NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7 CONSULTATION
BIOLOGICAL OPINION

AGENCY:
Bureau of Ocean Energy Management
Bureau of Safety and Environmental Enforcement
National Marine Fisheries Service
U.S. Army Corps of Engineers
U.S. Coast Guard
U.S. Environmental Protection Agency

ACTIVITY CONSIDERED:
Construction, Operation, Maintenance and Decommissioning of the Vineyard Wind Offshore Energy Project (Lease OCS-A 0501)
GARFO-2019-00343

CONDUCTED BY:
National Marine Fisheries Service
Greater Atlantic Regional Fisheries Office

DATE ISSUED:
September 11, 2020

APPROVED BY:
Michael Pentony
Regional Administrator

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1.0 INTRODUCTION

This constitutes NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Opinion) issued to the Bureau of Ocean Energy Management (BOEM), as the lead federal agency, in accordance with section 7 of the Endangered Species Act of 1973 (ESA), as amended, on the effects of the construction, operation, maintenance, and decommissioning of the Vineyard Wind Offshore Wind Project (Lease OCS-A 0501). Vineyard Wind LLC (Vineyard Wind) is proposing to construct and operate a commercial-scale offshore wind energy facility within Lease Area OCS-A 0501 that would generate approximately 800 megawatts (MW) of electricity.

BOEM is the lead federal agency for purposes of section 7 consultation; the other action agencies include the Bureau of Safety and Environmental Enforcement (BSEE), the U.S. Army Corps of Engineers (USACE), the U.S. Environmental Protection Agency (EPA), the U.S. Coast Guard (USCG) and the NMFS Office of Protected Resources (OPR). This Opinion considers effects of the proposed action on ESA-listed whales, sea turtles, fish, and designated critical habitat that occur in the action area. A complete administrative record of this consultation will be kept on file at our Greater Atlantic Regional Fisheries Office.

1.1 Regulatory Authorities

The Energy Policy Act of 2005 (EPAct), Public Law 109-58, added section 8(p)(1)(c) to the Outer Continental Shelf Lands Act. The new section authorized the Secretary of Interior to issue leases, easements, and rights-of-way (ROW) in the OCS for renewable energy development, including wind energy. The Secretary delegated this authority to the former Minerals Management Service, and later to BOEM. Final regulations implementing this authority (30 CFR part 585) were promulgated on April 22, 2009. These regulations prescribe BOEM's responsibility for determining whether to approve, approve with modifications, or disapprove Vineyard Wind's Construction and Operations Plan (COP). Vineyard Wind filed their COP with BOEM on December 19, 2017[1].

BSEE's mission is to enforce safety, environmental, and conservation compliance with any associated legal and regulatory requirements during project construction and future operations. 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.

USACE issued a Public Notice (NAE-2017-01206[2]) describing their proposed authorizations on December 26, 2018. In the notice USACE notes that work regulated by USACE, through section 10 of the Rivers and Harbors Act of 1899 and section 404 of the Clean Water Act, 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 22.6 mile route within state waters. The cable route will begin at the Vineyard Wind lease site OCS-A 0501, will either take the Western Muskeget

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[1] COP is available online at: https://www.boem.gov/vineyard-wind. Last accessed September 4, 2020.

[2] Public Notice is online at https://www.nae.usace.army.mil/Portals/74/docs/regulatory/PublicNotices/NAE-2017-01206.pdf. Last accessed June 25, 2019.

Channel Route or the Eastern Muskeget Channel Route, and will make landfall at Covell's Beach in Barnstable, Massachusetts.

The Outer Continental Shelf (OCS) Air Regulations, found at 40 CFR part 55, establish the applicable air pollution control requirements, including provisions related to permitting, monitoring, reporting, fees, compliance, and enforcement, for facilities subject to section 328 of the Clean Air Act; EPA issues OCS Air Permits. On August 17, 2018, Vineyard Wind submitted to EPA Region 1 an application requesting a Clean Air Act (CAA) permit under Section 328 of the CAA for the construction and operation of an offshore windfarm, including export cables, on the OCS with the potential to generate 800 MW of electricity (the windfarm). EPA reports that they received a complete application for an Outer Continental Shelf Air Permit from Vineyard Wind on January 29, 2019. On April 18, 2019, VW submitted an application for a title V operating permit (operating permit) in accordance with 310 CMR 7.00, Appendix C. On June 28, 2019, EPA issued a draft permit for public comment (Docket # EPA-R01-OAR-2019-0355[3]. In the fact sheet, EPA notes that as the decommissioning phase of the windfarm will occur well into the future, the EPA is unable to determine best achievable control technology (BACT) and lowest achievable emissions reductions (LAER) for the decommissioning phase and will not be permitting this phase at this time. Therefore, this consultation does not consider any EPA actions in regards to decommissioning. However, reinitiation of this consultation may be required to consider any changes to EPA's existing proposed action, or any new proposed action, regarding decommissioning.

The EPA also proposes to issue a National Pollutant Discharge Elimination System (NPDES) General Permit for construction activities under the Clean Water Act. The EPA uses general permits issued under section 402 of the Clean Water Act (33 U.S.C. 1342 et seq.; CWA), to authorize routine discharges by multiple dischargers. Coverage for discharges under a general permit is granted to applicants after they submit a notice of intent to discharge (NOI). Once the NOI is submitted and any review period specified under the Construction General Permit has closed, the applicant is authorized to discharge under the terms of the general permit.

The USCG administers the permits for private aids to navigation (PATON) 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 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 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.

The Marine Mammal Protection Act of 1972 (MMPA) as amended, and its implementing regulations (50 CFR part 216) allows, upon request, the incidental take of small numbers of

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[3] *https://www.regulations.gov/docket?D=EPA-R01-OAR-2019-0355*; last accessed on August 13, 2020

marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographic region. Incidental take is defined under the MMPA (50 CFR 216.3) as, "harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal. This includes, without limitation, any of the following: The collection of dead animals, or parts thereof; the restraint or detention of a marine mammal, no matter how temporary; tagging a marine mammal; the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal; and feeding or attempting to feed a marine mammal in the wild."

On September 7, 2018, NMFS OPR received a request from Vineyard Wind for an incidental harassment authorization (IHA) to take marine mammals incidental to construction of an offshore wind energy project south of Massachusetts. Vineyard Wind submitted revised versions of the application on October 11, 2018 and on January 28, 2019. The application was deemed adequate and complete on February 15, 2019. Vineyard Wind's request is for take of 15 species of marine mammals by harassment. Neither Vineyard Wind nor NMFS expects serious injury or mortality to result from this activity and, therefore, NMFS determined that an IHA is appropriate. A notice of the proposed IHA was published in the *Federal Register* on April 30, 2019 (84 FR 18346).

2.0 CONSULTATION HISTORY

BOEM submitted a Biological Assessment and request for initiation of ESA consultation on December 6, 2018. We requested additional information in correspondence dated March 14 and April 3, 2019. BOEM responded to those requests in correspondence dated March 27 and April 10, 2019; consultation was initiated on April 10, 2019. In September 2019, BOEM announced that the permitting process for the project would be delayed to allow for additional review and development of a supplemental EIS focused on cumulative effects. Additional information on the proposed action was provided to NMFS through July 2020, including supplemental analysis provided on May 19, 2020. The supplemental DEIS was issued on June 12, 2020. The ESA consultation was paused between August 9, 2019 and May 19, 2020.

3.0 DESCRIPTION OF THE PROPOSED ACTION

3.1 Overview of Proposed Federal Actions

BOEM is the lead federal agency for the project for purposes of this ESA consultation and coordination under the National Environmental Policy Act (NEPA); BOEM is proposing to approve a Construction and Operations Plan (COP) to authorize the construction, operation, and eventual decommissioning of the Vineyard Wind offshore energy project. BSEE will provide recommendations for enforcing safety, environmental, and conservation compliance with any associated legal and regulatory requirements during project construction and future operations; oversee inspections/enforcement actions, as appropriate; oversee closeout verification efforts; oversee facility removal inspections/monitoring; and oversee bottom clearance confirmation. The EPA proposes to issue a National Pollutant Discharge Elimination System (NPDES) General Permit for construction activities and an Outer Continental Shelf Air Permit. The USACE proposes to issue a permit for in-water work, structures, and fill under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. NMFS proposes to issue a

Marine Mammal Protection Act (MMPA) incidental harassment authorization (IHA). The USCG proposes to issue a Private Aids to Navigation (PATON) authorization.

3.2 Vineyard Wind Project

3.2.1. Overview

BOEM is proposing to authorize Vineyard Wind to construct, operate, maintain, and eventually decommission an 800 megawatt (MW) offshore wind energy project in Lease Area OCS-A 0501, offshore Massachusetts. The other Federal actions identified in section 2.1 authorize various aspects of the proposed action. Here, for simplicity, we may refer to BOEM's authorization when that authorization may also include other Federal actions (e.g., construction of the wind turbines requires authorizations from BOEM, USACE, EPA, USCG, and NMFS). Vineyard Wind's proposed activity would occur in the northern portion of the 675 square kilometer (km) (166,886 acre) Vineyard Wind Lease Area, also referred to as the wind development area (WDA). At its nearest point, the WDA is just over 23 km (14 miles (mi)) from the southeast corner of Martha's Vineyard and a similar distance from Nantucket. Water depths in the WDA range from approximately 37–49.5 meters (m) (121–162 feet (ft.)). Based on the anticipated commercial availability of a 14 MW turbine, there may be as few as 57 turbines installed. However, BOEM is proposing to authorize the installation of up to 100 WTGs under the project design envelope (PDE) to accommodate the needed flexibility in the permitted project design. Therefore, the project would consist of up to 100 offshore wind turbine generators (WTGs) of 8 to 14 MW capacity (with higher capacity requiring fewer turbines), and one or two electrical service platforms (ESP), an onshore substation, offshore and onshore cabling, and onshore operations and maintenance facilities. The capacity of the project will be approximately 800 MW, regardless of the number of WTGs installed.

Vineyard Wind anticipates construction and installation to occur between 2021 and 2023. They anticipate beginning land-based construction before the offshore components. The proposed Project is being developed and permitted using the PDE concept; this means that the "maximum impact scenario" (i.e., greatest number of piles, largest turbines, etc.) is proposed for authorization in permits and is being analyzed in accompanying review documents (see Table 3.1). Further discussion of construction methods and schedule are provided in COP Volume I, Section 3.0 (Epsilon 2020) and summarized below. Additional relevant details of the proposed activities are also included in the Effects of the Action section of this Opinion.

Table 3.1: Range of the Project Design Envelope from which the Maximum Impact is Derived

Capacity and Arrangement		
Wind Facility Capacity	Approximately 800 MW [a]	
Wind Turbine Generator Foundation Arrangement Envelope	Up to 100 monopiles (100 WTG and 2 ESPs)	Up to 12 may be jacket foundations (10 WTG and 2 ESP)
Wind Turbine Generators	**Minimum Turbine Size**	**Maximum Turbine Size**
Turbine Generation Capacity	8 MW	14 MW
Number of Turbine Positions [b]	Up to 106	106
Number of Turbines Installed	Up to 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	624 ft. (190 m) MLLW [c]	754 ft. (230 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	624 ft. (19 m)	754 ft. (23 m)
Number of Piles/Foundation	1	1
Number of Piles Driven/Day within 24 hours [e]	2	2
Typical Installation Time to Pile Drive [f]	≤ 3 hours	≤ 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 Installation Time to Pile Drive [f]	≤ 3 hours	≤ 3 hours
Hammer Size	3,000 kJ	3,000 kJ

Source: COP Volume I (Epsilon 2020)

[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 hammering time for pile driving a monopile is expected to take less than approximately 3 hours to achieve the target penetration depth, and that pile driving for a jacket pin pile would take significantly less than 3 hours to achieve the target penetration depth. Different hammer sizes are used for installation of the monopile and jacket foundations.

3.2.2 Facilities and Offshore Activities

Wind Turbine Generators

Vineyard Wind would erect up to 100 WTGs of 8 to 14 MW capacity extending up to 837 feet (255 m) 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 m) 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 m) into the seabed. Although monopiles are currently planned, Vineyard Wind may 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). Each WTG would contain approximately 1,700 gallons (6,500 liters) of transformer oil and approximately 2,113.4 gallons (8,000 liters) of general oil (for hydraulics and gearboxes). Use of other chemicals would include diesel fuel, coolants/refrigerants, grease, paints, and sulphur hexafluoride. BOEM indicated while anti-fouling paint is not necessary on most parts of the WTG and ESP foundations, anti-fouling paint may be used at each foundation in the immediate area of the opening for the cable pull-in (within an approximately 4-foot (1.2-m) diameter circle centered on the opening for the cable).

Electrical Service Platforms

Vineyard Wind would construct one or two ESPs, each installed on a monopile or jacket foundation, in the WDA (Table 3.2). The ESPs would serve as the interconnection point between the WTGs and the export cables. 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-kV inter-array cables 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. If two ESPs are constructed, a 200-kV inter-link cable would be required to connect the ESPs together. Each ESP would contain up to approximately 123,209.9 gallons (466,400 liters) of transformer oil and approximately 348.7 gallons (1,320 liters) of general oil. WTGs and ESPs would be equipped with secondary containment sized according to the largest oil chamber.

WTGs and ESPs would include lighting and marking that complies with Federal Aviation Administration (FAA) and USCG standards, and is consistent with BOEM best practices. A detailed description of lighting and marking is provided in COP Volume I, Section 3.1 (Epsilon 2020).

Table 3.2: Vineyard Wind Project ESP Specifications with Maximum Design Scenario

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)
Foundation Type	Monopile or Jacket	Jacket
Number of Piles/Foundation	1	3 to 4
Maximum Height [b]	215 ft. (65.5 m) MLLW	218 ft. (66.5 m) MLLW

Source: COP Volume I, Table 3.1-1 (Epsilon 2020)

[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.

WTG Installation

Vineyard Wind would install foundations and WTGs using a jack-up vessel and/or a vessel capable of dynamic positioning, as well as necessary support vessels and barges. These installation vessels would be equipped with a crane and a pile-driving hammer. In order to initiate impact pile driving, the pile must be upright, level, and stable. The preferred options to achieve this are by utilizing a gripper frame, which may sit on the sea floor and holds the pile. After the monopile is lowered to the seabed, the crane hook would be released, and the hammer would be picked up and placed on top of the monopile. Concurrent driving (*i.e.*, the driving of more than one pile at the same time) would not occur and is not analyzed in this Opinion.

Vineyard Wind estimates that each monopile will typically take less than three hours of hammering to install to target penetration depth (less for pin piles). Pre-construction surveys have identified turbine locations that are suitable to install the WTG foundations by impact hammer. However, under extenuating circumstances (e.g., 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. Drilling and vibratory piling are not planned installation methods under the proposed action, but alternative methods such as those may be required as a contingency to deal with unforeseen and extenuating circumstances. If necessary, 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. Vibratory hammering is accomplished by rapidly alternating (~250 Hz) forces to the pile. A system of counter-rotating eccentric weights powered by hydraulic motors is designed such that horizontal vibrations cancel out, while vertical vibrations are transmitted into the pile. The vibrations produced cause liquefaction of the substrate surrounding the pile, enabling the pile to be driven into the ground using the weight of the pile plus the impact hammer. If required, a vibratory hammer will be used before impact hammering begins to ensure the pile is stable in the seabed and is level for impact hammering. However, as stated above, impact driving is the preferred method of pile installation and vibratory driving would only occur for very short periods of time and only if Vineyard Wind engineers determine vibratory driving is required to seat the pile. If vibratory pile driving were required, Vineyard Wind anticipates that any vibratory pile driving would occur for less than 10 minutes per pile, in rare cases up to 30 minutes, as it would be used only to seat a pile such that impact driving can commence.

Vineyard Wind has indicated that impact pile driving is the preferred method of pile installation for the proposed project. Impact pile driving entails the use of a hammer that utilizes a rising and falling piston to repeatedly strike a pile and drive it into the ground. Vineyard Wind would begin pile driving by using a soft start before driving intensity increases. A temporary steel cap called a helmet would be placed on top of the pile to minimize damage to the head during impact driving. The intensity (*i.e.*, hammer energy level) would be gradually increased based on the resistance that is experienced from the sediments. The expected hammer size for monopiles is up to 4,000 kJ (however, required energy may ultimately be far less than 4,000 kJ). Vineyard Wind expects the typical hammering time for pile driving to take less than three hours to achieve the target penetration depth. Vineyard Wind plans to drive no more than two piles into the seabed per day.

Scour protection would be placed around all foundations, and would consist of rock and stone ranging from 4 to 12 inches (10 to 30 cm) diameter. The scour protection would be up to approximately 3 to 6 ft. (1 to 2 m) in height and would serve to stabilize the seabed near the foundations as well as the foundations themselves. To maximize precision when placing scour protection, Vineyard Wind would use the fall pipe method whenever feasible. Table 3.3 provides scour protection information for proposed foundations. See COP Volume I, Section 3.1.3 for detailed specifications of proposed scour protection and COP Volume I, Section 4.2.3.2 for a complete discussion of the proposed scour protection construction approach (Epsilon 2020).

Table 3.3: 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 2020)

Cable Laying
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. Cable burial operations will occur both in the WDA for the inter-array cables connecting the WTGs to the ESPs, and in the offshore export cable corridor (OECC) for the cables carrying power from the ESPs to land. Inter-array cables will connect radial "strings" of 6 to 10 WTGs to the ESPs. Two offshore export cables will connect the offshore ESPs to the shore. An inter-link cable will connect the ESPs to each other (if two ESPs are used). Vineyard Wind would bury the cables primarily using a jet plow, mechanical plow, and/or mechanical trenching, as suited for the bottom type in the immediate area. In any case, cable burial may use a tool that slides along the seafloor on skids or tracks (up to 3.3 to 6.6 ft. [1 to 2 m] wide), which would not dig into the seafloor but would still cause temporary disturbance. 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 2020). Vineyard Wind anticipates that dredging would occur within a corridor that is 65.6 ft. (20 m) wide and 1.6 feet (0.5 m) deep, and potentially as deep as 14.7 feet (4.5 m). Vineyard Wind anticipates the installation of an offshore export cable to last approximately 13-14 days per cable for each of the nearshore and mid-shore segments, and a further approximately 7 days for the offshore segment (these estimates do not include transit time, equipment preparation time, splice time, or cable pull-in at the Landfall Site). For the inter-array cables, the expected installation method is to lay the cable section on the seafloor and then subsequently bury the cable. The estimated installation time for the inter-array cables is approximately four months for burial. Installation days are not continuous and do not include equipment preparation or down time that may result from weather or maintenance. More information on cable laying associated with the proposed project is provided in COP Volume I, Section 4.2.3 (Volume I; Epsilon 2020).

For the installation of the two offshore export cables, Vineyard Wind expects 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).[4] TSHD would discharge the sand removed from the vessel within the 2,657-foot (810-meter) wide cable corridor.[5] 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

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[4] 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.

[5] 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.

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.

Vineyard Wind anticipates 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.[6] Vineyard Wind has conservatively estimated up to 10 percent of the inter-array and offshore export cables would require one of these protective measures.

Construction-Related Vessel Activity
According to Vineyard Wind, 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. Vineyard Wind conservatively estimated that a maximum of approximately 46 vessels could be on-site (at the WDA or along the OECC) at any given time. On average, Vineyard Wind expects approximately 25 vessels would be at the WDA and along the OECC during this period. Many of these vessels will remain in the WDA or OECC for days or weeks at a time, potentially making only infrequent trips to port for bunkering and provisioning, as needed. 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. The Jones Act requires project components that move between U.S. ports be transported on Jones Act compliant, U.S.-flagged vessels. According to information provided to us by BOEM in July 2020, it is estimated that up to 16 different European-origin construction/installation vessels would be used over the course of the Project's offshore construction period. These vessels are expected to remain on site for the duration of the work that they are contracted to perform, which could range from two to twelve months. The procurement processes for many of the offshore installation activities are ongoing at this time; thus, the ports of origin are unknown.

Ports that may be used to support proposed Project activities are located in Massachusetts (New Bedford, Brayton Point, and Montaup) and Rhode Island (Providence and Quonset Point). Additionally, project vessels may transit to the project area from one or more ports in Canada (e.g., Sheets Port, St. John, and Halifax). According to information presented to us by BOEM in July 2020, Vineyard Wind anticipates that monopiles, transition pieces, WTG components, ESP components, and offshore cables will be shipped from Europe, either directly to the WDA or first

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[6] 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 2020).

to a U.S. port before being transported to the WDA. Consistent with the COP, the following vessel trips are anticipated:

- Overseas transition piece transport: ~16 trips from Europe, which equates to ~2 trips per month.
- Overseas monopile transport: ~22 trips from Europe, which equates to ~2 trips per month.
- Overseas WTG tower transport: ~34 trips from Europe, which equates to ~3 trips per month.
- Overseas WTG blades transport: ~46 trips from Europe, which equates to ~4 trips per month.
- Overseas ESP transport: 2 trips from Europe over the course of construction.
- Offshore export cable transport: ~2 trips from Europe over the course of construction.

This results in approximately 122 round trips to transport project components from Europe. The trips for the five activities listed above might not necessarily occur within the same timeframe. On average, vessels transporting components from Europe will make ~five round trips per month over a two-year offshore construction schedule. As with the construction vessels described above, the ports of origin are unknown.

As described in the COP (Epsilon 2020), these trips from Europe will be to a marshalling port (one of the Massachusetts, Rhode Island, or Canadian ports noted above) or directly to the offshore site. The installation concept and method of bringing components to the WDA will be based on supply chain availability and final contracting. The monopiles (or jackets) are expected to be installed by one or two heavy lift or jack-up vessel(s) that may also originate from Europe. The main installation vessel(s) will likely remain at the WDA during the installation phase and transport vessels, tugs, and/or feeder barges will provide a continuous supply of foundations to the WDA. If Jones Act compliant vessels are available, the foundation components could be picked up directly in the marshalling port by the main installation vessel(s).

The majority of Project vessel traffic will occur within the Project area (WDA, OECC), and vessel transit corridors to New Bedford and Vineyard Haven. The New Bedford Marine Commerce Terminal (MCT) 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. 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]).

Onshore Facilities - Landfall Site

At the time the BA was prepared, the proposed Project had two proposed cable landfall locations, Covell’s Beach in Barnstable and New Hampshire Avenue in Yarmouth. On June 26, 2020, Vineyard Wind informed BOEM that they are no longer pursuing the New Hampshire

Avenue landing site. In July 2020, BOEM informed us that the New Hampshire Avenue location was no longer being considered and that the COP would be modified to remove this potential landfall location. As such, the analysis in this Opinion only considers the Covell's Beach landfall site. 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 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 the proposed landfall site. One or more underground concrete transition vaults would be constructed at the landfall site. These would be accessible after construction via a manhole. Inside the splice vault(s), the 220-kilovolt (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 2020). Further discussion of proposed landfall site construction approach is provided in COP Volume I, Section 4.2.3.8 (Epsilon 2020).

Onshore Export Cable and Substation Site
The proposed Project considers an onshore export cable route (OECR). The route would begin at the Covell's Beach landfall site in Barnstable passing 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 ft. (1.5 m) wide by 2.5 ft. (0.8 m) 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 ft. (0.9 m) 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 8.6 acres (34,803 square meters [m^2]). The buried duct bank would enter the proposed onshore substation site via Independence Drive. 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 (see Figure 1-2).

Detailed specifications of the onshore export cable are provided 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 2020).

3.2.3 Operations and Maintenance

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)). The proposed Project, however, has a designed life span of 30 years. Vineyard Wind would need to request an extension of its operations term from BOEM to operate the proposed project for 30 years. For purposes of the maximum-case scenario and to ensure impacts are evaluated if BOEM grants such an extension, BOEM analyzes a 30-year operations term. 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. This consultation does not consider operation of the proposed Project beyond the 30-year designed life span. Vineyard Wind would monitor operations primarily from the Operations and Maintenance Facilities in Vineyard Haven on Martha's Vineyard and a 24-hour a day / seven days a week control center on the mainland.

Crew transfer vessels and helicopters would transport crews to the proposed offshore Project area during operations and maintenance. During the operations phase, there would be trips by crew transport vessels (CTV) (about 75 ft. [22.3 m] in length), multipurpose vessels, and service operations vessels (SOV) (260 to 300 ft. [79.2 to 91.4 m] in length), with larger vessels based at the MCT and smaller vessels based at Vineyard Haven. Vineyard Wind anticipates that on average fewer than three operations and maintenance vessels 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, Vineyard Wind anticipates 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. 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 is anticipated to be changed after 5, 13, and 21 years of service. Additional operations and maintenance information can be found in COP Section 4.3.

3.2.4. 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 two years of termination of the lease and either reuse, recycle, or responsibly dispose of all materials removed.

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

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 under BOEM. BSEE will review decommissioning plans and provide recommendations to BOEM as part of the 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.

During decommissioning, Vineyard Wind estimates the level of trips to be about 90 percent of those occurring during construction, or a maximum of approximately 990 trips per month from New Bedford, 90 trips per month from Brayton Point, Montaup, Providence, 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, Vineyard Wind anticipates decommissioning activities will require approximately 4,800 vessel trips (approximately 240 vessel trips may originate from Canada).

3.2.5. Proposed Measures to Minimize and Monitor Effects of the Action

There are a number of measures that Vineyard Wind is proposing to take and/or BOEM is proposing to require as conditions of COP approval that are designed to avoid, minimize, or monitor effects of the action on ESA listed species. More information on these measures is included in COP Volume III Attachment-M and BOEM's March 2019 BA. In January 2019, Vineyard Wind entered into an agreement with the Natural Resources Defense Council, the Conservation Law Foundation, and the National Wildlife Federation that outlined a number of commitments designed to minimize effects of the construction of the proposed project on North Atlantic Right Whales (Vineyard Wind NGO Agreement 2019). To the extent that these commitments are reflected in Vineyard Wind's COP, BOEM's description of the proposed action, and/or NMFS' proposed IHA, those measures are incorporated into the description of the proposed action as described herein. We note that the agreement includes several commitments, including research funding, which are outside the scope of the proposed action considered here.

Vineyard Wind defines the following terms as:

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 or clearance zone and observed to greatest extent practicable. The area beyond the exclusion or clearance 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 or Exclusion Zone: The clearance or exclusion 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 three 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 three times (e.g. 3 single strikes, delay, 3 single strikes, delay, 3 single strikes, delay).

Measures Proposed During Pile Driving:

- Seasonal Restrictions: No pile driving will occur 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.[7]
    - 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.
    - One monopile and one jacket may be installed without attenuation in order to establish baseline noise measurements from which to determine the amount of attenuation provided by the attenuation mitigation technology.
- 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) will be used to maintain the clearance zone (i.e., monitor for protected species and communicate with the pile driving vessel to ensure no pile driving is initiated if the zone is not clear) and visually observe the monitoring zone for the presence of protected species. Measures include:
    - 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,

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[7] A maximum impact scenario of only a -6 dB reduction is analyzed in the BA and considered in this Opinion since the type of sound reduction system that will be used is not yet identified that could be evaluated for past effectiveness during use and analysis of existing technologies indicates that a 6 dB reduction is a reasonable worst case scenario.

  - 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,
  - 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 (North Atlantic Right Whales (North Atlantic right whales) 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 North Atlantic right whale in the area and to implement mitigation measures as appropriate (such as if a DMA were established),
  - Monitoring zones and clearance zones will be monitored around the pile center for marine mammals from the vantage point that provides maximum visibility, and
  - PSOs would record behavioral activity of animals observed.
- Pre-piling Monitoring Timing: clearance zone(s) must be clear for the following time period prior to pile driving:
  - Mysticete whales and sea turtles: 30 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 of vocalizing whales. 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.
  - 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 shutdown 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.
  - PAM detection of a North Atlantic right whale within 10 km of the clearance zone during the shoulder seasons (May 1 through May 14 and November 1 through December 31) will result in the postponement of pile driving and would not commence until the following day, or, until a follow-up aerial or vessel-based survey could confirm the extended clearance zone is clear of right whales, as determined by the lead PSO.
  - PAM would be used to inform visual monitoring during construction; no mitigation actions would be required on PAM detection alone. The PAM system would not be located on the pile installation vessel.

  - PAM detection of any other species (listed or otherwise) does not trigger delay/shutdown under any circumstances.
- Clearance zones for monopile and jacket installation (the size of these zones is designed to exceed the distance from a pile where exposure to pile driving noise has the potential to result in injury):
  - Mysticete Whales: 500 m, and
    - North Atlantic right whales: 10 km from May 1 – May 14, and
    - North Atlantic right whales: 1,000 m from May 15 - Oct 31, and
  - Odontocetes, Pinnipeds and Sea Turtles: 50 m, and
    - Harbor porpoise: 120 m
- Monitoring zone for monopile and jacket installation (the size of these zones is designed to match the expected distance that can be observed visually by the PSOs):
  - 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 pile driving may not be able to 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 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 shutdown 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

Vineyard Wind would also implement the following measures specific to avoiding and minimizing effects of pile installation on North Atlantic right whales:

- From May 1 to May 14:
  - An extended PAM monitoring zone of 10 km would be implemented for North Atlantic right whale

    - PAM will be operated 24/7, if piling is anticipated
    - 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 North Atlantic right whale is sighted during the visual survey or detected via PAM, piling operations would not be conducted that day unless an additional survey is conducted to confirm the 10 km zone is clear of North Atlantic right whale
- From November 1 to December 31:
    - November 1 to December 31: implement an extended PAM monitoring zone of 10 km for North Atlantic right whale with PAM operated 24/7, if piling is anticipated. If a North Atlantic right whale is sighted by the PSOs or detected via PAM, piling operations would not be conducted that day unless an additional survey is conducted to confirm the 10 km zone is clear of North Atlantic right whale
- From May 15 to Oct 31:
    - Maintain 1,000 m clearance zone for minimum of 30 minutes before pile driving commences

Measures to avoid or reduce potential impacts on Atlantic sturgeon:

- Use soft-start during pile-driving,
- 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 minimize release of electromagnetic field (EMF)

Measures Proposed For Vessel Operations:

- November 1 to May 14:
    - All project vessels, regardless of size, would travel at less than 10 knots within the WDA,
    - When transiting to or from the WDA all project vessels would travel at less than 10 knots or would implement visual surveys or PAM to ensure the transit corridor is clear of North Atlantic right whale and at least one visual observer to monitor for North Atlantic right whales (with the exception of vessel transit within Nantucket Sound unless a DMA is in place),
    - CTVs 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, and

- Year-Round:
    - In the event that any dynamic management area is established that overlaps with an area where a project vessel would operate, that vessel, regardless of size, will transit that area at a speed less than 10 knots unless visual surveys or PAM are conducted which demonstrate that North Atlantic right whale are not present in the transit corridor, and
    - Any project vessel that will travel at speeds over 10 knots will have an observer who has undergone marine mammal training who will be in communication with the captain to report any marine mammal sightings. Speeds will immediately be reduced to 10 knots or less if any right whales are sighted by the observer or otherwise reported to the captain.

3.3 MMPA IHA

The NMFS Office of Protected Resources (OPR) Permits and Conservation Division has proposed to issue an IHA, as well as a possible one-year renewal to Vineyard Wind, LLC for the take of marine mammals incidental to construction of a commercial wind energy project offshore Massachusetts. More information on the proposed IHA, including Vineyard Wind's application is available online (*https://www.fisheries.noaa.gov/action/incidental-take-authorization-vineyard-wind-llc-construction-vineyard-wind-offshore-wind*).

3.3.1. Estimated Take

The initial IHA would be effective for a period of one year, and, if issued as proposed, would authorize harassment as the only type of take expected to result from activities during the construction phase of the project. Section 3(18) of the Marine Mammal Protection Act defines ‘‘harassment’’ as any act of pursuit, torment, or annoyance, which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment). It is important to note that the MMPA definition of harassment is not the same as the ESA definition. This issue is discussed in further detail in the Effects of the Action section of this Opinion.

The proposed IHA would authorize the take, by Level A and Level B harassment, of some species of ESA listed marine mammals. Authorized take for this Project would primarily be by Level B harassment, as noise from pile driving has the potential to result in disruption of behavioral patterns for individual marine mammals. NMFS OPR predicts that marine mammals are likely to be behaviorally harassed in a manner consistent with Level B harassment when exposed to underwater anthropogenic noise above received levels of 160 dB re 1 mPa (rms) for impulsive and/or intermittent sources (*e.g.*, impact pile driving). For some species, NMFS OPR predicts that there is also some potential for auditory injury (Level A harassment) to occur. Table 3.4 shows the modeled radial distances to the dual Level A harassment thresholds using NMFS (2018) frequency weighting for marine mammals, with zero, 6, and 12 dB sound attenuation incorporated. For the peak level, the greatest distances expected are shown, typically occurring at the highest hammer energies. The distances to Sound exposure level (SEL;

represented as dB re 1 μPa^2-s) thresholds were calculated using the hammer energy schedules for driving one monopile or four jacket piles, as shown. The radial distances shown in Table 3.4 are the maximum distances from the piles, averaged between two modeled locations. The radial distances shown in Table 3.5 are the maximum distances to the Level B harassment threshold from the piles, averaged between two modeled locations, using the maximum hammer energy. Of the ESA listed whales that occur in the action area (see section 4.0 of this Opinion), all are categorized as low frequency cetaceans (LFC in Table 3.4) except for sperm whales which are categorized as mid frequency cetaceans (MFC in Table 3.4). Only information relevant to LFC and MFC is discussed here; the IHA also addresses non-ESA listed species that fall into the HFC and pinniped categories.

Table 3.4: Radial distances (m) to Level A Harassment Thresholds for Each Foundation Type with 0, 6, and 12 dB Sound Attenuation Incorporated

Foundation type	**Hearing group**	**Level A harassment (peak)**			**Level A harassment (SEL)**		
		No attenuation	**6 dB attenuation**	**12 dB attenuation**	**No attenuation**	**6 dB attenuation**	**12 dB attenuation**
10.3 m (33.8 ft.) monopile	LFC [a] (all baleen whales, including North Atlantic right whale)	34	17	8.5	5,443	3,191	1,599
	MFC [b] (sperm whales)	10	5	2.5	56	43	0
Four, 3 m (9.8 ft.) jacket piles	LFC [a]	7.5	4	2.5	12,975	7,253	3,796
	MFC [b]	2.5	1	0.5	71	71	56

* Radial distances were modeled at two different representative modeling locations as described above. Distances shown represent the average of the two modeled locations.

[a] LFC: Low-Frequency Cetaceans

[b] MFC: Mid-Frequency Cetaceans

Table 3.5: Radial distances (m) to the Level B harassment threshold (i.e., 160 dB re 1uPa rms).

Foundation type	No attenuation	6 dB attenuation	12 dB attenuation
10.3 m (33.8 ft.) monopile	6,316	4,121	2,739
Four, 3 m (9.8 ft.) jacket piles	4,104	3,220	2,177

NMFS OPR expects the proposed mitigation and monitoring measures to minimize the severity of such taking. According to NMFS OPR, no mortality is anticipated or proposed to be authorized for this activity. For the purposes of the proposed IHA, NMFS OPR estimated the amount of take by considering: (1) acoustic thresholds above which NMFS OPR determined the best available science indicates marine mammals will be behaviorally harassed or incur some degree of permanent hearing impairment; (2) the area or volume of water that will be ensonified above these levels in a day; (3) the density or occurrence of marine mammals within these ensonified areas; and, (4) and the number of days of activities. Take numbers proposed for authorization are shown in Table 3.6.

Table 3.6: Total Numbers of Potential Incidental Take of Marine Mammals Proposed for Authorization

Species	Takes by Level A harassment	Takes by Level B harassment	Total takes proposed for authorization
Fin Whale ………………………………………..	4	33	37
North Atlantic Right Whale ……………………...	0	20	20
Sperm Whale …………………………………….	2	5	7
Sei Whale ………………………………………...	2	4	6

3.3.2. Proposed Mitigation Measures to be Included in the IHA

As part of the IHA, Vineyard Wind has set forth a variety of minimization and monitoring methods it concluded are designed to ensure that the proposed project has the least practicable adverse impact upon the affected species or stocks and their habitat. In addition to the specific measures described later in this section, Vineyard Wind would conduct briefings for construction supervisors and crews, the marine mammal and acoustic monitoring teams, and Vineyard Wind staff prior to the start of all pile driving activity, and when new personnel join the work, in order to explain responsibilities, communication procedures, the marine mammal monitoring protocol, and operational procedures. We note that some of the measures identified here overlap or are duplicative with the measures that were described in section 2.2 above.

Seasonal Restriction on Pile Driving

As part of the IHA, Vineyard Wind has agreed that no pile driving activities would occur between January 1 through April 30. This seasonal restriction would be established to minimize the potential for North Atlantic right whales to be exposed to pile driving noise. Based on the best available information (Kraus et al., 2016; Roberts et al., 2017), the highest densities of right whales in the project area are expected during the months of January through April.

Clearance Zones

Vineyard Wind would use protected species observers (PSOs) and real-time PAM to establish clearance zones around the pile driving equipment to ensure these zones are clear of marine mammals prior to the start of pile driving (Table 3.7). The purpose of "clearance" for a particular zone is to prevent potential instances of auditory injury and potential instances of more severe behavioral disturbance as a result of exposure to pile driving noise. These zones are based on the expected noise levels. If marine mammals are detected within certain pre-defined distances of the pile driving equipment, NMFS OPR determined that serious injury or death are unlikely outcomes even in the absence of mitigation measures by delaying the activity before it begins. Proposed clearance zones would apply to both monopile and jacket installation. These zones vary depending on species, for more additional information see the IHA.

Table 3.7: Proposed Clearance Zones during Vineyard Wind Pile Driving

Species	**Clearance Zone**
North Atlantic right whale	1,000 m*
Sei and fin whales	500 m
Sperm whales	50 m

*An extended clearance zone of 10 km for North Atlantic right whales is proposed from May 1-14 and November 1 – December 31.

As part of the IHA, prior to the start of pile driving activity, the clearance zones will be monitored for 60 minutes to ensure that they are clear of the relevant species of marine mammals as detailed here. The clearance zones may only be declared clear, and pile driving started, when the entire clearance zones are visible (*i.e.*, when not obscured by dark, rain, fog, etc.) for a full 30 minutes. If a marine mammal is observed approaching or entering the clearance zones prior to the start of pile driving operations, pile driving activity will be delayed until either the marine mammal has voluntarily left the respective clearance zone and been visually confirmed beyond that clearance zone, or, 30 minutes have elapsed without re-detection of the animal in the case of mysticetes (baleen whales) and sperm whales.

Extended Clearance Zones for North Atlantic Right Whales

In addition to the clearance zones described above, through the IHA requirements, NMFS OPR proposes to require extended clearance zones for North Atlantic right whales during certain times of year. NMFS OPR designed these extended zones as part of the proposed IHA to further minimize the potential for right whales to be exposed to pile driving noise. The extended clearance zones are proposed during times of year that are considered to be "shoulder seasons" in terms of right whale presence in the project area: November 1 through December 31, and May 1 through May 14. According to the best available information, right whales may occur in the project area during these times of year, though presence during these times of year is considered less likely than during the proposed seasonal closure (January through April) (Roberts et al, 2017; Kraus et al. 2016). According to the proposed IHA, extended clearance zones will be maintained through passive acoustic monitoring (PAM) as well as by visual observation conducted on aerial or vessel-based surveys as described below. The extended clearance zones for North Atlantic right whales are as follows:

- May 1 through May 14: An extended clearance zone of 10 km would be established based on real-time PAM. Real-time PAM would begin at least 60 minutes prior to pile driving. In addition, an aerial or vessel-based survey would be conducted across the extended 10 km extended clearance zone, using visual PSOs to monitor for right whales.
- November 1 through December 31: An extended clearance zone of 10 km would be established based on real-time PAM. In addition, an aerial survey may be conducted across the extended 10 km extended clearance zone, using visual PSOs to monitor for right whales.

As part of the proposed IHA, if a right whale is detected via real-time PAM or vessel-based or aerial surveys within 10 km of the pile driving location during these periods (November 1 through December 31), pile driving would be postponed and would not commence until the following day, or, until a follow-up aerial or vessel-based survey could confirm the extended clearance zone is clear of right whales, as determined by the lead PSO. Aerial surveys would not begin until the lead PSO on duty determines adequate visibility and at least one hour after sunrise (on days with sun glare). Vessel-based surveys would not begin until the lead PSO on duty determines there is adequate visibility. For the period of May 1-14, if a right whale is detected via real-time PAM or vessel-based or aerial surveys within 10 km of the pile driving location during these periods, pile driving would be postponed and would not commence until the following day.

Under the proposed IHA, real-time acoustic monitoring would begin at least 60 minutes prior to pile driving. The real-time PAM system would be designed and established such that detection capability extends to 10 km from the pile driving location. The real-time PAM system must ensure that acoustic detections can be classified (*i.e.*, potentially originating from a North Atlantic right whale) within 30 minutes of the original detection. The PAM operator must be trained in identification of mysticete vocalizations. The PAM operator responsible for determining if the acoustic detection originated from a North Atlantic right whale within the 10 km PAM monitoring zone would be required to make such a determination if they had at least 75 percent confidence that the vocalization within 10 km of the pile driving location originated from a North Atlantic right whale. A record of the PAM operator's review of any acoustic detections would be reported to NMFS OPR.

Soft Start

In the proposed IHA, NMFS OPR states that the use of a soft start procedure is expected to provide additional protection to marine mammals by warning them or providing them with a chance to leave the area prior to the hammer operating at full capacity. Soft start requires initiating sound from the hammer at reduced energy followed by a waiting period. Vineyard Wind will utilize soft start techniques for impact pile driving by performing an initial set of three strikes from the impact hammer at a reduced energy level followed by a one-minute waiting period. We note that it is difficult to specify the reduction in energy for any given hammer because of variation across drivers and, for impact hammers, the actual number of strikes at reduced energy will vary because operating the hammer at less than full power results in "bouncing" of the hammer as it strikes the pile, resulting in multiple "strikes"; however, Vineyard Wind has proposed that they will target less than 40 percent of total hammer energy for the initial hammer strikes during soft start. The soft start process would be conducted a total of three times prior to driving each pile (*e.g.*, three single strikes followed by a one minute delay, then three additional single strikes followed by a one minute delay, then a final set of three single strikes followed by an additional one minute delay). Soft start would be required at the beginning of each day's impact pile driving work and at any time following a cessation of impact pile driving of thirty minutes or longer.

Shutdown

According to NMFS OPR, the purpose of a shutdown is to prevent some undesirable outcome, such as auditory injury or behavioral disturbance of sensitive species, by halting the activity. If a marine mammal is observed entering or within the respective clearance zones after pile driving has begun, the PSO will request a temporary cessation of pile driving. Vineyard Wind has proposed that, when called for by a PSO, shutdown of pile driving would be implemented when feasible but that shutdown would not always be technically practicable once driving of a pile has commenced as it has the potential to result in pile instability. The proposed shutdown measure would be implemented when feasible, with a focus on other proposed mitigation measures as the primary means of minimizing potential impacts on marine mammals from noise related to pile driving. If shutdown is called for by a PSO, and Vineyard Wind determines a shutdown to be technically feasible, pile driving would be halted immediately.

Under the proposed IHA, in situations when shutdown is called for but Vineyard Wind determines shutdown is not practicable due to human safety or operational concerns, reduced hammer energy would be implemented when practicable. After shutdown, pile driving may be initiated once all clearance zones are clear of marine mammals for the minimum species-specific time periods, or, if required to maintain installation feasibility. Installation feasibility refers to ensuring that the pile installation results in a usable foundation for the WTG (*e.g.*, installed to the target penetration depth without refusal and with a horizontal foundation/tower interface flange). In cases where pile driving is already started and a PSO calls for shutdown, the lead engineer on duty will evaluate the following to determine whether shutdown is feasible: 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 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.

Visibility Requirements

According to the proposed IHA, Vineyard Wind will not initiate pile driving at night, or, when the full extent of all relevant clearance zones cannot be confirmed to be clear of marine mammals, as determined by the lead PSO on duty. The clearance zones may only be declared clear, and pile driving started, when the full extent of all clearance zones are visible (*i.e.*, when not obscured by dark, rain, fog, etc.) for a full 30 minutes prior to pile driving. Pile driving may continue after dark only when the driving of the same pile began during the day when clearance zones were fully visible and must proceed for human safety or installation feasibility reasons.

Sound Attenuation Devices

Vineyard Wind would implement sound attenuation technology that would target at least a 12 dB reduction in pile driving noise, and that must achieve at least a 6 dB reduction in pile driving noise, as described above. The attenuation system may include one of the following or some combination of the following: a Noise Mitigation System, Hydro-sound Damper, Noise Abatement System, and/or bubble curtain. Vineyard Wind would also have a second back-up attenuation device (*e.g.*, bubble curtain or similar) available, if needed, to achieve the targeted reduction in noise levels, pending results of sound field verification testing. One monopile and one jacket may be installed without attenuation in order to establish baseline noise measurements from which to determine the amount of attenuation provided by the attenuation mitigation technology.

If Vineyard Wind uses a bubble curtain, NMFS OPR would require the bubble curtain to distribute air bubbles around 100 percent of the piling perimeter for the full depth of the water column. The lowest bubble ring shall be in contact with the mudline for the full circumference of the ring, and the weights attached to the bottom ring shall ensure 100 percent mudline contact. No parts of the ring or other objects shall prevent full mudline contact. Vineyard Wind would require that construction contractors train personnel in the proper balancing of airflow to the bubblers, and would require that construction contractors submit an inspection/performance report for approval by Vineyard Wind within 72 hours following the performance test. Corrections to the attenuation device to meet the performance standards would occur prior to impact driving.

Monitoring Protocols

According to the proposed IHA, Vineyard Wind will monitor for protected species before, during, and after pile driving activities. In addition, observers will record all incidents of marine mammal occurrence, regardless of distance from the construction activity, and monitors will document any behavioral reactions in concert with distance from piles being driven. Observations made outside the clearance zones will not result in delay of pile driving; that pile segment may be completed without cessation, unless the marine mammal approaches or enters the clearance zone, at which point pile driving activities would be halted when practicable, as described above. Pile driving activities include the time to install a single pile or series of piles, as long as the time elapsed between uses of the pile driving equipment is no more than 30 minutes.

