Vineyard Wind Offshore Wind Energy Project Biological Assessment

December 2018 (Revised March 2019)

For the National Marine Fisheries Service

U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs

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ACRONYMS AND ABBREVIATIONS

Acronym	Definition
°C	degrees Celsius
μPa	micropascal
$\mu Pa^2 s$	micropascal squared second
μT	microtesla
AC	alternating current
BA	Biological Assessment
BIA	Biologically Important Area
BOEM	Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
COP	Construction and Operations Plan
cSEL	cumulative sound exposure level
CWA	Clean Water Act
dB	decibel
DP	dynamic positioning
DPS	distinct population segment
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EMF	electromagnetic fields
EPACT	Energy Policy Act
ESP	electrical service platform
ESA	Endangered Species Act
Fed. Reg.	Federal Register
ft	foot
g/m^2	grams per square meter
HDD	horizontal directional drilling
HRG	high-resolution geoghysical
HSI	hot spot index
Hz	hertz
JASMINE	JASCO Animal Simulation Model Including Noise Exposure
kHz	kilohertz
kJ	kilojoule
kV	kilovolt
km^2	square kilometers
LAA	likely to adversely affect
LFC	low-frequency cetacean
L_E	cumulative sound exposure
L_p	sound pressure
L_{E24}	cumulative sound exposure over a 24 hour period
L_{p24hr}	sound pressure level over 24 hours
L_{pk}	peak sound pressure
m	meter
MA WEA	Massachusetts Wind Energy Area
MCT	New Bedford Marine Commerce Terminal
MFC	mid-frequency cetacean
MLLW	mean lower low water
MMPA	Marine Mammal Protection Act
mg/L	milligram per liter
MW	megawatt
NA	not applicable
NARW	North Atlantic right whale

Acronym	Definition
NE	no effect
NLAA	not likely to adversely affect
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NWP	Nationwide Permit
OCS	Outer Continental Shelf
OECC	Offshore Export Cable Corridor
OCSLA	Outer Continental Shelf Lands Act
PAM	passive acoustic monitoring
PDE	Project Design Envelope
PSO	Protected Species Observer
PTS	permanent threshold shift
RFI	Request for Interest
RMS	root mean square
ROV	remotely operated vehicle
SAG	surface active group
SEL	sound exposure level
SOV	service operations vessel
SPL	sound pressure level
SPUE	sightings per unit effort
TSHD	trailing suction hopper dredge
TTS	temporary threshold shift
UME	Unusual Mortality Event
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
Vineyard Wind	Vineyard Wind LLC
WBWS	Wellfleet Bay Wildlife Sanctuary
WDA	Wind Development Area
WEA	Wind Energy Area
WLA	Wind Lease Area
WTG	wind turbine generators

1. INTRODUCTION

The Energy Policy Act (EPACT) of 2005, Public Law No. 109-58, added Section 8(p)(1)(C) to the Outer Continental Shelf Lands Act (OCSLA), which grants the Secretary of the Interior the authority to issue leases, easements, or rights-of-way on the Outer Continental Shelf (OCS) for the purpose of renewable energy development (43 United States Code [USC] § 1337(p)(1)(C)). The Secretary delegated this authority to the former Minerals Management Service, now the Bureau of Ocean Energy Management (BOEM). On April 22, 2009, BOEM (formerly the Bureau of Ocean Energy Management, Regulation, and Enforcement) promulgated final regulations implementing this authority at 30 Code of Federal Regulations (CFR) § 585.

This Biological Assessment (BA) has been prepared pursuant to the Endangered Species Act (ESA) to evaluate potential effects of the Proposed Action described herein on ESA-listed species. This BA provides a comprehensive description of the Proposed Action, defines the Action Area, describes those species potentially impacted by the Proposed Action, and provides an analysis and determination of how the Proposed Action may affect listed species and/or their habitats. The activities being considered include approving the Construction and Operations Plan (COP) for the construction, operations, maintenance, and eventual decommissioning of the proposed offshore wind energy facility. Proposed is the installation of a wind facility with a maximum capacity of approximately 800 megawatts (MW) and associated submarine and upland cable interconnecting the wind facility to the proposed substation located in Barnstable, Massachusetts. The Wind Development Area (WDA) is located in the northern portion of the Vineyard Wind LLC (Vineyard Wind) Lease Area OCS-A 0501 (Figure 1-1). A separate BA document was prepared for the consultation with the U.S. Fish and Wildlife Service (USFWS) for ESA-listed species under their oversight.

1.1. BACKGROUND

BOEM began evaluating OCS wind energy offshore Massachusetts in 2009 by establishing an intergovernmental renewable energy task force comprised of elected officials from state, local, and tribal governments and affected federal agency representatives. After extensive consultation with the task force, BOEM removed some areas from further consideration for offshore wind leasing. BOEM then conducted the following activities concerning planning and leasing:

- In December 2010, BOEM published a Request for Interest (RFI) in the Federal Register (Fed. Reg.) to determine commercial interest in wind energy development in an area offshore Massachusetts (Commercial Leasing for Wind Power on the OCS Offshore Massachusetts –RFI, 75 Fed. Reg. 82055 [December 29, 2010]). BOEM invited the public to provide information on environmental issues and data for consideration in the RFI area and also to express interest in offshore wind energy development. BOEM re-opened the comment period in March 2011 in response to requests from the public and the Commonwealth of Massachusetts. BOEM received 260 public comments and 11 indications of interest from ten companies interested in obtaining a commercial lease. Subsequently, BOEM made the planning area 50 percent smaller than the original area in response to comments on navigational and commercial fishery concerns.

- In February 2012, BOEM published a Call for Information and Nominations (Call) in the Fed. Reg. to solicit industry interest in acquiring commercial leases for developing wind energy projects in the Call area (Commercial Leasing for Wind Power on the OCS Offshore MA – Call for Information and Nominations, 77 Fed. Reg. 5821 [February 6, 2012]). In the same month, BOEM published a Notice of Intent (NOI) to prepare an Environmental Assessment (EA) for commercial wind leasing and site assessment activities offshore Massachusetts. The comment period for the Call yielded 32 comments and ten nominations of commercial interest.
- In May 2012, BOEM publicly identified a Wind Energy Area (WEA) offshore Massachusetts, excluding additional areas from commercial leasing addressed in comments from the Call, including an area of high sea duck concentration and an area of high-value fisheries. After conducting an EA, BOEM issued a "Finding of No Significant Impact," which concluded that reasonably foreseeable environmental effects associated with the activities that would likely be performed following lease issuance (e.g., site characterization surveys in the WEA and deployment of meteorological towers or buoys) would not significantly impact the environment. The Revised Massachusetts Environmental Assessment (BOEM 2014) more fully describes the development of the WEA.
- In June 2014, BOEM published a Proposed Sale Notice identifying 742,974 acres (3,007 square kilometers [km2]) offshore MA in federal waters would be available for commercial wind energy leasing.
- In January 2015, BOEM held a competitive lease sale pursuant to 30 CFR 585.211 for the lease areas within the Massachusetts WEA (MA WEA). Offshore MW LLC (subsequently renamed to Vineyard Wind LLC) won the competition for Lease Area OCS-A 0501 in the auction (Figure 1.1-1). This lease area is 166,886 acres (675 km^2).

In December 2017, Vineyard Wind submitted to BOEM an initial COP for the proposed Project. BOEM provided comments on the initial COP, and Vineyard Wind updated the COP and resubmitted it on March 15, 2018 (Epsilon 2018). After addressing additional comments from BOEM, Vineyard Wind resubmitted a further updated COP on October 22, 2018. The Draft COP is available for viewing at BOEM's project-specific website.[1] The COP proposes to develop approximately 800 MW of wind energy capacity in the WDA amounting to 75,614 acres (306 km^2, see Figures 1-1 and 1-2).

[1] The Draft COP can be reviewed at https://www.boem.gov/Vineyard-Wind/.

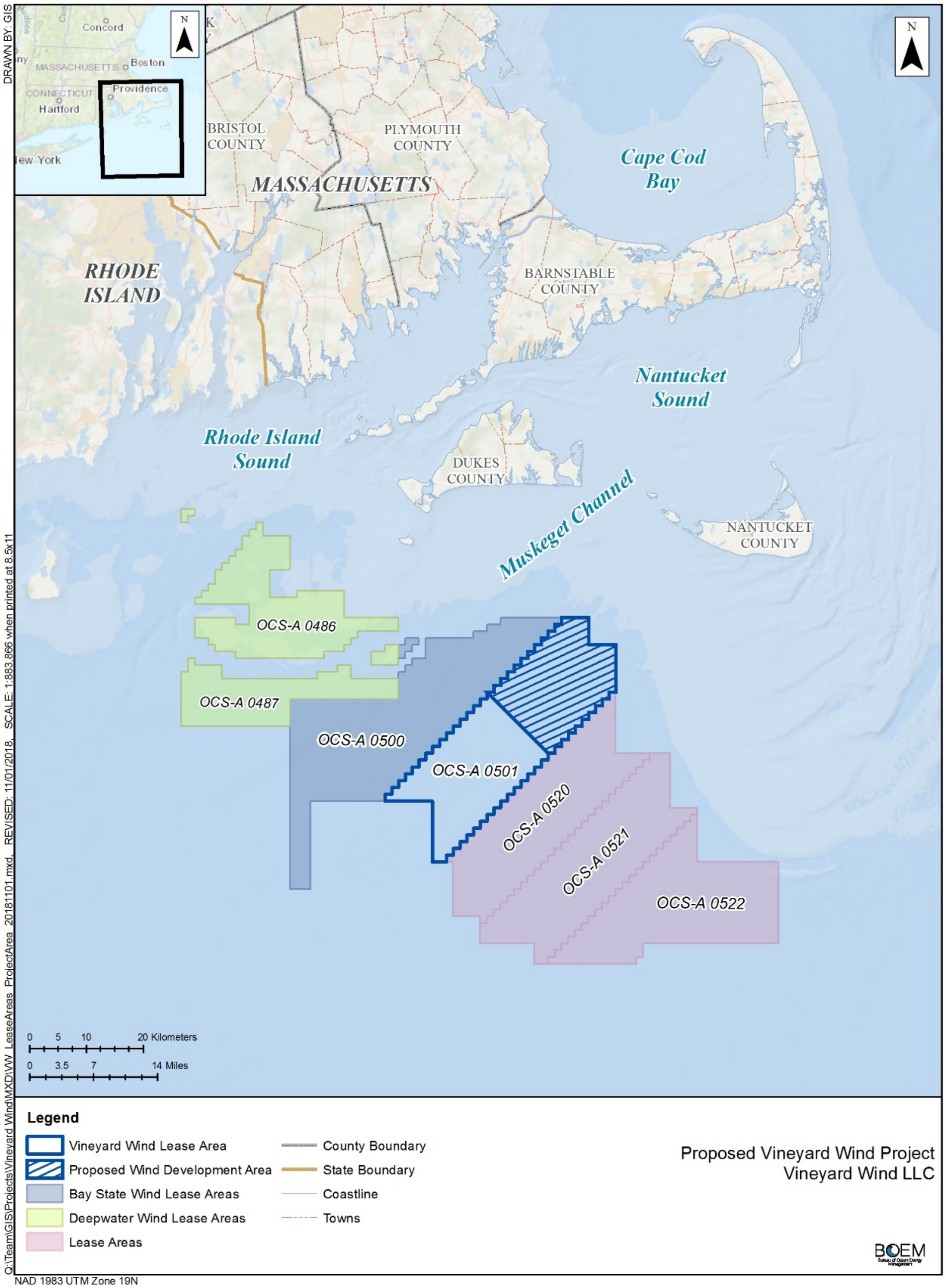


Figure 1-1: Proposed Project Area Relative to Massachusetts and Rhode Island Lease Areas

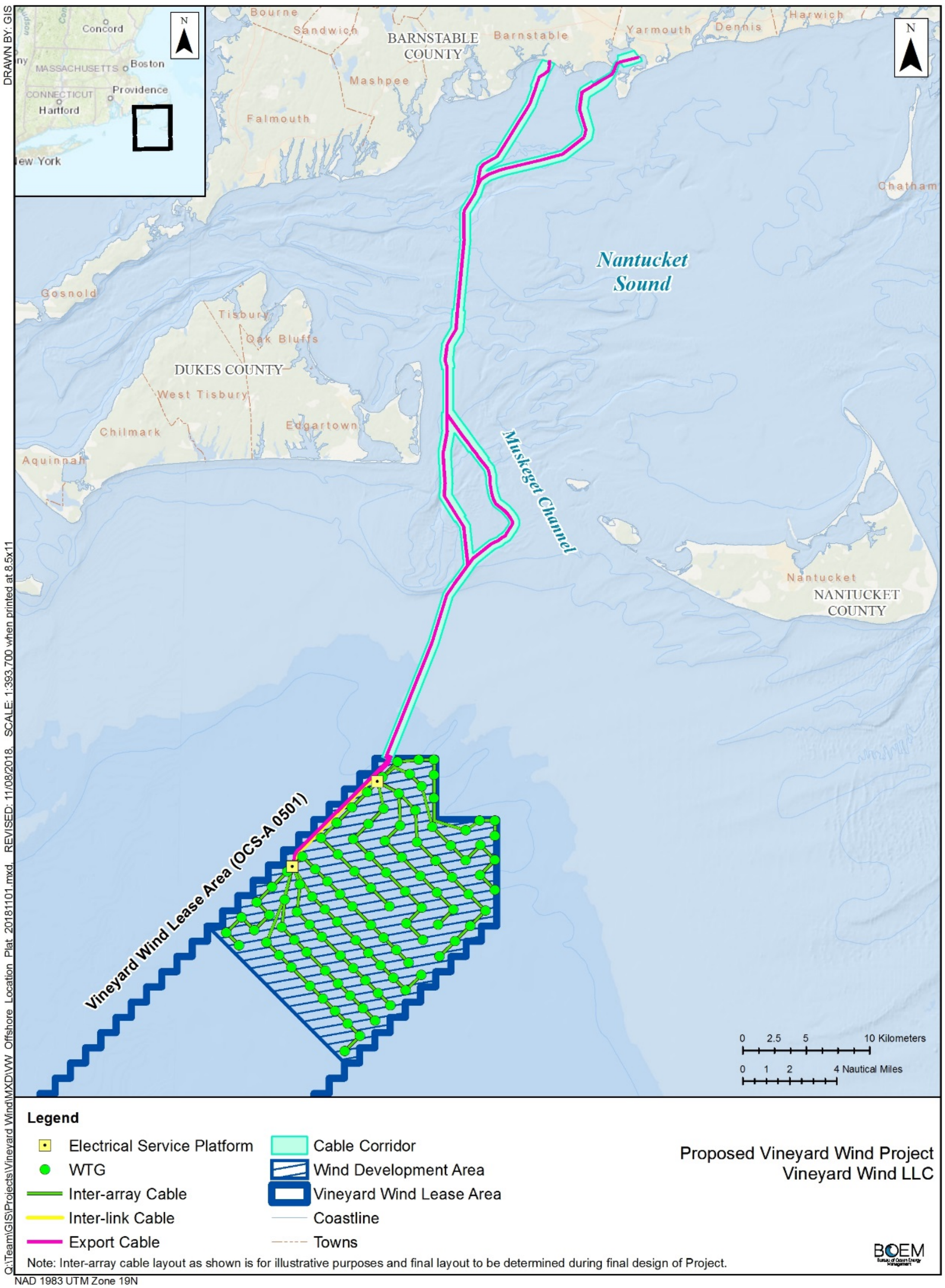


Figure 1-2: Proposed Offshore Project Elements

1.2. ACTION AREA

The proposed Project area in southern New England includes a region south of Martha's Vineyard (northern Mid-Atlantic Bight) and extends north through Muskeget Channel to landfall in south-central Cape Cod (COP Volume III, Section 6.6.1; Epsilon 2018; Figures 1-1 and 1-2). Benthic habitat in the region is predominantly flat with sand or sand-dominated substrate becoming increasingly muddy toward the south end of the proposed Project area and increasingly gravelly toward the northwest corner (Guida et al. 2017).

This region is part of the Northeast U.S. Continental Shelf Ecosystem, which extends from the Gulf of Maine to Cape Hatteras, North Carolina (BOEM 2014). The WDA and Offshore Export Cable Corridor (OECC) would be located within the Southern New England sub-region of the Northeast U.S. Shelf Ecosystem, which is distinct from other regions based on differences in productivity, species assemblages and structure, and habitat features (Cook and Auster 2007). Similar to much of the Northeast U.S. Shelf Ecosystem, the southern sub-region habitat is dominated by sandy substrate, a characteristic reflected in the finfish and invertebrate species assemblages found there. A summary of the major finfish and invertebrate species identified in the vicinity of MA WEA are listed in COP Table 6.6-1 (Volume III, Section 6.6.1; Epsilon 2018). This resource includes resident and migratory species as well as demersal and pelagic species. Many of the species included also have designated Essential Fish Habitat.

The Action Area under the ESA refers to the area directly or indirectly affected by the proposed action (50 CFR § 402.02). This includes both the proposed Project's footprint and the area that may be affected by direct and indirect effects of associated activities with the Project. Thus, the Action area includes not only the Project area described above, but also vessel transit areas between ports and the proposed Project area may impact listed species, and other areas affected by interdependent and interrelated actions. Noise from proposed Project activities would also further extend the area of consideration for potential direct or indirect impacts. Thus, the Action Area for this BA conservatively includes the WDA, OECC, vessel transit corridors to and from ports, and the surrounding areas ensonified by proposed Project noise at levels that may cause impacts. Ports that may be used to support proposed Project activities are located in Massachusetts (New Bedford, Brayton Point, and Montaup), Rhode Island (Providence and Quonset Point), one or more ports in Canada, and transport of manufactured components from Europe. As a consequence of some ports being considered for use only during the staging and construction stages for the Project, portions of the Action Area in vessel transit areas may change between the construction and operational/decommissioning stages of the Project.

1.3. PROPOSED ACTION

The Proposed Action would allow Vineyard Wind to construct, operate, maintain, and eventually decommission an approximately 800 MW wind energy facility on the OCS offshore of Massachusetts within Vineyard Wind's WDA, including associated export cables. Vineyard Wind has submitted a COP outlining its Proposed Action, which is summarized in more detail in Section 3 of this document. In brief, power generated by the wind turbine generators (WTGs) in the WDA would be transformed by electrical service platforms (ESPs; also in the WDA) and transferred to Cape Cod through two cables buried within a single OECC (of which two segments are potentially variable). The offshore export cables would make landfall at one of two sites and be spliced to onshore export cables, which would be buried along existing right-of-way corridors leading to a new electrical substation in the north-central portion of the Town of Barnstable, Massachusetts. No identified direct or indirect effects on listed species from upland construction and maintenance would occur, therefore this document focuses on the offshore portions of the proposed Project (Figure 1-1 and Figure 1-2).

2. ENDANGERED SPECIES ACT SECTION 7 CONSULTATION HISTORY

Section 7(a)(2) of the ESA of 1973, as amended (16 USC §1531 et seq.), requires that each federal agency ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of those species. When the action of a federal agency may affect a protected species or its critical habitat, that agency is required to consult with either the National Marine Fisheries Service (NMFS) or USFWS, depending upon the jurisdiction of the Services. This BA serves as the consultation document with NMFS for proposed activities considered in the COP that could affect listed species. No critical habitat is designated in the Action Area; thus, none would be affected. In a July 26, 2018 letter to NMFS, BOEM requested any comments or information necessary to be included in preparation of this BA.

The existing 2013 Biological Opinion (NMFS 2013) addresses data collection activities including high-resolution geophysical surveys, geotechnical surveys, biological surveys, and other related data collection activities associated with the proposed Project. NMFS concluded that the above actions may adversely affect by PTS and harassment, but are not likely to jeopardize, the continued existence of Kemp’s ridley (*Lepidochelys kempii*), green (*Chelonia mydas*), or leatherback (*Dermochelys coriacea*) sea turtles; the Northwest Atlantic distinct population segment (DPS) of loggerhead (*Caretta caretta*) sea turtles; North Atlantic right whale (*Eubalaena glacialis* [NARW]), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), or sperm whale (*Physeter macrocephalus*); or the Gulf of Maine, New York Bight, Chesapeake Bay, or South Atlantic DPS of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Since the 2013 Biological Opinion was issued, new information has become available, such as new National Oceanic and Atmospheric Administration (NOAA) sound exposure guidelines (NMFS 2016), new information on the sound sources (Crocker and Fratantonio 2016), and changes in the listing status of humpback (*Megaptera novaeangliae*) whales and green sea turtles. This new information warrants the re-evaluation of the effects of data collection activities. Completion of Section 7 consultation associated with this Data Collection BA is expected to supersede and replace the 2013 Biological Opinion. However, it is expected that the April 10, 2013, Biological Opinion will remain in effect until it is replaced.

Pursuant to 50 CFR § 402.07, BOEM has accepted designation as the lead federal agency for the purposes of fulfilling interagency consultation under Section 7 of the ESA. The Bureau of Safety and Environmental Enforcement (BSEE), U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (EPA), the U.S. Coast Guard (USCG), and NMFS are cooperating agencies for the development of the EIS for the Vineyard Wind project under the National Environmental Policy Act, and will also be co-action agencies for the ESA consultation.

2.1. BSEE

In 2010, the creation of BOEM and BSEE focused on dividing regulatory responsibility for the offshore mineral development program and left regulatory responsibility for renewable energy entirely with BOEM. However, the Secretarial Order that created the two bureaus always envisioned that there would be a future division of administrative responsibility for renewable energy. This division of responsibility for renewable energy would have BOEM continue to oversee the identification and leasing of offshore areas for renewable energy development and evaluation of proposed development plans; while BSEE's mission is to enforce safety, environmental, and conservation compliance with any associated legal and regulatory requirements during project construction and future operations. The bureaus are working together to implement these changes. BOEM will retain authority to approve, approve with modification, or disapprove any site assessment plans, while BSEE will be in charge of the review of Facility Design and Fabrication and Installation Reports, oversee inspections/enforcement actions as appropriate, oversee closeout verification efforts, oversee facility removal inspections/monitoring, and oversee bottom clearance confirmation. Under the renewable energy regulations, the issuance of leases and subsequent approval of wind energy development on the OCS is a staged decision-making process.

2.2. EPA

Section 328(a) of the Clean Air Act (42 U.S.C. § 7401 *et seq.*) as amended by Public Law 101-549 enacted on November 15, 1990, required the EPA to establish air pollution control requirements for OCS sources subject to the OCSLA for all areas of the OCS, except those located in the Gulf of Mexico west of 87.5 degrees longitude (near the border of Florida and Alabama),[2] in order to attain and maintain Federal and State ambient air quality standards and comply with the provisions of part C of title I of the Act.[3] To comply with this statutory mandate, on September 4, 1992, EPA promulgated "Outer Continental Shelf Air Regulations" at 40 C.F.R. part 55. 57 Fed. Reg. 40,791. 40 C.F.R. part 55 also established procedures for implementation and enforcement of air pollution control requirements for OCS sources. 40 C.F.R. § 55.2 states an OCS source means any equipment, activity, or facility, which:

1. Emits or has the potential to emit any air pollutant;
2. Is regulated or authorized under OCSLA (43 U.S.C. § 1331 *et seq.*); and,
3. Is located on the OCS or in or on waters above the OCS.

This definition shall include vessels only when they are: Permanently or temporarily attached to the seabed and erected thereon and used for the purpose of exploring, developing, or producing resources therefrom …; or Physically attached to an OCS facility, in which case only the stationary sources aspects of the vessels will be regulated.

OCS sources, pursuant to this definition, can include wind energy development sources which are authorized under OCSLA at 43 U.S.C. § 1337(p)(1)(C).[4] On April 22, 2009, BOEM announced final

[2] Public Law 112-74, enacted on December 23, 2011, amended § 328(a) to add an additional exception from EPA regulation for OCS sources "located offshore of the North Slope Borough of the State of Alaska."

[3] Part C of title I contains the Prevention of Significant Deterioration of Air Quality requirements.

[4] The Energy Policy Act of 2005 (Pub. L. No. 109-58) amended OCSLA to add subsection (p)(1)(C), granting the Secretary of the Interior the authority to issue leases, easements, or rights-of-way on the OCS for activities that "produce or support production, transportation, or transmission of energy from sources other than oil and gas" which includes renewable energy

regulations for the OCS Renewable Energy Program. These regulations, codified at Title 30 of the Code of Federal Regulations (C.F.R.) part 585, provide a framework for issuing leases, easements, and rights-of-way for OCS activities that support production and transmission of energy from sources other than oil and natural gas. BOEM issues commercial leases and approves COPs to construct, operate, and decommission offshore wind projects. Thus, where these projects emit or will have the potential to emit air pollutants and are located on the OCS or in or on waters above the OCS, the projects will be subject to the 40 C.F.R. part 55 requirements, including the 40 C.F.R. § 55.6 permitting requirements.

The USEPA Region 1 received an application for a permit from Vineyard Wind on August 17, 2018. The EPA determined the application was complete on January 29, 2019. The anticipated date of permit issuance is November 14, 2019 or no longer than 90 days after issuance of the record of decision for the ERIS being prepared for this project.

2.3. USACE

The USACE has regulatory responsibilities under Section 10 of the Rivers and Harbors Act to approve/permit any structures or activities conducted below the ordinary high water elevation of navigable waters of the United States. The USACE also has responsibilities under Section 404 of the Clean Water Act (CWA) to prevent water pollution, obtain water discharge permits and water quality certifications, develop risk management plans, and maintain such records. A general condition of a Nationwide Permit (NWP) for water quality stipulates that where states, authorized tribes, or the EPA, where applicable, have not previously certified compliance of a NWP with CWA Section 401, individual 401 Water Quality Certification must be obtained or waived (33 CFR 330.4(c)). The USACE District Engineer, state, or tribe may require additional water quality management measures to ensure that the authorized activity, such as site characterization, does not result in more than minimal degradation to water quality. A CWA Section 404/Section 10 permit application was received on December 18, 2018 and a public notice issued by the USACE on February 1, 2019 (NAE-2017-01206, see https://www.nae.usace.army.mil/Missions/Regulatory/PublicNotices.aspx). Work regulated by the USACE will include the construction of up to 100 offshore wind turbine generators (WTGs), scour protection around the base of the WTGs, up to two electrical service platforms (ESPs), inter-array cables connecting the WTGS to the ESPs, inter-link cables between ESPs (if two ESPs are placed), and two offshore export cables within a single 23.3 mile route. It is anticipated a final permit will be issued no later than November 14, 2019.

2.4. USCG

The USCG administers the permits for PATONs located on structures positioned in or near navigable waters of the United States. PATONS and federal aids to navigation (ATONS), including radar transponders, lights, sound signals, buoys, and lighthouses are located throughout the Project area. It is anticipated that USCG approval of additional private aids to navigation (PATONS) during construction of the WTGs, ESPs, and along the offshore export cable corridor may be required. These aids serve as a visual reference to support safe maritime navigation. Vineyard Wind would establish marine coordination

development, including wind energy development. The Department of the Interior delegated this authority to the Minerals Management Service (now BOEM).

to control vessel movements throughout WDA as required. Federal regulations governing PATON are found within 33 CFR Part 66 and address the basic requirements and responsibilities.

2.5. NMFS

Vineyard Wind submitted an application to NMFS on September 7, 2018, for an Incidental Take Authorization (ITA) pursuant to Section 101(A)(5) of the Marine Mammal Protection Act (MMPA). Vineyard Wind is currently coordinating with NMFS on any additional information necessary to consider the level of impacts and number of takes that may be subject to authorization under the MMPA. If any additional information is deemed necessary for the MMPA application, such information will also be provided as supplemental information to this BA for consideration during ESA consultation. Depending on receipt of a complete application from Vineyard Wind, NMFS intends to publish a proposed ITA in the *Federal Register* on April 30, 2019, and a final Incidental ITA by November 14, 2019. BOEM anticipates that any take of ESA-listed marine mammals authorized under the MMPA will also be authorized through the Incidental Take Statement of any resulting biological opinion for the Proposed Action.

3. THREATENED AND ENDANGERED SPECIES IN THE ACTION AREA

This BA evaluates ESA-listed species of whales, sea turtles, and marine fish that may be affected by the Proposed Action. Among marine mammal species that may be affected include four endangered whales: NARW, fin whale, sei whale, and sperm whale (Table 3.1-1). Four ESA-listed species of sea turtles may occur in the U.S. Northwest Atlantic Ocean: leatherback, loggerhead, Kemp’s ridley, and green. (Table 3.2-1). All of these sea turtles are migratory and enter New England waters primarily in the summer and fall. Among these species, four sea turtles are likely to occur in the proposed Action Area, which includes the WDA, OECC, and surrounding waters: leatherback, loggerhead (Northwest Atlantic Ocean DPS), Kemp’s ridley, and green (North Atlantic DPS) sea turtles. One species of marine fish listed under the ESA, Atlantic sturgeon, may occur in the Action Area and be affected by the proposed action.

Analysis of Listed Species Considered, but Discounted from Additional Analysis

The following subsection provides an analysis of effects for listed species that were considered in this BA, but were not carried forth for additional analysis because any potential effects were determined to be discountable or insignificant, not having any discernable positive or negative effects on those species as a result of the proposed action. The occurrence of and risk to blue whales have been considered in this BA, but discounted from further analysis. Sightings and strandings data indicate that blue whales occur along the U.S. east coast rarely (NMFS 1998; Kraus et al. 2016b) and their presence in the Project area in not expected. Although blue whales are not expected in the Project area, the Action Area includes potential transit areas where barges transporting offshore WTG components from Europe or Canada may traverse deepwater habitat areas. Any vessels transporting manufactured components in international waters are considered interrelated effects of the proposed action, but part of Action Area. The operational speed of transport barges is 10 kt (COP Volume I, p. 4-30). The likelihood of a strike for the small, temporary increase in vessel traffic from transport of components would be a rare event compared to the high level of commercial vessel traffic in the North Atlantic. In addition to the unlikely event of a vessel strike with a blue whale, the slow 10 kt operating speed of barges will allow adequate time for a barge captain to detect any potential hazard, including whales, and take evasive action. Similarly, the number of transport vessels is relatively insignificant compared to baseline traffic, and the temporary vessel noise from transporting components will have insignificant effects on blue whales. Despite these discountable and insignificant effects, Vineyard Wind has voluntarily proposed vessel strike avoidance measures apply to all marine mammals sighted during vessel operations associated with their project which would further avoid any potential interactions between whales and vessel traffic associated with the proposed action.

Hawksbill sea turtles (*Eretmochelys imbricata*) are rare in Massachusetts and are not expected to occur in the Action Area. Hawksbill sea turtles have a circumtropical distribution and usually occur between latitudes 30°N and 30°S in the Atlantic Ocean. In the western Atlantic, hawksbills are widely distributed throughout the Caribbean Sea, off the coasts of Florida and Texas in the continental United States. Nesting occurs on insular and mainland sandy beaches throughout the tropics and subtropics, and no nesting beaches are found in the northeast U.S. near the Action Area. Additionally, stranding data do not indicate any hawksbills occurring in the area. The presence of hawksbills would be considered extralimital and outside their normal range. The best available data show hawksbill sea turtles are not expected to occur in the Action Area, and thus, will not be affected by the proposed action.

Shortnose sturgeon (*Acipenser brevirostrum*) are found regionally but are typically found in freshwater or estuarine environments. Movement of shortnose sturgeon between rivers is rare and their presence in the marine environment is uncommon (BOEM 2018). There is no potential for impacts to shortnose sturgeon in the WDA or OECC project area. Although very uncommon, rare movements of shortnose sturgeon between the mouths of coastal rivers were considered and determined these movement are so rare there is a discountable potential for shortnose sturgeon to occur in vessel transit areas and be exposed to noise. Therefore, the potential for effects occurring to shortnose sturgeon from the proposed action will be discountable. Therefore, no effects will occur to shortnose sturgeon and this species is not discussed further in this BA.

Atlantic salmon are endangered as the Gulf of Maine DPS (Androscoggin River, Maine north to the Dennys River, Maine) and are an unlikely to be present in the Action Area (BOEM 2018). No detectable effects to salmon are expected and this species is not discussed further in the BA. Miller and Klimovich (2017) indicate that the giant manta ray (*Manta birostris*) ranges north to New Jersey. Giant manta rays would be rare and are not be expected to occur in the WDA or OECC (Miller and Klimovich 2017), nor would not be affected by any proposed activities occurring there. However, giant manta travel long distances during seasonal migrations, and may be found in upwelling waters at the shelf break south or east of the project area. There is a small chance that the transport of foundation and WTG components from Europe could potentially traverse some upwelling areas. Since the barges transporting these components travel at slow operation speeds of 10 kt, it is likely manta rays would avoid slow-moving barges and temporarily swim away from the vessel. The likelihood of any potential impacts resulting from temporary avoidance would be discountable. Therefore, giant manta rays are not considered further in this BA.

No other species are currently proposed to be listed under the ESA occur in the Action Area. The designation as a “species of concern” does not carry protection under the ESA (ESA; NOAA 2018b). Those listed as species of concern are regarded as: “in danger of extinction, risk of being endangered but sufficient data does not exist to validate listing, or a previous candidate species where listing was not warranted but concerns or uncertainties remain" (NOAA 2018b). Candidate species are defined as those being considered by NOAA for listing as endangered or threatened (NOAA 2018c).

In summary, the occurrence and potential effects to blue whales, hawksbill sea turtles, Atlantic salmon, and giant manta ray were considered in this BA, but found to not be positively or negatively affected by the proposed action. The following sections provide an in-depth description and analysis of potential effects to listed species and critical habitat that BOEM has evaluated and found to be both present and be affected by the proposed action.

3.1. MARINE MAMMALS

Marine mammals use the coastal waters of the northwest Atlantic OCS for feeding, breeding, nursery grounds, socializing, and migration (Stone et al. 2017; Leiter et al. 2017). NARWs, fin whales, sei whales, and sperm whales may occur in the Action Area and may be affected by the proposed action (Table 3.1-1). Of particular importance is the occurrence of the critically endangered NARW known to frequent the area at certain times of year. Accordingly, several marine zones near the proposed Project area are managed using seasonal or year-round restrictions to protect NARWs and their habitats. A list of all marine mammals that may occur in the area and corresponding detailed descriptions can be found in Section 6.7 of the COP, Volume III (Epsilon 2018) and in BOEM 2014. These species rely on OCS habitats for a variety of important life functions, including feeding, breeding, nursery grounds, socializing, and migration.

Table 3.1-1: Federally Listed Marine Mammals that May Be Affected in the Action Area

Common Name	Scientific Name	ESA Status (MA status)	Relative Occurrence in Region [b]	Seasonal Occurrence in Region
Order Cetacea, Suborder Mysticeti (Baleen whales)				
Family Balaenopteridae				
North Atlantic right whale [c]	*Eubalaena glacialis*	E (E)	Common	Year-round, peak winter-spring
Fin whale [c]	*Balaenoptera physalus*	E (E)	Common	Year-round, peak spring-summer
Sei whale [c]	*Balaenoptera borealis*	E (E)	Regular	Spring-summer
Suborder Odontoceti (Toothed whales and dolphins)				
Family Physeteridae				
Sperm whale [c]	*Physeter macrocephalus*	E (E)	Common	Year-round, peak summer-fall

ESA = Endangered Species Act; ESA status E = endangered; MA = Massachusetts; WDA = Wind Development Area

[b] Based on occurrence within Rhode Island Ocean Special Area Management Plan Study Area (which includes the WDA and surrounding Project area): Common = greater than 100 records; Regular = 10–100 records; Rare = less than 10 records (Kenney and Vigness-Raposa 2010).

[c] NEFSC and SEFSC 2011a

Cetaceans rely heavily on acoustics for communication, foraging, mating, avoiding predators, and navigation (Madsen et al. 2006; Weilgart 2007). Marine mammals occurring in the Action Area may be affected by underwater sound if the sound frequencies overlap the frequency range of hearing for the animal exposed to the sound, and/or the sound pressure levels produced are high enough for a sufficient duration (NSF and USGS 2011). Noise-producing proposed-Project activities, such as pile driving, wind turbine operation noise, and vessel noise may affect marine mammals during foraging, orientation, migration, response to predators, and social interactions (Southall et al. 2007). Impacts from noise can interfere with these functions, with the potential to cause responses ranging from mild behavioral changes to physical injury. Marine mammals engaged in foraging, socializing, mating, and migrating may also be affected by non-acoustic proposed Project activities including vessel strike, accidental spills, and changes to foraging habitat.

Regional, pre-existing threats to these whale species include entanglement in fisheries gear, vessel strike, vessel noise, climate change, contaminants, and disease (NMFS 2017). Commercial fisheries occurring in the southeastern New England region include bottom trawl, midwater trawl, dredge, gillnet, longline, and pots and traps (COP Volume III, Section 7.8; Epsilon 2018). Targeted fisheries species include monkfish, scallop, surfclam/quahog, squid, mackerel, herring, and lobster, among others. Commercial vessel traffic in the region is variable depending on location and vessel type. The commercial vessel types and relative density in the proposed Project region during 2013 include cargo (low), passenger (high), tug-tow (high), and tanker (low) (COP Volume III, Section 7.8.2.1; Epsilon 2018). Meyer-Gutbrod et al. (2015) indicate that interannual to interdecadal climate processes that affect *Calanus finmarchicus* (*C. finmarchicus*) distribution subsequently affect NARW reproduction. A range of environmental processes, especially prey availability, may be limiting NARW recovery (Meyer-Gutbrod et al. 2015).

Recent studies in the Deepwater Wind Lease Area, Bay State Wind Lease Areas, Vineyard Wind Lease Area, and Lease Areas (shown in Figure 1-1) (referred to hereafter as the study area) have collected distribution, abundance, and temporal occurrence data for these endangered whale species (Kraus et al. 2016b; Leiter et al. 2017; Stone et al. 2017). The study area was defined as the wider geographic area encompassing the waters from Block Island east to approximately 7.5 miles (12 kilometers) east of Nantucket, and approximately 1.9 miles (3 kilometers) north of Martha’s Vineyard on the north to approximately 12 kilometers south of the Lease Areas (OSC-A 0520, 0521, and 0522, Figure 1-1) (Leiter et al. 2017). The objectives of these studies were to provide information on the inter-annual variability in distribution and habitat use by looking at a combination of acoustic, aerial, and photographic survey results. In addition, other regional studies have collected aerial (NEFSC and SEFSC 2010, 2011b, 2012, 2013, 2014, 2015, 2016, 2017) and acoustic (Davis et al. 2017) data that include the proposed Project area. The sections below will summarize these and other study results.

A total of 176 sightings of endangered whales totaling an estimated 350 animals were recorded within the study area over a 4-year period between October 2011 and June 2015 (Kraus et al. 2016b). The endangered whales sighted included fin whale (87 sightings, 155 animals), NARW (60 sightings, 145 animals), sei whale (25 sightings, 41 animals), and sperm whale (four sightings, nine animals) (see Table 3.1-2 below; Kraus et al. 2016b). The endangered whale species with the highest abundance estimates were fin whales in the spring (March through May; 60 whales) and summer (June through August; 92 whales) and NARWs in the winter (December through February; 54 whales) and spring (March through May; 91 whales; Kraus et al. 2016b) followed in lesser abundance by sei whales and sperm whales.

Table 3.1-2: Summary of the Total Number of Sightings and Number of Animals Sighted in the Large Pelagic Survey Study Area during the Surveys from 2011-2015

Species	Scientific Name	Fall		Winter		Spring		Summer	
		S	A	S	A	S	A	S	A
North Atlantic Right Whale	*Eubalaena glacialis*	0	0	25	54	35	91	0	0
Fin Whale	*Balaenoptera physalus*	2	2	1	1	35	60	49	92
Sei Whale	*Balaenoptera borealis*	0	0	0	0	12	22	13	19
Sperm Whale	*Physeter macrocephalus*	1	1	0	0	0	0	3	8

Source: adapted from Kraus et al. 2016b

A= number of animals observed; S = number of sightings (only definite and probable identifications included);

Whale distribution in the action area may vary both seasonally and inter-annually depending on species and activity. Sightings per unit effort (SPUE) for endangered whales were relatively high in the WDA during spring and summer, and included the highest level of SPUE (30 to 1,771 animals per 621.4 miles [1,000 kilometers] of survey track) and relatively lower during fall (10 to 30 animals per 621.4 miles [1,000 kilometers] of survey track; Kraus et al. 2016b). NARWs were an exception, and were present in the winter and spring, with highest sighting rates and estimates of abundance in the spring. No NARWs were detected within the WDA in the winter; however, NARWs may occur in relatively high numbers (70 animals per 621.4 miles [1,000 kilometers] of survey track; Kraus et al. 2016b; Stone et al. 2017) in the waters southeast of Martha's Vineyard in which the proposed OECC is located. Sightings of large whales in the winter were almost entirely NARWs (Kraus et al. 2016b).

To identify areas with increased cetacean activity within the northwest Atlantic, the Atlantic Marine Assessment Program for Protected Species study calculated a hot spot index (HSI) for groups of species including the ESA-listed whale group (including fin, sei, and sperm whales, and humpback whales) that were listed as endangered prior to 2016, but are not currently listed (Palka et al. 2017). Vessel-based and aerial sightings data were collected from August 2010 through July 2014. The report compared relative cetacean densities within WEAs along the U.S. east coast. The HSI for the large whale group indicated that among all study area had the highest number of ESA-listed whales (including humpbacks; Palka et al. 2017). The HSI also indicated that on average, the offshore portions of all wind energy study areas had the fewest ESA-listed whales (Palka et al. 2017).

Seasonal distribution maps of the listed species in the Project area and details regarding their seasonal occurrence are presented below. The distribution maps present species occurrence in the proposed Project area using a combination of habitat-based density estimates (Roberts 2016a, 2016b) and sightings data overlaid as density dots (circles representing the number of animals sighted over the time period; Right Whale Consortium 2018). The density estimates and sightings data are the products of two separate databases, but the combination of these datasets provides a comprehensive assessment of distribution based on available data. Both databases include a compilation of datasets from various sources. Many of the same data sources are included in both databases, but not all. For example, the density estimates are based on data collected from 1992 to 2014, while the sightings data were collected from 1978 to 2017. The density estimates represent the number of animals predicted to occur per 38.5 square mile (100 km^2).

The sightings data are an historical account of the number of whales that have been observed in a particular area, and they do not account for the presence (or absence) of whales in areas not surveyed. BOEM did not correct these sightings data for effort; they are represented as different color and density scales for each species, and thus should not be used to interpret the relative densities of whales.

3.1.1. North Atlantic Right Whales

The western NARW is known to inhabit continental shelf and coastal waters in the northeast U.S., ranging from wintering and calving grounds in coastal Florida and Georgia, to summer feeding and nursery grounds in New England waters and northward to the Bay of Fundy, the Scotian Shelf, the Gulf of St. Lawrence, Iceland, Greenland, northern Norway, and the Azores (Hayes et al. 2018). The location of most of the population during the winter is unknown. There are seven areas where western NARWs aggregate seasonally: the coastal waters of the southeastern U.S.; 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 (Brown et al. 2001; Cole et al. 2013).

Movements within and between habitats are extensive and a Biologically Important Area (BIA) for migration has been identified during March through April and November through December (LaBrecque et al. 2015). The BIA, which includes the proposed Project area, encompasses the waters offshore of Provincetown to the continental shelf, extending southward along the shelf ending in waters offshore of northeastern Florida (LaBrecque et al. 2015). Although NARW calving occurs primarily in the waters off Georgia and Florida, there is at least one case of a calf being born in the Gulf of Maine (Patrician et al. 2009) and a newborn calf was observed in Cape Cod Bay in 2013 (Center for Coastal Studies, Provincetown, MA, USA, unpub. data as cited in Hayes et al. 2018). Generally, NARWs may be transiting, feeding, socializing, or nursing calves in the Action area.

NARWs feed on extremely dense patches of certain copepod species, primarily the late juvenile developmental stage of *C. finmarchicus*. These dense patches can be found throughout the water column depending on time of day and season. They are known to undergo daily vertical migration where they are found within the surface waters at night and at depth during daytime to avoid visual predators. NARWs' diving behavior is strongly correlated to the vertical distribution of *C. finmarchicus*. Baumgartner et al. (2017) investigated NARW foraging ecology by tagging 55 whales in six regions of the Gulf of Maine and southwestern Scotian Shelf Right in late winter to late fall from 2000 to 2010. Results indicated that on average NARWs spent 72 percent of their time in the upper 33 feet (10 meters) of water and 15 of 55 whales (27 percent) dove to within 16.5 feet (5 meters) of the seafloor, spending as much as 45 percent of the total tagged time at this depth. While NARWs are always at risk of ship strike due to the time spent at the surface to breathe. NARWs in springtime habitats (including the WDA) are particularly vulnerable to ship strike because they spend the vast majority of their time in the top 33 feet (10 meters) of the water column (Baumgartner et al. 2017).

In 2016, the Northeastern U.S. Foraging Area Critical Habitat for NARWs was expanded to include all U.S. waters of the Gulf of Maine. Recent surveys (2012 to 2015) have detected fewer individuals in the Great South Channel and the Bay of Fundy, and additional sighting records indicate that other habitats may exist, suggesting that existing habitat use patterns may be changing (Weinrich et al. 2000; Cole et al. 2007, 2013; Whitt et al. 2013; Khan et al. 2014). Baumgartner et al. (2017) discuss that ongoing and future environmental and ecosystem changes may displace *C. finmarchicus* from the Gulf of Maine and Scotian Shelf. The authors also suggest that NARWs are dependent on the high lipid content of calanoid copepods from the Calanidae family (i.e., *C. finmarchicus, C. glacialis, C. hyperboreus*), and would not likely survive year-round only on the ingestion of small, less nutritious copepods in the area (i.e., *Pseudocalanus* spp., *Centropages* spp., *Acartia* spp., *Metridia* spp.). It is also possible that even if *C. finmarchicus* remained in the Gulf of Maine, changes to the water column structure from climate change may disrupt the mechanism that causes the very dense vertically compressed patches that NARWs depend on (Baumgartner et al. 2017).

