Array Warning System ("PAVE/PAWS") installation at Joint Base Cape Cod. Additional details on that system are provided in Appendix III-I.

Weather radar systems operating in the Project Region include NEXRAD, which is also known as Next-Generation Radar. NEXRAD is a network of 160 high-resolution S-band Doppler weather radars operated by the National Weather Service ("NWS") in a joint effort with the US Departments of Commerce, Defense, and Transportation, the US Air Force Weather Agency, and the FAA. The primary function of the NEXRAD system is to supply data to meteorologists for weather forecasting purposes. A NEXRAD installation is located at the NWS's Taunton facility ("KBOX"), located approximately 97 km (60 mi) to the north of the WDA.

The FAA also operates a Terminal Doppler Weather Radar ("TDWR") installation at the Boston Logan International Airport. TDWR systems are used primarily for the detection of hazardous wind shear conditions, precipitation, and winds aloft on and near major airports situated in climates with great exposure to thunderstorms, such as Boston, Massachusetts. The TDWR system at Logan Airport is located approximately 145 km (90 mi) to the north of the WDA.

An initial review indicates that the following 10 radar sites are located within approximately 100 nautical miles (nm) of the Project:

- Boston Airport Surveillance Radar model-9 (ASR-9);
- Boston Terminal Doppler Weather Radar (TDWR);
- Cape Cod Early Warning Radar (EWR);
- Falmouth Airport Surveillance Radar model-8;
- Nantucket ASR-9;
- North Truro Air Route Surveillance Radar model-4 (ARSR-4);
- Providence ASR-9;
- Riverhead ARSR-4;
- Boston ("KBOX") WSR-88D; and
- Brookhaven WSR-88D.

These radar sites provide radar data to multiple DoD, Department of Homeland Security (DHS), FAA, and NOAA facilities for conducting air traffic control, air defense, ballistic missile defense, homeland security, space surveillance, and weather operations.

7.9.2 Potential Impacts of the Project

Table 7.9-1 Impact-producing Factors for Other Uses

Impact-producing Factors	Wind Development Area	Offshore Export Cable Corridor	Construction & Installation	Operations & Maintenance	Decommissioning
Vessel Traffic	X	X	X	X	X
WTGs/ESPs	X		X	X	X
Transporting WTGs	X		X		X
Cable Installation		X	X		
Marine Commerce Terminal/Port Facilities			X		X
Helicopters	X			X	

7.9.2.1 Construction and Installation

As described in Section 3.0 of Volume I, Project components will be installed in the offshore environment, including wind turbine generators ("WTGs"), up to four electrical service platforms ("ESPs"), and export, inter-array, and inter-link cables. The Project is located in the MA WEA, which was selected, in part, because it avoids and/or minimizes conflicts with the uses described in this section.

7.9.2.1.1 National Security

At various points during construction, large vessels with limited maneuverability will be delivering WTGs and associated equipment to one or more port facilities and to the WDA. At times, these vessels will be operating within restricted navigation channels or will be on-station while construction and installation activities are being conducted. These activities are not anticipated to affect national security or Navy interests. However, Vineyard Wind and the USCG will provide Notices to Mariners that describe Project-related activities that may be of interest to national security interests, including Navy personnel operating within the Project Region.

Representatives from Vineyard Wind have been in contact with personnel at the Navy's Fleet Area Control and Surveillance Facility to discuss the Project's parameters and to solicit input on potential impacts to Navy operations in the Project Region. No concerns with the Project have been identified. Vineyard Wind will continue to provide relevant Project updates to the Navy throughout the life of the Project.

Vineyard Wind has been working cooperatively with USCG personnel to address any navigation, operations, or other concerns with Project-related activities. Vineyard Wind will continue to coordinate Project activities with the USGC.

7.9.2.1.2 Aviation and Air Traffic

The following sections address the potential airspace impacts associated with the onshore construction staging area and the vessel routes. DoD warning areas are also discussed. Proposed marking and lighting of the turbines is discussed in Section 3.1.1 of Volume I. Appendix III-J contains an aviation impact analysis of the WDA.

At various points during construction, three areas will contain turbines, cranes, and equipment that may have an effect on flight operations. These areas are: 1) the onshore construction staging areas; 2) vessel routes used to transport equipment and turbines from the Onshore Project Area to the Offshore Project Area; and 3) the Offshore Project Area that will be the final, constructed location of the turbines.