In the proposed IHA, NMFS OPR proposes the following additional measures for visual monitoring:

(1) Monitoring will be conducted by qualified, trained PSOs, who will be placed on the installation vessel, which represents the best vantage point to monitor for marine mammals and implement shutdown procedures when applicable;
(2) A minimum of two PSOs will be on duty at all times during pile driving activity. A minimum of four PSOs will be stationed at the pile driving site at all times during pile driving activity;
(3) 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;

(4) Monitoring will be conducted from 60 minutes prior to commencement of pile driving, throughout the time required to drive a pile, and for 30 minutes following the conclusion of pile driving;

(5) PSOs will have no other construction-related tasks while conducting monitoring;

(6) PSOs should have the following minimum qualifications:

- Visual acuity in both eyes (correction is permissible) sufficient for discernment of moving targets at the water's surface with ability to estimate target size and distance; use of binoculars may be necessary to correctly identify the target;
- Ability to conduct field observations and collect data according to assigned protocols;
- Experience or training in the field identification of marine mammals, including the identification of behaviors;
- Sufficient training, orientation, or experience with the construction operation to provide for personal safety during observations;
- Writing skills sufficient to document observations including, but not limited to: the number and species of marine mammals observed; dates and times when in-water construction activities were conducted; dates and times when in-water construction activities were suspended to avoid potential incidental injury of marine mammals from construction noise within a defined shutdown zone; and marine mammal behavior; and
- Ability to communicate orally, by radio or in person, with project personnel to provide real-time information on marine mammals observed in the area as necessary.

According to the proposed IHA, NMFS OPR requires observer teams employed by Vineyard Wind in satisfaction of the mitigation and monitoring requirements described in the proposed IHA must meet the following additional requirements:

- Independent observers (*i.e.*, not construction personnel) are required;
- At least one observer must have prior experience working as an observer;
- Other observers may substitute education (degree in biological science or related field) or training for experience;
- One observer will be designated as lead observer or monitoring coordinator. The lead observer must have prior experience working as an observer; and
- NMFS will require submission and approval of observer CVs.

Vessel Strike Avoidance

According to the proposed IHA, NMFS OPR requires that vessel strike avoidance measures will include, but are not limited to, the following, except under circumstances when complying with these measures would put the safety of the vessel or crew at risk:

- All vessel operators and crew must maintain vigilant watch for cetaceans and pinnipeds, and slow down or stop their vessel to avoid striking these protected species;

- All vessels transiting to and from the WDA and traveling over 10 knots would have a visual observer who has undergone marine mammal training stationed on the vessel. Visual observers monitoring the vessel strike avoidance zone may be third-party observers (*i.e.*, PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena and broadly to identify a marine mammal as a right whale, other whale (defined in this context as sperm whales or baleen whales other than right whales), or other marine mammal;
- From November 1 through May 14, all vessels, regardless of size, must travel at less than 10 knots (18.5 km/hr.) within the WDA;
- From November 1 through May 14, when transiting to or from the WDA, vessels must either travel at less than 10 knots, or, must implement visual surveys with at least one visual observer to monitor for North Atlantic right whales (with the exception of vessel transit within Nantucket Sound);
- All vessels must travel at 10 knots (18.5 km/hr.) or less within any designated Dynamic Management Area (DMA), with the exception of crew transfer vessels;
- Crew transfer vessels traveling within any designated DMA must travel at 10 knots (18.5 km/hr.) or less, unless North Atlantic right whales are clear of the transit route and WDA for two consecutive days, as confirmed by vessel based surveys conducted during daylight hours and real-time PAM, or, by an aerial survey, conducted once the lead aerial observer determines adequate visibility. If confirmed clear by one of the measures above, vessels transiting within a DMA must employ at least two visual observers 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 less than 10 knots until clearance of the transit route for two consecutive days is confirmed by the procedures described above;
- All vessels greater than or equal to 65 ft. (19.8 m) in overall length will comply with 10 knot (18.5 km/hr.) or less speed restriction in any Seasonal Management Area (SMA) per the NOAA ship strike reduction rule (73 FR 60173; October 10, 2008);
- All vessel operators will reduce vessel speed to 10 knots (18.5 km/hr.) or less when any large whale, any mother/calf pairs, pods, or large assemblages of non-delphinoid cetaceans are observed near (within 100 m (330 ft.)) an underway vessel;
- All survey vessels will maintain a separation distance of 500 m (1,640 ft.) or greater from any sighted North Atlantic right whale;
- If underway, vessels must steer a course away from any sighted North Atlantic right whale at 10 knots (18.5 km/hr.) or less until the 500 m (1640 ft.) minimum separation distance has been established. If a North Atlantic right whale is sighted in a vessel’s path, or within 500 m (330 ft.) to an underway vessel, the underway vessel must

reduce speed and shift the engine to neutral. Engines will not be engaged until the right whale has moved outside of the vessel's path and beyond 500 m. If stationary, the vessel must not engage engines until the North Atlantic right whale has moved beyond 500 m;

- All vessels will maintain a separation distance of 100 m (330 ft.) or greater from any sighted non-delphinoid cetacean. If sighted, the vessel underway must reduce speed and shift the engine to neutral, and must not engage the engines until the non-delphinoid cetacean has moved outside of the vessel's path and beyond 100 m. If a vessel is stationary, the vessel will not engage engines until the non-delphinoid cetacean has moved out of the vessel's path and beyond 100 m;
- All vessels will maintain a separation distance of 50 m (164 ft.) or greater from any sighted delphinoid cetacean, with the exception of delphinoid cetaceans that voluntarily approach the vessel (*i.e.*, bow ride). Any vessel underway must remain parallel to a sighted delphinoid cetacean's course whenever possible, and avoid excessive speed or abrupt changes in direction. Any vessel underway must reduce vessel speed to 10 knots (18.5 km/hr.) or less when pods (including mother/calf pairs) or large assemblages of delphinoid cetaceans are observed. Vessels may not adjust course and speed until the delphinoid cetaceans have moved beyond 50 m and/or the abeam of the underway vessel;
- All vessels will maintain a separation distance of 50 m (164 ft.) or greater from any sighted pinniped; and
- All vessels underway will not divert or alter course in order to approach any whale, delphinoid cetacean, or pinniped. Any vessel underway will avoid excessive speed or abrupt changes in direction to avoid injury to the sighted cetacean or pinniped.

According to the proposed IHA, NMFS OPR requires Vineyard Wind to ensure that vessel operators and crew maintain a vigilant watch for marine mammals by slowing down or stopping the vessel to avoid striking marine mammals. Project-specific training will be conducted for all vessel crew prior to the start of the construction activities. Confirmation of the training and understanding of the requirements will be documented on a training course log sheet.

3.3.3 Proposed Monitoring and Reporting

In order to issue an IHA for an activity, Section 101(a)(5)(D) of the MMPA states that NMFS must set forth requirements pertaining to the monitoring and reporting of such taking. The MMPA implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for authorizations must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or impacts on populations of marine mammals that are expected to be present in the proposed action area. Effective reporting is critical both to compliance and for ensuring that the most value is obtained from the required monitoring.

Monitoring and reporting requirements prescribed by NMFS in an MMPA take authorization should contribute to improved understanding of one or more of the following:

- Occurrence of marine mammal species or stocks in the area in which take is anticipated (*e.g.*, presence, abundance, distribution, density).
- Nature, scope, or context of likely marine mammal exposure to potential stressors/impacts (individual or cumulative, acute or chronic), through better understanding of: (1) action or environment (*e.g.*, source characterization, propagation, ambient noise); (2) affected species (*e.g.*, life history, dive patterns); (3) co-occurrence of marine mammal species with the action; or (4) biological or behavioral context of exposure (*e.g.*, age, calving or feeding areas).
- Individual marine mammal responses (behavioral or physiological) to acoustic stressors (acute, chronic, or cumulative), other stressors, or cumulative impacts from multiple stressors.
- How anticipated responses to stressors affect either: (1) long-term fitness and survival of individual marine mammals; or (2) populations, species, or stocks.
- Effects on marine mammal habitat (*e.g.*, marine mammal prey species, acoustic habitat, or other important physical components of marine mammal habitat).
- Mitigation and monitoring effectiveness.

Visual Marine Mammal Observations
According to the proposed IHA, NMFS OPR requires Vineyard Wind to collect sighting data and behavioral responses to pile driving activity for marine mammal species observed while pile driving activities are taking place. All observers will be trained in marine mammal identification and behaviors and are required to have no other construction-related tasks while conducting monitoring. PSOs would monitor all clearance zones at all times. PSOs would also monitor an area extending to the distance where noise that may result in Level B harassment is predicted (*i.e.*, 4,121 m for monopiles and 3,220 m for jacket piles) and would document any marine mammals observed within these zones, to the extent practicable. NMFS OPR expects that the PSOs will be able to reliably detect large whales within 2,500 m of the pile being installed. Vineyard Wind would conduct monitoring before (beginning at least 60 minutes prior to planned start of pile driving), during, and after pile driving, with observers located at the best practicable vantage points on the pile driving vessel to maximize detectability of whales in the monitoring zone.

According to the proposed IHA, NMFS OPR requires Vineyard Wind to implement the following procedures for pile driving:

- A minimum of two PSOs will maintain watch at all times when pile driving is underway.
- PSOs would be located at the best vantage point(s) on the installation vessel to ensure that they are able to observe the entire clearance zones and as much of the Level B harassment zone as possible.
- During all observation periods, PSOs will use binoculars and the naked eye to search continuously for marine mammals.

- PSOs will be equipped with reticle binoculars and night vision binoculars.
- If the clearance zones are obscured by fog or poor lighting conditions, pile driving will not be initiated until clearance zones are fully visible. Should such conditions arise while impact driving is underway, the activity would be halted when practicable, as described above.
- The clearance zones will be monitored for the presence of marine mammals before, during, and after all pile driving activity.
- When monitoring is required during vessel transit (as described above), the PSO(s) will be stationed on vessels at the best vantage points to ensure maintenance of standoff distances between marine mammals and vessels (as described above). Vineyard Wind would implement the following measures during vessel transit when there is an observation of a marine mammal:
- PSOs will record the vessel's position and speed, water depth, sea state, and visibility will be recorded at the start and end of each observation period, and whenever there is a change in any of those variables that materially affects sighting conditions.
- PSOs will record the time, location, speed, and activity of the vessel, sea state, and visibility.
- Individuals implementing the monitoring protocol will assess its effectiveness using an adaptive approach. PSOs will use their best professional judgment throughout implementation and seek improvements to these methods when deemed appropriate. Any modifications to the protocol will be coordinated between NMFS and Vineyard Wind.

Data Collection

Under the proposed IHA, observers are required to use standardized data forms. Among other pieces of information, Vineyard Wind will record detailed information about any implementation of delays or shutdowns, including the distance of animals to the pile and a description of specific actions that ensued and resulting behavior of the animal, if any. NMFS OPR requires that, at a minimum, the following information be collected on the sighting forms:

- Date and time that monitored activity begins or ends;
- Construction activities occurring during each observation period;
- Weather parameters (*e.g.*, wind speed, percent cloud cover, visibility);
- Water conditions (*e.g.*, sea state, tide state);
- Species, numbers, and, if possible, sex and age class of marine mammals;
- Description of any observable marine mammal behavior patterns, including bearing and direction of travel and distance from pile driving activity;
- Distance from pile driving activities to marine mammals and distance from the marine mammals to the observation point;
- Type of construction activity (*e.g.*, monopile or jacket pile installation) when marine mammals are observed.
- Description of implementation of mitigation measures (*e.g.*, delay or shutdown).

- Locations of all marine mammal observations; and
- Other human activity in the area.
- Vineyard Wind will note behavioral observations, to the extent practicable, if an animal has remained in the area during construction activities.

Acoustic Monitoring

According to the proposed IHA, Vineyard Wind would utilize a PAM system to supplement visual monitoring. The PAM system would be monitored by a minimum of one acoustic PSO (with no other PSO duties) beginning at least 30 minutes prior to ramp-up of pile driving and at all times during pile driving. Acoustic PSOs would immediately communicate all detections of marine mammals to visual PSOs, including any determination regarding species identification, distance, and bearing and the degree of confidence in the determination. Under the proposed IHA, PAM would be used to inform visual monitoring during construction; outside of the May 1 – May 14 and November 1 – December 31 shoulder periods, no mitigation actions would be required on PAM detection alone. The PAM system would not be located on the pile installation vessel.

As per the proposed IHA, acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least two hours between watches. Acoustic PSOs would be required to complete specialized training for operating PAM systems. PSOs can act as acoustic or visual observers (but not simultaneously) as long as they demonstrate that their training and experience are sufficient to perform each task.

As part of the proposed IHA, Vineyard Wind would be required to conduct sound source verification during pile driving to ensure that the required 6 dB re 1 µPa noise attenuation is working correctly. Sound source verification would be required during impact installation of a 10.3 m monopile (or, of the largest diameter monopile used over the duration of the IHA) with noise attenuation activated; during impact installation of the same size monopile, without noise attenuation activated (if a monopile is installed without noise attenuation; impact pile driving without noise attenuation would be limited to one monopile); and, during impact installation of the largest jacket pile used over the duration of the IHA. At this time, no specific measurement locations have been selected to conduct sound source verification. Vineyard Wind will submit a sound source characterization plan closer to the construction period. Selected sound source verification locations will be selected to at least allow for characterization of the Level A and Level B harassment zones. In the meantime, BOEM and NMFS will continue efforts to develop a standard sound source characterization measurements and procedures for offshore wind projects. For each pile that is monitored via hydroacoustic monitoring, a minimum of two autonomous acoustic recorders will be deployed. Each acoustic recorder will consist of a vertical line array with two hydrophones deployed at depths spanning the water column (one near the seabed and one in the water column).

Vineyard Wind would be required to empirically determine the distances to the isopleths corresponding to the Level A and Level B harassment thresholds either by extrapolating from in situ measurements conducted at several points from the pile being driven, or by direct measurements to locate the distance where the received levels reach the relevant thresholds or below. Isopleths corresponding to the Level A and Level B harassment thresholds would be empirically verified for impact driving of the largest diameter monopile used over the duration of the IHA, and impact driving of the largest diameter jacket pile used over the duration of the IHA. For verification of the extent of the Level B harassment zone, Vineyard Wind would be required to report the measured or extrapolated distances where the received levels SPLrms decay to 160-dB, as well as integration time for such SPLrms.

According to the proposed IHA, the acoustic monitoring report would include: peak sound pressure level (SPLpk), root-mean-square sound pressure level that contains 90 percent of the acoustic energy (SPLrms), single strike sound exposure level, integration time for SPLrms, SELss spectrum, and 24-hour cumulative SEL extrapolated from measurements. All these levels would be reported in the form of median, mean, max, and minimum. The sound levels reported would be in median and linear average (*i.e.*, taking averages of sound intensity before converting to dB). The acoustic monitoring report would also include a description of depth and sediment type at the recording location. Recording would also occur when no construction activities are occurring in order to establish ambient sound levels.

Reporting

Under the proposed IHA, a draft report would be submitted to NMFS within 90 days of the completion of monitoring for each installation's in-water work window. The report would include marine mammal observations pre-activity, during-activity, and post-activity during pile driving days, and would also provide descriptions of any behavioral responses to construction activities by marine mammals. The report would detail the monitoring protocol, summarize the data recorded during monitoring including an estimate of the number of marine mammals that may have been harassed during the period of the report, and describe any mitigation actions taken (*i.e.*, delays or shutdowns due to detections of marine mammals, and documentation of when shutdowns were called for but not implemented and why). The report would also include results from acoustic monitoring including dates and times of all detections, types and nature of sounds heard, whether detections were linked with visual sightings, water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, a record of the PAM operator's review of any acoustic detections, and any other notable information. Vineyard Wind must submit a final report to NMFS OPR within 30 days following resolution of comments on the draft report.

3.4 Action Area

The action area is defined in 50 CFR 402.02 as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The action area includes the 75,614 acre WDA where project activities will occur and the surrounding areas ensonified by proposed Project noise; the OECC, which extends north through Muskeget Channel to landfall in south-central Cape Cod; the vessel transit areas between the WDA and ports in Massachusetts (New Bedford, Brayton Point, and Montaup), Rhode Island (Providence and Quonset Point, Rhode Island) and Canada (Sheets Port, St. John, and Halifax) and the routes used by vessels transporting manufactured components from Europe (see Figure 1, 2, and 3) inclusive of the portion of the Atlantic Ocean that will be transited by those vessels and the territorial sea of nations along the European Atlantic coast from which those vessels will originate.

Figure 1: Vineyard Wind Lease and Wind Development Area, Proposed Port Facilities, Export Cable Route, and Surrounding Lease Areas

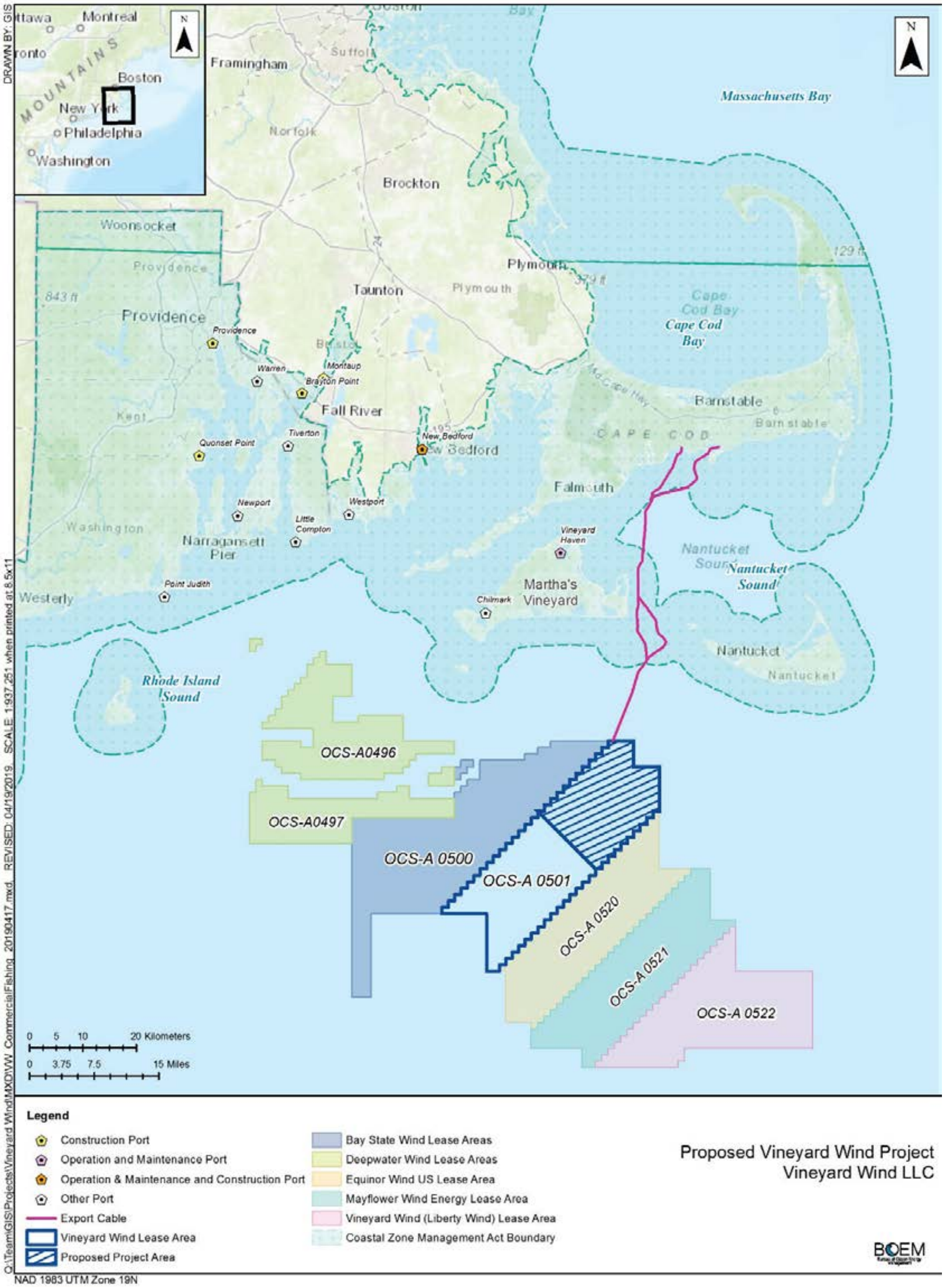
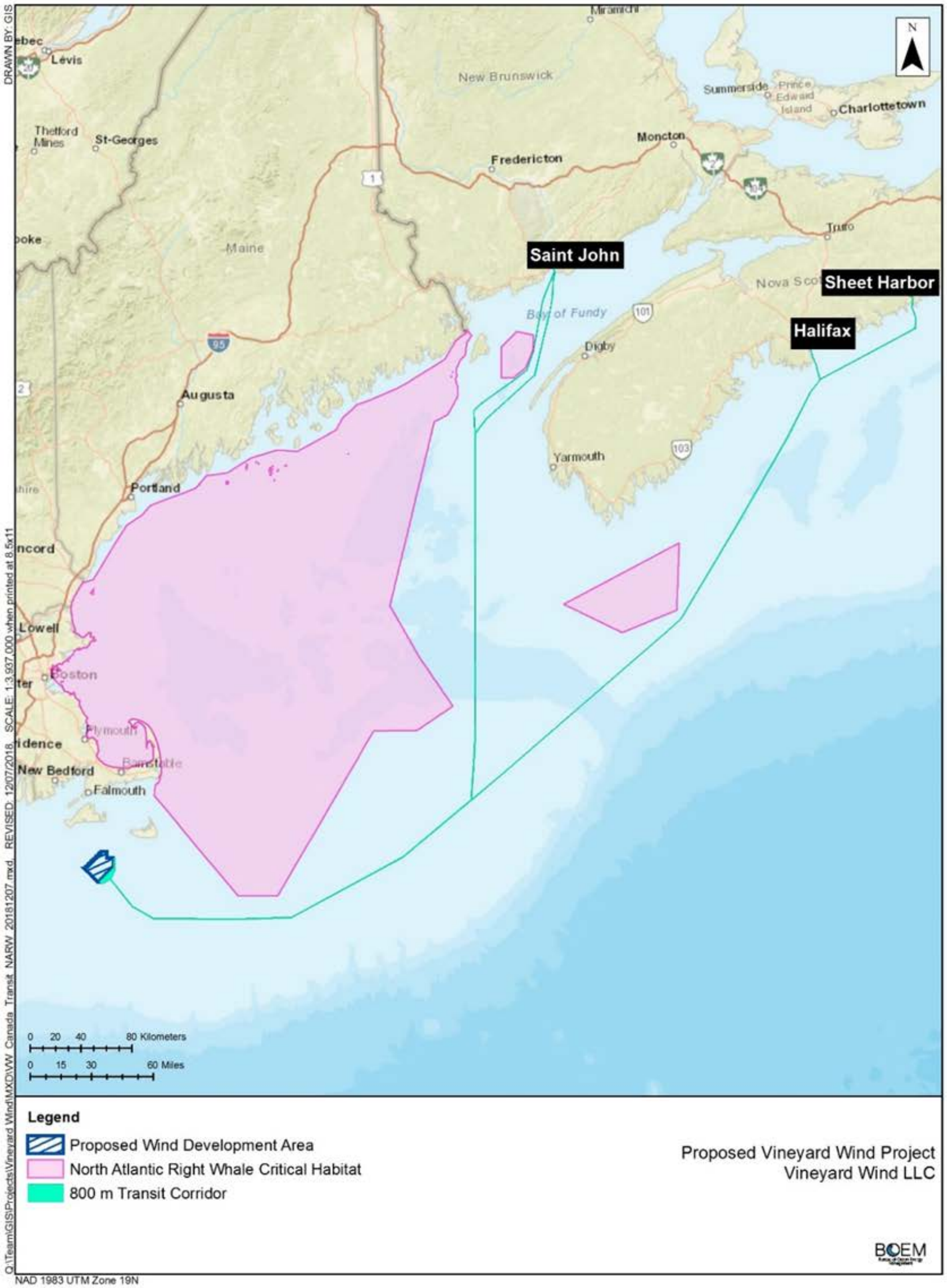


Figure 2. Vessel Traffic Routes from Canadian Ports



As explained in the Effects of the Action section of this Opinion, the vessels transiting to the project area from Europe are trans-Atlantic cargo vessels that routinely travel between the U.S. and Europe. The exact vessel route from port facilities in Europe is unknown at this time and will depend on several factors including the origin and destination of particular trips. All trips originating from Europe will either travel directly to the project site within the WDA or to one of the ports in Canada, Massachusetts, or Rhode Island that were identified above. At this time, the port(s) of origin are unknown. Vessel routes will depend, on a trip-by-trip basis, on weather and sea-state conditions, other vessel traffic, and any maritime hazards. Based on a review of AIS data (see Figure 4), we expect vessels approaching the project area from Europe to have a track that eventually approaches the precautionary area at the intersection of the Boston Harbor Traffic Lanes and the Nantucket to Ambrose Traffic Lane and then tracks along the Nantucket to Ambrose Traffic Lane. At some point, the vessel will depart the Nantucket to Ambrose Traffic Lane and travel directly to the WDA or to the Narragansett Bay or Buzzards Bay traffic separation scheme. According to information provided by BOEM, vessels traveling to the WDA or to the MA or RI ports from Canada will travel along the route illustrated above in Figure 2. We assume that vessels traveling from Europe to the WDA or the MA, RI, or Canadian ports will take the most direct route; thus, we consider the action area to include the portion of the North Atlantic Ocean as illustrated in Figure 3, where we assume that any project vessels transiting from Europe will operate.

Figure 3. Map Representing the Entirety of the Action Area. Note that given the scale of the map, this is meant only to serve as a general visual representation of the text description of the action area provided above.

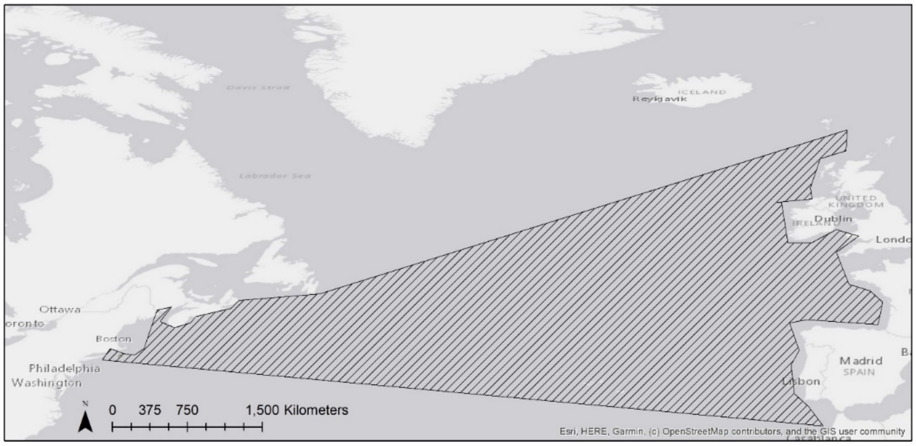
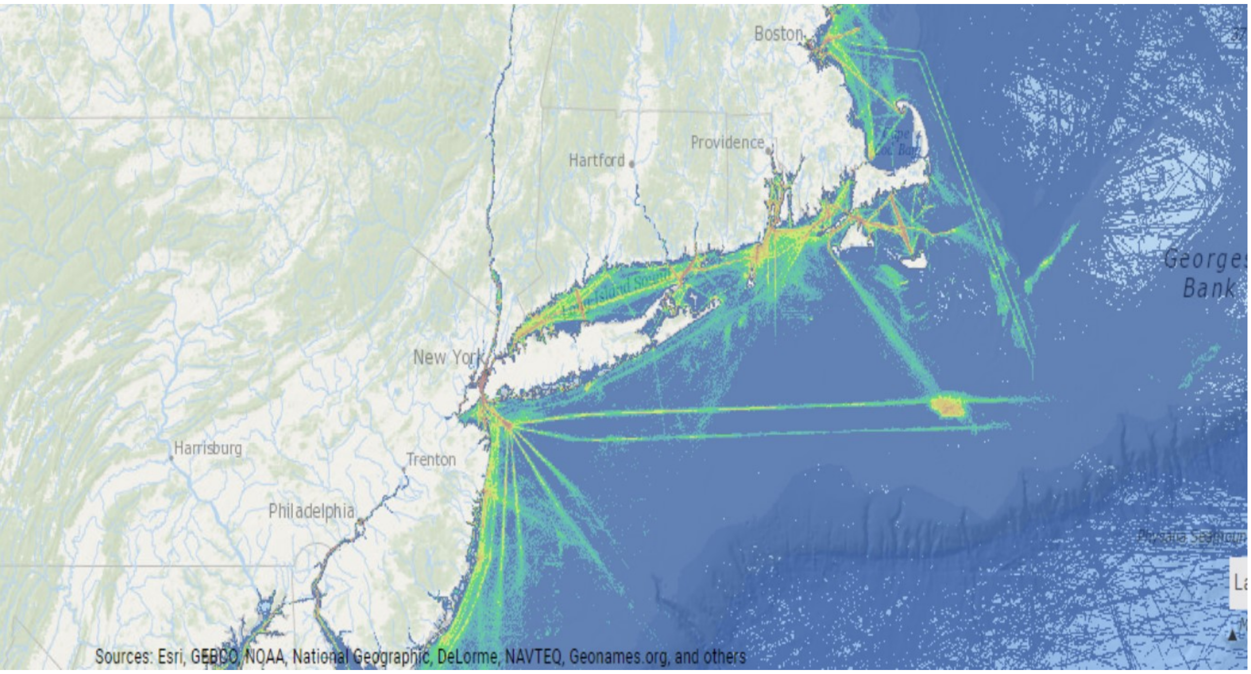


Figure 4. AIS Vessel Transit Counts (2019) from Mid-Atlantic Ocean Data Portal. *https://bit.ly/33eYIro*; last accessed September 9, 2020.



4.0 SPECIES AND CRITICAL HABITAT NOT CONSIDERED FURTHER IN THIS OPINION

In the BA, BOEM concludes that the proposed action is not likely to adversely affect blue whales, shortnose sturgeon, and giant manta rays and that hawksbill sea turtles and Atlantic salmon do not occur in the action area. BOEM also concludes that the proposed action will have no effect on critical habitat designated for North Atlantic right whales. We have also determined that the proposed action is not likely to adversely affect the oceanic white tip shark or the Northeast Atlantic DPS of loggerhead sea turtles. Here, we provide rationale to support these determinations. In this Opinion, we also concluded that the proposed action is not likely to adversely affect any DPS of Atlantic sturgeon; however, given the anticipated exposure of Atlantic sturgeon to many of the stressors associated with the proposed action and the extent of the analysis necessary to support our conclusion, Atlantic sturgeon are considered in the "Effects of the Action" section of this Opinion.

Blue whales (*Balaenoptera musculus*) – Endangered

In the North Atlantic Ocean, the range of blue whales extends from the subtropics to the Greenland Sea. As described in Waring et al. 2010 (the most recent stock assessment report), blue whales have been detected and tracked acoustically in much of the North Atlantic with most of the acoustic detections around the Grand Banks area of Newfoundland and west of the British Isles. Photo-identification in eastern Canadian waters indicates that blue whales from the St. Lawrence, Newfoundland, Nova Scotia, New England and Greenland all belong to the same stock, while blue whales photographed off Iceland and the Azores appear to be part of a separate population (CETAP 1982; Wenzel et al. 1988; Sears and Calambokidis 2002; Sears and Larsen 2002). In the action area, blue whales are most frequently sighted in the waters off eastern Canada, with the majority of recent records in the Gulf of St. Lawrence (Waring et al. 2010) which is outside the action area. The largest concentrations of blue whales are found in the lower St. Lawrence Estuary (LeSage et al. 2017, Comtois et al. 2010) which is outside of the action area. Blue whales do not regularly occur within the U.S. EEZ and typically occur further offshore in areas with depths of 100 m or more (Waring et al. 2010).

Migration patterns for blue whales in the eastern North Atlantic Ocean are poorly understood. However, blue whales have been documented in winter months off Mauritania in northwest Africa (Baines & Reichelt 2014); in the Azores, where their arrival is linked to secondary production generated by the North Atlantic spring phytoplankton bloom (Visser et al. 2011); and traveling through deep-water areas near the shelf break west of the British Isles (Charif & Clark 2009). Blue whale calls have been detected in winter on hydrophones along the mid-Atlantic ridge south of the Azores (Nieukirk et al. 2004).

Blue whales have not been documented in the WDA[8]. There are recorded sightings of blue whales is the northern portion of the transit route from ports in Canada that may be used during the construction phase (see figure 2). There is an area off the coast of Nova Scotia (overlapping with the potential vessel transit route from Halifax and Sheet Harbor) with approximately 30 sightings of blue whales recorded; however, all of these sightings are from a three year period in the 1960s (1966-1968), despite sighting effort since then. The portion of the action area that overlaps with the vessel transit route from St. John has about seven sightings between 1975 and 2006. The rarity of observations in this area is consistent with the conclusion in Waring et al. (2010) that the blue whale is best considered as an occasional visitor in U.S. Atlantic EEZ waters and would be rare along the vessel transit route from Canada. In the BA, BOEM estimates a maximum of two vessels per day will travel between either St. John, Halifax, or Sheet Harbor, over the construction period for a total of no more than 265 trips. Given the rarity of blue whales in this area, it is extremely unlikely that any blue whales will co-occur in the area with these vessel trips. Similarly, given the rarity of blue whales along any transit routes from Europe, co-occurrence with any of those trips is not reasonably expected. However, even if co-occurrence did occur, any effects are extremely unlikely to occur. This is because the slow transit speed (not exceeding 10 knots) and the use of a dedicated lookout, will allow vessel operators to avoid interactions with any whales along the vessel transit route.). Traveling at speeds not exceeding 10 knots provides a significant reduction in risk of vessel strike as it both provides for greater opportunity for a whale to evade the vessel but also ensures that vessels are operating at such a speed that they can make evasive maneuvers in time to avoid a collision (Laist et al., 2001; Jensen and Silber, 2003; Vanderlaan and Taggart, 2007). Therefore, based on the unexpected co-occurrence of blue whales and project vessels as well as the speed reductions and use of a lookout, any effects to blue whales are extremely unlikely to occur.

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[8] Available sightings data at: http://seamap.env.duke.edu/species/180528. Last accessed July 2, 2020.

Shortnose sturgeon (*Acipenser brevirostrum*) – Endangered
Shortnose sturgeon are benthic fish that mainly occupy the deep channel sections of large rivers. There are no records of shortnose sturgeon captures in state fisheries surveys or fisheries observer program records in the action area. The closest population to the action area is within the Connecticut River. Within the Gulf of Maine, some portion of the shortnose sturgeon population natal to the Kennebec River make nearshore coastal migrations north to at least the Penobscot River and south to the Merrimack River. Despite intense study of shortnose sturgeon in New England, there is only one recorded occurrence of a shortnose sturgeon making a coastal migration outside of the Gulf of Maine. In fall 2014, a shortnose sturgeon was caught in the Merrimack River (MA) carrying a tag that was implanted in the Connecticut River in 2001 (pers. comm. Kieffer and Savoy 2014). The genetic differentiation between the Connecticut and Merrimack River sturgeon populations is a reflection of the rarity of these types of movements. Based on the information summarized here, we do not expect shortnose sturgeon to occur in the action area. Therefore, we do not anticipate that any shortnose sturgeon will be exposed to effects of the proposed action.

Giant Manta Ray (*Manta birostris)* – Threatened
The giant manta inhabits temperate, tropical, and subtropical waters worldwide, between 35° N and 35° S latitudes. In the western Atlantic Ocean, this includes South Carolina south to Brazil and Bermuda. Occasionally, manta rays are observed as far north as New Jersey (Miller and Klimovich 2017). There are no records of giant manta ray occurrence in the action area. Given the known distribution of this species, it is not expected to occur in the action area. Therefore, we do not expect any manta rays to be exposed to effects of the proposed action.

Hawksbill sea turtle (*Eretmochelys imbricate)* – Endangered
The hawksbill sea turtle is found in tropical and subtropical regions of the Atlantic, Pacific, and Indian Oceans and is uncommon in the waters of the continental United States. Hawksbills are typically associated with coral reefs, such as those found in the Caribbean and Central America. Occurrence north of Florida is considered rare (NMFS and USFWS 1993). Based on the information summarized here, we do not expect hawksbill sea turtles to occur in the action area. Therefore, we do not anticipate that any hawksbill sea turtles will be exposed to effects of the proposed action.

Gulf of Maine DPS of Atlantic salmon *(Salmo salar)* – Endangered
The only remaining populations of Gulf of Maine distinct population segment (GOM DPS) Atlantic salmon are in Maine. Smolts migrate from their natal river to foraging grounds in the North Atlantic and after one or more winters at sea, adults return to their natal river to spawn. The migration route of GOM DPS Atlantic salmon overlaps with the route that BOEM has indicated will be used by barges transporting project components from Canada. There is no evidence of interactions between vessels and Atlantic salmon. Vessel strikes are not identified as a threat in the listing determination (74 FR 29344) or the recent recovery plan (NMFS and USFWS 2019). We have no information to suggest that vessels in the ocean have any effects on migrating Atlantic salmon. Therefore, we do not expect any effects to Atlantic salmon even if migrating individuals co-occur with project vessels moving between the project site and the identified ports in Canada.

Oceanic White Tip Shark (*Carcharhinus longimanus*) – Threatened

The oceanic whitetip shark is usually found offshore in the open ocean, on the outer continental shelf, or around oceanic islands in deep water greater than 184 m. As noted in Young et al. 2017, the species has a clear preference for open ocean waters between 10°N and 10°S, but can be found in decreasing numbers out to latitudes of 30°N and 35°S, with abundance decreasing with greater proximity to continental shelves. In the Western Atlantic, oceanic whitetips occur from Maine to Argentina, including the Caribbean and Gulf of Mexico. In the Central and Eastern Atlantic, the species occurs from Madeira, Portugal south to the Gulf of Guinea, and possibly in the Mediterranean Sea. Oceanic white tip sharks are not known to occur in the WDA; the only portion of the action area that overlaps with their distribution is the open ocean waters that may be transited by vessels from Europe. Vessel strikes are not identified as a threat in the status review (Young et al., 2017), listing determination (83 FR 4153) or the recovery outline (NMFS 2018). We have no information to suggest that vessels in the ocean have any effects on oceanic white tip sharks. Therefore, we do not expect any effects to this species even if migrating individuals co-occur with project vessels.

Northeast Atlantic DPS of Loggerhead Sea Turtles (*Caretta caretta*) – Endangered

The Northeast Atlantic DPS of loggerhead sea turtles occurs in the Northeast Atlantic Ocean north of the equator, south of 60° N. Lat., and east of 40° W. Long., except in the vicinity of the Strait of Gibraltar where the eastern boundary is 5°36′ W. Long. The only portion of the action area that loggerheads from the Northeast Atlantic DPS are present in is along the portion of any vessel transit routes from Europe that are east of 40° W. Long. In this portion of the action area, co-occurrence of project vessels and individual sea turtles is expected to be extremely unlikely; this is due to the dispersed nature of sea turtles in the open ocean and the only intermittent presence of project vessels. Together, this makes it extremely unlikely that any Northeast Atlantic DPS loggerheads will be struck by a project vessel. No other effects to sea turtles from this DPS are anticipated.

Critical Habitat Designated for North Atlantic Right Whales

On January 27, 2016, NMFS issued a final rule designating critical habitat for North Atlantic right whales (81 FR 4837). Critical habitat includes two areas (Units) located in the Gulf of Maine and Georges Bank Region (Unit 1) and off the coast of North Carolina, South Carolina, Georgia and Florida (Unit 2). The action area does not overlap with Unit 1 or Unit 2. In the BA, BOEM described the vessel transit routes to be used for project vessels traveling to or from Canada; based on our review of the information provided by BOEM in the BA, these vessels will not travel through Unit 1.

As identified in the final rule (81 FR 4837), the physical and biological features essential to the conservation of the North Atlantic right whale that provide foraging area functions in Unit 1 are: The physical oceanographic conditions and structures of the Gulf of Maine and Georges Bank region that combine to distribute and aggregate *C. finmarchicus* for right whale foraging, namely prevailing currents and circulation patterns, bathymetric features (basins, banks, and channels), oceanic fronts, density gradients, and temperature regimes; low flow velocities in Jordan, Wilkinson, and Georges Basins that allow diapausing *C. finmarchicus* to aggregate passively below the convective layer so that the copepods are retained in the basins; late stage *C.*

finmarchicus in dense aggregations in the Gulf of Maine and Georges Bank region; and diapausing *C. finmarchicus* in aggregations in the Gulf of Maine and Georges Bank region.

We have considered whether the proposed action would have any effects to right whale critical habitat. Copepods in critical habitat originate from Jordan, Wilkinson, and George's Basin. The effects of the proposed action, including those of vessels going to/from Canada, do not extend to these areas, and we do not expect any effects to the generation of copepods in these areas that could be attributable to the proposed action. The proposed action will also not affect any of the physical or oceanographic conditions that serve to aggregate copepods in critical habitat. Offshore wind farms can reduce wind speed and wind stress which can lead to less mixing, lower current speeds, and higher surface water temperature (Afsharian et al. 2020), cause wakes that will result in detectable changes in vertical motion and/or structure in the water column (e.g. Christiansen & Hasager 2005, Broström 2008), as well as detectable wakes downstream from a wind farm by increased turbidity (Vanhellemont and Ruddick, 2014). However, these effects will not extend more than a few hundred meters from each foundation. The Vineyard Wind project is a significant distance from right whale critical habitat and, thus, it is not anticipated to affect the oceanographic features of critical habitat. Further, the Vineyard Wind project is not anticipated to cause changes to the physical or biological features of critical habitat by worsening climate change, given the energy generated by the project is anticipated to displace electricity generated by existing fossil-fuel fired plants (Epsilon 2020) and to only support existing uses. Therefore, we have determined that the proposed action will have no effect on right whale critical habitat.

5.0 STATUS OF THE SPECIES

5.1 Marine Mammals

5.1.1 Fin Whale

Globally there is one species of fin whale, *Balaenoptera physalus*. Fin whales occur in all major oceans of the Northern and Southern Hemispheres (NMFS, 2010). Within this range, three subspecies of fin whales are recognized: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachonica* (a pygmy form) in the Southern Hemisphere (NMFS, 2010). For management purposes, in the northern Hemisphere, the United States divides *B. p. physalus* into four stocks: Hawaii, California/Oregon/Washington, Alaska (Northeast Pacific), and Western North Atlantic (Hayes, 2019; NMFS, 2010). The Western North Atlantic stock occurs in the action area.

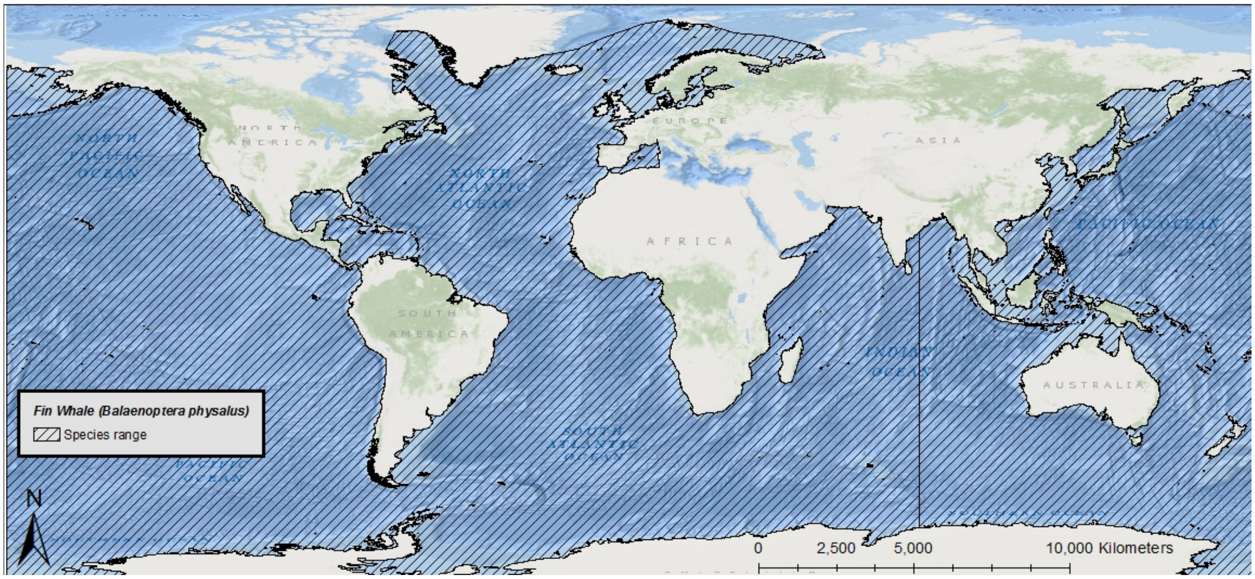

Figure 5: Range of the endangered fin whale.

Fin whales are distinguishable from other whales by a sleek, streamlined body, with a V-shaped head, a tall falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface. The lower jaw is gray or black on the left side and creamy white on the right side. The fin whale was listed as endangered on December 2, 1970 (35 FR 18319).

Information available from the recovery plan (NMFS, 2010), recent stock assessment reports (Muto, 2019; Hayes, 2019; Carretta, 2019), status review (NMFS, 2011), as well as the recent International Union for the Conservation of Nature's (IUCN) fin whale assessment (Cooke, 2018) was used to summarize the life history, population dynamics and status of the species as follows.

Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year and calves nurse for six to seven months. Sexual maturity is reached between 6 and 10 years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas.

Population Dynamics

The pre-exploitation estimate for the fin whale population in the entire North Atlantic was approximately 30,000-50,000 animals (Sergeant 1977), and for the entire North Pacific Ocean, approximately 42,000 to 45,000 animals (Ohsumi, 1974). In the Southern Hemisphere, prior to exploitation, the fin whale population was approximately 40,000 whales (IWC 1979). In the North Atlantic Ocean, fin whales were heavily exploited from 1864 to the 1980s; over this timeframe, approximately 98,000 to 115,000 fin whales were killed (IWC 2017). Between 1910-1975, approximately 76,000 fin whales were recorded taken by modern whaling in the North Pacific; this number is likely higher as many whales killed were not identified to species or while killed, where not successfully landed (Allison 2017). Over 725,000 fin whales were killed in the Southern Hemisphere from 1905 to 1976 (Allison 2017).