The diversity of zooplankton across the Northeast U.S. Continental Shelf is relatively high (> 100 species); seasonal and interannual trends in abundance differ among species (NEFSC 2018; Johnson et al. 2014; DFO 2017). Biovolume, or the total volume of material caught in zooplankton nets, can be used as a rough measure of total zooplankton abundance. Seasonal trends in overall zooplankton abundance have been detected over the shelf waters of southern New England, ranging from relatively low densities (0.73 to 1.4 cubic inches per 2.4 cubic mile [12 to 23 cubic centimeters per 100 cubic meters]) in January through February to relatively high densities (greater than 3.36 cubic inches per 2.4 cubic mile [55 cubic centimeters per 100 cubic meters]) during May through August (NEFSC 2018). These trends are also present for *C. finmarchicus*, which is also an important food source for many fish species, as well as for NARWs. On average, *C. finmarchicus* has been the most abundant during the spring and summer (March through August), with a peak density in May through June along the Northeast U.S. Shelf (NEFSC 2018). Levels of zooplankton biovolume have been remarkably consistent over the past 20 years with some inter-annual variability. Mean total density for *C. finmarchicus* along the Northeast U.S. Shelf varied greatly from year to year, commonly halving or doubling from one year to the next (NEFSC 2018). Results from Runge et al. (2015) and Ji et al. (2017) specify that predicting fluctuations in abundance or circumstances for disappearance of *C. finmarchicus* in the northwest Atlantic will require models that address the roles of local production and advection.

3.1.1.1. Current Status of NARW Population

NARWs in U.S. waters belong to the Western Atlantic stock. The best estimate of the living population is 450 whales (Pettis et al. 2017; Hayes et al. 2018). Over the last several years, NARW distribution and patterns of habitat use have shifted, in some cases dramatically (Pettis et al. 2017). Elevated NARW mortalities have occurred since June 7, 2017. A total of 19 confirmed dead whales, with an additional five live whale entanglements in Canada, have been documented to date (NOAA 2018a). Twelve of the 19 dead whales were located in the Gulf of St. Lawrence and 7 were in the United States (NOAA 2018a). Of the seven mortalities in the U.S., three were located south of Cape Cod: one in Buzzards Bay and the other two between Martha’s Vineyard and Nantucket. Human interactions (i.e., fishery-related entanglements and vessel strikes) have been identified as the most likely cause of this Unusual Mortality Event (UME). In addition to this recent UME, the reproductive output for the species has declined by 40 percent since 2010 (Kraus et al. 2016a). In 2018, no new NARW calves were documented, but at least seven new calves have been documented so far during the 2019 calving season. A reduction in adult female survival rates relative to male survival rates has caused a divergence between male and female abundance. In 1990, there were an estimated 1.15 males per female, and by 2015, estimates indicated 1.46 males per female (Pace et al. 2017). This combination of factors threatens the very survival of this species

(Pettis et al. 2017). If reduced *C. finmarchicus* abundance results in a decrease in reproduction similar to that observed in the late 1990s, which authors hypothesize has occurred during the past five years, then extinction could take place in just 27 years (Meyer-Gutbrod et al. 2018).

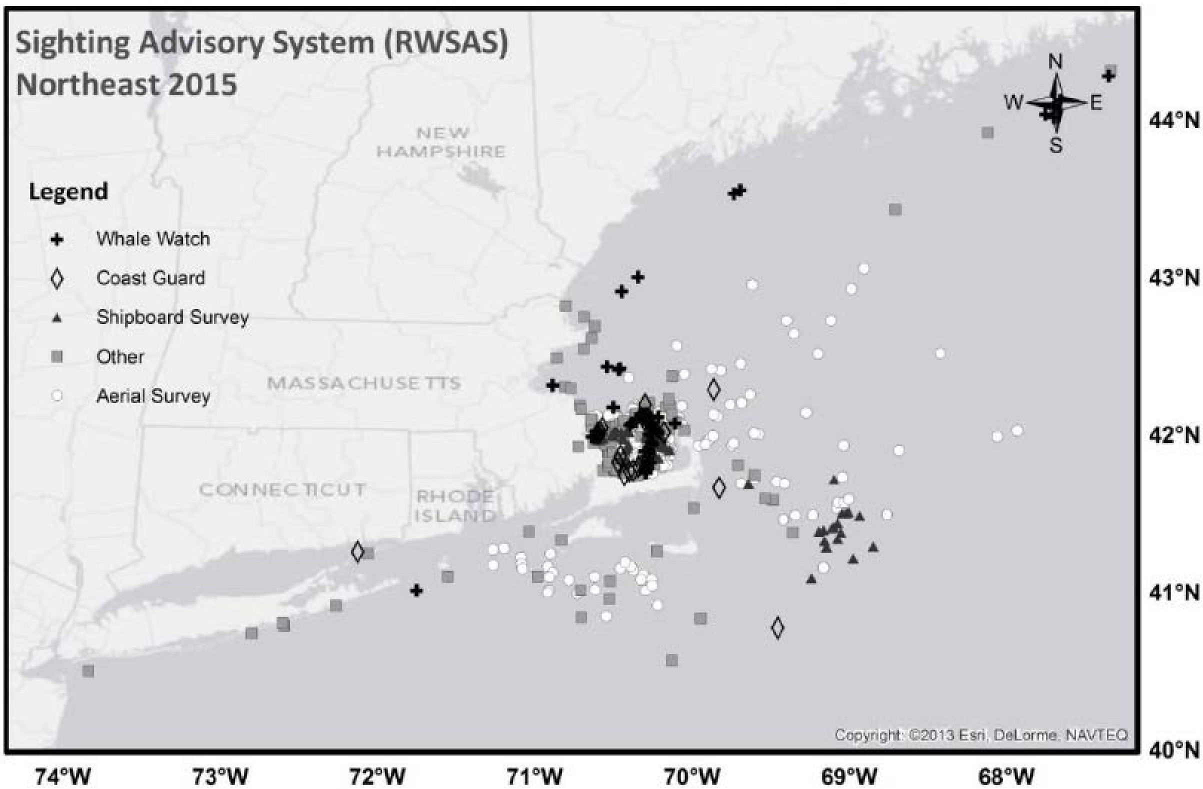
Records in Massachusetts waters from 2011 through 2015 indicate an annual average human-caused mortality and serious injury of 4.55 NARWs by fisheries entanglement and an average of 0.81 whales per year affected by vessel strike (Hayes et al. 2018). Kraus et al. (2016b), suggests that threats to the population are still pervasive, and may be getting worse. Indicators of this trend include: declining overall body condition (Rolland et al. 2016); very high and apparently increasing rates of entanglement in fishing gear (Knowlton et al. 2012, Knowlton et al. 2016) suggesting previous management interventions have not measurably reduced entanglement or entanglement-related mortality (Pace et al. 2015). Research has revealed the substantial energy drain on individual whales from drag related to ongoing entanglements, which likely results in reduced health and fitness (van der Hoop et al. 2015, 2017). Other studies indicate noise from shipping increases stress hormone levels (Rolland et al., 2012), and modeling suggests that their communication space can be reduced substantially by vessel noise in busy traffic lanes (Hatch et al. 2012). In addition to anthropogenic threats, NARWs also face environmental stressors including algal toxins, oceanographic changes from climate change, and reduced prey availability (Rolland et al. 2007; Doucette et al. 2012; and Fortune et al. 2013).

3.1.1.2. Presence and Abundance in the Action Area

Vessel-Based and Aerial Surveys

NARWs are more difficult to observe when migrating, compared to when the whales are skim-feeding or socializing at the surface (Hain et al. 1999; Clark et al. 2010). Hain et al. (1999) concluded that diving behavior and time submerged were the principal factors affecting observability in the calving ground. As expected, a higher percentage of whales are likely to be observed when whales remain in the survey area for extended periods, in good weather, and when multiple flights are flown. Because of these factors, the characterization of the occurrence of NARWs in the proposed Project area from visual survey data alone may be considered conservatively in some areas, and the use of upper confidence estimates may be warranted.

The most recent report of the Right Whale Sighting Advisory System within the Northeast region indicates the presence of NARWs in the Action Area (Gatzke et al. 2017). NARWs were observed engaging in mating/courtship behavior and foraging, and cows with calves were sighted in recent surveys in the study area (Leiter et al. 2017; Stone et al. 2017). The effort-weighted average sighting rate for NARWs in the study area from October 2011 through June 2015 was highest in winter (4.31 animals per 621.4 miles [1,000 kilometers]) and second highest in spring (3.58 animals per 621.4 miles [1,000 kilometers]; Table 3.1-2; Kraus et al. 2016b). Abundance estimates were highest during spring (91 whales) and winter (54 whales; Table 3.1-2; Kraus et al. 2016b), except in the winter of 2013. NARWs were consistently detected visually during winter and spring in the WDA and OECC over the same time period (Kraus et al. 2016b; Stone et al. 2017). Winter distribution primarily occurred in the waters north of the WDA delineation, but within the OECC area (Figure 3.1-1). Aerial survey results indicate that NARWs begin to arrive in the WDA in December and remain in the area through April. However, acoustic detections occurred during all months, with peak number of detections between December and late May (Kraus et al. 2016b; Leiter et al. 2017). Seasonal variation among years ranged from 0 in the winter of 2012 to a high of 35 in the winter of 2013 (Leiter et al. 2017). The 95 percent confidence limits for these estimates were typically wide, with the upper confidence limit ranging up to 296. The abundance estimates are not corrected for whales below the surface that were not sighted during aerial surveys (Leiter et al. 2017).

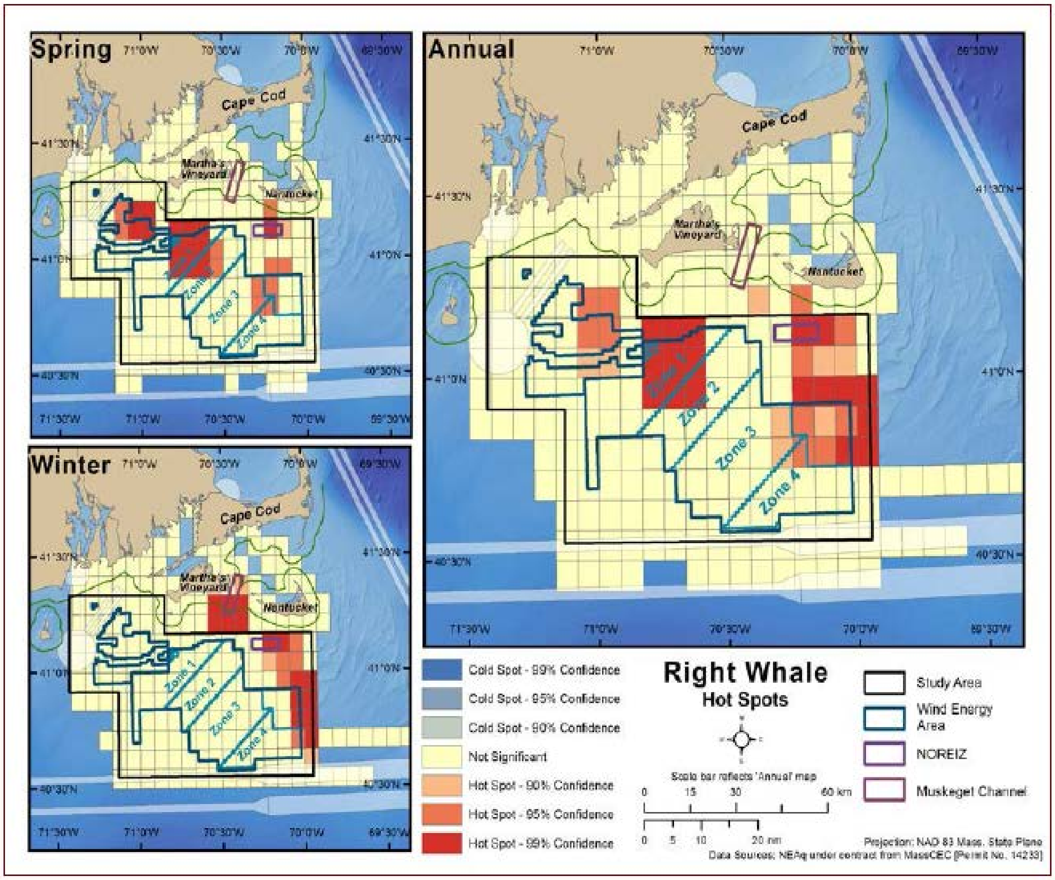


Source: Gatzke et al. 2017

Notes: Shown by reporting source. The category "other" includes reports made by the general public, commercial ships, and fishing vessels. Unconfirmed reports were excluded.

Figure 3.1-1: Locations of all Right Whales reported to the Right Whale Sighting Advisory System within the Northeast Region (New York to Maine), 2015

To identify areas with statistically higher animal clustering than surrounding regions, a hot spot analysis was performed for the study area (Kraus et al. 2016b). Hot spot analysis provides a relative measure of presence in the survey area per unit effort, not actual numbers of whales in an area. The hot spot analysis is included here to illustrate which areas within the study area NARWs are most likely to occur during those survey periods. Hot spots (upper 99 % confidence level) were identified in the winter just offshore of the Muskeget Channel, overlapping the proposed OECC area (Kraus et al. 2016b; Figure 3.1-2). Hot spots were also identified in the spring in the southwest portion of the WDA (upper 95% confidence level). When viewed annually, hot spots persisted in the southwest portion of the WDA and the area immediately to the west of the WDA (upper 99 % confidence level). Although survey results indicate distribution patterns among years, and some aggregations appear to be ephemeral, the hot spot analysis suggests that there is some regularity in NARW use of this region when averaged over several years of consistent effort (Kraus et al. 2016b; Figure 3.1-2). Behavioral data indicate that during April and May whales are most often engaged in feeding, and animals observed before that time were sometimes engaged in social behavior.



Source: Kraus et al. 2016b

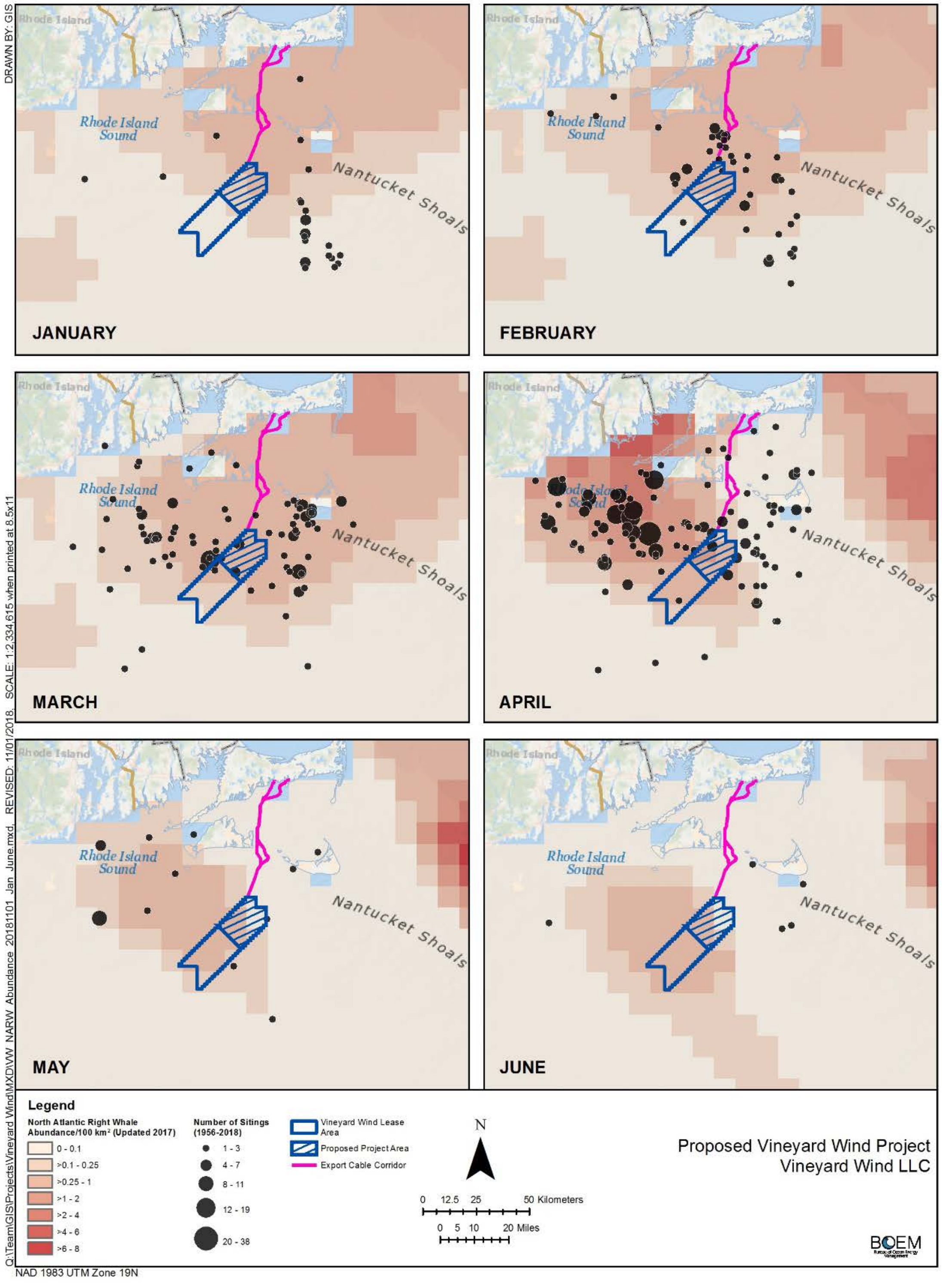
Figure 3.1-2: Hot Spot Analysis of North Atlantic Right Whale SPUE Data Showing Spring, Winter, and Annual Patterns (2012 to 2015)

Behavioral data associated with sightings within the study area and surrounding waters from January 2010 through June 2015 included surface active groups (SAG, defined as two or more whales rolling and touching at the surface) and feeding (Leiter et al. 2017). SAGs can be indicative of courtship (Kraus and Hatch 2001; Parks et al. 2007), and feeding. Thirteen instances of SAG behavior were recorded. SAGs occurred during all years during the study period, except 2011, primarily during March, and involved a total of 61 whales. The average SAG group size was 4.7 whales, with a range of 2 to 14 whales. Although mating does not necessarily occur in SAGs, authors suggest that the regular observations of SAGs may indicate that animals are mating in this habitat (Kraus and Hatch 2001, Parks et al. 2007).

Feeding behavior was recorded for 39 of 117 (33 percent) sightings, in all years of the study period (2010 to 2015), and occurred exclusively during the months of March and April. NARWs were observed skim feeding in the northern portion of the study area. However, the authors suggested that whales may also be feeding sub-surface; without visual detection this could not be confirmed (Leiter et al. 2017).

From January 2010 through June 2015, 271 records of 196 individuals were photo-identified in the study area (Leiter et al. 2017). Thirty-two of the 196 individuals (16 percent) were only documented in the study area and not in any other known habitat during this period (Leiter et al. 2017). This total number of individuals (196) represents 43 percent of the most recent population estimate of 451 individuals (Pettis 2017). Counts of individuals through photo-identification only include those whales that are sighted (on the surface) and photographed. It is thus likely that some animals were missed and that the numbers represent a minimum. Of these individuals, 35 percent (number = 68) were females, 58 percent (number = 114) were males, and the remaining 7 percent were of unknown sex. Thirty-four of the females were known calving females (30 percent of the total currently presumed alive). Of these known calving females that visited the study area, 11 (32 percent) visited in more than 1 year. For eight of these known calving females, these sightings in the study area were the only documented record since the start of 2010 (Leiter et al. 2017). In addition, six cow/calf pairs were sighted in the study area, with the majority of sightings during the month of April. Documentation of these females is important to population monitoring, since the loss of one known calving female can negatively impact the recovery of the population (Fujiwara and Caswell 2001). In addition, pregnant females and cow/calf pairs spend more time at the surface in the summer than other demographic groups, likely increasing the risk for ship strike (Baumgartner and Mate 2003). Of the 188 whales that were assigned an age class, 64 percent were adults and 32 percent were juveniles, and six calves (mentioned above) were identified in the study area (Leiter et al. 2017).

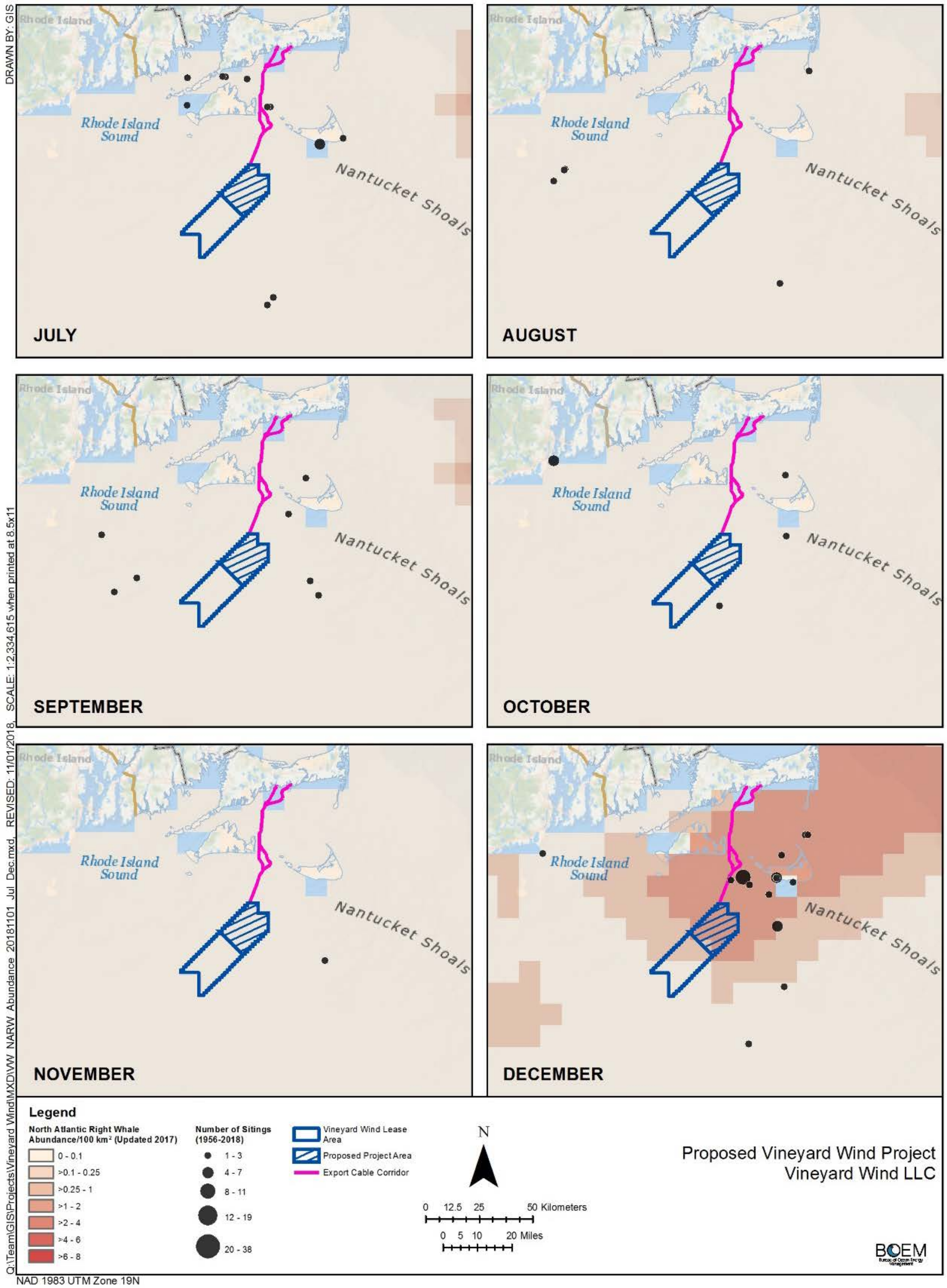
The most recent abundance data (1992 through 2017) indicate that NARWs are expected to occur in the proposed Project area in relatively moderate to high densities from December through May and in low densities in June. Although NARWs have been detected acoustically in all seasons, these are brief, transitory events by individuals, and the species is not expected to occur for any significant periods or regularity in the Project area between July and November (Figures 3.1-4 and 3.1-5; Roberts et al. 2016a). These data were used in the acoustic model (Pyć et al. 2018) and appear to correlate well with the sightings data (from 1956 through 2018; North Atlantic Right Whale Consortium 2018) with a few exceptions. NARWs may occur in the area just to the east of the WDA in April in higher numbers than the density data indicate, and may also occur along the cable route in July (Figures 3.1-4 and 3.1-5).



Roberts et al. 2016b; North Atlantic Right Whale Consortium 2018

Note: Number of whales per 24,710.5 acres (100 km^2)

Figure 3.1-3: North Atlantic Right Whale Abundance Estimates from January through June with Sightings Data from 1956–2018 Overlaid in the Vineyard Wind Project Area



Roberts et al. 2016b; North Atlantic Right Whale Consortium 2018

Note: Number of whales per 24,710.5 acres (100 km^2)

Figure 3.1-4: North Atlantic Right Whale Abundance Estimates from July through December with Sightings Data from 1956–2018 Overlaid in the Vineyard Wind Project Area

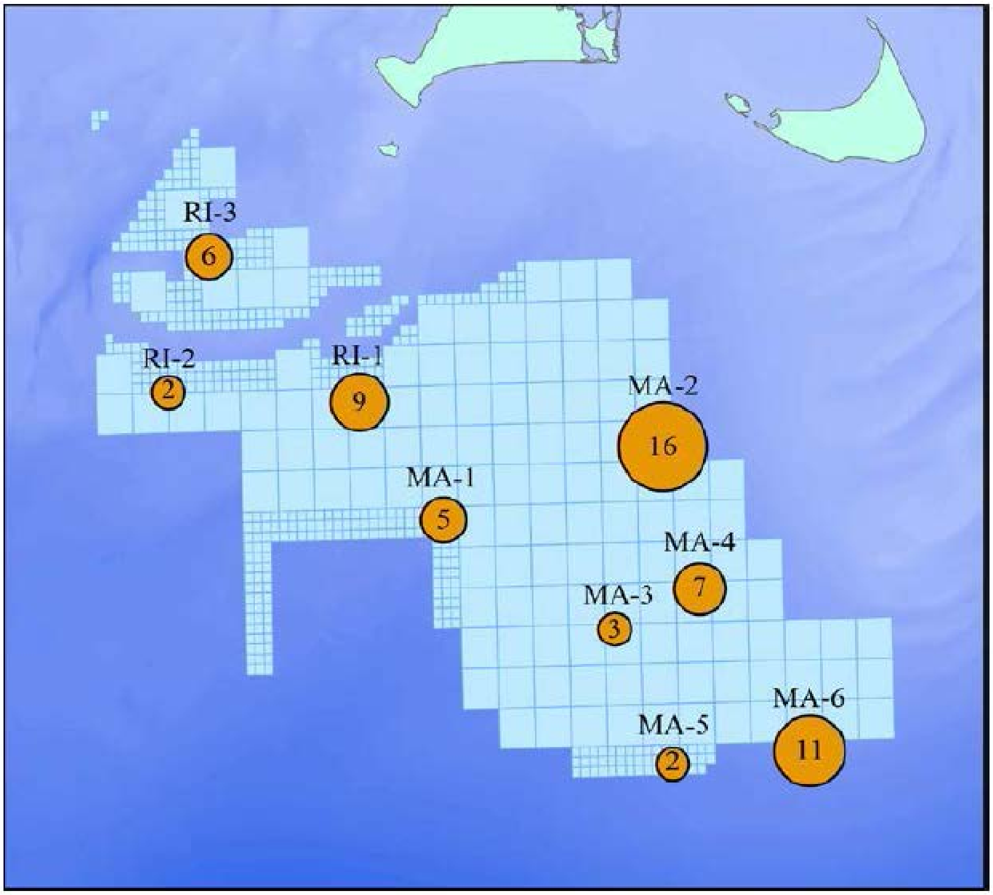
Acoustic Detection

NARW occurrence in the WDA is likely underestimated using only aerial survey results. A more accurate picture of whale presence is gained by a combination of aerial and acoustic surveys. Comparisons between detections from passive acoustic recorders and observations from aerial surveys in Cape Cod Bay between 2001 and 2005 demonstrated that aerial surveys found whales on approximately two-thirds of the days during which acoustic monitoring detected whales (Clark et al. 2010). These data suggest that the current understanding of the distribution and movements of NARWs in the Gulf of Maine and surrounding waters is incomplete (Hayes et al. 2018).

Over the study period, from November 2011 through March 2015, NARW up-calls were detected on approximately 47 percent (478 of 1,020 days) of recordings in the study area and approximately 43 percent (number = 443) of the days recorded in the Vineyard WLA (Kraus et al. 2016b). Up-calls are one of several types of sounds NARWs make and are useful for acoustic detection because they are distinctive and are used often. NARWs were acoustically detected in 30 out of the 36 recorded months, with no calls detected in November 2011, June through August 2012, August 2013, and July 2014. Acoustic detections are not able to be used to count the number of animals, and these detections could be from single, transitory animals moving through the area.

During 17 of the 30 months with detections, NARW calls were detected on at least 50 percent of the days per month. Months with the greatest monthly acoustic presence (> 90 percent) occurred in the late winter/early spring (March 2012, February through March 2013, April 2014, and February through March 2015). An increase in monthly acoustic presence was detected during November and December of 2014 (84 percent and 90 percent) compared to the same months in previous years suggesting some annual variation in habitat use may be occurring. This increase was also detected in the adjusted mean daily call rates during the last 3 months of the study (January through March 2015) when the number of NARW up-calls per month was substantially higher (54 percent of all up-calls detected throughout the study period) compared to the previous months and years.

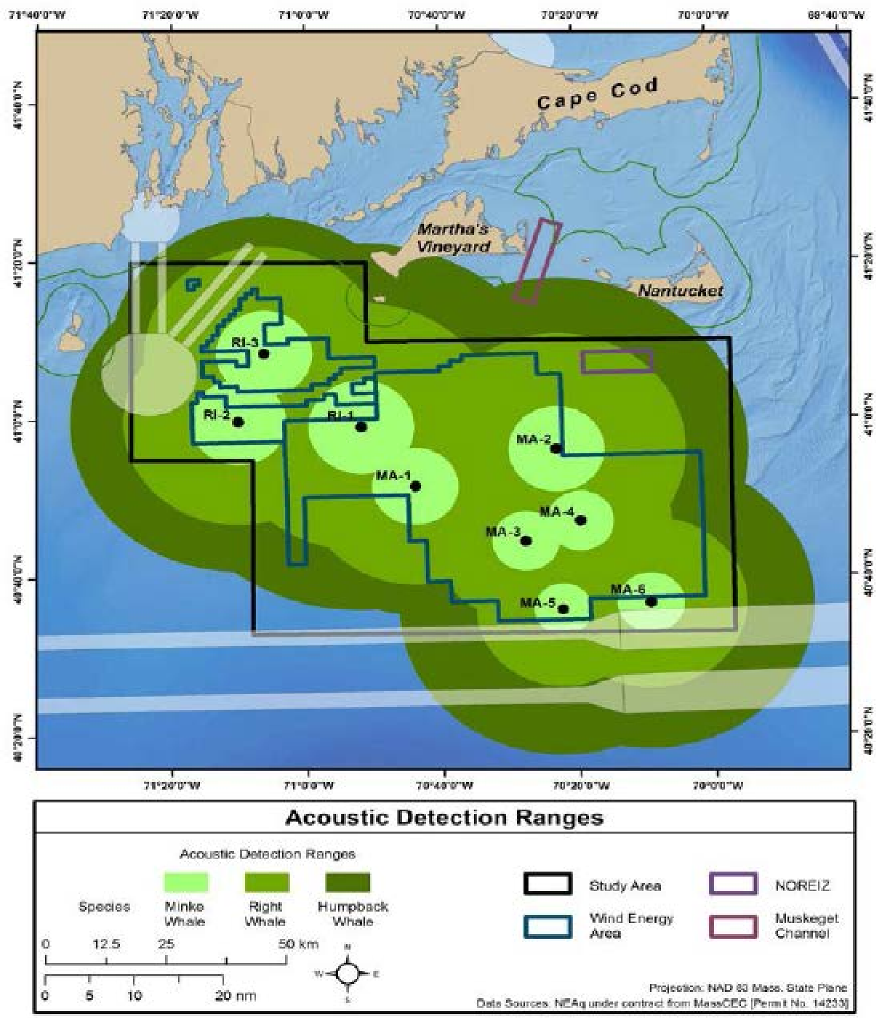
Overall, among all sampling sites within the OCS-A 0500, 501, 520, 0521, and 0522 (which includes the Project area), most of the up-calls were detected within the WDA (site MA-2; Figure 3.1-5; Kraus et al. 2016b). Among all areas, winter had the most acoustic activity, comprising 54 percent of all up-calls, and the lowest activity was recorded during summer, with only 4 percent of all up-calls. During the spring, autumn, and winter seasons most calls were detected at the MA-2 site which includes the WDA (number = 5,269, number = 813, and number = 7,289, respectively; Figure 3.1-5; Kraus et al. 2016b). The detection range for NARW vocalizations at site MA-2 overlaps fully with the WDA, but also includes waters to the northwest of the immediate Project area (Figure 3.1-5).



Source: Kraus et al. 2016b

Notes: Normalized up-calls are the sum of NARW up-calls divided by the number of acoustic recording days. The size of each circle indicates relative acoustic presence at each site summed across all seasons and years. The value within each circle represents the Normalized Site Presence.

Figure 3.1-5: Normalized Right Whale Up-Calls at Each Passive Acoustic Recording Array Site



Source: Kraus et al. 2016b

Notes: Detection ranges for recording units are shown in medium green for NARWs. The MA-2 unit encompasses all of the WDA. Recorder locations are shown as black dots with labels.

Figure 3.1-6: Map of Massachusetts and Rhode Island/Massachusetts Passive Acoustic Recording Arrays

Davis et al. (2017) presents results from a long-term passive acoustic survey of the western North Atlantic from the western Scotian Shelf to the waters off Jacksonville, Florida, from 2004 through 2014. Results indicated that NARWs were acoustically present along the entire eastern seaboard of North America for most of the year. Data also indicate that NARW distribution appears to have started to shift in 2010 from previously prevalent northern grounds, such as the Bay of Fundy and greater Gulf of Maine, to more time spent in mid-Atlantic regions year-round, including the waters south of Cape Cod (Region 7 in the study). Past visual surveys led to the assumption that a majority of NARWs migrated between winter calving grounds in the south and summer feeding grounds in the north. The location of the remaining members of the population was not known.

Davis et al. (2017) indicate that NARWs are present nearly year-round across their entire habitat range, particularly north of Cape Hatteras, suggesting that not all of the population undergoes the annual north-south migration. The authors suggest that non-migrating whales could be mobile individuals occupying a broader, more diffuse geographic area through the year, but these potential cohort-specific behaviors require additional study. Between years, a comparison of average weekly detections from 2004 to 2010 and 2011 to 2014, show a significantly higher presence (presence < 0.001) was detected during the 2011 to 2014 time period compared to the 2004 to 2010 in the southeastern New England area (Region 7 of the study, which includes the WDA). The greatest increases were observed from January to July, with little change indicated from July through October, with no to low presence detected (Davis et al. 2017).

NARW up-call acoustic presence was detected in Region 7 one to seven days per week in every month except mid-July and August and in Region 6 of the study (the area encompassing the OECC) during one to seven days per week from March through early July, with a peak during March and April (Davis et al. 2017). Comparison between time periods was not possible for Region 6 because data were not available from 2004 through 2010. Seasonal occurrence maps indicate relatively high occurrence (60 to 90 days) of NARWs in the area just south of Martha's Vineyard and Nantucket during all seasons (e.g., winter, spring, and summer) with the exception of fall (August through October) when NARWs were detected for fewer days (1 to 3 days) and farther offshore (Davis et al. 2017).

Another example of a shift of NARW distribution is found in Meyer-Gutbrod et al. (2018). Authors indicate that starting in 2012, NARW sightings in several traditional feeding habitats began to decline, causing speculation that a shift in NARW habitat usage was occurring (Pettis et al., 2017). Further studies in 2015 revealed an aggregation of NARWs in the southern Gulf of St. Lawrence, well north of the known and protected critical feeding habitats (Meyer-Gutbrod et al. 2015).

3.1.1.3. Summary of Presence in the Proposed Project Area

Visual survey results indicate NARWs are likely to occur in the Action Area during winter and spring, with the highest densities during February, March, and April. However, acoustic survey results, suggest that some individuals may occur at any time of year in the Action Area, but animals primarily occur there during winter and spring. Kraus et al. (2016b) suggest that the areas of lowest NARW use appear to be in the southern portion of the MA WEA lease blocks, which may indicate that development in these areas would have less impact on the species.

3.1.1.4. Critical Habitat

No critical habitat for NARWs has been designated in the Action Area.

3.1.1.5. Hearing Range

NARWs belong to the low-frequency mysticete hearing group of marine mammals, with the ability to hear sounds ranging from 10 hertz (Hz) to 22 kilohertz (kHz) (Parks et al. 2007).

3.1.2. Fin Whales

Fin whales are very common over the continental shelf waters from Cape Hatteras, North Carolina, northwards (Hayes et al. 2018) and are present in every season throughout the U.S. Exclusive Economic Zone (EEZ) north of Cape Hatteras (Edwards et al. 2015). They are typically found along the 328-foot (100-meter) isobath but also in shallower and deeper water, including submarine canyons along the shelf break (Kenney and Winn 1986). Fin whales are migratory, moving seasonally into and out of feeding areas, but the overall migration pattern is complex and specific routes are not known (NMFS 2018a). The species occur year-round in a wide range of latitudes and longitudes, but the density of individuals in any one area changes seasonally. Thus, their movements overall are patterned and consistent, but distribution of individuals in a given year may vary according to their energetic and reproductive condition, and climatic factors (NMFS 2010).

Fin whales are fast swimmers, and are often found in social or feeding groups of two to seven (NMFS 2018a). These whales feed during summer and are known to have site fidelity to feeding grounds in New England during this period (Seipt et al. 1990). Fin whales in the North Atlantic feed on krill (*Meganyctiphanes norvegica* and *Thysanoessa inermis*) and schooling fish such as capelin (*Mallotus villosus*), herring (*Clupea harengus*), and sand lance (*Ammodytes* spp.) (Borobia et al. 1995) by skimming the water or lunge feeding. Several studies suggest that distribution and movements of fin whales along the east coast of the U.S. is influenced by the availability of sand lance (Kenney and Winn 1986; Payne et al. 1990). Fin whales fast in the winter while they migrate to warmer waters.

A BIA for feeding has been delineated for the area east of Montauk Point, New York to the west boundary of the MA WEA between the 49-foot (15-meter) and 164-foot (50-meter) depth contour from March to October (Labrecque et al. 2015).

3.1.2.1. Current Status of Fin Whale Population

Fin whales in U.S. waters belong to the Western North Atlantic stock. The best abundance estimate available for this stock is 1,618 individuals (Hayes et al. 2018); however, it is likely that this estimate underestimates this stock’s abundance because much of the stock’s range was not included in the surveys upon which the estimate is based. For 2011 through 2015, the minimum annual rate of human-caused (i.e., vessel strike and entanglement in fishery gear) mortality and serious injury was 2.65 per year (Hayes et al. 2018). There are insufficient data to determine the population trend for fin whales.

3.1.2.2. Presence and Abundance in the Action Area

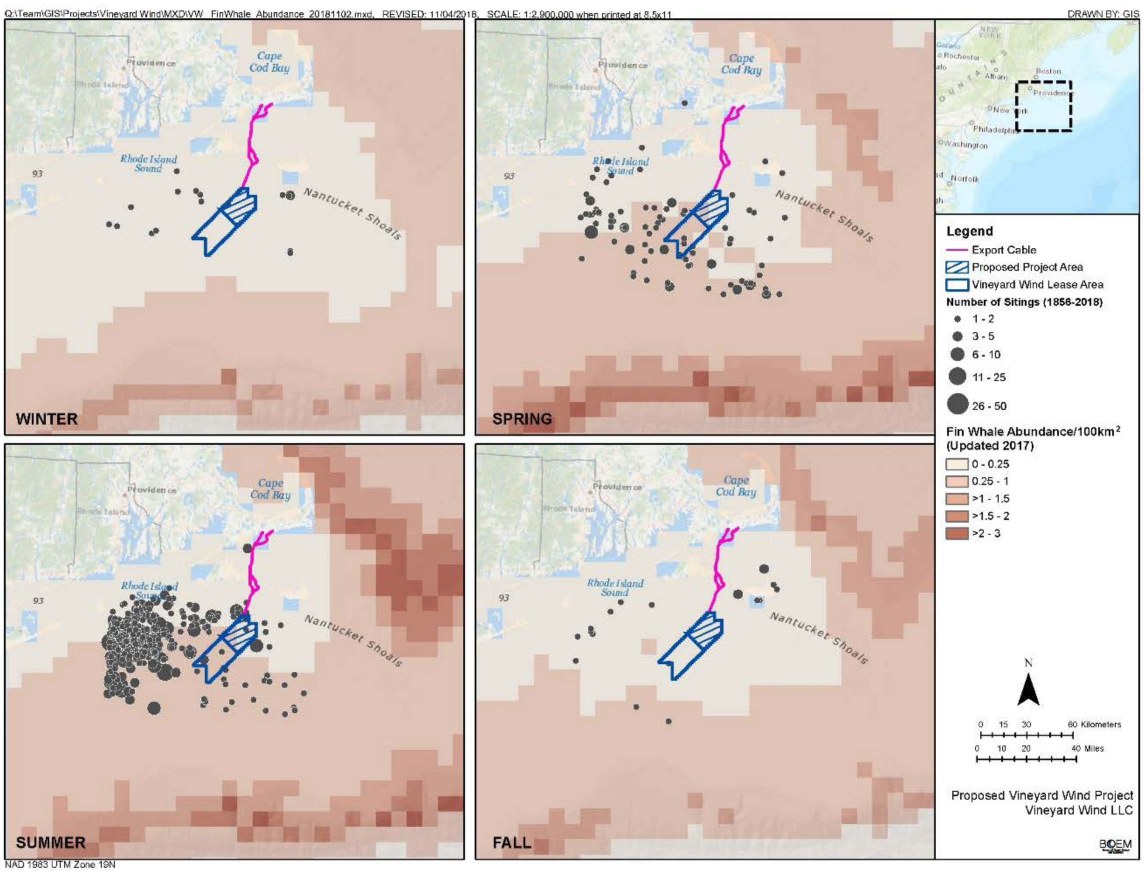
Visual Detection

Visual surveys of the study area from October 2011 through June 2015, resulted in fin whales encountered more than any other large whale species, with 87 sightings of fin whales; a total of 154 animals were observed over the study period (Stone et al. 2017). Summer 2015 had the highest density of fin whales (0.0076 individuals per 0.38 mile [1 km^2]), which yielded the highest abundance (59) of any large whale for any season (Stone et al. 2017). The effort-weighted average sighting rate for fin whales in the study area during the study period was highest in summer (4.75 animals per 621.4 survey miles [1,000 kilometers]) and second highest in spring (2.70 animals per 621.4 survey miles [1,000 kilometers]; Table 3.1-2; Kraus et al. 2016b). Fin whales were visually observed in the study area every year from October 2011 through June 2015, and sightings occurred in every season, with peaks between April and August (Stone et al. 2017; Kraus et al. 2016b). Three cow/calf pairs were observed in the study area (Kraus et al. 2016b).

Over the same time period, fin whales were visually detected in the northern portion of the WDA during the summer in relatively high numbers, with SPUE ranging from 1 to 30 animals per 621.4 miles

[1,000 kilometers] and in the spring in relatively low numbers (Kraus et al. 2016b). Fin whales were not observed in the WDA or proposed Project area during fall or winter. Summer sightings in the WDA and surrounding waters (i.e., the Action Area) suggest that fin whales may use this area each summer for feeding (Kraus et al. 2016b).

Although not corrected for effort, sightings data from 1976 through 2018 indicate similar seasonal occurrence in the proposed Project area, with relatively high numbers in the summer and relatively low numbers in the spring (North Atlantic Right Whale Consortium 2018; Figure 3.1-7). Roberts et al. (2016b) density estimates indicate very low densities of fin whales (0.25 to 1 whale per 24,710.5 acres [100 km^2]) during spring and summer (Figure 3.1-7). These data appear to underestimate the occurrence of fin whales to the west of the WDA in the summer. These data were used to estimate the number of fin whales that may be impacted by pile driving noise in Pyć et al. (2018).



Roberts et al. 2016b; North Atlantic Right Whale Consortium 2018

Note: Number of whales per 24,710.5 acres (100 km^2). Fourteen sightings of mostly single whales were prior to 1975; all others were from 1976–2018 in the proposed Project area.

Figure 3.1-7: Fin Whale Abundance Estimates with Sightings Data Overlaid

Acoustic Detection

Fin whales were acoustically detected year-round in OCS-A 0500, 501, 520, 0521, and 0522 in all sampled months from November 2011 through March 2015 (Kraus et al. 2016b). Since the detection rate for this species is greater than 124 miles (200 kilometers), detections do not confirm that fin whales were vocalizing within the study area. However, in many cases, the arrival patterns of fin whale pulses received by the acoustic sensors indicated that fin whales were vocalizing from within the study area (Kraus et al. 2016b). Presence in a majority of those months exceeded 80 percent monthly presence. Fin whales were present on 87 percent (889 out of 1,020 days) of the days analyzed in the proposed Project area. The acoustic data revealed no strong seasonality to fin whale occurrence in the study area, with year-round presence.

Although visual survey results indicate fin whales may only occur in the Action Area during spring and summer, the combination of visual and acoustic survey results suggest a year-round presence.

3.1.2.3. Critical Habitat

No critical habitat has been designated for fin whales in the Action Area.

3.1.2.4. Hearing Range

Fin whales belong to the low-frequency mysticete hearing group of marine mammals, with the best hearing sensitivity ranging from 20 Hz to 150 kHz (Erbe 2002).

3.1.3. Sei Whales

The Nova Scotia stock of sei whales is distributed across the continental shelf waters from the northeast U.S. coast northward to south of Newfoundland (Hayes et al. 2017). This species is highly mobile, and there is no indication that any population remains in a particular area year-round (NMFS 2011). Sei whale occurrence in a particular feeding ground is considered unpredictable or irregular (Schilling et al. 1992), but may be correlated to incursions of relatively warm waters of the Irminger Current off West Greenland (Hayes et al.). Olsen et al. (2009) also indicated that sei whales' movements appear to be associated with oceanic fronts, sea surface temperatures, and specific bathymetric features. NMFS (2011) indicated that climate change may negatively impact sei whale habitat availability and food availability, as migration, feeding, and breeding locations may be affected by ocean currents and water temperature.