The FAA has jurisdiction to review "structures interfering with air commerce," 49 U.S.C. § 44718, within US territorial waters which extend 22 km (12 nm) offshore. It is anticipated that eight turbines will be located within US territorial waters and are therefore subject to FAA jurisdiction. FAA also has jurisdiction to review certain structures used at construction staging areas and transported on vessels within territorial waters.

Under FAA's regulations anyone who proposes building certain structures, including those more than 61 m (200 ft) tall, must notify FAA. FAA then evaluates the proposed structure to determine if it would constitute an obstruction to air navigation that may affect the safe and efficient use of navigable airspace or the operation of planned or existing air navigation and communication facilities. Whether a proposed structure is an "obstruction" is determined by the structure's height and location. If FAA concludes the proposed structure would be an obstruction or would have a substantial adverse physical or electromagnetic effect on the operation of air navigation facilities, or if FAA otherwise determines it necessary, FAA will conduct an aeronautical study to decide the extent of any adverse impact on the safe and efficient use of the airspace, facilities, or equipment.

With partially and fully constructed turbine heights in excess of 110 m (361 ft) Above Mean Sea Level (AMSL) onshore, en route to the WDA, and within the WDA, it may be necessary for FAA to conduct aeronautical studies of turbines and equipment located within territorial waters that meet the obstruction criteria.

Onshore Project Area

For each port being evaluated for use by the Project, it is anticipated that WTG components can be delivered from ship to shore, and stored in laydown areas without impacting aviation operations in the area. Ports being considered for delivery and storage of project components, therefore, would have no additional impacts to aviation should they be selected for use by Vineyard Wind.

Construction staging areas, including pre-assembly of turbine components, may be located at the New Bedford Terminal or other nearby facilities, located approximately 93 km (50 nm) northwest of the Offshore Project Area. The New Bedford Terminal is a multi-purpose facility designed to support the construction, assembly, and deployment of offshore wind projects and is ideally located for the erection of tall structures from an aviation standpoint. It is located approximately 6 km (3.75 mi) from the nearest airport, New Bedford Regional Airport ("EWB").

Incoming and outgoing ships with Project components and partial turbine assemblies may use this location. During the construction and installation phase of the Project, onshore cranes will be utilized for tower assembly and loading and unloading ships. Many of the ports under consideration for construction and installation, or related activities, already have cranes and other equipment necessary to handle WTG components

With a temporary height of 100 m (328 ft) above ground level ("AGL"), the turbine towers while at the construction staging area may exceed the 61 m (200 ft) AGL and therefore may require notice to the FAA. Cranes used in both the assembly process and the unloading and loading of Project components on vessels have an assumed height of 130 m (427 ft) AGL and may similarly require notice to FAA. Vineyard Wind expects to coordinate with FAA on defining the boundary of the assembly area. FAA Form 7460-1 Notice of Proposed Construction or Alteration would be submitted via the FAA's Obstruction Evaluation/Airport Airspace Analysis online portal (2017a).

Vineyard Wind conducted a preliminary analysis of the potential for impact of the onshore assembly site on visual flight rules ("VFR") operations and instrument flight rules ("IFR") procedures. FAA uses level and sloping imagery surfaces to determine if a proposed structure is an obstruction to navigation. With a site elevation of roughly 3 m (9 ft) AMSL, the top of the construction cranes could be as high as 133 m (437 ft) AMSL. At this height, structures will exceed public-use airport imaginary surfaces defined in 14 C.F.R. Part §77. As a result, structures of this height are likely to be subject to marking and lighting in accordance with FAA Advisory Circular 70/7460-1L.

At 133 m (437 ft) AMSL, cranes will exceed EWB's VFR traffic pattern airspace. However, considering the temporary nature of the construction staging area and existing obstacles adjacent to the site, it is likely that the FAA would accommodate this impact.

The lowest IFR height constraints overlying the Onshore Project Area range from 167 m to in excess of 183 m (549-600 ft) AMSL and are associated with minimum vectoring altitudes and instrument departure procedures. Given that these heights are greater than the heights of the cranes and onshore equipment, it is unlikely that the FAA would have concerns about their use.