In the North Atlantic Ocean, the IWC has defined seven management stocks of fin whales: (1) North Norway (2) East Greenland and West Iceland (EGI); (3) West Norway and the Faroes; (4) British Isles, Spain and Portugal; (5) West Greenland and (6) Nova Scotia, (7) Newfoundland and Labrador (Donovan 1991; NMFS 2010a). Based on three decades of survey data in various portions of the North Atlantic, the IWC estimates that there are approximately 79,000 fin whales in this region. Under the present IWC scheme, fin whales off the eastern United States, Nova Scotia, and the southeastern coast of Newfoundland are believed to constitute a single stock; in U.S. waters, NMFS classifies these fin whales as the Western North Atlantic stock (Donovan 1991; Hayes et al. 2019b; NMFS 2010a). NMFS' best estimate of abundance for the Western North Atlantic Stock of fin whales is 7,418 individuals (N_{min}=6,029); this estimate is the sum of the 2016 NOAA shipboard and aerial surveys and the 2016 Canadian Northwest Atlantic International Sightings Survey (Palka, 2012). Currently, there is no population estimate for the entire fin whale population in the North Pacific (Cooke 2018a). However, abundance estimates for three stocks in U.S. Pacific Ocean waters do exist: Northeast Pacific (N= 3,168; N_{min}=2,554), Hawaii (N=154; N_{min}=75), and California/Oregon/Washington (N= 9,029; N_{min}=8,127) (Nadeem, 2016). Abundance data for the Southern Hemisphere stock remain highly uncertain; however, available information suggests a substantial increase in the population has occurred (Thomas, 2016).

In the North Atlantic, estimates of annual growth rate for the entire fin whale population in this region is not available (Cooke, 2018). However, in U.S. Atlantic waters NMFS has determined that until additional data is available, the cetacean maximum theoretical net productivity rate of 4.0% will be used for the Western North Atlantic stock (Hayes et al. 2019b). In the North Pacific, estimates of annual growth rate for the entire fin whale population in this region is not available (Cooke 2018a). However, in U.S. Pacific waters, NMFS has determined that until additional data is available, the cetacean maximum theoretical net productivity rate of 4.0% will be used for the Northeast Pacific stock (Muto et al. 2019b; NMFS 2016). Overall population growth rates and total abundance estimates for the Hawaii stock of fin whales are not available at this time (Carretta et al. 2018). In addition, (Nadeem, 2016), based on line transect studies between 1991-2014, estimated a 7.5% increase in mean annual abundance in fin whales occurring in waters off California, Oregon, and Washington; to date, this represents the best available information on the current population trend for the overall California/Oregon/Washington stock of fin whales (Carretta et al. 2019a).[9] For Southern Hemisphere fin whales, as noted above, overall information suggests a substantial increase in the population; however, the rate of increase remains poorly quantified (Cooke 2018a).

Archer (2013) recently examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial DNA genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of

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[9] Since 2005, the fin whale abundance increase has been driven by increases off northern California, Oregon, and Washington; numbers off Central and Southern California have remained stable (Carretta et al. 2019a; Nadeem et al. 2016).

which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean, which may indicate a revision of the subspecies delineations is warranted. Generally, haplotype diversity was found to be high both within and across ocean basins. Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some populations having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes.

Vocalizations and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hz range (Edds 1988; Thompson et al. 1992; Watkins 1981; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 Hz range, but only males are known to produce these (Clark et al. 2002; Patterson and Hamilton 1964). The most typically recorded call is a 20 Hz pulse lasting about one second, and reaching source levels of 189 ± 4 dB re: 1 µPa at 1 m (Charif et al. 2002; Clark et al. 2002; Edds 1988; Garcia et al. 2018; Richardson et al. 1995; Sirovic et al. 2007; Watkins 1981; Watkins et al. 1987). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 Hz), and can be repeated over the course of many hours (Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Richardson et al. (1995) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981; Watkins et al. 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20 Hz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (U.S. Navy 2010; U.S. Navy 2012). An additional fin whale sound, the 40 Hz call described by Watkins (1981), was also frequently recorded, although these calls are not as common as the 20 Hz fin whale pulses. Seasonality of the 40 Hz calls differed from the 20 Hz calls, since 40 Hz calls were more prominent in the spring, as observed at other sites across the northeast Pacific Ocean (Sirovic et al. 2012). Source levels of Eastern Pacific Ocean fin whale 20 Hz calls has been reported as 189 ± 5.8 dB re: 1 µPa at 1 m (Weirathmueller et al. 2013). Some researchers have also recorded moans of 14 to 118 Hz, with a dominant frequency of 20 Hz, tonal and upsweep vocalizations of 34 to 150 Hz, and songs of 17 to 25 Hz (Cummings and Thompson 1994; Edds 1988; Garcia et al. 2018; Watkins 1981). In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 µPa at 1 m (see also Clark and Gagnon 2004; as compiled by Erbe 2002). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20-Hz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Thompson et al. 1992; Watkins et al. 1987).

Although their function is still in doubt, low frequency fin whale vocalizations travel over long distances and may aid in long distance communication (Edds-Walton 1997; Payne and Webb 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpback whales (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999). Also, it has been suggested that some fin whale sounds may function for long range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999). Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995). This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hz and 12 kHz and a maximum sensitivity to sounds in the 1 to 2 kHz range. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA 2018).

Status

The fin whale is endangered as a result of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whales may be killed under “aboriginal subsistence whaling” in Greenland, under Japan’s scientific whaling program, and Iceland’s formal objection to the International Whaling Commission’s ban on commercial whaling. Additional threats include vessel strikes, reduced prey availability due to overfishing or climate change, and sound. The species’ overall large population size may provide some resilience to current threats, but trends are largely unknown.

Critical Habitat

No critical habitat has been designated for the fin whale.

Recovery Goals

Recovery is the process of restoring endangered and threatened species to the point where they no longer require the safeguards of the Endangered Species Act. A recovery plan serves as a road map for species recovery—the plan outlines the path and tasks required to restore and secure self-sustaining wild populations. It is a non-regulatory document that describes, justifies, and schedules the research and management actions necessary to support recovery of a species. The goal of the 2010 Recovery Plan for the fin whale (NMFS 2010a) is to promote the recovery of fin whales to the point at which they can be downlisted from endangered to threatened status, and ultimately to remove them from the list of Endangered and Threatened Wildlife and Plants, under the provisions of the ESA. The intermediate goal is to reclassify the species from endangered to threaten. The recovery plan also includes downlisting and delisting criteria. Key elements for the recovery program for fin whales are:

1. Coordinate state, federal, and international actions to implement recovery actions and maintain international regulation of whaling for fin whales;
2. Determine population discreteness and population structure of fin whales;
3. Develop and apply methods to estimate population size and monitor trends in abundance;
4. Conduct risk analysis;

5. Identify, characterize, protect, and monitor habitat important to fin whale populations in U.S. waters and elsewhere;
6. Investigate causes and reduce the frequency and severity of human-caused injury and mortality;
7. Determine and minimize any detrimental effects of anthropogenic noise in the oceans;
8. Maximize efforts to acquire scientific information from dead, stranded, and/or entrapped fin whales; and,
9. Develop post-delisting monitoring plan.

In February 2019, NMFS published a Five-Year Review for fin whales. This 5-year review indicates that, based on a review of the best available scientific and commercial information, that the fin whale should be downlisted from endangered to threatened. The review also recommended that NMFS consider whether listing at the subspecies or distinct population segment level is appropriate in terms of potential conservation benefits and the use of limited agency resources (NMFS 2019).

5.1.2 North Atlantic Right Whale

There are three species classified as right whales (genus *Eubalaena*): North Pacific (*E. japonica*), Southern (*E. australis*), and North Atlantic (*E. glacialis*). The North Atlantic right whale is the only species of right whale that occurs in the North Atlantic Ocean and therefore, is the only species of right whale that may occur in the action area.

Today, North Atlantic right whales occur primarily in the western North Atlantic Ocean. There are, however, acoustic detections, reports, and/or sightings of North Atlantic right whales in waters off Greenland (east/southeast), Newfoundland, northern Norway, and Iceland, as well as within Labrador Basin (Knowlton et al. 1992; Jacobsen et al. 2004; Hamilton et al. 2007; Mellinger et al. 2011). These latter sightings/detections are consistent with historic records documenting North Atlantic right whales south of Greenland, in the Denmark straits, and in eastern North Atlantic waters (Kraus, 2007). There is also evidence of possible historic North Atlantic right whale calving grounds being located in the Mediterranean Sea (Rodrigues, 2018), an area not currently considered as part of this species historical range.

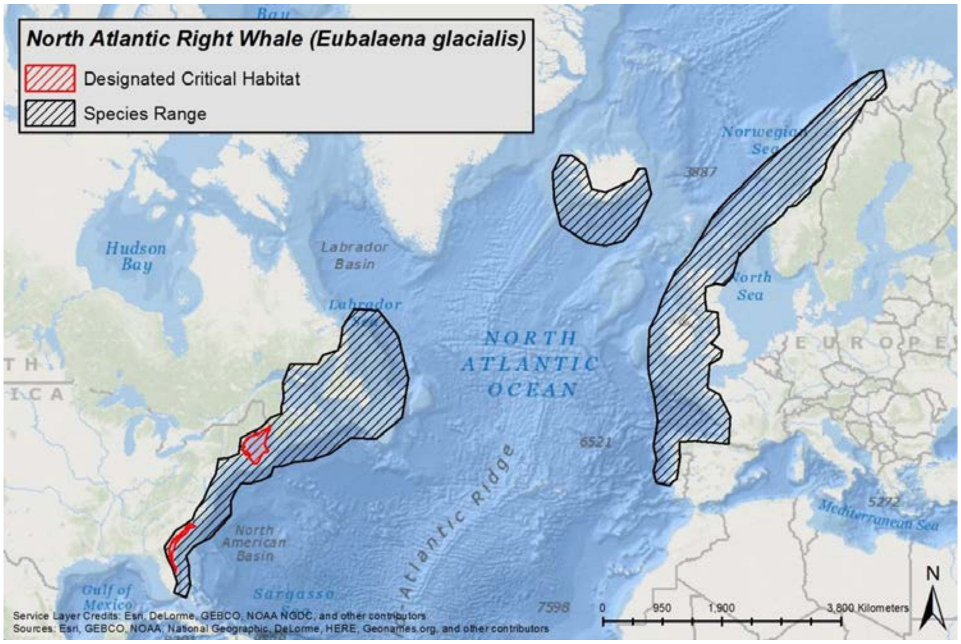

Figure 6: Approximate historic range and currently designated U.S. critical habitat of the North Atlantic right whale.

The North Atlantic right whale is distinguished by its stocky body and lack of a dorsal fin. The species was listed as endangered on December 2, 1970. We used information available in the most recent five-year review for North Atlantic right whales (NMFS, 2017), the most recent stock assessment report (Hayes, 2018), and the scientific literature to summarize the best available information on the species, as follows.

Life history

The maximum lifespan of North Atlantic right whales is unknown, but one individual reached at least 70 years of age (Hamilton, 1998; Kenney, 2009). Previous modelling efforts suggest that in 1980, females had a life expectancy of approximately 51.8 years of age, which was twice that of males at the time (Fujiwara, 2001); however, by 1995, female life expectancy was estimated to have declined to approximately 14.5 years (Fujiwara, 2001). Most recent estimates indicate that North Atlantic right whale females are only living to 45 and males to age 65 (https://www.fisheries.noaa.gov/species/north-atlantic-right-whale). A recent study demonstrates that females, ages 5+, have reduced survival relative to males, ages 5+, resulting in a decrease in female abundance relative to male abundance (Pace, 2017). Specifically, state-space mark-recapture model estimates show that from 2010-2015, males declined just under 4.0%, and females declined approximately 7% (Pace et al. 2017).

Gestation is estimated to be between 12 and 14 months, after which calves typically nurse for around one year (Kraus et al, 2001, Cole et al. 2013, Lockyer, 1984; Kenney, 2009; Kraus, 2007). After weaning calves, females typically undergo a ‘resting’ period before becoming pregnant again, presumably because they need time to recover from the energy deficit experienced during lactation (Fortune, 2012;Fortune, 2013;Pettis, 2017). From 1983 to 2005, annual average calving intervals ranged from 3 to 5.8 years (overall average of 4.23 years)

(Knowlton, 1994; Kraus, 2007). Between 2006 and 2015, annual average calving intervals continued to vary within this range, but in 2016 and 2017 longer calving intervals were reported (6.3 to 6.6 years in 2016 and 10.2 years in 2017; Pettis, 2017;Pettis, 2016;Pettis, 2015;Surrey-Marsden, 2017;Hayes, 2018). Females have been known to give birth as young as five years old, but the mean age of first partition is about 10 years old (Kraus, 2007).

Pregnant North Atlantic right whales migrate south, through the mid-Atlantic region of the United States, to low latitudes during late fall where they overwinter and give birth in shallow, coastal waters (Kenney, 2009; Krzystan, 2018). During spring, these females and new calves migrate to high latitude foraging grounds where they feed on large concentrations of copepods, primarily *Calanus finmarchicus* (NMFS, 2017; Mayo, 2018). Some non-reproductive North Atlantic right whales (males, juveniles, non-reproducing females) also migrate south, although at more variable times throughout the winter. Others appear to not migrate south and remain in the northern feeding grounds year round or go elsewhere (Morano, 2012; Bort, 2015; NMFS, 2017 ; Mayo, 2018; Stone, 2017).

Nonetheless, calving females arrive to the southern calving grounds earlier and stay in the area more than twice as long as other demographics (Krzystan, 2018). Little is known about North Atlantic right whale habitat use in the mid-Atlantic, but recent acoustic data indicate near year round presence of at least some whales off the coasts of New Jersey, Virginia, and North Carolina (Salisbury, 2016;Hodge, 2015;Whitt, 2013;Davis, 2017). While it is generally not known where North Atlantic right whales mate, some evidence suggests that mating may occur in the northern feeding grounds (Cole, 2013; Matthews, 2014).

Population dynamics

Today, North Atlantic right whales are primarily found in the western North Atlantic, from their calving grounds in lower latitudes off the coast of the southeastern United States to their feeding grounds in higher latitudes off the coast of New England and Nova Scotia (Hayes, 2018). In recent years, the location of feeding grounds has shifted, with fewer animals being seen in the Great South Channel and the Bay of Fundy and more animals being observed in the Gulf of Saint Lawrence and mid-Atlantic (Hayes, 2018; Pace, 2017; Davis, 2017;Daoust, 2017;Meyer-Gutbrod, 2018;Hayes, 2018).

There are currently two recognized populations of North Atlantic right whales, an eastern and a western population. Very few individuals likely make up the population in the eastern Atlantic, which is thought to be functionally extinct (Best, 2001). However, in recent years, a few known individuals from the western population have been seen in the eastern Atlantic, suggesting some individuals may have wider ranges than previously thought (Kenney, 2009). Specifically, there have been acoustic detections, reports, and/or sightings of North Atlantic right whales in waters off Greenland (east/southeast), Newfoundland, northern Norway, and Iceland, as well as within Labrador Basin (Knowlton et al. 1992; Jacobsen et al. 2004; Hamilton et al. 2007; Mellinger et al. 2011). Monsarrat et al. (2016) estimated that the North Atlantic historically (i.e., pre-whaling) supported between 9,000 and 21,000 right whales. The western population may have numbered fewer than 100 individuals by 1935, when international protection for right whales came into effect (Kenney, 1995).

Genetic analysis, based upon mitochondrial and nuclear DNA analyses, have consistently revealed an extremely low level of genetic diversity in the North Atlantic right whale population (Malik, 1999;McLeod, 2010) (Malik, 2000;Schaeff, 1997;Hayes, 2018). Waldick et al. (2002) concluded that the principal loss of genetic diversity occurred prior to the 18th century, with more recent studies hypothesizing that the loss of genetic diversity may have occurred prior to the onset of Basque whaling during the 16th and 17th century (Rostogi et al. 2004; McLeod et al. 2008; Reeves et al. 2001; Reeves et al. 2007). The persistence of low genetic diversity in the North Atlantic right whale population might indicate inbreeding; however, based on available data, no definitive conclusions can be reached at this time (Hayes et al. 2019b; Radvan 2019; Schaeff et al. 1997). However, by combining 25 years of field data (1980-2005) with high resolution genetic data, Frasier et al. (2013) found that North Atlantic right whale calves born between 1980 and 2005 had higher levels of microsatellite (nuclear) heterozygosity than would be expected from this species gene pool. Frasier et al. (2013) concluded that this level of heterozygosity is due to postcopulatory selection of genetically dissimilar gametes, and that this mechanism is a natural means to mitigate the loss of genetic diversity, over time, in small populations.

In the western North Atlantic, North Atlantic right whale abundance was estimated to be 270 animals in 1990 (Pace et al. 2017). Between 1990 to 2011, right whale abundance increased by approximately 2.8 percent per year, despite a decline in 1993 and no growth between 1997 and 2000 (Pace, 2017). However, since 2011, when the abundance peaked at 481 animals, the population has been in decline, with a 99.99 percent probability of a decline of just under one percent per year (Pace, 2017). Using the methods in Pace et al. (2017), as of 2017, the final median estimate of right whale abundance is 428 animals (95% credible intervals (CI) 406-447), and the minimum population estimate (N_{min}) is 418 animals (as of January 2017); this estimate does not account for the 17 confirmed mortalities observed in June 2017 (12 in Canada; 5 in the United States) that triggered the designation of a Unusual Mortality Event (UME) for North Atlantic right whales (Hayes et al. 2019b). Given this, and the fact that there have been three confirmed dead stranded right whales in the United States in 2018, and 10 confirmed dead stranded right whales (nine in Canada and one in the United States) in 2019 (https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2019-north-atlantic-right-whale-unusual-mortality-event), estimated right whale abundance is likely lower than the estimated abundance provided in Hayes et al. (2019b) .

In addition to finding an overall decline in the North Atlantic right whale population, Pace et al. (2017) also found that between 1990 and 2015, the survival of age 5+ females relative to 5+ males has been reduced; this has resulted in diverging trajectories for male and female abundance. Specifically, there was an estimated 142 males (95% CI=143-152) and 123 females (95% CI=116-128) in 1990; however, by 2015, model estimates show the species was comprised of 272 males (95% CI=261-282) and 186 females (95% CI=174-195; Pace et al. 2017). Calving rates also varied substantially between 1990 and 2015 (i.e., 0.3% to 9.5%), with low calving rates coinciding with three periods (1993-1995, 1998-2000, and 2012-2015) of decline or no growth (Pace, 2017). Using Generalized Linear Models, Corkeron et al. (2018) found that between 1992 and 2016, North Atlantic right whale calf counts increased at a rate of 1.98% per year. Relative to three populations of southern right whales that increased 5.34%, 6.58%, and 7.21% per year, this rate of increase for North Atlantic right whales is substantially less

(Corkeron et al. 2018). Using the highest annual estimates of survival recorded over the time series from Pace et al. (2017), and an assumed calving interval of approximately four years, Corkeron et al. (2018) suggests that the North Atlantic right whale population could potentially increase at a rate of at least 4% per year if there was no anthropogenic mortality.[10]

Vocalization and Hearing

North Atlantic right whales vocalize during social interaction and likely to communicate over long distances (McCordic et al. 2016; Parks and Clark 2007; Parks et al. 2011b; Tyson et al. 2007). Calls among North Atlantic right whales are similar to those of other right whale species, and can be classified into six major call types: screams, gunshots, blows, upcalls, warbles, and downcalls (McDonald and Moore 2002; Parks et al. 2011b; Parks and Tyack 2005; Soldevilla et al. 2014). The majority of vocalizations occur in the 200 Hz to one kHz range with most energy being below one kHz, but there is large variation in frequency depending on the call type (Hatch et al. 2012; Parks and Tyack 2005; Trygonis et al. 2013; Vanderlaan et al. 2003). Source levels range from 137 to 192 dB re: 1 µPa at 1 m (rms), with gunshot calls having higher source levels as compared to other call types (Hatch et al. 2012; Parks and Tyack 2005; Trygonis et al. 2013). Some of these levels are low compared to some other baleen whales, which may put North Atlantic right whales at greater risk of communication masking compared to other species (Clark et al. 2009; Hatch et al. 2012). However, recent evidenced suggests that gunshot calls with their higher source levels may be less susceptible to masking compared to other baleen whale sounds (Cholewiak et al. 2018). Individual calls typically have a duration of 0.04 to 1.5 seconds depending on the call type, and bouts of calls can last for several hours (Parks et al. 2012a; Parks and Tyack 2005; Trygonis et al. 2013; Vanderlaan et al. 2003).

Vocalizations vary by demographic and context. Upcalls are perhaps the most ubiquitous call type, being commonly produced by all age and sex classes (Parks et al. 2011b). Other non-stereotyped tonal calls (e.g., screams) are also produced by all age sex classes (Parks et al. 2011b) but have been primarily attributed to adult females (Parks and Tyack 2005). Warbles are thought to be produced by calves and may represent ‘practice’ screams (Parks and Clark 2007; Parks and Tyack 2005). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Gunshots appear to be largely or exclusively male vocalizations and may be a form of vocal display (Parks and Clark 2007; Parks et al. 2005; Parks et al. 2011b). Downcalls have been less frequently recorded, and while it is not known if they are produced by specific age-sex classes, they have been recorded in various demographic make ups of surface-active groups (Parks and Tyack 2005). A recent study examining the development of calls in North Atlantic right while found age-related changes in call production continue into adulthood (Root-Gutteridge et al. 2018).

All types of right whale calls have been recorded in surface-active groups, with smaller groups vocalizing more than larger groups and vocalization being more frequent in the evening, at night,

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[10] Based on information in the North Atlantic Right Whale Catalog, the mean calving interval is 4.69 years (P. Hamilton 2018, unpublished, in Corkeron et al. 2018). Corkeron et al. (2018) assumed a 4 year calving interval as the approximate mid-point between the North Atlantic Right Whale Catalog calving interval and observed calving intervals for Southern right whales (i.e., 3.16 years for South Africa, 3.42 years for Argentina, 3.31 years for Auckland Islands, and 3.3 years for Australia).

and perhaps on the calving grounds (Matthews et al. 2001; Matthews et al. 2014; Morano et al. 2012; Parks and Clark 2007; Parks et al. 2012a; Salisbury et al. 2016; Soldevilla et al. 2014; Trygonis et al. 2013). Screams are usually produced within 10 m of the surface (Matthews et al. 2001). Upcalls have been detected nearly year-round in Massachusetts Bay, peaking in April (Mussoline et al. 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of upcall and gunshot vocalizations from November through January possibly associated with mating (Bort et al. 2015; Matthews et al. 2014; Morano et al. 2012; Mussoline et al. 2012). Upcalls may be used for long distance communication (McCordic et al. 2016), including to reunite calves with mothers (Parks and Clark 2007; Tennessen and Parks 2016). In fact, a recent study indicates they contain information on individual identity and age (McCordic et al. 2016). However, while upcalls are frequently heard on the calving grounds (Soldevilla et al. 2014), they are infrequently produced by mothers and calves here perhaps because the two maintain visual contact until calves are approximately three to four months of age (Parks and Clark 2007; Parks and Van Parijs 2015; Trygonis et al. 2013). North Atlantic right whales shift calling frequencies, particularly those of upcalls, and increase call amplitude over both long and short term periods due to exposure to vessel sound, which may limit their communication space by as much as 67 percent compared to historically lower sound conditions (Hatch et al. 2012; Parks and Clark 2007; Parks et al. 2007a; Parks et al. 2011a; Parks et al. 2012b; Parks et al. 2009; Tennessen and Parks 2016).

There are no direct data on the hearing range of North Atlantic right whales, although they are considered to be part of the low frequency hearing group with a hearing range between 7 Hz and 35 kHz (NOAA 2018). However, based on anatomical modeling, their hearing range is predicted to be from 10 Hz to 22 kHz with a functional range probably between 15 Hz to 18 kHz (Parks et al. 2007b).

Status

The North Atlantic right whale is listed under the ESA as endangered. Anthropogenic mortality is limiting the recovery of North Atlantic right whales (Corkeron et al. 2018) and the most recent 5-year review (NMFS 2017) recommends that the listing status remain unchanged. With whaling now prohibited, the two major known human causes of mortality are vessel strikes and entanglement in fishing gear (Hayes, 2018). Estimates of total annual anthropogenic mortality (i.e., ship strike and entanglement in fishing gear), as well as the number of undetected anthropogenic mortalities for North Atlantic right whales have been provided by Hayes et al. (2019b) and Pace et al. (2017); these estimates show that the total annual North Atlantic right whale mortality exceed or equal the number of detected serious injurious and mortalities.[11] These anthropogenic threats appear to be worsening (Hayes, 2018), as evidenced by the North Atlantic right whale UME declared by NMFS on June 7, 2017, as a result of elevated right whale mortalities along the Western North Atlantic Coast. At the time the UME closed in 2019, total mortalities for the UME equaled 30 dead stranded right whales (21 in Canada; 9 in the United States; https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2019-north-atlantic-right-whale-unusual-mortality-event). Full necropsy examinations have been conducted on 18 of the 30 whales and final results from the examinations are still pending; however, preliminary

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[11] Currently, 72% of mortalities since 2000 are estimated to have been observed (Hayes et al. 2019b).

findings indicate that vessel strikes or entanglement in fishing gear (e.g., vertical lines) as the cause of death (https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2019-north-atlantic-right-whale-unusual-mortality-event; (Daoust, 2017).

While data are not yet available to statistically estimate the population's trend beyond 2017, there is evidence the North Atlantic right whale population continues to decline. As provided above, between 1990 to 2011, right whale abundance increased by approximately 2.8 percent per year; however, since 2011 the population has been in decline (Pace, 2017). In fact, recent modeling efforts indicate that low female survival, a male biased sex ratio, and low calving success are contributing to the population's current decline (Pace, 2017). For instance, only five new calves were documented in 2017 (Pettis, 2017), and in 2018, no new calves were reported (Pettis et al. 2018); these number of births are well below the number needed to compensate for expected mortalities (Pace, 2017;Zoodsma, personal communication to E. Patterson on February 26, 2018). Seven calves were born in 2019 and ten in 2020. Long-term photographic identification data also indicate new calves rarely go undetected, so these years likely represent a continuation of low calving rates that began in 2012 (Pace, 2017;Kraus, 2007). While there are likely a multitude of factors involved, low calving has been linked to poor female health (Rolland, 2016) and reduced prey availability (Meyer-Gutbrod, 2014;Meyer-Gutbrod, 2018 ;Meyer-Gutbrod, 2018; Devine, 2017; Johnson, 2017). Furthermore, entanglement in fishing gear appears to have substantial health and energetic costs that affect both survival and reproduction (van der Hoop, 2017; Pettis, 2017; Rolland, 2017; Robbins, 2015; Lysiak, 2018; Hayes, 2018; Hunt, 2018).

Kenney et al. (2018) projected that if all other known or suspected impacts (e.g., vessel strikes, calving declines, climate change, resource limitation, sub-lethal entanglement effects, disease, predation, and ocean noise) on the population remained the same between 1990 and 2016, and none of the observed fishery related SI/M occurred, the projected population in 2016 would be 12.2% higher (506 individuals). Furthermore, if the actual mortality resulting from fishing gear is double the observed rate (as estimated in Pace et al. 2017), eliminating all mortalities (observed and unobserved) could have resulted in a 2016 population increase of 24.6% (562 individuals) and possibly over 600 in 2018 (Kenney et al. 2018).

Given the above information, North Atlantic right whales resilience to future perturbations is expected to be very low (Hayes, 2018). Using a matrix population projection model, it is estimated that by 2029 the population will decline from 160 females to the 1990 estimate of 123 females if the current rate of decline is not altered (Hayes, 2018). Consistent with this, recent modelling efforts by (Meyer-Gutbrod, 2018) indicate that the species may decline towards extinction if prey conditions worsen, and anthropogenic mortalities are not reduced. In fact, recent data from the Gulf of Maine and Gulf of St. Lawrence indicate prey densities may already be in decline (Devine, 2017; Johnson, 2017; Meyer-Gutbrod, 2018).

Recovery Goals

The goal of the 2005 Recovery Plan for the North Atlantic right whale (NMFS, 2005) is to promote the recovery of North Atlantic right whales to a level sufficient to warrant their removal from the List of Endangered and Threatened Wildlife and Plants under the ESA. The intermediate goal is to reclassify the species from endangered to threatened. The recovery strategy identified in the Recovery Plan focuses on reducing or eliminating deaths and injuries from anthropogenic activities, namely shipping and commercial fishing operations; developing demographically-based recovery criteria; the characterization, monitoring, and protection of important habitat; identification and monitoring of the status, trends, distribution and health of the species; conducting studies on the effects of other potential threats and ensuring that they are addressed, and conducting genetic studies to assess population structure and diversity. The plan also recognizes the need to work closely with State, other Federal, international and private entities to ensure that research and recovery efforts are coordinated. The plan includes the following downlisting criteria:

> North Atlantic right whales may be considered for reclassifying to threatened when all of the following have been met: 1) The population ecology (range, distribution, age structure, and gender ratios, etc.) and vital rates (age-specific survival, age-specific reproduction, and lifetime reproductive success) of right whales are indicative of an increasing population; 2) The population has increased for a period of 35 years at an average rate of increase equal to or greater than 2% per year; 3) None of the known threats to North Atlantic right whales (summarized in the five listing factors) are known to limit the population's growth rate; and 4) Given current and projected threats and environmental conditions, the right whale population has no more than a 1% chance of quasi-extinction in 100 years.

The most recent five-year review for right whales was completed in 2017 (NMFS 2017). The recommendation in that plan was for the status to remain as endangered. The plan noted that in many ways, progress toward right whale recovery had regressed since the previous 5-year review was completed in 2012 citing the declining population trend, below average calving rates, and worsened body condition.

5.1.3 Sei Whale

Globally there is one species of sei whale, *Balaenoptera borealis borealis*. Sei whales occur in subtropical, temperate, and subpolar marine waters across the Northern and Southern Hemispheres (Cooke 2018b; NMFS 2011b; Figure 7). For management purposes, in the Northern Hemisphere, the United States recognizes four sei whale stocks: Hawaii, Eastern North Pacific, and Nova Scotia (NMFS 2011b; see NMFS Marine Mammal Stock Assessment Reports: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock).

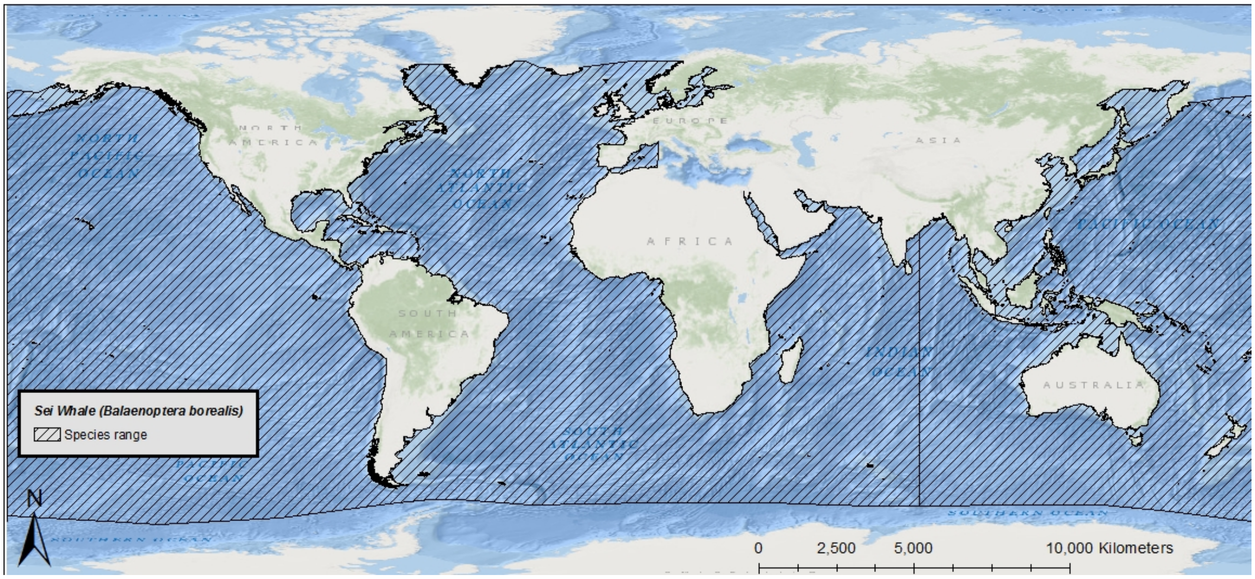


Figure 7: Range of the endangered sei whale.

Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum. The sei whale was listed as endangered on December 2, 1970 (35 FR 18319).

Information available from the recovery plan (NMFS, 2011), recent stock assessment reports (Carretta, 2018; Hayes, 2018; Muto, 2018), status review (NMFS, 2012), as well as the recent IUCN sei whale assessment (Cooke 2018b) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of 10 to 12 months, and calves nurse for six to nine months. Sexual maturity is reached between 6 and 12 years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill), small schooling fishes, and cephalopods.

Population Dynamics

There are no estimates of pre-exploitation sei whale abundance in the entire North Atlantic Ocean; however, approximately 17,000 sei whales were documented caught by modern whaling in the North Atlantic (Allison 2017). In the North Pacific, Tillman (1977) estimated the pre-whaling sei abundance to be approximately 42,000. In the Southern Hemisphere, approximately 63,100 to 65,000 occurred in the Southern Hemisphere prior to exploitation (Braham 1991; Mizroch et al. 1984; NMFS 2011b).

In the North Atlantic, Cattanach et al. (1993) estimated that the entire North Atlantic sei whale population, in 1989, was 10,300 whales. While other surveys have been completed in portions of the North Atlantic since 1989, the survey coverage levels in these studies are not as complete as those done in Cattanach et al. (1993) (Cooke 2018b). As result, to date, updated abundance estimates for the entire North Atlantic population of fin whales are not available. However, in the western North Atlantic, Palka et al. (2017) has provided a recent abundance estimate for the Nova Scotia stock of sei whales. Based on survey data collected from Halifax, Nova Scotia, to Florida between 2010 and 2013, Palka et al. (2017) estimated that there are approximately 6,292 sei whales (N_{min}=3,098); this estimate is considered the best available for the Nova Scotia stock (Hayes et al. 2019b). In the North Pacific, an abundance estimate for the entire North Pacific population of sei whales is not available. However, in the western North Pacific, it is estimated that there are 35,000 sei whales (Cooke 2018b). In the eastern North Pacific (considered east of longitude 180^o), two stocks of sei whales occur in U.S. waters: Hawaii and Eastern North Pacific. Abundance estimates for the Hawaii stock are 391 sei whales (N_{min}=204), and for Eastern North Pacific stock, 519 sei whales (N_{min}=374) (Carretta et al. 2019a). In the Southern Hemisphere, recent abundance of sei whales is estimated at 9,800 to 12,000 whales. Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales; however, in U.S. waters, NMFS has determined that until additional data is available, the cetacean maximum theoretical net productivity rate of 4.0% will be used for the Hawaii, Eastern North Pacific, and Hawaii stocks of sei whales (Hayes et al. 2019b).

Based on genetic analyses, there appears to be some differentiation between sei whale populations in different ocean basins. In an early analysis of genetic variation in sei whales (Wada and Numachi 1991) found some differences between Southern Ocean and the North Pacific sei whales (Wada, 1991). However, more recent analyses of mtDNA control region variation show no significant differentiation between Southern Ocean and the North Pacific sei whales, though both appear to be genetically distinct from sei whales in the North Atlantic (Baker, 2004; Huijser, 2018). Within ocean basin, there appears to be intermediate to high genetic diversity and little genetic differentiation despite there being different managed stocks (Huijser, 2018; Kanda, 2011; Kanda, 2006; Kanda, 2015; Kanda, 2013; Danielsdottir, 1991).

Vocalizations and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 second duration and tonal and upsweep calls in the 200 to 600 Hz range of one to three second durations (McDonald et al. 2005). Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kHz (Thomson and Richardson 1995). Source levels of 189 ±5.8 dB re: 1 µPa at 1 m have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller et al. 2013).

Direct studies of sei whale hearing have not been conducted, but it is assumed that they can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995). This suggests sei whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA 2018).

Status

The sei whale is endangered as a result of past commercial whaling. Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include vessel strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic sound. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

Critical Habitat

No critical habitat has been designated for the sei whale.

Recovery Goals

The 2011 Recovery Plan for the sei whale (NMFS 2011b) indicates that, "because the current population status of sei whales is unknown, the primary purpose of this Recovery Plan is to provide a research strategy to obtain data necessary to estimate population abundance, trends, and structure and to identify factors that may be limiting sei whale recovery." The goal of the Recovery Plan is to promote the recovery of sei whales to the point at which they can be downlisted from Endangered to Threatened status, and ultimately to remove them from the list of Endangered and Threatened Wildlife and Plants, under the provisions of the ESA. The intermediate goal is to reclassify the species from endangered to threatened. The recovery plan incorporates an adaptive management strategy that divides recovery actions into three tiers. Tier I involves: 1) continued international regulation of whaling (i.e., a moratorium on commercial sei whaling); 2) determining population size, trends, and structure using opportunistic data collection in conjunction with passive acoustic monitoring, if determined to be feasible; and 3) continued stranding response and associated data collection.

NMFS completed the most recent five-year review for sei whales in 2012 (NMFS 2012). In that review, NMFS concluded that the listing status should remain unchanged. They also concluded that recovery criteria outlined in the sei whale recovery plan (NMFS 2011) are current but whether these criteria have been met is unknown because of data deficiencies. With regard to the biological criteria, no reliable trend information is available for any of the three ocean basins (Criterion 1), and a risk analysis has not been conducted (Criterion 1) because sufficient information to conduct a robust analysis is not available at this time. With regard to the threats-based criteria, the magnitude and impact of the threat is uncertain (e.g., ship strikes, anthropogenic noise, fisheries entanglements, and loss of prey base due to climate change), thus Making the degree of threat unknown. This problem is exacerbated by the lack of information on the status and trends of the species, which, if known to be increasing steadily, would assist in determining whether these factors are limiting the recovery of the species. Finally, while actions have been taken to address some of the factors that may be limiting recovery of other baleen whales as required by the threats-based criteria (e.g., ship strike rule, fishing gear entanglement risk reduction measures), additional measures may be necessary to fully mitigate these threats.

5.1.4 Sperm Whale

Globally there is one species of sperm whale, *Physeter macrocephalus*. Sperm whales occur in all major oceans of the Northern and Southern Hemispheres (NMFS 2010b; Figure 8). For management purposes, in the Northern Hemisphere, the United States recognizes six sperm whale stocks: California/Oregon/Washington, Hawaii, North Pacific, North Atlantic, Northern Gulf of Mexico, and Puerto Rico and the U.S. Virgin Islands (NMFS 2010b; see NMFS Marine Mammal Stock Assessment Reports: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock).

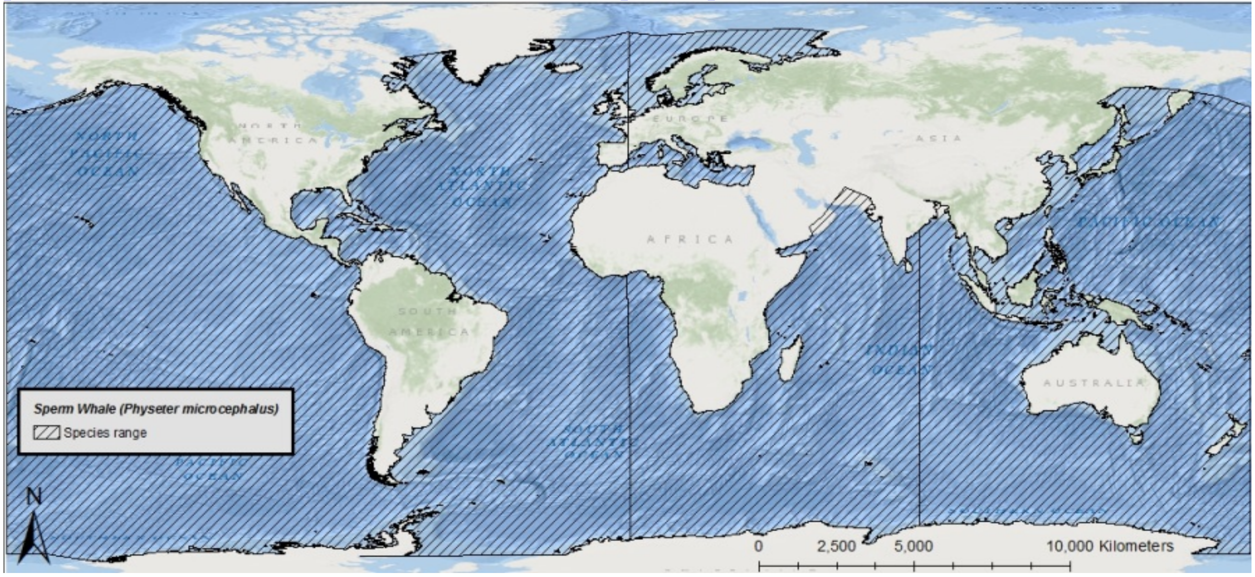


Figure 8: Range of the endangered sperm whale.

The sperm whale is the largest toothed whale and distinguishable from other whales by its extremely large head, which takes up 25 to 35 percent of its total body length and a single blowhole asymmetrically situated on the left side of the head near the tip. The sperm whale was originally listed as endangered on December 2, 1970 (35 FR 18319).

Information available from the recovery plan (NMFS, 2010), recent stock assessment reports (Carretta, 2018; Hayes, 2018; Muto, 2018), status review (NMFS, 2015), as well as the recent IUCN sperm whale assessment (Taylor et al. 2019) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead, 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years, though they may begin to forage for themselves within the first year of life (Tønnesen, 2018). Sexual maturity is reached between 7 and 13 years of age for females with an average calving interval of four to six years. Male sperm whales reach full sexual maturity in their 20s. Sperm whales mostly inhabit areas with a water depth of 600 m or more, and are uncommon in waters less than 300 m deep. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

Population Dynamics

Pre-whaling, the global population of sperm whales was estimated to be approximately 1,100,000 animals (Taylor et al. 2019; Whitehead 2002). By 1880, due to whaling, the population was approximately 71% of its original level (Whitehead 2002). In 1999, ten years after the end of large-scale whaling, the population was estimated to be about 32% of its original level (Whitehead 2002).

The most recent global sperm whale population estimate is 360,000 whales (Whitehead, 2009). There are no reliable estimates for sperm whale abundance across the entire (North and South) Atlantic Ocean. However, estimates are available for two of three U.S. stocks in the western North Atlantic Ocean; the Northern Gulf of Mexico stock is estimated to consist of 763 individuals (N_{min}=560;Waring et al. 2016) and the North Atlantic stock is estimated to consist of 4,349 individuals (N_{min}=3,451; Hayes et al. 2019b). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock (Waring et al. 2010). Similar to the Atlantic Ocean, there are no reliable estimates for sperm whale abundance across the entire (North and South) Pacific Ocean. However, estimates are available for two of three U.S. stocks that occur in the eastern Pacific; the California/Oregon/ Washington stock is estimated to consist of 1,997 individuals (N_{min}=1,270; Carretta et al. 2019b), and the Hawaii stock is estimated to consist of 4,559 individuals (N_{min}=3,478; Carretta et al. 2019a). We are aware of no reliable abundance estimates for sperm whales in other major oceans in the Northern and Southern Hemispheres. Although maximum net productivity rates for sperm whales have not been clearly defined, population growth rates for sperm whale populations are expected to be low (i.e., no more than 1.1% per year; Whitehead 2002). In U.S. waters, NMFS determined that, until additional data is available, the cetacean maximum theoretical net productivity rate of 4.0% will be used for, among others, the North Atlantic, Northern Gulf of Mexico, and Puerto Rico and the U.S. Virgin Islands stocks of sperm whales (Carretta et al. 2019a,b; Hayes et al. 2019b; Muto et al. 2019a,b; Waring et al. 2010; Waring et al. 2016).

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm, 1998). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick, 2011; Rendell, 2012). Furthermore, sperm whales from the Gulf of Mexico, the western North Atlantic Ocean, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt, 2009). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and ‘allee’ effects, although the extent to which is currently unknown. Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40°, only adult males venture into the higher latitudes near the poles.

Vocalizations and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hz to greater than 30 kHz (Watkins 1977) and dominant frequencies between 1 to 6 kHz and 10 to 16 kHz. Another class of sound, “squeals,” are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re: 1 µPa at 1 m, although lower source level energy has been suggested at around 171 dB re: 1 µPa at 1 m (Goold and Jones 1995; Mohl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kHz and 10 to 16 kHz (Goold and Jones 1995; Weilgart and Whitehead 1993). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz and 1.7 kHz) with estimated source levels between 140 to 162 dB re: 1 µPa at 1 m (Madsen et al. 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris and Harvey 1972).

Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Miller et al. 2004; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997; Whitehead and Weilgart 1991). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Laplanche et al. 2005; Miller et al. 2004). Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Rendell and Whitehead 2004; Weilgart and Whitehead 1997). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Pavan et al. 2000; Weilgart and Whitehead 1997). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kHz and highest sensitivity to frequencies between 5 to 20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al. 1997). Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hz and one kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NOAA 2018).

Status

The sperm whale is endangered as a result of past commercial whaling. Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed, however, illegal hunting may occur. Continued threats to sperm whale populations include vessel strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and sound. The Deepwater Horizon Natural Resource Damage Assessment Trustees assess effects of oil exposure on sea turtles and marine mammals (DWH NRDA Trustees 2016). Sperm whales in the Gulf of Mexico were also impacted by the oil spill with 3% of the stock estimated killed. The species' large population size shows that it is somewhat resilient to current threats.

Critical Habitat

No critical habitat has been designated for the sperm whale.

Recovery Goals

The goal of the Recovery Plan is to promote recovery of sperm whales to a point at which they can be downlisted from endangered to threatened status, and ultimately to remove them from the list of Endangered and Threatened Wildlife and Plants, under the provisions of the ESA. The primary purpose of this Recovery Plan is to identify and take actions that will minimize or eliminate effects of human activities that are detrimental to the recovery of sperm whale populations. Immediate objectives are to identify factors that may be limiting abundance/recovery/ productivity, and cite actions necessary to allow the populations to increase. The Recovery Plan includes downlisting and delisting criteria (NMFS 2010).

The most recent Five-Year Review for sperm whales was completed in 2015 (NMFS 2015). In that review, NMFS concluded that no change to the listing status was recommended.