This species is typically sighted on the U.S. Atlantic mid-shelf and the shelf edge and slope (Olsen et al. 2009). Sei whales are usually observed alone or in small groups of two to five animals. Groups of up to 10 sei whales in the inshore waters of the southern Gulf of Maine were reported on 30 of 67 days during the summer of 1986. Previously sei whales were believed to only occasionally occur in the inshore waters of the Gulf of Maine (Schilling et al. 1992); However, Baumgartner et al. (2011) report sei whale observations during springtime in the Great South Channel from 2004 to 2010, suggesting that these whales are relatively common in the area.

Sei whales dive 5 to 20 minutes and feed on plankton (primarily on calanoid copepods), with a secondary preference for euphausiids (Christensen et al. 1992), krill, small schooling fish, and cephalopods (including squid) by both gulping and skimming. They prefer to feed at dawn and may exhibit unpredictable behavior while foraging and feeding on prey (NMFS 2018b).

3.1.3.1. Current Status of Sei Whale Population

Sei whales occurring in the U.S. Atlantic EEZ belong to the Nova Scotia stock. The best abundance estimate for this stock is 357 individuals (Hayes et al. 2017). 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). Threats to sei whales include vessel strike and entanglement in fisheries gear. No population trend is available for this stock.

3.1.3.2. Presence and Abundance in the Action Area

Sei whales were observed in the study area from October 2011 through June 2015 every year with enough sightings to estimate abundance (Stone et al. 2017). Sei whales were observed in the study area from March through June, with peaks in May and June, with mean abundances ranging from 0 to 26 animals (Stone et al. 2017). The effort-weighted average sighting rate in the study area during the study period was highest in summer (0.78 animals per 621.4 miles [1,000 kilometers]) and second highest in spring (0.10 animals per 621.4 miles [1,000 kilometers]; Table 3.1-2; Kraus et al. 2016b).

Over the same time period, sei whales were observed in the northern portion of the WDA during summer, with estimated SPUE ranging from 5 to 10 animals per 621.4 miles [1,000 kilometers] (Kraus et al. 2016b). Cow/calf pairs were observed in the study area on three occasions throughout the study period. Due to the uncertainty associated with sei whale vocalization, this species was not included in the acoustic surveys.

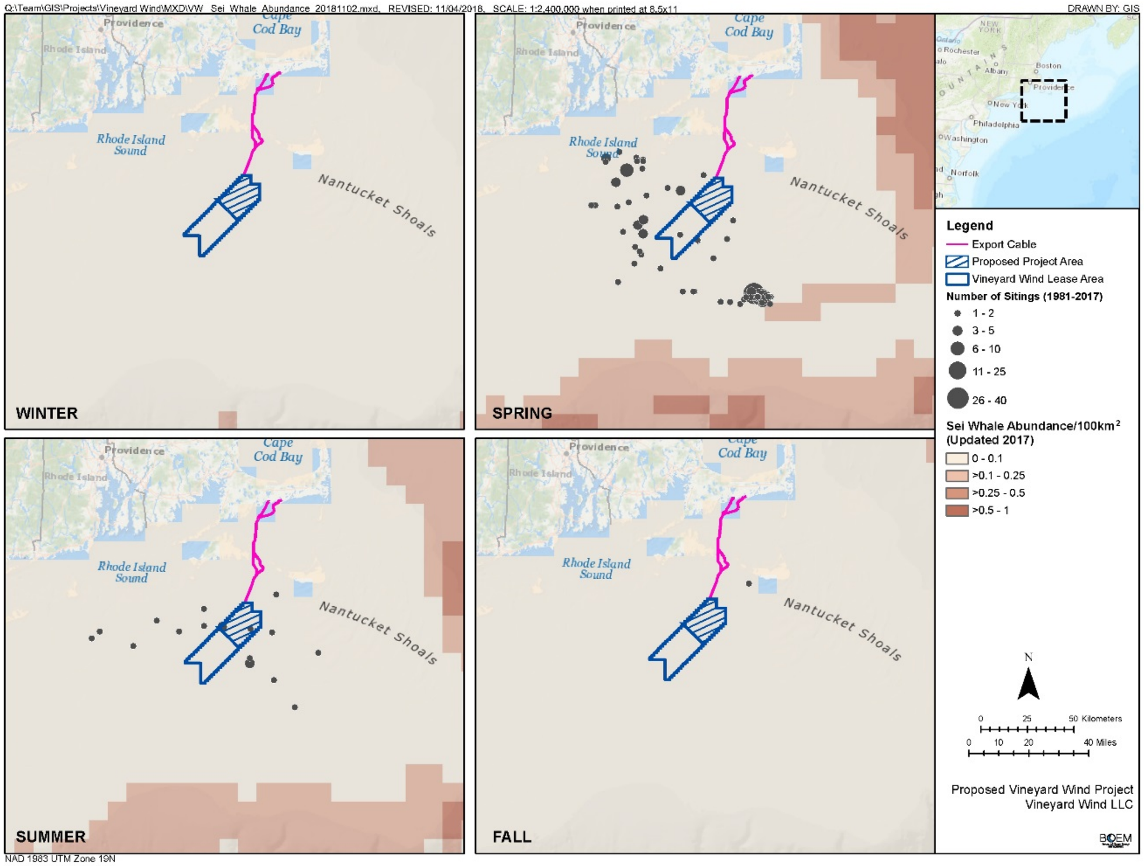
From 1981 to 2018, sightings data indicate that sei whales may occur in the proposed Project area in relatively moderate numbers during the spring and in low numbers in the summer (Figure 3.1-8; North Atlantic Right Whale Consortium 2018). The Roberts et al. (2016a) is the best available density data for modeling, but those estimates provide estimates of no occurrence of sei whales in the modeled area during any season. The Pyć et al. (2018) acoustic model for sei whales is likely accurate that there is likely no likely risk of exposure of sei whales based on their low rate of occurrence. However, it is noted that the modeling does not account for the low, but potential occurrence of sei whales to occur in the Action Area.

3.1.3.3. Critical Habitat

No critical habitat has been designated for sei whales in the Action Area.

3.1.3.4. Hearing Range

Sei whales belong to the low-frequency mysticete hearing group of marine mammals, with the best sensitivity for hearing ranging from 1.5 to 3.5 kHz (Erbe 2002).



Source: Roberts et al. 2016b; North Atlantic Right Whale Consortium 2018

Note: Number of whales per 24,710.5 acres (100 km^2)

Figure 3.1-8: Sei Whale Abundance Estimates with Sightings Data from 1981–2018 Overlaid in the Vineyard Wind Project Area

3.1.4. Sperm Whales

Sperm whales are widely distributed throughout the deep waters of the North Atlantic. Distribution along the U.S. east coast is centered along the shelf break and over the slope (CETAP 1982). An exception to this distribution pattern is found in the shallow continental shelf waters of southern New England, where relatively high numbers of sightings have been reported, particularly between late spring and autumn (Scott and Sadove 1997).

Geographic distribution of sperm whales appears to be linked to social structure. Most females will form lasting bonds with other related females and their young, and form social units of usually 12 females (NMFS 2018d). While females generally stay with the same unit all their lives in and around tropical waters, young males will leave when they are between 4 and 21 years old to form "bachelor schools" with other males of about the same age and size. As males get older and larger, they leave their bachelor schools and begin to migrate toward the poles; the largest males are largely solitary and often found alone (NMFS 2018d).

Sperm whales are known to dive in very deep waters (>9842.5 feet [3,000 meters]), but feed at 1640.5 to 3281 feet (500 to 1,000 meters), where most of their prey is found (NMFS 2010). Sperm whales are thought to feed year-round (NMFS 2010). Sperm whales' diet includes large- and medium-sized squid, octopus, and medium-and large-sized demersal fish, such as rays, sharks, and many teleosts (NMFS 2018d).

3.1.4.1. Current Status of Sperm Whale Population

The stock structure of the Atlantic population of sperm whales is poorly understood. It is not clear whether the western North Atlantic population is discrete from the eastern North Atlantic population (Waring et al. 2015). However, the portion of the population found within the U.S. EEZ likely belongs to a larger stock in the western North Atlantic. Sperm whales are listed under the ESA as the global population, with the best available estimate of 300,000-450,000 whales (NMFS 2015). The total annual estimated average human-caused mortality to this stock during 2008 to 2012 was 0.8 whales per year. There were three sperm whale strandings in Massachusetts from 2008 to 2012 (Waring et al. 2015).

3.1.4.2. Presence and Abundance in the Action Area

Sperm whale sightings in the study area from October 2011 through June 2015 only occurred during the summer and fall, with three of the four sightings within a single year, 2012 (Kraus et al. 2016b). There were two sightings on August 7, 2012, of four and one individuals, and one sighting of a single whale on September 17, 2012. The last sperm whale sighting was a group of three individuals observed on June 20, 2015. The sightings in summer occurred north of OCS-A 0486 and OSC-A 0487, just southwest of Martha's Vineyard, in the southern portion of OCS-A 0500, 501, 520, 0521, and 0522, and just north of the WDA south of the Muskeget Channel (Figure 3.1-9; Stone et al. 2017). The sighting in the fall occurred immediately west of the WDA (Stone et al. 2017). Sperm whales acoustic presence was not reported in Kraus et al. (2016b) because their high-frequency clicks exceeded the maximum frequency of recording equipment settings used.

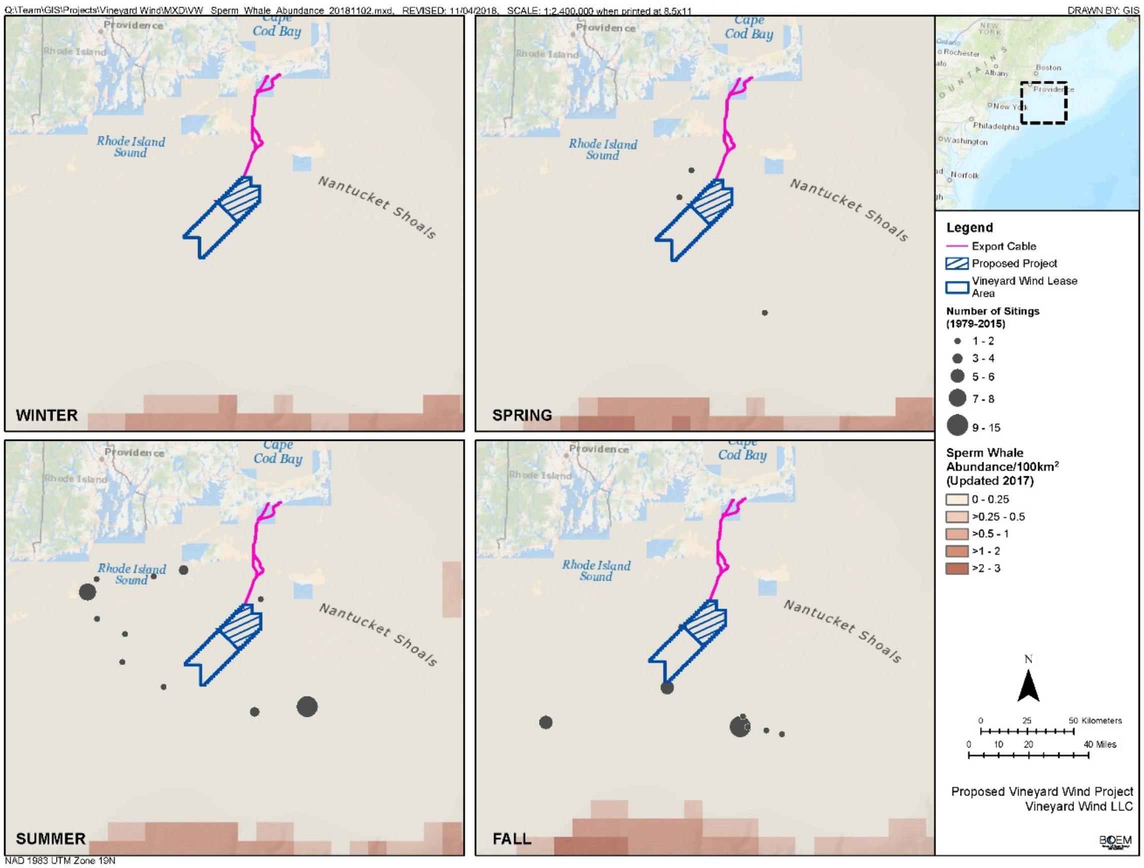
Historical sightings data from 1979 to 2018 indicate that sperm whales may occur in the waters to the west, south, and southeast of the WDA during summer and fall in relatively low to moderate numbers (North Atlantic Right Whale Consortium 2018). These data correlate with the Roberts et al. (2016a) estimates of 0 to 0.25 whales per 24,710.5 acres (100 km^2) in the proposed Project area during all seasons (Figure 3.1-9).

3.1.4.3. Critical Habitat

No critical habitat has been designated for sperm whales in the Action Area.

3.1.4.4. Hearing Range

Sperm whales belong to the mid-frequency odontocete hearing group of marine mammals. Members of this group have a presumed total frequency range of 150 Hz to 160 kHz (NMFS 2018e). However, sperm whales are most sensitive to sound in the 5 to 20 kHz hearing range (Cure et al. 2013).



Roberts et al. 2016b; North Atlantic Right Whale Consortium 2018

Note: Number of whales per 24,710.5 acres (100 km^2)

Figure 3.1-9: Sperm Whale Abundance Estimates with Sightings Data from 1979–2018 Overlaid in the Vineyard Wind Project Area

3.2. SEA TURTLES

Five ESA-listed species of sea turtles may occur in the U.S. northwest Atlantic Ocean: leatherback, loggerhead, Kemp's ridley, green, and hawksbill (Table 3.2-1). All of these sea turtles are migratory and enter New England waters primarily in the summer and fall. Among these species, four sea turtles are likely to occur in the proposed Project area, which includes the WDA, OECC, and surrounding waters: leatherback, loggerhead (Northwest Atlantic Ocean DPS), Kemp's ridley, and green (North Atlantic DPS) sea turtles. The other species may use the proposed Project area for travel, foraging, diving at depth for extended periods, and possibly for extended rest periods on the sea floor. Targeted surveys have been conducted for sea turtles near the proposed Project area, and the results can be found in Kraus et al. 2016b. Typically, sea turtles that may occur in the Action Area occur seasonally with changes in water temperature. Sea turtles found cold-stunned in early winter are considered out-of-habitat animals and typically occur in shallow, inshore waters that can undergo rapid temperature changes compared to thermally-buffered offshore waters. Although there is a potential for out-of-habitat cold-stunned turtles to occur in inshore waters of the Action Area, it is likely offshore turtles would remain mobile and would migrate south before winter.

Table 3.2-1: Summary of Sea Turtles Likely to Occur in the Coastal Waters off Rhode Island and Massachusetts

Common Name	Scientific Name	DPS/Stock	ESA Status (Massachusetts ESA Status)	Regional Sightings, Strandings, and Bycatch 1974-2008 [a]	Relative Occurrence in the Action Area [b]	Seasonal Occurrence in the Action Area (Peak) [c]
Leatherback	*Dermochelys coriacea*	Atlantic	E (E)	142	Common	Spring to Fall
Loggerhead	*Caretta caretta*	Northwest Atlantic DPS	T (T)	233	Common	Spring to Fall
Kemp's ridley	*Lepidochelys kempi*	NA	E (E)	14	Regular	Spring to Fall
Green	*Chelonia mydas*	North Atlantic DPS	T (T)	1	uncommon, limits of range	Possibly Spring to Fall

DPS = distinct population segments; ESA = Endangered Species Act; E = Endangered: T = Threatened; WDA = Wind Development Area; NA = Not Available

[a] Summarizes occurrence records from four data sources from1974-2008: (1) aerial and shipboard surveys conducted by various agencies and archived by the North Atlantic Right Whale Consortium; (2) opportunistic sightings records with no associate survey, also archived by the North Atlantic Right Whale Consortium; (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; and Kenney and Vigness-Raposa 2010.

[b] Common > 100 turtles; Regular = 10 to 100 turtles; Rare < 10 turtles. Although sightings records suggest rare occurrence of Kemp's ridley sea turtles, the stranding records indicate regular occurrence in the area.

[c] Based on Kraus et al. 2016b

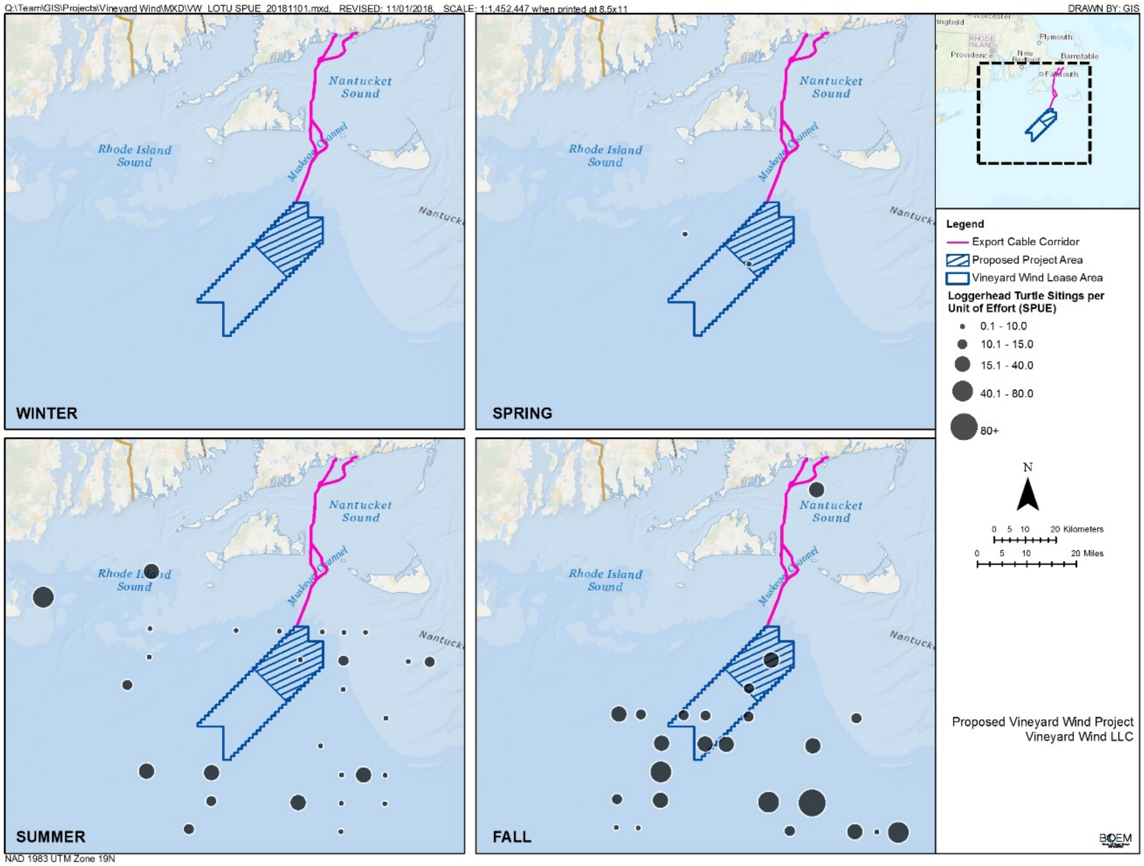
While in the coastal waters in and near the proposed Project area, sea turtles may be found swimming, foraging, migrating, diving at depth for extended periods of time, basking at the surface (Spotila and Standora 1985), and possibly engaged in extended rest periods on the ocean bottom. All sea turtle species are at risk from vessel traffic, with potential impacts including behavioral modification from vessel noise and injury or mortality from vessel strike. Other acoustic impacts include behavioral modification during wind turbine operation and pile driving and potential injury during pile driving activities. Benthic forage including crustaceans, mollusks, and vegetation, for loggerheads, green, and Kemp's ridley sea turtle, may be impacted by proposed Project activities affecting the sea floor. Sea turtles are known to orient to changes in magnetic fields and electromagnetic fields (EMF) emitted from power cables are likely detectable by sea turtles at close ranges (Normandeau et al. 2011), but no adverse effects to sea turtles from the numerous submarine power cables around the world have been documented to occur.

Regional, pre-existing threats to sea turtles include entanglement in fisheries gear, fisheries bycatch, and vessel strike. In addition, loggerhead, Kemp's ridley, and green sea turtles are susceptible to cold stunning. Cold stunning is the hypothermic reaction that occurs when sea turtles are exposed to prolonged cold-water temperatures, causing a decreased heart rate, decreased circulation, and lethargy, followed by shock, pneumonia, and possibly death. Cold stunning may occur from late October through January (WBWS 2018). Commercial fisheries occurring in the southeastern New England region include bottom trawl, midwater trawl, dredge, gillnet, longline, and pots and traps (COP Volume III, Section 7.8; Epsilon

2018). Targeted fisheries species include monkfish, scallop, surfclam/quahog, squid, mackerel, herring, and lobster among others. Commercial vessel traffic in the region is variable depending on location and vessel type. The commercial vessel types and relative density in the project region during 2013 include cargo (low), passenger (high), tug-tow (high), and tanker (low; Epsilon 2018).

3.2.1. Description of the Affected Environment for Sea Turtles

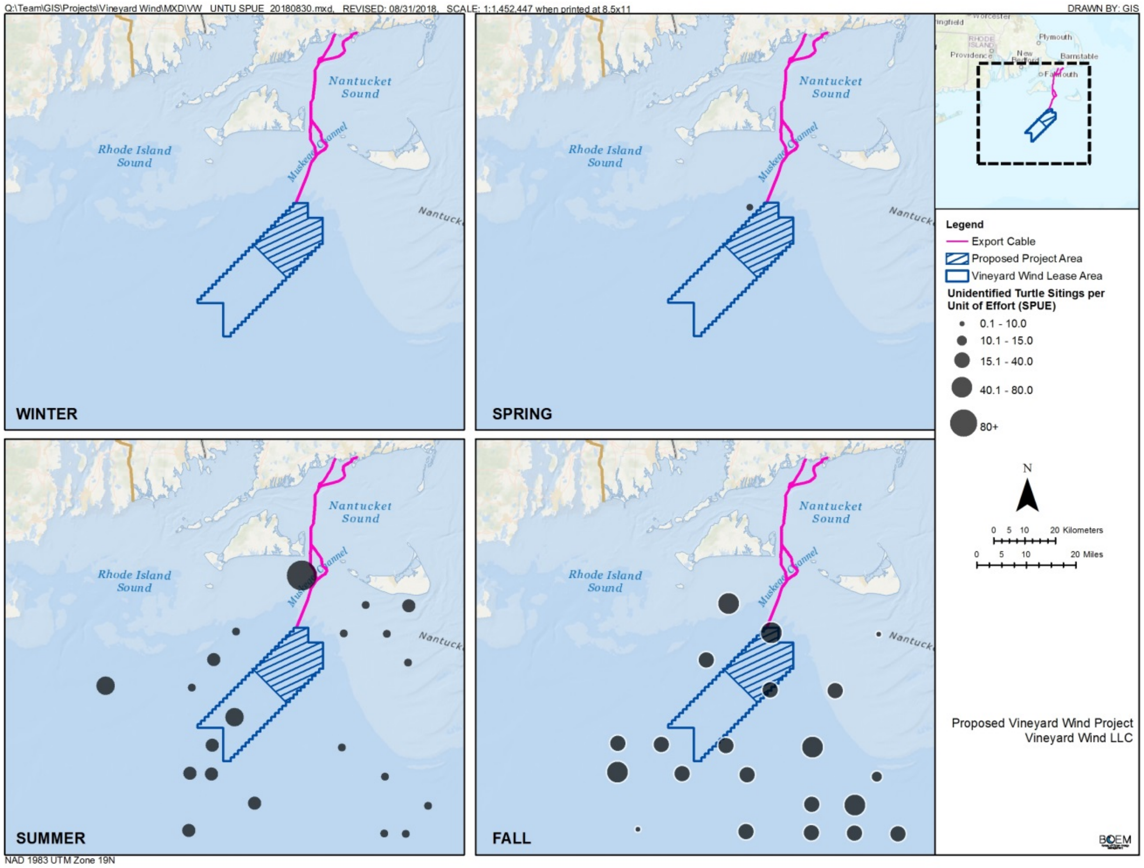
The most accurate account of a species' regional presence is gained by combining sightings, strandings, and bycatch data. This section of the BA summarizes data from the most current sightings surveys of the MA WEA (including the WDA Kraus et al. 2016b and SPUE data from 1998 through 2017, North Atlantic Right Whale Consortium 2018), NMFS Sea Turtle Stranding and Salvage Network (STSSN; NMFS 2018c), Wellfleet Bay Wildlife Sanctuary (WBWS) stranding data (cold-stunned stranded turtles; WBWS 2018), and historical regional data (Kenney and Vigness-Raposa 2010). Figures 3.2-1 through 3.2-4 were populated using SPUE data from the North Atlantic Right Whale Consortium and include available Massachusetts Clean Energy Center, NMFS, and aerial Atlantic Marine Assessment Program for Protected Species I data (not all data from each source were available at the time of this report). Because of their high submergence rate, sea turtles are difficult to spot during surveys, and their occurrence in the area is likely underestimated.



Source: North Atlantic Right Whale Consortium 2018

Note: Number of turtles per 621.4 miles (1,000 kilometers) in the proposed Project area during winter (December–February), spring (March–May), summer (June–August), and fall (September–November)

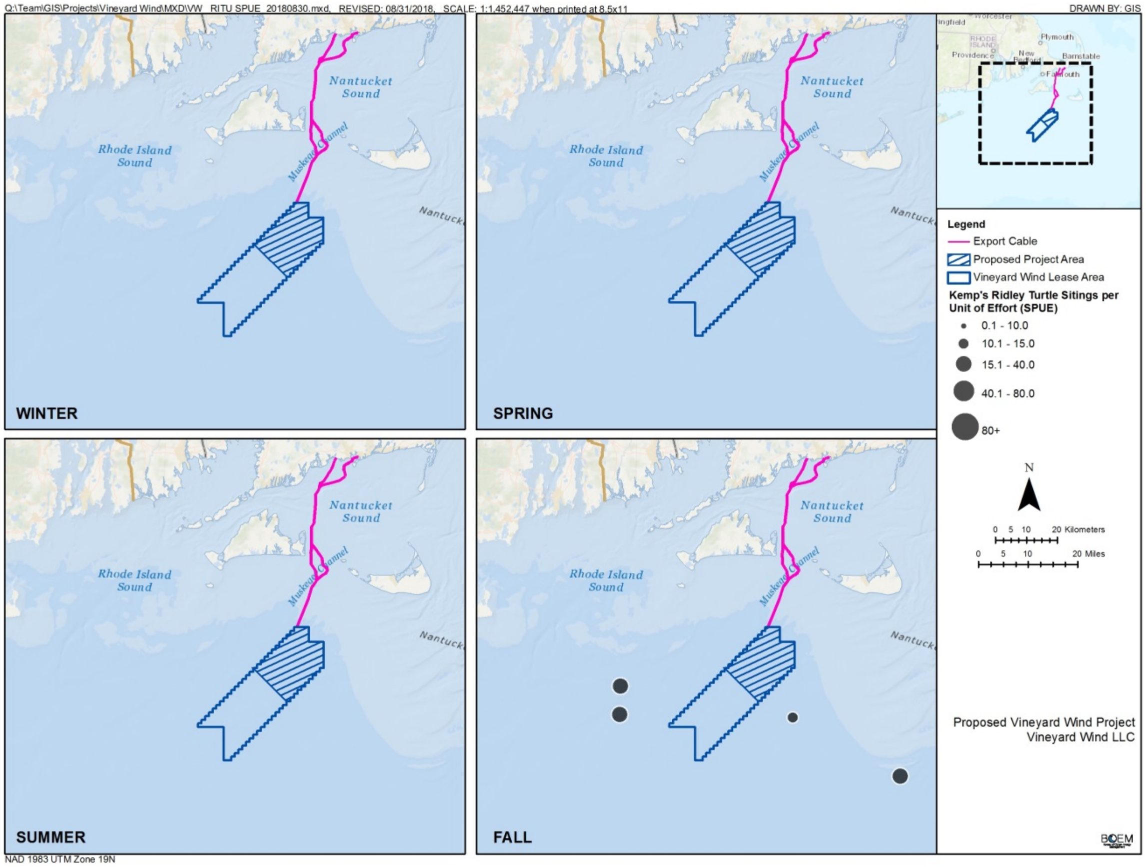
Figure 3.2-1: Loggerhead Sea Turtle SPUE



Source: North Atlantic Right Whale Consortium 2018

Note: Number of turtles per 621.4 miles (1,000 kilometers) in the proposed Project area during winter (December–February), spring (March–May), summer (June–August), and fall (September–November)

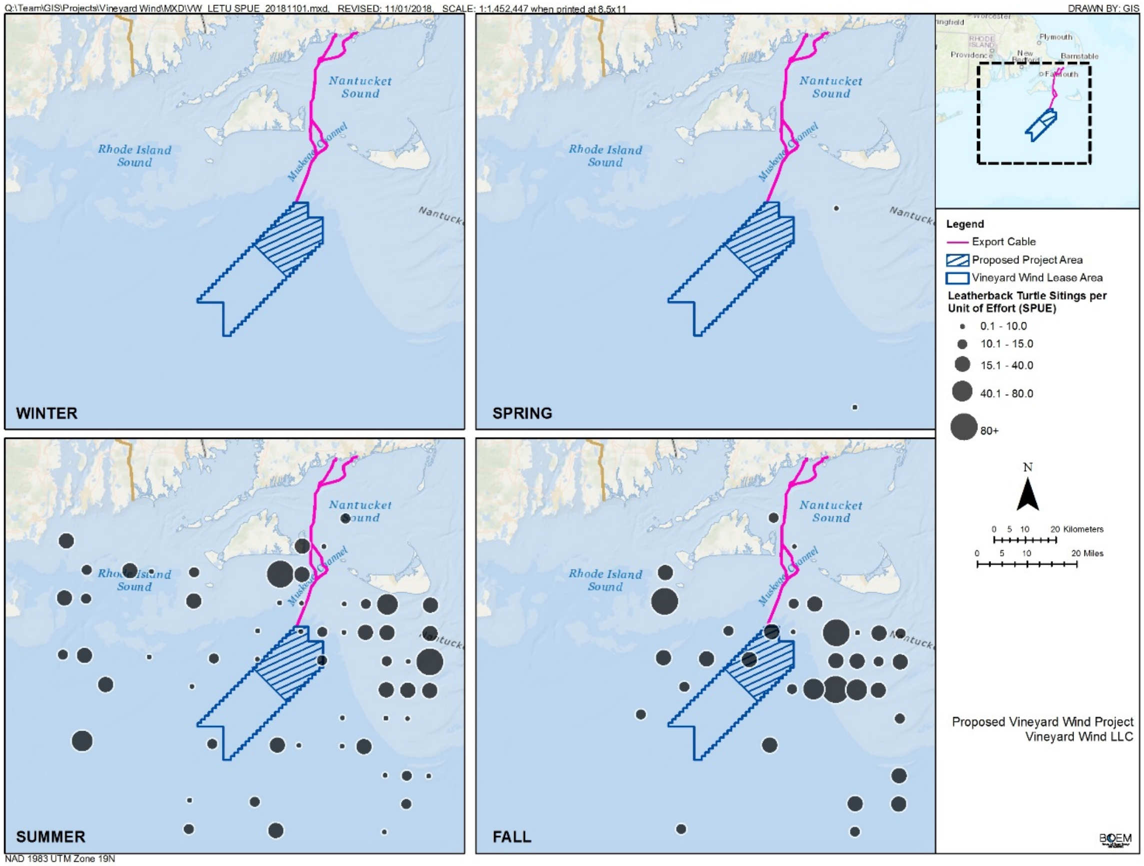
Figure 3.2-2: Unidentified Sea Turtle SPUE



Source: North Atlantic Right Whale Consortium 2018

Note: Number of turtles per 621.4 miles (1,000 kilometers) in the proposed Project area during winter (December–February), spring (March–May), summer (June–August), and fall (September–November)

Figure 3.2-3: Kemp's Ridley Sea Turtle SPUE



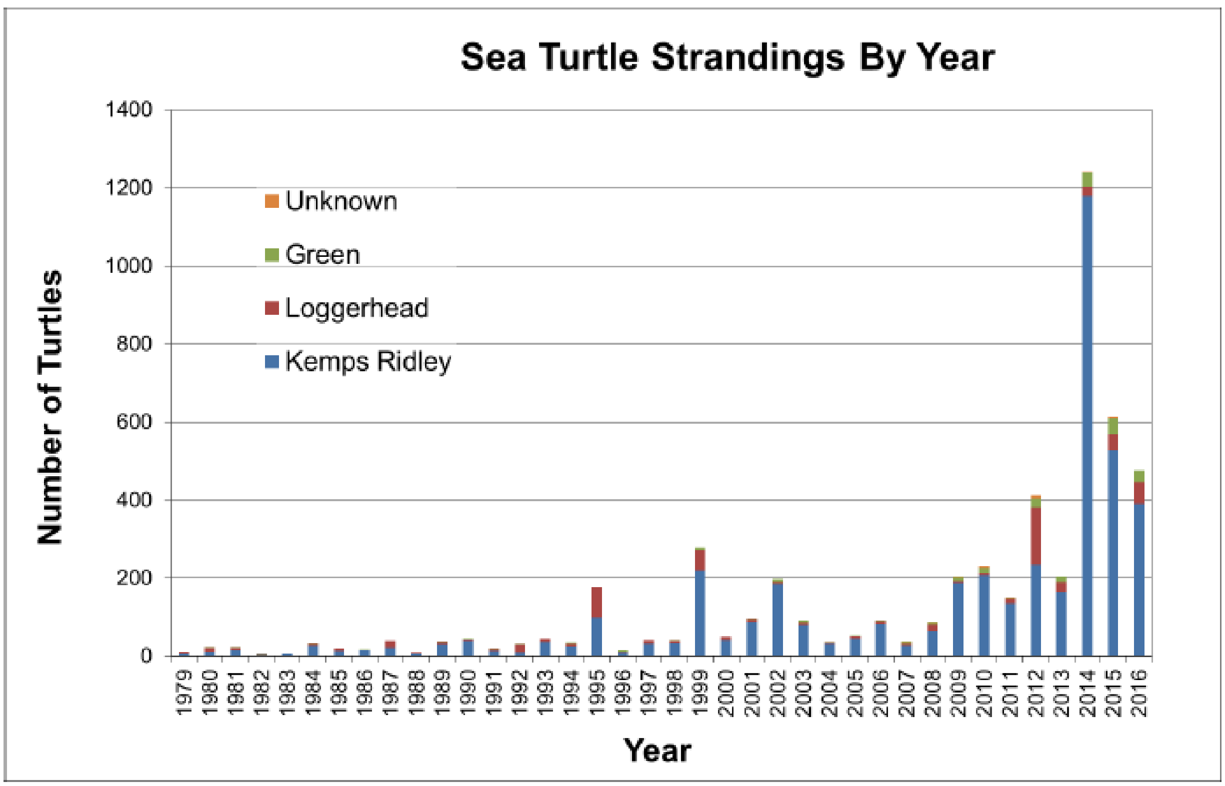
Source: North Atlantic Right Whale Consortium 2018

Note: Number of turtles per 621.4 miles (1,000 kilometers) in the proposed Project area during winter (December–February), spring (March–May), summer (June–August), and fall (September–November)

Figure 3.2-4: Leatherback Sea Turtle SPUE

3.2.2. Regional Setting

Leatherback, loggerhead, Kemp's ridley, and green sea turtles are highly migratory and known to occur in the coastal waters of the northeast United States in the summer and fall to forage. Regional historical sightings, strandings, and bycatch data indicate that loggerhead and leatherback turtles are relatively common, Kemp's ridley turtles are regular, and green turtles are relatively rare in the waters off Massachusetts and Rhode Island (Kenney and Vigness-Raposa 2010). WBWS strandings data also indicated that loggerhead strandings are relatively common, and green sea turtle strandings are relatively rare in the area. WBWS strandings data are not available for leatherback sea turtles because these data are specific to cold-stunned turtles, and leatherback sea turtles are not susceptible to cold stunning. Kemp's ridley strandings have been more common in recent years, with the highest number (approximately 1,200 turtles) occurring on Cape Cod in 2014 (WBWS 2018; Figure 3.2-5). These data suggest a shift towards higher numbers of Kemp's ridley sea turtles in the area over the past few years (WBWS 2018). This increase is likely due to a combination of successful conservation efforts on the nesting beaches in Mexico and Texas and changes in ocean temperatures, and possibly currents, driven by climate change (WBWS 2018). Strandings (all species combined) on Cape Cod from 2014 through 2016 have occurred from November through January, with peak periods depending on year (WBWS 2018). For example, in 2014 the peak stranding period was mid- to late November, in 2015 most strandings occurred during mid- to late December, and in 2016, strandings occurred primarily from November through December (WBWS 2018).



Source: WBWS 2018

Figure 3.2-5: Sea Turtle Strandings by Year on Cape Cod, MA from 1979 through 2016

Northeast Fisheries Observer Program statistical area 537 encompasses the waters from the southern shores of Martha's Vineyard and Nantucket south (including the proposed Project area) to the OCS shelf waters off New York (NMFS 2018c). NMFS bycatch data in this area indicated that a total of 31 turtles (4 leatherback, 2 green, 20 loggerhead, and 5 unidentified hard-shelled turtles) were incidentally caught in monkfish, squid, and skate fishery gear from 2008 through 2017 (NMFS 2018c). These data under represent the actual number of bycaught turtles due to the limited observer coverage for each fishery. The turtles were caught from June through December, with the majority in July (18 of 31) and August (5 of 31). In area 538, which includes the waters from the south shore of Cape Cod to the southern shores of Martha's Vineyard and Nantucket (and the proposed Project OECC area), one loggerhead turtle was incidentally caught in August of 2014 (NMFS 2018c). No Kemp's ridley turtles were incidentally caught in either area from 2008 through 2017 despite the relatively high number of strandings in the area for this species. Interactions with sea turtles and fisheries gear in the WDA are low compared to regional data. Over the past twenty years, six sea turtles (two leatherback, one green, two loggerhead, and one unidentified) were recorded as bycatch from bottom and otter trawls in the WDA. This number represents three percent of the estimated annual turtle bycatch (231 loggerheads) for sea turtles throughout the mid-Atlantic and Georges bank regions from 2012 through 2016 (NMFS 2018c). A total of 31 turtles (20 loggerheads, 3 leatherback, 1 green, and 7 unidentified) were reported as bycatch for gillnet, fixed or anchored, sink and other gear in the WDA, which accounted for 16 percent (197 turtles: 141 loggerhead, 25 Kemp's ridley, 5 leatherback, and 22 unidentified) of the regional bycatch for those fisheries (NMFS 2018c).

3.2.3. Hearing Range

Studies indicate that hearing in sea turtles is confined to lower frequencies, below 1,600 Hz, with the range of highest sensitivity between 100 and 700 Hz (Dow Piniak et al. 2012). Current data for species-specific hearing range frequencies are summarized in Table 3.2-2. Behavioral studies in loggerhead sea turtles indicated startle responses were elicited at frequencies between 50 and 800 Hz (Martin et al. 2012).

Table 3.2-2: Sea Turtle Hearing Range

Sea Turtle Species	Scientific Name	Hearing Range (Hertz)	Most Sensitive Hearing Range (Hertz)	Reference
Loggerhead	*Caretta caretta*	100–1130 [a] 50–800 [b]	200–400 (110 dB re1µPa) 100 (98 dB re1µPa)	Martin et al. 2012
Kemp's Ridley	*Lepidochelys kempi*	100–500	100–200	Bartol and Ketten 2006
Green (juvenile)	*Chelonia mydas*	50–1,600	600–700	Piniak et al. 2016
Leatherback	*Dermochelys coriacea*	50–1,200	100–400	Dow Piniak et al. 2012

µPa = micropascal; dB = decibel

[a] Auditory evoked potential

[b] Behavioral testing

3.2.4. Loggerhead Sea Turtle

Loggerhead turtles can be found throughout the global ocean in subtropic and temperate waters (NMFS and USFWS 2008). This species is known to occur within essentially all shelf waters of the northwest Atlantic from Florida to Nova Scotia (NMFS and USFWS 2008). Adult and juvenile loggerhead turtles are known to forage in coastal areas from Florida to Cape Cod from June to mid-September and into the fall. However, most loggerheads in southern New England waters are juveniles, ranging in length from 15 to 36 inches (38 to 91 centimeters) and in weight from approximately 24 to 99 pounds (11 to 45 kilograms) (Massachusetts Audubon 2012).

Juvenile loggerhead turtle diet includes benthic invertebrates, with mollusks and benthic crabs considered the primary food items (Burke et al. 1993a and b). Studies indicate that their diet may shift depending on prey abundance and/or geographic differences in prey selection (Plotkin et al. 1993; Ruckdeschel and Shoop 1988). For example, loggerhead turtle diet in Chesapeake Bay, Virginia shifted from primarily horseshoe crabs (*Limulus polyphemus*) in the early to mid-1980s to predominantly blue crabs in the 1980s, and then to finfish discarded by fisheries in the mid-1990s and in 2000 to 2002 (Seney and Musick 2007).

3.2.4.1. Occurrence in the Project Area

Loggerhead sea turtles were the second most commonly sighted sea turtle species in the study area from 2011 through 2015 (87 animals over 4 years). Loggerhead turtles were observed in the study area from April through September with peak occurrence during August and September, with a few sightings in May (Table 3.2-3; Kraus et al. 2016b). The highest number of loggerhead turtles occurred in September (45 turtles) and the second highest number was recorded in August (27 turtles; Kraus et al. 2016b).

Table 3.2-3: Effort-Weighted Average Number of Sightings and Number of Animals Observed

Species	Scientific Name	Fall		Winter		Spring		Summer	
		S	A	S	A	S	A	S	A
Leatherback	*Dermochelys coriacea*	59	62	0	0	2	2	92	98
Loggerhead	*Caretta*	45	52	0	0	2	3	31	32
Kemp's Ridley	*Lepidochelys kempi*	4	5	0	0	0	0	1	1
All turtles [a]		133	140	0	0	5	5	146	165

Source: Kraus et al. 2016b

A = number of animals observed; S = number of sightings (only definite and probable identifications included)

[a] All turtles includes unidentified turtles.

From October 2011 through June 2015, loggerhead turtle SPUE were relatively high in summer (5 to 30 animals per 621.4 miles [1,000 kilometers]) and fall (10 to 30 animals per 621.4 miles [1,000 kilometers]), and somewhat lower in the spring (5 to 10 animals per 621.4 miles [1,000 kilometers]; Kraus et al. 2016b). SPUE are likely to be underestimated for this species as a result of the relatively small size of the turtles and their long submergence time, which make visual detection difficult. From 1998 through 2017, loggerhead turtles were observed in relatively low numbers (0.1 to 15 turtles per 621.4 miles [1,000 kilometers] in the WDA and surrounding waters during the summer (June through

August) and in moderate numbers (10 to 40 turtles per 621.4 miles [1,000 kilometers]; North Atlantic Right Whale Consortium 2018; Figure 3.2-1).

The North Atlantic Right Whale Consortium database also includes SPUE for unidentified sea turtles. Although speciation was not possible, likely due to weather or sea state conditions, the turtles should still be accounted for. Figure 3.2-2 indicates that from 1998 through 2017, turtles may occur in relatively high numbers (more than 80 turtles per 621.4 miles [1,000 kilometers]) along the OECC route southeast of Martha's Vineyard, and in moderate numbers in and surrounding the WLA in the summer and in relatively high numbers (15 to 80 turtles per 621.4 miles [1,000 kilometers]; North Atlantic Right Whale Consortium 2018) in the WDA in the fall.

3.2.4.2. Population Status and Trend

The most recent regional abundance estimate for loggerhead sea turtles in the Northwest Atlantic Continental Shelf water in 2010 was approximately 588,000 individuals (NMFS NEFSC 2011). The three largest nesting subpopulations responsible for most of the production in the western North Atlantic (Peninsular Florida, Northern United States, and Quintana Roo, Mexico) have all been declining since at least the late 1990s, indicating a downward trend for this population (TEWG 2009).

3.2.5. Kemp's Ridley Sea Turtle

Kemp's ridley sea turtles inhabit the Gulf of Mexico and Northwest Atlantic as far north as the Grand Banks and Nova Scotia (NMFS USFWS and SEMARNAT 2011). During the summer and early fall, this species can be found inshore along the Atlantic seaboard from Florida to New England, but only juveniles (12 to 15 inch [30 to 38 centimeters] and approximately 4.4 pounds [2 kilograms]) have been reported in New England (Massachusetts Audubon 2012). Adults are rare in New England waters (TEWG 2000). When inshore, Kemp's ridleys can be found in waters less than 164 feet [50 meters] deep.

Optimal habitats for neritic juveniles appear to include rich sources of crabs and other invertebrates (Metz 2004). Kemp's ridley sea turtles are known to forage on mollusks, natural and synthetic debris, sea horses, cownose rays, jellyfish, and tunicates (Burke et al. 1993a and b, 1994; Witzell and Schmid 2005). Good foraging habitats may include a variety of substrates such as sandy bottoms (Morreale and Standora 1992), mud bottom, or a combination of communities and substrates (Rudloe et al. 1991). In addition, live bottom (sessile invertebrates attached to hard substrate) has been documented as a preferred habitat of neritic juveniles in the coastal waters of western Florida (Schmid et al. 2003; Schmid and Braichivich 2006).

3.2.5.1. Occurrence in the Project Area

From October 2011 through June 2015, a total of six Kemp's ridley turtles were sighted in the study area: one in August and five in September (Kraus et al. 2016b). There were insufficient data for sighting rate, SPUE, or density/abundance analyses (Kraus et al. 2016b). From 1998 through 2017, Kemp's ridley turtles were observed during the fall (September through November in the waters surrounding the WDA in relatively moderate numbers (10 to 40 turtles per 621.4 survey miles [1,000 kilometers]; Figure 3.2-3; North Atlantic Right Whale Consortium 2018).

3.2.5.2. Population Status and Trend

The Kemp's ridley sea turtle population was severely decimated in 1985 due to intensive egg collection and fishery bycatch, with only 702 nests counted during the entire year (NMFS and USFWS 2015; Bevan et al. 2016). After initiation of conservation measures, the population increased through 2009; however, since 2009 there has been a noted decline in nests (NMFS and USFWS 2015). Evaluations of hypothesized causes of the nesting setback, including the Deepwater Horizon oil spill in 2010, have been inconclusive, and experts suggest that various natural and anthropogenic causes could have contributed to the nesting setback either separately or synergistically (Caillouet et al. 2018). Despite the increased number of local strandings in 2014, recent models indicate a persistent reduction in survival and/or recruitment to the nesting population, suggesting that the population is not recovering. Current threats include bycatch from some fisheries, marine debris, and boat strikes (NMFS and USFWS 2015).