Offshore Project Area

As previously stated, the Federal Aviation Administration (FAA) has jurisdiction to review "structures interfering with air commerce," per 49 U.S.C. § 44718, within US territorial waters which extend 12 nautical miles offshore. It is assumed that eight turbines will be located within US territorial waters and are therefore subject to FAA jurisdiction. However, BOEM is confirming whether this assumption is correct. FAA does have jurisdiction to review the structures used at the onshore staging area and structures transported on vessels within the territorial waters.

Wind turbines within territorial waters must be submitted to the FAA for evaluation. With expected tip heights to be up to 212 meters (696 feet), the proposed wind turbines will be considered obstructions under 14 CFR Part 77.17(a)(1) because they exceed a height of 499 feet at the site of the structure; therefore, aeronautical studies will be conducted. However, heights in excess of this surface are feasible provided the proposed wind turbines do not exceed FAA obstacle clearance surfaces requiring procedural changes that would affect a significant volume of operations. At 212 meters (696 feet), as many as 52 of the proposed turbine locations could affect the airspace above the WDA. However, considering the historical operations transiting the airspace, as well as flights transiting in close proximity to the Lease Area, it is unlikely that any potential impacts would affect a significant volume of flight operations.

Appendix III-J contains a comprehensive aviation impact analysis of the WDA. The purpose for this analysis was to identify aviation impacts resulting from the construction of wind turbines with tip heights of up to 212 meters (696 feet) above mean lower-low water (MLLW) within the Lease Area.

The Preliminary Screening Tool (PST) on the FAA Obstruction Evaluation/Airport Airspace Analysis website provides a cursory indication whether wind turbines may be visible, that is, within radar line-of-sight to one or more radar sites, and likely to affect radar performance.[28] The PST Long Range Radar (LRR) analysis accounts for Air Route Surveillance Radar sites and a few select Airport Surveillance Radar sites used for air

28 See http://oeaaa.faa.gov.

defense and homeland security.[29] The PST Long Range Radar analysis does not account for all DoD, DHS, and/or FAA radar sites including early warning radar sites. Further, the PST NEXRAD analysis accounts for WSR-88D radar sites but does not account for FAA TDWR radar sites.[30]

The PST is helpful for identifying potential impacts to Long Range Radar and NEXRAD; however, the results are preliminary, as suggested by the title of the PST, and do not provide an official decision as to whether impacts are acceptable to operations.

The PST Long Range Radar results show four air traffic control, air defense, and homeland security radar sites within approximately 40 nm of the Project (the four sites are the Falmouth Airport Surveillance Radar model-8 [ASR-8], Nantucket Airport Surveillance Radar model-9 [ASR-9], North Truro Air Route Surveillance Radar model-4 (ARSR-4), and Providence ASR-9). The PST analysis results for Long Range Radar show that the Project falls within red and yellow areas for the Nantucket ASR-9 and a yellow area for the Falmouth ASR-8 (Figure 7.9-1). Red indicates that impacts are highly likely, as indicated by a 20 nm area around all Long Range Radar sites, and yellow indicates that impacts are likely. While the PST indicates that impacts may occur to two of the four radar sites, based on the fact that there are multiple radar sites within approximately 100 nm of the Project, overlapping coverage in addition to radar optimization are expected to mitigate any potential effects of the Project.

For NEXRAD, the PST analysis results show that the Project falls within a green area, or "No Impact Zone", which indicates that impacts are not likely to WSR-88D operations (Figure 7.9-1).