5.2 Sea Turtles

5.2.1 Loggerhead Sea Turtle (Northwest Atlantic Ocean DPS)

Loggerhead sea turtles are circumglobal and are found in the temperate and tropical regions of the Indian, Pacific, and Atlantic Oceans. The loggerhead sea turtle is distinguished from other turtles by its reddish-brown carapace, large head and powerful jaws. The species was first listed as threatened under the Endangered Species Act in 1978 (43 FR 32800, July 28, 1978). On

September 22, 2011, the NMFS and U.S. FWS designated nine distinct population segments of loggerhead sea turtles, with the Northwest Atlantic Ocean DPS listed as threatened (76 FR 58868). The Northwest Atlantic Ocean DPS of loggerheads is found along eastern North America, Central America, and northern South America (Figure 9).

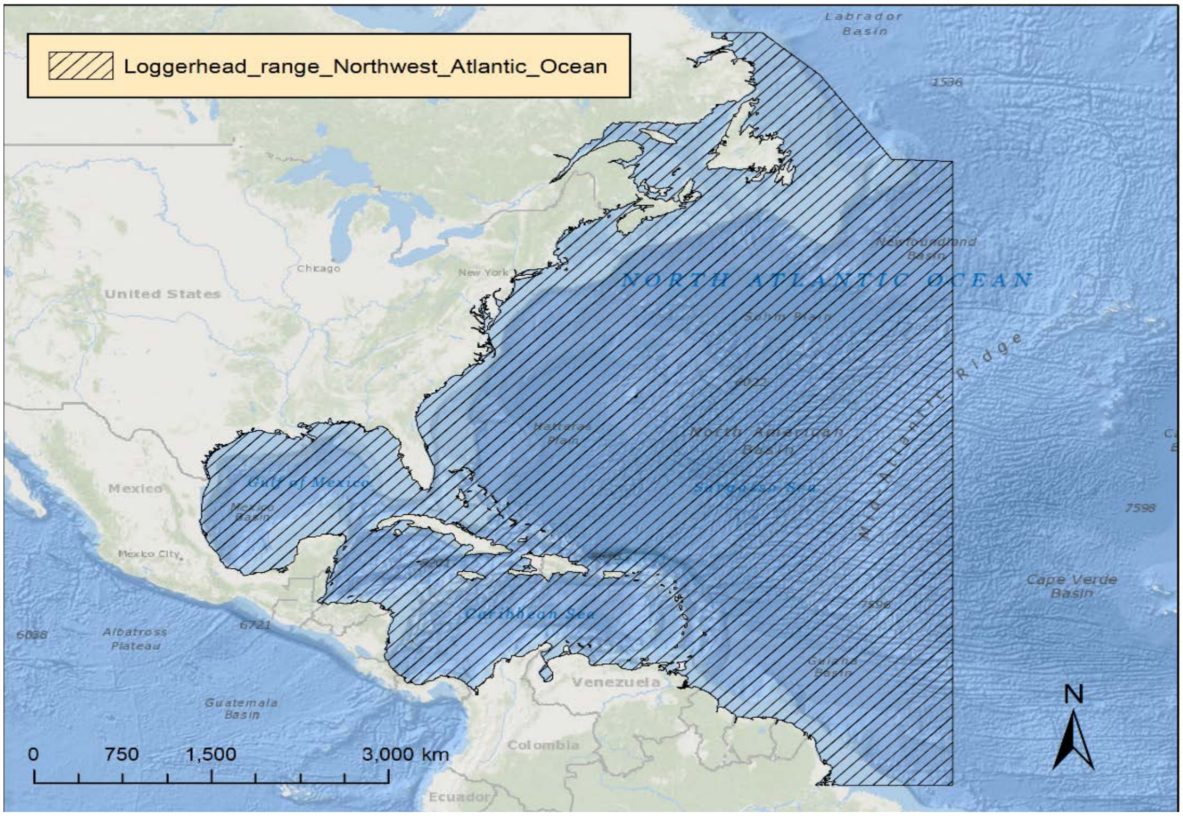


Figure 9: Range of the Northwest Atlantic Ocean DPS of loggerhead sea turtles.

We used information available in the 2009 Status Review (Conant *et al.* 2009), the final listing rule (76 FR 58868, September 22, 2011), the relevant literature, and recent nesting data from the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (FWRI)to summarize the life history, population dynamics and status of the species, as follows.

Life History

Nesting occurs on beaches where warm, humid sand temperatures incubate the eggs. Northwest Atlantic females lay an average of five clutches per year. The annual average clutch size is 115 eggs per nest. Females do not nest every year. The average remigration interval is three years (Conant *et al.* 2009). There is a 54% emergence success rate (Conant et al. 2009). As with other sea turtles, temperature determines the sex of the turtle during the middle of the incubation period. Turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in coastal waters. Some juveniles may periodically move between the oceanic zone and coastal waters (Witzell 2002, Bolten 2003, Morreale and Standora 2005, McClellan and Read 2007, Mansfield 2006, Eckert *et al*. 2008, Conant et al. 2009). Coastal waters provide important foraging, inter-nesting, and migratory habitats for adult loggerheads.

In both the oceanic zone and coastal waters, loggerheads are primarily carnivorous, although they do consume some plant matter as well (Conant et al. 2009). Loggerheads have been documented to feed on crustaceans, mollusks, jellyfish and salps, and algae (Bjorndal 1997; Seney and Musick 2007; Donaton et al. 2019).

Avens et al. (2015) used three approaches to estimate age at maturation. Mean age predictions associated with minimum and mean maturation straight carapace lengths were 22.5-25 and 36-38 years for females and 26-28 and 37-42 years for males. Male and female sea turtles have similar post-maturation longevity, ranging from 4 to 46 (mean 19) years (Avens et al. 2015).

Loggerhead hatchlings from the western Atlantic disperse widely, most likely using the Gulf Stream to drift throughout the Atlantic Ocean. MtDNA evidence demonstrates that juvenile loggerheads from southern Florida nesting beaches comprise the vast majority (71%-88%) of individuals found in foraging grounds throughout the western and eastern Atlantic: Nicaragua, Panama, Azores and Madeira, Canary Islands and Andalusia, Gulf of Mexico, and Brazil (Masuda 2010). LaCasalla et al. (2013) found that loggerheads, primarily juveniles, caught within the Northeast Distant (NED) waters of the North Atlantic mostly originated from nesting populations in the southeast United States and, in particular, Florida. They found that nearly all loggerheads caught in the NED came from the Northwest Atlantic DPS (mean = 99.2%), primarily from the large eastern Florida rookeries. There was little evidence of contributions from the South Atlantic, Northeast Atlantic, or Mediterranean DPSs ((LaCasella *et al.* 2013)).

More recently, Stewart et al. (2019) assessed sea turtles captured in fisheries in the Northwest Atlantic. The analysis included samples from 850 (including 24 turtles caught during fisheries research) turtles caught from 2000-2013 in coastal and oceanic habitats. The turtles were primarily captured in pelagic longline and bottom otter trawls. Other gears included bottom longline, hook and line, gillnet, dredge, and dip net. Turtles were identified from 19 distinct management units; the western Atlantic nesting populations were the main contributors with little representation from the Northeast Atlantic, Mediterranean, or South Atlantic DPSs ((Stewart *et al.* 2019)). There was a significant split in the distribution of small (≤63 cm SCL) and large (>63 cm SCL) loggerheads north and south of Cape Hatteras, North Carolina. North of Cape Hatteras, large turtles came mainly from southeast Florida (44%±15%) and the northern United States management units (33%±16%); small turtles came from central east Florida (64%±14%). South of Cape Hatteras, large turtles came mainly from central east Florida (52%±20%) and southeast Florida (41%±20%); small turtles came from southeast Florida (56%±25%). The authors concluded that bycatch in the western North Atlantic would affect the Northwest Atlantic DPS almost exclusively ((Stewart *et al.* 2019)).

Population Dynamics

A number of stock assessments and similar reviews (NMFS 2001; Heppell et al. 2003b; TEWG 1998, 2000, 2009; NMFS and U.S. FWS 2008e; Conant et al. 2009; NMFS 2009a; Richards et al. 2011) have examined the stock status of loggerheads in the Atlantic Ocean, but none have been able to develop a reliable estimate of absolute population size. As with other species, counts of nests and nesting females are commonly used as an index of abundance and population trends, even though there are doubts about the ability to estimate the overall population size.

Adult nesting females often account for less than 1% of total population numbers (Bjorndal *et al.* 2005).

Based on genetic analysis of nesting subpopulations, the Northwest Atlantic Ocean DPS is divided into five recovery units: Northern, Peninsular Florida, Dry Tortugas, Northern Gulf of Mexico, and Greater Caribbean (Conant *et al.* 2009). A more recent analysis using expanded mtDNA sequences revealed that rookeries from the Gulf and Atlantic coasts of Florida are genetically distinct (Shamblin *et al.* 2014). The recent genetic analyses suggest that the Northwest Atlantic Ocean DPS should be considered as ten management units: (1) South Carolina and Georgia, (2) central eastern Florida, (3) southeastern Florida, (4) Cay Sal, Bahamas, (5) Dry Tortugas, Florida, (6) southwestern Cuba, (7) Quintana Roo, Mexico, (8) southwestern Florida, (9) central western Florida, and (10) northwestern Florida (Shamblin *et al.* 2012).

The Northwest Atlantic Ocean's loggerhead nesting aggregation is considered the largest in the world (Casale and Tucker 2017). Using data from 2004-2008, the adult female population size of the DPS was estimated at 20,000 to 40,000 females (NMFS 2009). More recently, Ceriani and Meylan (2017) reported a 5-year average (2009-2013) of more than 83,717 nests per year in the southeast United States and Mexico (excluding Cancun (Quintana Roo, Mexico)). These estimates included sites without long-term (≥10 years) datasets. When they used data from 86 index sites (representing 63.4% of the estimated nests for the whole DPS with long-term datasets, they reported 53,043 nests per year. Trends at the different index nesting beaches ranged from negative to positive. In a trend analysis of the 86 index sites, the overall trend for the Northwest Atlantic DPS was positive (+2%) (Ceriani and Meylan 2017). Uncertainties in this analysis include, among others, using nesting females as proxies for overall population abundance and trends, demographic parameters, monitoring methodologies, and evaluation methods involving simple comparisons of early and later 5-year average annual nest counts. However, the authors concluded that the subpopulation is well monitored and the data evaluated represents 63.4 % of the total estimated annual nests of the subpopulation and, therefore, are representative of the overall trend (Ceriani and Meylan 2017).

About 80% of loggerhead nesting in the southeast United States occurs in six Florida counties (NMFS and U.S. FWS 2008). The Peninsula Florida Recovery Unit and the Northern Recovery Unit represent approximately 87% and 10%, respectively of all nesting effort in the Northwest Atlantic DPS (NMFS and U.S. FWS 2008; Ceriani and Meylan 2017). As described above, FWRI's INBS collects standardized nesting data. The index nest counts for loggerheads represent approximately 53% of known nesting in Florida. There have been three distinct intervals observed: increasing (1989-1998), decreasing (1998-2007), and increasing (2007-2019). At core index beaches in Florida, nesting totaled a minimum of 28,876 nests in 2007 and a maximum of 65,807 nests in 2016 (https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/). In 2019, more than 53,000 nests were documented. The nest counts in Figure 10 represent peninsular Florida and do not include an additional set of beaches in the Florida Panhandle and southwest coast that were added to the program in 1997 and more recent years. Nest counts at these Florida Panhandle index beaches have an upward trend since 2010.

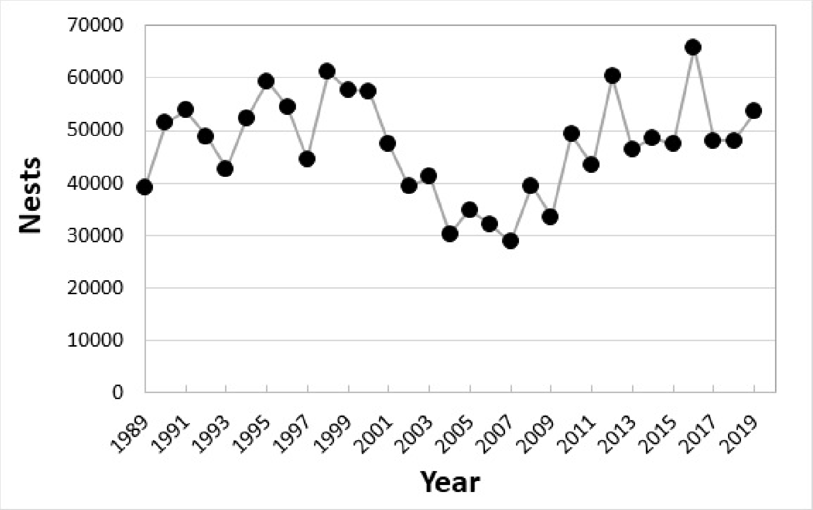


Figure 10: Annual nest counts for loggerhead sea turtles on Florida core index beaches in peninsular Florida, 1989-2019 Source: https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/.

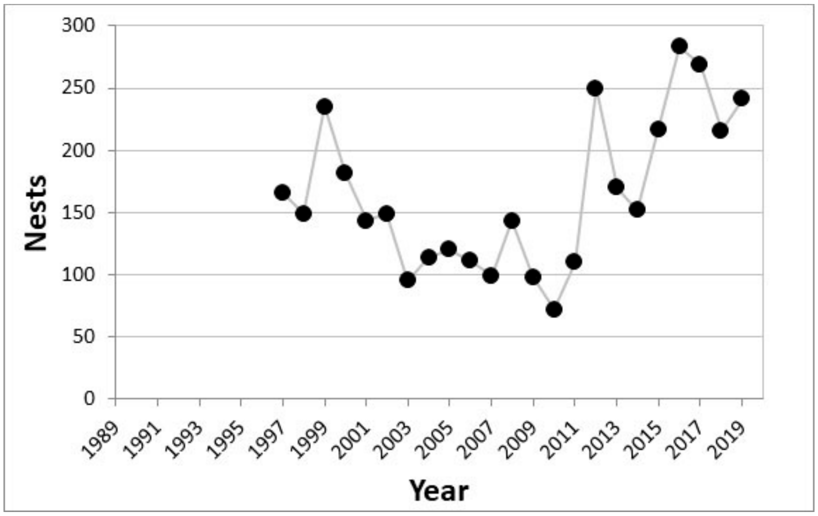


Figure 11: Annual nest counts on index beaches in the Florida Panhandle, 1997-2019. Source: https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/.

The annual nest counts on Florida's index beaches fluctuate widely, and we do not fully understand what drives these fluctuations. In assessing the population, Ceriani and Meylan (2017) and Bolten et al. (2019) looked at trends by recovery unit. Trends by recovery unit were variable.

The Peninsular Florida Recovery Unit extends from the Georgia-Florida border south and then north (excluding the islands west of Key West, Florida) through Pinellas County on the west coast of Florida. Annual nest counts from 1989 to 2018 ranged from a low of 28,876 in 2007 to a high of 65,807 in 1998 (Bolten et al. 2019). More recently (2008-2018), counts have ranged from 33,532 in 2009 to 65,807 in 2016 (Bolten et al. 2019). Nest counts taken at index beaches in Peninsular Florida showed a significant decline in loggerhead nesting from 1989 to 2007, most likely attributed to mortality of oceanic-stage loggerheads caused by fisheries bycatch (Witherington *et al.* 2009). Trend analyses have been completed for various periods. From 2009 through 2013, a 2% decrease for this recovery unit was reported (Ceriani and Meylan 2017). Using a longer time series from 1989-2018, there was no significant change in the number of annual nests (Bolten et al. 2019). It is important to recognize that an increase in the number of nests has been observed since 2007. The recovery team cautions that using short term trends in nesting abundance can be misleading and trends should be considered in the context of one generation (50 years for loggerheads) (Bolten et al. 2009).

The Northern Recovery Unit, ranging from the Florida-Georgia border through southern Virginia, is the second largest nesting aggregation in the DPS. Annual nest totals for this recovery unit from 1983 to 2019 have ranged from a low of 520 in 2004 to a high of 5,555 in 2019 (Bolten et al. 2019). More recently (2008-2019), counts have ranged from 1,289 nests in 2014 to 5,555 nests in 2019 (Bolten et al. 2019). Nest counts at loggerhead nesting beaches in North Carolina, South Carolina, and Georgia declined at 1.9% annually from 1983 to 2005 (NMFS and U.S. FWS 2007a). Recently, the trend has been increasing. Ceriani and Meylan (2017) reported a 35% increase for this recovery unit from 2009 through 2013. A longer-term trend analysis based on data from 1983 to 2019 indicates that the annual rate of increase is 1.3% (Bolten et al. 2019).

The Dry Tortugas Recovery Unit includes all islands west of Key West, Florida. A census on Key West from 1995 to 2004 (excluding 2002) estimated a mean of 246 nests per year, or about 60 nesting females (NMFS and U.S. FWS 2007a). No trend analysis is available because there was not an adequate time series to evaluate the Dry Tortugas recovery unit (Ceriani and Meyland 2017; Bolten et al. 2019), which accounts for less than 1% of the Northwest Atlantic DPS (Ceriani and Meyland 2017).

The Northern Gulf of Mexico Recovery Unit is defined as loggerheads originating from beaches in Franklin County on the northwest Gulf coast of Florida through Texas. From 1995 to 2007, there were an average of 906 nests per year on approximately 300 km of beach in Alabama and Florida, which equates to about 221 females nesting per year (NMFS and U.S. FWS 2008. Annual nest totals for this recovery unit from 1997-2018 have ranged from a low of 72 in 2010 to a high of 283 in 2016 (Bolten et al. 2019). Evaluation of long-term nesting trends for the Northern Gulf of Mexico Recovery Unit is difficult because of changed and expanded beach coverage. However, there are now over 20 years of Florida index nesting beach survey data. A number of trend analyses have been conducted. From 1995 to 2005, the recovery unit exhibited a significant declining trend (NMFS and U.S. FWS 2007a; Conant et al. 2009). Nest numbers have increased in recent years (Bolten et al. 2019; https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/). In the 2009-2013 trend analysis by Ceriani and Meylan (2017), a 1% decrease for this recovery unit was reported, likely due to diminished nesting on beaches in Alabama, Mississippi, Louisiana, and Texas. A longer-term analysis from 1997-2018 found that there has been a non-significant increase of 1.7% (Bolten 2019).

The Greater Caribbean Recovery Unit encompasses nesting subpopulations in Mexico to French Guiana, the Bahamas, and the Lesser and Greater Antilles. The majority of nesting for this recovery unit occurs on the Yucatán Peninsula, in Quintana Roo, Mexico, with 903 to 2,331 nests annually (Zurita et al. 2003). Other significant nesting sites are found throughout the Caribbean, including Cuba, with approximately 250 to 300 nests annually (Ehrhart *et al.* 2003), and over 100 nests annually in Cay Sal in the Bahamas (NMFS and U.S. FWS 2008). In the trend analysis by Ceriani and Meylan (2017), a 53% increase for this Recovery Unit was reported from 2009 through 2013.

Status

Fisheries bycatch is the highest threat to the Northwest Atlantic DPS of loggerhead sea turtles (Conant et al. 2009). Other threats include boat strikes, marine debris, coastal development, habitat loss, contaminants, disease, and climate change. Nesting trends for each of the loggerhead sea turtle recovery units in the Northwest Atlantic Ocean DPS are variable. Overall, short-term trends have shown increases, however, over the long-term the DPS is considered stable.

Recovery Goals

The recovery goal for the Northwest Atlantic loggerhead is to ensure that each recovery unit meets its recovery criteria alleviating threats to the species so that protection under the ESA is not needed. The recovery criteria relate to the number of nests and nesting females, trends in abundance on the foraging grounds, and trends in neritic strandings relative to in-water abundance. The 2008 Final Recovery Plan for the Northwest Atlantic Population of Loggerheads includes the complete downlisting/delisting criteria (NMFS and U.S. FWS 2008). The recovery objectives to meet these goals include:

1. Ensure that the number of nests in each recovery unit is increasing and that this increase corresponds to an increase in the number of nesting females.
2. Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes.
3. Manage sufficient nesting beach habitat to ensure successful nesting.
4. Manage sufficient feeding, migratory and internesting marine habitats to ensure successful growth and reproduction.
5. Eliminate legal harvest.
6. Implement scientifically based nest management plans.
7. Minimize nest predation.
8. Recognize and respond to mass/unusual mortality or disease events appropriately.
9. Develop and implement local, state, federal and international legislation to ensure long-term protection of loggerheads and their terrestrial and marine habitats.
10. Minimize bycatch in domestic and international commercial and artisanal fisheries.
11. Minimize trophic changes from fishery harvest and habitat alteration.
12. Minimize marine debris ingestion and entanglement.
13. Minimize vessel strike mortality.

No Five-Year review has been completed for the Northwest Atlantic DPS of loggerhead sea turtles that post-dates the 2008 recovery plan.

5.2.2 Leatherback Sea Turtle

The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to subpolar latitudes, worldwide (Figure 12).

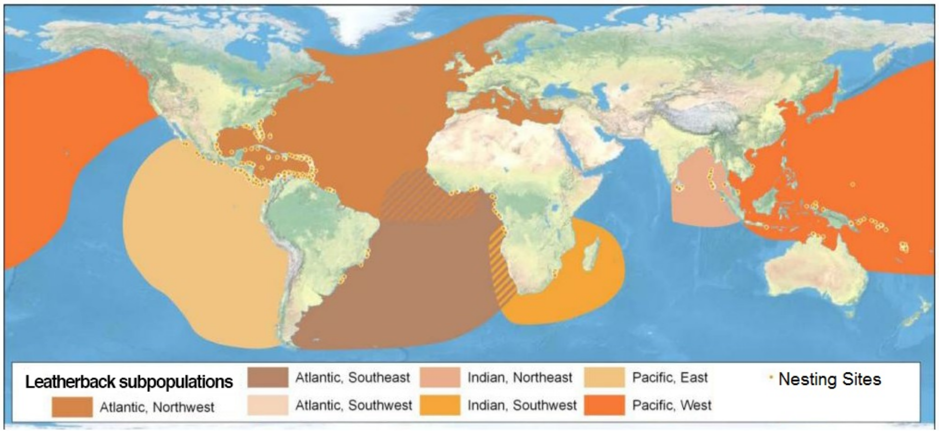


Figure 12. Map identifying the range of the endangered leatherback sea turtle. From NMFS http://www.nmfs.noaa.gov/pr/species/turtles/leatherback.html, adapted from Wallace *et al*. (2010).

Leatherbacks are the largest living turtle, reaching lengths of six feet long, and weighing up to one ton. Leatherback sea turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly. The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973.
We used information available in the five-year review (NMFS and U.S. FWS 2013b), the critical habitat designation (44 FR 17710), relevant literature, and recent nesting data from the Florida FWRI to summarize the life history, population dynamics and status of the species, as follows.

Life History

Leatherbacks are a long-lived species that delay age of maturity, have low and variable survival in the egg and juvenile stages, and have relatively high and constant annual survival in the subadult and adult life stages (Chaloupka 2002; Crouse 1999; Heppell et al. 1999; Heppell et al. 2003a; Spotila et al. 1996; Spotila et al. 2000). Age at maturity has been difficult to ascertain, with estimates ranging from five to twenty-nine years (Spotila et al. 1996; Avens et al. 2009). Females lay up to seven clutches per season, with more than sixty-five eggs per clutch (Reina et al. 2002; Wallace et al. 2007). The number of leatherback hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately 50% worldwide (Eckert et al. 2012). Females nest every one to seven years.

Leatherbacks have a greater tolerance for colder waters compared to all other sea turtle species due to their thermoregulatory capabilities (Shoop and Kenney 1992). Evidence from tag returns and strandings in the western Atlantic suggests that adult leatherback sea turtles engage in routine migrations between temperate/boreal and tropical waters (NMFS and U.S. FWS 1992).

Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback sea turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherbacks must consume large quantities to support their body weight. Leatherbacks weigh about 33% more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005; Wallace et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2006).

Population Dynamics

The distribution is global, with nesting beaches in the Pacific, Atlantic, and Indian oceans. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson *et al*. 2011).

Detailed population structure is unknown, but is likely dependent upon nesting beach location. Based on estimates calculated from nest count data, there are between 34,000 and 94,000 adult leatherbacks in the North Atlantic (TEWG 2007). In contrast, leatherback populations in the Pacific are much lower. Overall, Pacific populations have declined from an estimated 81,000 individuals to less than 3,000 total adults and subadults (Spotila *et al*. 2000). Population abundance in the Indian Ocean is difficult to assess due to lack of data and inconsistent reporting. Available data from southern Mozambique show that approximately ten females nest per year from 1994 to 2004, and about 296 nests per year counted in South Africa (NMFS and U.S. FWS 2013b).

Population growth rates for leatherback sea turtles vary by ocean basin. Counts of leatherbacks at nesting beaches in the western Pacific indicate that the subpopulation has been declining at a rate of almost 6% per year since 1984 (Tapilatu *et al*. 2013). Leatherback nesting in the Northwest Atlantic is also showing an overall negative trend, with the most notable decrease occurring during the most recent period of 2008-2017 (Northwest Atlantic Leatherback Working Group 2018). From 1989-2018, leatherback nests at core index beaches in Florida have varied from a minimum of 30 nests in 1990 to a maximum of 657 in 2014. Since 2014, leatherback nest numbers on Florida beaches have been declining (Figure 13).

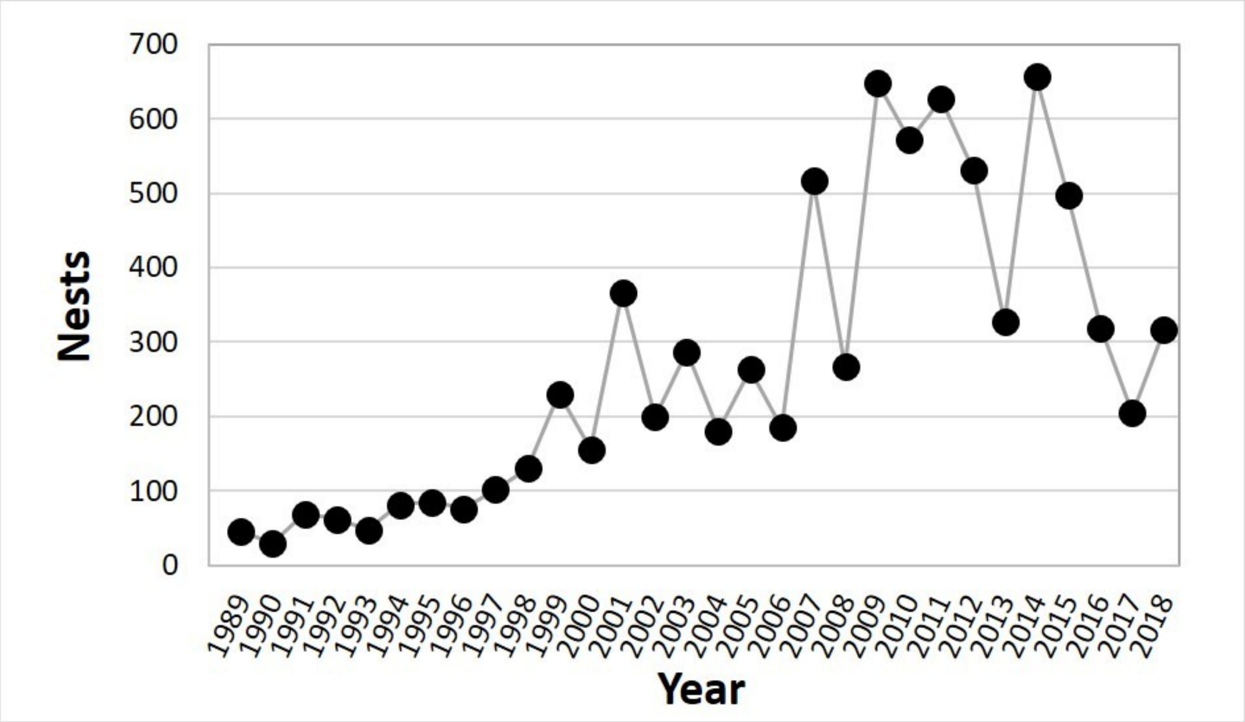


Figure 13. Number of leatherback sea turtle nests counted on core index beaches in Florida from 1989-2018. Source: https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/.

Analyses of mitochondrial DNA from leatherback sea turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton *et al*. 1999). Further analysis of samples taken from individuals from rookeries in the Atlantic and Indian oceans suggest that each of the rookeries represent demographically independent populations (NMFS and U.S. FWS 2013b).

Status

The leatherback sea turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. Leatherback turtle nesting in the Northwest Atlantic is showing an overall negative trend, with the most notable decrease occurring during the most recent time frame of 2008 to 2017 (NW Atlantic Leatherback Working Group 2018). The primary threats to leatherback sea turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea. Plastic ingestion is common in leatherbacks and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise. The species' resilience to additional perturbation both within the action area and worldwide is low.

Recovery Goals

The 1998 Recovery Plan for the U.S. Pacific population of leatherback sea turtles and the 1991 Recovery Plan for the U.S. Caribbean, Gulf of Mexico, and Atlantic populations of leatherback sea turtles share the goal of delisting (NMFS and USFWS 1998, NMFS and USFWS 1991). Both plans contain downlisting and delisting criteria. The recovery objectives for the Atlantic plan are related to increases in adult female abundance, protection of nesting habitat, and implementation of priority tasks.

The 2013 Five-Year Review (NMFS and USFWS 2013) concluded that the leatherback turtle should not be delisted or reclassified and notes that the 1991 and 1998 recovery plans are dated and do not address the major, emerging threat of climate change.

5.2.3 Green Sea Turtle

The green sea turtle has a circumglobal distribution, occurring throughout tropical, subtropical and, to a lesser extent, temperate waters. They commonly inhabit nearshore and inshore waters. It is the largest of the hardshell marine turtles, growing to a weight of approximately 350 pounds (159 kilograms) and a straight carapace length of greater than 3.3 feet (one meter). The species was listed under the ESA on July 28, 1978 (43 FR 32800) as endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed 11 DPSs of green sea turtles as threatened or endangered under the ESA (81 FR 20057). The North Atlantic DPS of green turtle is found in the North Atlantic Ocean and Gulf of Mexico (Figure 14) and is listed as threatened. Green turtles from the North Atlantic DPS range from the boundary of South and Central America (7.5°N, 77°W) in the south, throughout the Caribbean, the Gulf of Mexico, and the U.S. Atlantic coast to New Brunswick, Canada (48°N, 77°W) in the north. The range of the DPS then extends due east along latitudes 48°N and 19°N to the western coasts of Europe and Africa.

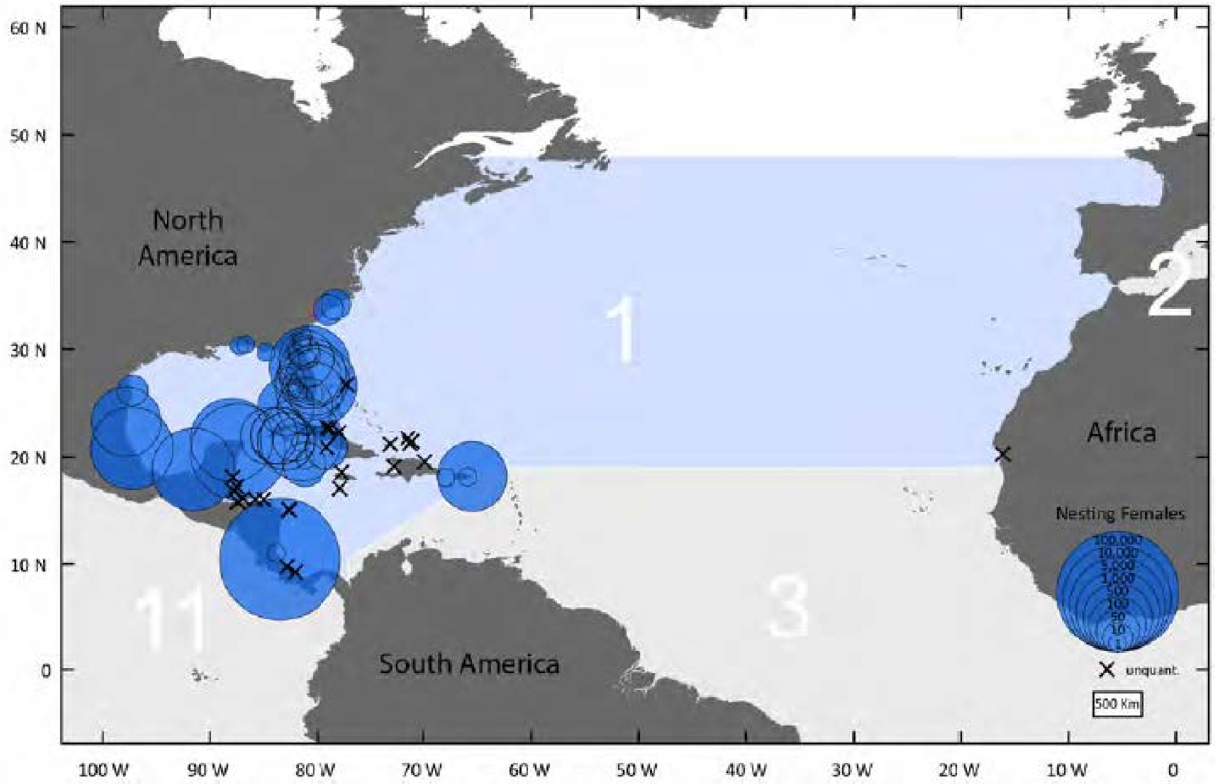


Figure 14: Geographic range of the North Atlantic distinct population segment green turtle (1), with location and abundance of nesting females. From Seminoff et al. (2015).

We used information available in the 2015 Status Review (Seminoff *et al.* 2015a), relevant literature, and recent nesting data from the Florida FWRI to summarize the life history, population dynamics and status of the species, as follows.

Life history

Costa Rica (Tortuguero), Mexico (Campeche, Yucatan, Quintana Roo), United States (Florida) and Cuba (Figure 14) support nesting concentrations of particular interest in the North Atlantic DPS ((Seminoff *et al.* 2015b)). In the southeastern United States, females generally nest between May and September (Seminoff *et al.* 2015b, Witherington *et al.* 2006). Green sea turtles lay an average of three nests per season with an average of one hundred eggs per nest ((Hirth 1997, Seminoff *et al.* 2015b)). The remigration interval (period between nesting seasons) is two to five years ((Hirth 1997); (Seminoff *et al.* 2015b)). Nesting occurs primarily on beaches with intact dune structure, native vegetation, and appropriate incubation temperatures during the summer months.

Sea turtles are long-lived animals. Size and age at sexual maturity have been estimated using several methods, including mark-recapture, skeletochronology, and marked, known-aged individuals. Skeletochronology analyzes growth marks in bones to obtain growth rates and age at sexual maturity (ASM) estimates. Estimates vary widely among studies and populations, and methods continue to be developed and refined (Avens and Snover, 2013). Early mark-recapture studies in Florida estimated the age at sexual maturity 18-30 years (Mendonça 1981; Frazer and

Ehrhart, 1985, Ehrhardt and Witham 1992). More recent estimates of age at sexual maturity are as high as 35–50 years (Goshe 2010; Avens and Snover 2013), with lower ranges reported from known age turtles from the Cayman Islands (15–19 years; Bell et al., 2005) and Caribbean Mexico (12–20 years; Zurita et al., 2012). A study of green turtles that use waters of the southeastern United States as developmental habitat found the age at sexual maturity likely ranges from 30 to 44 years (Goshe et al. 2010). Green turtles in the Northwestern Atlantic mature at 85–100+ cm straight carapace lengths (SCL) (Avens and Snover, 2013).

Adult turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green sea turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat other invertebrate prey ((Seminoff *et al.* 2015b).

Population dynamics

Compared to other DPSs, the North Atlantic DPS exhibits the highest nester abundance, with approximately 167,424 females at seventy-three nesting sites (using data through 2012), and available data indicated an increasing trend in nesting ((Seminoff *et al.* 2015b)). Counts of nests and nesting females are commonly used as an index of abundance and population trends, even though there are doubts about the ability to estimate the overall population size. Nesting occurs primarily in Costa Rica, Mexico, Florida, and Cuba. The largest nesting site in the North Atlantic DPS is in Tortuguero, Costa Rica, which hosts 79% of nesting females for the DPS (Seminoff *et al.* 2015a, Seminoff *et al.* 2015b).

The North Atlantic DPS has a globally unique haplotype, which was a factor in defining the discreteness of the DPS. Evidence from mitochondrial DNA studies indicates that there are at least four independent nesting subpopulations in Florida, Cuba, Mexico and Costa Rica ((Seminoff *et al.* 2015b)). More recent genetic analysis indicates that designating a new western Gulf of Mexico management unit might be appropriate (Shamblin *et al.* 2016).

There are no reliable estimates of population growth rate for the DPS as a whole, but estimates have been developed at a localized level. The status review for green sea turtles assessed population trends for seven nesting sites with more 10 years of data collection in the North Atlantic DPS. The results were variable with some sites showing no trend and others increasing. However, all major nesting populations (using data through 2011-2012) demonstrated increases in abundance ((Seminoff *et al.* 2015b)).

More recent data is available for the southeastern United States. The FWRI monitors sea turtle nesting through the Statewide Nesting Beach Survey and Index Nesting Beach Survey (INBS). Since 1979, the SNBS had surveyed approximately 215 beaches to collect information on the distribution, seasonality, and abundance of sea turtle nesting in Florida. Since 1989, the INBS has been conducted on a subset of SNBS beaches to monitor trends through consistent effort and specialized training of surveyors. The INBS data uses a standardized data-collection protocol to allow for comparisons between years and is presented for green, loggerhead, and leatherback sea turtles. The index counts represent 27 core index beaches. The index nest counts represent approximately 67% of known green turtle nesting in Florida (https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/).

Nest counts at Florida's core index beaches have ranged from less than 300 to almost 41,000 in 2019. The nest numbers show a mostly biennial pattern of fluctuation (https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/).

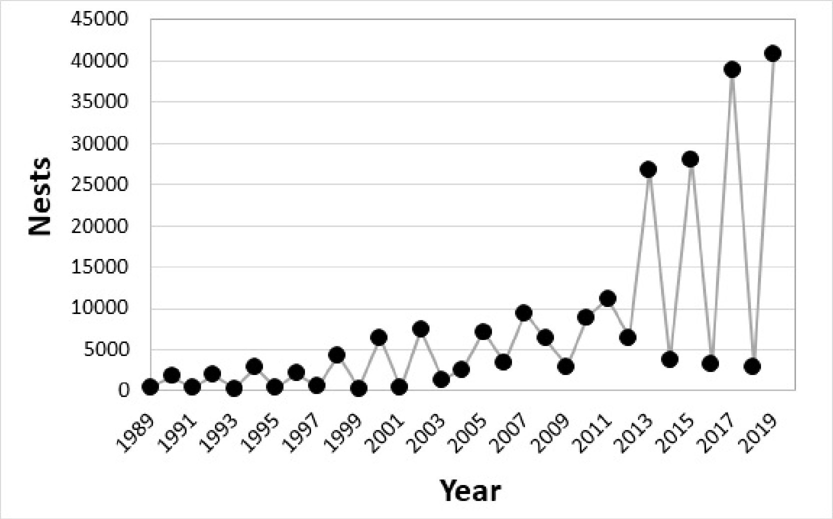


Figure 15: Number of green sea turtle nests counted on core index beaches in Florida from 1989-2019. Source: https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/.

Status

Historically, green sea turtles in the North Atlantic DPS were hunted for food, which was the principle cause of the population's decline. Apparent increases in nester abundance for the North Atlantic DPS in recent years are encouraging but must be viewed cautiously, as the datasets represent a fraction of a green sea turtle generation which is between 30 and 40 years ((Seminoff *et al.* 2015b)). While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue, the North Atlantic DPS appears to be somewhat resilient to future perturbations.

Recovery Goals

No recovery plan for green sea turtles has been issued since the DPSs were listed in 2016. The goal of the 1991 Recovery Plan for the U.S. population of green sea turtles is delist the species once the recovery criteria are met (NMFS and U.S.FWS 1991). The recovery plan includes criteria for delisting related to nesting activity, nesting habitat protection, and reduction in mortality.

Priority actions to meet the recovery goals include:

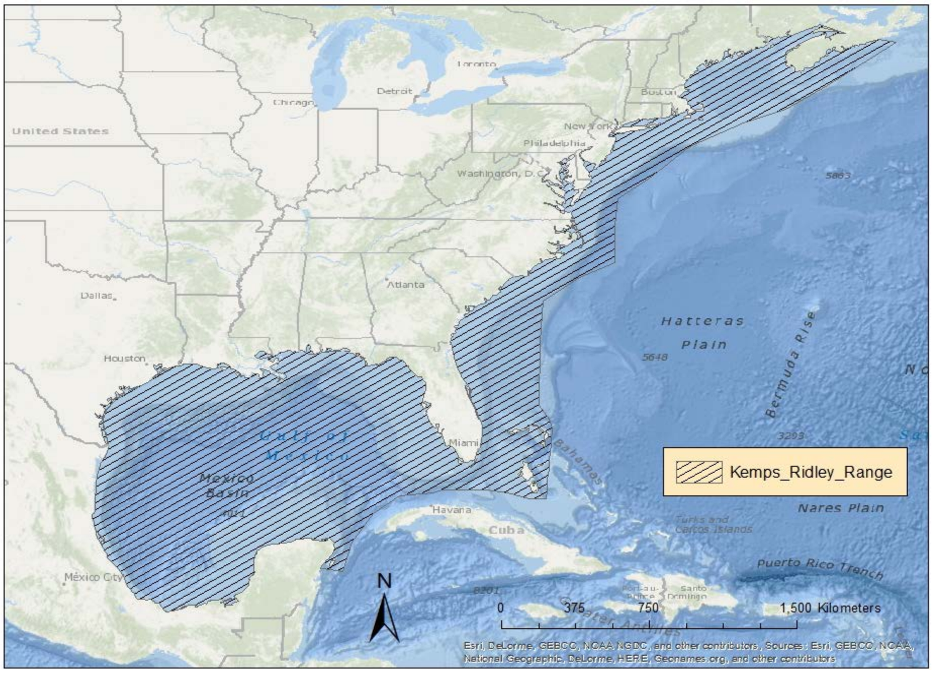
1. Providing long-term protection to important nesting beaches.
2. Ensuring at least a 60% hatch rate success on major nesting beaches.
3. Implementing effective lighting ordinances/plans on nesting beaches.

4. Determining distribution and seasonal movements of all life stages in the marine environment.
5. Minimizing commercial fishing mortality.
6. Reducing threat to the population and foraging habitat from marine pollution.

No Five-Year review has been conducted since the 2016 listing.

5.2.4 Kemp's Ridley Sea Turtle

The range of Kemp's ridley sea turtles extends from the Gulf of Mexico to the Atlantic coast (Figure 16). They have occasionally been found in the Mediterranean Sea, which may be due to migration expansion or increased hatchling production (Tomas and Raga 2008). They are the smallest of all sea turtle species, with a nearly circular top shell and a pale yellowish bottom shell. The species was first listed under the Endangered Species Conservation Act (35 FR 18319, December 2, 1970) in 1970 and has been listed as endangered under the ESA since 1973.



Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors, Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

Figure 16: Range of the endangered Kemp's ridley sea turtle.

We used information available in the revised recovery plan (NMFS 2011), the Five-Year Review (NMFS 2015), and published literature to summarize the life history, population dynamics and status of the species, as follows.

Life History

Kemp's ridley nesting is essentially limited to the western Gulf of Mexico. Approximately 97% of the global population's nesting activity occurs on a 146-km stretch of beach that includes Rancho Nuevo in Mexico ((Wibbels and Bevan 2019)). In the United States, nesting occurs primarily in Texas and occasionally in Florida, Alabama, Georgia, South Carolina, and North Carolina (NMFS and U.S FWS 2015) Nesting occurs from April to July in large arribadas (synchronized large-scale nesting). The average remigration interval is two years, although intervals of 1 and 3 years are not uncommon (TEWG 1998, 2000, NMFS and U.S. FWS 2011). Females lay an average of 2.5 clutches per season (NMFS and U.S. FWS 2011). The annual average clutch size is 95 to 112 eggs per nest ((NMFS 2015)). The nesting location may be particularly important because hatchlings can more easily migrate to foraging grounds in deeper oceanic waters, where they remain for approximately two years before returning to nearshore coastal habitats (Epperly et al. 2013; Snover et al. 2007; NMFS and U.S. FWS 2015). Modeling indicates that oceanic-stage Kemp's ridley turtles are likely distributed throughout the Gulf of Mexico into the northwestern Atlantic (Putnum et al. 2013). Kemp's ridley nearing the age when recruitment to nearshore waters occurs are more likely to be distributed in the northern Gulf of Mexico, eastern Gulf of Mexico, and the western Atlantic (Putnum et al. 2013).

Several studies, including those of captive turtles, recaptured turtles of known age, mark-recapture data, and skeletochronology, have estimated the average age at sexual maturity for Kemp's ridleys between 5 to 12 years (captive only, Bjorndal et al. 2014), 10 to 16 years (Chaloupka and Zug 1997; Schmid and Witzell 1997; Zug et al.1997; Schmid and Woodhead, 2000), 9.9 to 16.7 years (Snover et al.2007), 10 and 18 years (Shaver and Wibbels 2007), 6.8 to 21.8 years (mean 12.9 years) (Avens et al. 2017).

During spring and summer, juvenile Kemp's ridleys generally occur in the shallow coastal waters of the northern Gulf of Mexico from south Texas to north Florida and along the U.S. Atlantic coast from southern Florida to the Mid-Atlantic and New England. In addition, the NEFSC caught a juvenile Kemp's ridley during a recent research project in deep water south of Georges Bank (NEFSC, unpublished data). In the fall, most Kemp's ridleys migrate to deeper or more southern, warmer waters and remain there through the winter (Schmid 1998). As adults, many turtles remain in the Gulf of Mexico, with only occasional occurrence in the Atlantic Ocean (NMFS *et al.* 2010). Adult habitat largely consists of sandy and muddy areas in shallow, nearshore waters less than 120 feet (37 meters) deep (Seney and Landry 2008; Shaver et al. 2005; Shaver and Rubio 2008), although they can also be found in deeper offshore waters. As larger juveniles and adults, Kemp's ridleys forage on swimming crabs, fish, jellyfish, mollusks, and tunicates (NMFS 2011).