3.2.6. Green Sea Turtle

Green sea turtles are known to occur in tropical and sub-tropical waters, and to a lesser extent, temperate waters (NMFS and USFWS 2007). Green turtles spend the majority of their lives in coastal foraging grounds including open coastline waters (NMFS and USFW 2007). Green turtles often return to the same foraging grounds following periodic nesting migrations (Godley et al. 2002). However, some green sea turtles remain in the open ocean habitat for extended periods, and possibly never recruit to coastal foraging sites (Pelletier et al. 2003). Although previously thought to be strictly herbivorous, studies indicate that while offshore, and sometimes in coastal habitats, this species also forages on invertebrates including jellyfish, sponges, sea pens, and pelagic prey (Heithaus et al. 2002). Only juvenile green turtles have been recorded in New England (Massachusetts Audubon 2012).

3.2.6.1. Occurrence in the Project Area

Although green sea turtles were not observed in the Kraus et al. (2016b) surveys from October 2011 through June 2015 or identified in the North Atlantic Right Whale Consortium (2018) sightings data from 1998 through 2017, stranding records indicate the presence of green sea turtles in the area.

3.2.6.2. Population Status and Trend

The primary nesting beaches for the North Atlantic DPS of green sea turtles are Costa Rica, Mexico, U.S. (Florida), and Cuba. According to Seminoff et al. (2015), nesting trends are generally increasing for this DPS.

3.2.7. Leatherback Sea Turtle

Leatherback sea turtles nest on beaches in the tropics and sub-tropics and forage into higher-latitude subpolar waters (NMFS and USFWS 2013). Leatherbacks are the only species of sea turtle that can regulate their body temperature to some degree, and generally do not strand as a result of cold stunning. In the Atlantic Ocean, they are found as far north as the North Sea, Barents Sea, Newfoundland, and Labrador and as far south as Argentina and the Cape of Good Hope, South Africa (NMFS and USFWS 2013). Leatherbacks travel great distances between their foraging and breeding and nesting areas, sometimes travelling up to 6835 miles (11,000 kilometers) from their breeding areas (Benson et al. 2011). Studies suggest that leatherback turtles use magnetic inclination to navigate (Luschi 2013), possibly relying on a large-scale magnetic map to bring them back to the general target area, and then use local cues to reach the destination nesting beach or foraging area (Mills Flemming et al. 2010; Sale and Luschi 2009).

Leatherbacks mainly eat gelatinous organisms, particularly of the class Scyphozoa, but other taxa including crustaceans, vertebrates, and plants are ingested (Eckert et al. 2012; Dodge et al. 2011). Dodge et al. (2011) indicated that offshore foraging areas (e.g., sargassum) are important to the early life stage of the leatherback in the western North Atlantic.

A tagging study of 38 leatherbacks off Nova Scotia during the summers of 1999 through 2003 showed that these turtles' movements are concentrated in the waters off eastern Canada and the northeastern United States in June through December, although most turtles left the area for the southward migration during October (James et al. 2005). The Continental Shelf waters south of Cape Cod were among the highest areas visited among the tagged leatherbacks.

3.2.7.1. Occurrence in the Project Area

Leatherback sea turtles were the most commonly sighted sea turtle species in the study area from 2011 through 2015 (161 animals over 4 years), occurring primarily during summer and fall, with a few sightings in the spring (Kraus et al. 2016b). The highest number of leatherback turtles occurred in August (71 turtles) and the second highest number was recorded in September (33 turtles). Leatherbacks were sighted in the WDA and OECC area in the summer and fall with SPUE ranging from 10 to 20 turtles per 621.4 miles [1,000 kilometers] (Kraus et al. 2016b; COP Volume III, Figure 6.8.3; Epsilon 2018). From 1998 through 2017, SPUE of leatherback turtles were similar, with relatively high numbers (15 to more than 80 turtles per 621.4 miles [1,000 kilometers]) observed just west of the OECC to the southeast of Martha's Vineyard (North Atlantic Right Whale Consortium 2018). Leatherback turtles were observed over the same time period in the WDA in moderate numbers (15 to 40 turtles per 621.4 miles [1,000 kilometers], during fall; North Atlantic Right Whale Consortium 2018).

3.2.7.2. Population Status and Trend

The most current population estimate (total number of adults) of leatherback sea turtles in the Atlantic (estimated from the seven nesting sites within the Atlantic from the Caribbean to Florida) is 34,000 to 94,000 (NMFS and USFWS 2013; TEWG 2007). Aside from the western Caribbean, nesting trends at all other Atlantic nesting sites are generally stable or increasing (NMFS and USFWS 2013; TEWG 2007).

3.3. MARINE FISH

As stated above, only Atlantic sturgeon is likely to be present in the Action Area, and is analyzed further herein. There are five DPSs of Atlantic sturgeon present or likely to be present in the WDA and OECC.

3.3.1.1. Atlantic Sturgeon

NOAA Fisheries has identified the following federally listed species as present or potentially present in the Action Area:

- Gulf of Maine DPS of Atlantic Sturgeon: Threatened
- New York Bight DPS of Atlantic Sturgeon: Endangered
- Chesapeake Bay DPS of Atlantic Sturgeon: Endangered
- South Atlantic DPS of Atlantic Sturgeon: Endangered
- Carolina DPS of Atlantic Sturgeon: Endangered

Final determinations listing the Atlantic Sturgeon New York Bight and Chesapeake Bay DPSs as endangered, Gulf of Maine DPS as threatened (77 Fed. Reg. 5880), and Carolina and South Atlantic DPSs as endangered (77 Fed. Reg. 5914) were issued in February 2012, and the rulings became effective April 6, 2012.

As part of the final rule listing, factors leading to the five statutory ESA listing factors were identified: (1) present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) predation or disease; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting their continued existence. The listing rule from 2012 included the following threats to recovery of Atlantic sturgeon: destruction of habitat or range, dams and tidal turbines, dredging and blasting, and degradation of water quality (77 Fed. Reg. 5880).

3.3.1.2. General Life History

Atlantic sturgeon spend most of their lives in marine waters along the Atlantic coast. They are a large anadromous, bottom-feeding species that spawn in large coastal rivers and mature in marine waters. Atlantic sturgeon is a member of the family Acipenseridae, and ranges from the Hamilton River, Labrador, to northeastern Florida. They are known to inhabit 38 major estuarine and associated riverine systems in the eastern United States (ASSRT 2007). Atlantic sturgeon is one of the largest fish species in North America with a maximum-recorded length of about 14 feet (4.2 meters) (Bain 1997). Male Atlantic sturgeon generally do not reach maturity until at least 12 years and females as late as 19 years (Dovel and Berggren 1983). Their inter-annual spawning period can range from 3 to 5 years, and adults inhabit marine waters either all year during non-spawning years or seasonally during spawning years (Bain 1997). Tagging data show that while at sea, adults intermix with populations from other rivers (Collins et al. 2000 in ASSRT 2007). Despite their ability to range widely along the Atlantic coast, tagging and genetic studies indicate high site fidelity in natal rivers and very low gene flow among populations (Dovel and Berggren 1983; Savoy and Pacileo 2003; Grunwald et al. 2008).

Migratory adults and sub-adults have been collected in shallow near-shore areas of the continental shelf (32.9 to 164 feet [10 to 50 meters]) on any variety of bottom types (silt, sand, gravel, or clay). Evidence suggests that Atlantic sturgeon orient to specific coastal features that provide foraging opportunities linked to depth-specific concentrations of fauna. Concentration areas of Atlantic sturgeon near Chesapeake Bay and North Carolina were strongly correlated with the coastal features formed by the bay mouth, inlets, and the physical and biological features produced by outflow plumes (Kingsford and Suthers 1994 in Stein et al. 2004a). They are also known to commonly aggregate in areas that presumably provide optimal foraging opportunities, such as the Bay of Fundy, Massachusetts Bay, Rhode Island, New Jersey, and Delaware Bay (Dovel and Berggren 1983; Johnson et al. 1997; Rochard et al. 1997; Kynard et al. 2000; Eyler et al. 2004; Stein et al. 2004a; Dadswell 2006 in ASSRT, 2007).

Spawning adults migrate upriver in the spring/early-summer; February to March in southern systems, April to May in mid-Atlantic systems, and May to July in Canadian systems (Murawski and Pacheco 1977; Smith 1985; Bain 1997; Smith and Clugston 1997; Caron et al. 2002 in ASSRT 2007). Spawning occurs between the salt front of estuaries and the fall line of large rivers, with optimal flows ranging from 18 to 30 inches (46 to 76 centimeters) per second and depths from 36 to 89 feet (11 to 27 meters) (Borodin 1925; Leland 1968; Scott and Crossman 1973; Crance 1986; Bain et al. 2000 in 75 Fed. Reg. 838). Males have been noted to initiate their spawning migration earlier than females and remain within the spawning area longer than females, who generally demonstrate a rapid spawning migration upstream and a quick departure following spawning (Bain 1997).

Atlantic sturgeon deposit highly adhesive eggs on the bottom substrate, usually on hard surfaces such as cobble (Gilbert 1989; Smith and Clugston 1997 in 75 Fed. Reg. 838). Atlantic sturgeon eggs hatch approximately 94 to 104 hours after deposition at temperatures of 18 to 20 degrees Celsius (°C), and the larvae are demersal. After hatching, Atlantic sturgeon enter a larval yolk-sac phase that lasts approximately 8 to 12 days. Larvae move downstream towards the estuary to their rearing grounds (Kynard and Horgan 2002). In laboratory experiments, yolk-sac phase Atlantic sturgeon sought cover in substrate until 6 to 7 days old. By 8 days old, they emerged from protective substrate and began migrating using a swim-up and drift behavior (Kynard and Horgan 2002). During the first half of the migration, larval movement is known to occur primarily at night, with gravel substrates providing refuge during the day. Towards the latter half of their migration, downstream movements occur during both day and night. As post-larval Atlantic sturgeon develop and become juveniles, their tolerance for salinity increases. They reside in the estuary for months or years until the sub-adult phase (size of approximately 30 to 36 inches [76 to 92 centimeters]) and subsequently undertake long migrations in the open ocean (Holland and Yelverton 1973; Dovel and Berggren 1983; Waldman et al. 1996; Dadswell 2006; Murawski and Pacheco 1977; Smith 1985 in ASSRT 2007). Table 3.3-1 provides general descriptions for Atlantic sturgeon life stages and the approximate duration of each.

Table 3.3-1: Atlantic Sturgeon General Life Stage and Duration Information

Stage	Size	Duration	Description
Eggs	~0.08-0.12 inches (2 –3 mm) diameter (Van Eenannnam et al. 1996 p.773)	Hatching occurs ~3-6 days after egg deposition and fertilization (ASSRT 2007, p. 4)	Fertilized or unfertilized
Yolk-Sac Larvae (YSL)	~0.24-0.55 inches (6–14 mm) (Bath et al. 1981, pp. 714-715)	8-12 days post hatch (ASSRT 2007, p. 4)	Negative photo-taxis, nourished by yolk sac
Post Yolk-Sac Larvae (PYL)	~0.24-1.46 inches (14–37mm) (Bath et al. 1981, pp. 714-715)	12-40 days post hatch	Free swimming; feeding; silt/sand bottom, deep channel; fresh water
Young of Year (YOY)	0.1 ounce (0.3 grams) < 16 inches (410 mm) total length	From 40 days to 1 year	Fish that are >3 months and <1 year old; capable of capturing and consuming live food
Juveniles	>16 inches (410 mm) and <30 inches (760 mm) total length	1 year to time at which first coastal migration is made	Fish that are at least 1 year old, are not sexually mature, and do not make coastal migrations
Subadults	>30 inches (760 mm) and <59 inches (1500 mm) total length	From first coastal migration to sexual maturity	Fish that are not sexually mature, but make coastal migrations
Adults	>59 inches (1500 mm) total length	Post-maturation	Fish that are sexually mature

Source: NOAA 2018e

mm = millimeter

Sub-adult Atlantic sturgeon habitat selection is derived from a variety of physicochemical characteristics, including water temperature, salinity, dissolved oxygen, depth, substrate type, and available prey resources (ASMFC 2017). A number of studies have identified sub-adult preferred habitats as primarily oligohaline (USACE 2011). Although Atlantic sturgeon can occupy water where temperatures range as high as 30°C, activity and growth are more optimal in cooler waters (<25°C) (Cech and Doroshov 2004). In the presence of elevated water temperatures, Atlantic sturgeon are believed to limit movement and seek thermal refuge in deep water where dissolved oxygen levels are generally higher (Dovel and Berggren 1983; Moser and Ross 1995; Cech and Doroshov 2004; Niklitschek and Secor 2005 in USACE 2011).

3.3.1.3. Occurrence in the Action Area

The New York Bight DPS includes all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, Massachusetts, to the Delaware-Maryland border on Fenwick Island. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (Murawski and Pacheco 1977; Secor 2002; ASSRT 2007). Spawning still occurs in the Delaware and Hudson Rivers (ASSRT 2007) and in June 2014, several age-0 Atlantic sturgeon captured in the Connecticut River were subjected to mitochondrial DNA control region sequence and microsatellite analysis indicating successful spawning within that river in 2013 (Savoy et al. 2017). Analysis also indicated that the offspring were primarily from South Atlantic DPS and Chesapeake Bay DPS origins (Savoy et al. 2017). The results of Savoy et al. (2017) along with previous genetic and tagging studies provide ample evidence of large-scale coastal movements and mixing of DPS stocks along the Atlantic Coast (ASSRT 2007). Sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT 2007; Savoy 2007; Wirgin and King 2011). Based on the descriptions provided in Table 3.3-1, the most likely life stage encountered in the WDA and OECC would be the sub-adult and adult. The primary habitat type (sand or silt) and depth (mostly < 164 feet [50 meters]) in the WDA and OECC fits the preferred coastal habitat occupied by sub-adult and adult sturgeon described in the life history section above. Primary threats to Atlantic sturgeon include bycatch in trawl and gillnet fisheries, habitat degradation and loss, ship strikes, and general depletion from historical fishing. Historically, no Atlantic sturgeon have been reported captured as bycatch in fisheries or fisheries-independent surveys within the Vineyard Wind WDA (Stein et al. 2004b; Dunton et al. 2010).

3.3.1.4. Critical Habitat Designation

The final rule for Atlantic sturgeon critical habitat (all DPSs) was issued on August 17, 2017 (82 Fed. Reg. 35701). Included in this rule are 31 units, all rivers, occurring from Maine to Florida. No marine habitats were identified as critical habitat as the physical and biological features in these habitats essential for the conservation of Atlantic sturgeon could not be identified. In the letter from NOAA Fisheries, dated April 27, 2018, it was determined that there was no critical habitat overlapping with the proposed Project area (Michael Pentony, Pers. Comm., April 27, 2018). Critical habitat designations for the New York Bight include the Hudson, Connecticut, and Housatonic Rivers to where the mainstem discharges into either New York Harbor or Long Island Sound. No critical habitat has been designated for Atlantic sturgeon within drainages where potential ports are located (50 CFR § 226; COP, Volume I, Figure 3.2-3; Epsilon 2018). Vineyard Wind has reduced the PDE for the potential ports that may be used and have eliminated any ports that may affect critical habitat in Housatonic and Connecticut Rivers. Therefore, no critical habitat for Atlantic sturgeon will be affected. . There is no designated critical habitat for Atlantic sturgeon in marine waters.

Since proposed Project activities will not occur in close proximity to critical habitat for Atlantic sturgeon, BOEM concludes that the Proposed Action would not affect any critical habitat for Atlantic sturgeon that has been designated under the ESA.

4. PROPOSED ACTION

The Proposed Action would allow Vineyard Wind to construct, operate, maintain, and eventually decommission an approximately 800 MW wind energy facility on the OCS offshore Massachusetts within Vineyard Wind’s WDA, including associated export cables. Vineyard Wind has submitted a COP outlining its Proposed Action, which is summarized below. The proposed Project is being developed and permitted using the Design Envelope Concept, allowing flexibility in proposed Project elements while ensuring a timely and thorough environmental review. Further discussion of construction methods and schedule are provided in COP Volume I, Section 3.0 (Epsilon 2018) and summarized below. The Proposed Action excludes additional mitigation measures that could be implemented by federal agencies as part of their reviews and potential approval processes. Additional details related to the Proposed Action can be found in COP Volume I (Epsilon 2018).

Foundations and WTGs would be installed using a jack-up vessel or a vessel capable of dynamic positioning, as well as necessary support vessels and barges. Vessels would be equipped with a crane and a pile-driving hammer. Vineyard Wind would begin pile driving by using a soft start to help enable some marine life to leave the area before driving intensity increases. ESP foundation installations may require specialized crane vessels. It is possible that monopiles would be transported to the WDA by floating them in the water while being pulled by tugs.

The proposed action and analysis of effects also includes any associated federal activities associated with the proposed action from the Co-Action Agencies BSEE, EPA, USACE, USCG, and NMFS (see Section 2 above for additional details of Co-Action Agency regulatory roles and responsibilities). The New England District Corps of Engineers has received a permit application under Section 10 of the Rivers and Harbors Act and Section 4 of the CWA (File No. NAE-2017-01206), from Vineyard Wind to conduct work in waters of the United States No impacts to onshore wetlands are proposed as part of the Vineyard Wind Project. In offshore areas where impacts to marine resources are unavoidable, the applicant has avoided all Corps defined special aquatic sites (SAS) including eelgrass beds, intertidal mud flats, coral reef complexes, etc. Impacts are anticipated to consist of structures and temporary construction impacts with no permanent losses of Waters of the United States. The permit indicates compensatory mitigation requirements are under consideration, but none are proposed. Any mitigation and monitoring measures, if required for the permit, will be developed through ESA consultations (and Essential Fish Habitat consultation) with NMFS. As such, the proposed permit is incorporated by reference in this BA for consultation. Issuance of an air quality permit received by the EPA is not expected to have any discernable impacts on listed species or critical habitat, and no related mitigation and monitoring measures for protected species are proposed for this action. No other permits or authorizations are proposed not anticipated by other agencies at this time.

4.1. OFFSHORE FACILITIES

Proposed offshore Project components include WTGs and their foundations, electrical service platforms (ESPs) and their foundations, scour protection for all foundations, inter-array cables that connect the WTGs to the ESPs, the inter-link cable that connects the ESPs, and the export cable to the landfall location. The proposed offshore Project elements are located within federal waters, with the exception of a portion of the export cable located within state waters. COP Section 4.2.3 provides a detailed description of proposed construction and installation methods (Volume I; Epsilon 2018).

4.1.1. Wind Turbine Generators

Vineyard Wind would erect up to 100 WTGs of 8 to 10 MW capacity extending up to 696 feet (212 meters) above mean lower low water (MLLW) with a spacing between WTGs of approximately 0.75 to 1 nautical mile within the 75,614 acre (306 km^2) WDA. Vineyard Wind would mount the WTGs on either monopile or jacket foundations. A monopile is a long steel tube driven 66 to 148 feet (20 to 45 meters) into the seabed. A jacket foundation is a latticed steel frame with three or four supporting piles driven 98 to 197 feet (30 to 60 meters) into the seabed. Vineyard Wind would likely install jacket foundations in deeper WTG locations. Vineyard Wind's Project Design Envelope (PDE) includes up to 12 jacket foundations for the proposed Project (up to 10 jackets for WTG foundations and up to 2 jackets for ESP foundations). Table 4.1-1 summarizes the range of pertinent WTG characteristics provided in the PDE.

See COP Volume 1, Section 3.1.1 (Epsilon 2018) for detailed WTG descriptions. A complete discussion of the proposed WTG construction approach is provided in the COP Volume I, Sections 4.2.3.4 and 4.2.3.7 (Epsilon 2018) for foundations and WTGs, respectively.

Table 4.1-1: Vineyard Wind Project WTG Specifications with Maximum Design Scenario

Capacity and Arrangement		
Wind Facility Capacity	Approximately 800 MW [a]	
Wind Turbine Generator Foundation Arrangement Envelope	Up to 100 monopiles	Up to 10 may be jacket foundations
Wind Turbine Generators	**Minimum Turbine Size**	**Maximum Turbine Size**
Turbine Generation Capacity	8 MW	10 MW
Number of Turbine Positions [b]	106	88
Number of Turbines Installed	100	80
Total Tip Height	627 ft (191 m) MLLW [c]	696 ft (212 m) MLLW [c]
Hub Height	358 ft (109 m) MLLW [c]	397 ft (121 m) MLLW [c]
Rotor Diameter	538 ft (164 m) MLLW [c]	591 ft (180 m) MLLW [c]
Tip Clearance	89 ft (27 m) MLLW [c]	102 ft (31 m) MLLW [c]
Platform Level/Interface Level Height for Monopile	62 ft (19 m) MLLW [c]	75 ft (23 m) MLLW [c]
Tower Diameter for WTG	20 ft (6 m)	28 ft (8.5 m)
Monopile Foundations [d]	**Minimum Foundation Size**	**Maximum Foundation Size**
Diameter	25 ft (7.5 m)	34 ft (10.3 m)
Pile footprint	490 ft^2 (45.5 m^2)	908 ft^2 (84.3 m^2)
Height between Seabed and MLLW (water depth)	121 ft (37 m)	162 ft (49.5 m)
Penetration	66 ft (20 m)	148 ft (45 m)
Transition Piece Tower Diameter	20 ft (6 m)	28 ft (8.5 m)
Transition Piece Length	59 ft (18 m)	98 ft (30 m)
Platform Level/Interface Level Height	64 ft (19.5 m)	74 ft (22.5 m)
Number of Piles/Foundation	1	1
Number of Piles Driven/Day within 24 hours [e]	1	2
Typical Foundation Time to Pile Drive [f]	approximately 3 hours	approximately 3 hours
Hammer size	4,000 kJ	4,000 kJ
Jacket (Pin Piles) Foundation	**Minimum Foundation Size**	**Maximum Foundation Size**
Diameter for WTG and ESP	5 ft (1.5 m)	10 ft (3 m)
Jacket Structure Height for WTG	180 ft (55 m)	262 ft (80 m)
Jacket Structure Height for ESP	180 ft (55 m)	213 ft (65 m)
Platform Level/Interface Level Height for WTG and ESP	74 ft (22.5 m) MLLW	94 ft (28.5 m) MLLW
Pile Penetration for WTG	98 ft (30 m)	197 ft (60 m)
Pile Penetration for ESP	98 ft (30 m)	246 ft (75 m)
Pile Footprint for WTG	59 ft (18 m)	115 ft (35 m)
Pile Footprint for ESP	59 ft (18 m)	248 ft (45 m)
Number of Piles/Foundation	3 to 4	3 to 4
Number of Piles Driven/Day within 24 Hours [e]	1 (up to 4 pin piles)	1 (up to 4 pin piles)
Typical Foundation Time to Pile Drive [f]	approximately 3 hours	approximately 3 hours
Hammer Size	3,000 kJ	3,000 kJ

Source: COP Volume I (Epsilon 2018)

ESP = electrical service platform; ft = foot; ft^2 = square feet; kJ = kilojoule; m = meter; m^2 = square meters; MLLW = mean lower low water; MW = megawatt; WTG = wind turbine generator

[a] Vineyard Wind's Proposed Action is for an approximately 800 MW offshore wind energy project. The Draft Environmental Impact Statement evaluates the potential impacts of a facility up to 800 MW to ensure that it covers projects constructed with a smaller capacity.

[b] Additional WTG positions allow for spare turbine locations or additional capacity to account for environmental or engineering challenges.

[c] Elevations relative to mean higher high water are approximately 3 feet (1 meter) lower than those relative to MLLW.

[d] The foundation size is not connected to the turbine size/capacity. Foundations are individually designed based on seabed conditions and the largest foundation size could be used with the smallest turbine.

[e] Work would not be performed concurrently. No drilling is anticipated; however, it may be required if a large boulder or refusal is met. If drilling is required, a rotary drilling unit would be mobilized or vibratory hammering would be used.

[f] Vineyard Wind has estimated that typical pile driving for a monopile is expected to take less than approximately 3 hours to achieve the target penetration depth, and that pile driving for the jacket foundation would take approximately 3 hours to achieve the target penetration depth. Different hammer sizes are used for installation of the monopile and jacket foundations.

4.1.2. Electrical Service Platforms

Vineyard Wind would construct one to two ESPs, each installed on a monopile or jacket foundation, in the WDA. The ESPs would serve as the interconnection point between the WTGs and the export cable. The ESPs would be located along the northwest edge of the WDA and would include step-up transformers and other electrical equipment needed to connect the 66-kilovolt (kV) inter-array cable to the 220-kV offshore export cables. Between 6 and 10 WTGs would be connected through an inter-array cable that would be buried below the seabed and then connected to the ESPs. Table 4.1-2 summarizes the range of pertinent ESP characteristics provided in the PDE.

If the proposed Project uses more than one ESP, a 200-kV inter-link cable would be required to connect the EPSs together. Each ESP would contain up to 123,209.9 gallons (466,400 liters) of transformer oil and 348.7 gallons (1,320 liters) of general oil. COP Section 4.2 provides additional details related to chemicals and their anticipated volumes (Volume I; Epsilon 2018). Detailed specifications of the ESPs are provide in the COP Volume 1, Section 3.1.4 (Epsilon 2018). A complete discussion of the proposed ESP construction approach is provided in the COP Volume I, Sections 4.2.3.4 and 4.2.3.5 (Epsilon 2018) for foundations and ESPs, respectively.

Table 4.1-2: Vineyard Wind Project ESP Specifications with Maximum Design Scenario [a]

Electrical Service Platform (ESP)		
Dimensions	148 ft x 230 ft x 125 ft (45 m x 70 m x 38 m)	148 ft x 230 ft x 125 ft (45 m x 70 m x 38 m)
Number of Conventional ESPs	1 (800 MW)	2 (400 MW each)
Number of Transformers per ESP	1	2
Foundation Type	Monopile	Jacket
Number of Piles/Foundation	1	3 to 4
Maximum Height [b]		218 ft (66.5 m) MLLW

Source: COP Volume I, Table 3.1-1 (Epsilon 2018)

ESP = electrical service platform; ft = foot; m = meter; MW = megawatt

[a] Vineyard Wind's Proposed Action is for an approximately 800 MW offshore wind energy project. The Draft Environmental Impact Statement evaluates the potential impacts of a facility up to 800 MW to ensure that it covers projects constructed with a smaller capacity.

[b] Elevations provided are relative to Mean Lower Low Water—average of all the lower low water heights of each tidal day observed over the National Tidal Datum Epoch.

4.1.3. Scour Protection

Scour protection would be placed around all foundations, and would consist of rock and stone ranging from 4 to 12 inches (10 to 30 centimeters). The scour protection would be approximately 3 to 6 feet (1 to

2 meters) in height and would serve to stabilize the seabed near the foundations as well as the foundations themselves. Table 4.2-3 provides scour protection information for proposed foundations. See COP Volume I, Section 3.1.3 for detailed specifications of proposed scour protection. A complete discussion of the proposed scour protection construction approach is provided in COP Volume I, Section 4.2.3.2 (Epsilon 2018).

Table 4.1-3: Vineyard Wind Project Scour Protection Information

Scour Protection for Foundations	Minimum	Maximum
Scour Protection Area at Each Monopile WTG and ESP	up to 16,146 ft^2 (1,500 m^2)	up to 22,600 ft^2 (2,100 m^2)
Scour Protection Volume at Each Monopile WTG and ESP	up to 52,972 ft^3 (1,500 m^3)	up to 127,133 ft^3 (3,600 m^3)
Scour Protection Area at Each Jacket WTG	up to 13,993 ft^2 (1,300 m^2)	up to 19,375 ft^2 (1,800 m^2)
Scour Protection Volume at Each Jacket WTG	up to 45,909 ft^3 (1,300 m^3)	up to 91,818 ft^3 (2,600 m^3)
Scour Protection Area at Each Jacket ESP	up to 13,993 ft^2 (1,300 m^2)	up to 26,900 ft^2 (2,500 m^2)
Scour Protection Volume at Each Jacket ESP	up to 45,909 ft^3 (1,300 m^3)	up to 134,196 ft^3 (3,800 m^3)

Source: COP Volume I, Table 3.1-1 (Epsilon 2018)

ESP = electrical service platform; ft^2 = square feet; ft^3 = cubic feet; m^2 = square meters; m^3 = cubic meters; WTG = wind turbine generator

4.1.4. Offshore Cables

Two offshore export cables in one cable corridor would connect the proposed wind facility to the onshore electrical grid. Each offshore export cable would consist of three-core 220-kV alternating current (AC) cables that would deliver power from the ESPs to the onshore facilities. The cable routes currently being considered contain several routing options. The OECC from the WDA could pass through the deepest part of Muskeget Channel proper, or it could pass atop the shoals to the east of the deepest area (see Figure 2.1-3). As the offshore export cable approaches Cape Cod, the final route would be contingent on the choice of landfall site, which would occur either at Cavell’s Beach in Barnstable or at New Hampshire Avenue in Yarmouth.

As part of the PDE, Vineyard Wind has proposed several cable route installation methods for the inter-array cable, inter-link cable, and offshore export cable. Vineyard Wind would bury the cables using a jet plow, mechanical plow, and/or mechanical trenching, as suited for the bottom type in the immediate area. Prior to installation of the cables, a pre-lay grapnel run would be performed in all instances to locate and clear obstructions such as abandoned fishing gear and other marine debris. Following the pre-grapnel run, dredging within the OECC would occur (where necessary) to allow for effective cable laying through the sand waves. The majority of dredging would occur on large sand waves, which are mobile features. See COP Volume II-A, Figure 2.1-13 for an indication of areas prone to large sand waves (Epsilon 2018). Vineyard Wind anticipates that dredging would occur within a corridor that is 65.6 feet (20 meters) wide and 1.6 feet (0.5 meters) deep, and potentially as deep as 14.7 feet (4.5 meters). Vineyard Wind is proposing to lay most of the inter-array cable and offshore export cable using simultaneous lay and bury via jet embedment. In certain areas, alternative installation methods may be needed. In any case, cable burial would likely use a tool that slides along the seafloor on skids or tracks (up to 3.3 to 6.6 feet [1 to 2 meters] wide), which would not dig into the seafloor but would still cause temporary disturbance. The installation methodologies are described in detail in COP Volume I, Section 4.2.3 (Volume I; Epsilon 2018).

For the installation of the two cables, total dredging could impact up to 69 acres (279,400 m^2) and could include up to 214,500 cubic yards (164,000 cubic meters) of dredged material. Vineyard Wind could use several techniques to accomplish the dredging: trailing suction hopper dredge (TSHD) or jetting (also known as mass flow excavation).[5] TSHD would discharge the sand removed from the vessel within the 2,657-foot (810-meter) wide cable corridor.[6] Jetting would use a pressurized stream of water to push sand to the side. The jetting tool draws in seawater from the sides and then jets this water out from a vertical down pipe at a specified pressure and volume. The down pipe is positioned over the cable alignment, enabling the stream of water to fluidize the sands around the cable, which allows the cable to settle into the trench. This process causes the top layer of sand to be side-casted to either side of the trench; therefore, jetting would both remove the top of the sand wave and bury the cable. Typically, a number of passes are required to lower the cable to the minimum target burial depth.

Protection conduits installed at the approach to each WTG and ESP foundation would protect all offshore export cables and inter-array cables. In the event that cables cannot achieve proper burial depths or where the proposed offshore export cable crosses existing infrastructure, Vineyard Wind could use the following protection methods: (1) rock placement, (2) concrete mattresses, or (3) half-shell pipes or similar product made from composite materials (e.g., Subsea Product from Trelleborg Offshore) or cast iron with suitable corrosion protection.[7] Vineyard Wind has conservatively estimated up to 10 percent of the inter-array and offshore export cables would require one of these protective measures.

Vessels types proposed for the cable installation could be vessels capable of dynamic positioning, anchored vessels, self-propelled vessels, and/or barges.

Utilizing the PDE Concept for this part of the proposed Project, a single primary offshore export cable corridor with two potential routes through Muskeget Channel is analyzed in this BA. Two potential landfall sites are also considered in this BA, Covell’s Beach in Barnstable, Massachusetts, and New Hampshire Avenue in Yarmouth, Massachusetts (see Figure 3). Detailed specifications of offshore export cables and inter-array cables are provided in the COP Volume I, Sections 3.1.5 and 3.1.6, respectively (Epsilon 2018).

[5] TSHD can be used in sand waves of most sizes, whereas the jetting technique is most likely to be used in areas where sand waves are less than 6.6 feet (2 meters) high. Therefore, the sand wave dredging could be accomplished entirely by the TSHD, 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.

[6] Vineyard Wind anticipates that the TSHD would dredge along the OECC until the hopper was filled to an appropriate capacity, then the TSHD would sail several hundred meters away (while remaining within the 2,657-foot [810-meter] corridor) and bottom dump the dredged material.

[7] Half-shell pipes come in two halves and are fixed around the cable to provide mechanical protection. Half-shell pipes or similar solutions are generally used for short spans, at crossings or near offshore structures, where there is a high risk from falling objects. The pipes do not provide protection from damage due to fishing trawls or anchor drags (COP Volume I, Section 3.1.5.3; Epsilon 2018a)

4.1.5. Operations and Maintenance

The proposed Project would have a designed operating phase of 30 years[8]. Vineyard Wind would monitor operations continuously from the Operations and Maintenance Facilities and possibly other remote locations as well. Specifically, Vineyard Wind may use a new operations and maintenance facility in Vineyard Haven on Martha's Vineyard. The Operations and Maintenance Facilities would include offices, control rooms, shop space, and pier space, which may be supplemented by continued use of the New Bedford Marine Commerce Terminal (MCT) on the mainland; again, Vineyard Wind does not propose to direct or implement any port improvements. Therefore, none of these activities would be occurring as a direct result of the Proposed Action (COP Volume I, Section 3.2.5; Epsilon 2018).

Crew transfer vessels and helicopters would transport crews to the proposed offshore Project area during operations and maintenance. The Proposed Action would generate trips by crew transport vessels (about 75 feet [22.3 meters] in length), multipurpose vessels, and service operations vessels (SOV) (260 to 300 feet [79.2 to 91.4 meters] in length), with larger vessels based at the MCT and smaller vessels based at Vineyard Haven. In a typical year, the Proposed Action would generate 256 crew transfer vessel trips, 110 multipurpose vessel trips, and 26 service operation vessel trips (COP Volume I, Section 4.3.4, Table 4.3-2; Epsilon 2018). Dedicated crew transport vessels specifically designed for offshore wind energy work would provide access. These vessels would be based primarily at the Operations and Maintenance Facilities. Helicopters may also be used for access and/or for visual inspections. The helicopters would be based at a general aviation airport near the Operations and Maintenance Facilities.

WTG gearbox oil would be changed after years 5, 13, and 21 of service. Additional operations and maintenance information can be found in COP Section 4.3 (Volume I; Epsilon 2018).

4.1.6. Decommissioning

According to 30 CFR Part 585 and other BOEM requirements, Vineyard Wind would be required to remove or decommission all installations and clear the seabed of all obstructions created by the proposed Project. All facilities would need to be removed 15 feet (4.6 meters) below the mudline (30 CFR § 585.910(a)). Absent permission from BOEM, Vineyard Wind would have to complete decommissioning within 2 years of termination of the lease and either reuse, recycle, or responsibly dispose of all materials removed.

Although the proposed Project has a designed life span of 30 years, some installations and components may remain fit for continued service after this time. Vineyard Wind would have to apply for an extension if it wished to operate the proposed Project for more than 30 years.

Offshore cables may be retired in place or removed. In consideration of mobile gear fisheries (i.e., dredge and bottom trawl gears), Vineyard Wind is committed to removing scour protection during decommissioning.

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[8] Vineyard Wind's lease with BOEM (Lease OCS-A 0501) has an operations term of 25 years that commences on the date of COP approval. (See https://www.boem.gov/Lease-OCS-A-0501/ at Addendum B; see also 30 CFR § 585.235(a)(3)) Vineyard Wind would need to request an extension of its operations term from BOEM in order to operate the proposed Project for 30 years. For purposes of the maximum-impact scenario and to ensure National Environmental Policy Act coverage if BOEM grants such an extension, the Draft EIS analyzes a 30-year operations term.

Vineyard Wind would drain WTG and ESP fluids into vessels for disposal in onshore facilities before disassembling the structures and bringing them to port. Foundations would be temporarily emptied of sediment, cut 15 feet (4.6 meters) below the mudline in accordance with BOEM regulations (30 CFR § 585.910(a)), and removed. The portion buried below 15 feet (4.6 meters) would remain, and the depression would be refilled with the sediment that had been temporarily removed.

By maintaining an inventory list of all components of the proposed Project, the decommissioning team would be able to track each piece so that no component would be lost or forgotten.

The above decommissioning plans are subject to a separate approval process. This process will include an opportunity for public comment and consultation with municipal, state, and federal management agencies. Vineyard Wind would require separate and subsequent approval from BOEM to retire any portion of the Proposed Action in place. Regulations default to complete site clearance.

4.2. Onshore Facilities

4.2.1. Landfall Site

The proposed Project has two proposed landfall locations, Covell’s Beach in Barnstable and New Hampshire Avenue in Yarmouth. The Covell’s Beach landfall site is located on Craigville Beach Road near a paved parking lot entrance to a public beach that is owned and managed by the Town of Barnstable. The New Hampshire Avenue landfall site is located inside of Lewis Bay at a dead-end road just west of Englewood Beach at a low concrete bulkhead. The transition of the export cable from offshore to onshore would be accomplished by horizontal directional drilling (HDD), which would bring the proposed cables beneath the nearshore area, the tidal zone, beach, and adjoining coastal areas to one of the two proposed landfall sites. Alternatively, the proposed cables could be brought ashore at the New Hampshire Avenue landfall through the use of direct bury. Vineyard Wind has requested approval of both landfall locations as part of its PDE; however, only one landfall location would be implemented for the Proposed Action. The Draft EIS assesses both proposed landfall locations, as well as the different proposed installation methods. One or more underground concrete transition vaults, also called splice vaults, would be constructed at the landfall site. These would be accessible after construction via a manhole. Inside the splice vault(s), the 220-kV AC offshore export cables would be connected to the 220 kV onshore export cables.

A detailed description of the proposed landfall sites are provided in COP Volume I, Section 3.2.1 (Epsilon 2018). Further discussion of proposed landfall site construction approach is provide in COP Volume I, Section 4.2.3.8 (Epsilon 2018).

4.2.2. Onshore Export Cable and Substation Site

The proposed Project contemplates two onshore export cable routes (OECRs), with alternative options within each route. The western route would begin at the Covell’s Beach landfall site in Barnstable, while the eastern route would begin at the New Hampshire Avenue landfall site in Yarmouth. The majority of the two proposed OECRs would pass through already-developed areas, primarily paved roads and existing utility rights of way, and would be entirely underground. Vineyard Wind would run the onshore export cables through a single concrete duct bank buried along the entire OECR. The duct bank may vary in size along its length, and the planned duct bank could be arrayed four conduits wide by two conduits deep (flat layout) measuring up to 5 feet (1.5 meters) wide by 2.5 feet (0.8 meter) deep or vice versa with an upright layout with two conduits wide by four conduits deep. The top of the duct bank would typically have a minimum of 3 feet (0.9 meter) of cover comprised of properly compacted sand topped by pavement.

The proposed onshore export cables would terminate at the proposed substation site. This previously developed site is adjacent to an existing substation within Independence Park, a commercial/industrial area in Barnstable. The new onshore substation site would occupy 7 acres (28,328.1 square meters [m^2]). The buried duct bank would enter the proposed onshore substation site via an access road that provides access to the transmission corridor from Mary Dunn Road. Vineyard Wind plans to connect the proposed Project to the grid via available positions at the Eversource Barnstable Switching Station, just north of the proposed onshore substation site; however, Vineyard Wind's COP also includes an option to connect at the West Barnstable Switching Station (see Figure 1-2).

Detailed specifications of the onshore export cable are provide in COP Volume I, Section 3.2.3. Further discussion of the proposed onshore export cable construction approach is provided in COP Volume I, Section 4.2.3.9 (Epsilon 2018).

4.3. Proposed Mitigation Measures

Vineyard Wind's self-imposed measures to avoid or reduce potential impacts on listed whales species and turtles are listed below during pile driving (COP Volume III Attachment-M). Additional mitigation and monitoring measures are also proposed by BOEM for consultation in this BA. The following definitions are used for terms below:

Monitoring Zone: The monitoring zone is the area around an impact-producing activity that is to be observed for the presence of endangered and threatened species and biological indicators such as schools of fish, jellyfish, or other indicators of possible marine mammal and sea turtle presence. This zone includes and extends beyond the exclusion zone and observed to greatest extent practicable. The area beyond the exclusion zone is demarcated and intended to document animal presence in the area and monitor movements toward the clearance zone. Identification of the species, direction of travel, behavior, oceanic and biological conditions, and other data reporting are conducted within this zone.

Clearance Zone: The clearance zone is the area around an impact-producing activity which is observed to ensure no endangered or threatened species are present prior to the commencement of the activity. Adequate numbers of PSOs and monitoring conditions must be present for effective monitoring of the clearance zone. The size of this zone may vary depending on the activity. Data collection such as animal behavior, actions taken, and other data are conducted in this zone.

Soft Start: The soft start process will consist of 3 single hammer strikes at less than 40 percent hammer energy followed by at least one minute delay before the subsequent hammer strikes. This process shall be conducted a total of 3 times (e.g. 3 single strikes, delay, 3 single strikes, delay, 3 single strikes, delay). This approach is consistent with that required in the Block Island Incidental Take Authorization issued by NMFS.

- Seasonal Restrictions[9]: Vineyard Wind would establish a restriction on pile driving between January 1 and April 30.
- Sound Reduction Technology: Vineyard Wind would implement attenuation mitigation to reduce sound levels by a target of approximately 12 dB (a maximum impact scenario of only a -6 dB reduction is analyzed in the BA since the type of sound reduction system that will be used is not yet identified that could be evaluated for past effectiveness during use).
  - A noise attenuation technology would be implemented (e.g., Noise Mitigation System [NMS], Hydro-sound Damper [HSD], Noise Abatement System [AdBm], bubble curtain, or similar), and a second back-up attenuation technology (e.g. bubble curtain or similar) will be on-hand, if needed pending results of field verification
- Sound Source Characterization: Sound levels would be recorded for each of the pile types for comparison with model results
- Low Visibility Construction Operations: Pile driving would not be initiated when the clearance zone cannot be visually monitored
- Protected Species Observers (PSOs):
  - A minimum of two PSOs would maintain watch during daylight hours when pile driving is underway,
  - PSOs may not perform another duty while on watch,
  - PSOs will communicate with vessel operators verbally via radio or cell phone communication. Vessel operators will be briefed on the Project monitoring and mitigation measures and buffer distances before the Project starts, and communication protocols agreed between PSOs and vessel operators. These reviews will be repeated whenever there are personnel changes,
  - PSOs may not exceed four consecutive watch hours; must have a minimum two hour break between watches; and may not exceed a combined watch schedule of more than 12 hours in a 24-hour period (Baker et al. 2013),
  - All PSOs would have training certificates that meet or exceed BOEM/BSEE criteria or have NMFS approval, or will be pre- approved by NMFS,
  - PSOs would be deployed on the installation vessel,
  - PSOs would check the NMFS Sighting Advisory System for NARWs on a daily basis. Additionally, vessel captains will monitor Coast Guard VHF Channel 16 throughout the day to receive notifications of any sightings. This information would be used to alert the team to the presence of a NARW in the area and to implement mitigation measures as appropriate (such as if a DMA were established),

[9] This restriction is intended to minimize the amount of pile driving that occurs when the migratory NARW is likely to be in the Offshore Project Area and thus limit sound exposure for this endangered species. Density data from Roberts et al. (2016) and survey data (both visual and acoustic) from Kraus et al. (2016) suggest that the highest density of NARWs in the WDA occurs annually during the month of March. Over 93 percent of the sightings in the Kraus et al. (2016) study occurred in the months of January through April, with no NARWs sighted from May through August.

- Monitoring zones and clearance zones will be monitored around the pile center for marine mammals would record behavioral activity of animals observed, and
- PSOs would record behavioral activity of animals observed

- Pre-piling Monitoring Timing: PTS zone(s) must be clear for the following time period prior to pile driving:
  - Mysticete whales and sea turtles[10] for 30 minutes, and
  - Odontocetes and Pinnipeds for 15 minutes
- Soft-start would be implemented during pile driving.
- A Passive Acoustic Monitoring (PAM) system will be used by trained PAM operators to monitor for acoustic detections. The PAM system will be in operation in accordance with the pre-piling clearance timing described in Table 31 of Appendix III-M of the COP. Any PAM detection of a listed whale within the clearance zone would be treated the same as a visual observation. If a marine mammal is detected (via PAM or visual observation) approaching the clearance zone, pile driving will not start until the clearance zones are clear for 15-30 minutes (as specified in Table 31 of Appendix III-M of the COP), or, if pile driving has commenced, the PSO will request a temporary cessation of pile driving. Where shut-down is not possible to maintain installation feasibility, reduced hammer energy will be requested and implemented where practicable. The PAM system will follow technical specifications to detect marine mammals and be deployed such that interference by other operational noise will be minimized.
- Clearance zones for monopile and jacket installation:
  - Mysticete Whales: 500 m, and
  - Odontocetes, Pinnipeds and Sea Turtles: 50 m
- Monitoring zone for monopile and jacket installation:
  - During Monopile Installation: 2,750 m, and
  - During Jacket Installation: 2,200 m
- Shut downs:
  - If a marine mammal or sea turtle is observed approaching the clearance zone, the PSO would request a temporary cessation of pile driving. For safety reasons during the initial stages of pile driving, the piling cannot be stopped because the pile penetration must be deep enough to ensure pile stability in an upright position. Later in the pile driving process, piling must often continue to ensure foundation stability by reaching the target penetration depth without early refusal due to cessation of pile driving. In the instance where pile driving is already started and a PSO recommends pile driving be halted, the lead engineer on duty will evaluate the following: 1) Use the site-specific soil data and the real-time hammer log information to judge whether a stoppage would risk causing piling refusal at re-start of piling; and 2) Check that the pile penetration is

[10] Consistent with sea turtle clearance times for seismic activity in the Atlantic and Gulf of Mexico - 30 minutes (BOEM 2012, BOEM-NTL-2016-G02).

deep enough to secure pile stability in the interim situation, taking into account weather statistics for the relevant season and the current weather forecast. Determinations by the lead engineer on duty will be made for each pile as the installation progresses and not for the site as a whole. Where shut-down is not possible to maintain installation feasibility, reduced hammer energy would be requested and implemented where practicable. Reduced hammer energy is more likely to be feasible under circumstances where the pile is advancing at a typical rate and would be expected to continue to advance under lower hammer energy.