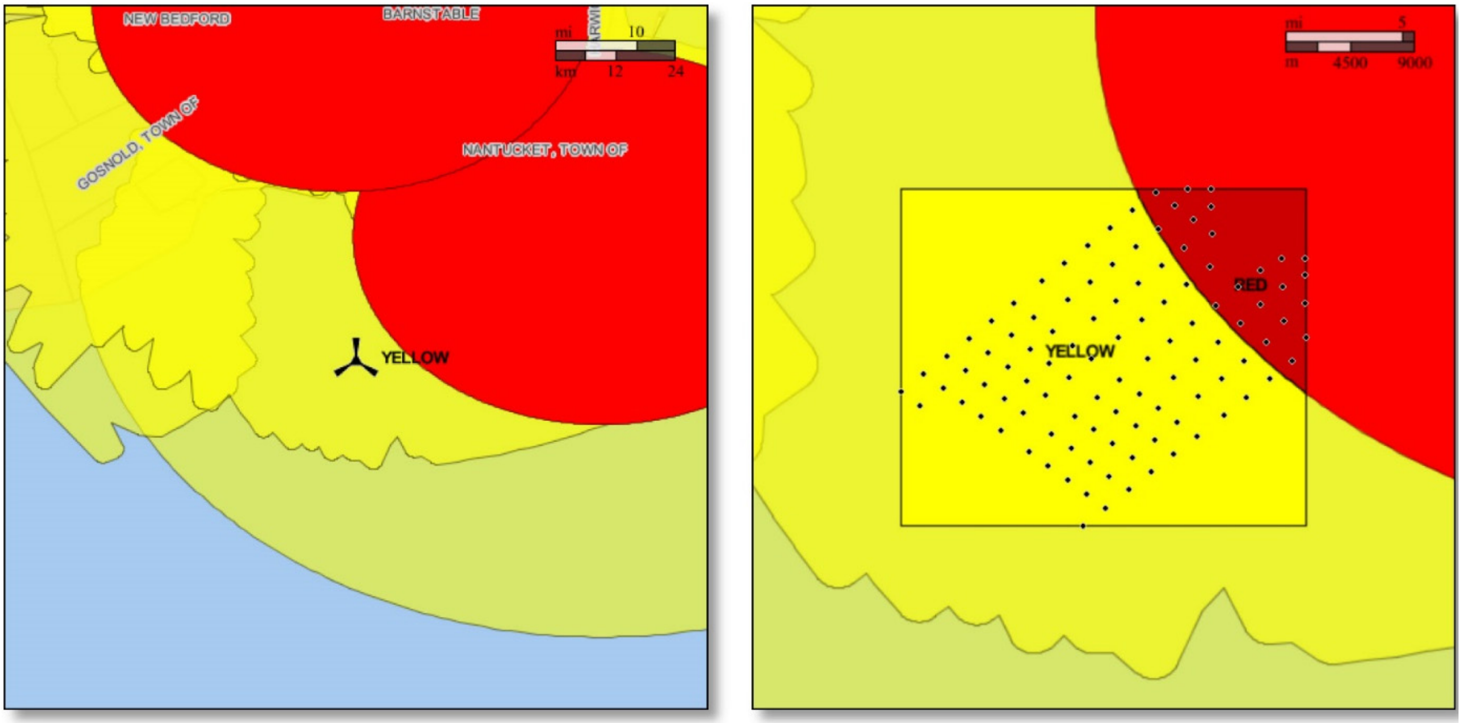
Marine Vessel Transportation of Project Components

The transport of Project components into and out of the New Bedford Terminal and to the Offshore Project Area is an essential element of the Project. The height of a loaded vessel could range from 50-110 m (164-361 ft) MLLW.

Airports and heliports located along the shore in the vicinity of the vessel routes could be affected by vessels carrying turbine towers. However, an initial airspace analysis indicates that no impacts would occur.

[29] For LRR, the PST uses a buffered radar line-of-sight analysis at a blade-tip height of 750 feet Above Ground Level (AGL).