Population Dynamics

Of the sea turtles species in the world, the Kemp's ridley has declined to the lowest population level. Nesting aggregations at a single location (Rancho Nuevo, Mexico) were estimated at 40,000 females in 1947. By the mid-1980s, the population had declined to an estimated 300 nesting females. From 1980 to 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased at 15% annually (Heppell *et al.* 2005). However, due to recent declines in nest counts, decreased survival of immature and adult sea turtles, and updated population modeling, this rate is not expected to continue and the overall trend is unclear (NMFS and U.S. FWS 2015; Caillouett et al. 2018). In 2019, there were 11,090 nests, a 37.61% decrease from 2018 and a 54.89% decrease from 2017, which had the highest number (24,587) of nests (Figure 17; unpublished data). The reason for this recent decline is uncertain.

Using the standard IUCN protocol for sea turtle assessments, the number of mature individuals was recently estimated at 22,341 ((Wibbels and Bevan 2019)). The calculation took into account the average annual nests from 2016-2018 (21,156), a clutch frequency of 2.5 per year, a remigration interval of 2 years, and a sex ratio of 3.17 females:1 male. Based on the data in their analysis, the assessment concluded the current population trend is unknown ((Wibbels and Bevan 2019)).

Genetic variability in Kemp's ridley turtles is considered to be high, as measured by nuclear DNA analyses (i.e., microsatellites) (NMFS 2011). If this holds true than rapid increases in population over one or two generations would likely prevent any negative consequences in the genetic variability of the species (NMFS and U.S. FWS 2011). Additional analysis of the mtDNA taken from samples of Kemp's ridley turtles at Padre Island, Texas, showed six distinct haplotypes, with one found at both Padre Island and Rancho Nuevo (Dutton *et al.* 2006).

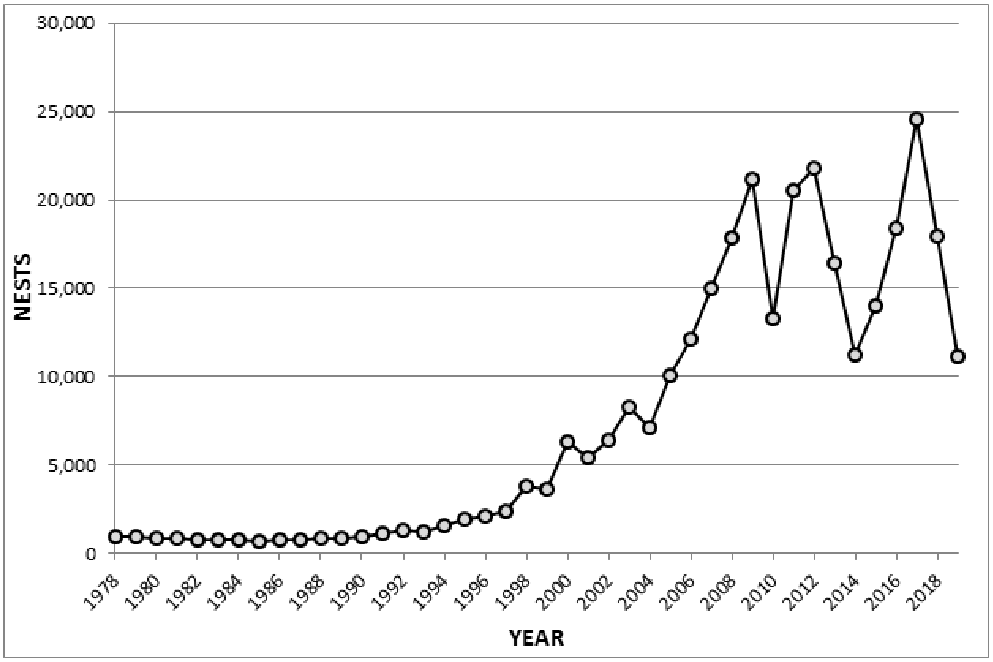


Figure 17: Kemp's ridley nest totals from Mexican beaches (Gladys Porter Zoo nesting database 2019).

Status

The Kemp's ridley was listed as endangered in response to a severe population decline, primarily the result of egg collection. In 1973, legal ordinances in Mexico prohibited the harvest of sea turtles from May to August, and in 1990, the harvest of all sea turtles was prohibited by presidential decree. In 2002, Rancho Nuevo was declared a Sanctuary. Nesting beaches in Texas have been re-established. Fishery interactions are the main threat to the species. Other threats include habitat destruction, oil spills, dredging, disease, cold stunning, and climate change. The current population trend is uncertain. While the population has increased, recent nesting numbers have been variable. In addition, the species' limited range and low global abundance make it vulnerable to new sources of mortality as well as demographic and environmental randomness, all of which are often difficult to predict with any certainty. Therefore, its resilience to future perturbation is low.

Recovery Goals

As with other recovery plans, the goal of the 2011 Kemp's ridley recovery plan (NMFS, USFWS, and SEMARNAT 2011) is to conserve and protect the species so that the listing is no longer necessary. The recovery criteria relate to the number of nesting females, hatchling recruitment, habitat protection, social and/or economic initiatives compatible with conservation, reduction of predation, TED or other protective measures in trawl gear, and improved information available to ensure recovery. In 2015, the bi-national recovery team published a number of recommendations including four critical actions (NMFS and USFWS 2015). These include: (a) continue funding by the major funding institutions at a level of support needed to run the successful turtle camps in the State of Tamaulipas, Mexico, in order to continue the high level of hatchling production and nesting female protection; (b) increase turtle excluder device (TED) compliance in U.S. and MX shrimp fisheries; 3 (c) require TEDs in U.S. skimmer trawl fisheries and other trawl fisheries in coastal waters where fishing overlaps with the distribution of Kemp's ridleys; (d) assess bycatch in gillnets in the Northern Gulf of Mexico and State of Tamaulipas, Mexico, to determine whether modifications to gear or fishing practices are needed.

The most recent Five-Year Review was completed in 2015 (NMFS and USFWS 2015) with a recommendation that the status of Kemp's ridley sea turtles should remain as endangered. In the Plan, the Services recommend that efforts continue towards achieving the major recovery actions in the 2015 plan with a priority for actions to address recent declines in the annual number of nests.

5.3 Atlantic Sturgeon

Atlantic sturgeon are listed as five distinct population segments under the ESA (77 FR 5880 and 77 FR 5914, February 6, 2012). The oceanic range of the five DPSs extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida (ASMFC 2006; Stein et al. 2004) (Figure 18). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King, 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada occur throughout the full range of the species. Therefore, sturgeon originating from any of the five DPSs may occur in the action area. Critical habitat has been designated for each DPS (82 FR 39160, August 17, 2017); however, there is no critical habitat in the action area.

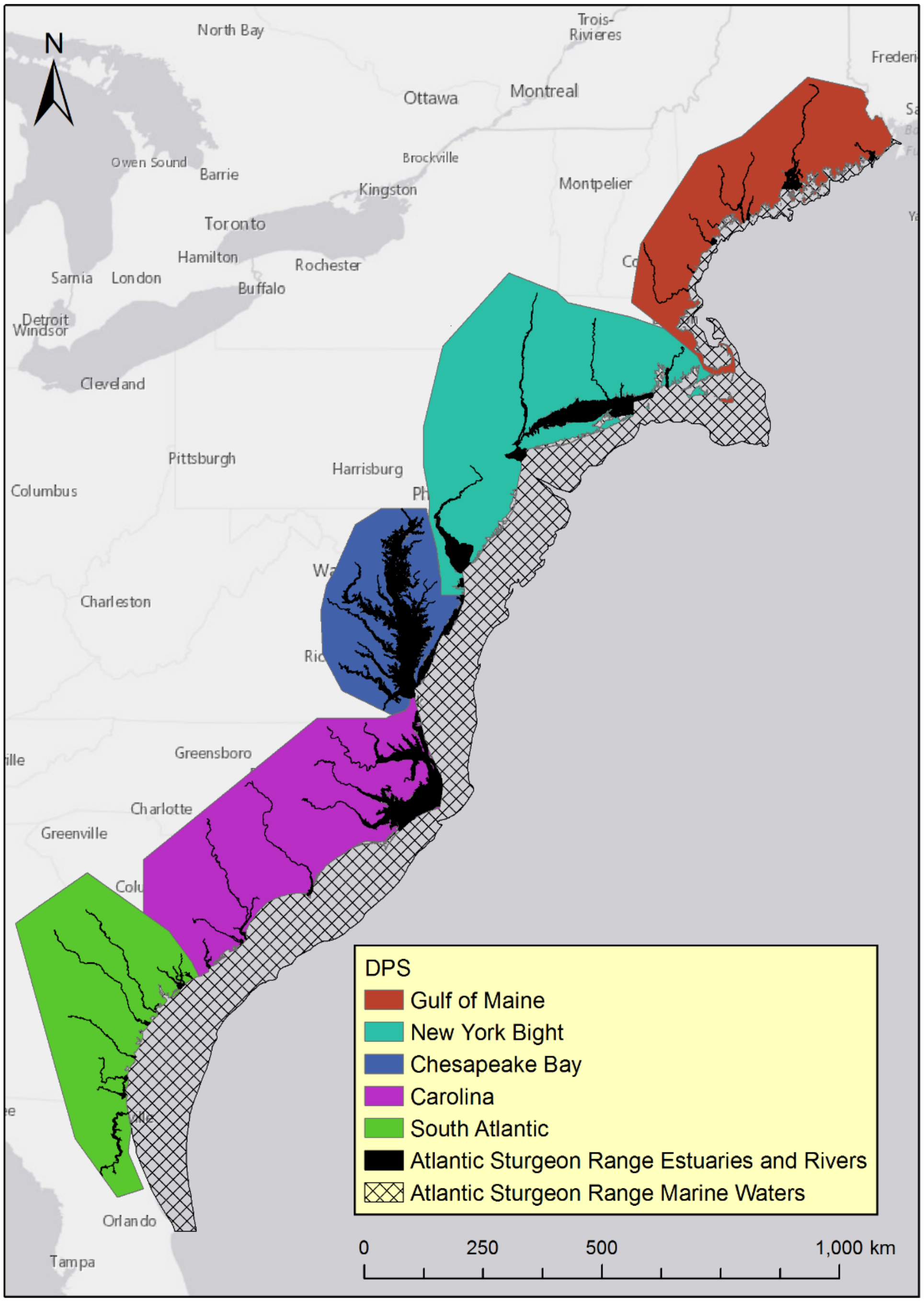


Figure 18. Geographic range for all five Atlantic sturgeon DPSs.

The Atlantic sturgeon is a long-lived, late maturing, anadromous species. Atlantic sturgeon attains lengths of up to approximately 14 feet, and weights of more than 800 pounds. They are bluish black or olive brown dorsally with paler sides and a white ventral surface and have five major rows of dermal scutes (Colette and Klein-MacPhee 2002). Five DPSs were listed under the Endangered Species Act on February 6, 2012. The Gulf of Maine DPS was listed as threatened, and the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs were listed as endangered (Table 5.1).

Table 5.1: Atlantic sturgeon information bar provides species' Latin name, common name, and current Federal Register notice of listing status, designated critical habitat, Distinct Population Segment, recent status review, and recovery plan.

Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Gulf of Maine	Threatened	2007	77 FR 5880	No	82 FR 39160
New York Bight	Endangered	2007	77 FR 5880	No	82 FR 39160
Chesapeake	Endangered	2007	77 FR 5880	No	82 FR 39160
Carolina	Endangered	2007	77 FR 5914	No	82 FR 39160
South Atlantic	Endangered	2007	77 FR 5914	No	82 FR 39160

Atlantic sturgeon were once present in 38 river systems and, of these, spawned in 35 of them. Individuals are currently present in 36 rivers, and spawning occurs in at least 20 of these (ASSRT 2007). The decline in abundance of Atlantic sturgeon has been attributed primarily to the large U.S. commercial fishery, which existed for the Atlantic sturgeon from the 1870s through the mid-1990s. The fishery collapsed in 1901 and landings remained at between one to five percent of the pre-collapse peak until ASMFC placed a two generation moratorium on the fishery in 1998 (ASMFC 1998). The majority of the populations show no signs of recovery, and new information suggests that stressors such as bycatch, ship strikes, and low dissolved oxygen can and do have substantial impacts on populations (ASSRT 2007). Additional threats to Atlantic sturgeon include habitat degradation from dredging, damming, and poor water quality (ASSRT 2007). Climate change related impacts on water quality (e.g., temperature, salinity, dissolved oxygen, contaminants) have the potential to affect Atlantic sturgeon populations using impacted river systems. These effects are expected to be more severe for southern portions of the U.S. range of Atlantic sturgeon (Carolina and South Atlantic DPSs).

Life history

Atlantic sturgeon size at sexual maturity varies with latitude with individuals reaching maturity in the Saint Lawrence River at 22 to 34 years (Scott and Crossman 1973). Atlantic sturgeon spawn in freshwater, but spend most of their adult life in the marine environment. Spawning adults generally migrate upriver in May through July in Canadian systems (Bain 1997; Caron et al. 2002; Murawski and Pacheco 1977; Smith 1985; Smith and Clugston 1997). Atlantic sturgeon spawning is believed to occur in flowing water between the salt front and fall line of large rivers at depths of three to 27 meters (Bain et al. 2000; Borodin 1925; Crance 1987; Leland

1968; Scott and Crossman 1973). Atlantic sturgeon likely do not spawn every year; spawning intervals range from one to five years for males (Caron et al. 2002; Collins et al. 2000; Smith 1985) and two to five years for females (Stevenson and Secor 2000; Van Eenennaam et al. 1996; Vladykov and Greeley 1963).

Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces (Gilbert 1989; Smith and Clugston 1997) between the salt front and fall line of large rivers (Bain et al. 2000; Borodin 1925; Crance 1987; Scott and Crossman 1973). Following spawning in northern rivers, males may remain in the river or lower estuary until the fall; females typically exit the rivers within four to six weeks (Savoy and Pacileo 2003). Hatching occurs approximately 94 to 140 hours after egg deposition at temperatures of 20 and 18 degrees Celsius, respectively (Theodore et al. 1980). The yolk sac larval stage is completed in about eight to 12 days, during which time larvae move downstream to rearing grounds over a six to 12 day period (Kynard and Horgan 2002). Juvenile sturgeon continue to move further downstream into waters ranging from zero to up to ten parts per thousand salinity. Older juveniles are more tolerant of higher salinities as juveniles typically spend two to five years in freshwater before eventually becoming coastal residents as sub-adults (Boreman 1997; Schueller and Peterson 2010; Smith 1985).

Upon reaching the subadult phase, individuals move to coastal and estuarine habitats (Dovel and Berggren 1983; Murawski and Pacheco 1977; Smith 1985; Stevenson 1997). Tagging and genetic data indicate that subadult and adult Atlantic sturgeon travel widely once they emigrate from rivers. Despite extensive mixing in coastal waters, Atlantic sturgeon exhibit high fidelity to their natal rivers (Grunwald et al. 2008; King et al. 2001; Waldman et al. 2002). Because of high natal river fidelity, it appears that most rivers support independent populations (Grunwald et al. 2008; King et al. 2001; Waldman and Wirgin 1998; Wirgin et al. 2002; Wirgin et al. 2000). Atlantic sturgeon feed primarily on polychaetes, isopods, American sand lances and amphipods in the marine environment, while in fresh water they feed on oligochaetes, gammarids, mollusks, insects, and chironomids (Guilbard et al. 2007; Johnson et al. 1997; Moser and Ross 1995; Novak et al. 2017; Savoy 2007).

2017 ASMFC Stock Assessment

The ASMFC released a new benchmark stock assessment for Atlantic sturgeon in October 2017 (ASMFC 2017a). The assessment used both fishery-dependent and fishery-independent data, as well as biological and life history information. Fishery-dependent data came from commercial fisheries that formerly targeted Atlantic sturgeon (before the moratorium), as well as fisheries that catch sturgeon incidentally. Fishery-independent data were collected from scientific research and survey programs.

At the coastwide and DPS levels, the stock assessment concluded that Atlantic sturgeon are depleted relative to historical levels. The low abundance of Atlantic sturgeon is not due solely to effects of historic commercial fishing, so the ‘depleted’ status was used instead of ‘overfished.’ This status reflects the array of variables preventing Atlantic sturgeon recovery (e.g., bycatch, habitat loss, and ship strikes).

As described in the Assessment Overview, Table 5.2 shows "the stock status determination for the coastwide stock and DPSs based on mortality estimates and biomass/abundance status relative to historic levels, and the terminal year (i.e., the last year of available data) of indices relative to the start of the moratorium as determined by the ARIMA[12] analysis."

Table 5.2: Stock status determination for the coastwide stock and DPSs (from the ASMFC's Atlantic Sturgeon Stock Assessment Overview, October 2017)

	Mortality Status	**Biomass/Abundance Status**	
Population	**Probability that $Z > Z_{50\%EPR}$ 80%**	**Relative to Historical Levels**	**Average probability of terminal year of indices > 1998* value**
Coastwide	7%	Depleted	95%
Gulf of Maine	74%	Depleted	51%
New York Bight	31%	Depleted	75%
Chesapeake Bay	30%	Depleted	36%
Carolina	75%	Depleted	67%
South Atlantic	40%	Depleted	Unknown (no suitable indices)

***** For indices that started after 1998, the first year of the index was used as the reference value. EPR= Eggs Per Recruit.

Despite the depleted status, the assessment did include signs that the coastwide index is above the 1998 value (95% chance). The Gulf of Maine, New York Bight, and Carolina DPS indices also all had a greater than 50% chance of being above their 1998 value; however, the index from the Chesapeake Bay DPS (highlighted red) only had a 36% chance of being above the 1998 value. There were no representative indices for the South Atlantic DPS. Total mortality from the tagging model was very low at the coastwide level. Small sample sizes made mortality estimates at the DPS level more difficult. The New York Bight, Chesapeake Bay, and South Atlantic DPSs all had a less than 50% chance of having a mortality rate higher than the threshold. The Gulf of Maine and Carolina DPSs (highlighted red) had 74%-75% probability of being above the mortality threshold (ASMFC 2017a).

As described below, individuals originating from all five listed DPSs may occur in the action area. Information general to all Atlantic sturgeon as well as information specific to each of the relevant DPSs is provided below.

Determination of DPS Composition in the Action Area

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated. The proposed action takes place in the Connecticut River. Until they are subadults, Atlantic sturgeon do not leave their natal river/estuary. Therefore, any early life stages (eggs, larvae), young of year and juvenile Atlantic sturgeon in the Connecticut River, and thereby, in the action area, will have originated from the

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[12] "The ARIMA (Auto-Regressive Integrated Moving Average) model uses fishery-independent indices of abundance to estimate how likely an index value is above or below a reference value" (ASMFC 2017a).

Connecticut River and belong to the NYB DPS. Subadult and adult Atlantic sturgeon can be found throughout the range of the species; therefore, subadult and adult Atlantic sturgeon in the Connecticut River generally, and the action area specifically would not be limited to just individuals originating from the NYB DPS. A mixed stock analysis of 69 Atlantic sturgeon collected in the Connecticut River (in 1991 and 2005-2010) indicates that subadult and adult Atlantic sturgeon in the action area likely originate from four of the five DPSs at the following frequencies: Gulf of Maine 11%; NYB 76%; Chesapeake Bay 8%; and, South Atlantic 1%. Four percent of the Atlantic sturgeon were from the St. John River, Canada and are not part of the listed entity. Sampling in Long Island Sound (n=275, 2006-2010) indicates a similar frequency. Fish from the Carolina DPS have been documented in Long Island Sound (n=1, 0.05% of the 275 samples analyzed). Because there is nothing preventing Atlantic sturgeon in Long Island Sound from accessing the Connecticut River, it is reasonable to expect that occasional sturgeon originating from the Carolina DPS may be present in the Connecticut River. The genetic assignments have a plus/minus 5% confidence interval; however, for purposes of section 7 consultation we have selected the reported values above, which approximate the mid-point of the range, as a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. These assignments and the data from which they are derived are described in detail in Damon-Randall *et al.* (2012a).

Threats faced by Atlantic sturgeon throughout their range

Atlantic sturgeon are susceptible to over exploitation given their life history characteristics (e.g., late maturity, dependence on a wide-variety of habitats). Atlantic sturgeon experienced range-wide declines from historical abundance levels due to overfishing (for caviar and meat) and impacts to habitat in the 19th and 20th centuries (Taub, 1990; Smith and Clugston, 1997; Secor and Waldman, 1999).

Because a DPS is a group of populations, the stability, viability, and persistence of individual populations that make up the DPS can affect the persistence and viability of the larger DPS. The loss of any population within a DPS could result in: (1) a long-term gap in the range of the DPS that is unlikely to be recolonized; (2) loss of reproducing individuals; (3) loss of genetic biodiversity; (4) loss of unique haplotypes; (5) loss of adaptive traits; and (6) reduction in total number. The persistence of individual populations, and in turn the DPS, depends on successful spawning and rearing within the freshwater habitat, emigration to marine habitats to grow, and return of adults to natal rivers to spawn.

Based on the best available information, we concluded that unintended catch of Atlantic sturgeon in fisheries, vessel strikes, poor water quality, water availability, dams, lack of regulatory mechanisms for protecting the fish, and dredging are the most significant threats to Atlantic sturgeon (77 FR 5880 and 77 FR 5914; February 6, 2012). While all of the threats are not necessarily present in the same area at the same time, given that Atlantic sturgeon subadults and adults use ocean waters from the Labrador, Canada to Cape Canaveral, FL, as well as estuaries of large rivers along the U.S. East Coast, activities affecting these water bodies are likely to impact more than one Atlantic sturgeon DPS. In addition, given that Atlantic sturgeon depend on a variety of habitats, every life stage is likely affected by one or more of the identified threats.

An ASMFC interstate fishery management plan for sturgeon (Sturgeon FMP) was developed and implemented in 1990 (Taub, 1990). In 1998, the remaining Atlantic sturgeon fisheries in U.S. state waters were closed per Amendment 1 to the Sturgeon FMP. Complementary regulations were implemented by NMFS in 1999 that prohibit fishing for, harvesting, possessing, or retaining Atlantic sturgeon or its parts in or from the Exclusive Economic Zone in the course of a commercial fishing activity.

Commercial fisheries for Atlantic sturgeon still exist in Canadian waters (DFO, 2011). Sturgeon belonging to one or more of the DPSs may be harvested in the Canadian fisheries. In particular, the Bay of Fundy fishery in the Saint John estuary may capture sturgeon of U.S. origin given that sturgeon from the Gulf of Maine and the New York Bight DPSs have been incidentally captured in other Bay of Fundy fisheries (DFO, 2010; Wirgin and King, 2011). Because Atlantic sturgeon are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), the U.S. and Canada are currently working on a conservation strategy to address the potential for captures of U.S. fish in Canadian directed Atlantic sturgeon fisheries and of Canadian fish incidentally in U.S. commercial fisheries. At this time, there are no estimates of the number of individuals from any of the DPSs that are captured or killed in Canadian fisheries each year.

Based on geographic distribution, most U.S. Atlantic sturgeon that are intercepted in Canadian fisheries likely originate from the Gulf of Maine DPS, with a smaller percentage from the New York Bight DPS.

Individuals from all five DPSs are caught as bycatch in fisheries operating in U.S. waters. At this time, we have an estimate of the number of Atlantic sturgeon captured and killed in sink gillnet and otter trawl fisheries authorized by Federal FMPs (NMFS NEFSC 2011) in the Northeast Region but do not have a similar estimate for Southeast fisheries. We also do not have an estimate of the number of Atlantic sturgeon captured or killed in state fisheries. At this time, we are not able to quantify the effects of other significant threats (e.g., vessel strikes in rivers and estuaries, poor water quality, water availability, dams, and dredging) in terms of habitat impacts or loss of individuals. While we have some information on the number of mortalities that have occurred in the past in association with certain activities (e.g., mortalities in the Delaware and James rivers that are thought to be due to vessel strikes), we are not able to use those numbers to extrapolate effects throughout one or more DPS. This is because of (1) the small number of data points and, (2) lack of information on the percent of incidences that the observed mortalities represent.

As noted above, the NEFSC prepared an estimate of the number of encounters of Atlantic sturgeon in fisheries authorized by Northeast FMPs (NEFSC 2011). The analysis prepared by the NEFSC estimates that from 2006 through 2010 there were 2,250 to 3,862 encounters per year in observed gillnet and trawl fisheries, with an average of 3,118 encounters. Mortality rates in gillnet gear are approximately 20%. Mortality rates in otter trawl gear are believed to be lower at approximately 5%.

Recovery Goals

A Recovery Plan has not been completed for any DPS of Atlantic sturgeon. In 2018, NMFS published a Recovery Outline to serve as an initial recovery planning document. In this, the recovery vision is stated, “Subpopulations of all five Atlantic sturgeon DPSs must be present across the historical range. These subpopulations must be of sufficient size and genetic diversity to support successful reproduction and recovery from mortality events. The recruitment of juveniles to the sub-adult and adult life stages must also increase and that increased recruitment must be maintained over many years. Recovery of these DPSs will require conservation of the riverine and marine habitats used for spawning, development, foraging, and growth by abating threats to ensure a high probability of survival into the future.” The Outline also includes steps that are expected to serve as an initial recovery action plan. These include protecting extant subpopulations and the species’ habitat through reduction of threats; gathering information through research and monitoring on current distribution and abundance; and addressing vessel strikes in rivers, the effects of climate change and bycatch.

5.3.1 Gulf of Maine DPS of Atlantic sturgeon

The Gulf of Maine DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, MA. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT, 2007). Spawning occurs in the Kennebec River, and it is possible that it occurs in the Penobscot River as well. The capture of a larval Atlantic sturgeon in the Androscoggin River below the Brunswick Dam in the spring of 2011 indicates spawning may also occur in that river. There is no evidence of recent spawning in the remaining rivers. Atlantic sturgeons that are spawned elsewhere continue to use habitats within all of these rivers as part of their overall marine range (ASSRT, 2007). The movement of subadult and adult sturgeon between rivers, including to and from the Kennebec River and the Penobscot River, demonstrates that coastal and marine migrations are key elements of Atlantic sturgeon life history for the Gulf of Maine DPS (ASSRT, 2007; Fernandes, *et al.*, 2010).

The current status of the Gulf of Maine DPS is affected by historical and modern fisheries dating as far back as the 1800s (Squiers *et al.*, 1979; Stein *et al.*, 2004; ASMFC 2007). Incidental capture of Atlantic sturgeon in state and Federal fisheries continues today. As explained above, we have estimates of the number of subadults and adults that are killed as a result of bycatch in fisheries authorized under Northeast FMPs. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats. Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

Spawning for the Gulf of Maine DPS is known to occur in the Kennebec River. Recent collection of an Atlantic sturgeon larva in the Androscoggin indicates spawning may occur there as well. Spawning may be occurring in other rivers, such as the Sheepscot or Penobscot, but has not been confirmed. There are indications of increasing abundance of Atlantic sturgeon belonging to the Gulf of Maine DPS. Atlantic sturgeon continue to be present in the Kennebec River; in addition, they are captured in directed research projects in the Penobscot River, and are observed in rivers where they were unknown to occur or had not been observed to occur for many years (e.g., the Saco, Presumpscot, and Charles rivers). These observations suggest that abundance of the Gulf of Maine DPS of Atlantic sturgeon is sufficient such that recolonization to rivers historically suitable for spawning may be occurring. However, despite some positive signs, there is not enough information to establish a trend for this DPS.

Some of the impacts from the threats that contributed to the decline of the Gulf of Maine DPS have been removed (e.g., directed fishing), or reduced as a result of improvements in water quality and removal of dams (e.g., the Edwards Dam on the Kennebec River in 1999, the Veazie Dam on the Penobscot River). There are strict regulations on the use of fishing gear in Maine state waters that incidentally catch sturgeon. In addition, there have been reductions in fishing effort in state and federal waters, which most likely would result in a reduction in bycatch mortality of Atlantic sturgeon. A significant amount of fishing in the Gulf of Maine is conducted using trawl gear, which is known to have a much lower mortality rate for Atlantic sturgeon caught in the gear compared to sink gillnet gear (ASMFC, 2007). Atlantic sturgeon from the GOM DPS are not commonly taken as bycatch in areas south of Chatham, MA, with only 8 percent (e.g., 7 of the 84 fish) of interactions observed in the Mid Atlantic/Carolina region being assigned to the Gulf of Maine DPS (Wirgin and King, 2011). Tagging results also indicate that Gulf of Maine DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south. However, data on Atlantic sturgeon incidentally caught in trawls and intertidal fish weirs fished in the Minas Basin area of the Bay of Fundy (Canada) indicate that approximately 35 percent originated from the Gulf of Maine DPS (Wirgin *et al.*, in draft).

As noted previously, studies have shown that in order to rebuild, Atlantic sturgeon can only sustain low levels of bycatch and other anthropogenic mortality (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007; Brown and Murphy, 2010). NMFS has determined that the Gulf of Maine DPS is at risk of becoming endangered in the foreseeable future throughout all of its range (i.e., is a threatened species) based on the following: (1) significant declines in population sizes and the protracted period during which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect recovery.

5.3.2 New York Bight DPS of Atlantic sturgeon

The New York Bight DPS includes the following: all anadromous Atlantic sturgeon spawned in the watersheds that drain into coastal waters from Chatham, MA 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. There is no recent evidence (within the last 15 years) of spawning in the Taunton River (ASSRT, 2007). Atlantic 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).

In 2014, several presumed age-0 Atlantic sturgeon were captured in the Connecticut River; the available information indicates that successful spawning took place in 2013 by a small number of adults. Genetic analysis of the juveniles indicates that the adults were likely migrants from the South Atlantic DPS (Savoy et al. 2017). As noted by the authors, this conclusion is counter to prevailing information regarding straying of adult Atlantic sturgeon. As these captures represent the only contemporary records of possible natal Atlantic sturgeon in the Connecticut River and the genetic analysis is unexpected, more information is needed to establish the frequency of spawning in the Connecticut River and whether there is a unique Connecticut River population of Atlantic sturgeon.

The abundance of the Hudson River Atlantic sturgeon riverine population prior to the onset of expanded exploitation in the 1800s is unknown but has been conservatively estimated at 10,000 adult females (Secor, 2002). Current abundance is likely at least one order of magnitude smaller than historical levels (Secor, 2002; ASSRT, 2007; Kahnle *et al.*, 2007). As described above, an estimate of the mean annual number of mature adults (863 total; 596 males and 267 females) was calculated for the Hudson River riverine population based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.*, 2007). Kahnle *et al.* (1998; 2007) also showed that the level of fishing mortality from the Hudson River Atlantic sturgeon fishery during the period of 1985-1995 exceeded the estimated sustainable level of fishing mortality for the riverine population and may have led to reduced recruitment. A decline in the abundance of young Atlantic sturgeon appeared to occur in the mid to late 1970s followed by a secondary drop in the late 1980s (Kahnle *et al.*, 1998; Sweka *et al.*, 2007; ASMFC, 2010). At the time of listing, catch-per-unit-effort (CPUE) data suggested that recruitment remained depressed relative to catches of juvenile Atlantic sturgeon in the estuary during the mid-late 1980s (Sweka *et al.*, 2007; ASMFC, 2010). In examining the CPUE data from 1985-2007, there are significant fluctuations during this time. There appears to be a decline in the number of juveniles between the late 1980s and early 1990s while the CPUE is generally higher in the 2000s as compared to the 1990s. Given the significant annual fluctuation, it is difficult to discern any trend. Despite the CPUEs from 2000-2007 being generally higher than those from 1990-1999, they are low compared to the late 1980s. Standardized mean catch per net set from the NYSDEC juvenile Atlantic sturgeon survey have had a general increasing trend from 2006 – 2015, with the exception of a dip in 2013.

In addition to capture in fisheries operating in Federal waters, bycatch and mortality also occur in state fisheries; however, the primary fishery (shad) that impacted juvenile sturgeon in the Hudson River, has now been closed and there is no indication that it will reopen soon. In the Hudson River, sources of potential mortality include vessel strikes and entrainment in dredges. Individuals are also exposed to effects of bridge construction (including the replacement of the Tappan Zee Bridge). Impingement at water intakes, including the Danskammer, Roseton and Indian Point power plants has been documented in the past. Recent information from surveys of juveniles (see above) indicates that the number of young Atlantic sturgeon in the Hudson River is increasing compared to recent years, but is still low compared to the 1970s. There is currently not enough information regarding any life stage to establish a trend for the entire Hudson River population.

There is no abundance estimate for the Delaware River population of Atlantic sturgeon. Harvest records from the 1800s indicate that this was historically a large population with an estimated 180,000 adult females prior to 1890 (Secor and Waldman, 1999; Secor, 2002). Sampling in 2009 to target young-of- the year (YOY) Atlantic sturgeon in the Delaware River (i.e., natal sturgeon) resulted in the capture of 34 YOY, ranging in size from 178 to 349 mm TL (Fisher, 2009) and the collection of 32 YOY Atlantic sturgeon in a separate study (Brundage and O'Herron in Calvo *et al.*, 2010). Genetics information collected from 33 of the 2009-year class YOY indicates that at least 3 females successfully contributed to the 2009-year class (Fisher, 2011). Therefore, while the capture of YOY in 2009 provides evidence that successful spawning is still occurring in the Delaware River, the relatively low numbers suggest the existing riverine population is limited in size.

Several threats play a role in shaping the current status and trends observed in the Delaware River and Estuary. In-river threats include habitat disturbance from dredging, and impacts from historical pollution and impaired water quality. A dredged navigation channel extends from Trenton seaward through the tidal river (Brundage and O'Herron, 2009), and the river receives significant shipping traffic. Vessel strikes have been identified as a threat in the Delaware River; however, at this time we do not have information to quantify this threat or its impact to the population or the New York Bight DPS. Similar to the Hudson River, there is currently not enough information to determine a trend for the Delaware River population.

Summary of the New York Bight DPS

Atlantic sturgeon originating from the New York Bight DPS spawn in the Hudson and Delaware rivers. While genetic testing can differentiate between individuals originating from the Hudson or Delaware rivers, the available information suggests that the straying rate is high between these rivers. There are no indications of increasing abundance for the New York Bight DPS (ASSRT, 2009; 2010). Some of the impact from the threats that contributed to the decline of the New York Bight DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act (CWA). In addition, there have been reductions in fishing effort in state and federal waters, which may result in a reduction in bycatch mortality of Atlantic sturgeon. Nevertheless, areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in state and federally-managed fisheries, and vessel strikes remain significant threats to the New York Bight DPS.

In the marine range, New York Bight DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.*, 2004; ASMFC 2007). As explained above, currently available estimates indicate that at least 4% of adults may be killed as a result of bycatch in fisheries authorized under Northeast FMPs. Based on mixed stock analysis results presented by Wirgin and King (2011), over 40 percent of the Atlantic sturgeon bycatch interactions in the Mid Atlantic Bight region were sturgeon from the New York Bight DPS. Individual-based assignment and mixed stock analysis of samples collected from sturgeon captured in Canadian fisheries in the Bay of Fundy indicated that approximately 1-2% were from the New York Bight DPS. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat, and altering the benthic forage base. Both the Hudson and Delaware rivers have navigation channels that are maintained by dredging. Dredging is also used to maintain channels in the nearshore marine environment. Dredging outside of Federal channels and in-water construction occurs throughout the New York Bight region. While some dredging projects operate with observers present to document fish mortalities many do not. We have reports of one Atlantic sturgeon entrained during hopper dredging operations in Ambrose Channel, New Jersey, and four fish were entrained in the Delaware River during maintenance and deepening activities in 2017 and 2018. At this time, we do not have any additional information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects. We are also not able to quantify any effects to habitat.

In the Hudson and Delaware Rivers, dams do not block access to historical habitat. The Holyoke Dam on the Connecticut River blocks further upstream passage; however, the extent that Atlantic sturgeon would historically have used habitat upstream of Holyoke is unknown. Connectivity may be disrupted by the presence of dams on several smaller rivers in the New York Bight region. Because no Atlantic sturgeon occur upstream of any hydroelectric projects in the New York Bight region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area.

New York Bight DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Hudson and Delaware over the past decades (Lichter *et al.* 2006; EPA, 2008). Both the Hudson and Delaware rivers, as well as other rivers in the New York Bight region, were heavily polluted in the past from industrial and sanitary sewer discharges. While water quality has improved and most discharges are limited through regulations, many pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds as developing eggs and larvae are particularly susceptible to exposure to contaminants.

Vessel strikes occur in the Delaware River. Twenty-nine mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2004 to 2008, and at least 13 of these fish were large adults. Additionally, 138 sturgeon carcasses were observed on the Hudson River and reported to the NYSDEC between 2007 and 2015. Of these, 69 are suspected of having been killed by vessel strike. Genetic analysis has not been completed on any of these individuals to date, given that the majority of Atlantic sturgeon in the Hudson River belong to the New York Bight DPS, we assume that the majority of the dead sturgeon reported to NYSDEC belonged to the New York Bight DPS. Given the time of year in which the fish were observed (predominantly May through July), it is likely that many of the adults were migrating through the river to the spawning grounds.

Studies have shown that to rebuild, Atlantic sturgeon can only sustain low levels of anthropogenic mortality (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007; Brown and Murphy, 2010). There are no empirical abundance estimates of the number of Atlantic sturgeon in the New York Bight DPS. We determined that the New York Bight DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

5.3.3 Chesapeake Bay DPS of Atlantic sturgeon

The Chesapeake Bay (CB) DPS includes the following: all anadromous Atlantic sturgeon that spawn or are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, Virginia. The marine range of Atlantic sturgeon from the CB DPS extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the CB DPS and the adjacent portion of the marine range are shown in Figure 18. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT 2007). Based on the review by Oakley (2003), 100% of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e., dams) are located upriver of where spawning is expected to have historically occurred (ASSRT 2007).

At the time of listing, the James River was the only known spawning river for the Chesapeake Bay DPS (ASSRT, 2007; Hager, 2011; Balazik et al., 2012). Since the listing, evidence has been provided of both spring and fall spawning populations for the James River, as well as fall spawning in the Pamunkey River, a tributary of the York River, and fall spawning in Marshyhope Creek, a tributary of the Nanticoke River (Hager et al., 2014; Kahn et al., 2014; Balazik and Musick, 2015; Richardson and Secor, 2016). In addition, detections of acoustically tagged adult Atlantic sturgeon in the Mattaponi and Rappahannock Rivers at the time when spawning occurs in others rivers, and historical evidence for these as well as the Potomac River supports the likelihood of Atlantic sturgeon spawning populations in the Mattaponi, Rappahannock, and potentially the Potomac river.

Age to maturity for CB DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit variation across their geographic range with faster growth and earlier age to maturity for those that originate from southern waters, and slower growth and later age to maturity for those that originate from northern waters (75 FR 61872; October 6, 2010). Age at maturity is five to 19 years for Atlantic sturgeon originating from South Carolina rivers (Smith *et al.* 1982) and 11 to 21 years for Atlantic sturgeon originating from the Hudson River (Young *et al.* 1998). Therefore, age at maturity for Atlantic sturgeon of the CB DPS likely falls within these values.

Several threats play a role in shaping the current status of CB DPS Atlantic sturgeon. Historical records provide evidence of the large-scale commercial exploitation of Atlantic sturgeon from the James River and Chesapeake Bay in the 19th century (Hildebrand and Schroeder 1928; Vladykov and Greeley 1963; ASMFC 1998b; Secor 2002; Bushnoe *et al.* 2005; ASSRT 2007) as well as subsistence fishing and attempts at commercial fisheries as early as the 17th century (Secor 2002; Bushnoe *et al.* 2005; ASSRT 2007; Balazik *et al.* 2010). Habitat disturbance caused by in-river work, such as dredging for navigational purposes, is thought to have reduced available spawning habitat in the James River (Holton and Walsh 1995; Bushnoe *et al.* 2005; ASSRT 2007). At this time, we do not have information to quantify this loss of spawning habitat.

Decreased water quality also threatens Atlantic sturgeon of the CB DPS, especially since the Chesapeake Bay system is vulnerable to the effects of nutrient enrichment due to a relatively low tidal exchange and flushing rate, large surface-to-volume ratio, and strong stratification during the spring and summer months (Pyzik *et al.* 2004; ASMFC 1998a; ASSRT 2007; EPA 2008). These conditions contribute to reductions in dissolved oxygen levels throughout the Bay. The availability of nursery habitat, in particular, may be limited given the recurrent hypoxia (low dissolved oxygen) conditions within the Bay (Niklitschek and Secor 2005, 2010). Heavy industrial development during the 20th century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery.

Although there have been improvements in the some areas of the Bay's health, the ecosystem remains in poor condition. At this time, we do not have sufficient information to quantify the extent that degraded water quality effects habitat or individuals in the Chesapeake Bay watershed.

Vessel strikes have been observed in the James River (ASSRT 2007). Eleven Atlantic sturgeon were reported to have been struck by vessels from 2005-2007. Several of these were mature individuals. Balazik et al. (2012) found 31 carcasses in tidal freshwater regions of the James River between 2007 and 2010, and approximately 36 between 2013 and 2017 (Balazik, pers comm). Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the CB DPS on a regular basis. However, Balazik et al. estimates that current monitoring in the James River only captures approximately one third of all mortalities related to vessel interaction.

In the marine and coastal range of the CB DPS from Canada to Florida, fisheries bycatch in federally and state-managed fisheries poses a threat to the DPS, reducing survivorship of subadults and adults and potentially causing an overall reduction in the spawning population (Stein *et al.* 2004b; ASMFC TC 2007; ASSRT 2007).

Areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in U.S. state and federally-managed fisheries, Canadian fisheries, and vessel strikes remain significant threats to the CB DPS of Atlantic sturgeon. Of the 35% of Atlantic sturgeon incidentally caught in the Bay of Fundy, about 1% were CB DPS fish (Wirgin *et al.* 2012). Studies have shown that Atlantic sturgeon can only sustain low levels of bycatch mortality (Boreman 1997; ASMFC TC 2007; Kahnle *et al.* 2007). The CB DPS is currently at risk of extinction given (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect the potential for population recovery.

5.3.4 Carolina DPS of Atlantic sturgeon

The Carolina DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) from Albemarle Sound southward along the southern Virginia, North Carolina, and South Carolina coastal areas to Charleston Harbor. The marine range of Atlantic sturgeon from the Carolina DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida.

Rivers in the Carolina DPS considered to be spawning rivers include the Neuse, Roanoke, Tar-Pamlico, Cape Fear, and Northeast Cape Fear rivers, and the Santee-Cooper and Pee Dee river (Waccamaw and Pee Dee rivers) systems. Historically, both the Sampit and Ashley Rivers were documented to have spawning populations at one time. However, the spawning population in the Sampit River is believed to be extirpated and the current status of the spawning population in the Ashley River is unknown. We have no information, current or historical, of Atlantic sturgeon using the Chowan and New Rivers in North Carolina. Recent telemetry work by Post et al. (2014) indicates that Atlantic sturgeon do not use the Sampit, Ashley, Ashepoo, and Broad-

Coosawhatchie Rivers in South Carolina. These rivers are short, coastal plains rivers that most likely do not contain suitable habitat for Atlantic sturgeon. Fish from the Carolina DPS likely use other river systems than those listed here for their specific life functions.

Historical landings data indicate that between 7,000 and 10,500 adult female Atlantic sturgeon were present in North Carolina prior to 1890 (Armstrong and Hightower 2002, Secor 2002). Secor (2002) estimates that 8,000 adult females were present in South Carolina during that same time frame. Reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the Carolina DPS. Currently, the Atlantic sturgeon spawning population in at least one river system within the Carolina DPS has been extirpated, with a potential extirpation in an additional system. The ASSRT estimated the remaining river populations within the DPS to have fewer than 300 spawning adults; this is thought to be a small fraction of historic population sizes (ASSRT 2007).

Threats

The Carolina DPS was listed as endangered under the ESA as a result of a combination of habitat curtailment and modification, overutilization (i.e., being taken as bycatch) in commercial fisheries, and the inadequacy of regulatory mechanisms in ameliorating these impacts and threats.

The modification and curtailment of Atlantic sturgeon habitat resulting from dams, dredging, and degraded water quality is contributing to the status of the Carolina DPS. Dams have curtailed Atlantic sturgeon spawning and juvenile developmental habitat by blocking over 60 percent of the historical sturgeon habitat upstream of the dams in the Cape Fear and Santee-Cooper River systems. Water quality (velocity, temperature, and dissolved oxygen (DO)) downstream of these dams, as well as on the Roanoke River, has been reduced, which modifies and curtails the extent of spawning and nursery habitat for the Carolina DPS. Dredging in spawning and nursery grounds modifies the quality of the habitat and is further curtailing the extent of available habitat in the Cape Fear and Cooper Rivers, where Atlantic sturgeon habitat has already been modified and curtailed by the presence of dams. Reductions in water quality from terrestrial activities have modified habitat utilized by the Carolina DPS. In the Pamlico and Neuse systems, nutrient-loading and seasonal anoxia are occurring, associated in part with concentrated animal feeding operations (CAFOs). Heavy industrial development and CAFOs have degraded water quality in the Cape Fear River. Water quality in the Waccamaw and Pee Dee rivers have been affected by industrialization and riverine sediment samples contain high levels of various toxins, including dioxins. Additional stressors arising from water allocation and climate change threaten to exacerbate water quality problems that are already present throughout the range of the Carolina DPS. The removal of large amounts of water from the system will alter flows, temperature, and DO. Existing water allocation issues will likely be compounded by population growth and potentially, by climate change. Climate change is also predicted to elevate water temperatures and exacerbate nutrient-loading, pollution inputs, and lower DO, all of which are current stressors to the Carolina DPS.

Overutilization of Atlantic sturgeon from directed fishing caused initial severe declines in Atlantic sturgeon populations in the Southeast, from which they have never rebounded. Further, continued overutilization of Atlantic sturgeon as bycatch in commercial fisheries is an ongoing impact to the Carolina DPS. Little data exists on bycatch in the Southeast and high levels of bycatch underreporting are suspected. Stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins and low DO). This may result in reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality.