- After shut down, piling can be initiated once the clearance zone is absent of the animals for the minimum species-specific time period, or if required to maintain installation feasibility

In addition to the self-imposed measures identified above, Vineyard Wind would also implement the following measures specific to NARWs:

- Time of year restriction from May 1 to May 14.
  - An extended PAM monitoring zone of 10 km would be implemented for NARW
  - PAM will be operated 24/7
  - Prior to piling, an aerial or boat survey would be conducted across the extended 10 km monitoring zone
  - Aerial surveys would not begin until the lead PSO determines adequate visibility and at least 1 hour after sunrise (on days with sun glare as determined by the lead PSO on duty)
  - Boat surveys would not begin until the lead PSO determines there is adequate visibility
  - If a NARW is sighted during the survey, piling operations would not be conducted that day unless an additional survey is conducted to confirm the zone is clear of NARW
- Vineyard Wind from May 1 to December 31would implement 60 minute pre-piling monitoring time period and the PTS Zone would be a minimum 1000 m.
- Vineyard Wind from November 1 to December 31 would implement an extended PAM monitoring zone of 10 km for NARW and PAM would be operated 24/7.

In addition to the self-imposed measures identified above, Vineyard Wind will also implement the following measures specific to NARWs associated with vessel speed:

- Vineyard Wind from November 1 to May 14 would implement the following:
  - Vessels would travel at less than 10 knots within the WDA,
  - When transiting to or from the WDA (except while in Nantucket Sound, which has been demonstrated by best available science to not provide consistent habitat for NARW) Vineyard Wind would either travel at less than 10 knots or would implement visual surveys or PAM to ensure the transit corridor is clear of NARW,
- Vineyard Wind would reduce speeds within a voluntary dynamic management area to 10 knots unless visual surveys or PAM are conducted which demonstrate that NARW are not present in the transit corridor, and

- Vineyard Wind would implement year-round an observer who has undergone marine mammal training to be stationed on vessels transiting to and from the WDA if traveling over 10 knots

BOEM mitigation measures being considered for the proposed Project are listed below. The mitigation measures may not all be within BOEM's statutory and regulatory authority to be required; however, they could potentially be imposed by other governmental entities and include, but are not limited to:

- Adaptive management: Reduce impacts on marine trust resources through near-term refinement of exclusion zones based on field measurements of noise reduction systems, and long-term refinements of other pile-driving monitoring protocols based on monthly and/or annual monitoring results,
- Pile Driving: Use noise reduction technologies during all pile-driving activities to achieve a required minimum attenuation (reduction) of 6 dB re 1 μPa to reduce noise impacts during construction,
- Long-term PAM: Use fixed PAM buoys or autonomous PAM devices to continuously record ambient noise in the lease area (before, during, and immediately after construction), record marine mammal vocalizations, and monitor Project noise including vessel noise, pile driving, and WTG operation. Data collection, archival, analysis, and reporting of the results would be conducted by third parties following established guidelines specified by BOEM,
- Sunrise and sunset prohibition on pile driving: When sun glare prevent effective observations, the Lead PSO will prohibit commencing pile driving from 1 hour before sunset or 1 hour after sunrise to ensure effective visual monitoring can be accomplished in all directions. However, ongoing pile driving may continue after 1 hour before sunset until completed,
- Daily pre-construction surveys: PAM and visual surveys must be conducted each day before pile driving begins to establish the abundance, presence, behavior, and travel directions of protected species in the area. The PSOs will consider visibility, sea state, glare and other factors in coordinating with vessel operators regarding vessel strike avoidance measures. The Project's proposed vessel strike avoidance measures are listed in Table 31 of Appendix III-M of the COP, which call for buffers of 50-500 m between vessels and marine mammals. (Specific to North Atlantic Right Whales [NARW], Appendix III-M states the Project will maintain 500 m between all transiting vessels and NARW.) If the PSO decides that they cannot adequately monitor out to the proposed buffer distances, they may request the implementation of additional mitigation measures, such as vessel speed reductions to <10 knots. Standard protocols and data collection will be followed as specified by BOEM,
- Ecological monitoring: Conduct long-term monitoring to document the changes to the ecological communities on, around, and between WTG foundations and other benthic areas disturbed by the proposed Project, including protected species movement and habitat use,
- Regional monitoring initiative for protected species: Centrally fund long-term regional monitoring of population level impacts. BOEM has held 2 workshops on protected species monitoring needs in 2017 and 2018. The Research Framework report from May 30-31, 2018 workshop in New Bedford, Ma. A draft is expected in May 2019. The report is anticipated to be adopted as the initial planning document for identifying monitoring priorities for the regional monitoring strategy. There are active discussions among stakeholders and the offshore wind industry on this collaborative effort to answer

specific scientific research questions about long-term impacts from the offshore wind industry as a whole, and

- Annual underwater ROV surveys, reporting, and monofilament and other fishing gear clean up around WTG foundations: Monitor indirect impacts associated with charter and recreational gear lost from expected increases in fishing around WTG foundations. Surveys would inform frequency and locations of debris removal to decrease ingestion by and entanglement of protected species

Vineyard Wind's self-imposed measures to avoid or reduce potential impacts on Atlantic sturgeon include:

- Utilization of soft-start during pile-driving,
- Perform pre- and post-construction fisheries monitoring,
- Utilization of mid-line buoys, if feasible and safe, to minimize impacts and installation equipment that minimizes installation impacts, such as jet plow,
- Avoidance, to the extent feasible, of eelgrass and hard bottom sediments, and
- Cables to be buried in the substrate or covered with rock or concrete mattresses to mitigate the impacts of EMF

BOEM mitigation measures being considered for the proposed Project are listed below. The mitigation measures may not all be within BOEM's statutory and regulatory authority to be required; however, they could potentially be imposed by other governmental entities and include:

- Landfall site construction method: Require use of horizontal directional drilling (HDD) at landfall transition sites,
- Adaptive management: Reduce impacts on marine trust resources through near-term refinement of exclusion zones based on field measurements of noise reduction systems, and long-term refinements of other pile-driving monitoring protocols based on monthly and/or annual monitoring results,
- Pile Driving: Use noise reduction technologies during all pile-driving activities to achieve a required minimum attenuation (reduction) of 6 dB re 1 μPa to reduce noise impacts during construction,
- Long-term PAM: Use fixed PAM buoys or autonomous PAM devices to continuously record ambient noise in the lease area (before, during, and immediately after construction), record marine mammal vocalizations, and monitor Project noise including vessel noise, pile driving, and WTG operation. Data collection, archival, analysis, and reporting of the results would be conducted by third parties following established guidelines specified by BOEM,
- Ecological monitoring: Conduct long-term monitoring to document the changes to the ecological communities on, around, and between WTG foundations and other benthic areas disturbed by the proposed Project, including protected species movement and habitat use, and

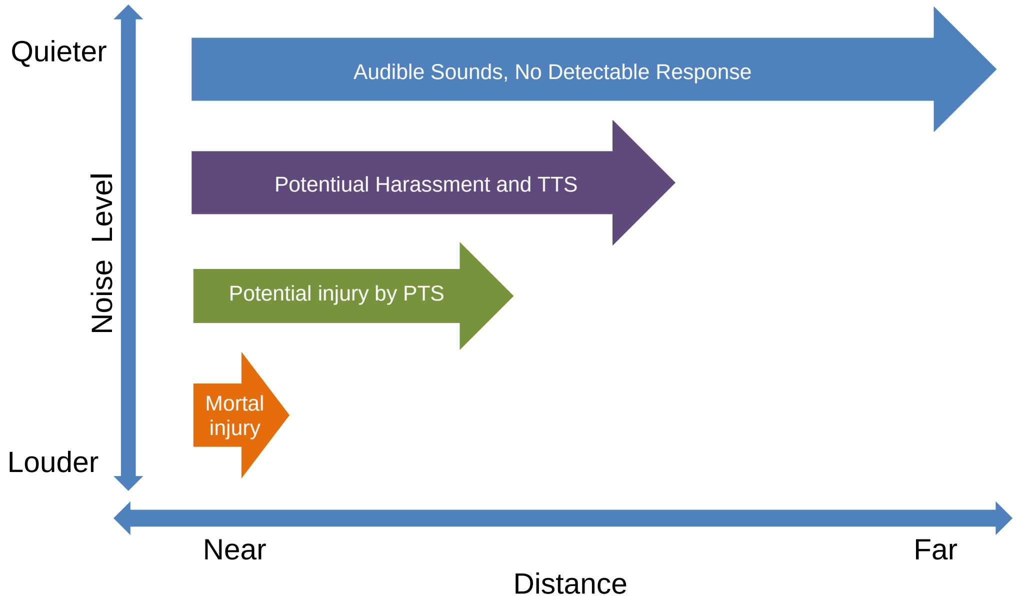
Regional monitoring initiative for protected species: Centrally fund long-term regional monitoring of population level impacts. Annual underwater ROV surveys, reporting, and monofilament and other fishing gear clean up around WTG foundations: Monitor indirect impacts associated with charter and recreational gear lost from expected increases in fishing around WTG foundations. Surveys would inform frequency and locations of debris removal to decrease ingestion by and entanglement of protected species.

5. EFFECTS OF THE PROPOSED ACTION

Effects of the action are evaluated for the potential to result in harm to listed species. If a project activity may effect a listed species, the exposure level and duration of effects are evaluated further for the potential for those effects to harass or injure listed species. The following sections present the potential Project-related effects on listed species of marine marines, sea turtles, and Atlantic sturgeon from the construction/installation, operations/maintenance, and decommissioning stages over the lifetime of the project.

Background on the Effects of Underwater Sound

Although several potential impacts are analyzed in more detail below, a focus of potential impacts includes an analysis of effects resulting from the production of underwater sound. The following provides background on underwater noise and some of the assumptions used in the analysis. Depending on the type and location of a noise, potential effects from noise sources can range from increases in background noise (ambient noise) to disturbance and in some cases injury from very loud sounds. Disturbance of normal behaviors may result in potentially adverse effects on feeding success, resting periods, migration, diving patterns, or breeding behaviors. Exposure to very loud, high pressure, or persistent noises, may impair animals through temporary and permanent hearing loss. In general, mortal injury is not expected of marine mammals and sea turtles from the sound sources associated with the proposed action, but fish, especially small fish, with swim bladders could suffer mortal swim bladder injury at very close distances to a pile being driven by an impact hammer if no mitigation is implemented to avoid such injuries from occurring.



Generalized diagram of the relative response to noise with loudness level and distance from the sound source

Marine mammals use sound for vital biological functions, including socialization, foraging, responding to predators, and orientation. Effects on hearing ability or disturbance can result in disturbance of important biological behaviors such as migration, feeding, resting, communication, and breeding. It has been documented that some anthropogenic noise can negatively impact the biological activities of marine mammals in some instances (Southall et al. 2007). The response of marine mammals to sound depends on a range of factors including: (1) the SPL (frequency, duration, and novelty of the sound); (2) the physical and behavioral state of the animal at the time of perception; and (3) the ambient acoustic features of the environment (Hildebrand 2004; Nowacek et al. 2004; Southall et al. 2011). Although the traditional criteria for behavioral disturbance will be used, in all likelihood there will be a spectrum of behavioral responses with some animals or species showing tolerance of some noise while others may elicit stronger responses based on the signal characteristics (Nowacek et al. 2004).

In general, while many anthropogenic sounds are above ambient levels, and hence can be heard, animals have different hearing abilities which directly affect their sensitivities and potential responses to certain types of sound. In order for a sound to potentially effect an animal, it must be able to be heard by the species of interest. Sea turtles generally hear sounds 50 Hz to 2 kHz, baleen whales 7 Hz to 35 kHz, and sperm whales 275 Hz to 160 kHz. Atlantic sturgeon are low frequency generalists with best hearing below 2,000 Hz. Therefore, listed sea turtles and fish can likely hear low frequency sounds produced by large vessels and pile driving, but cannot hear the mid and high frequency noise sources such as sonars. Although whale hearing is much broader than in fish or turtles, baleen whales have best hearing focused in lower frequencies up to 35 kHz. Sperm whales have mid-frequency hearing abilities and have a broad ability to hear many underwater sounds from 150 Hz to 160 kHz (see species description sections for additional information on hearing abilities). Although sperm whales can likely hear the sounds produced by pile driving, they are believed be less sensitive than baleen whales that have best hearing in the lower frequencies produced by pile driving.

Exposure thresholds are useful to estimate when potential effects are likely to occur. Applying thresholds to assess potential impacts, sound exposure levels above certain thresholds would have the greatest potential to disturb or cause injury and require additional analysis to determine if adverse impacts are likely, or not likely to occur. Marine mammal exposure thresholds have been published for assessing the effect of sound exposure on marine mammal hearing (National Marine Fisheries Service 2016). Studies of some marine mammals indicate that the onset of TTS and permanent threshold shift (PTS) are correlated with the peak pressure, and sound exposure level depending on the frequency, duration, and intensity of exposure to a sound source. There is also some evidence of TTS in sea turtles from loud impulsive sources. Although airgun arrays will not be used for renewable energy program surveys, most information on sea turtle responses to impulsive sounds is available for airguns. Therefore, impulsive sources such as pile driving and the potential effects on sea turtles are inferred from the available information from other sound types. In a study of juvenile loggerheads sponsored by the U.S. Army Corps of Engineers (Moein et al. 1994), sea turtles were contained in a pen in shallow water as they were exposed to pulses from a single airgun. Physiological and behavioral responses were observed. The turtles avoided airgun pulses, at received levels of 175-180 dB re 1 μPa, but either habituated or suffered TTS by the third presentation of the sounds. In some cases, these animals remained close to the airgun as it was operating. In 10-15% of the sea turtles exposed to airgun pulses, a temporary shift in auditory responses was measured.

Behavioral reactions are expected to occur over a wide spectrum of responses, some which may be negligible, while others can possibly result in disturbance. To assess the potential for disturbance, BOEM currently follows NMFS traditional threshold criteria for marine mammals, and commonly used thresholds for sea turtles and fish. Exposures to sound levels above these thresholds are considered to have a potential to adversely affect listed species. Unlike impacts to hearing abilities, the likelihood of an exposure being adverse depends on a number of factors including the context of the exposure, time of year, and habitat.

- 160 re 1 μPa root mean square (RMS) for the potential onset of behavioral disturbance (Level B) from a *non-continuous* source (e.g., impact pile driving, HRG surveys)
- 166-175 dB re 1 μPa (RMS) for sea turtles, and
- 150 dB re 1 μPa (RMS) for Atlantic sturgeon.

Animals exposed to levels above the threshold will be further considered for their potential to be injured or disturbed. Another method for marine mammals applies a probabilistic approach that predicts the percentage of animals exposed that may be disturbed by sound (Wood et al. 2012). The model proposes that marine mammals will generally show a gradually increasing behavioral response to mammal hearing weighted (M-weighted) sound levels (L_{rms}). The application of this approach is not used in this BA. In general, the application of the traditional criteria is more conservative and assumes 100 percent of animals will have the potential to be disturbed from impulsive noise at 160 dB (RMS).

5.1. Effects of the Proposed Action on Marine Mammals

5.1.1. Construction and Installation

Construction and installation of offshore components consists of six elements: WTG foundation pile driving, ESP foundation pile driving, inter-array and interlink cable installation, scour protection, and installation of offshore export cables.

5.1.1.1. Acoustic Impacts

Cetaceans rely heavily on acoustics for communication, foraging, mating, avoiding predators, and navigation (Madsen et al. 2006; Weilgart 2007). Proposed Action activities could potentially affect marine mammals if the sound frequencies produced overlap with the functional hearing range of the animal exposed (NSF and USGS 2011). Noise-producing Proposed-Action activities may negatively affect marine mammals during foraging, orientation, migration, predator detection, social interactions, or other activities (Southall et al. 2007). Noise exposure associated with the proposed action can interfere with these functions, with the potential to cause a range of responses ranging from insignificant behavioral changes to ear injury, depending on the intensity and duration of the exposure. Marine mammals may also be affected by non-acoustic activities including vessel operations, accidental spills, and habitat impacts associated with the Proposed Action. For example, studies indicate that noise from shipping increases stress hormone levels in NARWs (Rolland et al. 2012), and modeling suggests that their communication space could be reduced substantially by vessel noise in a busy shipping lane (Hatch et al. 2012). These authors also expressed concern that physiological stress may contribute to suppressed immunity and reduced reproductive rates and fecundity in the NARW (Hatch et al. 2012; Rolland et al. 2012), but a clear distinction between stress induced by shipping noise from other stress-producing factors that can reduce reproductive success in NARWS (e.g., contaminants and entanglements) has not yet been established. The release of stress hormones is a typical response in mammals and may be are expected to occur in other species for other marine mammals. Animals may be motivated to remain in an area to feed or other reasons that may prolong noise exposure and increase stress levels. Other responses to Project-related noise may include avoidance of an ensonified area, which may have energetic consequences on individuals.

Pile Driving

Pyć et al. (2018) conducted acoustic modeling of underwater sound generated by construction of the Project and the modeled exposure of marine mammals to Project noise at different times of year according to the proposed construction schedule. The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the probability of exposure of animals to sound arising from the Project's pile driving operations. Sound exposure models like JASMINE use simulated animals (animats) to sample the predicted 3D sound fields with movement rules derived from animal observations. The output of the simulation is the exposure history for each animat within the simulation. Modeled sound fields are generated from representative pile locations and animats are programmed to behave like the marine animals that may be present in the offshore Project area. The parameters used for forecasting realistic behaviors (e.g., diving, foraging, aversion, surface times, etc.) are determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species as referenced in Pyć et al. 2018. An individual animat's sound exposure levels are summed over a specified duration, such as the amount of pile driving occurring over a 24-hour period, to determine its total received energy, and then compared to the threshold level criteria to assess potential impacts on the animals (see Pyć et al. 2018 for modeling methods).

For estimating marine mammal densities (animals/km^2) for modeling, Pyć et al. (2018) used the Duke University Marine Geospatial Ecological Laboratory model results (Roberts et al. 2016a) and an unpublished updated model for NARW densities (Roberts et al. 2016b) that incorporates more sighting data, including those from the Atlantic Marine Assessment Program for Protected Species (NEFSC and SEFSC 2010, 2011b, 2012, 2013, 2014). This is considered the best available information to be used for modeling in this assessment. Because uncommon occurrences of sei whales in the Project area may be underrepresented in the Duke modeling as not occurring because of the very low sightings rates, sei whales have still been included in this BA as potentially occurring. This does not mean the exposure estimates for sei whales are not accurate, because their occurrence is still expected to be uncommon. However, the probability modeling does account for the uncommon, but not completely discountable occurrence of sei whales in the Project area based on recent surveys. The mean density for each month was calculated using the mean of all 6.2 x 6.2 mile (10 x 10 kilometer) grid cells partially or fully within the buffer zone polygon. Mean values from the density maps were converted from units of abundance (animals/100 km2 [38.6 square miles]) to units of density (animals/km2). Densities were computed for months May-December to coincide with planned pile driving activities (see Table 6 in Pyć et al. 2018 for mean monthly marine mammal density estimates used in the model).

The NMFS guidance for determining the potential for permanent threshold shift (PTS) in marine mammals (Table 5.1-1), also considered potential Level A Harassment[11]as defined by the MMPA, was used in sound exposure modeling to assess the potential impacts of PTS on marine mammals. These numbers represent modeled exposure numbers/24-hr period and may require further analysis for the potential level and amount of take through consultation with NMFS.

PTS (or permanent hearing loss at certain frequencies) is considered an unrecoverable injury to the ear, while temporary threshold shift (TTS), considered potential Level B Harassment as defined by the MMPA, is a temporary impairment to hearing ability that is fully recoverable. The frequencies animals are exposed to in the PTS modeling have been weighted based on the hearing sensitivity for each species. Low frequency cetaceans (LFC) include NARW, fin, and sei whales; sperm whales belong to the mid-frequency cetacean hearing group.

Table 5.1-1: PTS Onset Acoustic Threshold Levels

Hearing Group	PTS Onset Thresholds[a] (received level)	
	Impulsive	Non-impulsive
LFC	Lpk, flat 219 dB LE24 183 dB	LE24 199 dB
MFC	Lpk, flat 230 dB LE24 185 dB	LE24 198 dB

Source: Pyć et al. 2018; NMFS 2018e

dB = decibel; L_{pk} flat = peak sound pressure is flat weighted or unweighted and has a reference value of 1µPa; L_{E24} = cumulative sound exposure over a 24 hour period and has a reference value of 1 μPa^2s; LFC = low-frequency cetacean (all the large whales except sperm whales); MFC = mid-frequency cetacean (sperm whales); PTS = permanent threshold shift

[a] Dual-metric acoustic thresholds for impulsive sounds. Use whichever results in the largest isopleth (mapped distance) for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

NMFS has not yet released technical guidance on assessing behavioral responses to sound exposure. Until NMFS develops national guidance for assessing behavioral impacts on marine mammals, BOEM is assessing two prominent methods currently in use. The first method applies an unweighted, 160 root mean square (RMS) (NOAA 2005 as cited in Pyć et al. 2018) traditionally used by NMFS that assumes all animals exposed at that level or higher have the potential to adversely respond through a behavioral response.. This level of exposure does not consider frequency weighting or the variable response of individuals at different exposure levels. The second method applies frequency-weighted sound pressure levels (SPLs) for each hearing group (Wood et al. 2012) to estimate behavioral responses based on a gradual increase, or step function, that estimated a greater number of responses at higher SPLs and fewer adverse responses at lower SPLs farther from a sound source. This method applies a wider sound exposure range with different percentages of animals responding to noise exposure at each step between SPLs of 120-140, 140-160, and160-180 decibels (dBs) (Table 5.1-2).

[11] Level A harassment "has the potential to injure a marine mammal or marine mammal stock in the wild" (NOAA 2017).

Table 5.1-2: Behavioral Exposure Criteria (based on Wood et al. 2012)

Marine Mammal Group	Probability of response to frequency-weighted SPL (dB re 1 µPa)				Unweighted (dB root mean square) [a]
	120	**140**	**160**	**180**	
Migrating mysticete whales	10%	50%	90%		160
All other species (and behaviors)		10%	50%	90%	160

Source: Adapted from Wood et al. 2012; Pyć et al. 2018

µPa = micropascal; dB = decibel; SPL = sound pressure level

Note: Probability of behavioral response frequency-weighted sound pressure level (SPL dB re 1 µPa); probabilities are not additive.

[a] Pyć et al. 2018

Pyć et al. (2018) modeled the two possible design scenarios: 100 monopiles (34-foot-diameter [10.3-meter]) and up to 2 ESP jacket foundations (Scenario 1) or a combination of 90 monopiles and up to 12 jacket foundations (Scenario 2). The jacket-type foundation would have a higher acoustic impact and a greater risk of exposure than the monopile foundation because of the longer time required to install more piles (up to four 9.8-foot [3-meter] pin piles per jacket) (Pyć et al. 2018). Sound exposure levels are higher for marine mammals under Scenario 2 than under the Scenario 1 (Pyć et al. 2018). Thus, Scenario 2 would be considered the maximum-impact scenario, and model results for that scenario are the basis for this analysis of effects and proposed mitigation measures. Pyć et al. (2018) also modeled three levels of attenuation: 0 dB (no attenuation), 6 dB, and 12 dB. The 0 dB unmitigated level was modelled as a reference point to evaluate the effectiveness of the proposed mitigation of sound reduction technology (e.g. Hydro-sound Damper, bubble curtains or similar). When considering the most conservative level of attenuation (6 dB or 12 dB) to use for this analysis, BOEM identified 6 dB as the most appropriate because the type and manufacturer of a sound attenuation system has not yet been identified. Therefore, BOEM finds it is conservatively protective to assume a maximum impact scenario where the least effective attenuation level is achieved.

The monopile foundations are 312 feet (95 meters) in length and would be driven to a penetration depth of 66 to 148 feet (20 to 45 meters). The jacket piles foundations are 213 feet (65 meters) for the WTGs or 263 feet (80 meters) for the ESPs and would be driven to a penetration depth ranging from 98 to 246 feet (30 to 75 meters). Pyć et al. utilized the following assumptions: an IHC S-4000 hammer for driving the monopile foundations; an IHC S-2500 for driving the 9.8-foot (3-meter) jacket piles; total number of strikes to drive the monopile foundations was 5,500 and to drive the jacket pile foundation was 9,900. At full energy for the monopile, the strike rate was approximately 36 strikes per minute and the analysis assumed a slower strike rate of approximately 30 strikes per minute for the monopile installation resulting in a duration of approximately 11,000 seconds (3.05 hours) for continuous pile driving. Although individual piles for either foundation type are not expected to take more than a total of 3 hours to install, at a steady hammer rate, a jacket foundation would result in a driving duration of approximately 12,600 seconds (3.5 hours) [per pile or 14 hours per jacket foundation]. Table 5.1-3 presents the number of pile driving days for each month Vineyard Wind is anticipating for construction. With a rate of one pile (or jacket foundation) per day, the maximum number of pile driving days would be 102 days; however if conditions allow, two foundations could be driven per day. A comparison of number of the number of piles driven per day does not yield significantly different exposure estimates (Pyć et al. 2018), therefore the maximum number of days assuming one foundation installed per day yields the maximum impact scenario under NMFS' guidance to assess impacts based on each 24-hr. exposure period.

Table 5.1-3: Number of Monopiles Installed per Month

Month	Scenario 1 (number of pile driving days)[a]		Scenario 2 (number of pile driving days)[a]	
	Monopile	Jacket	Monopile	Jacket
May	12	0	12	1
June	16	0	14	2
July	18	1	16	2
August	18	1	16	2
September	14	0	12	2
October	12	0	12	1
November	8	0	6	1
December	2	0	2	1
Total Number of Foundations	100	2	90	12

[a] Assuming one pile per day (Pyć et al. 2018)

Model results show little difference in PTS, injurious exposures whether one or two monopile foundations are installed per day. However, for behavioral responses and potential harassment, exposure estimates for one monopile foundation per day are somewhat higher than for two monopoles foundations per day (Pyć et al. 2018). This is because the ensonified area that may result in behavioral disruption is larger than the area that may result in injury. Because behavioral disruption is assessed on the maximum single exposure, a behavioral disruption may be registered in response to both piles driven in a day but the animat is only counted once. With two monopile foundations per day, there are half as many days of pile driving so there is likewise a reduced number of predicted behavioral response exposures (Pyć et al. 2018).

As stated above, both Scenarios 1 and 2 would include the installation of monopile and jacket foundations. Table 5.1-4 shows a comparison of foundation types and that the jacket pile foundations would incur a larger radial distance to in which PTS may occur. Pyć et al. (2018) provides a radial distance to PTS for installation of one 34-foot (10.3-meter) monopile and four 10-foot (3-meter) jacket piles for each hearing group under the maximum-impact scenario (see Table 5.1-4). Radial distances to PTS are greater for four jacket piles compared to one monopile for all hearing groups (see Table 5.1-4) (Pyć et al. 2018). When comparing all hearing groups, radii are the largest for the low-frequency hearing group (mysticetes), and range from 4.5 miles (7,253 meters) for the jacket foundation to 2.0 miles (3,191 meters) for the monopile foundation under the maximum-impact scenario. Pyć et al. (2018) assumed jacket foundation installation occurring for a maximum of 12 pile-driving days under Scenario 2 (up to 10 WTG and two ESP jacket foundations; 2 days each month from June through September and 1 day each month during May, and October through December). In addition, under Scenario 1, Pyć et al. (2018) assumed jacket foundation installation occurring for two pile-driving days (two ESP jacket foundations; 1 day each month in July and August).

Table 5.1-4: Radial Distances (R95% in meters) to Sound Pressure Level for PTS and Harassment Thresholds for Marine Mammals with 6 dB Attenuation

Foundation Type	Hearing Group	Number of pile driving days for 1 foundation installed per day	PTS (L_{pk})	PTS (L_{E24})	Harassment Unweighted 160 dB (root mean square)	Harassment Frequency-Weighted Mean 50% Probability of Response (L_{E24}) [b]
34-foot (10.3-meter) diameter monopile	LFC	90	17	3,191	4,121	4,007
	MFC [a]	90	5	43	4,121	821
Four, 10-foot (3-meter) diameter jacket piles	LFC	12	4	7,253	3,220	3,302
	MFC [a]	12	1	71	3,220	1,406

Source: NOAA 2005, Pyć et al. 2018, and Wood et al. 2012

µPa2s = micropascal squared second; dB = decibel; LFC = low-frequency cetacean (all the large whales except sperm whales); Lpk = peak sound pressure; LE24 = cumulative sound exposure over a 24 hour period and has a reference value of 1 µPa2s; MFC = mid-frequency cetacean (sperm whales); WDA = Wind Development Area

Note: Level A distances are the average of two measured positions. Potential Harassment ranges are calculated using the average maximum hammer energy at two modeling sites for marine mammal functional hearing groups estimated for each scenario foundation type. Gray shaded cells = maximum radial distance for potential PTS and Harassment for each hearing group.

[a] The mysticetes found in the WDA during planned operations are likely foraging even if they are migrating (e.g., Leiter et al. 2017). The migrating mysticete category in Wood et al. (2012) was not used to select ranges used in the table.

[b] Wood et al. 2012

Based on the analysis, there is a potential risk of PTS and harassment to marine mammals from pile driving due to the large radial distance to this threshold and maximum-impact over the total of 102 days that pile driving may occur. Vineyard Wind's self-imposed measures of utilizing soft start, PSOs, and PAM would reduce the potential impacts on marine mammals. Additionally, the peak season of NARW occurrence between January and April will be completed avoided and no pile driving will occur at that time. Additional detail on Vineyard Wind's self-imposed measures are described in detail in Pyć et al. 2018, Table 31. However, an extremely small risk of exposure is possible if NARWs were not detected by PSOs and PAM. To account for this uncertainty for NARWs, anytime PSOs cannot visually see the entire exclusion zone or at night, pile driving operations may not continue until visual observing conditions improve. Therefore, BOEM considers the potential exposure of NARWs to pile driving noise to be discountable due to their low rate occurrence expected during months pile driving is allowed, and the additional measures to ensure whales are detected and exposure at intensities or durations that may result in harm or harassment are avoided, should the species occur. Because NARWs are the most sensitive endangered species to be avoided, pile driving must occur during months other listed species are expected to occur in greater numbers. Therefore, the risk of exposure is greater for other large whales and sea turtles occurring in the action area. Despite the higher risk due to their greater densities May-November, the implementation of required mitigation to not pile driving at night or in adverse monitoring conditions, PSOs, PAM, and soft starts, the intensity and duration of any incidental exposures will be minimized, thugs reducing the severity of any potential impacts.

Additional mitigation measures are being considered by BOEM that could further reduce potential impacts on marine mammals, as outlined in Section 2.2.1 and Appendix D of the DRAFT EIS. These additional measures under consideration include long-term PAM monitoring; daily, pre-construction PAM and visual surveys; a sunrise and sunset prohibition on pile driving, and the required use of noise reduction technologies during all pile-driving to achieve a required minimum attenuation level. These above measures would reduce noise impacts during construction and the likelihood of impacts on marine mammals, but would not result in a change to the significance level of impacts.

The isopleths for PTS during installation of a jacket foundation for NARW, fin, and sei, whales (4.5 miles [7,253 meters]) is too large to monitor effectively by visual observation. Isopleths to injury thresholds during pile driving of monopile foundations are smaller than those for jacket piles, although the radial distance to PTS for large whales is still too large to be effectively monitored using visual observation (3.3 miles [5,443 meters]; see Table 5.1-4) (Pyć et al. 2018). The maximum number of pile-driving days is 102, at the rate of one monopile installed per day (see Table 5.1-5).

Table 5.1-5 summarizes the number of animals estimated to be exposed to sound levels above potential PTS and Harassment threshold criteria during pile driving for 1 to 2 piles per day with 6 dB attenuation. Under the maximum-impact scenario, up to 5.32 fin whales, 1.39 NARWs, and 0.21 sei whales are predicted to be exposed to PTS SPLs; and 39.03 fin whales, 13.25 NARWs, and 1.68 sei whales may experience potentially harassing SPLs (Table 5.1-3; Pyć et al. 2018). Due to their relatively low numbers and higher frequency range of hearing, no sperm whales are predicted to be exposed to potential PTS or Harassment SPLs. Low-frequency cetaceans are more likely to exceed the SEL (L_E in Table 5.1-5) exposure threshold because the hearing frequency of this group overlaps with the highest energy of the frequency bands produced during pile driving.

Table 5.1-5: Number of Animals Estimated to be Exposed above Sound Levels for Potential PTS and Harassment for Scenario 2 (1–2 piles per day) with 6 dB attenuation.

Listed Whale Species Common Name	Listed Whale Species Scientific Name	PTS (L_{pk})	PTS (L_E)	Harassment ($L_{p,\ 24\ hr}$)
Fin	*Balaenoptera physalus*	0.12 - 0.12	4.90 – 5.32	39.03 – 35.04
NARW	*Eubalaena glacialis*	0.03 - 0.02	1.36 – 1.39	13.25 – 11.75
Sei	*Balaenoptera borealis*	0 - 0	0.21 – 0.21	1.68 – 1.44
Sperm	*Physeter macrocephalus*	0 - 0	0 – 0	0 - 0

Source: Pyć et al. 2018

Note: Scenario 2 = 90 monopiles and up to 12 jacket foundations

L_E = cumulative sound exposure; L_{pk} = peak sound pressure; $L_{p,24hr}$ = sound pressure level over 24 hours; NARW = North Atlantic right whale

The traditional method of assessing the potential for behavioral responses in marine mammals is an unweighted 160 dB SPL (NOAA 2005 as cited in Pyć et al. 2018). However, the application of a step function that evaluates weighted exposures as a percentage of animals responding between each step between different threshold levels has gained recent acceptance (Wood et al. 2012;(Nowacek et al. 2015)). Analyses of both approaches to assess the consequences of sound exposure on marine mammals can produce very different results (Farmer et al. 2018). Since there is no NMFS guidance available on either single metric or probabilistic dose-response functions required to evaluate the impacts of sound exposure for marine mammals, BOEM has applied both approaches in this analysis. Maximum distances are presented using the hammer energy schedule for one 34-foot (10.3-meter) diameter monopile and four jacket piles, corresponding to the most conservative hammer and energy combination (see Table 5.1-4).

As noted in Table 5.1-4, during installation of a monopile, underwater noise levels of 160 dB RMS (or harassment) will extend out to 2.6 miles (4,121 meters) from the pile being driven, resulting in a maximum ensonified area of 13,171 acres (53 km^2) for both hearing groups. During installation of a jacket foundation, the distance to harassment threshold will be 2.1 miles (3,302 meters) or an area of 8,451 acres (34.2 km^2) for mysticetes and 2 miles (3,220 meters), or an area of 8,056 acres (33 km^2) for sperm whales. Available information suggests that impulsive noise above 160 dB re 1µPa RMS may trigger a behavioral response in whales ranging from a startle with immediate resumption of normal behaviors to complete avoidance of the area above 160 dB re 1µPa RMS. It is also possible that whales could change their foraging behavior (NMFS 2015). Any whales present in the ensonified area during pile driving (total of 443 hours) may react behaviorally to this noise.

Vineyard Wind has estimated that typical pile driving for a monopile is expected to take less than approximately 3 hours to achieve the target penetration depth and that pile driving for the jacket foundation would take approximately 3 hours to install. Pre-construction surveys have identified turbine locations that are suitable to install the WTG foundations by impact hammer. However, under extenuating circumstances where a large boulder is unexpectedly encountered or early pile refusal is met before the target depth is achieved, other methods may temporarily be required to ensure a safe foundation depth is achieved. No drilling or vibratory piling is a planned installation method under the proposed action, but alternative methods may be required as a contingency to deal with unforeseen and extenuating circumstances. If drilling is required, it is expected a rotary drilling unit would be mobilized or vibratory hammering would be used on a limited basis to ensure the pile can be installed to the target depth. A compendium of pile driving measurements shows that the SPLs from vibratory pile driving are much lower than impact pile driving (Caltrans 2015). Compared to impact hammers, vibratory hammers produce lower frequencies and SPLs, but may take longer to install piles than impact driving methods (Caltrans 2015). In BOEM's 2016 Environmental Assessment (BOEM 2016) vibratory pile driving of meteorological tower foundations was evaluated using the largest source level reported in Caltrans (2015) for up to 3-8 hrs per day. BOEM's analysis showed that the largest possible cumulative sound exposure distances of the PTS zone would be between 116-189 m for low-frequency cetaceans, and 19-31 m for sperm whales. These distances are extremely smaller than the PTS zones for impact pile driving reported in Table 5.1-4 above. The same trend of much lower noise levels and impacts can be expected for sea turtles and sturgeon. Although the impacts of vibratory pile driving are expected to much less than impact pile driving, the same mitigation and monitoring protocols would be required as for impact hammers. In summary, any contingency construction methods would be expected to be short-term and no additional exposure of listed species to noise is anticipated than has already been modeled under the maximum impact scenario.

Vineyard Wind has committed to the following monitoring during pile driving for harassment zones: 1.7 miles (2,750 meters) during monopile installation and 1.4 miles (2,200 meters) during jacket installation. If whales were migrating through the area while exposed to pile driving noise, animals that were disturbed would make behavioral adjustments, resulting in an energetic cost (NMFS 2015). If the adjustment means leaving the area, the response would be short-term and limited to the time that the animal is no longer in the zone of influence from the pile driving noise could result in such a response. The energetic cost could be measurable (the cost of swimming up to 4 km), but would not last long enough to cause any detectable harm to the animals. This assumes that the whale would travel in a straight line to escape the noise. Given that there would be a single sound source of low intensity, NMFS (2015) indicates that this is a reasonable assumption.

Whales may also experience physiological stress during this avoidance behavior, but this stress hormones would begin to return to normal once the whale is outside of the ensonified area. NARWs typically swim at speeds of 1.3 kilometers/hour (Hain et al. 2013; including individuals, groups and mother-calf pairs) while fin (speeds of 9–15 kilometers/hour and burst speeds of up to 42 kilometers/hour; as cited in NMFS 2015, Society for Marine Mammology, accessed December 2013) and sei whales (which can reach speeds of 55 kilometers/hour; NMFS 2018b) swim considerably faster. This suggests that at normal swimming speeds, NARWs would be able to swim out of the area with disturbing levels of noise within approximately three hours and fin and whales could swim out of the area in under one hour. Thus, the period of exposure causing the stressed state would be temporary and any disruption or delay in foraging or resting is expected to be temporary for whales that avoid the area.

Resting or foraging would resume once the whale left the noisy area. Whales would be displaced for no more than 6 hours per day during monopile installation and up to 14 hours per day during jacket installation. Thus, foraging disruptions would be temporary and are not expected to last longer than a day. This displacement would result in a relatively small energetic consequence that would not be expected to have long-term impacts on whales. Pile-driving noise has the potential to cause PTS and harassment to marine mammals. Vineyard Wind would use sound-reducing technologies to minimize harmful impacts on marine mammals, but as discussed above, attenuation level may vary with local conditions. With a proposed target of 12 dB and maximum-impact scenario of 6 dB attenuation, the area of ocean affected by pile driving noise would be reduced, but there remains a risk of harassment to marine mammals due to the large radial distance to this threshold and the up-to-102 days that pile driving may occur. With the added requirement of 6 dB attenuation from BOEM to the supplementary NARW mitigation, pile-driving impacts **may affect, but not likely to adversely affect** NARWs due to avoidance of peak seasons of occurrence and **may affect, likely to adversely affect** all fin, sei and sperm whales.

Vessel Noise

The Navigation Risk Assessment (COP, Volume III, Attachment III-I) for the Project area indicates that the maximum number of vessels in the WDA during construction is estimated to be 46 per day (with an average of 24 per day) (COP Appendix III-I; Epsilon 2018). This volume of traffic would vary monthly depending on weather and proposed Project activities. In maximum conditions WTG construction, on a daily basis, up to 46 construction vessels (or 92 round trips per day for 102 days) would be transiting in and out of the staging port and three to four vessels would be transiting to and from secondary ports. Over the course of construction, the Proposed Action anticipates an average of 10 daily vessel trips between both the primary and secondary ports and the WDA, compared to the current amount of 25 vessels daily (measured per Automatic Identification System 2011 lease block area; as mentioned in the COP Volume III, Appendix III-I; Epsilon 2018). Vineyard Wind would be using MCT as the primary port for construction, with potential secondary ports located in Rhode Island, Massachusetts, Connecticut, and

Canada. Vessels would deliver components from European ports. Any vessels transiting from Canada and Europe would follow the major navigation routes.

According to the Navigation Risk Assessment (COP Appendix III-I; Epsilon 2018), current vessel traffic in the Project area and surrounding waters is relatively high, and vessel traffic within the MA WEA and WDA is relatively moderate. Current, non-project traffic includes pleasure craft, passenger ferries, high-speed craft, and commercial fishing vessels in order of frequency (COP Appendix III-I; Epsilon 2018). The Navigational Risk Assessment (COP Appendix III-I; Epsilon 2018) also indicated that the Project area experiences increased vessel traffic during the summer months; however, there is no significant disruption of normal traffic patterns anticipated.

Vessel noise is considered a continuous noise source that will occur intermittently. Vessels transmit noise through water primarily through propeller cavitation. Vessel traffic associated with the proposed Project would produce levels of noise of 150 to 170 dB re 1 μPa-meter at frequencies below 1,000 Hz (NMFS 2015) with the exception of vessels with ducted propellers that have somewhat higher source levels. Ducted propellers are shrouded in an assembly fitted with a non-rotating nozzle that provides higher efficiency at lower speeds, course stability, and decreased vulnerability to debris.

Vineyard Wind would use vessels with ducted propellers will be used during construction and installation activities. Of the nineteen different Project vessel types listed in COP Table 4.2-1 (Volume I; Epsilon 2018) all except three—barge, floating crane, and smaller support vessels which use jet-drive propulsion—are described as having “blade propeller system/blade thrusters.” Assuming sound sources for blade propeller system/blade thrusters are similar to those for ducted propellers, vessel noise may cause short-term behavioral reactions for some marine mammals as vessels pass near an animal. Sound-source levels for ducted propeller thrusters were modeled for a project offshore of Virginia (BOEM 2015) and measured during the installation of the Block Island Wind Farm transmission cable. For both projects, the sound-source level was 177 dB (RMS) at 3 feet (1 meter). Ducted propeller thruster use may exceed threshold criteria for injury at a distance of 351 feet (107 meters) (BOEM 2014). However, marine mammals would need to remain within that distance for a prolonged period to be impacted by PTS, which is extremely unlikely to occur. Distances to the threshold criteria for harassment for marine mammals would be approximately 0.9 to 2 miles (1.4 to 3.2 kilometers).

No whales are expected to be exposed to PTS-causing SPLs from vessel noise. Although the radial distance in which harassment may occur is relatively large, vessels are transitory noise sources and are expected to have short-term and minor effects of an animal’s behavior with no resulting harassment or harm to individuals. Communication between animals within and located on different sides of the Project area could be intermittently masked as vessels are transiting through the area on a daily basis. This masking is expected to last intermittently while animals remain in the area. Since the greatest amount of vessel traffic will occur concurrently with pile driving activities, whales may choose to leave the area during construction. In either scenario, some **short-term harassmnent is expected to occur** due to vessel operations or pile driving during construction. Restrictions on vessel approaches near whales will ensure that project vessels are never within 1,640 feet (500 meters) of NARWs and 328 feet (100 meters) from all other whales, minimizing the exposure to harassment from vessels. In non-peak vessel traffic periods, exposure to listed-whales within the Action Area is expected to be transient and temporary, as individual vessels pass by along their route, and whale behavior and use of the habitat would be expected to return to normal following the passing of a vessel (NMFS 2015). Thus, as no avoidance behaviors are anticipated any effects to listed whale species from Project **vessel noise outside of the construction period would be insignificant**.

Vineyard Wind may use several different methods to lay the offshore cable, but expects to install the majority of the export and inter-link cable using simultaneous lay and bury via jet plowing. 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. The cumulative sound exposure level over 24 hours (L_{E24}) during cable laying is expected to reach approximately 237 dB re one micropascal squared second (1µPa^{2}s) at 3.3 feet (1 meter) (Xodus Group 2015), which exceeds the NMFS threshold criteria for PTS from non-impulsive noise (L_{E24} 199 dB re 1µPa^{2}s; Pyć et al. 2018). Noise produced during cable laying includes the continuous source from dynamic positioning (DP) thruster use. The sound source-level assumption employed in the underwater acoustic analysis was 177 dB re 1 µPa at 1 meter and a vessel draft of 8 feet (2.5 meters) for placing source depth. To evaluate PTS (applying the old exposure criteria of180 dB re 1 µPa [RMS]) for marine mammals, it was concluded that the distance would be within 3.2 feet (1 meter) of the vessel, therefore no injury is anticipated (NMFS 2015). Model results from DP thruster operation for the Deepwater Wind Project (TetraTech 2013 a, b as cited in NMFS 2015) indicated that the average ensonified area at the 120 dB RMS isopleth extends 2.95 miles (4.75 kilometers) from the source, with the total size of the area experiencing noise of 120 dB RMS or greater ranging from 8.9 square miles (23 km^2) along the offshore export route to 9.7 square miles (25.1 km^2) along the inter-array cable route. Cable laying activities for Deepwater Wind were proposed to occur for 24 hours per day (NMFS 2015). Information for Vineyard Wind is not available, but this report will assume 24 hours per day for cable laying activities. Since the DP vessel would be continually moving along the cable route over a 24-hour period, the area within the 120 dB RMS isopleth would also be constantly moving over the same period. Thus, the estimated ensonified areas would not remain in the same location for more than a few hours (NMFS 2015). Considering the available information on potential vessel noise during construction and installation activities, BOEM concludes that this noise **may affect, but not likely to adversely affect** listed whale species.

According to Figure 4.1-1 of the COP Volume I (Epsilon 2018), inter-array cable laying activities would occur from February through September. The timeframe for offshore export cable installation is still being developed in response to time-of-year considerations, especially those provided by the Massachusetts Division of Marine Fisheries. Additionally, the scheduling of the offshore export cable installation considers ongoing construction planning and sequencing for the entire project, as well as refinements to the statistical weather modeling. At this point, it is likely that offshore export cable installation will occur in the period from April through October (Vineyard Wind 2018b). Sightings and abundance data for listed whales indicated that NARWs are likely to be foraging along the inter-array cable route during March and along the OECC route during February through April; fin whales are expected to be present along the inter-array from June through August, and along the OECC during June; and sei whales along the inter-array from June through August (Figures 3.1-3, 3.1-4, 3.1-7, 3.1-8). No sperm whales are expected to occur in the ensonified area during cable laying activities (Figure 3.1-9).