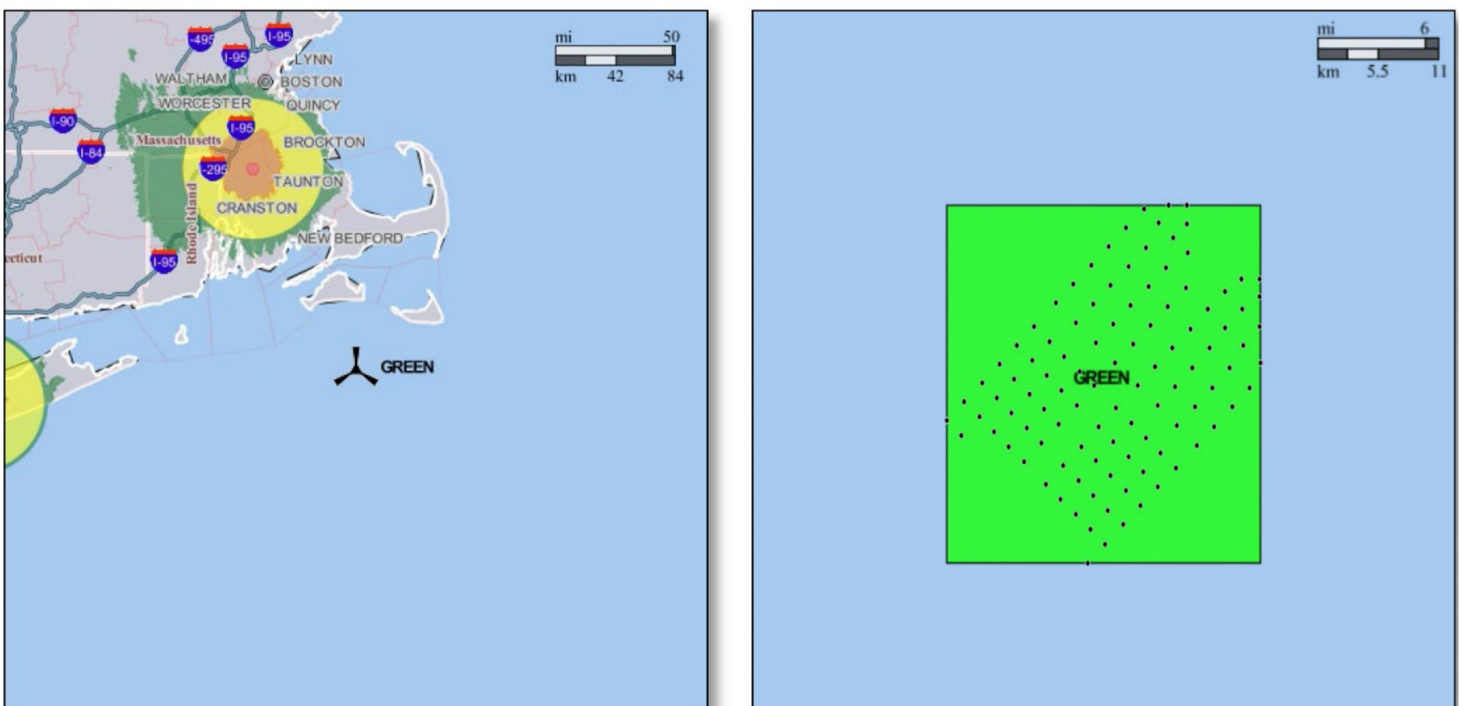
[30] For NEXRAD, the PST uses a blade-tip height of 160 meters (525 feet) AGL.



Long Range Radar Results

Left panel: zoomed out view of a single point within the WDA

Right panel: zoomed in view of the WDA



NEXRAD Results

Left panel: zoomed out view of a single point within the WDA

Right panel: zoomed in view of the WDA

Through coordination with FAA, certain actions may be necessary to protect air traffic operations on a temporary basis during vessel operations. These actions could include the publication of Notices to Airmen for each vessel movement above a specified height and Temporary Flight Restriction which would restrict specific low altitude aircraft movements. Temporary low/medium intensity obstruction lighting may also be required on the highest point of the structure during transit.

Department of Defense Warning Areas

DoD uses domestic and international airspace for readiness training and exercises. To make pilots aware of military operations, the FAA designates sectors of airspace as warning areas and charts these areas on aeronautical charts with an identifying number. The Navy and, occasionally, other DoD organizations use the airspace over and adjacent to the WDA. As noted above, this airspace has been designated as W-105A (Appendix III-J, Figure 4).

The scheduling of W-105A is managed by Fleet Area Control and Surveillance Facility, Virginia Capes, (an organizational element of the Navy located in Virginia Beach, VA. The vertical limits of W-105A begin at the surface of the water and extend to 15,240 m (50,000 ft) AMSL. Publicly available information for this warning area indicates that it is used for flight testing by the Navy. Adjacent sections of W-105A are used for surface-to-air gunnery exercises using conventional ordnance and antisubmarine warfare exercises.

This warning area was identified in BOEM's Revised Environmental Assessment for the Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore Massachusetts (BOEM, 2014), and BOEM has coordinated with DoD on its final MA WEA. In addition, Vineyard Wind has consulted with the Navy and has been informed that the Project does not raise concerns for the Navy.