As a wide-ranging anadromous species, Carolina DPS Atlantic sturgeon are subject to numerous Federal (U.S. and Canadian), state and provincial, and inter-jurisdictional laws, regulations, and agency activities. While these mechanisms have addressed impacts to Atlantic sturgeon through directed fisheries, there are currently no mechanisms in place to address the significant risk posed to Atlantic sturgeon from commercial bycatch. Though statutory and regulatory mechanisms exist that authorize reducing the impact of dams on riverine and anadromous species, such as Atlantic sturgeon, and their habitat, these mechanisms have proven inadequate for preventing dams from blocking access to habitat upstream and degrading habitat downstream. Further, water quality continues to be a problem in the Carolina DPS, even with existing controls on some pollution sources. Current regulatory regimes are not necessarily effective in controlling water allocation issues (e.g., no restrictions on interbasin water transfers in South Carolina, the lack of ability to regulate non-point source pollution, etc.)

5.3.5 South Atlantic DPS of Atlantic sturgeon

The South Atlantic DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) of the Ashepoo, Combahee, and Edisto Rivers (ACE) Basin southward along the South Carolina, Georgia, and Florida coastal areas to the St. Johns River, Florida.

Rivers known to have current spawning populations within the range of the South Atlantic DPS include the Combahee, Edisto, Savannah, Ogeechee, Altamaha, St. Marys, and Satilla Rivers. Recent telemetry work by Post et al. (2014) indicates that Atlantic sturgeon do not use the Sampit, Ashley, Ashepoo, and Broad-Coosawhatchie Rivers in South Carolina. These rivers are short, coastal plains rivers that most likely do not contain suitable habitat for Atlantic sturgeon. Post et al. (2014) also found Atlantic sturgeon only use the portion of the Waccamaw River downstream of Bull Creek. Due to manmade structures and alterations, spawning areas in the St. Johns River are not accessible and therefore do not support a reproducing population.

Secor (2002) estimates that 8,000 adult females were present in South Carolina prior to 1890. Prior to the collapse of the fishery in the late 1800s, the sturgeon fishery was the third largest fishery in Georgia. Secor (2002) estimated from U.S. Fish Commission landing reports that approximately 11,000 spawning females were likely present in the state prior to 1890. Reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the South Atlantic DPS. Currently, the Atlantic sturgeon spawning population in at least one river system within the South Atlantic DPS has been extirpated. The Altamaha River population of Atlantic sturgeon, with an estimated 343 adults spawning annually, is believed to be the largest population in the Southeast, yet is estimated to be only 6 percent of its historical population size. The ASSRT estimated the abundances of the remaining river populations within the DPS, each estimated to have fewer than 300 spawning adults, to be less than 1 percent of what they were historically (ASSRT 2007).

Threats

The South Atlantic DPS was listed as endangered under the ESA as a result of a combination of habitat curtailment and modification, overutilization (i.e., being taken as bycatch) in commercial fisheries, and the inadequacy of regulatory mechanisms in ameliorating these impacts and threats.

The modification and curtailment of Atlantic sturgeon habitat resulting from dredging and degraded water quality is contributing to the status of the South Atlantic DPS. Maintenance dredging is currently modifying Atlantic sturgeon nursery habitat in the Savannah River and modeling indicates that the proposed deepening of the navigation channel will result in reduced DO and upriver movement of the salt wedge, curtailing spawning habitat. Dredging is also modifying nursery and foraging habitat in the St. Johns River. Reductions in water quality from terrestrial activities have modified habitat utilized by the South Atlantic DPS Non-point source inputs are causing low DO in the Ogeechee River and in the St. Marys River, which completely eliminates juvenile nursery habitat in summer. Low DO has also been observed in the St. Johns River in the summer. Sturgeon are more sensitive to low DO and the negative (metabolic, growth, and feeding) effects caused by low DO increase when water temperatures are concurrently high, as they are within the range of the South Atlantic DPS. Additional stressors arising from water allocation and climate change threaten to exacerbate water quality problems that are already present throughout the range of the South Atlantic DPS. Large withdrawals of over 240 million gallons per day mgd of water occur in the Savannah River for power generation and municipal uses. However, users withdrawing less than 100,000 gallons per day (gpd) are not required to get permits, so actual water withdrawals from the Savannah and other rivers within the range of the South Atlantic DPS are likely much higher. The removal of large amounts of water from the system will alter flows, temperature, and DO. Water shortages and “water wars” are already occurring in the rivers occupied by the South Atlantic DPS and will likely be compounded in the future by population growth and potentially by climate change. Climate change is also predicted to elevate water temperatures and exacerbate nutrient-loading, pollution inputs, and lower DO, all of which are current stressors to the South Atlantic DPS.

Overutilization of Atlantic sturgeon from directed fishing caused initial severe declines in Atlantic sturgeon populations in the Southeast, from which they have never rebounded. Further, continued overutilization of Atlantic sturgeon as bycatch in commercial fisheries is an ongoing impact to the South Atlantic DPS. The loss of large subadults and adults as a result of bycatch impacts Atlantic sturgeon populations because they are a long-lived species, have an older age at maturity, have lower maximum fecundity values, and a large percentage of egg production occurs later in life. Little data exist on bycatch in the Southeast and high levels of bycatch underreporting are suspected. Further, a total population abundance for the DPS is not available, and it is therefore not possible to calculate the percentage of the DPS subject to bycatch mortality based on the available bycatch mortality rates for individual fisheries. However, fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may access multiple river systems, they are subject to being caught in multiple fisheries throughout their range. In addition, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins and low DO). This may result in reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality.

As a wide-ranging anadromous species, Atlantic sturgeon are subject to numerous Federal (U.S. and Canadian), state and provincial, and inter-jurisdictional laws, regulations, and agency activities. While these mechanisms have addressed impacts to Atlantic sturgeon through directed fisheries, there are currently no mechanisms in place to address the significant risk posed to Atlantic sturgeon from commercial bycatch. Though statutory and regulatory mechanisms exist that authorize reducing the impact of dams on riverine and anadromous species, such as Atlantic sturgeon, and their habitat, these mechanisms have proven inadequate for preventing dams from blocking access to habitat upstream and degrading habitat downstream. Further, water quality continues to be a problem in the South Atlantic DPS, even with existing controls on some pollution sources. Current regulatory regimes are not necessarily effective in controlling water allocation issues (e.g., no permit requirements for water withdrawals under 100,000 gpd in Georgia, no restrictions on interbasin water transfers in South Carolina, the lack of ability to regulate non-point source pollution.)

6.0 ENVIRONMENTAL BASELINE

The "environmental baseline" represents the current biological and physical conditions of the action area and reflects: the past and present impacts of all federal, state, or private activities; the anticipated impacts of all proposed federal actions that have already undergone Section 7 consultation; and, the impacts of state or private actions that are contemporaneous with the proposed project (50 C.F.R. §402.02).

There are a number of existing activities that regularly occur in various portions of the action area, including operation of vessels and federal and state authorized fisheries. Other activities that occur occasionally or intermittently include scientific research, military activities, and geophysical and geotechnical surveys. There are also environmental conditions caused or exacerbated by human activities (i.e., water quality and noise) that may affect listed species in the action area. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strike, fisheries), whereas others result in more indirect or non-lethal impacts. For all of the listed species considered here, the status of the species in the action area is the same as the rangewide status presented in the Status of the Species section of this Opinion. Below, we describe the conditions of the action area, present a summary of the best available information on the use of the action area by listed species, and address the impacts to listed species of federal, state, and private activities in the action area.

The Vineyard Wind project area is located within multiple defined marine areas. The broadest area, the U.S. Northeast Shelf Large Marine Ecosystem, extends from the Gulf of Maine to Cape Hatteras, North Carolina (Kaplan 2011). The WDA is 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). The action area also overlaps with the Mid-Atlantic Bight, which is bounded by Cape Cod, MA to the north and Cape Hatteras, NC to the south. The physical oceanography of this region is influenced by the seafloor, freshwater input from multiple rivers and estuaries, large-scale weather patterns, and tropical or winter coastal storm events. Weather-driven surface currents, tidal mixing, and estuarine outflow all contribute to driving water movement through the area (Kaplan 2011). Due to these factors, the Northeast U.S. shelf area experiences one of the largest summer to winter temperature changes of any part of the ocean around the world. The result is a unique ocean feature called the Cold Pool, a band of cold bottom water that extends the length of the Mid-Atlantic Bight from spring through early fall (MARACOOS). This temperature-salinity water mass occupies nearshore and offshore regions, including over Nantucket Shoals, creating a persistent frontal zone in the area. Additionally, the region has seasonal upwelling and downwelling regimes, influenced by the edge of the continental shelf, which creates a shelf-break front. These oceanographic fronts are often used by marine vertebrates for foraging and migration as they can aggregate prey (Scales et al. 2014).

Offshore from Martha’s Vineyard and Nantucket, shelf currents flow predominantly toward the southwest, beginning as water from the Gulf of Maine heading south veers around and over Nantucket Shoals. Tidal water masses from nearshore transitioning through Nantucket Sound mix with the shelf current generally following depth contours offshore (Ullman and Cornellion 1999, VW FEIS).

Water depths in the WDA range from 35-60m (VW COP), and sea surface water temperatures seasonally vary between approximately 37 °F (3 °C) in winter to 65 °F (18 °C) in summer (VW DEIS). Benthic habitat in the WDA is predominantly flat with sand or sand-dominated substrate, with areas of mud to the south end and gravel to the northwest corner (BA Guida et al. 2017).

6.1 Summary of Information on Listed Large Whale Presence in the Action Area

North Atlantic right whale (Eubalaena glacialis)

The North Atlantic right whale ranges from calving grounds in the southeastern United States to feeding grounds in New England waters and into Canadian waters (Hayes et al., 2018). Surveys have demonstrated the existence of seven areas where North Atlantic right whales congregate seasonally, including north and east of the WDA in Georges Bank, off Cape Cod, and in Massachusetts Bay (Hayes et al., 2018). In the late fall months (e.g. October), right whales generally depart from the feeding grounds in the North Atlantic and move south to their calving grounds off Georgia and Florida. However, recent research indicates our understanding of their movement patterns remains incomplete (Davis et al. 2017). A review of passive acoustic monitoring data from 2004 to 2014 throughout the western North Atlantic demonstrated nearly continuous year-round right whale presence across their entire habitat range (for at least some individuals), including in locations previously thought of as migratory corridors, suggesting that not all of the population undergoes a consistent annual migration (Davis et al. 2017). Acoustic monitoring data from 2004 to 2014 indicated that the number of North Atlantic right whale vocalizations detected in the proposed project area were relatively constant throughout the year, with the exception of August through October when detected vocalizations showed an apparent decline (Davis et al. 2017), suggesting that during the period of this study, right whale distribution in the project area was lowest in the August to October period.

NMFS’ regulations at 50 CFR 224.105 designated nearshore waters of the Mid-Atlantic Bight as Mid-Atlantic U.S. Seasonal Management Areas (SMA) for right whales in 2008. SMAs were developed to reduce the threat of collisions between ships and right whales around their migratory route and calving grounds. Vessels 65 feet or greater in length are required to travel at speeds of 10 knots or less while in the Block Island SMA from November 1 – April 30 each year. A portion of one SMA, which occurs off Block Island, Rhode Island, occurs near the WDA and overlaps with the western edge of the action area where some project vessels may transit.

In 2016, the Northeastern U.S. Foraging Area Critical Habitat for North Atlantic right whales was expanded to include all U.S. waters of the Gulf of Maine. No portion of the action area overlaps with the designated critical habitat and all vessel transits to and from Canada will transit around the critical habitat area. 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 at least some right whales are shifting to other habitats, 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 North Atlantic right whales 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 North Atlantic right whales depend on (Baumgartner et al. 2017). One of the consequences of this may be a shift of North Atlantic right whales out of typical habitats in the Gulf of Maine and into areas like the area south of Nantucket (which partially overlaps with the action area) where right whales have been documented for the last several winters and are suspected to be foraging.

North Atlantic right whales 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. North Atlantic right whales' diving behavior is strongly correlated to the vertical distribution of *C. finmarchicus*. Baumgartner et al. (2017) investigated North Atlantic right whale 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 North Atlantic right whales 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 North Atlantic right whales are always at risk of ship strike due to the time spent at the surface to breathe, North Atlantic right whales 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).

The Right Whale Sighting Advisory System (RWSAS) alerts mariners to the presence of the right whales, and collects sighting reports from a variety of sources including aerial surveys, shipboard surveys, whale watch vessels, and opportunistic sources (Coast Guard, commercial ships, fishing vessels, and the general public). In 2016, North Atlantic right whales were observed in the shelf waters south of Martha's Vineyard and Nantucket during January, February, and May. In 2017, North Atlantic right whales were observed in the shelf waters south of Martha's Vineyard and Nantucket in every month except January, August, and December. In 2018 and 2019, North Atlantic right whales were observed in the shelf waters south of Martha's Vineyard and Nantucket in every month except October (NEFSC SAS).

During aerial surveys conducted from 2011-2015 in the MA/RI WEA, including the proposed Project area, the highest number of right whale sightings occurred in March (n=21), with sightings also occurring in December (n=4), January (n=7), February (n=14), and April (n=14), and no sightings in any other months (Kraus et al., 2016). There was not significant variability in sighting rate among years, indicating consistent annual seasonal use of the area by right whales. North Atlantic right whales were acoustically detected in 30 out of the 36 recorded months (Kraus et al., 2016). However, right whales exhibited strong seasonality in acoustic presence, with mean monthly acoustic presence highest in January (mean = 74%), February (mean = 86%), and March (mean = 97%), and the lowest in July (mean = 16%), August (mean = 2%), and September (mean = 12%). Aerial survey results indicate that North Atlantic right whales 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).

As described in the BA, the effort-weighted average sighting rate for North Atlantic right whales in the Kraus et al. (2016) 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. North Atlantic right whales 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). Seasonal variation among years ranged from zero 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).

Also as described in the BA, 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. 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). 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 vary among years, and some aggregations appear to be ephemeral, the hot spot analysis suggests that there is some regularity in North Atlantic right whale 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.

In summary, we anticipate individual right whales to occur year round in the action area, primarily in winter, spring and summer months in both coastal, shallower waters as well as offshore, deeper waters. We expect these individuals to be moving through the project area as they make seasonal migrations, and to be foraging when copepod patches of sufficient density are present. The widespread distribution of North Atlantic right whales in the area is likely tied to the occurrence of productive prey areas, which is largely driven by the dynamic oceanographic environment. Behavioral data associated with sightings within the action area and surrounding waters included surface active groups (SAG, defined as two or more whales rolling and touching at the surface) and feeding as well as adults traveling with calves (Leiter et al. 2017, Kraus et al. 2016). SAGs can be indicative of courtship (Kraus and Hatch 2001; Parks et al. 2007), and feeding. 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. North Atlantic right whales were observed skim feeding in the northern portion of the study area. However, the authors suggested that whales might also be feeding sub-surface; without visual detection this could not be confirmed (Leiter et al. 2017).

Nova Scotia Stock of Sei whale (Balaenoptera borealis)

Sei whales occurring in the North Atlantic belong to the Nova Scotia stock (Hayes et al. 2019). They can be found in deeper waters of the continental shelf edge waters of the northeastern United States and northeastward to south of Newfoundland (Hain et al. 1985), and NMFS aerial surveys found substantial numbers of sei whales in this region, in particular south of Nantucket, in the spring of 2001. Sei whales often occur along the shelf edge to feed, but also may come up to shallower shelf waters. Although known to eat fish in other oceans, sei whales off the northeastern U.S. are largely planktivorous, feeding primarily on euphausiids and copepods (Flinn et al. 2002, Hayes et al. 2017). These aggregations of prey are largely influenced by the dynamic oceanographic processes in the region. During seasonal aerial surveys conducted from 2011-2015 in the MA/RI WEA, sei whales were observed in the proposed Project area between March and June every year, with the greatest number of sightings in May (n = 8) and June (n = 13) (Kraus et al. 2016). 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 (North Atlantic Right Whale Consortium 2018).

As described in the BA, sei whales were observed in the WEA 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 zero 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.

In summary, we anticipate individual sei whales to occur in offshore waters (south of 41°15’0” N) of the action area primarily in spring and summer months. We expect these individuals to be moving through the project area as they make seasonal migrations, and to be foraging when krill are present. Foraging adult sei whales are most common in the area but adult sei whales with calves have been observed during spring and summer months (Kraus et al. 2016).

North Atlantic Stock of Sperm whale (Physeter macrocephalus)
Sperm whales occurring in the North Atlantic belong to the North Atlantic stock (Hayes et al. 2019). Sperm whales are widely distributed throughout the deep waters of the North Atlantic, primarily along the continental shelf edge, over the continental slope, and into mid-ocean regions (Hayes et al., 2018). In summer, the distribution of sperm whales includes the area east and north of Georges Bank and into the Northeast Channel region, as well as the continental shelf (inshore of the 100-m isobath) south of New England. In the fall, sperm whale occurrence south of New England on the continental shelf is at its highest level. In winter, sperm whales are concentrated east and northeast of Cape Hatteras. Sperm whale diet includes large- and medium-sized squid, octopus, and medium-and large-sized demersal fish, such as rays, sharks, and many teleosts (NMFS 2018). 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). During seasonal aerial surveys conducted from 2011-2015 in the MA/RI WEA, only four sightings of sperm whales occurred, three in summer and one in autumn (Kraus et al., 2016), with three of those sightings in a single year (2012). 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.

In summary, we anticipate adult individual sperm whales to occur infrequently in deeper, offshore waters of the action area primarily in summer and fall months. We expect these individuals to be moving through the project area as they make seasonal migrations, and to be foraging along the shelf break. No adults were observed foraging or with calves during the 2011-2015 aerial surveys (Kraus et al. 2016). As sperm whales typically forage at deep depths

(500-1,000 m) (NMFS 2018), well beyond the depths of the action area, we do not expect foraging to occur in the action area.

Western North Atlantic stock of fin whales (Balaenoptera physalus)
Fin whales occurring in the North Atlantic belong to the western North Atlantic stock (Hayes et al. 2019). 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 unknown (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 the largest of the baleen whales observed in the proposed Project area. During seasonal aerial and acoustic surveys conducted from 2011-2015 in the MA/RI WEA, fin whales were observed every year, and sightings occurred in every season with the greatest numbers during the spring (*n* = 35) and summer (*n* = 49) months (Kraus et al., 2016). Observed behavior included feeding and migrating. Despite much lower sighting rates during the winter, a hydrophone array confirmed fin whales presence throughout the year (Kraus et al. 2016).

The offshore waters (northern Mid-Atlantic Bight) of the proposed Project area in represents a major feeding ground for fin whales as the physical and biological oceanographic structure of the area aggregates prey. Fin whales in this area 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). A Biologically Important Area (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).

As described in the BA, 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); however, these data appear to underestimate the occurrence of fin whales to the west of the WDA in the summer.

Also as described in the BA, fin whales were acoustically detected year-round in the lease area 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).

In summary, we anticipate individual fin whales to occur in the action area year-round, with the highest numbers in the spring and summer. Adult fin whales are most common in the area but fin whales with calves have been observed during spring and summer months (Kraus et al. 2016). We expect these individuals to be moving through the project area as they make seasonal coastal migrations, and to be foraging when krill and schooling fish, particularly sand lance, are present. Fin whales will most commonly be foraging during spring and summer months, as they fast in the winter as they migrate to warmer waters (Kenney and Winn 1986; Payne et al. 1990). While migrating or foraging in the action area, fin whales are most commonly found in offshore waters (south of 40°50’0” N) of the proposed Project area during the spring months, and further inshore (south of 41°15’0” N) during the summer. In surveys of the area between 2011-2015, no fin whales were observed north of 41°30’0” N, as the water depth is likely too shallow. The widespread distribution of fin whales in the area is likely tied to the occurrence of productive prey areas, as they move in and out of feeding areas.

6.2 Summary of Information on Listed Sea Turtles in the Action Area

Leatherback sea turtles (Dermochelys coriacea), North Atlantic DPS of green sea turtles (Chelonia mydas), Northwest Atlantic Ocean DPS of loggerhead sea turtles (Caretta caretta), Kemp’s ridley sea turtles in the Atlantic Ocean (Lepidochelys kempii)

Four ESA-listed species of sea turtles (Leatherback sea turtles, North Atlantic DPS of green sea turtles, Northwest Atlantic Ocean DPS of loggerhead sea turtles, Kemp’s ridley sea turtles) make seasonal migrations into the proposed Project area including the coastal waters (Buzzards Bay, Vineyard Sound, and Nantucket Sound) and offshore waters (northern Mid-Atlantic Bight) south of Cape Cod that may be transited by project vessels. Sea turtles are less frequent in U.S. waters north of Cape Cod. Along the vessel transit routes to Canadian ports, only leatherback and loggerheads are likely to occur. In the open ocean area where vessels from Europe will be transiting, all four species may be present.

The four species of sea turtles considered here are highly migratory, with the smaller species of sea turtles typically occurring in areas of warmer water (≥15°C), as they are susceptible to cold stunning if water temperature is too low, while the larger turtles like leatherbacks are able to withstand colder waters because they can regulate their body temperature (Shoop and Kenney 1992, Bolstrom et al 2010, WBWS 2018). Sea turtles most frequently occur in the action area during summer and fall months when water temperatures are the warmest (Kraus et al. 2016). Sea turtles typically use these waters for foraging, migrating, and resting – both on the ocean floor and basking at the surface (Spotila and Standora 1985).

Regional historical sightings, strandings, and bycatch data indicate that loggerhead and leatherback turtles are relatively common in waters of southern New England, while Kemp's ridley turtles and green turtles are less common (Kenney and Vigness-Raposa 2010). Aerial surveys conducted seasonally, from 2011-2015, in the MA WEA recorded the highest abundance of endangered sea turtles during the summer and fall, with no significant inter-annual variability. For most species of sea turtles, relative density was even throughout the WEA. However, leatherback sea turtles showed an apparent preference for the northeastern corner of the WEA, which is consistent with results from a tagging study on leatherbacks in the area (Kraus et al. 2016, Dodge et al., 2014). These results suggest an important seasonal habitat for leatherbacks in southern New England (Kraus et al. 2016, Dodge et al) that overlaps with a portion of the action area. Sea turtles in the action area are adults or juveniles; due to the distance from any nesting beaches, no hatchlings occur in the action area. Similarly, no reproductive behavior is known or suspected to occur in the action area.

Sea turtles feed on a variety of both pelagic and benthic prey, and change diets through different life stages. Adult loggerhead and Kemp's ridley sea turtles are carnivores that feed on crustaceans, mollusks, and occasionally fish, green sea turtles are herbivores and feed primarily on algae, seagrass, and seaweed, and leatherback sea turtles are pelagic feeders that forage throughout the water column primarily on gelatinivores. As juveniles, loggerhead and green sea turtles are omnivores (Wallace et al. 2009, Dodge et al. 2011, BA - Eckert et al. 2012, https://www.seeturtles.org/sea-turtle-diet, Murray et al 2013, Patel et al. 2016). The distribution of pelagic and benthic prey resources is primarily associated with dynamic oceanographic processes, which ultimately affect where sea turtles forage (Polovina et al. 2006). During late-spring, summer, and early-fall months when water temperatures are suitable, the physical and biological structure of both the pelagic and benthic environment in the WDA provide habitat for both the four species of sea turtles in the region as well as their prey.

Below, we present a summary of recent sightings information for sea turtles in the WDA. In addition to the Kraus et al. (2016) survey, 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. From 1998 through 2017, turtles occurred 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.

Leatherback sea turtles

As described in the BA, 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 sightings per unit effort (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 2020). 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).

Loggerhead sea turtles

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). 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).

Kemp's ridley sea turtles

As described in the BA, 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).

Green sea turtles
As described in the BA, 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 and they are expected to occur at least occasionally in the action area.

6.3 Summary of Information on Listed Marine Fish Presence in the Action Area

Atlantic sturgeon (Acipenser oxyrinchus oxyrinchus)
Adult and subadult (less than 150cm in total length, not sexually mature, but have left their natal rivers) Atlantic sturgeon from all five DPSs undertake seasonal, nearshore (i.e., typically depths less than 50 meters), coastal marine migrations along the United States eastern coastline including in waters of southern New England (Dunton et al. 2010, Erickson et al. 2011). Given their anticipated distribution in depths primarily 50 m and less, Atlantic sturgeon are not expected to occur in the deep, open-ocean portion of the action area that will be transited by project vessels carrying turbine components.

Based on tag data, sturgeon migrate to southern waters (e.g. off the coast of North Carolina and Virginia) during the fall, and migrate to more northern waters (e.g. off the coast of New York, southern New England, as far north as Maine) during the spring (Dunton et al. 2010, Erickson et al. 2011, Wippelhauser et al. 2017). In areas with gravel, sand and/or silt bottom habitats and relatively shallow depths (primarily <50 meters), sturgeon may also be foraging during these trips on prey including mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (Stein et al. 2004b, Dadswell 2006, Dunton et al. 2010, Erickson et al. 2011).

Atlantic sturgeon aggregate in several distinct areas along the Mid-Atlantic coastline; Atlantic sturgeon are most likely to occur in areas adjacent to estuaries and/or coastal features formed by bay mouths and inlets (Stein *et al.* 2004a; Laney *et. al* 2007; Erickson *et al*. 2011; Dunton *et al*. 2010). These aggregation areas are located within the coastal waters off North Carolina; waters between the Chesapeake Bay and Delaware Bay; the New Jersey Coast; and the southwest shores of Long Island (Laney *et. al* 2007; Erickson *et al*. 2011; Dunton *et al*. 2010). Based on five fishery-independent surveys, Dunton *et al*. (2010) identified several “hotspots” for Atlantic sturgeon captures, including an area off Sandy Hook, New Jersey, and off Rockaway, New York. These “hotspots” are aggregation areas that are most often used during the spring, summer, and fall months (Erickson *et al*. 2011; Dunton *et al*. 2010). These aggregation areas are believed to be where Atlantic sturgeon overwinter and/or forage (Laney *et. al* 2007; Erickson *et al*. 2011; Dunton *et al*. 2010). Areas between these sites are used by sturgeon migrating to and from these areas, as well as to spawning grounds found within natal rivers.

Adult sturgeon return to their natal river to spawn in the spring. South of Cape Cod, the nearest rivers to the action area that is known to regularly support Atlantic sturgeon spawning is the Hudson River. Atlantic sturgeon may also at least occasionally spawn in the Connecticut River. Marine and estuarine areas adjacent to spawning rivers are high use areas for Atlantic sturgeon; no such areas exist in the action area. The action area has not been systematically surveyed for Atlantic sturgeon; however, a number of surveys occur regularly in the action area that are designed to characterize the fish community and use sampling gear that is expected to collect Atlantic sturgeon if they were present in the area. One such survey is the Northeast Area Monitoring and Assessment Program (NEAMAP), which samples from Cape Cod, MA south to Cape Hatteras, NC and targets both juvenile and adult fishes. Atlantic sturgeon are regularly captured in this survey; however, there are few instances of collection in the action area. The area is also sampled in the NEFSC bottom trawl surveys; few Atlantic sturgeon are collected in this area.

Between March 2009 and February 2012, 173 Atlantic sturgeon were documented as bycatch in Federal fisheries by the Northeast Observer Program. Observers operated on fishing vessels from the Gulf of Maine to Cape Hatteras. Observer Program coverage across this entire area for this period was 8% of all trips with the exception that Observer coverage for the New England ground fish fisheries, extending from Maine to Rhode Island, was an additional 18% (26% coverage in total). Despite the highest observer coverage in the ground fish fisheries that overlap with the action area and the regular occurrence of commercial fishing activity in the action area, only 2 of the 173 Atlantic sturgeon observed by the observer program in this period were collected in the action area.

None of the scientific literature that has examined the distribution of Atlantic sturgeon in the marine environment has identified the project area as a “hot spot” or an identified aggregation area (see above). However, given the depths (less than 50m) and the predominantly sandy substrate which are consistent habitat parameters with offshore areas where Atlantic sturgeon are known to occur, and the occasional collection of Atlantic sturgeon in this area in regional surveys and in commercial fisheries, at least some Atlantic sturgeon are likely to be present in the project area. Based on the location of spawning rivers both north and south of the project area and the general distribution of Atlantic sturgeon in the marine environment, we expect that individual Atlantic sturgeon will be moving through the project area during the warmer months of the area and may be foraging opportunistically in areas where benthic invertebrates are present; however, the area is not known to be a preferred foraging area.

Spawning, juvenile growth and development, and overwintering are not known to occur in the action area. While individuals may be present year-round, we expect the majority of individual Atlantic sturgeon to be present from April to November.

However, given the known marine mixing of Atlantic sturgeon in waters south of Cape Cod, we expect that individuals from any of the five DPSs could be present in the action area, with the majority of individuals from the Gulf of Maine and New York Bight DPSs.

6.4 Consideration of Federal, State and Private Activities in the Action Area

Fishing Activity in the Action Area

Commercial and recreational fishing occurs throughout the action area. Excluding the vessel routes to Canada, the action area overlaps with a portion of NMFS statistical areas 537, 538, and 539. The WDA occupies a small portion (<1%) of area 537. The vessel routes to Canadian ports and the area that may be transited by vessels from Europe overlap with a number of offshore statistical areas. Commercial fishing in the action area is authorized by the individual states or by NMFS under the Magnuson-Stevens Fishery Conservation and Management Act. Fisheries that operate pursuant to the MSFCMA have undergone consultation pursuant to section 7 of the ESA. It is important to note that in nearly all cases, the location where a whale first encountered entangling gear is unknown and the location reported is the location where the entangled whale was first sighted. Given that fisheries occur in the action area that are known to interact with large whales, we consider that there is a past and ongoing risk of entanglement in the action area; the degree of risk in the future may change in association with fishing practices and accompanying regulations.

The risk of entanglement in fishing gear to fin, sei, and sperm whales in the action area appears to be low. Hayes et al. (2016) reports that no confirmed fishery-related mortalities or serious injuries of sei whales have been reported in the NMFS Sea Sampling bycatch database and that a review of the records of stranded, floating, or injured sei whales for the period 2010 through 2014 on file at NMFS found no records with substantial evidence of fishery interactions causing serious injury or mortality, which results in an annual serious injury and mortality rate of 0 sei whales from fishery interactions. Waring et al. (2015), reports that sperm whales have not been documented as bycatch in the observed U.S. Atlantic commercial fisheries. No confirmed fishery-related mortalities or serious injuries of fin whales have been reported in the NMFS Sea Sampling bycatch database and a review of the records of stranded, floating, or injured fin whales for the period 2012 through 2016 on file at NMFS found no records with substantial evidence of fishery interactions causing mortality in U.S. waters ((Hayes et al. 2019).
We have reviewed the most recent five years of data available on reported entanglements for the ESA listed whale stocks that occur in the action area (2012-2016 for fin and right whales (Hayes et al. 2019); 2008-2012 for sperm whales (Waring et al. 2015); and 2010-2014 for sei whales (Hayes et al, 2017)). For the period of review, the minimum rate of serious injury or mortality resulting from incidental interactions with U.S. fisheries is reported as 5.15/year for right whales, 1.1/year for fin whales, 0.8 for sei whales, and 0 for sperm whales (Hayes et al., 2019; Waring et al. 2015; Hayes et al., 2017). In all cases, the authors note that this is a minimum estimate of the amount of entanglement and resultant serious injury or mortality. These data represent only known mortalities and serious injuries; more, undocumented mortalities and serious injuries have likely occurred and gone undetected due to the offshore habitats where large whales occur.

We also reviewed available data that post-dates the information presented in the most recent stock assessment reports. As reported by NMFS[13], in 2017, 12 dead right whales were observed in Canada; all sightings were outside of the action area. Entanglement was identified as the cause of death of two of the six whales where cause of death could be determined. One of the individuals was anchored by the entangling gear in the Gulf of St. Lawrence, the other was also documented in the Gulf of St. Lawrence and the entangling gear was present. Five dead right whales were observed in the U.S. in 2017, of three that could be examined, entanglement was the suspected or probable cause of death. No entangled right whales were observed in Canada in 2018; however, three dead right whales were observed in the U.S. in 2018. Of these, one had

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[13] Information in this paragraph related to the UME is available at: *https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2020-north-atlantic-right-whale-unusual-mortality-event*; last accessed on August 13, 2020

gear present and the other two had a cause of death of suspected entanglement. In, 2019, 9 dead right whales were observed in Canada, all in the Gulf of St. Lawrence. Of the four whales for which cause of death has been determined, the cause was recorded as suspected or probable blunt force trauma due to vessel strike. Also in 2019, one right whale mortality was recorded in U.S. waters (off Long Island) with the cause of death recorded as probably acute entanglement. To date in 2020, a single right whale mortality has been documented – a calf in New Jersey with a cause of death attributable to vessel strike.

Given the co-occurrence of fisheries and large whales in the action area, we assume that there have been entanglements in the action area in the past and that this risk will persist at some level throughout the life of the project. However, it is important to note that several significant actions have been taken to reduce the risk of entanglement in fisheries that operate in the action area and that new efforts to revise the regulations under the Atlantic Large Whale Take Reduction Plan are ongoing. As of July 2020, NMFS is in the process of developing a draft Environmental Impact Statement to address measures to reduce entanglements of large whales through modifications to the ALWTRP. The goal of the ALWTRP is to reduce injuries and deaths of large whales due to incidental entanglement in fishing gear. The ALWTRP is an evolving plan that changes as NMFS learns more about why whales become entangled and how fishing practices might be modified to reduce the risk of entanglement. It has several components including restrictions on where and how gear can be set; research into whale populations and whale behavior, as well as fishing gear interactions and modifications; outreach to inform and collaborate with fishermen and other stakeholders; and a large whale disentanglement program that seeks to safely remove entangling gear from large whales whenever possible. We expect that through the current initiative the risk of entanglement within the action area will decrease over the life of the action due to compliance of state and federal fisheries with new ALWTRP measures. All states that regulate fisheries in the action area codify the ALWTRP measures into their state fishery regulations.

Atlantic sturgeon are captured as bycatch in trawl and gillnet fisheries. An analysis of the NEFOP/ASM bycatch data from 2000-2015 (ASMFC 2017) found that most trips that encountered Atlantic sturgeon were in depths less than 20 meters and water temperatures between 45-60°F. Average mortality in bottom otter trawls was 4% and mortality averaged 30% in gillnets (ASMFC 2017). We queried the most recent five years of data in the NMFS NEFOP and ASM database for the number of reports of Atlantic sturgeon bycatch in the three statistical areas that overlap with the action area (537, 538, and 539[14]) where we expect Atlantic sturgeon to occur. The NEFOP program samples a percentage of trips from the Gulf of Maine to Cape Hatteras while the ASM program provides additive coverage for the New England ground fish fisheries, extending from Maine to New York. For the most recent five-year period that data are available (2014-2018), a total of 74 Atlantic sturgeon were reported as bycatch in bottom otter trawls and gillnets in these three statistical areas that overlap the action area, this represents approximately 5% of the total bycatch of Atlantic sturgeon in the Maine to Cape Hatteras area where the NEFOP, and Maine to New York area where the ASM program, operates. Note that

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[14] Map available at: https://www.greateratlantic.fisheries.noaa.gov/educational_resources/gis/gallery/grafostatisticalareas.html

the action area occupies only a portion of area 538 and 539 and a very small percentage of area 537. We expect that incidental capture of Atlantic sturgeon will continue in the action area at a similar rate over the life of the proposed action. While the rate of encounter is low and survival is relatively high (96% in otter trawls and 70% in gillnets), bycatch is expected to be the primary source of mortality of Atlantic sturgeon in the action area.

Sea turtles are vulnerable to capture in trawls as well as entanglement in gillnets and vertical lines. Using the same data source as for Atlantic sturgeon, there were a total of 25 incidents of observed sea turtle bycatch in gillnet, trap/pot, and bottom otter trawl fisheries in areas 537, 538, and 539 (1 green, 2 Kemp's ridley, 3 leatherback, 15 loggerhead and 4 unknown). Leatherback sea turtles are particularly vulnerable to entanglement in vertical lines. Since 2005, over 230 leatherbacks have been reported entangled in vertical lines in Massachusetts alone. In response to high numbers of leatherback sea turtles found entangled in the vertical lines of fixed gear in the Northeast Region, NMFS established the Northeast Atlantic Coast Sea Turtle Disentanglement Network (STDN). Formally established in 2002, the STDN is an important component of the National Sea Turtle Stranding and Salvage Network. The STDN works to reduce serious injuries and mortalities caused by entanglements and is active throughout the action area responding to reports of entanglements. Where possible, turtles are disentangled and may be brought back to rehabilitation facilities for treatment and recovery. This helps to reduce the rate of death from entanglement. We expect that incidental capture and entanglement of sea turtles will continue in the action area at a similar rate over the life of the proposed action. Safe release and disentanglement protocols help to reduce the severity of impacts of these interactions and these efforts are also expected to continue over the life of the project.

Vessel Operations

All portions of the action area are used by a variety of vessels ranging from small recreational fishing vessels to large commercial cargo ships. Commercial vessel traffic in the action area includes research, tug/barge, liquid tankers, cargo, military and search-and-rescue vessels, and commercial fishing vessels. In the COP, Vineyard Wind reports on vessel traffic in the WDA based on AIS data from 2016 and 2017. Based on this data, the most common type of vessels transiting in the WDA are commercial fishing vessels. Commercial vessel traffic in the region is variable depending on location and vessel type. The Northeast Regional Ocean Council (NROC) assessed AIS data in the project area from 2011-2013 and established relative densities of various vessel types. Commercial vessel types and relative density in the area during 2011-2013 included cargo (low), passenger (high), tug-tow (high), and tanker (low) (COP Volume III; Epsilon 2020). As described in Appendix III-I of the COP, commercial vessel traffic in the vicinity of the WDA is heaviest in four primary areas: 1) vessels approaching, entering, and exiting Narragansett Bay; 2) vessels entering and exiting Buzzards Bay; 3) vessels traveling from Hyannis to Nantucket; and 4), vessels traveling from Woods Hole to Vineyard Haven. A high volume of passenger ferry traffic occurs between Cape Cod and Nantucket and Martha's Vineyard. These vessels typically stay within 9.6 km (6 mi) of the shoreline while transporting passengers throughout Rhode Island and Massachusetts, but must cross Nantucket Sound and the proposed cable corridor when transporting passengers to Martha's Vineyard and Nantucket. Both seasonal and year-round service is provided by several ferry companies, with more than twenty-four daily trips between Hyannis and Nantucket during the peak of the summer season.

In addition to commercial fishing activity, recreational boating, including paddle sports, sport fishing, and diving occur in the action area. Recreational boating activity varies seasonally, with peak boating season occurring between May and September. Other boat-based recreational activities, including canoeing, kayaking, and paddle boarding take place close to shore, in sheltered waters, and predominantly within one mile of the coastline. Recreational fishing vessels operate from nearly every harbor in Massachusetts and Rhode Island; in addition, ramp-launched vessels are brought to the action area from other parts of New England. BOEM estimates that, of the nearly two million angler trips occurring in Massachusetts between 2007 and 2012, approximately 4.4% of those angler trips occurred within one mile of the Massachusetts Wind Energy Area (MA WEA) (Kirkpatrick et al., 2017). Substantially fewer numbers of angler trips originating in New York and Rhode Islands occurred within one mile of the MA WEA. During that same time period, recreational angler trips occurring within one mile of the MA WEA most frequently originated from Tisbury, Nantucket, and Falmouth Harbors; while fewer than 600 angler trips originated from Rhode Island (Kirkpatrick et al., 2017).

Atlantic sturgeon, sea turtles, and ESA listed whales are all vulnerable to vessel strike, although the risk factors and areas of concern are different. Vessels have the potential to affect animals through strikes, sound, and disturbance by their physical presence. Vessel strike is a significant and widespread concern for the recovery of the listed species that occur in the action area. However, Atlantic sturgeon are only known to be at risk of vessel strike within rivers and estuaries. As these habitats do not occur in the action area, we do not expect Atlantic sturgeon to be struck by vessels in the action area.

A review of available data on serious injury and mortality determinations for sei, fin, sperm, and right whales for 2000-2019, includes three records of fin whales and two records of right whales presumed to have been killed by vessel strike that were first detected in the action area. No vessel struck sei or sperm whales have been documented in the action area. We expect that a similar rate of strike will continue in the action area over the life of the project and that vessel strike will continue to be a source of mortality for right and fin whales in the action area. As outlined below, there are a number of measures that are in place to reduce the risk of vessel strikes to large whales that apply to vessels that operate in the action area.

To comply with the Ship Strike Reduction Rule (50 CFR 224.105), all vessels greater than or equal to 65 ft. (19.8 m) in overall length and subject to the jurisdiction of the United States and all vessels greater than or equal to 65 ft. in overall length entering or departing a port or place subject to the jurisdiction of the United States must slow to speeds of 10 knots or less in seasonal management areas (SMA). One such SMA, the Block Island SMA, overlaps with a portion of the action area. All vessels 65 feet or longer that transit the SMA from November 1 – April 30 each year (the period when right whale abundance is greatest) must operate at 10 knots or less. Mandatory speed restrictions of 10 knots or less are required in Seasonal Management Areas along the U.S. East Coast during times when right whales are likely to be present. The purpose of this regulation is to reduce the likelihood of deaths and serious injuries to these endangered whales that result from collisions with ships.

Restrictions are in place on how close vessels can approach right whales to reduce vessel-related impacts, including disturbance. NMFS rulemaking (62 FR 6729, February 13, 1997) restricts vessel approach to right whales to a distance of 500 yards. This rule is expected to reduce the potential for vessel collisions and other adverse vessel-related effects in the environmental baseline. The Mandatory Ship Reporting System (MSR) requires ships entering the northeast and southeast MSR boundaries to report the vessel identity, date, time, course, speed, destination, and other relevant information. In return, the vessel receives an automated reply with the most recent right whale sightings or management areas and information on precautionary measures to take while in the vicinity of right whales.

Seasonal Management Areas are supplemented by Dynamic Management Areas (DMAs) that are implemented for 15-day periods in areas in which right whales are sighted outside of SMA boundaries (73 FR 60173; October 10, 2008). DMAs can be designated anywhere along the U.S. eastern seaboard, including the action area, when NOAA aerial surveys or other reliable sources report aggregations of three or more right whales in a density that indicates the whales are likely to persist in the area. DMAs are put in place for two weeks in an area that encompass an area commensurate to the number of whales present. Mariners are notified of DMAs via email, the internet, Broadcast Notice to Mariners (BNM), NOAA Weather Radio, and the Mandatory Ship Reporting system (MSR). NOAA requests that mariners route around these zones or transit through them at 10 knots or less. Compliance with these zones is voluntary.

NMFS' Sea Turtle Stranding and Salvage Network (STSSN) database provides information on records of stranded sea turtles in the region. We queried the STSSN database for records of stranded sea turtles with evidence of vessel strike throughout the waters of Rhode Island and Massachusetts, south and east of Cape Cod. Out of the 118 recovered stranded sea turtles in the southern New England region during the most recent three year period for which data was available, there were 33 recorded sea turtle vessel strikes, primarily between the months of August and November. The majority of strikes were of leatherbacks with a smaller number of loggerhead and green; there are no records of Kemp's ridleys struck in the action area. We expect that a similar rate of strike will continue in the action area over the life of the project and that vessel strike will continue to be a source of mortality for sea turtles in the action area.

Other Activities in the Action Area

Other activities that occur in the action area that may affect listed species include scientific research and geophysical and geotechnical surveys. Military operations in the action area are expected to be restricted to vessel transits, the effects of which are subsumed in the discussion of vessel strikes above.

Scientific Surveys

Numerous scientific surveys, including fisheries and ecosystem surveys carried out by NMFS operate in the action area. Regulations issued to implement section 10(a) (1)(A) of the ESA allow issuance of permits authorizing take of ESA-listed species for the purposes of scientific research. Prior to the issuance of such a permit, an ESA section 7 consultation must take place. No permit can be issued unless the proposed research is determined to be not likely to jeopardize the continued existence of any listed species. Scientific research permits are issued by NMFS for ESA listed whales and Atlantic sturgeon; the U.S. Fish and Wildlife Service is the permitting authority for ESA listed sea turtles.

Marine mammals, sea turtles, and Atlantic sturgeon have been the subject of field studies for decades. The primary objective of most of these field studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Research on ESA listed whales, sea turtles, and Atlantic sturgeon has occurred in the action area in the past and is expected to continue over the life of the proposed action. Authorized research on ESA-listed whales includes close vessel and aerial approaches, photographic identification, photogrammetry, biopsy sampling, tagging, ultrasound, exposure to acoustic activities, breath sampling, behavioral observations, passive acoustic recording, and underwater observation. No lethal interactions are anticipated in association with any of the permitted research. ESA-listed sea turtle research includes approach, capture, handling, restraint, tagging, biopsy, blood or tissue sampling, lavage, ultrasound, imaging, antibiotic (tetracycline) injections, laparoscopy, and captive experiments. Most authorized take is sub-lethal with limited amounts of incidental mortality authorized in some permits (i.e., no more than one or two incidents per permit and only a few individuals overall). Authorized research for Atlantic sturgeon includes capture, collection, handling, restraint, internal and external tagging, blood or tissue sampling, gastric lavage, and collection of morphometric information. Most authorized take of Atlantic sturgeon for research activities is sub-lethal with small amounts of incidental mortality authorized (i.e., no more than one or two incidents per permit and only a few individuals overall).

Noise

The ESA-listed species that occur in the action area are regularly exposed to several sources of anthropogenic sounds in the action area. The major source of anthropogenic noise in the action area are vessels. Other sources are minor and temporary including short-term dredging, construction and research activities. As described in the DEIS, typically, military training exercises occur in deeper offshore waters southeast of the WDA, though transit of military vessels may occur throughout the area; therefore, while military operations can be a significant source of underwater noise that is not the case in the action area. ESA-listed species may be impacted by either increased levels of anthropogenic-induced background sound or high intensity, short- term anthropogenic sounds. Ambient noise within the Lease Area was measured as, on average, between 76.4 and 78.3 decibels (dB) re 1 µPa2 /Hz (Alpine Ocean Seismic Surveying Inc., 2017 in COP Volume III, section 6); no effects to listed species are anticipated on exposure to noise at these levels. Short term increases in noise in the action area associated with vessel traffic and other activities, including geotechnical and geophysical surveys that have taken place in the past and will continue in the future in the portions of the action area that overlap with other offshore wind lease areas and/or potential cable routes. Exposure to these noise sources can result in temporary masking or temporary behavioral disturbance; however, in all cases, these effects are expected to be temporary and short term (e.g., the seconds to minutes it takes for a vessel to pass by) and not result in any injury or mortality in the action area. No acoustic surveys using seismic equipment or airguns have been proposed in the action area and none are anticipated to take place in the future, as that equipment is not necessary to support siting of future offshore wind development that is anticipated to occur in the action area.