Available information suggests that continuous noise above 120 dB re 1µPa RMS may illicit a behavioral response in whales ranging from a startle with immediate resumption of normal behaviors to complete avoidance of the area where noise is elevated above 120 dB re 1µPa RMS, which could also cause a change in foraging behavior (NMFS 2015). Any whales present in the area where noise is elevated above 120 dB RMS when the DP thruster is operational may have behavioral reactions to this noise. NMFS (2015) provides a detailed discussion regarding DP thruster noise, whales' abilities to swim away from the noise, and resulting behavioral adjustments to the noise. Overall, NMFS (2015) determined that any whales that may be foraging in the action area and are exposed to DP thruster noise are expected to continue foraging, but may forage less efficiency due to increased energy spent on vigilance behaviors. This change may have short term metabolic consequences for individual animals and may result in a period of physiological stress; however, this stressed state and less efficient foraging is only expected to last as long as prey distribution overlaps with the area ensonified above 120 dB RMS, which is expected to be temporary and due to the constant movement of the DP vessel, would never persist more than a few hours. The acoustic impacts on marine mammals during DP thruster use from cable laying activities may cause temporary and short-term behavioral impacts on listed whale species.

Vineyard Wind may use helicopters to supplement crew transport and for proposed Project support during both construction and operations (COP Volume I, Section 4.2.4; Epsilon 2018) and may cause behavioral changes to NARWs, fin, and sei whales. Aircraft operation may ensonify areas, albeit for short periods at any one location while in transit. Helicopters produce sounds (resulting from rotors) generally below 500 Hz with estimated source levels for a Bell 212 helicopter of 149 to 151 dB re 1 μPa-m (Richardson et al. 1995). At incident angles greater than 13° from the vertical, much of the incident noise from passing aircraft is reflected and does not penetrate the water (Urick 1972).

Several authors have reported that sperm whales react to fixed-wing aircraft or helicopters (Clarke 1956; Fritts 1983; Mullin et al. 1991; Richter et al. 2003; Richter et al. 2006; Smultea et al. 2008; Würsig et al. 1998). A study observing bowhead whales (*Balaena mysticetus*) behavioral responses to helicopters indicated that their presence causes some behavioral changes including short surfacing durations, abrupt dives, and percussive behavior (e.g. breach, tail slap; Patenaude et al. 2002). Of the 63 bowhead groups observed, 14 percent reacted to the helicopter, with the majority of the responses occurring when the helicopter was at altitudes of 492 feet (150 meters) and lateral distances of 820 feet (250 meters). Patenaude et al. (2002) included an analysis of the underwater noise that from two aircraft recorded at 9.8 and 59 feet (3 and 18 meters) depth, a Bell 212 helicopter and a fixed-wing De Havilland Twin Otter. The helicopter was 7 to 17.5 dB louder than the fixed-wing aircraft, with a peak received level of approximately 126 dB re 1 μPa. Sound levels decreased considerable with flight altitude. The study suggested that the bowhead responses to the helicopter were acoustic rather than visual (Patenaude et al. 2002).

Smultea et al. (2008) studied the response of sperm whales to low-altitude (764 to 883 feet [233 to 269 meters]) flights by a small fixed-wing airplane off Kauai and reviewed data available from other studies. They concluded that sperm whales responded behaviorally to aircraft passes in about 12 percent of encounters. All of the reactions consisted of sudden dives and occurred when the aircraft was less than 1,181 feet (360 meters) from the whales (lateral distance). They concluded that the sperm whales had perceived the aircraft as a predatory stimulus and responded with defensive behavior. In at least one case, Smultea and et al. (2008) reported that the sperm whales formed a semi-circular “fan” formation that was similar to defensive formations in sperm whales reported by other investigators. In a review of aircraft noise effects on marine mammals, resting animals seemed to be disturbed the most, with low flying aircraft with close lateral distances over shallow water elicited stronger disturbance responses than higher flying aircraft with greater lateral distances over deeper water (Luksenburg and Parsons 2009).

During the Project, helicopters can be used when rough weather limits or precludes the use of crew transport vessels (CTVs) as well as for fast response visual inspections and repair activities, as needed to support operations and maintenance activities. Helicopters would be able to land on helipads with which some of the larger support vessels (i.e., SOV are equipped. BOEM expects that helicopters transiting to the Project area would fly at altitudes above those that would cause behavioral responses from whales except when flying low to inspect WTGs or take off and land on the SOV. If a listed whale is within 250 to 360 m of the helicopter, it is possible that behavior responses may occur, but they are expected to be short-term and temporary. NARW approach regulations (50 CFR 222.32) prohibit approaches within 500 yards. BOEM will require all aircraft operations to comply with current approach regulations for any sighted NARWs or unidentified large whale. While helicopter traffic may cause some short-term and minor behavioral reactions in marine mammals while helicopters move to a safe distance, BOEM does not expect it to cause injury. Thus, the potential impacts from helicopter noise **may affect, but is not likely to adversely affect** listed whales.

The dominant source of vessel noise from the Proposed Action is propeller cavitation, although other ancillary noises may be produced. The intensity of noise from service vessels is roughly related to ship size and speed. Large ships tend to be noisier than small ones, and ships underway with a full load (or towing or pushing a load) produce more noise than unladen vessels. Project-related vessel noise may cause behavioral responses from listed whale species including avoidance of the ensonified area. These responses are expected to be temporary and minor, and occur infrequently between individual whale and Project-related vessels. In addition, noise from the incremental increase in Project-related vessel traffic would not be measureable. Due to the extremely temporary nature of the response, vessel noise would have insignificant effects on listed whales. Therefore, vessel noise **may affect, but is not likely to adversely affect** listed whale species.

5.1.1.2. Non-Acoustic Impacts

Vessel Strike

Vessel strike is relatively common with cetaceans (Kraus et al. 2005) and one of the primary causes of death to NARWs with as many as 75 percent of known anthropogenic mortalities of NARWs likely resulting from collisions with large ships along the US and Canadian eastern seaboard (Kite-Powell et al. 2007). Marine mammals are more vulnerable to vessel strike when they are within the draft of the vessel and when they are beneath the surface and not detectable by visual observers. Some conditions that make marine mammals less detectable include weather conditions with poor visibility (e.g., fog, rain, and wave height) or nighttime operations. Vessels operating at speeds exceeding 10 knots have been associated with the highest risk for vessel strikes of NARWs (Vanderlaan and Taggart 2007). Reported vessel collisions with whales show that serious injury rarely occurs at speeds below 10 kt (Laist et al. 2001). Data show that the probability of a vessel strike increases with the velocity of a vessel (Pace and Silber 2005; Vanderlaan and Taggart 2007).

COP Table 4.2-1 (Volume I, Section 4.2.4; Epsilon 2018) summarizes vessel details including type/class, number of each type, length, and speed for each proposed Project activity during construction. The maximum transit speed of these vessels varies from 6 to 30 knots maximum transit speeds. Operational vessels within the WDA would usually be stationary or travelling at slow speeds, although transits between ports and the WDA may result in speeds ≥10-knots. For example, transits of heavy cargo vessels, deck carriers, and semi-submersible vessels (lengths ranging from 394 to 732 feet [120 to 223 meters]) used for overseas foundation transport have an operational speed of 13 to 18 knots; multi-role survey vessels or smaller support vessels (lengths from 43 to 367 feet [13 to 112 meters]) used for pre-installation surveys have operational speeds ranging from 18 to 22 knots; and crew transfer vessels (66 to 98 feet [20 to 30 meters]) used for crew transfer, refueling, or as a service boat, have operational speeds of 25 knots (COP Volume I, Table 4.2-1; Epsilon 2018). Vineyard Wind's self-imposed measures are described in Section 4.3 above

COP Tables 3.2-1 and 3.2-2 (Volume I; Epsilon 2018, in a March 25, 2019 project update Connecticut ports were eliminated from the PDE) summarize the ports likely to be used during construction, operations and maintenance. The New Bedford Marine Commerce Terminal will be the primary port used to support construction and decommissioning. Other U.S. ports (e.g., Brayton Point and Quonset) may also be used. Although Canadian ports (e.g., Sheets Port, St. John, and Halifax) may be used during construction or decommissioning, it is anticipated that 5 percent or less of vessel trips would originate from Canada (a maximum of 2 trips in a single day during construction) (Vineyard Wind RFI #13, October 26, 2018). One-way distance from each of the potential ports to the WDA as delineated in Figure 5.1-1 are estimated as follows moving from west to east: New Bedford, westernmost route (61 miles [98 km]), New Bedford second route (50 miles [81 km]), New Bedford third route (45 miles [72 km]), New Bedford easternmost route (51 miles [82 km]), Brayton Point (69 miles [111 km]), Quonset (62 miles [99 km]), St. John, Canada (440 miles [708 km]), and Sheet Harbor, Canada (554 miles [891 km]).

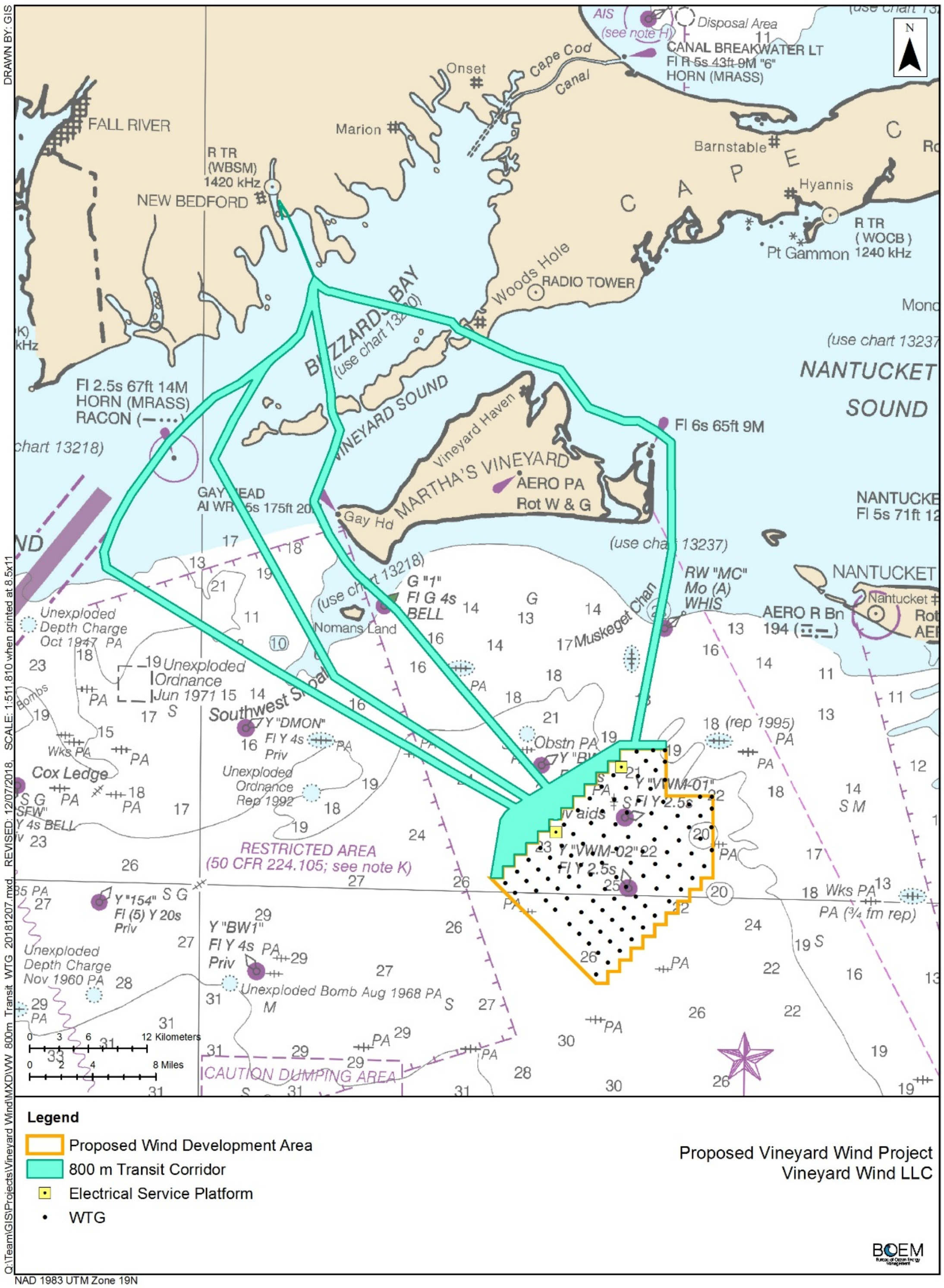


Figure 5.1-1: Typical Vessel Routes between WDA and New Bedford

As described in the COP (Appendix III-I), the most intense period of vessel traffic would occur during the construction phase when wind turbine foundations, inter-array cables, and WTGs are installed in parallel. It is conservatively estimated that a maximum of approximately 46 vessels could be on-site (at the WDA or along the OECC) at any given time (Table 5.1-6). However, the maximum number of vessels involved in the proposed Project area 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. On average, approximately 25 vessels would be at the WDA and along the OECC during this period. Vessel routes are preliminary plans subject to modification for each transit. Individual vessel masters will need to consider weather, loading conditions, and visibility before selecting their route. Therefore, vessel masters may alter the routes shown for safety or logistical purposes. It is expected that vessel traffic routes will continue to be developed through the construction planning process, but the routes provided can be considered as the general routes that can be expected.

During construction, the following numbers of estimated maximum daily and monthly vessel trips have been conservatively developed for the below ports. These numbers are conservative in that they account for the maximum potential activity during a given day or month of construction. Because construction activity will vary over the course of the construction period, they do not represent the expected number of trips that will occur each day and month of the entire construction period. During construction, a maximum total of 265 vessel trips may originate from Canada. According to Figure 4.1-1 in COP Appendix III-I, the peak level of construction is expected to occur during pile driving activities, with little potential overlap with NARW from May through December. However, mobilization to and from the WDA would occur before and after this period, during which more potential for overlap with NARW and Project vessels may occur. Fin and sei whales are expected to occur in the Action Area in relatively high densities during the spring and summer, coinciding with the peak construction period. Sperm whales may occur in the Action Area in low numbers during summer and fall.

Table 5.1-6. Estimated maximum daily trips and trips per month during Project construction.

Origin or Destination	Est. Max. Daily Trips	Est. Max Trips/Month
New Bedford	46	1,100
Brayton Point	4	100
Montaup	4	100
Providence	4	100
Quonset	4	100
Canada (either Sheet Harbor, St. John, or Halifax)	5	50

During construction and installation will include a maximum of 46 vessel trips per day. New Bedford Harbor is expected to be the primary port used to support construction activities. Because established shipping lanes into New Bedford Harbor are located to the southwest of New Bedford Harbor (see Figure 3.5 in COP Volume III, Appendix III-I) and the WDA is located southeast of New Bedford Harbor, it is assumed that Project vessels will not use the shipping lanes, but instead will take the most direct route to the WDA. The most direct route would be to travel around the Elizabeth Islands and the west coast of Martha's Vineyard, and then head southeast to the WDA.

During operations and maintenance, and as described in Section 7.8.2.2 of Volume III of the COP, it is anticipated that on average one CTV or survey/inspection vessel will operate in the WDA per day for regularly scheduled maintenance and inspections. 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. Consequently, although unlikely, it is anticipated that there would be a maximum of three to four daily trips from New Bedford Marine Commerce Terminal and/or Vineyard Haven. This equates to a maximum of 124 vessel trips per month from either port.

During decommissioning, the level of trips is estimated to be about 90 percent of those occurring during construction, or a maximum of 990 trips per month from New Bedford, 90 trips per month from Brayton Point or Quonset, and 45 trips per month from Canada. Assuming that decommissioning is essentially the reverse of construction, except that offshore cables remain in place and Project components do not need to be transported overseas, decommissioning activities will require approximately 4,800 vessel trips (a total of 240 vessel trips may originate from Canada). Assuming that decommission also lasts two years, this equates to approximately six or seven vessel trips per day.

The following measures are proposed to reduce vessel strike with listed species:

- Two PSOs will be stationed on vessels to look out for listed species.
- NARW sightings information will be checked daily.
- If a NARW or large whale is observed within 328 feet (100 meters), the transiting vessel will shift engine to neutral and will not re-engage engines until the NARW has moved out of the vessel path and beyond 328 feet (100 meters).
- A 1,640-foot (500-meter) for NARWs (Vineyard Wind 2018a) and 328-foot (100-meter) setback for other listed whale species shall be maintained between all transiting construction-related vessels and whales.
- Transiting vessels will maintain a separation distance of 164 feet (50 meters) from sea turtles and dolphins.
- If cow/calf pairs or large groups of delphinids are observed within 164 feet (50 meters) of a vessel in transit, the vessel will reduce speed to 10 knots. Normal transit speed will be resumed only after the delphinids have moved outside the 164 foot- (50 meter-) zone.
- AIS will be required on each project vessel.

Other factors Considered in the Vessel Strike Analysis

Many factors may affect the ability of whales to detect and avoid oncoming vessels. In general, whales tend to not react to vessels until the vessel approaches within a certain proximity in which the animal perceives the vessel as a threat. The amount of time an animal spends at the surface, its awareness of an approaching vessel, reaction time, and experience with vessels may effects an animal’s response to oncoming vessels. Vessel captains typically react to any object in the water to avoid vessel damage and the risk of injury to crew members. A vessel’s operational speed and size influence both the probability of detecting an animal and the reaction time to avoid an animal at the surface. At slower vessel speeds, a particular location ahead of the vessel is within visual range for a longer period of time before the vessel arrives. Faster vessels are generally less maneuverable and less likely to be able to make evasive maneuvers to avoid a whale strike.

Study results indicate that with vessels travelling at greater than 14 knots, these measures may not be protective for whales between 328 and 820 feet (100 and 250 meters) directly in the path of a large vessel. Kite-Powell et al. (2007) modeled the likelihood of a strike with a NARW given that the ship is initially on a collision course with the whale. Model results suggest that oncoming vessels traveling at 15 knots or more are likely to strike more than half of NARWs located in or swimming into the vessels' path, even when they take evasive action (Kite-Powell et al. 2007). The model also suggests that the strike risk posed by a conventional ship moving at 20 to 25 knots can be reduced by 30 percent by slowing down to 12 or 13 knots, and by 40 percent at 10 knots. Whales are likely to be largely safe from ship strike if they detect and react to an oncoming vessel at a distance of 820 feet (250 meters) or more. Strike risk is considerable if the detection distance drops below 328 feet (100 meters).

These results suggest that for conventional ships at speeds in excess of 10 knots, encounters are virtually certain to result in ship strikes if the detection distance is 164 feet (50 meters) or less for animals in the immediate path of a vessel. When detection distance is around 328 feet (100 meters), there is no appreciable strike risk for ship speeds below 10 knots; the strike risk rises rapidly to between 50 and 80 percent at 15 knots, and exceeds 90 percent above 20 knots. For detection distance of 492 feet (150 meters), strike risk is negligible below 15 knots, and reaches 60 to 80 percent at 25 knots. At a 656 foot- (200 meter-) detection distance, strike risk begins at 20 knots and stays below 40 percent even at 25 knots. Detection distances of 820 feet (250 meters) or above imply very low ship strike risk from conventional vessels. In addition, Vanderlaan and Taggart (2007) estimated that the probability of a lethal injury given a ship strike increases from 21 percent at ship speeds of 8.6 knots to 50 percent at 11.8 knots and 79 percent at 15 knots.

Summary of Vessel Strike Analysis

Although vessel strike is among the leading sources of human-caused whale mortalities, several factors reduce the probability of a Project-related strike. The Project will have a period of peak vessel activity lasting approximately two years (during construction), when an average of approximately seven vessel trips per day will occur. In the context of regional vessel traffic, Project-related vessel activity will add a relatively moderate, but temporary increase in vessel traffic to the region. The majority of Project vessel traffic will occur within the Project area (WDA, OECC), and vessel transit corridors to New Bedford and Vineyard Haven, where whale densities are relatively low in comparison to the overall region. Transits from Canada and Europe to transport manufactured parts are expected to occur at slow speeds of 10 knots. Vessels operating in Project area will also be traveling at slow operational speeds under most circumstances, unless in transit to and from port. Slower operational speeds of less than or equal to 10 knots will allow whales to avoid vessels, vessels to avoid whales, or both to take evasive actions. For those vessels traveling faster than 10 knots, separation distances of 500 m for NARWs and 100 m from other whales are required. Whenever a whale is sighted in the path of the vessel, speed will be reduced to 10 knots or less and evasive action, or shift engines to neutral if the animal is sighted within 100 m from the vessel. In addition, several other measures are proposed (see bulleted list above and measures described in the proposed action), such as the use PSOs stationed on vessels, will ensure extra vigilance is taken to avoid and detect whales. Additionally, peak vessel activity (when WTG installation occurs simultaneously with other activities) will not occur during the time of year (January to April) when most NARWs are likely to occur in the Acton Area. The most recent sightings data indicate the area immediately to the west of the WDA area to be a hot spot for NARW (Leiter et al. 2017). Leiter et al. (2017) indicated a relatively high number (n = 32 from 2011 through 2015) of NARW feeding in the area to the west of the WDA during March and April.

The Action Area also includes potential transit areas where barges transporting offshore WTG components from Europe or Canada may traverse deepwater habitat areas. The operational speed of transport barges is 10 kt (COP Volume I, p. 4-30). The likelihood of a strike for the small, temporary increase in vessel traffic from transport of components would be a rare event compared to the high level of commercial vessel traffic in the North Atlantic. In addition to the unlikely event of a vessel strike, the slow 10 kt operating speed of barges will allow adequate time for a barge captain to detect any potential hazard, including whales, and take evasive action. Similarly, the number of transport vessels is relatively minor compared to baseline traffic, and the temporary vessel noise from transporting components will have insignificant effects on listed whales. Additionally, Vineyard Wind has voluntarily proposed to post a PSO on each vessel, and implement vessel strike avoidance measures that apply to all marine mammals, including 500 m for NARWs and 100 m for other large whales, and check for NARW sightings on a daily basis. The low risk of strikes will be further reduced to discountable levels with implementation of these mitigation measures. Any interactions between project-related vessels and listed species will be reduced to the lowest possible levels of any vessels operating in the area. In summary, in consideration of the proposed action, vessel strike information, and comprehensive measures proposed to minimize and avoid vessel strikes, that potential for vessel strikes will be discountable. Therefore, vessel traffic **may affect, but not likely to adversely affect** listed whale species.

Habitat Disturbance

With the addition of up to 102 WTG and ESP foundations, scour protection, and cable protection in the WDA, a total of 394 acres (1.6 km^2; Table 6.5-5 of COP Volume III; Epsilon 2018) of soft bottom would be permanently changed to hard bottom, equivalent to 0.5 percent of the WDA. With the addition of the WTGs and ESPs spaced from 0.76 to 1.0 nautical miles apart, there is a potential shift in the area immediately surrounding each monopile from soft sediment, open water habitat system to a structure-oriented system, including an increase in fouling organisms. In addition to providing forage items, fouling organisms and the physical structure of the WTG may provide shelter thereby attracting fish species to the area surrounding the WTG. As described above, fin and sei whales feed on schooling fish, and thus these whales may be attracted to the WDA to forage. Although some of the prey items that sperm whales forage on may be attracted to the WTG (sharks, rays fish, squid), this species is known to inhabit deeper waters, and is not expected to be attracted to the WDA. NARWs' diet is comprised of copepods. There is no evidence suggesting that the presence and abundance, or vertical distribution of copepods will be impacted by the WTG or foundations. The large spacing will not significantly influence currents in a manner that could impact copepods. Benthic soft-bottom communities that are affected by anchoring of vessels, installation of WTG and ESP foundations, inter-array and OECC cables, and scour protection could take some time to recover. However, benthic impacts are expected to be discountable for listed whales because none of the listed whale species that occur in the Project area forage on benthic organisms. Impacts from the shift of soft-bottom habitat to hard bottom **may affect, but not likely to adversely affect** listed whales.

Turbidity

OECC

Elevated levels of turbidity may potentially impact fish prey species and the ability to forage for some marine mammals. Model results of simulations of the OECC show that the use of the trailing suction hopper dredger for pre-cable installation dredging has the potential to generate temporary turbidity plumes throughout the entire water column of TSS at 10 milligrams per liter (mg/L) extending up to 9.9 miles (16 kilometers) and 750 mg/L extending up to 3.1 miles (5 kilometers) from the OECC centerline for 2 to 3 hours respectively, though this may be less extensive at varying locations along the route (Crowley et al. 2018).

Relatively high concentrations (>1000 mg/L) are predicted at distances up to 3.1 miles (5 kilometers) from the OECC centerline in response to the relatively high loading of dumping and swift transport of the dumped sediments, but this high concentration only persists for less than 2 hours. In general, excess TSS concentrations over 10 mg/L from dredging can extend several kilometers from the OECC centerline and may be present throughout the entire water column but are temporary and typically dissipate within about 6 hours (Crowley and Swanson 2018).

Data are not available regarding whales avoidance of localized turbidity plumes, however, Todd et al. (2015) suggest that since marine mammals often live in turbid waters, significant impacts from turbidity are not likely. If elevated turbidity caused any behavioral responses such as avoiding the turbidity zone or changes in foraging behavior, such behaviors would be temporary, only occurring for less than 2 to 6 hours per day from April through October (Vineyard Wind 2018b), and any negative impacts would be short-term and temporary. Cronin et al. (2017) suggest that vision may be used by NARW to find copepod aggregations, particularly if they locate prey concentrations by looking upwards. However, Fasick et al. (2017) indicate that NARWs certainly must rely on other sensory systems (e.g. vibrissae on the snout) to detect dense patches of prey in very dim light (at depths >160 meters or at night).

If turbidity from cable installation caused foraging whales to leave the area, there would be an energetic cost of swimming out of the turbid area. However, whales could resume foraging behavior once they were outside of the turbidity zone. Recent studies indicate that whales often in turbid waters, are likely able to forage in low visibility conditions, and thus could continue to feed in the elevated turbidity (Todd et al. 2015). Thus, potential impacts on listed whales from turbidity are expected to be negligible to minor and **may affect, but not likely to adversely affect** listed whales.

Inter-Array

Sediment dispersal model results indicate that during inter-array cable-laying activities most of the mass settles out quickly and is not transported for long by the currents (Crowley and Swanson 2018). The sediment plume is confined to the bottom 9.8 feet (3 meters) of the water column, which is only a fraction of the water column in the WDA. Deposition greater than 0.04 inch (1 millimeter) is confined within 328 feet to 492 feet (100 meters to 150 meters) of the trench centerline for the typical and maximum-impact simulations respectively, and maximum deposition in both simulations is less than 0.2 inch (5 millimeters). Water quality impacts from inter-array cable installation are therefore short-term and localized. Potential impacts on listed whales from turbidity during cable laying activities for the inter-array are expected to be insignificant and **may affect, but not likely to adversely affect** listed whales.

5.1.2. Operations and Maintenance

5.1.2.1. Acoustic Impacts

WTG Noise

In general, reported sound levels of operational wind turbines is low (Madsen et al. 2006) with SPL of about 151 dB and a frequency range of 60 to 300 Hz (Dow Piniak et al. 2012). According to measurements at the Block Island Wind Farm, low frequency noise generated by turbines reach ambient levels at 164 feet (50 meters; Miller and Potty 2017). Sound pressure level measurements from operational WTGs in Europe indicate a range of 109 to 127 dB re 1µPa at 46 and 65.6 feet (14 and 20 meters) from the WTGs (Tougaard and Henrikson 2009). Thomsen et al. (2016) indicated SPL ranging from 122 to 137 dB re 1µPa at 492 feet (150 meters) and 131 feet (40 meters), respectively with peak frequencies at 50 Hz and secondary peaks at 150 Hz, 400 Hz, 500Hz and 1200 Hz from a jacket foundation turbine. SPL measurements at a steel monopile foundation turbine ranged from 133 to 135 dB re 1µ Pa at 492 and 131 feet (150 and 40 meters), respectively with peak frequencies at 50 and 140 Hz (Thomsen et al. 2016). The nearfield recordings (i.e. at 131 feet [40 meters]) at the steel monopile were similar to those observed at, the jacket foundation wind turbine. However, at the greater distance of 492 feet (150 meters), the jacketed turbine was quieter (Thomsen et al. 2016). Although sound pressure levels may be different in the local conditions of the WDA, if sound levels at the WDA are similar, operational noise could be slightly higher than ambient, which ranged from 96 to greater than 103 dB re 11µPa in the 70.8– 224 Hz frequency band at the study area during 50 percent of the recording time between November 2011 and March 2015 (Kraus et al. 2016b). Based on the results from Thomsen et al. (2016) and Kraus et al. (2016b), the received SPLs generated by the Project turbines are expected to be at or below ambient levels at relatively short distances from the foundations. Impacts on listed whales from operational wind turbine noise are expected to be discountable and **may affect, but not likely to adversely affect** listed whales.

Vessel Noise

Vineyard Wind estimates the total annual number of vessel round trips during operations and maintenance would be between 401 and 887 (COP Volume I, Table 4.2-1; Epsilon 2018). Operation and maintenance vessels range in size from 66 to 98 feet (20 to 30 meters) to 394 to 732 feet (120 to 223 meters) with operational speeds from 10 to 30 knots. Potential impacts from vessel noise on listed whales are the same as those described above in the construction and installation section and may cause behavioral responses. However, because the number of Project-related vessels is relatively low compared to baseline traffic, and because the incremental increase in vessel noise compared to existing noise levels will be discountable, impacts on listed whale species will be infrequent and minor. Thus, vessel noise during operation and maintenance **may affect, but not likely to adversely affect** listed whale species.

5.1.2.2. Non-Acoustic Impacts

Vessel Strike

Potential impacts from vessel strike to listed whales are the same as those described above in the construction and installation section. Relatively high densities of NARWs have been sighted in the waters to the north of the WDA during winter and to the west of the WDA during spring. Other listed marine mammals have also been sighted in these areas where vessel transit would occur during project operations. Nonetheless, an estimated maximum of three vessels per day would be utilized during the operations and maintenance period. With onboard observers watching for marine mammals, it is anticipated that vessel strike **may affect, but not likely to adversely affect** listed whales.

EMF

The current literature suggests that cetaceans can sense the geomagnetic field and use it to navigate during migrations (Normandeau et al. 2011). It is not clear whether they use the geomagnetic field solely or in addition to other regional cues. It is also not known which components of the geomagnetic field cetaceans are sensing (i.e. the horizontal or vertical component, field intensity or inclination angle). Nor is it known what effects the perturbations in the geomagnetic field by EMF within the vicinity of buried power cables may have on these animals. No evidence of magnetic sensitivity has been reported for seals (Normandeau et al. 2011).

Marine mammals appear to have a detection threshold for magnetic intensity gradients (i.e. changes in magnetic field levels with distance) of 0.1 percent of the earth's magnetic field or about 0.05 microtesla (μT) (Kirschvink 1990) and are thus likely to be very sensitive to minor changes in magnetic fields (Walker et al. 2003). There is a potential for animals to react to local variations of the geomagnetic field caused by power cable EMFs. Depending on the magnitude and persistence of the confounding magnetic field, such an effect could cause a trivial temporary change in swim direction or a longer detour during the animal's migration (Gill et al. 2005). Such an effect on marine mammals is more likely to occur with direct current cables than with AC cables (Normandeau et al. 2011). However, there are numerous transmission cables installed across the seafloor and no adverse impacts to marine mammals have been demonstrated from this source of EMF. Because AC cables have been proposed and the Project area represents an extremely small areas within the coastal waters used by migrating marine mammals, BOEM expects little to no detectable effect on migratory behavior, therefore any potential effects will be discountable.

Both OECC and inter-array cable arrays are AC, and Vineyard Wind would bury these cables at a depth of 3 to 8 feet (1.5 to 2.5 meters). Modeled and measured magnetic field levels from various existing submarine power cables results indicate that AC cables buried to a depth of 3 feet (1 meter) would emit field intensities less than 0.05 μT to 82 feet (25 meters) above the cable, and 79 feet (24 meters) along the sea floor. Comparison of these results with marine mammals' sensitivity levels suggests that potential impacts from submarine cables would be discountable and **may affect, but not likely to adversely affect** listed whales.

Avoidance of Physical Presence of the WTGs

It is not likely listed whales would avoid the area due to the whales size relative to turbine spacing. The Proposed Action WTGs are laid out in a grid-like pattern with spacing of 0.76-1.0 nautical mile between turbines. The minimum distance between nearest turbines is no less than 0.65 nautical mile and the maximum distance between nearest turbines is no more than 1.1 nm. The average spacing between turbines is 0.86 nm. The upper range of whale lengths are as follows: NARW (59 feet [18 meters]), fin whale (79 feet [24 meters]), sei whale (59 feet 18 meters]), and sperm whales (59 feet [18 meters]). For reference, about 103, 59-ft long NARWs (large females) would fit end-to-end between two foundations spaced at 1 nm. However, there is some uncertainty with the prediction of whales' behavior related to turbine presence due to the novelty of this type of development in the Atlantic. Monitoring studies would be able to determine more precisely any changes in whale behavior. However, based on the best available information, none are anticipated.

If the presence of the WTGs and/or operation noise would cause listed whales to avoid the WDA. This would be a potential habitat loss of 75,614 acres (306 km^2), which when compared to the available surrounding coastal waters is relatively small. Avoidance of the WDA would result in an extra expenditure of energy for the whales. The energy cost would depend on the distance of diversion from the origin path but is not expected to be substantial. Because of the potential extra expenditure of energy, the effects of avoidance of the WDA **may affect, but not likely to adversely affect** listed whale species.

An avoidance of the WDA may also cause some animals to be at an increased level of risk to interactions with potentially high vessel traffic including fisheries vessels, and fisheries gear. NMFS has determined that the gear associated with sink gill net and lobster pots would have the potential to affect marine mammals (NMFS 2018f). In the WDA, of these two gear types, sink gill net is most likely to occur within the proposed Project area as shown in Table F.3.1-4 of the Draft EIS. BOEM has determined that the potential for displacement of fixed gear from the WDA is low due to the gear able to be deployed in a fixed location. There is the potential that in the short-term sink gillnet effort could shift into the WDA if catch is higher around wind turbine foundations. However, there would be no expected increases in the amount of gear or overall fishing effort based on current quotas. Additionally, this is considered a temporary effect as fishing effort would eventually depress any short-term increases in fish biomass (Roach et al. 2018). This impact is anticipated to be short term (1-2 years) and would have negligible if any impacts on marine mammals.

Based on the analysis above and possible outcomes of whale responses to WTGs, the presence of WTGs and foundations are not expected to have any direct or indirect effects on whales. Therefore, the presence of WTGs **may affect, but is not likely to adversely affect** listed whale species.

Accidental Spills

Rowe et al. (2018) present results from an oil spill model assessing the trajectory and weathering of oil following a catastrophic release of all oil contents from the topple of an ESP (the only proposed Project component containing more than 250 barrels of oil) located closest to shore within the WDA. This would be the maximum-impact discharge scenario, involving a relatively small and finite release of oil (on the order of 1,500-3,000 barrel). The oil spill scenarios modeled in the oil spill model study assume that no oil spill response or mitigation would occur. This is a very conservative assumption as the ESP would be designed with containment and Vineyard Wind would employ containment and recovery methods to contain and recover onshore and aquatic petroleum spills.

The model results indicate that the sea surface area exposed to oil exceeding the 10 grams per square meter (g/m^2) threshold would be contained within approximately 20 to 25 miles (32 to 40 kilometers) of the 400 MW ESP spill location and 30 to 50 miles (48 to 85.5 kilometers) of the approximately 800 MW ESP spill location for all four seasons, with the area for the winter simulation being relatively smaller than the other three seasons. The 10 g/m^2 oil thickness (or 0.01 millimeters) corresponds to a dark brown or metallic appearance on the water surface (Etkin et al. 2018), with a threshold expected to cause sub-lethal impacts on marine mammals, sea turtles, and floating Sargassum mats (Rowe et al. 2018). Etkin et al. (2018) indicate that the risk of mortality for sea turtles would occur at a thickness of 100 g/m^2 (or 0.1 millimeters). The model also predicted that there is a 1 to 40 percent probability of oil above a minimum thickness of 100 micrometers (100 g/m^2 on average over the grid cell) reaching the shorelines of Martha's Vineyard and Nantucket within 1 to 3 days of the release in all seasons.

COP Table 4.2-3 (Volume I; Epsilon2018) contains a list and approximate volume of potential chemicals that would be used during the proposed Project. The chemical product that would be used in the highest volume, and thus has the highest potential for impacting marine mammals is oil. Project estimates include a total of 4,502 gallons (17,041 liters) of oil per WTG and approximately 124,097 gallons (469,758 liters) in one approximately 800 MW ESP. The maximum most probable discharge volume is 124,097 gallons (469,758 liters) and the average most probable discharge volume is estimated to be 1,241 gallons (4,697 liters) (COP Volume I, Appendix 1-A; Epsilon 2018). According to Bejarano et al. (2013), the probability of occurrence of this type of catastrophic release, such as the topple of an ESP, is extremely small.

In the unlikely event of an accidental oil spill, oil at the 10 g/m^2 level may negatively impact marine mammals within 20 to 50 miles (32 to 80 kilometers) of the spill (Rowe et al. 2018). Oil at this level, seen as a dark brown slick or metallic sheen, and approximately 0.01 mm thick, is expected to be within the sublethal threshold for whales (Etkin et al. 2018). Potential negative impacts include skin irritation from contact with the oil inhalation of oil vapors (NOAA 2018f) and ingestion. The model indicates that in all seasons, the oil is expected to persist for 1 to 3 days, as there is a 1 to 40 percent probability of oil above a minimum thickness of 100 μm (100 g/m^2 on average over the grid cell) reaching the shorelines of Martha's Vineyard and Nantucket within 1 to 3 days of release (Rowe et al. 2018). Vineyard Wind would have an Oil Spill Response Plan in place that would decrease potential impacts. Therefore, potential negative impacts on marine mammals from accidental oil (or other chemicals in de minimis amounts) spills are considered discountable and **may affect, but not likely to adversely affect** listed whales.

5.1.3. Decommissioning

Decommissioning impacts include underwater noise emitted from underwater acetylene cutting torches, mechanical cutting, high-pressure water jet, and vacuum pump. Sound pressure levels are not available for these types of equipment, but are not expected to be higher than construction vessel noise (generally between 150 and up to 180 dB re 1µPa (Pangerc et al. 2016). Vineyard Wind would return the sediments previously removed from the inner space of the pile to the depression left when the pile is removed. In addition, Vineyard Wind would likely use a vacuum pump and diver or remotely operated vehicle-assisted hoses to minimize sediment disturbance and turbidity. Vineyard Wind may abandon the offshore export cables in place to minimize environmental impact; in which case there would be no impacts from their decommissioning. If required, Vineyard Wind would remove the cables from their embedded position in the seabed. Where necessary, Vineyard Wind would jet plow the cable trench to fluidize the sandy sediments covering the cables, and reel the cables onto barges. Risks from removing the cables would be short-term, localized to the Project Area, and be similar to those experienced during cable installation. Although some of the decommissioning activities (e.g., acoustic impacts and increased levels of turbidity) may cause marine mammals, including listed species, to avoid or leave the Proposed Action area, this disturbance would be short-term and temporary.

In summary, Project-related vessel noise may cause behavioral responses from listed whale species including avoidance of the ensonified area. These responses are expected to be temporary and occur infrequently between individual whale and Project-related vessels. In addition, noise from the incremental increase in Project-related vessel traffic would not be measureable. Therefore, vessel noise **may affect, but not likely to adversely affect** listed whale species.

In addition, Vineyard Wind proposes high-resolution geophysical (HRG) and remotely operated vehicle (ROV) surveys for site clearance activities. According to BOEM (2014b), there would be a discountable risks for PTS resulting from non-airgun HRG surveys. BOEM believes that the risk of PTS occurring in any listed species from HRG surveys is discountable because the threshold distances are small and have a discountable chance of exposing listed species to levels of sound causing ear injury. Depending on equipment used, distances to PTS threshold are estimated to be a maximum of 85.3 feet (26 meters) for mysticetes and 3.3 feet (1 meter) for sperm whales (BOEM 2018). The distance in which potential harassment may occur is approximately 32.8 to 1647 feet (10 to 502 meters) for baleen whales and 32.8 to 5200 feet (10 to 1,585 meters) for sperm whales depending on the suite of equipment used during any particular survey and the largest potential disturbance time is likely to be no longer than 24 seconds (BOEM 2018). Because the exposure distance for PTS is very small (1 to 26 m) and exposure to potentially harassing SPLs s very brief and temporary, impacts on listed whales from HRG noise would be **insignificant** and discountable and not rise to the level of causing any harm.

A summary of the determinations for potential impacts during decommissioning is as follows:

- Project-related vessel noise may cause harassment of listed whale species including avoidance of the ensonified area. These responses are expected to temporary, and occur infrequently between individual whale and project related vessels. In addition, noise from the incremental increase in Project-related vessel traffic would not be measureable. Therefore, vessel noise **may affect, and is not likely to adversely affect** listed whale species.
- Underwater noise generated from demolition equipment **may affect, but not likely to adversely affect** listed whales.
- Each Project vessel will have two PSOs aboard and BOEM’s requirement of AIS compliance will minimize potential vessel strikes. Thus, BOEM expects impacts from vessel strike **may affect, but not likely to adversely affect** listed whales.
- Potential impacts from turbidity **may affect, but not likely to adversely affect** listed whales.

Although some of the decommissioning activities (e.g. acoustic impacts and increased levels of turbidity) may cause listed whales to avoid or leave the Project area, this disturbance would be short term and temporary. Potential impacts on listed whales during decommissioning are expected to be **insignificant** and **discountable**.

5.1.4. Effects to Critical Habitat

No critical habitat for fin, sei, or sperm whales has been delineated in the Project Action Area. Although New Bedford Harbor is expected to be the primary port used to support construction activities, some vessels may transit from Canada. A total of 265 vessel round trips may transit from Canadian ports, resulting in a maximum of 2 trips in a single day. There are no impacts associated with these vessel trips that could affect the essential features (or primary constituent elements) of NARW critical habitat. However, Vineyard Wind will follow all applicable requirements related to any Seasonal Management Areas, Dynamic Management Areas, vessel strike avoidance measures, and 500 m separation distance from NARWs. BOEM concludes that Project-related vessel traffic from Canadian ports will have **no effect** on the foraging features for NARW critical habitat.

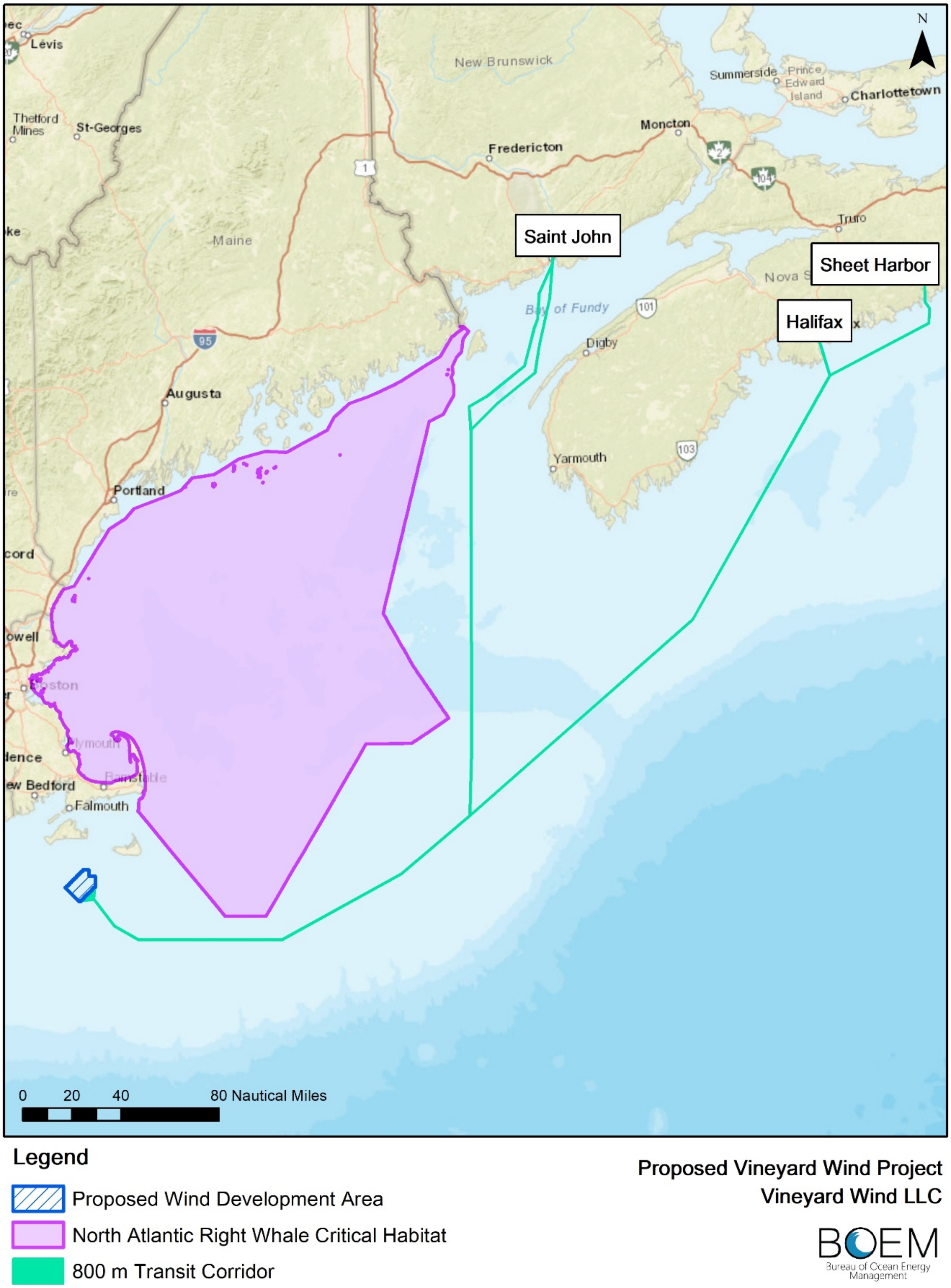


FIGURE 5.1-2: CRITICAL HABITAT FOR NORTH ATLANTIC RIGHT WHALE

5.2. FORAGING AREA EFFECTS OF THE PROPOSED ACTION ON SEA TURTLES

5.2.1. Construction and Installation

Construction and installation of offshore components consists of six main elements: monopile/jacket foundation pile driving, ESP foundation pile driving, inner cable array installation, scour protection, and installation of offshore export cables.