7.9.2.1.3 Offshore Energy

In conformance with the Section 7(a) of the Project's Commercial Lease of Submerged Lands for Renewable Energy Development on the OCS, the Project does not propose activities that will unreasonably interfere with or endanger activities or operations carried out under any lease or grant issued or maintained pursuant to the OCSLA.

7.9.2.1.4 Sand and Mineral Extraction

As described in Section 7.9.1.4, there are no federal OCS sand and mineral lease areas or identified significant sand resource blocks within the Offshore Project Area. Further, it is not anticipated that any sand or mineral extraction would occur within the areas designated by BOEM for offshore wind energy use (i.e., the MA WEA or RI/MA WEA).

The Project's construction and installation activities are not anticipated to affect sand and mineral extraction that may occur within the Project Region, other than potential, temporary vessel restrictions in areas of active offshore cable installation.

7.9.2.1.5 Cable and Pipeline

A submarine power cable owned by National Grid that services the Island of Nantucket, will be crossed if New Hampshire Ave Landfall Site is chosen for installation. Standard techniques for adequately protecting both the National Grid cable and the newly installed offshore export cable are well established, and those techniques will be followed. The specifics of this crossing will be developed with National Grid as Project planning continues.

7.9.2.1.6 Radar Systems

Experience with WTGs located in NEXRAD line of sight has shown that WTGs can impact radar reflectivity, internal algorithms that generate alerts and derive weather products, and other attributes. The severity of impacts, in general, is related to the separation distance between the WTGs and the NEXRAD facility. Impacts increase as distance decreases, especially for WTGs located within 17.7 km (11 mi) of the NEXRAD facility (Vogt et al, n.d.).

Because the closest NEXRAD facility to the WDA is approximately 97 km (60 mi), there are no anticipated impacts associated with the WTGs that would require the implementation of mitigation measures. Partially assembled WTG components at the New Bedford Terminal or transiting to the WDA are similarly not anticipated to affect the NEXRAD system.

As part of the US Department of Energy's (DOE) effort to address and remove siting barriers for wind energy developments, Sandia National Laboratories has partnered with the NOAA to develop a GIS-based NEXRAD screening tool that identifies potential impacts from WTG siting locations. The screening tool did not identify impacts to NEXRAD systems based on the Project-specific parameters supplied to the screening tool.

7.9.2.1.7 Avoidance, Minimization, and Mitigation Measures

Vineyard Wind will implement best management practices when practicable and develop a comprehensive communications plan to keep the relevant parties informed throughout the construction and installation phase of the Project. Additional analysis of Project components and activities by BOEM and the FAA (as applicable) may identify specific avoidance, minimization, and/or mitigation measures.

7.9.2.2 Operations and Maintenance

Upon completion of construction, impacts associated with operations and maintenance of the Project are not anticipated to have adverse effects on the uses contemplated in this section.

7.9.2.2.1 National Security

Project-related vessel traffic during the operations and maintenance phase of the Project is not anticipated to cause impacts to national security interest operating in the Project Region. Facilities in the WDA will be monitored and controlled remotely from the Project's Operations and Maintenance Facilities ("O&M Facilities"). During planned and unplanned maintenance events a crew would be dispatched to the identified location to complete repairs and restore normal operations. Typically such maintenance events involve the use of a crew transport vessel, which should have little impact on commercial fishing or other activities in or near the WDA.

7.9.2.2.2 Aviation and Air Traffic

During the operations and maintenance phase, it is not anticipated that components exceeding 61 m (200 ft) AGL will either be assembled at a port facility used by the Project, or delivered to and from the WDA.

Inspection and monitoring of the WDA may be conducted by helicopters, as needed (see Section 3.2.6 of Volume I). The helicopter(s) used to support operations and maintenance activities would ideally be based at a general aviation airport in reasonable proximity to the O&M Facilities. Any such flights will adhere to FAA and other requirements and are not anticipated to affect aviation and air traffic in the Project Region.

7.9.2.2.3 Offshore Energy

In conformance with the Section 7(a) of the Project's Commercial Lease of Submerged Lands for Renewable Energy Development on the OCS, the Project does not propose activities that will unreasonably interfere with or endanger activities or operations carried out under any lease or grant issued or maintained pursuant to the OCSLA.

7.9.2.2.4 Sand and Mineral Extraction

Operation and maintenance of the Project are not anticipated to impact any proposed future sand and mineral extraction.