Other Factors

Whales, sea turtles, and Atlantic sturgeon are exposed to a number of other stressors in the action area that are widespread and not unique to the action area which makes it difficult to determine to what extent these species may be affected by past, present, and future exposure within the action area. These stressors include water quality and marine debris. Marine debris in some form is present in nearly all parts of the world's oceans, including the action area. While the action area is not known to aggregate marine debris as occurs in some parts of the world (e.g., The Great Pacific garbage patch, also described as the Pacific trash vortex, a gyre of marine debris particles in the north central Pacific Ocean), marine debris, including plastics that can be ingested and cause health problems in whales and sea turtles is expected to occur in the action area.

A study conducted by the EPA evaluated over 1,100 coastal locations in 2010, as reported in their National Coastal Condition Assessment (EPA, 2015). The EPA used a Water Quality Index (WQI) to determine the quality of various coastal areas including the northeast coast from Virginia to Maine and assigned three condition levels for a number of constituents: good, fair, and poor. A number of the sample locations overlap with the action area. Chlorophyll a concentrations, an indicator of primary productivity, levels in northeastern coastal waters were generally rated as fair (45%) to good (51%) condition, and stations in the action area were all also fair to good (EPA, 2015). Nitrogen and phosphorous levels in northeastern coastal waters generally rated as fair to good (13% fair and 82% good for nitrogen and 62% and 26% good for phosphorous); stations in the action area were all also fair to good (EPA 2015). Dissolved oxygen levels in northeastern coastal waters are generally rated as fair (14%) to good (80%) condition, with consistent results for the sampling locations in the action area. Based on the available information, water quality in the action area appears to be consistent with surrounding areas. We are not aware of any discharges to the action area that would be expected to result in adverse effects to listed species or their prey. Outside of conditions related to climate change, discussed in section 7.3, we do not expect any negative effects of water quality on listed species while in the action area.

7.0 EFFECTS OF THE ACTION

This section of the biological opinion assesses the effects of the proposed action on threatened or endangered species. Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR §402.02 and § 402.17).

The effects of the issuance of an IHA and other ancillary permits/authorizations, such as the USACE and EPA permits, are considered effects of the action as they are consequences of another activity that is caused by the proposed action (e.g., the proposed construction of the Vineyard Wind project causes the need for an IHA); however, they are also separate Federal actions that trigger consultation in their own right. In this consultation, we have worked with NMFS through its Office of Protected Resources as the action agency proposing to authorize marine mammal takes under the MMPA through the IHA, as well as with other Federal agencies aside from BOEM that are proposing to issue permits or other approvals, and we have analyzed the effects of those actions along with the effects of BOEM's proposed action.

There are a number of lease areas geographically close to OCS-A 0501 where the proposed project will be built and two lease areas are adjacent to OCS-A 0501. The Vineyard Wind project is not the "but for" cause of any other projects. None of the future projects in other lease areas are dependent on the Vineyard Wind project and all would have an independent utility apart from the Vineyard Wind project. In addition, the potential projects in other lease areas are not, at this time, reasonably certain to occur, given the significant economic, administrative, and legal requirements necessary for the activity to go forward. While BOEM has received Construction and Operations Plans for review for a number of lease areas in the U.S. Atlantic, all of these are still undergoing review. Further, only one project (South Fork Wind Farm, Lease OCS A-0517) has started environmental review under NEPA, but the draft EIS is not due for release until January 2021 and no permitting decision is expected before January 2022[15]. Therefore, any future effects of development of these lease areas are not consequences of the proposed action. The proposed project would result in placement of WTGs in a portion of OCS-A 0501; it is possible that the remainder of the lease area could be developed in the future. However, any future construction on the remainder of OCS-A 0501 is outside the scope of the current proposed Vineyard Wind project and does not depend on the proposed Vineyard Wind project for its future justification. In addition, any future wind development on OCS-A 0501 would have independent utility apart from the proposed project. As such, these future potential actions are not effects of the Vineyard Wind Project. Any future construction, operations, and maintenance of wind energy facilities on the remainder of OCS-A 0501 or any other lease area would be considered in a subsequent and separate environmental review and would be the subject of separate ESA Section 7 consultation between BOEM (as lead Federal agency) and NMFS.

The purpose of the Vineyard Wind project is to generate electricity. Electricity will travel from the WTGs to the ESP and then by submarine cable to on-land cables in Massachusetts. From this point, electricity generated at the WTGs would be distributed to the New England Power Grid, which is managed by ISO New England, and pools electricity from numerous sources. Power from the project is expected to displace electricity generated by existing fossil-fuel fired plants (Epsilon 2020). Electricity will then be used to support existing uses. ISO New England reports about 31,000 MW of generating capability for summer and 33,000 MW for winter[16] and notes roughly 7,000 MW of generation have retired since 2013 or will retire in the next few years, with another 5,000 MW from coal- and oil-fired plants at risk of retirement in the coming years. The maximum electric output of the Vineyard Wind project is 800 MW. All of the electricity generated will support existing uses.

Even if we assume the Vineyard Wind project will increase overall supply of electricity, we are not aware of any new actions demanding electricity that would not be developed but for the Vineyard Wind project specifically. Because the electricity generated by Vineyard Wind will be pooled with that of other sources in the power grid, we are unable to trace any particular new use

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[15] *https://www.boem.gov/renewable-energy/state-activities/south-fork* and *https://www.permits.performance.gov/permitting-projects/south-fork-wind-farm-and-south-fork-export-cable*; last accessed August 24, 2020

[16] https://www.iso-ne.com/about/key-stats/resource-mix/; last accessed July 21, 2019.

to Vineyard Wind's contribution to the grid and, therefore, we cannot identify which impacts, positive or negative, if any, would occur because of the Vineyard Wind project. Therefore, there are not any identified consequences associated with Vineyard Wind's production of electricity.

In the BA, BOEM describes the various port facilities that may be used to support the Vineyard Wind project including a new operations and maintenance facility in Vineyard Haven on Martha's Vineyard. BOEM states that the Operations and Maintenance Facilities would include offices, control rooms, shop space, and pier space but that Vineyard Wind does not propose to direct or implement any port improvements. BOEM also states in the BA that no other port improvements are proposed. In July 2018, a pre-application meeting was held with the USACE to discuss potential improvements to Tisbury marina facilities. It is possible that these improved facilities could be used to support the Vineyard Wind project. However, because no permit applications have been submitted and there is uncertainty regarding the viability of the proposed improvements, these improvements are not reasonably certain to occur. As such, even if the Tisbury marina project would not occur but for the Vineyard Wind project, it is not reasonably certain to occur and therefore, does not meet the definition of an effect of the action. In conclusion, based on the information in the BA, which is consistent with the information in the COP (Volume I, Section 3.2.5; Epsilon 2020), there are no port improvements that would be considered effects of the action.

In the BA, BOEM characterizes vessels transporting manufactured components in international waters as "interrelated effects of the proposed action." We consider these vessel trips to be part of the proposed action as it is our understanding that these vessel trips would not occur but for the proposed action (i.e., while it is possible that the same vessels would make trans-Atlantic trips for other purposes absent the Vineyard Wind project, the trips considered here are for the sole purpose of supporting the Vineyard Wind project).

Here, we examine the activities associated with the proposed action and determine what the consequences of the proposed action are to listed species or critical habitat. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. In analyzing effects, we evaluate whether a source of impacts is "likely to adversely affect" listed species/critical habitat or "not likely to adversely affect" listed species/critical habitat. A "not likely to adversely affect" determination is appropriate when an effect is expected to be discountable, insignificant, or completely beneficial. As discussed in the FWS-NMFS Joint Section 7 Consultation Handbook (1998), "[b]eneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur. "Take" means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct" (ESA §3(19)). "Take" is not anticipated if an effect is beneficial, discountable, or insignificant.

7.1 Underwater Noise

In this section, we provide background information on underwater noise and listed species, establish the underwater noise that listed species are likely to be exposed to and then establish the expected response of the individuals exposed to that noise.

7.1.1 Background on Noise

This section contains a brief technical background on sound, on the characteristics of certain sound types, and on metrics used in this proposal inasmuch as the information is relevant to the specified activity and to a discussion of the potential effects of the specified activity on listed species found later in this document.

Sound travels in waves, the basic components of which are frequency, wavelength, velocity, and amplitude. Frequency is the number of pressure waves that pass by a reference point per unit of time and is measured in hertz (Hz) or cycles per second. Wavelength is the distance between two peaks or corresponding points of a sound wave (length of one cycle). Higher frequency sounds have shorter wavelengths than lower frequency sounds, and typically attenuate (decrease) more rapidly, except in certain cases in shallower water. Amplitude is the height of the sound pressure wave or the "loudness" of a sound and is typically described using the relative unit of the decibel (dB). A sound pressure level (SPL) in dB is described as the ratio between a measured pressure and a reference pressure (for underwater sound, this is 1 microPascal (μPa)), and is a logarithmic unit that accounts for large variations in amplitude; therefore, a relatively small change in dB corresponds to large changes in sound pressure. The source level (SL) represents the SPL referenced at a distance of 1 m from the source (referenced to 1 μPa), while the received level is the SPL at the listener's position (referenced to 1 μPa).

Root mean square (rms) is the quadratic mean sound pressure over the duration of an impulse. Root mean square is calculated by squaring all of the sound amplitudes, averaging the squares, and then taking the square root of the average (Urick, 1983). Root mean square accounts for both positive and negative values; squaring the pressures makes all values positive so that they may be accounted for in the summation of pressure levels (Hastings and Popper, 2005). This measurement is often used in the context of discussing behavioral effects, in part because behavioral effects, which often result from auditory cues, may be better expressed through averaged units than by peak pressures.

Sound exposure level (SEL; represented as dB re 1 μPa^2-s) represents the total energy in a stated frequency band over a stated time interval or event, and considers both intensity and duration of exposure. The per-pulse SEL is calculated over the time window containing the entire pulse (*i.e.*, 100 percent of the acoustic energy). SEL is a cumulative metric; it can be accumulated over a single pulse, or calculated over periods containing multiple pulses. Cumulative SEL represents the total energy accumulated by a receiver over a defined time window or during an event. Peak sound pressure (also referred to as zero-to-peak sound pressure or 0-pk) is the maximum instantaneous sound pressure measurable in the water at a specified distance from the source, and is represented in the same units as the rms sound pressure.

When underwater objects vibrate or activity occurs, sound-pressure waves are created. These waves alternately compress and decompress the water as the sound wave travels. Underwater sound waves radiate in a manner similar to ripples on the surface of a pond and may be either directed in a beam or beams or may radiate in all directions (omnidirectional sources), as is the case for sound produced by the pile driving activity considered here. The compressions and decompressions associated with sound waves are detected as changes in pressure by aquatic life and man-made sound receptors such as hydrophones.

Even in the absence of sound from the specified activity, the underwater environment is typically loud due to ambient sound, which is defined as environmental background sound levels lacking a single source or point (Richardson *et al*., 1995). The sound level of a region is defined by the total acoustical energy being generated by known and unknown sources. These sources may include physical (*e.g.*, wind and waves, earthquakes, ice, atmospheric sound), biological (*e.g.*, sounds produced by marine mammals, fish, and invertebrates), and anthropogenic (*e.g.*, vessels, dredging, construction) sound. A number of sources contribute to ambient sound, including wind and waves, which are a main source of naturally occurring ambient sound for frequencies between 200 hertz (Hz) and 50 kilohertz (kHz) (Mitson, 1995). In general, ambient sound levels tend to increase with increasing wind speed and wave height. Precipitation can become an important component of total sound at frequencies above 500 Hz, and possibly down to 100 Hz during quiet times. Marine mammals can contribute significantly to ambient sound levels, as can some fish and snapping shrimp. The frequency band for biological contributions is from approximately 12 Hz to over 100 kHz. Sources of ambient sound related to human activity include transportation (surface vessels), dredging and construction, oil and gas drilling and production, geophysical surveys, sonar, and explosions. Vessel noise typically dominates the total ambient sound for frequencies between 20 and 300 Hz. In general, the frequencies of anthropogenic sounds are below 1 kHz and, if higher frequency sound levels are created, they attenuate rapidly.

The sum of the various natural and anthropogenic sound sources that comprise ambient sound at any given location and time depends not only on the source levels (as determined by current weather conditions and levels of biological and human activity) but also on the ability of sound to propagate through the environment. In turn, sound propagation is dependent on the spatially and temporally varying properties of the water column and sea floor, and is frequency-dependent. As a result of the dependence on a large number of varying factors, ambient sound levels can be expected to vary widely over both coarse and fine spatial and temporal scales. Sound levels at a given frequency and location can vary by 10-20 decibels (dB) from day to day (Richardson *et al*., 1995). The result is that, depending on the source type and its intensity, sound from the specified activity may be a negligible addition to the local environment or could form a distinctive signal that may affect a particular species. As noted in the Environmental Baseline, ambient noise within the Lease Area was measured as, on average, between 76.4 and 78.3 decibels (dB) re 1 μPa^2 /Hz (with measurements ranging from 67.2 to 88.09 dB) re 1 μPa^2 /Hz (Alpine Ocean Seismic Surveying Inc., 2017 in COP Volume III, section 6).

Sounds are often considered to fall into one of two general types: pulsed and non-pulsed. The distinction between these two sound types is important because they have differing potential to cause physical effects, particularly with regard to hearing (*e.g.*, Ward, 1997 in Southall *et al*., 2007).

Pulsed sound sources (*e.g.*, impact pile driving) produce signals that are brief (typically considered to be less than one second), broadband, atonal transients (ANSI, 1986, 2005; Harris, 1998; NIOSH, 1998; ISO, 2003) and occur either as isolated events or repeated in some succession. Pulsed sounds are all characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures, and generally have an increased capacity to induce physical injury as compared with sounds that lack these features.

Non-pulsed sounds can be tonal, narrowband, or broadband, brief or prolonged, and may be either continuous or intermittent (ANSI, 1995; NIOSH, 1998). Some of these non-pulsed sounds can be transient signals of short duration but without the essential properties of pulses (*e.g.*, rapid rise time). Examples of non-pulsed sounds include those produced by vessels, aircraft, machinery operations such as drilling or dredging, and vibratory pile driving.

Specific to pile driving, the impulsive sound generated by impact hammers is characterized by rapid rise times and high peak levels. Vibratory hammers produce non-impulsive, continuous noise at levels significantly lower than those produced by impact hammers. Rise time is slower, reducing the probability and severity of injury, and sound energy is distributed over a greater amount of time (*e.g.*, Nedwell and Edwards, 2002; Carlson *et al*., 2005).

7.1.1 Summary of Available Information on Sources of Increased Underwater Noise

During the construction phase of the project, sources of increased underwater noise include pile driving, vessel operations, and other underwater construction activities (cable laying, placement of scour protection, dredging). During the operations and maintenance phase of the project, sources of increased underwater noise are limited to WTG operations, vessel and aircraft operations, and maintenance activities. During decommissioning, sources of increased underwater noise include removal of project components and associated surveys, as well as vessel and aircraft operations. Here, we present a summary of available information on these noise sources. More detailed information is presented in the COP (Appendix III-M) and BOEM's BA.

Pile Driving

Based on BOEM's description of the proposed action, up to 102 days of pile driving may occur between May 1 and December 31; no pile driving activities would occur from January 1 through April 30. No more than two foundations will be installed per day and the number of days of pile driving is directly related to the number of foundations installed (i.e., fewer foundations will require fewer days of pile driving). 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). Up to 100 monopile foundations and up to 12 jacket foundations may be installed; however, the total number of piles installed will not exceed 102.

The BA and supplemental information provided by BOEM present modeling scenarios that predict the underwater noise associated with installation of the various types of piles. 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 7.1 presents the maximum 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. If fewer than 102 piles are installed, pile driving would occur on proportionally fewer days.

Table 7.1: Maximum Pile Driving Days per Month

Month	100 monopiles/2 jackets (number of pile driving days)[a]		90 monopiles/12 jackets (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

As described above, Vineyard Wind has incorporated more than one design scenario in their planning of the project. This approach, called the "design envelope" concept, allows for flexibility on the part of the developer, in recognition of the fact that offshore wind technology and installation techniques are constantly evolving and exact specifications of the project are not yet certain as of the publishing of this document. In recognition of the need to ensure that the range of potential impacts to marine species from the various potential scenarios within the design envelope are accounted for, potential design scenarios were modeled separately in order to conservatively assess the impacts of each scenario. The two installation scenarios modeled to demonstrate the maximum impact of the design envelope are shown in Table 7.2 and consist of: (1) The "maximum design" consisting of ninety 10.3 m (33.8 ft.) WTG monopile foundations, 10 jacket foundations (*i.e.*, 40 jacket piles), and two jacket foundations for ESPs (*i.e.,* eight jacket piles), and (2) the "most likely design" consisting of one hundred 10.3 m (33.8 ft.) WTG monopile foundations and two jacket foundations for ESPs (*i.e.,* eight jacket piles). Note that at the time of model development, installation of 8 MW turbines was considered "most likely." At the time of completion of this Opinion, while these "maximum design" and "most likely design" scenarios are a reasonable representation of the maximum impact scenario, Vineyard Wind is considering installing fewer turbines of higher capacity. Depending on product selection, as few as 57 turbines may end up being installed.

Table 7.2: Potential Construction Scenarios Modeled

Design 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 number of piles	Total number of installation locations
Maximum design	90	10	2	138	102
Most likely design	100	0	2	108	102

As Vineyard Wind may install either one or two monopiles per day, both the "maximum design" and "most likely design" scenarios were modeled assuming the installation of one foundation per day and two foundations per day distributed across the same calendar period. No more than one jacket would be installed per day thus, one jacket foundation per day (four piles) was assumed for both scenarios. No concurrent pile driving (*i.e.,* driving of more than one pile at a time) would occur and therefore concurrent driving was not modeled. The pile-driving schedules for modeling were created based on the number of expected suitable weather days available per month (based on weather criteria determined by Vineyard Wind) in which pile driving may occur to better understand when the majority of pile driving is likely to occur throughout the year. The number of suitable weather days per month was obtained from historical weather data. The modeled pile-driving schedule for the Maximum Design scenario is shown in Table 7.2 above.

Piles for monopile foundations would be constructed for specific locations with maximum diameters ranging from ~8 m (26.2 ft.) up to ~10.3 m (33.8 ft.) and an expected median diameter of ~9 m (29.5 ft.). The 10.3 m (33.8 ft.) monopile foundation is the largest potential pile diameter proposed for the project; while a smaller diameter pile may ultimately end up being installed, 10.3 m represents the largest potential diameter (regardless of ultimate turbine capacity) and was therefore used in modeling of monopile installation to be conservative. Jacket foundations each require the installation of three to four jacket securing piles, known as jacket piles, of ~3 m (9.8 ft.) diameter. All modeling assumed 10.3 m piles would be used for monopiles and 3 m piles would be used for jacket foundations (other specifications associated with monopiles and jacket piles are shown in Table 3.1 in the Description of the Action section).

Representative hammering schedules of increasing hammer energy with increasing penetration depth were modeled, resulting in, generally, higher intensity sound fields as the hammer energy and penetration increases. For both monopile and jacket structure models, the piles were assumed to be vertical and driven to a penetration depth of 30 m and 45 m, respectively. While pile penetrations across the site would vary, these values were chosen as reasonable penetration depths. The estimated number of strikes required to drive piles to completion were obtained from drivability studies provided by Vineyard Wind. All acoustic modeling was performed assuming that only one pile is driven at a time.

Additional modeling assumptions for the monopiles were as follows:

- 1,030 cm steel cylindrical piling with wall thickness of 10 cm.
- Impact pile driver: IHC S-4000 (4000 kJ rated energy; 1977 kN ram weight).
- Helmet weight: 3234 kN.

Additional modeling assumptions for the jacket pile are as follows:

- 300 cm steel cylindrical pilings with wall thickness of 5 cm.
- Impact pile driver: IHC S-2500 (2500 kJ rated energy; 1227 kN ram weight).
- Helmet weight: 2401 kN.
- Up to four jacket piles installed per day.

Detailed information on the models is available in the COP (Appendix III-M) and the Federal Register notice announcing the Proposed IHA (84 FR 18346; April 30, 2019) and Appendix A of the IHA Application.

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. Vineyard Wind and BOEM have indicated that while it is not expected, if a large boulder is unexpectedly encountered or early pile refusal is met before the target depth is achieved, a rotary drilling unit or vibratory hammer may be used to complete installation. However, given the extensive surveying that has occurred in the project area and the identification of suitable foundation locations, this is not anticipated to be necessary. In the IHA application, Vineyard Wind indicates that in such a circumstance, drilling or vibratory hammering would be expected to take approximately 10 minutes. Both rotary drilling and vibratory hammers produce SPLs much lower than impact pile driving (Caltrans 2015, Willis et al. 2010). All of the modeling presented here assumes that an impact hammer will be used for the full duration of pile installation. In the unanticipated event that a rotary drill or vibratory hammer needed to be used, there would be less impact hammering. As the drill and vibratory hammer produce less noise than the impact hammer, the noise and exposure estimates presented here would be inclusive of any unanticipated use of a rotary drill or vibratory hammer. This is consistent with the consideration of these sources in the BA, IHA application, and proposed IHA.

BOEM will require, through conditions of COP approval, the use of a noise attenuation system designed to minimize the sound radiated from piles by 12 dB. This requirement will be in place for all piles to be installed, with the exception of one monopile and one jacket pile that may be installed without a noise attenuation system in place to establish baseline noise information from which to compare the effectiveness of the noise attenuation system (this exception is also considered in the proposed IHA). Noise attenuation systems, such as bubble curtains, are designed to decrease the sound levels radiated from a source. Bubbles create a local impedance change that acts as a barrier to sound transmission. The size of the bubbles determines their effective frequency band, with larger bubbles needed for lower frequencies. There are a variety of bubble curtain systems, confined or unconfined bubbles, and some with encapsulated bubbles or panels. Attenuation levels also vary by type of system, frequency band, and location. Small bubble curtains have been measured to reduce sound levels but effective attenuation is highly dependent on depth of water, current, and configuration and operation of the curtain (Austin, Denes, MacDonnell, & Warner, 2016; Koschinski & Lüdemann, 2013). Bubble curtains vary in terms of the sizes of the bubbles and those with larger bubbles tend to perform a bit better and more reliably, particularly when deployed with two separate rings (Bellmann, 2014; Koschinski & Lüdemann, 2013; Nehls et al. 2016).

Encapsulated bubble systems (*e.g.*, Hydro Sound Dampers (HSDs)), can be effective within their targeted frequency ranges, *e.g.*, 100-800 Hz, and when used in conjunction with a bubble curtain appear to create the greatest attenuation. The literature presents a wide array of observed attenuation results for bubble curtains. The variability in attenuation levels is the result of variation in design, as well as differences in site conditions and difficulty in properly installing and operating in-water attenuation devices. A California Department of Transportation (CalTrans) study tested several systems and found that the best attenuation systems resulted in 10-15 dB of attenuation (Buehler *et al.*, 2015). Similarly, Dähne, Tougaard, Carstensen, Rose, and Nabe-Nielsen (2017) found that single bubble curtains that reduced sound levels by 7 to 10 dB reduced the overall sound level by ~12 dB when combined as a double bubble curtain for 6 m steel monopiles in the North Sea. In modeling the sound fields for the proposed project, hypothetical broadband attenuation levels of 6 dB and 12 dB were modeled to gauge the effects on the ranges to thresholds given these levels of attenuation. In the BA, a maximum impact scenario of only a -6 dB reduction is analyzed since the type of sound reduction system that will be used is not yet identified that could be evaluated for past effectiveness during use and, regardless of system used, BOEM determined it is reasonable to expect at least a 6 dB reduction. As described in the *Federal Register* notice announcing the proposed IHA, based on the best available information, OPR determined it is reasonable to assume some level of effective attenuation due to implementation of noise attenuation during impact pile driving. In the absence of detailed information regarding the attenuation system that will be used, and in consideration of the available information on attenuation that has been achieved during impact pile driving, consistent with the conclusions reached by OPR in the *Federal Register* notice accompanying the proposed IHA, we conservatively assume that 6 dB sound attenuation will be achieved and agree with BOEM’s use of those model runs for assessing effects of pile driving on ESA listed species.

Vessel Noise

Vessel noise is considered a continuous noise source that will occur intermittently. Vessels transmit noise through water primarily through propeller cavitation, although other ancillary noises may be produced. The intensity of noise from 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. Radiated noise from ships varies depending on the nature, size, and speed of the ship. McKenna et al. (2012b) determined that container ships produced broadband source levels around 188 dB re 1 µPa and a typical fishing vessel radiates noise at a source level of about 158 dB re 1 µPa (Mintz and Filadelfo 2011c; Richardson et al. 1995b; Urick 1983b).

Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below about 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies (approximately around the one-third octave band centered at 100 Hz)

(Mintz and Filadelfo 2011c; Richardson et al. 1995b; Urick 1983b). Ship types also have unique acoustic signatures characterized by differences in dominant frequencies. Bulk carrier noise is predominantly near 100 Hz while container ship and tanker noise is predominantly below 40 Hz (McKenna et al. 2012b). Small craft types will emit higher-frequency noise (between 1 kHz and 50 kHz) than larger ships (below 1 kHz).

Project vessels will either have ducted propellers, blade propellers, or use jet drive propulsion. 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 during construction and installation activities. 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). Blade propeller systems are typical of small craft such as fishing vessels; therefore, the estimates for noise associated with fishing vessels (source level of 158 dB re 1 µPa) referenced above are expected. As most vessel noise is associated with propeller cavitation and a jet propulsion system has no external propeller, vessels with jet propulsion systems are quieter than similar vessels with propellers. Rudd et al. (2014) reports a maximum source level noise of 175 dB re 1uPa for a 117m jet propelled fast ferry traveling at a speed of 24 knots.

Aircraft Operation Noise

During the Project, helicopters may 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, which some of the larger support vessels have. 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 service operations vessel (SOV). 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). 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 considerably with flight altitude.

North Atlantic right whale 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 North Atlantic right whales or unidentified large whales.

Cable Installation

In the BA, BOEM indicates that 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. Nedwell et al. (2003) reports a sound source level for cable trenching operations in the marine environment of 178 dB re 1µPa at a distance of 1m from the source. Hale (2018) reports on unpublished information for cable jetting operations indicating a comparable sound source level, concentrated in the frequency range of 1 kHz to 15 kHz and notes that the sounds of cable burial were attributed to cavitation bubbles as the water jets passed through the leading edge of the burial plow.

Dredging

Monitoring of trailing suction hopper dredge operations indicates that underwater noise is dominated by propeller cavitation and bow thrusters (de Jory et al. 2010; Robinson 2015). As such, we expect underwater noise produced during the dredging of sand waves to facilitate cable installation to be comparable to noise of project vessel operations discussed above.

WTG Operations

Information on operational noise of wind turbines is available for projects in Europe and the Block Island project in Rhode Island. 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).

While site-specific differences in the foundations, water depth, and substrate type may result in differences in actual operational noise levels at different project sites, we expect that operational noise of the Vineyard Wind project will have similar characteristics to the field measurements described above. As such, operational noise is expected to 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.

HRG Surveys to Support Decommissioning

Vineyard Wind will carry out high-resolution geophysical (HRG) and remotely operated vehicle (ROV) surveys for site clearance activities. The HRG surveys would use only electromechanical sources such as boomer, sparker, and chirp subbottom profilers; side-scan sonar; and multibeam depth sounders. No air guns are proposed for use. Given their operating frequency, acoustic signals from electromechanical sources other than the boomer and sparker are not likely to be detectable by sea turtles and 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 table below (7.3) presents the anticipated underwater noise associated with the survey equipment.

Table 7.3: Acoustic Characteristics of Representative HRG Survey Equipment

HRG Source	Source Level (dB re 1 µPa at 1m)			Main Pulse Frequency (kHz)	Pulse Duration (seconds)	Pulses per Second (PPS)
	PK-PK	RMS	SEL			
Boomers	219	207	176	4.3	.0008	1
S-Boom	213	203	172	3.8	.0009	3
Bubble Gun	207	198	173	1.1	.0033	8
Sparkers	229	214	188	2.7	.0022	6
EdgeTech Sub-bottom Profiler	191	180	159	6.3	.0087	8
Knudsen 3202 Sub-bottom Profiler	220	209	193	3.3	.0217	4
Acoustic Corer Sub-bottom Profiler	-	190	-	6	481.5	16.6
Reson Seabat 7111 Multibeam Echosounder	233	224	185	100	.00015	20
Reson Seabat T20P Multibeam Echosounder	226	218	182	>200	.00025	50
Echotrac CV100 Single-Beam Echosounder	202	193	159	>200	.00036	20
Klein 3900 Side-Scan Sonar	232	220	179	>200	.000084	unreported

Source: Highest reported source levels reported in Crocker and Fratantonio (2016).

All noise producing survey equipment is towed behind a survey vessel and is only turned on when the vessel is traveling along survey transects; thus, the area ensonified is constantly moving, making survey noise transient and intermittent. The maximum anticipated distances from the HRG sound sources to noise thresholds of concern is presented in the table below (from BOEM 2019):

Table 7.4 Radius from "loudest" HRG Noise Source to Noise Thresholds of Concern

	Distance to Injury Threshold (m from source)	Distance to Behavioral Disturbance Threshold (m from source)
LFC (baleen whales)	26	502
MFC (sperm whales)	1	1,585
Sea Turtles	12	90
Atlantic sturgeon	12	1,996

7.1.2 Effects of Project Noise on ESA Listed Whales

Background Information – Acoustics and Whales

The *Federal Register* notice prepared for the Proposed IHA (84 FR 18346; April 30, 2019) presents extensive information on the potential effects of underwater sound on marine mammals. Rather than repeat that information, that information is incorporated by reference here. As explained in detail in the *Federal Register* notice, anthropogenic sounds cover a broad range of frequencies and sound levels and can have a range of highly variable impacts on marine life, from none or minor to potentially severe responses, depending on received levels, duration of exposure, behavioral context, and various other factors. Underwater sound from active acoustic sources can have one or more of the following effects: temporary or permanent hearing impairment, non-auditory physical or physiological effects, behavioral disturbance, stress, and masking (Richardson et al., 1995; Gordon et al., 2004; Nowacek et al., 2007; Southall et al., 2007; Götz et al., 2009). The degree of effect is intrinsically related to the signal characteristics, received level, distance from the source, and duration of the sound exposure. In general, sudden, high level sounds can cause hearing loss, as can longer exposures to lower level sounds. Temporary or permanent loss of hearing will occur almost exclusively for noise within an animal's hearing range.

Richardson et al. (1995) described zones of increasing intensity of effect that might be expected to occur, in relation to distance from a source and assuming that the signal is within an animal's hearing range. First is the area within which the acoustic signal would be audible (potentially perceived) to the animal but not strong enough to elicit any overt behavioral or physiological response. The next zone corresponds with the area where the signal is audible to the animal and of sufficient intensity to elicit behavioral or physiological responsiveness. Third is a zone within which, for signals of high intensity, the received level is sufficient to potentially cause discomfort or tissue damage to auditory or other systems. Overlaying these zones to a certain extent is the area within which masking may occur. Masking is when a sound interferes with or masks the ability of an animal to detect a signal of interest that is above the absolute hearing threshold. The masking zone may be highly variable in size.

The expected responses to pile driving noise may include threshold shift, behavioral effects, stress response, and auditory masking. Threshold shift is the loss of hearing sensitivity at certain frequency ranges (Finneran 2015). It can be permanent (PTS), in which case the loss of hearing sensitivity is not fully recoverable, or temporary (TTS), in which case the animal’s hearing threshold would recover over time (Southall et al., 2007). PTS is an auditory injury, which may vary in degree from minor to significant. Behavioral disturbance may include a variety of effects, including subtle changes in behavior (e.g., minor or brief avoidance of an area or changes in vocalizations), more conspicuous changes in similar behavioral activities, and more sustained and/or potentially severe reactions, such as displacement from or abandonment of high-quality habitat. An animal's perception of a threat may be sufficient to trigger stress responses consisting of some combination of behavioral responses, autonomic nervous system responses, neuroendocrine responses, or immune responses (e.g., Seyle, 1950; Moberg, 2000). In many cases, an animal's first and sometimes most economical response in terms of energetic costs is behavioral avoidance of the potential stressor. Autonomic nervous system responses to stress typically involve changes in heart rate, blood pressure, and gastrointestinal activity. These responses have a relatively short duration and may or may not have a significant long-term effect on an animal's fitness. Masking occurs when the receipt of a sound is interfered with by another coincident sound at similar frequencies and at similar or higher intensity, and may occur whether the sound is natural (e.g., snapping shrimp, wind, waves, precipitation) or anthropogenic (e.g., shipping, sonar, seismic exploration) in origin.

Criteria Used for Assessing Effects of Noise Exposure to Sei, Fin, Sperm, and Right Whales
NMFS *Technical Guidance for Assessing the Effects of Anthropogenic Noise on Marine Mammal Hearing* compiles, interprets, and synthesizes scientific literature to produce updated acoustic thresholds to assess how anthropogenic, or human-caused, sound affects the hearing of all marine mammals under NMFS jurisdiction (NMFS 2018[17]). Specifically, it identifies the received levels, or thresholds, at which individual marine mammals are predicted to experience temporary or permanent changes in their hearing sensitivity for acute, incidental exposure to underwater anthropogenic sound sources. As explained in the document, these thresholds represent the best available scientific information. These acoustic thresholds cover the onset of both temporary (TTS) and permanent hearing threshold shifts (PTS).

Table 7.5. Impulsive acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for the marine mammal species groups considered in this opinion (NMFS 2018).

Hearing Group	Generalized Hearing Range[18]	Permanent Threshold Shift Onset[19]	Temporary Threshold Shift Onset
Low-Frequency Cetaceans (LF: baleen whales)	7 Hz to 35 kHz	*L*pk,flat: 219 dB *L*E,LF,24h: 183 dB	*L*pk,flat: 213 dB *L*E,LF,24h: 168 dB
Mid-Frequency Cetaceans (MF: sperm whales)	150 Hz to 160 kHz	*L*pk,flat: 230 dB *L*E,MF,24h: 185 dB	*L*pk,flat: 224 dB *L*E,MF,24h: 170 dB

These thresholds are a dual metric for impulsive sounds, with one threshold based on peak sound pressure level (0-pk SPL) that does not incorporate the duration of exposure, and another based on cumulative sound exposure level ($\mathrm{SEL}_{\mathrm{cum}}$) that does incorporate exposure duration. The two metrics also differ in regard to considering information on species hearing. The cumulative sound exposure criteria incorporate auditory weighting functions, which estimate a species

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[17] See www.nmfs.noaa.gov/pr/acoustics/guidelines.htm for more information.

[18] Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall et al. 2007).

[19] $L_{\mathrm{pk,flat}}$: unweighted ($_{\mathrm{flat}}$) peak sound pressure level (L_{pk}) with a reference value of 1 µPa; $L_{\mathrm{E,XF,24h}}$: weighted (by species group; $_{\mathrm{LF}}$: Low Frequency, or $_{\mathrm{MF}}$: Mid-Frequency) cumulative sound exposure level (L_{E}) with a reference value of 1 µPa^{2}-s and a recommended accumulation period of 24 hours ($_{\mathrm{24h}}$)

group's hearing sensitivity, and thus susceptibility to TTS and PTS, over the exposed frequency range, whereas peak sound exposure level criteria do not incorporate any frequency dependent auditory weighting functions.

In using these thresholds to estimate the number of individuals that may experience auditory injury in the context of the MMPA, NMFS classifies any exposure equal to or above the threshold for the onset of PTS as auditory injury (and thus MMPA Level A harassment). Any exposure below the threshold for the onset of PTS, but equal to or above the 160 dB re: 1 µPa (rms) threshold is classified as MMPA Level B harassment. Among Level B exposures, the Permits and Conservation Division does not distinguish between those individuals that are expected to experience TTS and those that would only exhibit a behavioral response.

NMFS considers exposure to impulsive noise greater than 160 dB re 1uPa rms to result in behavioral disruption. This value is based on observations of behavioral responses of mysticetes (Malme et al. 1983; Malme et al. 1984; Richardson et al. 1986; Richardson et al. 1990), but is used for all marine mammal species.

Effects of Project Noise on ESA Listed Whales

Fin, sei, sperm, and right whales may be exposed to increased underwater noise during construction, operation, and decommissioning of the Vineyard Wind project. Vineyard Wind applied for an Incidental Harassment Authorization (IHA) to authorize Level A harassment of fin, sei, and sperm whales and Level B harassment of fin, sei, sperm, and right whales expected to result from exposure to pile driving noise. NMFS Office of Protected Resources (OPR) is proposing to authorize Level A harassment of fin, sei, and sperm whales and Level B harassment of fin, sei, sperm, and right whales they determined to be likely to result from exposure to pile driving noise. Vineyard Wind did not apply for an IHA for any other noise sources and OPR is not proposing to authorize MMPA take of any ESA listed whale species for any noise sources other than pile driving noise. Here, we consider the effects of exposure to pile driving noise in the context of the ESA and address exposure and response to underwater noise from additional sources during construction, operations, and decommissioning. Information on the relevant acoustic thresholds and a summary of the best available information on likely responses of whales to underwater noise is presented above. More information on Vineyard Wind's IHA application and details of the acoustic modeling is available in the *Federal Register* notice of the proposed IHA (84 FR 18346; April 30, 2019), the IHA application (available at: https://www.fisheries.noaa.gov/action/incidental-take-authorization-vineyard-wind-llc-construction-vineyard-wind-offshore-wind; last accessed August 5, 2020), and Pyc et al. 2018.

Pile Driving

In their IHA application, Vineyard Wind estimated exposure of fin, sei, sperm, and right whales to pile driving noise according to the MMPA definition of take, including Level A and Level B harassment. In addition, OPR conducted their own exposure analysis based on the information provided by the applicants, and any additional available information relevant to the exposure of cetaceans to the proposed project as referenced in the notice of proposed IHA.

For the purposes of this ESA section 7 consultation, we evaluated both the applicants' and OPR's exposure estimates of the number of ESA-listed cetaceans that would be "taken" relative to the definition of MMPA Level A and Level B harassment and considered this expected MMPA take in light of the ESA definition of take including the NMFS definition of harm (64 FR 60727; November 8, 1999) and NMFS interim guidance on the definition of harass (see NMFS policy directive 02-110-19[20]). We have adopted OPR's analysis of the number of fin, sei, sperm, and right whales expected to be exposed to pile driving noise because, after our independent review, we determined it utilized the best available information and methods to evaluate exposure to these whale species. Below we describe Vineyard Wind and NMFS OPR's exposure analyses for fin, sei, sperm, and right whales.

As described fully in the notice of proposed IHA (84 FR 18346; April 30, 2019), to predict the noise that would result from pile driving and the number of fin, sei, sperm, and right whales likely to be exposed to that noise, two project design scenarios were modeled: the "maximum design" consisting of ninety 10.3 m (33.8 ft.) WTG monopile foundations, 10 jacket foundations, and two jacket foundations for ESPs, and the "most likely design" consisting of one hundred 10.3 m (33.8 ft.) WTG monopile foundations and two jacket foundations for ESPs. Both of these design scenarios were also modeled with either one or two monopile foundations installed per day. All scenarios were modeled with no sound attenuation, 6 dB sound attenuation, and 12 dB sound attenuation incorporated. As noted above, it is possible that a reduced number of piles will be installed; thus, these modeling scenarios represent the "maximum impact" or "worst case" scenarios.

Acoustic propagation was modeled at two representative sites in the WDA. The locations were selected to provide representative propagation and sound fields for the project area. The sound propagation modeling incorporates site-specific environmental data that describes the bathymetry, sound speed in the water column, and seabed geoacoustics in the construction area; these are the environmental or site-specific conditions that are expected to influence propagation and account for variability. The sound velocity profile in the project area varies seasonally. The sound velocity profile for fall was used for the modeling because it is expected to produce the greatest propagation distances owing to its relatively high sound speed (greater distance per wavelength) and does not refract sound to interact with the bottom (Appendix A of the IHA application). Using the propagation ranges for the fall allows for a conservative estimate of noise propagation for the other seasons. Modeled pile locations were selected to represent variations in water depth and distance from the dominant bathymetric features–the coast. Water depth and environmental characteristics (*e.g.*, bottom-type) are similar throughout the WDA (Vineyard Wind, 2016), and minimal difference was found in sound propagation results for the two sites (see Appendix A of the IHA application for further detail) despite selecting two sites that were the most different. This conclusion supports the position that sound propagation from any particular pile installation of the same pile type and hammer, will be representative of other pile installations at the project site.

Table 7.6 shows the modeled radial distances to the dual Level A harassment thresholds using NMFS (2018) frequency weighting for marine mammals, with 0, 6, and 12 dB sound attenuation

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[20] Available at: https://www.fisheries.noaa.gov/national/laws-and-policies/protected-resources-policy-directives. Last accessed July 30, 2019.

incorporated. For the peak level, the greatest distances expected typically occur at the highest hammer energies. The distances to SEL thresholds were calculated using the hammer energy schedules for driving one monopile or four jacket piles, as shown. The radial distances shown in Table 7.6 are the maximum distances from the piles, averaged between the two modeled locations.

Table 7.6. Radial distances (m) to Level A Harassment Thresholds for Each Foundation Type with 0, 6, and 12 dB Sound Attenuation Incorporated.

Foundation type	Hearing group**	Level A harassment (peak)			Level A harassment (SEL)		
		No attenuation	6 dB attenuation	12 dB attenuation	No attenuation	6 dB attenuation	12 dB attenuation
10.3 m (33.8 ft.) monopile	LFC (fin, right, sei whales)	34	17	8.5	5,443	3,191	1,599
	MFC (sperm whales)	10	5	2.5	56	43	0
Four, 3 m (9.8 ft.) jacket piles	LFC (fin, right, sei whales)	7.5	4	2.5	12,975	7,253	3,796
	MFC (sperm whales)	2.5	1	0.5	71	71	56

* Radial distances were modeled at two different representative modeling locations as described above. Distances shown represent the average of the two modeled locations.
**Thresholds: LFC: Lpk, flat: 219 dB; LE, LF, 24h: 183 dB. MFC: Lpk, flat: 230 dB; LE, MF, 24h: 185 dB (NMFS 2018)

Table 7.7 shows the modeled radial distances to the Level B harassment threshold (160 dB re: 1 uPa rms) with no attenuation, 6 dB, and 12 dB sound attenuation incorporated. The radial distances shown in Table 2 is the maximum distance to the Level B harassment threshold from the piles, averaged between the two modeled locations, using the maximum hammer energy.

Table 7.7. Radial distances (m) to the Level B harassment threshold (160 dB re: 1 µPa (rms))**.**

Foundation type	No attenuation	6 dB attenuation	12 dB attenuation
10.3 m (33.8 ft.) monopile	6,316	4,121	2,739
Four, 3 m (9.8 ft.) jacket piles	4,104	3,220	2,177

As described fully in the notice of proposed IHA, the following steps were performed to estimate the potential numbers of marine mammal exposures above Level A and Level B harassment thresholds during pile driving:

1. Sound fields produced during pile driving were modeled by first characterizing the sound signal produced during pile driving using the industry-standard GRLWEAP (wave equation analysis of pile driving) model and JASCO Applied Sciences' (JASCO) Pile Driving Source Model (PDSM).
2. Acoustic propagation modeling was performed using JASCO's MONM and FWRAM that combined the outputs of the source model with the spatial and temporal environmental context (*e.g.*, location, oceanographic conditions, seabed type) to estimate sound fields;
3. Animal movement modeling integrated the estimated sound fields with species-typical behavioral parameters in the JASMINE model to estimate received sound levels for the animals that may occur in the operational area; and,
4. The number of potential exposures above Level A and Level B harassment thresholds was calculated for each potential scenario within the project design envelope.

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the probability of exposure of animals to sound from the Project's pile driving operations. JASMINE uses 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; in this case, 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 complete details on 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 North Atlantic right whale 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. 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 km^2 [38.6 square miles]) to units of density (animals/km^2). 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).

Results of marine mammal exposure modeling of these scenarios is shown in Tables 7.8-7.11. Note that while fractions of an animal cannot be taken, these tables are meant simply to show the modeled exposure numbers, versus the actual proposed take estimate. Requested and proposed take numbers are shown below in Tables 7.12 and 7.13.

Table 7.8. Mean numbers of marine mammals estimated to be exposed above Level A and Level B harassment thresholds during the proposed project using the Maximum Design scenario (90 monopile foundations, 12 jacket foundations; one foundation installed per day).

Species	**6 dB Attenuation**			**12 dB Attenuation**		
	Level A harassment (peak)	Level A harassment (SEL)	Level B harassment	Level A harassment (peak)	Level A harassment (SEL)	Level B harassment
Fin Whale	0.1	4.13	33.11	0.02	0.29	21.78
North Atlantic Right Whale	0.03	1.36	13.25	0	0.09	8.74
Sei Whale	0	0.14	1.09	0	0.01	0.74
Sperm Whale	0	0	0	0	0	0

Table 7.9. Mean numbers of marine mammals estimated to be exposed above Level A and Level B harassment thresholds during the proposed project using the Maximum Design scenario (90 monopile foundations, 12 jacket foundations; two foundations installed per day).

Species	**6 dB Attenuation**			**12 dB Attenuation**		
	Level A harassment (peak)	Level A harassment (SEL)	Level B harassment	Level A harassment (peak)	Level A harassment (SEL)	Level B harassment
Fin Whale	0.1	4.49	29.71	0	0.41	20.57
North Atlantic Right Whale	0.02	1.39	11.75	0.01	0.1	7.96
Sei Whale	0	0.14	0.93	0	0.01	0.65
Sperm Whale	0	0	0	0	0	0

Table 7.10. Mean numbers of marine mammals estimated to be exposed above Level A and Level B harassment thresholds during the proposed project using the "Most Likely" scenario (100 monopile foundations, 2 jacket foundations; one foundation installed per day).

Species	**6 dB Attenuation**			**12 dB Attenuation**		
	Level A harassment (peak)	Level A harassment (SEL)	Level B harassment	Level A harassment (peak)	Level A harassment (SEL)	Level B harassment
Fin Whale	0.11	2.84	29.85	0.02	0.23	19.43
North Atlantic Right Whale	0.04	0.72	10.82	0	0.04	7.09
Sei Whale	0	0.09	0.95	0	0.01	0.65
Sperm Whale	0	0	0	0	0	0

Table 7.11. Mean numbers of marine mammals estimated to be exposed above Level A and Level B harassment thresholds during the proposed project using the "Most Likely" scenario (100 monopile foundations, 2 jacket foundations; one foundation installed per day.