5.2.1.1. Acoustic Impacts

Pile Driving

Pyć et al. (2018) conducted acoustic modeling of underwater sound generated and potential effects on sea turtles and other marine species during piling installation for the proposed Project (see Section 5.1, Effects of the Proposed Action on Marine Mammals). There are limited density estimates for sea turtles in the WDA. For this analysis, sea turtle densities were obtained from the US Navy Operating Area Density Estimate (NODE) database on the Strategic Environmental Research and Development Program Spatial Decision Support System. Pyć et al. (2018) noted that the winter densities of sea turtles in the WDA were likely overestimated. Because these estimates are provided as a range of potential densities per 274 acres (1 km^2) within each grid square, the maximum density will always exceed zero. Thus, winter densities were reported even though turtles are unlikely to be present in winter, since Pyć et al. (2018) assumed maximum densities for all seasons. Details on data handling to develop these estimates are available in Pyć et al. (2018). These estimates suggest that loggerhead sea turtles are the most likely species of sea turtle to be found in the Project area, and their densities would be highest during the summer (Table 5.2-1; Pyć et al., 2018).

Two datasets are available to describe leatherback densities in the WDA: (1) the best available density estimates from NODE database on the Strategic Environmental Research and Development Program Spatial Decision Support System portal used in the acoustic model, and (2) the more recent site-specific data in Kraus et al. (2016). Kraus et al. (2016b) indicate higher density (0.8725 animals per 24,710 acres [100 km^2] in the fall and 0.63 animals per 24,710 acres [100 km^2] in the summer) compared to densities estimated in the acoustic model in the fall (0.0274 animals per 24,710 acres [100 km^2]) and summer (0 animals per 24,710 acres [100 km^2]; Pyć et al. 2018). Thus, the exposure of leatherback turtles to pile driving noise could be greater than that estimated in the acoustic model.

More recent site-specific density data for loggerhead or Kemp's ridley sea turtles from Kraus et al. (2016b) are not available. However, SPUE data indicate that loggerhead, leatherback, and unidentified sea turtles are most susceptible to impacts from pile driving during the fall (September through November), when expected abundance in the WDA is relatively moderate to high (Figures 3.2-1 to 3.2-4; Right Whale Consortium 2018).

Table 5.2-1: Sea Turtle Density Estimates used for Animal Movement Modeling

Common and Scientific Name	Density [a]			
	Spring	Summer	Fall	Winter
Leatherback Sea Turtle (*Dermochelys coriacea)*	0.0274	< 0.0001	0.0274	0.0274
Loggerhead Sea Turtle (*Caretta caretta)*	0.1117	0.1192	0.1111	0.1111
Kemp's Ridley Sea Turtle (*Lepidochelys kempii)*	0.0105	0.0105	0.0105	0.0105
Green Sea Turtle (*Chelonia Mydas*)	Very low during all seasons, no estimates available			

Source: Pyć et al. 2018. Sea turtle density estimates are derived from SERDPSDSS and represent the best data set to be used for animal movement modeling, as agreed to by BOEM and NMFS on July 24, 2018.

NODE database (density estimate from http://seamap.env.duke.edu/serdp).

km^2 = square kilometer

[a] Animals/38.6 square miles (100 km^2)

Data regarding threshold levels for impacts on sea turtles from sound exposure during pile driving are very limited, and no regulatory threshold criteria have been established for sea turtles. BOEM and NMFS have adopted the following thresholds based on current literature:

- Potential mortal injury: 210 dB cumulative sound exposure level, or greater than 207 dB peak SPL (Popper et al. 2014)
- Potential mortal injury: 180 dB re 1 μPa RMS (SPL; NMFS 2016)
- Behavioral harassment–166 dB to175 dB referenced to 1 μPa RMS

When comparing criteria between foundation types, the maximum radial distance to injury threshold for sea turtles would be largest during 34-foot (10.3-meter) monopile installation at 2,536.1 feet (773 meters), or an area of 470 acres (1.9 km^2). Monopile installation would occur for 3 to 6 hours per day at a rate of one or two piles per day, for 90 to 45 days respectively (Pyć et al. 2018). The radial distance to injury threshold during jacket installation would be 1,738.8 feet (530 meters), or an area of 222 acres (0.9 km^2) and would occur for 12 days for 14 hours per day (Table 5.2-2; Pyć et al. 2018).

The largest distance to behavioral harassment threshold would occur during monopile installation at 7,805 feet (2,379 meters) or 5,832 acres (23.6 km^2). Behavioral harassment noise would reach 6,378 feet (1,944 meters) from the pile during jacket installation with an area of 2,941 acres (11.9 km^2; Table 5.2-2; Pyć et al. 2018). Behavioral responses could range from a startle with immediate resumption of normal behaviors to complete avoidance of the area and could also include changes in diving patterns or changes in foraging behavior (NMFS 2015). Sea turtles in the area could be foraging, migrating, or resting. Sea turtles within 2.7 km of the pile being driven are expected to temporarily stop these behaviors and make evasive movements (changes in diving or swimming patterns) until they are outside the area where noise is elevated above 166 dB re 1uPa RMS (NMFS 2015). Given that the piles will be installed in an open ocean environment with no impediments to movement, sea turtles are expected to be able to avoid the ensonified area (NMFS 2015).

Sea turtles migrating through the area when pile driving occurs are expected to adjust their course to avoid the area where noise is elevated above 166 dB re 1uPa RMS. Depending on how close the individual is to the pile being driven, this could involve swimming up to 1.68 miles (2.7 kilometers). The turtle may experience physiological stress during this avoidance behavior but this stressed state is expected to dissipate once the sea turtle is outside the ensonified area.

Table 5.2-2: Mean Radial Distance (R95% in meters) to Threshold Criteria for Sea Turtles during Impact Hammering with 6 dB Attenuation System [a,b]

Foundation/Hammer Type	Injury 210 dB L_E (Popper et al. 2014)	Injury Unweighted 180 dB SPL (NMFS 2016)	Behavioral Harassment Unweighted 166 dB SPL (NMFS 2016)
10.3-meter monopole/IHC S-4000 hammer	477	773	2,739
Jacket (four 3-meter piles)/ IHC S-2500 hammer	530	243	1,944

Source: Pyć et al. 2018

dB = decibel; L_E = cumulative sound exposures; SPL = sound pressure level

[a] Mean of two measured positions within the WDA

[b] The R95% for a given sound level is the radial distance centered at a pile-driving location, encompassing 95 percent of the largest distances within the sound pressure levels above a given threshold.

The cumulative sound exposure level is the dominant threshold (Table 5.2-2). The maximum-impact scenario is defined by the highest number of individual sea turtles predicted to exceed injury threshold criteria with 6 dB attenuation. Under Scenario 2 (100 monopiles and 2 jacket foundations), two piles installed per day had the greater likelihood of exposing animals to the injury threshold level (0.33 animals), albeit the number is less than 1 turtle overall, and thus is considered the maximum-impact scenario. Table 5.2-3 provides the exposure estimates for injury and behavioral harassment for the sea turtles. Overall, under Scenario 2, the highest number of sea turtles predicted to be exposed to injury is 0.33 loggerheads, with less than 0.1 Kemp's ridley and leatherback sea turtles estimated to be exposed to injury (Pyć et al. 2018). An estimated 1.96 loggerhead, 0.31 Kemp's ridley, and 0.34 leatherback sea turtles are estimated to be exposed to behavioral harassment (Pyć et al. 2018).

Table 5.2-3. Estimated Number of Sea Turtles Exposed to Injury and Behavioral Harassment for Scenario 2 with One to Two Piles per day Using 6 dB of Attenuation [a]

Sea Turtle Species	Injury (NMFS 2016) SPL (L_p)		Behavioral Harassment (NMFS 2016) SPL (L_p)	
	1 pile per day	2 piles per day	1 pile per day	2 piles per day
Kemp's Ridley (*Lepidochelys kempii)*	0.04	0.03	0.31	0.18
Leatherback (*Dermochelys coriacea)*	0.05	0.04	0.34	0.24
Loggerhead (*Caretta caretta)*	0.21	0.33	1.50	1.96
Total	0.30	0.40	2.15	2.38

Source: Pyć et al. 2018

L_p = sound pressure; SPL = sound pressure level

[a] Evaluated for NMFS injury and behavioral harassment.

Assuming the model predictions are accurate, and considering that sea turtles would exhibit an avoidance response before receiving the 24-hour exposures in Table 5.2-2, BOEM anticipates minor impacts on sea turtles from pile driving. Risk of exposure for sea turtles to injury is very low while some sea turtles may be exposed to behavioral harassment causing behavioral responses including avoidance of the area. There have been no documented sea turtle mortalities associated with pile driving. Based on the low densities of sea turtles in the proposed Project area, soft-starts to allow turtles to leave the area before injurious levels are received, and the implementation of exclusion zones, mortal injury would not be expected. However, potential harassment may occur over 102 days of pile driving that may occur over the spring to fall months when sea turtles may be most likely to occur in the Project area. Therefore, pile driving **may affect, and is likely to adversely affect** sea turtles by harassment.

Vessel Noise

The frequency range for vessel noise (10 to 1000 Hz; MMS 2007) overlaps with sea turtles' known hearing range (less than 1000 Hz with maximum sensitivity between 200 to 700 Hz; Bartol et al. 1999) and would therefore be audible. However, Hazel et al. (2007) suggest that sea turtles' ability to detect approaching vessels is primarily vision-dependent, not acoustic. Sea turtles may respond to vessel approach and/or noise with a startle response (diving or swimming away) and a temporary stress response (NSF and USGS 2011). Samuel et al. (2005) indicated that vessel noise can have an effect on sea turtle behavior, especially their submergence patterns. BOEM anticipates that the potential effects of noise from construction and installation vessels would elicit brief responses to the passing vessel resulting in minor impacts on sea turtles. Noise from construction and installation vessels **may affect, but not likely to adversely affect** sea turtles.

In addition, the fall pipe technique used for placement of scour protection may include the use of an ROV. Data for underwater sound levels from ROVs are limited and highly variable. Estimates from one study indicated that levels with thrusters off were greater than 130 dB, and levels with all thrusters on were greater than 160 dB (Roundtree et al. 2002). BOEM does not expect these noise levels to cause injury but could cause temporary behavioral modification to sea turtles, with impacts expected to be minor. Impacts from ROV noise **may affect, but not likely to adversely affect** sea turtles.

5.2.1.2. Non-Acoustic Impacts

Vessel Strike

The maximum number of Project-related vessel trips would be 92 round trips (a maximum of 46 vessels). COP Table 4.2-1 (Volume I; Epsilon 2018) summarizes vessel details including type/class, number of each type, length, and speed for each Project activity during construction. The speed of these vessels varies from 6 to 30 knots maximum transit speed. Operational speeds are generally lower than transit speeds, but several exceed 10 knots. For example, transits of heavy cargo vessels, deck carriers, and semi-submersible vessels (lengths ranging from 394 to 732 feet [120 to 223 meters]) used for overseas foundation transport have an operational speed of 13 to 18 knots; multi-role survey vessels or smaller support vessels (lengths from 43 to 367 feet [13 to 112 meters]) used for pre-installation surveys have operational speeds ranging from 18 to 22 knots; and crew transfer vessels (66 to 98 feet [20 to 30 meters]) used for crew transfer, refueling, or as a service boat, have operational speeds of 25 knots (COP Volume I, Table 4.2-1; Epsilon 2018). Vineyard Wind's self-imposed measures are described in detail in Pyć et al. 2018, Table 31. Propeller and collision injuries from boats and ships are common in sea turtles. Vessel strike data from 1997 to 2005 for loggerhead sea turtles indicate that 14.9 percent of all stranded loggerheads in the U.S. Atlantic and Gulf of Mexico had evidence of some type of propeller or collision injuries, although the proportion of these injuries that were post- or ante-mortem is unknown (2008). The percentage of total strandings with vessel injuries in the U.S. Atlantic ranges from 15 percent (8 to 28 percent) in Florida (Foley et al. 2008, 2013) to 25 percent in Chesapeake Bay, Virginia (Barco et al. 2016). Similar data are not available for Massachusetts. However, the Action Area does not contain unusually high densities of turtles and there are no nearby nesting beaches. There are no foraging hotspots with the exception of the relatively high density (>80 animals per 1,000 km surveyed; see Figure 3.2-4 and Kraus et al. 2016) of leatherback turtles in the summer just south of the eastern shore of Martha's Vineyard. However, the vessel transit routes delineated in Figure 5.1-1 indicates minimal overlap with the relatively high density area of leatherbacks and the easternmost vessel route from New Bedford.

Sea turtles are likely to be most susceptible to vessel collision in coastal waters, where they forage from May through November. Vessel speed may exceed 10 knots in such waters, and those vessels travelling at greater than 10 knots would pose the greatest threat to sea turtles. The increase in vessel round trips during construction and installation is likely to increase the relative risk of vessel strike for sea turtles. However, the vessel strike avoidance measures the Vineyard Wind proposes to use to minimize the potential of vessel strikes for sea turtles by reducing vessel speed and maintaining a distance of 164 feet (50 meters) or greater from sighted turtles. The requirement of Automatic Identification System on all proposed-Project vessels would allow Vineyard Wind to monitor the number of vessels and traffic patterns for compliance with vessel speed requirements, and would decrease the potential for vessel strike for sea turtles. BOEM therefore anticipates the potential effects of vessel strike on sea turtles due to construction and installation vessels may affect, but not likely to adversely affect sea turtles.

Dredging

Due to the presence of sand waves in the proposed Project area (COP Volume I, Section 4.2.3.3.2; Epsilon 2018), those sand waves would need to be removed to reach stable sea bottom in order to achieve targeted cable burial depth. Dredging, likely through the use of a trailing suction hopper dredge, would create a 66-foot (20-meter) wide corridor and Vineyard Wind has determined that up to 69 acres (0.28 km^2) of seafloor bottom would be impacted. This would result in about 214,500 cubic yards (164,000 m^3) of dredged material that would be sidecast along the seafloor (COP Volume I, Section 4.2.3.3.2; Epsilon 2018). Dredging would increase turbidity and temporarily affect an overall very small area that may be used as foraging habitat by sea turtles. The potential capture of sea turtles in the dredging equipment could occur, but is more likely in channels and areas that otherwise have high densities of sea turtles. There are no known large aggregation areas or areas where turtles would be expected to spend large amounts of time stationary on the bottom where they could be entrained in a suction dredge. The likelihood of a sea turtle becoming entrained in a dreg associated with the proposed action is so low, it is discountable.

Habitat Disturbance

Proposed Action activities known to disturb the sea floor bottom and near-bottom, such as scour protection, pile driving, and cable laying, may directly affect sea turtle foraging habitat and associated prey. However, these activities would affect a very small percentage of the total coastal foraging habitat area (393 acres [1.6 km^2]) due to foundations, scour and cable protection, and jack-up barges in the WDA (approximately 0.5 percent of WDA); the maximum direct impact of the OECC is expected for the western route through Muskeget Channel to the New Hampshire Avenue landfall site, with a total area of 221 acres (approximately 0.9 km^2) disturbed (combining the impact of trench zones, skid tracks, dredging, anchoring, and cable protection).

Sea turtles in the WDA would likely be foraging, since the benthic community in the WDA includes several prey items including amphipods and other crustaceans, crabs, gastropods, and bivalves (BOEM 2014). Construction and installation would affect a small percentage of the available foraging habitat, and suspension of organic matter can attract prey items such as crabs to the area. Although colonization and recovery to pre-construction species assemblages is expected within up to 2 to 4 years (Van Dalfsen and Essink 2001), but may be as rapid as 100 days (Dernie et al., 2003) given the similarity of nearby habitat and species, these impacts are expected to be insignificant to sea turtles. Because impacts on foraging habitat are mostly temporary, localized, and may have no detectable effects on the foraging success of sea turtles, BOEM anticipates the impact of the Proposed Action activities associated with bottom disturbance on sea turtles to be insignificant. The impact **may affect, but not likely to adversely affect** sea turtles.

In addition, the proposed Project would convert soft-bottom habitat to hard-bottom due to scour protection over the life of the project. The total footprint of soft-bottom habitat converted to hard-bottom habitat would be approximately 117 acres (0.5 km^2). Hard-bottom (scour control and rock mattresses used to bury the OECC) and vertical structures (i.e., WTG and ESP foundations) in a soft-bottom habitat can create artificial reefs, thus inducing the 'reef' effect (Taormina et al. 2018; NMFS 2015). The reef effect is usually considered a beneficial impact, associated with higher densities and biomass of fish and decapod crustaceans (Taormina et al. 2018), providing a potential increase in available forage items and shelter for sea turtles compared to the surrounding soft-bottoms. This conversion would be a beneficial impact for sea turtles via habitat creation. Because impacts on foraging habitat are likely neutral, insignificant, or beneficial to sea turtles, impacts from habitat disturbance **may affect, but not likely to adversely affect** sea turtles.

Turbidity

Increased levels of turbidity resulting from cable-laying activities along the OECC and WDA inter-array are not expected to negatively affect sea turtles. Grosse et al. (2010) indicated that sea turtles' foraging abilities do not appear to be affected by turbidity. However, elevated levels of turbidity may negatively affect sea turtle forage items including benthic mollusks, crustaceans, sponges, and sea pens by clogging respiratory apparatuses. The more mobile prey items like crabs may also be negatively affected by turbidity by clogging their gills, but likely to a lesser extent due to their ability to leave the turbid area. Therefore, impacts from turbidity are expected to be minimal and **may affect, but not likely to adversely affect sea turtles**.

Entanglement

The potential for entanglement in anchor lines, towlines, and temporary buoy markers is possible for sea turtle species if such lines were slack and left in the water for extended periods. However, the only anchor lines deployed during the proposed-Project construction-related activities would be associated with some construction vessels. Steel anchor cables used on construction barges are typically 2 to 3 inches (5 to 7 centimeters) in diameter. These cables are under tension while deployed, eliminating the potential for entanglement. Similarly, towlines for cable installation are expected to be under constant tension. Thus, impacts from entanglement are expected to be discountable and would have **no effect** on sea turtles.

5.2.2. Operations and Maintenance

5.2.2.1. Acoustic Impacts

WTG Noise

Continuous underwater noise produced from the operation of wind turbines is low frequency, generally dominated by a series of pure tones below 1 kHz and in most cases below 700 Hz (Madsen et al. 2006). The reported sound levels of operational wind turbines have an SPL of about 151 dB and a frequency range of 60 to 300 Hz (Dow Piniak et al. 2012). Since most of sea turtles' sensitivity is in the range of 50 Hz to 2 kHz (Piniak et al. 2016; Martin et al. 2012; Dow Piniak et al. 2012; Bartol and Ketten 2006), they would be able to hear the operational noise. According to measurements at the Block Island Wind Farm, low frequency noise generated by turbines barely exceeds ambient noise levels at 164 feet (50 meters; Miller and Potty 2017). Sound pressure level measurements from operational wind turbines in Europe indicate a range of 109 to 127 dBs re 1 µPa at 46 and 65.6 feet (14 and 20 meters) from the turbines (Tougaard and Henrikson 2009). Although sound pressure levels may be different in the local conditions of the WDA, if sound levels at the WDA are similar, operational noise could be slightly higher than ambient, which ranged from 95 to greater than 104 dBs re 1 µPa at the study area from 2011 to 2015 (Kraus et al. 2016b). Based on the results from Thomsen et al. (2015) and Kraus et al. (2016b), the received SPLs generated by the proposed Project turbines are expected to be at or below ambient levels at relatively short distances from the foundations.

Information regarding sea turtles' response to turbine operation noise is not available, however NMFS (2015) determined that sea turtles would not be able to detect the operational noise of the WTGs as it is masked by other natural (and anthropogenic) underwater noises. There is no information suggesting the low SPLs of WTG will have any detectable impacts on sea turtles and any potential impacts are considered to be discountable. As a result, operational Impacts from operational wind turbine noise **may affect, but not likely to adversely affect** sea turtles because the SPL is relatively low, with a small ensonifed area (approximately 164 feet [50 meters] from the WTG).

Vessel Noise

Potential impacts from vessel noise on sea turtles during operations and maintenance are the same as those described above in the construction and installation section, but would occur at a much reduced level over the 30 years operation and maintenance period of the project. BOEM expects that the potential effects of noise from operations and maintenance vessels would elicit brief responses to the passing vessel resulting in minor impacts on sea turtles; the impacts **may affect, but not likely to adversely affect** sea turtles.

5.2.2.2. Non-Acoustic Impacts

Vessel Strike

Potential impacts from vessel strike on sea turtles are the same as those described above in the construction and installation section; however, due to the lower number of vessel trips expected annually, the level of threat would be present at a much reduced level over the 30 years operation and maintenance period of the project. Due to the relatively low number of vessel trips and implementation of the vessel strike avoidance measures, the potential impacts from vessel strike is discountable. Therefore, vessel operations may **affect, but not likely to adversely affect** sea turtles.

EMF

Sea turtles are known to possess geomagnetic sensitivity (but not electro sensitivity) that is used for orientation, navigation, and migration. They use the Earth's magnetic fields for directional or compass-type information to maintain a heading in a particular direction and for positional or map-type information to assess a position relative to a specific geographical destination (Lohmann et al. 1997). Multiple studies have demonstrated magneto sensitivity and behavioral responses to field intensities ranging from 0.0047 to 4000 μT for loggerhead turtles, and 29.3 to 200 μT for green turtles (Normandeau et al. 2011). While other species have not been studied, anatomical, life history, and behavioral similarities suggest that they could be responsive at similar threshold levels. Hatchling sea turtles are known to use the earth's magnetic field (and other cues) to orient and navigate from their natal beaches to their offshore habitat (Lohmann et al. 1997). However, there are no nearby nesting beaches or critical habitats in the Project area.

Both OECC and inter-array cable arrays are AC cables and Vineyard Wind would bury all cables at a depth of 3 to 8 feet (1 to 2.5 meters). Modeled and measured magnetic field levels from various existing submarine power cables results indicate that AC cables buried to a depth of 3.2 feet (1 meter) would emit field intensities less than 0.05 μT to 82 feet (25 meters) above the cable, and 79 feet (24 meters) along the seafloor.

Juvenile or adult sea turtles foraging on benthic organisms may be able to detect magnetic fields while they are foraging on the bottom near the cables and up to potentially 82 feet (25 meters) in the water column above the cable. Juvenile and adult sea turtles may detect the EMF over relatively small areas near cables (e.g., when resting on the bottom or foraging on benthic organisms near cables or concrete mattresses). There are no data on impacts on sea turtles from EMFs generated by underwater cables. However, any potential impacts from AC cables on turtle navigation or orientation would likely be undetectable under natural conditions, and thus would be insignificant (Normandeau et al. 2011). Although desktop studies suggest sea turtles suggests that turtles are capable of sensing magnetic fields from submarine cables (Normandeau et al. 2011), there is little evidence supporting that these small EMFs along a cable corridor will adversely affect sea turtles under natural conditions. Additionally, there are no nesting beaches, critical habitat, or other biologically important habitats identified in the Action Area that could result in harm to sea turtles should any minor behavioral response occur and animals leave the immediate area. The potential impacts on sea turtles exposed to magnetic fields from cables installed under the proposed will be insignificant, and therefore **may affect, but is not likely to adversely affect** sea turtles**.**

Accidental Spills

Please refer to Section 5.1.2.2 under marine mammals for a detailed discussion of the oil spill model and proposed amounts to be located within the WDA.

In the unlikely event of an accidental oil spill, oil may negatively impact sea turtles within 20 to 50 miles (32 to 85.5 kilometers) of the spill. The negative impacts are expected to be sublethal. Vineyard Wind would have an Oil Spill Response Plan in place that would decrease potential impacts. Therefore, potential negative impacts on sea turtles from accidental oil (or other chemical) spills are considered discountable. Negative effects from an accidental oil spill **may affect, but not likely to adversely affect** sea turtles.

Lighting

The proposed Project lighting system for the WDA would consist of up to 200 synchronized red flashing Federal Aviation Administration "L-864" aviation obstruction lights (two placed on the nacelle of each WTG), up to 208 yellow flashing marine navigation lights (two at each turbine and on the corners of each ESP); and ten yellow flashing significant peripheral structure lights along the WDA perimeter (see Figure in Appendix C, of Appendix III-I for lighting direction on each turbine; Epsilon 2018). Lighting on the turbines would be located on top of the work platform design level at a height of 66 to 75 feet (20 to 23 meters) above MLLW. Lighting on top of the substations would be placed at a similar height above MLLW. Lights on the turbines and ESP would be visible at two nautical miles with the exception of the significant peripheral structures, which would be visible at 5 nautical miles.

Lighting on offshore WTG and ESP platforms may generate sufficient downward illumination to affect sea turtles depending on species or life history stage. In laboratory experiments, captive-reared juvenile loggerhead turtles consistently oriented toward glowing lightsticks of all colors and types used by pelagic longline fisheries (Wang et al. 2007). These results indicate that WTG and ESP lighting may attract loggerhead, and possibly Kemp's ridley and green sea turtles. In a separate study, Gless et al. (2008) determined that juvenile leatherback sea turtles do not appear to be attracted to light. Gless et al. (2008) indicated that most juvenile leatherbacks, in contrast to loggerheads, either failed to orient or oriented at an angle away from the lights. The authors suggested that older, adult turtles might show responses that differ from those of juvenile turtles. Gless et al. (2008) also reviewed previous studies based upon logbook data and concluded that because of confounding factors, there is no convincing evidence that marine turtles are attracted to the longlines by lights. Orr et al. (2013) indicate that lights on wind generators that flash intermittently for navigation or safety purposes do not present a continuous light source, and thus do not appear to have disorientation effects on juvenile or adult sea turtles. More information regarding lighting effects on juvenile and adult sea turtles is needed. However, based on the best available information, the potential attraction of sea turtles to WTG lighting is not anticipated to have any detectable negative or positive effects on individuals. Decades of oil and gas platform operation in the Gulf of Mexico, that can have considerably more lighting than offshore WTGs, has not resulted in any known adverse impacts to sea turtles. Although some turtles could possibly be attracted to WTG lighting, the potential effects to sea turtles will be discountable. Therefore, WTG lighting **may affect, but not likely to adversely affect** sea turtles.

5.2.3. 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 impact-producing factor during decommissioning.

Decommissioning impacts include underwater noise emitted from underwater acetylene cutting torches, mechanical cutting, high-pressure water jets, and vacuum pumps. Sound pressure levels are not available for these types of equipment, but are not expected to be higher than construction vessel noise (generally between 150 and up to 180 dB re 1µPa (Pangerc et al. 2016). Vineyard Wind would return the sediments previously removed from the inner space of the pile to the depression left when the pile is removed. In addition, Vineyard Wind would likely use a vacuum pump and diver or remotely operated vehicle-assisted hoses to minimize sediment disturbance and turbidity. Vineyard Wind may abandon the offshore export cables in place to minimize environmental impact; in which case there would be no impacts from their decommissioning. If required, Vineyard Wind would remove the cables from their embedded position in the seabed. Where necessary, Vineyard Wind would jet plow the cable trench to fluidize the sandy sediments covering the cables, and reel the cables onto barges. Risks from removing the cables would be short-term, localized to the Project Area, and be similar to those experienced during cable installation. Although some of the decommissioning activities (e.g., acoustic impacts and increased levels of turbidity) may cause listed species to avoid or leave the Proposed Action area, this disturbance would be short term and temporary.

In addition, Vineyard Wind proposes HRG and ROV surveys for site clearance activities. According to BOEM (2014b), there would be little or no injury PTS resulting from non-airgun HRG surveys. The most likely and extensive effects of HRG surveys on sea turtles would be behavioral responses. The non-airgun HRG surveys would use only electromechanical sources such as boomer, sparker, and chirp subbottom profilers; side-scan sonar; and multibeam depth sounders. Acoustic signals from electromechanical sources other than the boomer and sparker are not likely to be detectable by sea turtles. The boomer has an operating frequency range of 200 Hz to 16 kHz and could be audible to sea turtles; however, it has very short pulse lengths (120, 150, or 180 microseconds) and a very low source level, with a 180 dB radius of less than 16 feet (5 meters; BOEM 2014b). Sparkers and bubble guns have a maximum distance to the PTS threshold of 39.4 feet (12 meters) and 295.3 feet (90 meters) to the behavioral disturbance threshold (BOEM 2018). Using the source levels of most boomer and sparker equipment and the HRG Survey Protocol, BOEM expects impacts from non-airgun HRG surveys using boomer or sparker subbottom profilers on sea turtles to range from negligible to minor based on the distance of the individual sea turtle from the sound pulse. Side scan sonars operate at high frequencies (>200 kHz) above hearing bandwidths of sea turtles and they would not be able to perceive sound associated with side scan sonar surveys. Depending on which equipment is used, impacts from HRG surveys **may affect, but not likely to adversely affect** sea turtles.

Although some of the decommissioning activities (e.g. acoustic impacts and increased levels of turbidity) may cause sea turtles to avoid or leave the Project area, this disturbance would be short term and temporary. Overall, potential impacts during decommissioning **may affect, but not likely to adversely affect** sea turtles.

5.2.4. Effects to Critical Habitat

No critical habitat for loggerhead, leatherback, Kemp's ridley, or green sea turtles has been delineated in the Project Action Area.

5.3. EFFECTS OF THE PROPOSED ACTION ON ATLANTIC STURGEON

5.3.1. Construction

5.3.1.1. Non-Acoustic Impacts

Loss of Benthic Habitat

Long-term habitat alteration would occur in the form of installation of the foundations, scour protection around the WTG and ESP foundations, as well as cable protection for the inter-array and export cables. Temporary habitat alteration would occur from activities associated with WTG and ESP construction and installation of the inter-array and export cable. Long-term habitat alteration from the construction of 100 WTGs and up to 2 ESPs and scour protection would amount to a total of 53 acres (0.21 km^2) in the WDA. Placement of cable protection (e.g., concrete mattresses, rock placement, and/or half-shell) would alter an additional 63 acres (0.26 km^2) of bottom habitat, resulting in a total of 117 acres (0.47 km^2) in the WDA that would be converted from sand/silt bottom habitat to rock/hard bottom habitat. Long-term habitat alteration may occur from the placement of scour protection along the OECC in areas where the cable cannot be buried to the acceptable depth is 35 acres (0.14 km^2). Surveys conducted in 2017 (see COP Volume II-A and Appendix II-H, Epsilon 2018) found hard/complex bottom covering much of the Eastern Muskeget Option of the OECC route, but not most of the Western Muskeget Option, which was mostly composed of sand waves. Overall, construction of the WTGs, ESPs, and scour protection would transform 152 acres (0.61 km^2) of potential foraging habitat for Atlantic sturgeon into coarse, hard bottom habitat. This represents a small portion of the soft bottom habitat available in this region. However, it is expected that due the large foraging areas over which sturgeon search and forage for food, there will be no detectable impacts on the foraging success of sturgeon. The foraging habitat and prey availability lost due to cable protection, scour protection, and construction of the WTGs and ESPs will have insignificant effects on foraging success, and therefore **may affect, but is not likely to adversely affect** Atlantic sturgeon.

Temporary habitat alterations occurring in the WDA and OECC would primarily be due to WTG and ESP construction, cable placement, dredging, and jack-up vessels. In the WDA, temporary disturbance of the seafloor would occur over 277 acres (1.12 km^2) from the installation of inter-link and inter-array cables and jack-up vessels. Temporary disturbance of the seafloor would occur over 186 acres (0.75 km^2) from the installation of export cable and dredging along the OECC. Export cable dredging would create a 66 foot (20 meter) wide corridor. Overall, a total of 463 acres (1.87 km^2) would be temporarily lost as foraging habitat to Atlantic sturgeon. After construction activities are completed, these areas should return to the baseline state. Generally, the disturbance of benthic habitat should be short-term and localized, with an abundance of similar foraging habitat and prey available in adjacent areas for Atlantic sturgeon.
The temporary disturbance of habitat would have insignificant effects on foraging, and therefore **may affect, but not likely to adversely affect** Atlantic sturgeon.

Turbidity from Cable Installation

Installation of the OECC and inter-array cable, as well as construction of WTGs and ESPs, would disrupt bottom habitat and suspend sediment in the water column. A maximum impact assessment includes 171 miles (275 kilometers) of 66 kV inter-array cable at the WDA and 98 miles (158 kilometers) of 220 kV export and inter-array cables in the WDA and OECC. The greatest potential impact from cable laying would occur if Vineyard Wind uses pre-cable installation dredging during the cable-laying process. Modeling of sediment and transport potential (COP Volume III, Appendix III-A; Pyć et al. 2018) was completed for typical and maximum impact installation of inter-array cables in the WDA and for dredging and installation of the OECC. This would result in about 214,500 cubic yards (164,000 m^3) of dredged material that would be sidecast along the seafloor (COP Volume I, Section 4.2.3.3.2; Epsilon 2018). Dredging would increase turbidity and temporarily affect habitat being used by Atlantic sturgeon.

In the WDA, modeling indicates that the TSS plume would be mostly confined to the bottom 1 foot (3 meters) of the water column. Simulation of the typical installation suggest plumes of greater than 10 mg/L TSS above ambient levels would occur up to 1.9 miles (3.1 kilometers) from the centerline with higher concentrations of 50 mg/L constrained to 525 feet (160 meters) from the centerline. Maximum impact installation indicated the 10 mg/L plume could extend up to 4.6 miles (7.5 kilometers) from the centerline while plumes at 50 mg/L and 100 mg/L would extend up to 1.2 miles (2.0 kilometers) and 0.53 miles (0.86 kilometers) from the centerline, respectively.

Installation of the OECC includes dredging in regions where sand waves would be encountered, requiring the cable to be properly buried beneath the stable seafloor. Pre-cable installation dredging indicated a 10 mg/L plume above the baseline levels extending 10 miles (16 kilometers) from the centerline while TSS of 750 mg/L and 1,000 mg/L could extend 3.2 miles (5 kilometers) and 1.2 miles (2 kilometers) respectively. Overall, TSS are expected to remain in the water column for less than 3 hours with excess concentrations of 10 mg/L lasting less than 6 to 12 hours. Cable installation is expected to be complete through typical (90 percent) and maximum-effect (10 percent) methods. Typical impact installation was modeled to suspend sediments at 10 mg/L above baseline levels for less than 4 to 6 hours to a distance of approximately 1.2 miles (2 kilometers) from the centerline, with the majority of the plume contained at less than 656 feet (200 meters) from the centerline. Maximum-impact installation had a similar impact with plumes extending slightly further from the centerline.

Suspended sediment can have adverse effects on benthic communities (Wilber and Clarke 2001; Berry et al. 2011). Atlantic sturgeon are adapted to natural fluctuations in water turbidity through repeated exposure (e.g., high water runoff in riverine habitat, storm events). There are potential negative impacts related to increased turbidity including reduced feeding rates, increased mortality, physiological stress, behavioral avoidance, physical injury (i.e., gill abrasion), and reduction in food source (Robertson et al. 2007). Effects from short-term turbidity (hours or days) are generally temporary and reversed over time with a return to baseline levels (Robertson et al. 2007). Tolerance of juvenile Atlantic sturgeon to suspended sediments has been evaluated in a laboratory setting and exposed individuals to TSS concentrations of 100, 250, and 500 mg/L for a three-day period (Wilkens et al. 2015). Of the fish exposed, 96 percent survived the test and the authors suggested that the absence of any significant effects on survival or swimming performance indicates that the impacts of sediment plumes in natural settings are minimal where fish have the ability to move or escape.

Maine Department of Transportation's Programmatic Biological Assessment (MaineDOT 2016) outlined biological responses for Atlantic salmon and classified them into three major categories. As sturgeon are assumed to be more tolerant of turbid conditions, Atlantic salmon are used as a very conservative proxy for the range of responses in varying turbidity conditions. The three categories are behavioral responses, sub-lethal effects, and potential mortality, and they are defined below.

- Behavioral responses—The range of turbidity releases expected to result in behavioral reactions ranging from a startle response to avoidance.
  - 1–20 mg/L for 1 hour
  - 1 mg/L for 24 hours
- Sub-lethal effects—The ranges of turbidity releases expected to result in sub-lethal effects including stress, reduction in feeding rates, and increased respiration rates.
  - 20–22,026 mg/L for 1 hour
  - 1 mg/L for 6 days
- Potential mortality—A higher range of releases with the potential to result in fish mortality.
  - >22,026 mg/L for 1 hour
  - 7 mg/L for 30 months

The modeling (Pyć et al. 2018 2018) does not predict any TSS concentrations for a period of time that might induce mortality for Atlantic sturgeon. In some instances, the plumes could fall within the impact range for behavioral or sub-lethal effects. Since Atlantic sturgeon are more tolerant and would likely depart or avoid conditions they may encounter. Suspended sediment and turbidity could result in some temporary avoidance of turbid areas, but these short term responses are not expected to result in any adverse effects to sturgeon. Therefore, suspended sediments associated with the proposed action **may affect, but not likely to adversely affect** Atlantic sturgeon.

Increased Vessel Traffic/Vessel Strike

Propeller boats and barges can pose a risk to fish that swim near the water surface and are a potential source of mortality for Atlantic sturgeon as a result of direct collisions with the hull or propeller (Brown and Murphy 2010). The majority of vessel-related Atlantic sturgeon mortality is likely caused by large transoceanic vessels in river channels (Brown and Murphy 2010; Balazik et al. 2012). Large vessels have been implicated because of their deep draft (up to 40-45 feet [12.2-13.7 meters]) relative to smaller vessels (15 feet [<4.5 meters]), which increases the probability of vessel collision with demersal fishes like Atlantic sturgeon, even in deep water (Brown and Murphy 2010). Although smaller vessels and those with relatively shallow drafts provide more clearance with the river bottom to reduce the probability of vessel-strikes, they can operate at a higher speed, which is expected to limit a sturgeons' ability to avoid being struck. Because the construction vessels (e.g., tugboats, barge crane, hopper scow) have relatively shallow drafts, the chances of vessel-related mortalities are expected to be low.

Atlantic sturgeon strikes are most likely to occur in areas with abundant boat traffic such as large ports or areas with relatively narrow waterways (ASSRT 2007). There ae no ports that would affect riverine habitats of sturgeon. In offshore areas, the chances of a vessel strike are likely to be minimal due to overall lower densities of sturgeon and available space for sturgeon to avoid vessels in these areas. Vessel operation, according to BOEM (2018), would have **no effect** on Atlantic sturgeon.

Dredging

Due to the presence of sand waves in the proposed Project area (COP Volume I, Section 4.2.3.3.2; Epsilon 2018), those sand waves would need to be removed to reach stable sea bottom in order to achieve targeted cable burial depth. Dredging, likely through the use of a trailing suction hopper dredge, would create a 66-foot (20-meter) wide corridor and Vineyard Wind has determined that up to 69 acres (0.28 km^2) of seafloor bottom would be impacted. Capture of Atlantic sturgeon in dredging equipment could potentially occur (Barbara Newman, Pers. Comm. October 27, 2016; Jennifer Anderson, Pers. Comm., August 24, 2018), but these captures are uncommon and more likely to occur in areas of large aggregations. The proposed dredging methodologies for installation of the OECC will occur where there are no known large aggregations of Atlantic sturgeon. Considering the low rate of occurrence of sturgeon expected and the limited amount of dredging that may be required to remove sand waves in the 66-foot corridor, the chance of capturing a sturgeon is considered discountable. Therefore, dredging **may affect, but is not likely to adversely affect** Atlantic sturgeon.

Waste Disposal and Accidental Spills

Waste materials generated during construction would include solid and liquid materials. Containment, storage, and disposal of these generated waste materials are discussed in COP Section 4.2.5 (Volume I; Epsilon 2018) and shown in Table 4.2-2 of that section. Non-routine events include fuel spills, accidental releases of waste material, collisions, and allisions. Adverse impacts on water quality and Atlantic sturgeon in the immediate area could be likely in the case of a non-routine event. However, non-routine events are unlikely; with the rarity of a spill to occur and the relatively small sizes of a potential spill, they are not expected to have any adverse effect on Atlantic sturgeon. BOEM (2018) indicated that emissions, discharges, and accidental releases of marine debris were **may affect, but not likely to adversely affect** Atlantic sturgeon.

Although spills are unlikely, vapors from fuel spills resulting either from vessel collisions/allisions or from servicing, the proposed Project may result in impacts on air and water quality. If such a spill were to occur, it would be expected to dissipate rapidly and then evaporate and biodegrade within a few days. Due to the expected rarity of spills and their small size, potential accidental discharges are **may affect, but not likely to adversely affect** Atlantic sturgeon.

5.3.1.2. Acoustic Impacts

Noise related impacts can occur from increased construction vessel traffic and construction activities (i.e., pile driving). Atlantic sturgeon, due to their swim bladder, are susceptible to barotrauma from underwater noise (sound pressure) even though their hearing only involves particle motion (Popper et al. 2014). When a fish with a swim bladder is exposed to a sound wave, gas in their swim bladder expands and contracts more than the surrounding tissue during the periods of under pressure and overpressure, respectively. This can cause the swim bladder to oscillate, resulting in tissue damage and possible rupture. Hearing loss in a fish is likely to result in reduced fitness from decreased ability to detect and avoid predators, locate prey, communicate with peers, or sense physical environment.

Sound is described as having two components: a pressure component and a particle motion component. Sound pressure consists of two basic sound types: continuous (e.g., motorized vessel) and impulsive (e.g., explosions, pile driving or hydraulic hammering; Southall et al. 2007; Hawkins and Popper 2014). Continuous sounds may be tonal or include a wide range of frequencies. Continuous sounds that are "rougher" than others have a high crest factor (Hawkins and Popper 2014). Impulsive sounds are characterized by a sharp rise time, brief duration, and a wide range of frequencies. They generally have an increased capacity to induce physical injury compared to continuous sounds. Particle motion is the oscillatory displacement, velocity, or acceleration of fluid particles in a sound field. All fish are sensitive to particle motion; however, some fish have adaptions (e.g., gas bubbles near the ear or swim bladders that functionally affect the ear) that also make them sensitive to sound pressure (Popper et al. 2014). Fishes with swim bladders (or other gas bubbles) that functionally affect the ear generally have lower thresholds and wider hearing bandwidths than species without these adaptations (Normandeau 2012). Hearing range and sensitivity varies considerably among fish species (Popper et al. 2014). Atlantic sturgeon are particle motion-sensitive species, although they have physostomous (open) swim bladders, these organs are not involved in their hearing (Hawkins and Johnstone 1978; Knudsen et al. 1992, 1994; Lovell et al. 2005; Meyer et al. 2010; Popper et al. 2014).

The pressure fluctuations resulting from impulsive noise are expressed in units of pressure (e.g., pounds per square inch). The Caltrans Bioacoustics manual explains the relationship as follows: "The mathematical definition of a decibel is the 'base 10 logarithmic function of the ratio of the pressure fluctuation to a reference point'" (Caltrans 2009). This results in a relation of 1 pound per square inch = 197 dB re 1 μPa. The intensity of a sound wave in water is expressed in terms of dB re μPa. Decibels are a log scale; each 10 dB increase represents a 10-fold increase in sound pressure. Accordingly, a 10 dB increase is a 10 times increase in sound pressure, and a 20 dB increase is a 100 times increase in sound pressure.

The following are commonly used measures of sound:

- Peak sound pressure level: the maximum sound pressure level (highest level of sound) in a signal measured in dB re 1 μPa.
- Sound exposure level (SEL): the integral of the squared sound pressure over the duration of the pulse (e.g., a full pile driving strike). SEL is the integration over time of the square of the acoustic pressure in the signal and is thus an indication of the total acoustic energy received by an organism from a particular source (such as pile strikes). It is measured in dB re 1μPa2-s.
- Single Strike SEL: the amount of energy in 1 strike of a pile.
- Cumulative sound exposure level (cSEL): the energy accumulated over multiple strikes. cSEL indicates the full energy to which an animal is exposed during any kind of signal. The rapidity with which the cSEL accumulates depends on the level of the single strike SEL. The actual level of accumulated energy (cSEL) is the logarithmic sum of the total number of single strike SELs. Thus, cSEL (dB) = Single-strike SEL + 10log10(N); where N is the number of strikes.
- RMS: the average level of a sound signal over a specific period of time.

The types of effect on and response from fishes to a sound source depends on distance. Very close to the source, effects may range from mortality to physical injury. Somewhat further from the source mortality is no longer an issue, and effects range from physiological to behavioral. The potential for effects declines as distance increases between the individual and the source. The actual nature of effects depends on a number of other factors, such as fish hearing sensitivity, source level, sound propagation and resultant sound level at the fish, whether the fish stays in the vicinity of the source, and motivation level of the fish. Generally speaking, species are thought to have different tolerances to noise and may exhibit different responses to the same noise source.

Underwater sound pressure waves can injure or kill fish (Normandeau 2012; Popper et al 2014). Fish with swim bladders are particularly sensitive to underwater impulsive sounds with a sharp sound pressure peak occurring in a short interval of time (Caltrans 2001 as cited in NMFS 2012). As the pressure wave passes through a fish, the swim bladder is rapidly squeezed due to the high pressure, and then rapidly expanded as the under pressure component of the wave passes through the fish. The pneumatic pounding on tissues contacting the swim bladder may rupture capillaries in the internal organs, as indicated by observed blood in the abdominal cavity and maceration of the kidney tissues (Caltrans 2001 as cited in NMFS 2012). Potential physiological effects resulting from sound exposure are highly diverse and range from very small ruptures of capillaries in fins (which are not likely to have any effect on survival) to severe hemorrhaging of major organ systems such as the liver, kidney, or brain. Other potential effects include rupture of the swim bladder. Underwater sounds must be louder than background level to be detected by a fish. Additionally, a sound may need to be biologically relevant to an individual to elicit a particular behavioral response (Plachta and Popper 2003; Doksaeter et al. 2009). Behavioral responses may range from a temporary startle to avoidance of an ensonified area.