7.9.2.2.5 Cable and Pipeline

Should the OECC cross the existing National Grid cable in Nantucket Bay, operations and maintenance activities may be required at, or near that crossing. In the unlikely event that maintenance activities are necessary at the cable crossing, industry standard techniques for adequately protecting both the National Grid cable and the offshore cable system will be implemented.

7.9.2.2.6 Radar Systems

As noted in Section 7.9.2.1.6, the closest NEXRAD facility to the WDA is approximately 97 km (60 mi). At that distance there are no anticipated impacts associated with the WTGs that would require the implementation of mitigation measures.

7.9.2.2.7 Avoidance, Minimization, and Mitigation Measures

Vineyard Wind will implement best management practices when practicable and develop a comprehensive communications plan to keep the relevant parties informed throughout the operations and maintenance phase of the Project.

7.9.2.3 Decommissioning

As currently envisioned, decommissioning the Project is largely the reverse of the construction and installation process as described in Volume I.

7.9.2.3.1 National Security

No aspects of the Project are anticipated to affect national security, including USCG or Navy interests. Vineyard Wind will continue to work cooperatively with USCG and Navy personnel to address any navigation, operations, or other concerns with decommissioning activities.

7.9.2.3.2 Aviation and Air Traffic

Impacts to aviation and air traffic during the decommissioning phase are anticipated to be similar to those described in Section 7.9.2.1.2.

7.9.2.3.3 Offshore Energy

In conformance with the Section 7(a) of the Project's Commercial Lease of Submerged Lands for Renewable Energy Development on the OCS, the Project does not propose activities that will unreasonably interfere with or endanger activities or operations carried out under any lease or grant issued or maintained pursuant to the OCSLA

7.9.2.3.4 Sand and Mineral Extraction

Impacts to sand and mineral extraction during the decommissioning phase are anticipated to be similar to those described in Section 7.9.2.1.4.

7.9.2.3.5 Cable and Pipeline

Impacts to cable and pipeline during the decommissioning phase are anticipated to be similar to those described in Section 7.9.2.1.5. If additional cables and/or pipelines are installed prior to the decommissioning phase, industry standard techniques for adequately protecting cable and/or pipeline systems will be implemented.

7.9.2.3.6 Radar Systems

Impacts to radar systems during the decommissioning phase are anticipated to be similar to those described in Section 7.9.2.1.6.

7.9.2.3.7 Avoidance, Minimization, and Mitigation Measures

Impacts and avoidance, minimization, and mitigation measures associated with decommissioning are similar to those described in Section 7.9.2.1.

Section 8.0

Low Probability Events

8.0 LOW PROBABILITY EVENTS

The following sections discuss low probability events that could occur during construction, operations, and/or decommissioning of the Project. Such events generally include collisions between vessels or between vessels and marine life, allisions between vessels and Wind Turbine Generators ("WTGs") or Electrical Service Platform ("ESPs"), spills resulting from refueling, maintenance, or catastrophic events, severe weather and natural events, and other accidental releases.

8.1 Collisions and Allisions

Collisions generally include vessels colliding with other vessels or colliding with marine life. Allisions generally would involve vessels and WTGs or ESPs. All such events could result in spills as described below, or in the case of a collision with marine life, injury or fatalities. In general, the risk of vessel collisions is low due to various mitigating factors, including US Coast Guard ("USCG") required lighting on vessels, the fact that higher vessel traffic areas were excluded from the Wind Energy Area ("WEA") (BOEM, 2014), and as safe and practicable, the National Oceanic and Atmospheric Administration's vessel strike guidance will also be implemented. The risk of allisions with WTGs or other facility components is low due to mitigating factors, including the distance of the Wind Development Area ("WDA") from typical vessel routes, the spacing between WTGs and other facility components (see Figure 3.1-2), and the lighting and marking plan that will be in place. Furthermore, the specific location of project components will be provided to USCG and National Oceanographic and Atmospheric Administration for inclusion in nautical charts. As such, impacts from collisions and allisions are unlikely.

8.2 Spills

For the purposes of this discussion, spills include those inadvertent releases resulting from refueling of vessels during construction or operations, spills potentially resulting from routine maintenance activities required for operations of the Project, inadvertent releases due to equipment malfunction or breakage, and more significant spills that could result from a catastrophic event occurring at or in proximity to the Project. Vessel fuel spills are not expected, and if one occurred, it is likely to be small. According to the USCG, between 2000 and 2011, the average oil spill size for vessels other than tank ships and tank barges in all US waters was 466 liters (123 gallons) (USCG, 2012). Because a diesel fuel or similar fuel spill of this size is expected to dissipate rapidly and evaporate within days, impacts to any affected resources would be short-term and localized to the vicinity of the spill. The potential for spills will be further minimized as a result of the fact that vessels will be expected to comply with USCG regulations at 33 C.F.R. § 151 relating to the prevention and control of oil spills. Additionally, the Oil Spill Response Plan ("OSRP Plan"), included in Appendix 1-A, will provide for rapid spill response, clean-up, and other measures that should also help to minimize any potential impact to affected resources as it relates to spills and accidental releases that might occur, including spills resulting from catastrophic events.

8.3 Severe Weather and Natural Events

As described in the Revised Environmental Assessment for the Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore Massachusetts severe weather events have the potential to cause structural damage and injury to personnel (BOEM, 2014). Although major storms, winter nor'easters, and, to a lesser extent, hurricanes pass through the WDA regularly, the Project components are designed to withstand severe weather events. In the event of a spill as a result of a catastrophic event due to severe weather, the OSRP Plan will provide for rapid spill response, clean-up, and other measures that should help to minimize the potential for harm to potentially affected resources.

Natural disasters, such as earthquakes, could potentially impact the buried concrete duct bank system onshore. Regardless of the cause, any damage to or breakage of the duct bank system would require excavation to uncover and repair the damaged section. Such work could impact wildlife habitat in the same way as the construction and installation activities discussed above in Section 6.1.2.1. Furthermore, while catastrophic damage to the transition vault or buried duct bank system is extremely unlikely, it could possibly occur as a result of a natural disaster such as a major hurricane or other coastal storm that results in severe flooding and coastal erosion. Repairs to extensive damage to the transition vault or adjacent duct bank could require a larger workspace that might disturb coastal habitats adjacent to the damaged infrastructure. Any required repair work that results in additional impact to coastal habitat will incorporate mitigation for construction and installation as described in Section 6.4.2.1. Should any emergency repairs be required to any onshore facilities within Priority Habitat of the Piping Plover, between early April and mid- to late August, the National Heritage and Endangered Species Program will be notified prior to initiation of the repair work.

8.4 Other Accidental Releases

Impacts to terrestrial and coastal fauna and other coastal habitats and resources could potentially result from the unlikely event of an accidental release of fuel lubricating, or hydraulic oils from construction equipment operating in or adjacent to the Landfall Site. Refueling and lubrication of stationary equipment will be conducted in a manner that protects coastal habitats from accidental spills. A Construction Spill Prevention Control and Countermeasures Plan will be prepared in accordance with all applicable federal, state, and local requirements. This Plan will identify all measures that will be implemented to prevent spills and the best management practices that that will be in place to contain spills that may occur.

Impacts to terrestrial and coastal fauna and other coastal habitats also could occur during horizontal directional drilling ("HDD") efforts. As is standard practice, the HDD operations will use bentonite or other naturally occurring non-hazardous drilling mud to while drilling to develop a "tunnel" beneath the coastal habitats that are seaward of the HDD entry point. HDD crews are trained to closely monitor the position of the drill head and pressures and reduce the risk of inadvertent releases of pressurized drilling mud to the surface. In the event of an inadvertent release, visual monitoring of the drill alignment over the land portion can be used to immediately depressurize the drill operation and minimize the amount of drilling mud released within coastal habitats. While it is not anticipated, in the unlikely event of an inadvertent release there could be some small impact. However, because drilling mud is natural and inert, and the amount of fluid is typically low, the released material is easily managed and could be removed from the site without harm to the environment.

Impacts to terrestrial and coastal fauna and other coastal habitats and resources could occur as a result of unexpected events occurring on the buried concrete duct bank system. However, damage to the buried concrete duct bank system is a low probability event as these systems are very robust. Once installed, they generally require no maintenance for the life of the project they serve. There is a remote chance the duct bank could be damaged at some point by an unrelated construction project. However, as the duct bank will be encased in concrete and buried at sufficient depth to avoid other utilities, this scenario is extremely unlikely.

Section 9.0

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