The Fisheries Hydroacoustic Working Group is comprised of biologists from NMFS, USFWS, Federal Highway Administration, and the California, Washington and Oregon Department of Transportations. In June 2008, the agencies developed interim criteria for assessing physiological effects of pile driving noise on fish. These are criteria for the onset of physiological effects and not levels at which fish are necessarily mortally damaged. These criteria apply to Green sturgeon and Pacific salmon, and both USFWS and NMFS (USDOI, USFWS, USDOC, and NMFS 1998) have assumed these criteria can be applied to Atlantic sturgeon. The interim criteria are:

- Peak sound pressure level: 206 dB re 1 μPa (for fish of any size);
- cSEL of 187 dB re 1μPa2-s for fishes above 2 grams (0.07 ounces); and
- cSEL of 183 dB re 1μPa2-s for fishes below 2 grams (0.07 ounces).

USFWS/NMFS has relied on these criteria in determining the potential for physiological effects in ESA Section 7 consultations.

For the proposed Project, Pyć et al. (2018) modeling of pile driving impact noise was evaluated using the categories and thresholds developed by Popper et al. (2014) and the NMFS acoustic tool (2016) which uses the Fisheries Hydroacoustic Working Group thresholds based on fish size. The modeling using Popper et al. (2014) criteria estimated a radial distance from the noise source that would cause 1) mortal or potentially mortal injury, 2) recoverable injury, and 3) temporary threshold shifts for groups of fish hearing categories. In summary, for fish with swim bladders not involved in hearing (e.g. Atlantic sturgeon) impact thresholds are 1) mortality or potential mortality injury (210 dB), 2) recoverable injury (203 dB), and 3) temporary threshold shift (186 dB). The dB levels are expressed as L_E or cumulative

(24-hour) exposure levels. Full tables from the model can be found in COP Volume III, Appendix III-M (Epsilon 2018; Pyć et al. 2018). Modeling using the NMFS acoustic tool estimates the radial distance at which injury (mortal and recoverable) and behavioral responses can occur. The 24 hour cumulative exposure for Atlantic sturgeon in the WDA is 187 dB for injury and 150 dB for behavioral responses.

Noise Effects from Construction Vessels and Vessel Traffic

Vessel operation is a continuous (albeit temporary) noise source that generates vibrations. Cumulative noise from construction vessels includes jack-up vessels and vessels with dynamic positioning with feeder barges. The potential cumulative impacts on sturgeon from underwater noise may include no effect, habituation to noise, behavioral response, and physiological stress. Non-pile driving construction noise and vessel noise may create temporary avoidance in pelagic and demersal species, but generally would not be loud enough for long enough to induce injury or death (MMS 2009). Analysis of vessel noise related to the Cape Wind Energy Project found that noise levels from construction vessels at 10 feet (3 meters) were loud enough to induce avoidance, but not to do physical harm (MMS 2009). Atlantic sturgeon within range of vessel noise capable of initiating any of these impacts would likely display an avoidance behavior and, as there is ample foraging habitat for these fish in the WDA and OECC, it is unlikely to have an adverse impact. BOEM (2018) determined that noise generated by vessel transit and operations is **may affect, but not likely to adversely affect** Atlantic sturgeon and that noise generated by vessel engines and thrusters would have **no effect**.

Noise Generated from Pile Driving

Pile driving would be used to install foundation piles for WTGs and ESPs. Each WTG and ESP would be on a foundation consisting of either a monopile (34-foot diameter [10.3 meters]) or jacketed pile (three or four 9.8 feet [3 meter] piles). Up to 100 WTGs could be installed consisting of either 100 monopiles and 2 ESP jacket foundations (Scenario 1) or a combination of 90 monopiles and up to 12 jacket foundations (Scenario 2). Monopile foundations require approximately 3 hours to install using a 4,000-kilojoule hammer; two foundations can be installed in a 24-hour period. Installation of jacketed foundations would occur at a rate of one foundation (three to four pin piles) per day. Each jacket would take less than 3 hours to install using a 3,000-kilojoule hammer.

Pyć et al. (2018), using the criteria from Popper et al. (2014), modeled the radial distance at which mortal injury, recoverable injury, and temporary threshold shift (temporary loss of hearing sensitivity) would occur as a result of the L_{pk} and 24 hour L_E pile driving noise associated with installing 34-foot [10.3-meter] monopile with 6 dB attenuation (Table 5.3-1). Within the WDA, if Atlantic sturgeon were in the vicinity they would be either sub-adult or adult fish; no eggs or larvae would be impacted by pile driving noise because they are not found in the Project area. Based on the modeled 24 hour L_E for fish with a swim bladder not involved in hearing, Atlantic sturgeon could be subject to mortality at a radial distance of 1,480-1,650 feet (451-503 meters), recoverable injury at up to 4,806 feet (1,465 meters), and temporary threshold shift at up to 24,423 feet (7,444 meters).

Table 5.3-1: Radial Distance (meters) to Thresholds for Atlantic Sturgeon from Impact Hammering

Group	Metric	Threshold (db)	P1 Hammer Energy (kJ)					P2 Hammer Energy (kJ)				
			500	1,000	1,500	2,000	2,500	500	1,000	1,500	2,000	2,500
Mortality and Potential Mortality												
Fish with swim bladder not involved in hearing	L_E	201	451					503				
	L_{pk}	207	41	53	54	57	78	14	14	23	32	56
Recoverable Injury												
Fish with swim bladder	L_E	203	1,287					1,465				
	L_{pk}	207	41	53	54	57	78	41	53	54	57	78
Temporary Threshold Shift												
All fish	L_E	186	6,121					7,444				

Source: COP Volume III, Appendix M, Table A-34, Epsilon 2018; Popper et al. 2014

dB = decibel; kj = kilojoule; L_E = cumulative sound pressure; L_{pk} = peak sound pressure

Note: Impact from hammering of a 34-foot (10.3-meter) pile using an IHC S-4000 hammer with 6 dB attenuation

Additional analysis conducted by Pyć et al. (2018) for pile driving impacts on Atlantic sturgeon were based on fish size and was completed using the NMFS acoustic tool (Table 5.3-2; NMFS 2016). NMFS Greater Atlantic Regional Fisheries Office developed the NMFS acoustic tool for assessing the potential effects to ESA-listed species exposed to elevated levels of underwater sound produced during pile driving. The NMFS acoustics tool sets the physiological (injury) threshold for large (> 2 grams) and small (< 2 grams) fish at 187 dB and 183 dB respectively and the behavioral response threshold at 150 dB for both categories (NMFS 2016). Only impacts associated with fish greater than 2.0 grams are relevant to Atlantic sturgeon. Adults and sub-adults utilize shallow near-shore areas of the continental shelf (10 to 50 meters) while smaller fish reside in freshwater or estuarine habitats. The radial distance at which physiological injury occurred from pile driving a 34-foot (10.3-meter) foundation in 24 hours with 6 dB of attenuation (Table A-35, Pyć et al. 2018) was 18,747 to 22,618 feet (5,714-6,894 meters). The range for behavioral responses to pile driving noise was 24,928 to 30,279 feet (7,598-9,229 meters).

Table 5.3-2: Ranges (R95% in meters) to thresholds (NMFS 2016) for Atlantic sturgeon in the WDA due to impact hammering of a 10.3-meter pile in 24 hours, using an IHC S-4000 hammer with 6 dB attenuation

Group	Metric	Threshold (db)	P1 Hammer Energy (kJ)					P2 Hammer Energy (kJ)				
			500	1,000	1,500	2,000	2,500	500	1,000	1,500	2,000	2,500
Large fish	$LE_{,12hr}$	187	5,714					6,894				
	L_{pk}	206	46	59	61	64	87	15	15	26	35	63
Large fish	L_p	150	4,428	5,438	6,519	7,167	7,598	4,733	6,351	7,760	8,689	9,229

Source: Table A-35 in Pyć et al. 2018

dB = decibel; kj = kilojoule; $L_{E,12hr}$ = cumulative sound pressure over 12 hours; L_p = sound pressure; L_{pk} = peak sound pressure

Note: Large fish are defined as having a total mass of ≥ 2 grams. Ranges (R95% in meters) to thresholds for fish and sea turtle groups (NMFS 2016) due to impact hammering of a 10.3-meter pile in 24 hours, using an IHC S-4000 hammer with 6 dB attenuation.

Impacts on subadult and adult sturgeon from pile driving based on the two models would be similar. The major difference in impacts is the radial distance at which injury or behavioral changes would occur. The maximum radial impact distance is greater using the NMFS acoustic tool based on the more sensitive threshold levels. Impacts on Atlantic sturgeon could be reduced substantially though attenuation and by a soft start technique (COP Volume III, Section 6.6.2.1.3; Epsilon 2018) which would initiate an avoidance response by Atlantic sturgeon, allowing them time to retreat to areas outside the impact radius before pile driving begins. Despite mitigation, pile driving is **may affect, and likely to adversely affect** Atlantic sturgeon inhabiting the WDA.

5.3.2. Operations and Maintenance

5.3.2.1. Non-Acoustic Impacts

Vessel Operation/Increased Traffic/Strikes

Noise associated with operations and maintenance vessels (COP Volume II, Section 4.3.4, Table 4.3-2; Epsilon 2018) would impact Atlantic sturgeon in a similar way to construction vessel traffic. However, the impacts would be smaller than construction because many of the vessels used (i.e., crew transport vessels) are smaller and would be used for shorter time periods. Atlantic sturgeon strikes are most likely to occur in areas with abundant boat traffic such as large ports or areas with relatively narrow waterways (ASSRT 2007). There are no proposed ports that would affect critical habitat of sturgeon. In offshore areas, the chances of a vessel strike are likely to be minimal due to overall lower densities of sturgeon and available area to avoid vessels. Vessel operation and potential strikes, according to BOEM (2018) would have **no effect** on Atlantic sturgeon.

OECC/WDA Cable Maintenance

Occasional maintenance activities to repair segments of the OECC or inter-array cables are anticipated and impacts are likely to be similar to those temporary habitat disturbances involved in the installation. Generally, the disturbance of benthic habitat should be short-term and localized with an abundance of similar foraging habitat and prey available in adjacent areas for Atlantic sturgeon. BOEM (2018) indicated that the temporary disturbance of habitat would be rated as **may affect, but not likely to adversely affect** Atlantic sturgeon.

EMF

Buried cables reduce, but do not entirely eliminate, EMF (Taormina et al. 2018). During the operations and maintenance phase of the Proposed Action, powered transmission cables would produce EMF and heat (Taormina et al. 2018). To minimize EMF generated by cables, all cabling would be contained in grounded metallic shielding to prevent detectable direct electric fields. Vineyard Wind would also bury cables to a target burial depth of approximately 6.6 feet (2 meters) below the surface or utilize cable protection (e.g., rock or concrete mattresses), which would diminish the effect of EMF and heat. Since the effects of habitat alteration from cable installation were already considered above, it is expected any recolonization would laterally or vertically avoid any temperatures that invertebrate species may be sensitive to. Since the cable will be buried at an average of 6.6 feet in most locations, the potential effects of cable heat and EMF to the availability of invertebrate prey to sturgeon is expected to be insignificant.

Current data suggest that while the swimming capability of some fish may be affected by EMF from submarine cables and some species specific avoidance behavior has been observed, no evidence of population scale impacts or adverse physiological impacts have been reported (Taormina et al. 2018).

Atlantic sturgeon have both electro and magneto sensitivity that can affect feeding, predator detection, and navigation (BOEM 2012), although research suggests marine species may be less likely to detect EMF from AC cables (BOEM 2012). Due to the linear nature of the area impacted by cables, small area around those cables that may have detectable levels of EMF, and lack of any substantial information suggesting sturgeon may be adversely affected, the effects of EMF on Atlantic sturgeon are expected to be insignificant. It is highly unlikely that EMF would have an adverse effect Atlantic sturgeon within the WDA or OECC, and therefore **may affect, but not likely to adversely affect** Atlantic sturgeon.

Lighting

Light during operations could have an impact on resources in the WDA. The COP details plans to minimize lighting effects on birds, bats, and marine mammals (COP Volume III, Section 4.2, Table 4.2-1; Epsilon 2018). Overall, as a benthic species, Atlantic sturgeon are not as likely to be impacted by lighting during operations. In the event that light does impact behavior, avoidance is the most likely effect. While Atlantic sturgeon have been documented as more active during low light conditions (Dadswell 1984), the efforts to shield other species from the operational lighting would likely provide adequate protection for sturgeon as well. This action is **may affect, but not likely to adversely affect** Atlantic sturgeon.

5.3.2.2. Acoustic Impacts

Operation and maintenance of the proposed Project could produce noise impacts on Atlantic sturgeon that may be present in the Project area. Generally, these impacts would be related to activities associated with vessel traffic, WTG operation, and maintenance.

Noise associated with vessels from operations and maintenance (COP Volume II, Section 4.3.4, Table 4.3-2; Epsilon 2018) would impact fish in a similar way to vessel traffic associated with construction. In general, operations and maintenance vessels should have a smaller impact as many of the vessels used (i.e., crew transport vessels) are smaller and would be in use for shorter time periods. Atlantic sturgeon within range of vessel noise capable of initiating impacts (habituation to noise, behavioral response, and physiological stress) would likely display an avoidance behavior and, as there is ample foraging habitat for these fish in the WDA and OECC, it is unlikely to have an adverse impact. BOEM (2018) determined that noise generated by vessel transit and operations was **may affect, but not likely to adversely affect** Atlantic sturgeon and that noise generated by vessel engines and thrusters should have **no effect**.

WTGs would also produce noise, although sound levels from wind turbines are typically low (Madsen et al. 2006). According to measurements at the Block Island Wind Farm, low frequency noise generated by turbines barely exceeds ambient noise levels at 164 feet (50 meters; Miller and Potty 2017). Sound pressure level measurements from operational wind turbines in Europe indicate a range of 109 to 127 dBs re 1 µPa at 46 and 65.6 feet (14 and 20 meters) from the turbines (Tougaard and Henrikson 2009). Although sound pressure levels may be different in the local conditions of the WDA, if sound levels at the WDA are similar, operational noise could be slightly higher than ambient, which ranged from 95 to greater than 104 dBs re 1 µPa at the study area from 2011 to 2015 (Kraus et al. 2016b).

Wind turbines would produce noise that can cause masking effects, but thus far, noise related to operational WTGs have not been found to have a negative impact on finfish (English et al. 2017). Detection distance from noise generated by WTGs depends on several variables (i.e., hearing capability of fish, depth, size and spacing of WTGs, wind speed) and does not create a level of noise capable of injury (Wahlberg and Westerberg 2005). No study has shown any behavioral impact of sound during the operational phase of wind farms, although due to the lower sound emissions during operation, measurements and research have remained a low priority in comparison with pile driving-generated sound (Thomsen et al. 2016). Based on this, the impacts are **may affect, but not likely to adversely affect** Atlantic sturgeon.

5.3.3. Decommissioning

5.3.3.1. Non-Acoustic and Acoustic Impacts

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 impact-producing factor during decommissioning.

WTG and ESP foundation and scour protection removal would have the same temporary habitat impacts as those associated with construction (with the exception that there would be no pile driving). Habitat previously converted to hard bottom would return to soft bottom habitat over time, shifting any changes in benthic community likely back to the pre-existing conditions. Turbidity from suspended sediment would impact habitat as discussed in the construction phase as methods similar to the installation would be employed to remove the export, inter-link, and inter-array cables.

In terms of vessel operations, waste disposal and other decommissioning operations, the impacts are expected to be similar to those described in the construction phase, including **may affect, but not likely to adversely affect** and **no effect** on Atlantic sturgeon.

In addition, Vineyard Wind proposes HRG surveys for site clearance activities that could result in acoustic impacts. The non-airgun HRG surveys would use only electromechanical sources such as boomer, sparker, and chirp subbottom profilers, side-scan sonar, and multibeam depth sounders. Acoustic signals from electromechanical sources other than the boomer, sparker, bubble gun, and chirp sub-bottom profiler are not likely to be detectable by Atlantic Sturgeon. The boomer has an operating frequency range of 200 Hz to 16 kHz and could be audible to sturgeon; however, it has very short pulse lengths (120, 150, or 180 μs) and a very low source level, with a PTS radius of 39.4 feet (12 meters) (BOEM 2018). Conservative estimates of the distance to harassment ranges from 105 feet (32 meters) for chirp sub-bottom profilers to 6,548 feet (1,996 meters) for sparkers and bubble guns (BOEM 2018). BOEM expects impacts from non-airgun HRG surveys using boomer or sparker sub-bottom profilers **may affect, but not likely to adversely affect** Atlantic Sturgeon.

5.3.4. Effects to Critical Habitat

No critical habitat for Atlantic sturgeon has been delineated in the WDA or OECC. There ae no proposed activities that will affect sturgeon critical habitat. Since proposed Project activities will not overlap with critical habitat for Atlantic sturgeon, BOEM concludes that the Proposed Action will have **no effect** any critical habitat for Atlantic sturgeon that has been designated under the ESA.

6. CONCLUSIONS

Based on the analysis in this BA regarding the effects of the Proposed Action on listed species and critical habitat occurring in the Vineyard Wind Action Area, BOEM has concluded:

- With the added requirement of 6 dB attenuation from BOEM to the supplementary NARW mitigation, pile-driving impacts **may affect, but not likely to adversely affect** NARWs due to avoidance of peak seasons of occurrence and listed sea turtles, and **may affect, likely to adversely affect** all fin, sei and sperm whales.
- Pile driving with the added requirement of 6 dB attenuation would result in **may affect, likely to have an adverse effect** Atlantic sturgeon inhabiting the WDA.
- Vessel noise **may affect by harassment, but not likely to adversely affect** NARWs, fin, sei, and sperm whales; loggerhead, Kemp's ridley, leatherback, and green sea turtles because short-term and temporary responses are not likely to result in harassment or harm to individuals or populations.
- Vessel noise generated by vessel transit and operations **may affect, but not likely to adversely affect** Atlantic sturgeon and that noise generated by vessel engines and thrusters would have **no effect**.
- Vessel traffic **may affect, but not likely to adversely affect** NARWs, fin, sei, and sperm whales; and loggerhead, Kemp's ridley, leatherback, and green sea turtles by increased potential for injury or mortality from strike.

Pile driving is not expected to have any measureable effect on the fitness of individuals or populations of NARW, fin, sei, and sperm whales, or loggerhead, leatherback, Kemp's ridley, or green sea turtles or Atlantic sturgeon. All other effects associated with construction, installation, operations, maintenance, and decommissioning **may affect, but not likely to adversely affect** or have **no effect** listed species. Some of these activities may have minor effects that are reduced to discountable levels with implementation of the Project's Proposed Action and BOEM's proposed best management practices. The Proposed Action would have no adverse effects on the Northeast US foraging critical habitat for NARWs.

Table 6-1 summarizes the effects determinations for the listed marine mammals, sea turtles, and fish present within the BA Area. There are three conclusions that an action agency may make based on their analyses of direct and indirect effects when determining whether formal consultation is necessary, based on the Endangered Species Consultation Handbook (USDOI, USFWS, USDOC, and NMFS 1998):

- **No Effect**—This is the appropriate determination when the action agency determines its proposed action is not expected to affect listed/proposed species or designated/proposed critical habitat.
- **May Affect, but Not Likely to Adversely Affect**—This is the appropriate determination when effects on listed species are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are positive effects without any adverse effects. Insignificant effects relate to the size of the impact; the impact cannot be meaningfully detected, measured, or evaluated, and should

never reach the scale where take occurs. Discountable effects are those that are extremely unlikely to occur.

- **May Affect, Likely to Adversely Affect**—This is the appropriate determination when adverse effects that are not beneficial, insignificant, or discountable are likely to occur to listed species/critical habitat.

Table 6-1: Summary of Effects Determination for the Proposed Project

Impact Producing Factor	Impact Type	Potential Effect	Atlantic Sturgeon	Listed Whales [a]	Listed Sea Turtles [b]
Construction and Installation					
Offshore export cable installation	Turbidity	Foraging/prey availability	NLAA	NLAA	NLAA
Offshore export and inner array cable installation, WTG installation	Benthic Habitat Loss	Foraging/prey availability	NLAA	NLAA	NLAA
Steel anchor cables used on construction barges	Entanglement	Injury/Mortality	NE	NA	NE
Pile driving up to 100 33.8-ft (10.3-m) monopiles and up to 12 jacket foundations	Noise	Disturbance, TTS, PTS	Sub-adult and Adult Atlantic; Sturgeon LAA	NARW NLAA, fin, sei, sperm whales LAA	NLAA
Vessel Traffic	Noise	Disturbance, TTS, PTS	NLAA	NLAA	NLAA
	Strike	Injury/Mortality	NLAA	NLAA	NLAA
Inner array cable installation	Turbidity	Foraging/prey availability	NLAA	NLAA	NE
Operation and Maintenance					
WTG	Noise	Disturbance	NLAA	NLAA	NLAA
	Accidental Spills (oil)	Physiological effects, inhalation, surfacing in the sheen	NLAA	NLAA	NLAA
	Lighting	Photoperiod disruption, attraction	NLAA	NA	NLAA

Impact Producing Factor	Impact Type	Potential Effect	Atlantic Sturgeon	Listed Whales [a]	Listed Sea Turtles [b]
Offshore export and inner array cables	EMF	Effects on orientation, migration, navigation	NLAA	NLAA	NLAA
Vessel Traffic	Noise	Disturbance, TTS, PTS	NE	NLAA	NLAA
	Strike	Injury/Mortality	NE	NLAA	NLAA
Decommissioning					
Removal of offshore export cable, WTG, and scour protection	Turbidity/Benthic Habitat Loss	Foraging/prey availability	NLAA	NLAA	NLAA
Vessel Traffic	Noise	Disturbance	NLAA	NLAA	NLAA
	Strike	Injury/Mortality	NLAA	NLAA	NLAA
HRG and ROV for site clearance	Noise	Disturbance	NLAA	NLAA	NLAA

ft = foot; LAA = “May affect, likely to adversely affect” means that one or more individuals of an ESA-listed species or one or more essential features of critical habitats are likely to be exposed to the actions and are likely to result in “take” or adverse effects, respectively; m = meter; NA = Not applicable; NARW = North Atlantic right whale; NE = “No effect” means ESA-listed species or critical habitat will not be affected, directly or indirectly; NLAA = “May affect, but not likely to adversely affect” means that all effects are beneficial, insignificant, or discountable.

[a] NARWs, fin whales, sei whales, and sperm whales

[b] Northwest Atlantic DPS of loggerhead sea turtles, green North Atlantic DPS, Kemp’s ridley, and leatherback sea turtles

7. STANDARD OPERATING CONDITIONS FOR PROTECTED SPECIES

Vineyard Wind’s self-imposed measures and BOEM’s mitigation measures being considered for the proposed Project are listed in Section 4.3 above.

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Supplemental Information for the Vineyard Wind 1 Project
Biological Assessment
May 11, 2020

This document transmits supplemental information to the March 27, 2019 Vineyard Wind 1 Project Biological Assessment (BA) as a result of updates to the project design envelope (PDE). In addition, this document addresses several outstanding requests discussed at the March in-person project meeting between The Bureau of Ocean Energy Management (BOEM) and National Marine Fisheries Service (NMFS).

On January 31, 2020, Vineyard Wind, LLC (Vineyard Wind) submitted an update to its PDE in an updated Construction and Operations Plan (COP). Primarily, the PDE increased the maximum wind turbine generator (WTG) size to up 14 megawatts (MW) from 10 MW, which was presented in the March 2019 BA. As shown below in Table 4.1-1, most of the updates relate to the WTG and associated rotor diameter, tip height, and hub height. Tables 4.1-1 and 4.1-2 from the BA can be replaced with the revised tables below. Changes from the BA have been highlighted in boldface type for your convenience.

Table 4.1-1: Vineyard Wind 1 Project WTG Specifications with Maximum Design Scenario

Wind Facility Capacity	Approximately 800 MW [a]	
Wind Turbine Generator Foundation Arrangement Envelope	Up to 100 monopiles	Up to 10 may be jacket foundations
Wind Turbine Generators	**Minimum Turbine Size**	**Maximum Turbine Size**
Turbine Generation Capacity	8 MW	**14** MW
Number of Turbine Positions [b]	106	88
Number of Turbines Installed	100	**57**
Total Tip Height	627 ft (191 m) MLLW [c]	**837** ft (**255** m) MLLW [c]
Hub Height	358 ft (109 m) MLLW [c]	**473** ft (**144** m) MLLW [c]
Rotor Diameter	538 ft (164 m) MLLW [c]	**729** ft (**222** m) MLLW [c]
Tip Clearance	89 ft (27 m) MLLW [c]	**105** ft (**32** m) MLLW [c]
Platform Level/Interface Level Height for Monopile	62 ft (19 m) MLLW [c]	75 ft (23 m) MLLW [c]
Tower Diameter for WTG	20 ft (6 m)	28 ft (8.5 m)
Monopile Foundations [d]	**Minimum Foundation Size**	**Maximum Foundation Size**
Diameter	25 ft (7.5 m)	34 ft (10.3 m)
Pile footprint	490 ft^2 (45.5 m^2)	908 ft^2 (84.3 m^2)
Height between Seabed and MLLW (water depth)	121 ft (37 m)	162 ft (49.5 m)
Penetration	66 ft (20 m)	148 ft (45 m)
Transition Piece Tower Diameter	20 ft (6 m)	28 ft (8.5 m)
Transition Piece Length	59 ft (18 m)	98 ft (30 m)
Platform Level/Interface Level Height	64 ft (19.5 m)	74 ft (22.5 m)
Number of Piles/Foundation	1	1
Number of Piles Driven/Day within 24 hours [e]	1	2
Typical Foundation Time to Pile Drive [f]	approximately 3 hours	approximately 3 hours
Hammer size	4,000 kJ	4,000 kJ
Jacket (Pin Piles) Foundation	**Minimum Foundation Size**	**Maximum Foundation Size**
Diameter for WTG and ESP	5 ft (1.5 m)	10 ft (3 m)
Jacket Structure Height for WTG	180 ft (55 m)	262 ft (80 m)
Jacket Structure Height for ESP	180 ft (55 m)	213 ft (65 m)
Platform Level/Interface Level Height for WTG and ESP	74 ft (22.5 m) MLLW	94 ft (28.5 m) MLLW
Pile Penetration for WTG	98 ft (30 m)	197 ft (60 m)

Pile Penetration for ESP	98 ft (30 m)	246 ft (75 m)
Pile Footprint for WTG	59 ft (18 m)	115 ft (35 m)
Pile Footprint for ESP	59 ft (18 m)	248 ft (45 m)
Number of Piles/Foundation	3 to 4	3 to 4
Number of Piles Driven/Day within 24 Hours [e]	1 (up to 4 pin piles)	1 (up to 4 pin piles)
Typical Foundation Time to Pile Drive [f]	approximately 3 hours	approximately 3 hours
Hammer Size	3,000 kJ	3,000 kJ

Source: COP Volume I (Epsilon **2020**)
ESP = electrical service platform; ft = foot; ft^2 = square feet; kJ = kilojoule; m = meter; m^2 = square meters; MLLW = mean lower low water; MW = megawatt; WTG = wind turbine generator
[a] Vineyard Wind's Proposed Action is for an approximately 800 MW offshore wind energy project. The Draft Environmental Impact Statement evaluates the potential impacts of a facility up to 800 MW to ensure that it covers projects constructed with a smaller capacity.
[b] Additional WTG positions allow for spare turbine locations or additional capacity to account for environmental or engineering challenges.
[c] Elevations relative to mean higher high water are approximately 3 feet (1 meter) lower than those relative to MLLW.
[d] The foundation size is not connected to the turbine size/capacity. Foundations are individually designed based on seabed conditions and the largest foundation size could be used with the smallest turbine.
[e] Work would not be performed concurrently. No drilling is anticipated; however, it may be required if a large boulder or refusal is met. If drilling is required, a rotary drilling unit would be mobilized, or vibratory hammering would be used.
[f] Vineyard Wind has estimated that typical pile driving for a monopile is expected to take less than approximately 3 hours to achieve the target penetration depth, and that pile driving for the jacket foundation would take approximately 3 hours to achieve the target penetration depth. Different hammer sizes are used for installation of the monopile and jacket foundations.

Table 4.1-2: Vineyard Wind 1 Project ESP Specifications with Maximum Design Scenario [a]
Electrical Service Platform (ESP)

Dimensions	148 ft x 230 ft x 125 ft (45 m x 70 m x 38 m)	148 ft x 230 ft x 125 ft (45 m x 70 m x 38 m)
Number of Conventional ESPs	1 (800 MW)	2 (400 MW each)
Number of Transformers per ESP	1	2
Foundation Type	Monopile	Jacket
Number of Piles/Foundation	1	3 to 4
Maximum Height [b]	**215 ft (65.5 m)**	218 ft (66.5 m) MLLW

Source: COP Volume I, Table 3.1-1 (Epsilon **2020**)
ESP = electrical service platform; ft = foot; m = meter; MW = megawatt
[a] Vineyard Wind's Proposed Action is for an approximately 800 MW offshore wind energy project. The Draft Environmental Impact Statement evaluated and the Supplemental to the Draft Environmental Impact Statement evaluates the potential impacts of a facility up to 800 MW to ensure covering the maximum-case scenario impact.
[b] Elevations provided are relative to Mean Lower Low Water—average of all the lower low water heights of each tidal day observed over the National Tidal Datum Epoch.

Increase in WTG Capacity

By increasing the upper WTG capacity to 14 MW, the minimum number of foundations required to generate a total of 800 MW decreases to 57. Therefore, the range in the possible number of WTG foundations is 57 to 100 with the PDE change. Note, the maximum number of foundations (and pile driving required) will not change as described in the BA. Additionally, there are also no changes to the PDE for dimensions, footprint, or installation methodologies for the foundations since the size of the piles for the foundations remains unchanged.

Vineyard Wind has indicated there will be no changes to the types, sizes, and number of vessels and cranes or the number of vessel trips during construction, operations, or maintenance. Please note that although the maximum number of WTGs included in the PDE (i.e., 100 WTGs) is not changing, as few as

57 WTGs may be required if 14 MW is selected. Accordingly, a shorter duration for pile driving would result with the 14 MW. With the 14 MW, up to 43 percent fewer WTGs would be required resulting in a direct percent reduction in the duration of pile driving time required. Fewer vessel trips during construction would be required if 57 WTGs are installed. Also, fewer WTGs would reduce the number of vessel trips required during operations, maintenance, and decommissioning. Although Vineyard Wind does not anticipate using multiple WTG sizes, the COP does not preclude Vineyard Wind from doing so and the total number of WTGs in the Proposed Action ranges from 57 to 100, plus 2 ESPs.

Pile Driving Exposure Estimates for the Lower Number of Possible Foundations

Exposure estimates for the maximum-case scenario are already completed and included in the COP, BA, and proposed Incidental Harassment Authorization under the Marine Mammal Protection Act (MMPA). Considering the range of WTG foundations, 57-100, and the amount of total take is directly related to the duration of construction, 43 percent fewer takes would be expected for 57 WTG foundations than for 100 under the maximum-case scenario. The scenarios considering a lower number of foundations for the 14 MW WTGs results in two additional exposure scenarios than described in the BA and in Table 5 of the proposed IHA (84 FR 18346).

Lower PDE Scenario for 57 WTG foundations	**WTG monopiles (pile size: 10.3 m (33.8 ft))**	**WTG jacket foundations (pile size: 3 m (9.8 ft))**	**ESP jacket foundations (pile size: 3 m (9.8 ft))**	**Total number of piles**	**Total number of installation locations**
Maximum Design	47	10	2	95	59
Most Likely Design	57	0	2	65	59

Using the number of exposures of listed marine mammals in Tables 10, 11, 12, and 13 of the proposed IHA (84 FR 18346) and Tables 26-29 of the sound modeling report for sea turtles, the tables below show the commensurate reduction in takes by 43 percent for the 57 WTG and 2 jacket ESP scenarios above.

Table 10-Mean Numbers Of Listed Whales And Sea Turtles Estimated To Be Exposed Above Auditory Impact And Harassment Thresholds During The Proposed Project Using 57 Monopiles, 2 Jacket ESPs and One Foundation Installed Per Day

Species	**6 dB Attenuation**		**12 dB attenuation**	
	Auditory Impact	**Harassment**	**Auditory Impact**	**Harassment**
Fin whale	2.35	18.87	0.17	12.41
NARW	0.78	7.55	0.05	4.98
Sei whale	0.08	0.62	0.01	0.42
Sperm whale	0.0	0.0	0.0	0.0
Kemp’s ridley	0.01	0.18	0.01	0.09
Leatherback	0.01	0.22	0.01	0.11
Loggerhead	0.04	0.98	0.01	0.51

Table 11-Mean Numbers Of Listed Whales And Sea Turtles Estimated To Be Exposed Above Auditory Impact And Harassment Thresholds During The Proposed Project Using 57 Monopile WTGs, 2 Jacket ESPs And Two Foundations Installed Per Day

Species	6 dB Attenuation		12 dB attenuation	
	Auditory Impact	Harassment	Auditory Impact	Harassment
Fin whale	2.56	16.93	0.23	11.71
North Atlantic right whale	0.79	6.70	0.06	4.54
Sei whale	0.08	0.53	0.01	0.37
Sperm whale	0.0	0.0	0.0	0.0
Kemp's ridley	0.01	0.11	0.0	0.06
Leatherback	0.01	0.17	0.0	0.09
Loggerhead	0.05	1.21	0.02	0.72

Table 12-Mean Numbers Of Listed Whales And Sea Turtles Estimated To Be Exposed Above Auditory Impact And Harassment Thresholds During The Proposed Project Using 47 WTGs, 10 Jacket WTGs, 2 ESPs And One Foundation Installed Per Day

Species	6 dB Attenuation		12 dB attenuation	
	Auditory Impact	Harassment	Auditory Impact	Harassment
Fin whale	1.62	17.01	0.13	11.08
North Atlantic right whale	0.41	6.17	0.03	4.04
Sei whale	0.05	0.45	0.01	0.31
Sperm whale	0.0	0.0	0.0	0.0
Kemp's ridley	0.01	0.18	0.0	0.09
Leatherback	0.01	0.19	0.0	0.10
Loggerhead	0.04	0.86	0.0	0.46

Table 13-Mean Numbers Of Listed Whales And Sea Turtles Estimated To Be Exposed Above Auditory Impact And Harassment Thresholds During The Proposed Project Using 47 WTGs, 10 Jacket WTGs, 2 ESPs And Two Foundations Installed Per Day

Species	6 dB Attenuation		12 dB attenuation	
	Auditory Impact	Harassment	Auditory Impact	Harassment
Fin whale	1.85	14.86	0.21	10.31
North Atlantic right whale	0.43	5.25	0.03	3.56
Sei whale	0..5	0.44	0.01	0.03
Sperm whale	0.0	0.0	0.0	0.0
Kemp's ridley	0.01	0.10	0.0	0.06
Leatherback	0.01	0.14	0.0	0.08
Loggerhead	0.05	1.12	0.02	0.69

Atmospheric and Oceanographic Influence from Larger WTGs

The Project layout was determined in accordance with industry best practices to reduce wake losses and optimize energy production on a Project level. The wake effects are determined using an ensemble of state-of-the-art wake models (e.g. N.O. Jensen and PARK2) which have been validated empirically and with computer models. In general, Project engineers target a wind turbine spacing of 6-9 rotor diameters to account for wake losses. The layout provides typical spacing of 1.4-1.8 km (0.76-1.0 NM) between turbines, which provides a typical spacing of at least 6 rotor diameters for even the largest turbines (with 222 m [729 ft] rotor diameters) included in the PDE.

There is no research that evaluates the relationship between turbine size and effects to the Cold Pool. It is understood that offshore wind turbines may result in minor wind or water wake effects; however, each of these effects is highly localized and not expected to have ecosystem level impacts nor adversely impact the habitat of listed species. The Cold Pool in the New England Shelf area is ~50 km (~27 NM) wide and ~35 m (~115 ft) thick and is located in water depths between ~80 (~262 ft) and ~40 m (~131 ft) as defined by the 6°C isotherm, but is always at least ~25 m (~82 ft) below the surface (Lentz 2017). Given that the wind and water wake effects are minor and restricted to local areas around the turbines, the Cold Pool stratification or stability is not expected to be affected by the Project.

Fuel and Oils

The larger 14 MW WTGs may include a larger amount of fuels/oils/HAZMAT. Oil sources in the WTGs will total up to approximately 4,887 gallons (116 barrels), increased from the previous value listed in the COP of 4,502 gallons (107 barrels) per WTG. If only 57 WTGs are used with 4,887 gallons of oil each, the total oil quantity for WTGs will be 278,559 gallons. This is less oil than if 100 WTGs were used with 4,502 gallons each, where the total oil quantity would be approximately 450,200 gallons. This information does not change BOEM's analysis in the BA that small accidental spills may affect, but not likely to adversely affect listed species.

Other Updates

Additional updates to the COP include updates to the Proposed Action (as updated in the 2020 COP amendment) that were previously submitted to BOEM. This information includes:

- The Project will not use Connecticut ports for major construction activities. No other changes to ports are proposed.
- The COP text was updated to accommodate for activities anticipated to occur that have in fact now occurred such as the 800 MW Power Purchase Agreement [PPA] was finalized in April 2019, instead of stating that the PPA would occur in the future.
- WTGs will be off-white/light grey (within the spectrum recommended by FAA) to reduce their visibility from against the horizon.
- Updated description of marine navigation lighting and marking to reflect refinements to the Project's lighting and marking plans that have been developed through extensive consultation with USCG.
- Change to the elevation of the marine navigation lights.
- Removed discussion of the outdated regional transit lanes that were presented during the September 20th, 2018 Massachusetts Fisheries Working Group (FWG) on Offshore Wind meeting. USCG is currently conducting a Massachusetts and Rhode Island Port Access Route Study (MARIPARS) to evaluate the need for vessel routing measures, including regional transit lanes, within the Rhode Island (RI)/Massachusetts (MA) and MA Wind Energy Areas (WEAs). On January 29, 2020, USCG published the draft MARIPARS (USCG-2019-0131), which recommended that WTGs be sited in a standard and uniform grid pattern with at least three lines of orientation. USCG concluded that "If such a uniform grid pattern is adopted and approved by BOEM, the USCG will not pursue vessel routing measures through the MA/RI WEA at this time."
- Updated the target burial depth and clarified that the minimum target burial depth is 1.5 m (described as 1-2 m in the BA).
- Clarified that anchoring may occur along the entire Offshore Export Cable Corridor (OECC).
- Clarified that there will be no dredging or dumping in hard bottom.

Other minor updates that do not have any potential effects to listed species can be found in the amended COP. Besides these minor updates and those directly related to modifying the PDE for the 14 MW WTG, the updated COP does not contain any other new information. Additional information from BOEM related to the National Environmental Policy Act (NEPA), such as the cumulative effects of offshore wind, are being coordinated separately between the BOEM and NMFS. Below are responses to outstanding questions discussed at the March 2-5, 2020 meeting between BOEM and NMFS.

Response to NMFS Questions from the March 2-5, 2020 Meeting

Please confirm if Vineyard intends to install one monopile and one jacket without sound attenuation.

The NMFS draft IHA for Vineyard Wind states in condition 4(h) that: "(i) Vineyard Wind must employ a noise attenuation device(s) during all impact pile driving, with the exception of one pile (described under condition 4(h)(iv)) " and "(iv) One single pile may be driven without the noise attenuation device(s) activated, for comparison purposes. Sound source verification (described under condition 5(c)(ii)) must be employed during the driving of this pile." Whether Vineyard Wind will exercise the option to install one pile without noise attenuation has not yet been determined and will be evaluated with the to-be-selected contractor. This information will be included in the Final EIS. ESA consultation includes NMFS as a co-action agency for issuance of the IHA(s) that will be issued for the Vineyard Wind Project. Consequently, BOEM expects the consultation will be consistent and cover the entirety of the Proposed Action.

Would the new 57 WTG construction scenario still include more than 2 jacket foundations?

Vineyard Wind has not modified the maximum PDE of the COP or the IHA application (up to 10 jackets for WTG and 2 jackets for ESPs). However, a most likely scenario includes up to 100 WTG monopiles, barring circumstances that may warrant up to 10 jacket foundation be used. This is consistent with the IHA application.

Table 1. Modeling scenarios **Scenario**	**WTG monopiles (pile size: 10.3 m [33.8 ft])**	**WTG jacket foundations (pile size 3 m [9.8 ft])**	**ESP jacket foundations (pile size 3 m [9.8 ft])**	**Total # piles**	**Total # locations**
Maximum design envelope	90	10	2	138	102
Most likely	100	--	2	108	102

Please provide an updated construction schedule for the construction scenarios, including 57-100 WTG foundations.

Regarding the construction schedule, Vineyard Wind indicates that the contracting process for the major project components must be repeated due to the permitting delay. Therefore, a more detailed construction schedule is not yet finalized. Vineyard Wind expects to provide an updated schedule to BOEM, at which time BOEM will also provide it to NMFS. Despite a detailed schedule not available yet, all seasonal restrictions and mitigation and monitoring measures proposed for all scenarios remain in place for consultation purposes.

Does Vineyard Wind have any additional information on how it would implement real-time PAM when vessels exceed 10 knots, and how that information would affect decision-making on vessel speed mitigation?

Vineyard Wind does not have any additional information at this time on how real-time PAM would be implemented or used in decision-making. Details on the implementation of the real-time PAM system are dependent on the future procurement process and the final selection of contractor. Please note, these are voluntary measures proposed by Vineyard Wind and included as part of the Proposed Action and BOEM believes these measures are subject to additional consultation with BOEM, as appropriate.

Please provide any additional details that may be available on the types and numbers of vessel trips that may originate from and return to Canada.

Table 3.7-1 of the COP Addendum (shown below) provides estimated vessel trips from Canada.

Origin or Destination	Estimated Maximum Daily Trips	Estimated Maximum Trips/Month
New Bedford	46	1,100
Brayton Point	4	100
Montaup	4	100
Providence	4	100
Quonset	4	100
Canada (at present, S heet Harbor, Saint John, or Halifax)*	5	50

Please clarify the proposed conditions (time of year, SMAs, DMAs) and vessel types that seasonal vessel speed restrictions will and will not apply to during operation.

Applicable to construction, operations, maintenance, and decommissioning, from November 1 through May 14, all vessels must travel at 10 knots or less when transiting to/from or within the WDA, except within Nantucket Sound (unless an active NMFS-designated Dynamic Management Area (DMA)is in place) and except crew transfer vessels as described below. From November 1 through May 14, crew transfer vessels may travel at over 10 knots if there is at least one visual observer on duty at all times aboard the vessel to visually monitor for large whales, and real-time PAM is conducted. If a North Atlantic right whale is detected via visual observation or PAM within or approaching the transit route, all crew transfer vessels must travel at 10 knots or less for the remainder of that day.

Applicable to construction, operations, maintenance, and decommissioning, all vessels must travel at 10 knots or less within any DMA, with the exception of crew transfer vessels as described above. Crew transfer vessels traveling within any NMFS-designated DMA must travel at 10 knots or less, unless North Atlantic right whales are confirmed to be clear of the transit route and WDA for two consecutive days, as confirmed by either vessel-based surveys conducted during daylight hours and PAM, or, by an aerial survey conducted once the lead aerial observer determines adequate visibility. If confirmed clear by one of these measures, vessels transiting within a DMA must employ at least two visual observers on duty to monitor for North Atlantic right whales. If a North Atlantic right whale is observed within or approaching the transit route, vessels must operate at 10 knots or less until clearance of the transit route for two consecutive days is confirmed by the procedures described above.

Applicable to construction, operations, maintenance, and decommissioning, all vessels greater than or equal to 65 ft (19.8 m) in overall length must comply with the 10-knot speed restriction in any SMA (see https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-ship-strikes-north-atlantic-right-whales)

The draft IHA that will also be consulted on may also address the vessel speed issue and is available at: https://www.fisheries.noaa.gov/webdam/download/9019150.

Please provide the Table referenced, but not included, in the August 5, 2019 BOEM response to NMFS for additional information requested by NMFS for historical vessel traffic.

Table 3.4.7-1: 2016 and 2017 AIS Vessel Traffic Data within the WDA 10-mile Analysis Area

	Vessel Dimensions (maximum-minimum)					Number of Unique Vessels	
Vessel Type [a]	Length	Beam	Draft	DWT [b]	Speed (knots)	2016	2017
Research Vessels	108–236 ft (33–72 m)	23–46 ft (7–14 m)	7–20 ft (2–6 m)	97–2,328 t (88–2,112 MT)	<1–19	1	1
Passenger Cruise Ships/Ferries	na	na	na	na	na	0	7
Commercial Fishing	36–197 ft (11–60 m)	13–49 ft (4–15 m)	13–16 ft (4–5 m)	453 t (411 MT)	<1–18	198	314
Dredging/Underwater/ Diving Operations	112–341 ft (34–104 m)	39–66 ft (12–20 m)	9–22 ft (3–7 m)	4,400 t (3,992 MT)	<1–22	2	1
Military or Military Training	141–269 ft (43–82 m)	39–43 ft (12–13 m)	11 ft (3 m)	1,820–2,250 t (1,651–2,041 MT)	3–9	4	8
Recreational (Pleasure, Sailing, Charter Fishing, High Speed Craft)	36–184 ft (11–56 m)	13–33 ft (4–10 m)	7–38 ft (2–12 m)	499 t (452 MT)	<1–58	143	178
Cargo	551–656 ft (168–200 m)	56–108 ft (17–33 m)	23–36 ft (7–11 m)	22,563 t 20,469 MT	2–8	5	13
Tug-and-barge	118–492 ft (36–150 m)	36–76 ft (11–23 m)	17–23 ft (5–7 m)	637 t (578 MT)	10–21	2	14
Other/Unspecified	na	na	na	na	na	76	147
Total						431	683

AIS = Automatic Identification System; DWT = deadweight tons; t = tons; MT = metric tons; ft = feet; m = meter; na = data not available

[a] Includes only vessels equipped with AIS (required for commercial vessels >65 feet in length)

[b] Displacement based on example vessels

Please describe vessel strike avoidance actions taken when a sea turtle is sighted.

Consistent with the requirements on all BOEM OCS leases in the Atlantic, BOEM also proposes the following protocols be required for all vessels for the Vineyard Wind Project regarding sea turtles.

- Vessel operators and crews must maintain a vigilant watch for sea turtles to avoid striking sighted protected species.
- Vessel operators must reduce vessel speed to 10 knots (18.5 mph) or less when sea turtles are observed in the path of an underway vessel, when safety permits. Vessels must route around the animals and maintain a minimum separation distance of 50 m from sea turtles whenever possible.
- Vessels underway must not divert their course to approach any protected species.
- Protected species may surface in unpredictable locations or approach slowly moving vessels. When a sea turtle is sighted in the vessel's path or within 50 m of 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.