Species	**6 dB Attenuation**			**12 dB Attenuation**		
	Level A harassment (peak)	Level A harassment (SEL)	Level B harassment	Level A harassment (peak)	Level A harassment (SEL)	Level B harassment
Fin Whale	0.11	3.24	26.07	0	0.36	18.08
North Atlantic Right Whale	0.02	0.76	9.21	0.01	0.06	6.25
Sei Whale	0	0.09	0.78	0	0.01	0.55
Sperm whale	0	0	0	0	0	0

As shown in Tables 7.8-7.11, the greatest potential number of marine mammal exposures above the Level A and Level B harassment threshold occurs under the Maximum Design scenario (90 monopiles, 12 jackets) with one monopile foundation installed per day (Table 7.8). Because of the inclusion of more jacket foundations, which would require more piles and more overall pile driving, marine mammal exposure estimates for the Maximum Design scenario (Tables 7.8 and 7.9) are higher than under the Most Likely scenario (Tables 7.10 and 7.12). In all scenarios, the maximum number of jacket foundations modeled per day was one (four jacket piles). Modeling indicates that whether one monopile foundation is installed per day or two makes little difference with respect to estimated Level A harassment exposures; total exposures above the Level A harassment threshold differed by less than one exposure over the duration of the project, for each species. For exposures above the Level B harassment threshold, exposure estimates for one monopile foundation per day are somewhat higher than for two monopile foundations per day. With two monopile foundations per day, there are half as many days of pile driving so there is likewise a reduced number of overall predicted Level B harassment exposures over the duration of the project.

These exposure estimates were developed to present a "worst case" or "maximum impact" scenario associated with the installation of 8 MW turbines. At this time, Vineyard Wind is considering installing turbines with a capacity as high as 14 MW; this would require only 57 turbines to reach the 800 MW project capacity. It is also possible that a 10 MW or 12 MW turbine could be installed. Based on total project capacity and the potential turbine capacity, the total number of turbines will be between 57 and 100. The number of whales expected to be exposed to pile driving noise is proportional to the number of piles to be installed. Installing 57 foundations would require 43% less pile driving and estimates of exposure would likewise be 43% less than the maximum impact scenarios presented above.

Vineyard Wind's Take Request

Vineyard Wind based their take request on the Maximum Design scenario with one monopile installed per day. Vineyard Wind also assumed that 12 dB sound attenuation can be achieved consistently during the proposed activity, thus their take request was based on modeled exposure numbers incorporating 12 dB effective attenuation.

Although the exposure modeling indicated that no Level A harassment takes are expected for sei whales, Vineyard Wind requested Level A harassment takes for sei whales as a precautionary measure, based on their conclusion that shutdown of pile driving may not be technically feasible once pile driving has begun, thus if a sei whale were to enter the Level A harassment zone after pile driving has commenced, pile driving may not be able to be stopped before the animal left the area where it could be exposed to noise louder than the Level A harassment threshold.

Vineyard Wind requested Level A harassment takes for whales based on mean group size for each respective species, based on an assumption that if one group member were to be exposed, it is likely that all animals in the same group would receive a similar exposure level. Thus, for the species for which exposure modeling indicated less than a group size would be taken (by either Level A or Level B harassment), Vineyard Wind increased the value from the exposure modeling results to equal one mean group size, rounded up to the nearest integer, for species with predicted exposures of less than one mean group size (with the exception of North Atlantic right whales, as described below). That is, if the mean group size was 4 and the modeled exposure was 2, the take request would be for 4. Mean group sizes for species were derived from Kraus et al. (2016), where available, as the best representation of expected group sizes within the RI/MA & MA WEAs (which includes the area where pile driving will occur for the Vineyard Wind project). These were calculated as the number of individuals sighted, divided by the number of sightings summed over the four seasons (from Tables 5 and 19 in Kraus et al., 2016). Sightings for which species identification was considered either definite or probable were used in the Kraus et al. (2016) data. For species that were observed very rarely during the Kraus et al. (2016) study, including sperm whales), data derived from AMAPPS surveys (Palka et al., 2017) were used to evaluate mean group size. For sperm whales, the number of individuals divided by the number of groups observed during 2010–2013 AMAPPS Northeast summer shipboard surveys and Northeast aerial surveys during all seasons was used (Appendix I of Palka et al., 2017). Calculated group sizes for all species are shown in Table 7.12.

Table 7.12. Mean group sizes of marine mammal species used to estimate takes.

Species	**Mean group size**
Fin Whale	1.8
North Atlantic Right Whale	2.4
Sei Whale	1.6
Sperm Whale	1.5

Vineyard Wind also requested Level B take numbers that differ from the numbers modeled and were instead based on monitoring data from site characterization surveys conducted in the WDA. Vineyard Wind reviewed monitoring data recorded during site characterization surveys in the WDA from 2016–2018 and calculated a daily sighting rate (individuals per day) for each species in each year, then multiplied the maximum sighting rate from the three years by the number of pile driving days under the Maximum Design scenario (*i.e.*, 102 days). This method assumes that the largest average group size for each species observed during the three years of surveys may be present on each day that pile driving occurs. Vineyard Wind used this method for all species that were documented by protected species observers (PSOs) during the 2016–2018 surveys. For sei whales, this approach resulted in the same number of estimated Level B harassment takes as Level A harassment takes (two), so Vineyard Wind doubled the Level A harassment value to arrive at the requested number of Level B harassment takes.

OPR's Proposed IHA

OPR reviewed Vineyard Wind's take request and proposes to authorize take numbers that are slightly different from the numbers requested for some species. Vineyard Wind's requested take numbers for Level A harassment authorization are based on an expectation that 12 dB sound attenuation will be effective during the proposed activity. NMFS reviewed the CalTrans bubble curtain "on and off" studies conducted during pile driving in San Francisco Bay in 2003 and 2004. Based on 74 measurements (37 with the bubble curtain on and 37 with the bubble curtain off) at both near (< 100 m) and far (> 100 m) distances, the linear averaged received level reduction is 6 dB (CalTrans, 2015). Nehls et al. (2016) reported that attenuation from use of a bubble curtain during pile driving at the Borkum West II offshore wind farm in the North Sea was between 10 dB and 17 dB (mean 14 dB) (peak).

Based on the best available information, OPR determined it is reasonable to assume some level of effective attenuation due to implementation of noise attenuation during impact pile driving. Vineyard Wind has not provided information regarding the attenuation system that will ultimately be used during the proposed activity (*e.g.*, what size bubbles and in what configuration a bubble curtain would be used, whether a double curtain will be employed, whether hydro-sound dampers, noise abatement system, or some other alternate attenuation device will be used, etc.) to support their conclusion that 12 dB effective attenuation can be expected. In the absence of specific information regarding the attenuation system that will be used, and in consideration of the available information on attenuation that has been achieved during impact pile driving for which monitoring information is available, OPR assumes that 6 dB sound attenuation will be achieved. Therefore, where Vineyard Wind's requested Level A take numbers were less than the Level A take numbers modeled based on 6 dB noise attenuation (*i.e.*, fin whale) OPR proposes to authorize higher Level A take numbers than those requested in order to reflect the expected exposure to pile driving noise with 6 dB attenuation rather than 12 dB attenuation. Vineyard Wind also requested all take numbers based on the Maximum Design scenario with one pile driven per day (Table 7.8); however, the Maximum Design scenario with two piles driven per day resulted in slightly higher modeled takes by Level A harassment (Table 7.9). OPR therefore proposes to authorize takes by Level A harassment based on the higher modeled take numbers as Vineyard Wind and BOEM have stated that installation of two monopoles per day may occur.

Vineyard Wind's requested take numbers for Level B harassment authorization are based on visual observation data recorded during the company's site characterization surveys, as described above. In some cases these numbers are lower than the Level B harassment exposure numbers modeled based on marine mammal densities reported by Roberts et al. (2016, 2017, 2018) with 6 dB sound attenuation applied (Table 7.8). As stated in the notice of proposed IHA, OPR agreed that Vineyard Wind's use of visual observation data as the basis for Level B harassment take requests is generally sound but OPR determined, that it is appropriate to use the higher of the two calculated take numbers (*i.e.*, take numbers based on available visual observation data, or, based on modeled exposures above threshold) to estimate Level B exposures. Therefore, for species for which the Level B harassment exposure numbers modeled based on marine mammal densities reported by Roberts et al. (2016, 2017, 2018) with 6 dB sound attenuation applied (Table 7.8) were higher than the take numbers based on visual observation data (*i.e.*, fin whale), OPR proposes to authorize take numbers based on those modeled using densities derived from Roberts et al. (2016, 2017, 2018) with 6 dB sound attenuation applied.

For North Atlantic right whales, one exposure above the Level A harassment threshold was modeled over the duration of the proposed project based on the Maximum Design scenario and 6 dB effective attenuation. However, Vineyard Wind has requested no authorization for Level A harassment takes of North Atlantic right whales, based on an expectation that any potential exposures above the Level A harassment threshold will be avoided through enhanced mitigation and monitoring measures proposed specifically to minimize potential right whale exposures. In the notice of proposed IHA, OPR states that, based on the enhanced mitigation and monitoring measures proposed specifically for North Atlantic right whales (described below, see "Proposed Mitigation"), including the proposed seasonal moratorium on pile driving from January through April and enhanced clearance measures from November through December and May 1 through May 14, any potential take of right whales by Level A harassment will be avoided. Therefore, OPR does not propose to authorize any takes of North Atlantic right whales by Level A harassment. As addressed in the section below considering the effectiveness of the minimization and monitoring measures that are included as part of the proposed action, we agree with this determination and also conclude that exposure of any right whales to noise that could result in Level A harassment is extremely unlikely to occur.

Take numbers proposed for authorization through issuance of an IHA to Vineyard Wind are shown in Table 7.13.

Table 7.13. Total Numbers of Potential Incidental Take of Marine Mammals Proposed for Authorization and Proposed Takes as a Percentage of Population.

Species	**Takes by Level A harassment**	**Takes by Level B harassment**	**Total takes proposed for authorization**	**Total takes as a percentage of stock taken***
Fin whale	4	33	37	0.8
North Atlantic Right Whale	0	20	20	4.9
Sei Whale	2	4	6	0.8
Sperm whale	2	5	7	0.1

*Calculations of percentage of stock taken are based on the best available abundance estimate as shown in Table 1 in the Notice of Proposed IHA. For North Atlantic right whales the best available abundance estimate is derived from the 2018 North Atlantic Right Whale Consortium 2018 Annual Report Card (Pettis et al., 2018). For all other species, the best available abundance estimates are derived from Roberts et al. (2016, 2017, 2018).

As described in the notice of proposed IHA, OPR considers the take numbers proposed for authorization (Table 7.13) to be conservative (i.e., to be unlikely to be an underestimate) for the following reasons:

- Proposed take numbers are based on an assumption that all installed monopiles would be 10.3 m in diameter, when some or all monopiles ultimately installed may be smaller;
- Proposed take numbers are based on an assumption that 102 foundations would be installed, when ultimately the total number installed may be lower;
- Proposed take numbers are based on a construction scenario that includes up to 10 jacket foundations, when it is possible no more than two jacket foundations may be installed;
- Proposed Level A take numbers do not account for the likelihood that marine mammals will avoid a stimulus when possible before that stimulus reaches a level that would have the potential to result in injury;
- Proposed take numbers do not account for the effectiveness of proposed mitigation and monitoring measures in reducing the number of takes (with the exception of North Atlantic right whales, for which proposed mitigation and monitoring measures are factored into the proposed Level A harassment take number);
- For sei whales, no Level A takes were predicted based on modeling, however proposed Level A take numbers have been conservatively increased from zero to mean group size for these species.

We agree that these factors are all relevant and taken together indicate that it is very unlikely that the proposed amounts of take underestimate the amount of take that is reasonably certain to occur. We note that the proposed IHA, while acknowledging the proposed installation of one monopile and one jacket without attenuation, does not explicitly address whether the take calculations reflect the consideration of noise associated with driving those piles. In August 2020, OPR carried out additional calculations that were transmitted to us that explicitly factored in the installation of one monopile and one jacket foundation without attenuation. The only change in exposure was an increase in exposure of one fin whale for both the Level A and Level B harassment exposures. That change is expected to be reflected in the final IHA and is incorporated here for a total of 5 fin whales expected to experience Level A harassment and 34 fin whales expected to experience Level B harassment.

Proposed Measures to Minimize Exposure of ESA Listed Whales to Pile Driving Noise

Here, we consider the measures that are part of the proposed action, either because they are proposed by Vineyard Wind and reflected in the proposed action as described to us by BOEM in the BA, or are proposed to be required through the IHA, and how those measures will serve to minimize exposure of ESA listed whales to pile driving noise. Details of these proposed measures are included in the Description of the Action section above.

Seasonal Restriction on Pile Driving

No pile driving activities would occur between January 1 through April 30 to avoid the time of year with the highest densities of right whales in the project area. This seasonal restriction is factored into the acoustic modeling that supported the development of the amount of take proposed in the IHA. That is, the modeling does not consider any pile driving in the January 1 – April 30, period. Thus, the take estimates do not need to be adjusted to account for this seasonal restriction.

Sound Attenuation Devices
Vineyard Wind would implement sound attenuation technology that would target at least a 12 dB reduction in pile driving noise, and that must achieve at least a 6 dB reduction in pile driving noise, as described above. The attainment of a 6 dB reduction in pile driving noise was incorporated into the take estimate calculations presented above. Thus, the take estimates do not need to be adjusted to account for the use of sound attenuation. If a reduction greater than 6 dB is achieved, the actual amount of take could be lower as a result of resulting smaller distances to thresholds of concern.

Clearance Zones
Vineyard Wind would use PSOs to establish clearance zones around the pile driving equipment to ensure these zones are clear of marine mammals prior to the start of pile driving. The primary goal is to avoid exposure to the areas with the loudest noise, which is the area closest to the pile being driven. This reduces the potential for injury and may reduce the extent of disturbance. The proposed clearance zones are larger than the modeled distances to the isopleths corresponding to Level A harassment (based on peak SPL) for all marine mammal functional hearing groups. Proposed clearance zones would apply to both monopile and jacket installation. These zones vary depending on species and are shown in Table 7.14. All distances to clearance zones are the radius from the center of the pile.

Table 7.14. Proposed Clearance Zones during Vineyard Wind Pile Driving.

Species	**Clearance Zone**
North Atlantic right whale	1,000 m*
sei, fin and sperm whale	500 m

*An extended clearance zone of 10 km for North Atlantic right whales is proposed from May 1-14 and November 1 – December 31, as described below.

Prior to the start of pile driving activity, the clearance zones will be monitored for 60 minutes to ensure that they are clear of the relevant species of marine mammals. If a marine mammal is observed approaching or entering the relevant clearance zones prior to the start of pile driving operations, pile driving activity will be delayed until either the marine mammal has voluntarily left the respective clearance zone and been visually confirmed beyond that clearance zone, or, 30 minutes have elapsed without re-detection of the animal. Pile driving would only commence once PSOs have declared the respective clearance zones clear of marine mammals. Marine mammals observed within a clearance zone will be allowed to remain in the clearance zone (*i.e.*, must leave of their own volition), and their behavior will be monitored and documented. The clearance zones may only be declared clear, and pile driving started, when the entire clearance zones are visible (*i.e.*, when not obscured by dark, rain, fog, etc.) for a full 30 minutes prior to pile driving.

If a marine mammal is observed entering or within the respective clearance zones (Table 7.14) after pile driving has begun, the PSO will request a temporary cessation of pile driving. Vineyard Wind has proposed that, when called for by a PSO, shutdown of pile driving would be implemented when feasible but that shutdown would not always be technically practicable once driving of a pile has commenced as it has the potential to result in pile instability. Therefore, the IHA will require that shutdown be implemented when feasible, with a focus on other proposed mitigation measures as the primary means of minimizing potential impacts on marine mammals from noise related to pile driving. If shutdown is called for by a PSO, and Vineyard Wind determines a shutdown to be technically feasible, pile driving would be halted immediately.

In situations when shutdown is called for but Vineyard Wind determines shutdown is not practicable due to human safety or operational concerns, reduced hammer energy would be implemented when practicable. After shutdown, pile driving may be initiated once all clearance zones are clear of marine mammals for the minimum species-specific time periods, or, if required to maintain installation feasibility (see Description of the Proposed Action section for more detail).

Pile driving would not be initiated at night, or, when conditions prevent the full extent of all relevant clearance zones to be confirmed to be clear of marine mammals, as determined by the lead PSO on duty. The clearance zones may only be declared clear, and pile driving started, when the full extent of all clearance zones are visible (*i.e.*, when not obscured by dark, rain, fog, etc.) for a full 30 minutes prior to pile driving. Pile driving may continue after dark only when the driving of the same pile began during the day when clearance zones were fully visible and it was anticipated that pile installation could be completed before sundown. In those cases, pile driving may only proceed for human safety or installation feasibility reasons.

In addition to the clearance zones described above, Vineyard Wind has proposed extended clearance zones for North Atlantic right whales during certain times of year. These extended zones are designed to further minimize the potential for right whales to be exposed to pile driving noise, and are proposed during times of year that are considered to be “shoulder seasons” in terms of right whale presence in the project area: November 1 through December 31, and May 1 through May 14. While North Atlantic right whales occur in the action area year round; peak occurrence is January 1 – April 30 with the next highest abundances in November, December, and early May (Roberts et al, 2017; Kraus et al. 2016). Extended clearance zones would be maintained through passive acoustic monitoring (PAM) as well as by visual observation conducted on aerial or vessel-based surveys as described below. PAM systems are designed to detected the vocalizations of marine mammals, allowing for detection of the presence of whales underwater or outside of the range where a visual observer may be able to detect the animals. Extended clearance zones for North Atlantic right whales are as follows:

- May 1 through May 14: An extended clearance zone of 10 km would be established based on real-time PAM. Real-time PAM would begin at least 60 minutes prior to pile driving. In addition, an aerial or vessel-based survey would be conducted across the extended 10 km extended clearance zone, using visual PSOs to monitor for right whales.
- November 1 through December 31: An extended clearance zone of 10 km would be established based on real-time PAM. In addition, an aerial survey may be conducted across

the extended 10 km extended clearance zone, using visual PSOs to monitor for right whales.

During these periods (May 1 through May 14 and November 1 through December 31), if a right whale were detected either via real-time PAM or vessel-based or aerial surveys within 10 km of the pile driving location, pile driving would be postponed and would not commence until the following day, or, until a follow-up aerial or vessel-based survey could confirm the extended clearance zone is clear of right whales, as determined by the lead PSO. Aerial surveys would not begin until the lead PSO on duty determines adequate visibility and at least one hour after sunrise (on days with sun glare). Vessel-based surveys would not begin until the lead PSO on duty determines there is adequate visibility.

Real-time acoustic monitoring would begin at least 60 minutes prior to pile driving. The real-time PAM system would be designed and established such that detection capability extends to 10 km from the pile driving location. The real-time PAM system must ensure that acoustic detections can be classified (*i.e.*, potentially originating from a North Atlantic right whale) within 30 minutes of the original detection. The PAM operator must be trained in identification of mysticete vocalizations. The PAM operator responsible for determining if the acoustic detection originated from a North Atlantic right whale within the 10 km PAM monitoring zone would be required to make such a determination if they had at least 75 percent confidence that the vocalization within 10 km of the pile driving location originated from a North Atlantic right whale.

Consideration of the Effectiveness of Clearance Zones

<u>Sperm Whales</u>

There will be at least two PSOs stationed at an elevated position at or near the pile being driven; given that PSOs are expected to reasonably be able to detect large whales at distances of approximately 1.5 km from their station (Roberts et al. 2016[21]), we expect that the PSOs will be able to effectively monitor the clearance zone (500 m). Given how close a sperm whale would need to be to the pile being driven to be exposed to peak noise above the Level A harassment threshold (see Table 7.6; with 6dB attenuation - for a monopile: 5 m for sperm whales; for jacket foundation: 1 m for sperm whales, with no attenuation – 10m for a monopile and 2.5 m for a jacket), we expect that the requirement to maintain the clearance zones will ensure that no sperm whales will be exposed to noise above the Level A harassment peak threshold.

For sperm whales, the distance to the cumulative Level A harassment threshold extends 43 m for a monopile and 71 m for the jacket foundation, with 6 dB attenuation and 56 m and 71 m, respectively for monopile and jacket without attenuation. Given the ability of a PSO to detect sperm whales at this distance, it is not reasonable to expect that pile driving would be started with a sperm whale at this distance. Further, the cumulative threshold considers that an individual whale is exposed to the total duration of pile driving during a 24-hour period. It is not

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[21] Roberts et al. 2016 reports an effective strip width (a measure of how far animals are seen from the vessel) for North Atlantic right whales (1,309 m) and beaked whales (1,587 m). Detectability from the pile driving platform may be greater given the stability, elevation of the observers, the number of observers used, and the requirement to only install piles during good visibility conditions.

reasonable to expect that even if a sperm whale swam into the exclusion zone while pile driving was occurring and pile driving could not be halted, that the whale would stay within 43 (or 56) m of a monopile foundation for the duration of all pile driving during a 24-hour period which would be approximately 3 hours for a single monopile. It is even less likely that on a day two monopiles were installed a sperm whale would stay within 43 m of the first monopile, then be far enough away for the exclusion zone to be cleared and pile driving to start on the second pile and then quickly return to the area and stay within 43 m of the second pile being installed. This potential is even lower for day that four jacket piles are installed, as it would involve a single whale staying within 71 m of the first jacket pile then leaving for long enough for the exclusion zone to be cleared and then returning and repeating this for the remaining three jacket piles. Based on this, maintenance of the exclusion zone is expected to result in exposure of sperm whales to noise above the Level A harassment threshold to be extremely unlikely to occur. As such, we conclude that it is extremely unlikely that any sperm whales will experience permanent threshold shift or any other injury.

Sei and Fin Whales

As explained above, we expect that the PSO will be able to reliably detect large whales at distances up to 1.5 km from their monitoring station (Roberts et al. 2016). The distance to the cumulative Level A harassment threshold for fin and sei whales extends beyond the clearance zone and beyond the distance that can be reliably observed by the visual PSOs (see Table 7.6; 3,191 m for a monopile: 7,253 m for a jacket). In order to be exposed to noise above the peak Level A harassment threshold a fin or sei whale would need to be within 17 m of a monopile and 4 m of a jacket foundation (see Table 7.6). Given the ability of PSOs to effectively monitor the 500 m exclusion zone, it is extremely unlikely that any pile driving would begin with a fin or sei whale within the exclusion zone. Even if a whale that detected the pile driving noise at a distance did not immediately swim away from the source, it is extremely unlikely that a sei or fin whale would get close enough to a pile being driven to be exposed to noise above the peak Level A harassment threshold. Based on this, it is extremely unlikely that any fin or sei whales will be exposed to noise above the Level A harassment peak threshold. However, given the size of the area we can not reduce or refine the take estimates based on the cumulative noise threshold based on consideration of the effectiveness of the exclusion zone.

Right Whales

The model results indicate that no more than one right whale is expected to be exposed to noise above the Level A harassment threshold. This exposure estimate incorporates the time of year restriction (i.e., no pile driving January 1 – April 30) and 6 dB sound attenuation. Vineyard Wind will implement a clearance zone of 1,000 m for right whales; that is, if any right whales are within 1,000 m of the pile to be driven, pile driving will not begin until the area is clear for at least 60 minutes. Once pile driving starts, we expect that right whales will not approach the sound source as they will detect the aversive stimuli and avoid it. Given the distance to the peak Level A threshold extends only 17 m from a monopile and 2.5 m from a jacket; exposure of any right whales to noise above the peak Level A threshold is extremely unlikely to occur.

The area with noise that would exceed the cumulative Level A threshold extends 3,191 m from a monopile and 7,253 m from a jacket. During November and December and between May 1 and May 15, if a right whale were detected either via real-time PAM or vessel-based or aerial surveys within 10 km of the pile driving location (which extends beyond the area where a right whale could be exposed to noise above the cumulative Level A threshold), pile driving would be postponed and would not commence until the following day, or, until a follow-up aerial or vessel-based survey could confirm the extended clearance zone is clear of right whales, as determined by the lead PSO. These procedures make it extremely unlikely that any pile driving will occur when a right whale is close enough to the pile to be driven to be exposed to noise above the cumulative Level A threshold during the period when the enhanced monitoring measures will be in place. Right whale occurrence in the WDA is lowest during the May 15 – October 31, period. During this time of year, in addition to monitoring for right whale presence in the area where noise may exceed the Level A harassment threshold and using visual PSOs to maintain the 1,000 m exclusion zone, as described in the BA Vineyard Wind will use available sources of information on right whale presence, including at least daily monitoring of the Right Whale Sightings Advisory System, monitoring of Coast Guard VHF Channel 16 throughout the day to receive notifications of any sightings and consideration of information associated with any Dynamic Management Areas to plan pile driving to minimize the potential for exposure of any right whales to pile driving noise. As noted above, even without considering any minimization measures for right whales beyond the time of year restriction and the 6 dB attenuation, only one right model was predicted to be exposed to noise above the Level A harassment threshold. As explained here, the additional minimization measures significantly reduce this risk. Based on consideration of these measures and their anticipated effectiveness, we agree with the conclusion reached by OPR in the notice of proposed IHA that exposure of any right whales to noise above the Level A harassment threshold will be avoided. As such, we conclude that it is extremely unlikely that any right whales will experience permanent threshold shift or any other injury.

Soft Start

Soft start procedure is designed to provide a warning to marine mammals or provide them with a chance to leave the area prior to the hammer operating at full capacity. Vineyard Wind will utilize soft start techniques for impact pile driving by performing an initial set of three strikes from the impact hammer at a reduced energy level followed by a one-minute waiting period. Vineyard Wind has proposed that they will target less than 40 percent of total hammer energy for the initial hammer strikes during soft start. The soft start process would be conducted a total of three times prior to driving each pile (*e.g.*, three single strikes followed by a one minute delay, then three additional single strikes followed by a one minute delay, then a final set of three single strikes followed by an additional one minute delay). Soft start would be required at the beginning of each day’s impact pile driving work and at any time following a cessation of impact pile driving of thirty minutes or longer.

Use of a soft start can reduce the cumulative sound exposure if animals respond to a stationary sound source by swimming away from the source quickly (Ainslie et al. 2017). The result of the soft start will be an increase in underwater noise in an area radiating from the pile that is expected to exceed the Level B harassment threshold and therefore, is expected to cause any whales exposed to the noise to swim away from the source. Noise during the soft start will not exceed the Level A harassment (peak) threshold; therefore, this allows for escape from the noisy area prior to noise being loud enough to result in PTS due to exposure to noise louder than the peak Level A harassment threshold. The use of the soft start gives whales near enough to the piles to be exposed to the soft start noise a “head start” on escape or avoidance behavior by causing them to swim away from the source. It is possible that some whales may swim out of the noisy area before full force pile driving begins; in this case, the number of whales exposed to noise that exceeds the cumulative Level A harassment threshold would be reduced. It is likely that by eliciting avoidance behavior prior to full power pile driving, the soft start will reduce the duration of exposure to noise that could result in Level A or Level B harassment. However, we are not able to predict the extent to which the soft start will reduce the number of whales exposed to pile driving noise or the extent to which it will reduce the duration of exposure. Therefore, while the soft start is expected to reduce effects of pile driving we are not able to modify the estimated take numbers to account for any benefit provided by the soft start.

Monitoring Beyond the Clearance Zones

PSOs would monitor all clearance zones at all times. To the extent practicable, PSOs would also monitor the area where noise exceeds the cumulative Level A harassment threshold (3,191 m for monopiles and 7,253 m for jacket foundations) and Level B harassment zones (*i.e.*, 4,121 m for monopiles and 3,220 m for jacket piles) and would document any marine mammals observed within these zones. At distances more than 1,500 m from the pile the observers ability to detect whales is reduced and observations beyond this distance may be unreliable and incomplete (Roberts et al. 2016). Monitoring beyond the clearance zones not only allows for documentation of any whales exposed to noise above thresholds of concern but also allows for greater awareness of the presence of whales in the project area. This information can be used to plan the pile driving schedule to minimize pile driving at times when whales are nearby and may be at risk of exposure to pile driving noise. In the unlikely event that a whale is approaching the sound source, this monitoring also allows the PSOs to provide advance notice to the pile driving crew before the whale is at risk of entering the clearance zone, which may allow for shutdown of pile driving and avoidance of further impacts. This monitoring is expected to be beneficial towards monitoring and managing risks to whales during pile driving operations but there are no quantifiable reductions in risk that would allow us to modify the estimated take numbers to account for this monitoring.

Acoustic Monitoring

Vineyard Wind would utilize a PAM system to supplement visual monitoring. The PAM system would not be located on the pile installation vessel. The PAM system would be monitored by a minimum of one acoustic PSO beginning at least 30 minutes prior to ramp-up of pile driving and at all times during pile driving. Acoustic PSOs would immediately communicate all detections of marine mammals to visual PSOs, including any determination regarding species identification, distance, and bearing and the degree of confidence in the determination. PAM would be used to inform visual monitoring during construction; the IHA does not proposed to require mitigative actions based on PAM detection alone. However, as described in BOEM's BA, any PAM detection of an ESA 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 30 minutes or, if pile driving has commenced, the PSO will request a temporary cessation of pile driving. Where shutdown 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.

PAM can be highly effective at detecting vocalizing marine mammals at greater distances from a source than can be observed by a visual PSO. Monitoring with PAM not only allows for potential documentation of any whales exposed to noise above thresholds of concern that were not detected by the visual PSOs but also allows for greater awareness of the presence of whales in the project area. As with the monitoring data collected by the visual PSOs, this information can be used to plan the pile driving schedule to minimize pile driving at times when whales are nearby and may be at risk of exposure to pile driving noise. This monitoring is expected to be beneficial towards monitoring and managing risks to whales during pile driving operations but there are no quantifiable reductions in risk that would allow us to modify the estimated take numbers to account for this monitoring.

Sound Source Verification

Vineyard Wind will also conduct hydroacoustic monitoring for a subset of impact-driven piles. As explained above, the differences in conditions across the lease area that could result in variations in noise propagation are minimal; thus, it is expected that any particular pile installation will be representative of other pile locations throughout the lease area. Hydroacoustic monitoring would be performed for at least one of each pile type (*e.g.*, monopile and jacket pile). For each pile that is monitored via hydroacoustic monitoring, a minimum of two autonomous acoustic recorders will be deployed. Each acoustic recorder will consist of a vertical line array with two hydrophones deployed at depths spanning the water column (one near the seabed and one in the water column). Sound source verification will be required for the first monopile and first jacket foundations that are installed, with no additional pile driving taking place until those results are available. Vineyard Wind is required to develop and submit a sound source verification protocol to BOEM and NMFS for review by agency acousticians; this plan will be reviewed to ensure that the proposed sound source verification protocol, including number and location of hydrophones and associated equipment is adequate.

Through the terms of the IHA, Vineyard Wind would be required to conduct sound source verification during pile driving. Sound source verification would be required during impact installation of a 10.3 m monopile (or, of the largest diameter monopile used over the duration of the IHA) with noise attenuation activated; during impact installation of the same size monopile, without noise attenuation activated (if a monopile is installed without noise attenuation; impact pile driving without noise attenuation would be limited to one monopile); and, during impact installation of the largest jacket pile used over the duration of the IHA. Sound source measurements would be conducted at varying distances from the pile being driven to determine peak noise and the distances to the various thresholds of interest.

Vineyard Wind would be required to empirically determine the distances to the isopleths corresponding to the Level A and Level B harassment thresholds either by extrapolating from in situ measurements conducted at several points from the pile being driven, or by direct measurements to locate the distance where the received levels reach the relevant thresholds or below. Isopleths corresponding to the Level A and Level B harassment thresholds would be empirically verified for impact driving of the largest diameter monopile used over the duration of the IHA, and impact driving of the largest diameter jacket pile used over the duration of the IHA. For verification of the extent of the Level B harassment zone, Vineyard Wind would be required to report the measured or extrapolated distances where the received levels SPLrms decay to 160-dB, as well as integration time for such SPLrms.

The required sound source verification will provide information necessary to confirm that the sound source characteristics predicted by the modeling are reflective of actual sound source characteristics in the field. In the event that sound source verification indicates that characteristics in the field are such that the model is invalid or is determined to underestimate exposure of listed species, reinitiation of this consultation may be necessary.

Effects to ESA Listed Whales from Exposure to Pile Driving Noise

Effects of Exposure to Noise Above the Level A Harassment Threshold

As explained above, up to five fin whales and two sei whales will be exposed to pile driving noise that is loud enough to result in Level A harassment. Consistent with OPR's determination in the notice of proposed IHA, in consideration of the duration and intensity of noise exposure we expect that the consequences of exposures above the Level A harassment threshold would be in the form of slight permanent threshold shift (PTS), i.e. minor degradation of hearing capabilities within regions of hearing that align most completely with the energy produced by pile driving (i.e. the low-frequency region below 2 kHz), not severe hearing impairment. If hearing impairment occurs, it is most likely that the affected animal would lose a few decibels in its hearing sensitivity, which, given the limited impact to hearing sensitivity, is not likely to meaningfully affect its ability to forage and communicate with conspecifics. No severe hearing impairment or serious injury is expected because of the received levels of noise anticipated and the short duration of exposure. The PTS anticipated is considered a minor auditory injury. The measures designed to minimize exposure or effects of exposure that will be required by NMFS through the terms of the IHA and by BOEM through the conditions of COP approval and implemented by Vineyard Wind, make it extremely unlikely that any whale will be exposed to pile driving noise that would result in severe hearing impairment or serious injury. This is because given sufficient notice through use of soft start, marine mammals are expected to move away from a sound source that is annoying prior to exposure resulting in a serious injury and avoid sound sources at levels that would cause hearing loss (Southall et al. 2007, Southall et al. 2016). The potential for serious injury is also minimized through the use of a sound attenuation system, and the implementation of clearance zones that would facilitate a delay of pile driving if marine mammals were observed approaching or within areas that could be ensonified above sound levels that could result in auditory injury. The proposed requirement that pile driving can only commence when the full extent of all clearance zones are fully visible to PSOs will ensure a high marine mammal detection capability, enabling a high rate of success in implementation of clearance zones to avoid serious injury.

Effects of Exposure to Noise Above the Level B Harassment Threshold

We anticipate that up to 34 fin, 20 right, 4 sei and 5 sperm whales will be exposed to noise above the Level B harassment threshold. Potential impacts associated with this exposure would include only low-level, temporary behavioral modifications, most likely in the form of avoidance behavior or potential alteration of vocalizations. In order to evaluate whether or not individual behavioral responses, in combination with other stressors, impact animal populations, scientists have developed theoretical frameworks that can then be applied to particular case studies when the supporting data are available. One such framework is the population consequences of disturbance model (PCoD), which attempts to assess the combined effects of individual animal exposures to stressors at the population level (NAS 2017). Nearly all PCoD studies and experts agree that infrequent exposures of a single day or less are unlikely to impact individual fitness, let alone lead to population level effects (Booth et al. 2016; Booth et al. 2017; Christiansen and Lusseau 2015; Farmer et al. 2018; Harris et al. 2017; Harwood and Booth 2016; King et al. 2015; McHuron et al. 2018; NAS 2017; New et al. 2014; Pirotta et al. 2018; Southall et al. 2007; Villegas-Amtmann et al. 2015).

Since we expect that any exposures would be brief (limited only to the time it takes to swim out of the area with noise above the Level B threshold but always less than three hours), and repeat exposures to the same individuals are unlikely (based on abundance, distribution and sightings data), any behavioral responses that would occur due to animals being exposed to pile driving are expected to be temporary, with behavior returning to a baseline state shortly after the acoustic stimuli ceases (i.e., pile driving stops or the animal swims far enough away from the source to no longer be exposed to disturbing levels of noise). Given this, and NMFS' evaluation of the available PCoD studies, any such behavioral responses are not expected to impact individual animals' health or have effects on individual animals' survival or reproduction. Specific effects to the different species are considered below.

North Atlantic Right Whales

We expect the behavioral disruption of up to 20 North Atlantic right whales from exposure to pile driving noise. When in the WDA, one of the primary activity North Atlantic right whales are expected to be engaged in is migration. However, we also expect the animals to perform other behaviors, including opportunistic foraging and resting. If North Atlantic right whales exhibited a behavioral response to the pile driving noise, the normal activity of the animals would be disrupted, and it may pose some energetic cost. However, as noted previously, responses to pile driving noise are anticipated to be short-term (no more than about three hours). Right whales are considerably slower than the other whale species in the action area, with maximum speeds of about 9 kph and median swim speeds of singles, non mother-calf pairs and mother-calf pairs in the southeastern United States recorded at 1.3 kph (Hatin et al. 2013). Studies of marine mammal avoidance of sonar, which like pile driving is an impulsive sound source, demonstrate clear, strong, and pronounced behavioral changes, including sustained avoidance with associated energetic swimming and cessation of feeding behavior (Southall et al. 2016) suggest that it is reasonable to assume that a whale exposed to noise above the Level B harassment threshold would take a direct path to get outside of the noisy area. As such, we would expect a right whale swimming at maximum speed would escape from the noise in less than an hour, but at the median speed observed in Hatin et al. (2013), exposure and disruption of behavior could last for the full duration of pile installation (approximately three hours).

Based on best available information that indicates whales resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013a; Melcon et al. 2012), we anticipate that exposed animals will be able to return to normal behavioral patterns after the exposure ends. If an animal exhibits an avoidance response, it would experience a cost in terms of the energy associated with traveling away from the acoustic source. That said, migration is not considered a particularly costly activity in terms of energetics (Villegas-Amtmann et al. 2015). Animals may also temporarily experience disruptions to foraging activity in these areas. Goldbogen et al. (2013a) hypothesized that if the temporary behavioral responses due to acoustic exposure interrupted feeding behavior, this could have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual whale could not compensate for this lost feeding opportunity by either immediately feeding at another location once it escapes the noisy area, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would likely still be available in the environment following the cessation of acoustic exposure (i.e., the pile driving is not expected to disrupt copepod prey). There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, which we do not expect, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al. 2007a).

Stress responses are also anticipated with each of these instances of disruption. However, the available literature suggests these acoustically induced stress responses will be of short duration (similar to the duration of exposure), and not result in a chronic increase in stress that could result in physiological consequences to the animal. These stress responses are expected to be in contrast to stress responses and associated elevated stress hormone levels that have been observed in North Atlantic right whales that are chronically entangled in fishing gear (Rolland et al. 2017). This is also in contrast to stress level changes observed in North Atlantic right whales due to fluctuations in chronic ocean noise. Rolland et al. (2012) documented that stress hormones in North Atlantic right whales significantly decreased following the events of September 11, 2001 when shipping was significantly restricted. This was thought to be due to the resulting decline in ocean background noise level because of the decrease in shipping traffic. The proposed action is not anticipated to result in detectable changes in ocean background noise due to the periodic nature of noise producing activities. In summary, we do not anticipate long duration exposures to occur and we do not anticipate the associated stress of exposure to result in significant costs to affected individuals**.**

Masking occurs when the receipt of a sound is interfered with by another coincident sound at similar frequencies and at similar or higher intensity. Pile driving noise may mask right whale calls and could have effects on mother-calf communication and behavior. If such effects were severe enough to prevent mothers and calves from reuniting or initiating nursing, they may result in missed feeding opportunities for calves, which could lead to reduced growth, starvation, and even death. Any mother-calf pairs in the action area would have left the southern calving grounds and be making northward migrations to northern foraging areas. The available data suggests that North Atlantic right whale mother-calf pairs rarely use vocal communication on the calving grounds and so the two maintain visual contact until calves are approximately three to four months of age (Parks and Clark 2007; Parks and Van Parijs 2015; Root-Gutteridge et al. 2018; Trygonis et al. 2013). Such findings are consistent with data on southern right and humpback whales, which appear to rely more on mechanical stimulation to initiate nursing rather than vocal communication (Thomas and Taber 1984; Videsen et al. 2017). When mother-calf pairs leave the calving grounds and begin to migrate to the northern feeding grounds, if they begin to rely on acoustic communication more, then any masking could interfere with mother-calf reunions. For example, even though humpback whales do not appear to use vocal communication for nursing, they do produce low-level vocalizations when moving that have been suggested to function as cohesive calls (Videsen et al. 2017). However, when calves leave the foraging grounds at around four months of age, they are expected to be more robust and less susceptible to a missed or delayed nursing opportunity. Any masking would only last for the duration of the exposure to pile driving noise, which in all cases would be no more than three hours. As such, even if masking were to interfere with mother-calf communication in the action area, we do not anticipate that such effects would result in fitness consequences given their short-term nature.

Harris et al. (2017a) summarized the research efforts conducted to date that have attempted to understand the ways in which behavioral responses may result in long-term consequences to individuals and populations. Efforts have been made to try to quantify the potential consequences of such responses, and frameworks have been developed for this assessment (e.g., Population Consequences of Disturbance). However, models that have been developed to date to address this question require many input parameters and, for most species, there are insufficient data for parameterization (Harris et al. 2017a). Nearly all studies and experts agree that infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015b; NAS 2017; New et al. 2014; Southall et al. 2007d; Villegas-Amtmann et al. 2015). Based on best available information, we expect this to be the case for North Atlantic right whales exposed to pile driving noise. We do not anticipate that instances of behavioral response and any associated energy expenditure or stress will result in fitness consequences to individual North Atlantic right whales.

NMFS Interim Guidance on the ESA Term "Harass" (PD 02-110-19; December 21, 2016[22] provides for a four-step process to determine if a response meets the definition of harassment. The Interim Guidance defines harassment as to "[c]reate the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." The guidance states that NMFS will consider the following steps in an assessment of whether proposed activities are likely to harass: 1) Whether an animal is likely to be exposed to a stressor or disturbance (i.e., an annoyance); and, 2) The nature of that exposure in terms of magnitude, frequency, duration, etc. Included in this may be type and scale as well as considerations of the geographic area of exposure (e.g., is the annoyance within a biologically important location for the species, such as a foraging area, spawning/breeding area, or nursery area?); 3) The expected response of the exposed animal to a stressor or disturbance (e.g., startle, flight, alteration [including abandonment] of important behaviors); and 4) Whether the nature and duration or intensity of that response is a significant disruption of those behavior patterns which include, but are not limited to, breeding, feeding, or sheltering, resting or migrating,

Here, we carry out that four-step assessment. For individual right whales exposed to disturbing levels of noise, there will be a significant disruption of their behavior because they will need to abandon that activity for up to three hours while they swim to an alternate area to resume this behavior or they will avoid the area extending approximately 4 km from the pile being driven for

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[22] Available at: https://www.fisheries.noaa.gov/national/laws-and-policies/protected-resources-policy-directives

the three hour duration of the pile driving. This means they will need to find an alternate migration route or alternate place for foraging. These whales will also experience masking and TTS, which would affect their ability to detect certain environmental cues for the duration of pile driving and may impact their ability to communicate. Based on this four-step analysis, we find that the 20 right whales exposed to pile driving noise louder than 160 dB re 1uPa rms are likely to be adversely affected and that effect amounts to harassment. As such, we expect the harassment of 20 right whales as a result of pile driving.

NMFS defines "harm" in the definition of "take" as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering" (50 CFR §222.102). No right whales will be injured or killed due to exposure to pile driving noise. Further, while exposure to pile driving noise will significantly disrupt behaviors of individual right whales, it will not significantly impair any essential behavioral patterns. This is due to the short term, localized nature of the effects and because we expect these behaviors to resume once the right whale is no longer exposed to the noise. The energetic consequences of the evasive behavior and delay in resting or foraging are not expected affect any individual's ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in breeding or calving . TTS will resolve within a week of exposure and is not expected to affect the health of any whale or its ability to migrate, forage, breed, or calve. Thus, the response of right whales to pile driving noise does not meet the definition of "harm."

Fin, Sei and Sperm Whales

Behavioral responses may impact health through a variety of different mechanisms, but most Population Consequences of Disturbance models focus on how such responses affect an animal's energy budget (Costa et al. 2016c; Farmer et al. 2018; King et al. 2015b; NAS 2017; New et al. 2014; Villegas-Amtmann et al. 2017). Responses that relate to foraging behavior, such as those that may indicate reduced foraging efficiency (Miller et al. 2009) or involve the complete cessation of foraging, may result in an energetic loss to animals. Other behavioral responses, such as avoidance, may have energetic costs associated with traveling (NAS 2017). Important in considering whether or not energetic losses, whether due to reduced foraging or increased traveling, will affect an individual's fitness is considering the duration of exposure and associated response. Nearly all studies and experts agree that infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget and that long duration and repetitive disruptions would be necessary to result in consequential impacts on an animal (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015b; NAS 2017; New et al. 2014; Southall et al. 2007d; Villegas-Amtmann et al. 2015). We also recognize that aside from affecting health via an energetic cost, a behavioral response could result in more direct impacts to health and/or fitness. For example, if a whale hears the pile driving noise and avoids the area, this may cause it to travel to an area with other threats such as vessel traffic or fishing gear. However, we find such possibilities (i.e., that a behavioral response would lead directly to a ship strike) to be extremely remote and not reasonably certain to occur, and so focus our analysis on the energetic costs associated with a behavioral response.

Quantifying the fitness consequences of sub-lethal impacts from acoustic stressors is exceedingly difficult for marine mammals and we do not currently have data to conduct a quantitative analysis on the likely consequences of such sub-lethal impacts. While we are unable to conduct a quantitative analysis on how sub-lethal behavioral effects and temporary hearing impacts (i.e., masking) may impact animal vital rates (and therefore fitness), based on the best available information, we expect an increased likelihood of consequential effects when exposures and associated effects are long-term and repeated, occur in locations where the animals are conducting critical activities, and when the animal affected is in a compromised state.

We do not have information to suggest that affected sperm, sei, or fin whales are likely to be in a compromised state at the time of exposure. During exposure, affected animals may be engaged in any number of activities including, but not limited to, migration, foraging, or resting. If fin, sei, or sperm whales exhibited a behavioral response to pile driving noise, these activities would be disrupted and it may pose some energetic cost. However, as noted previously, responses to pile driving noise are anticipated to be short term (less than three hours). Sperm whales normal cruise speed is 5-15 kph, with burst speed of up to 35-45 kph for up to an hour. Fin whales cruise at approximately 10 kph while feeding and have a maximum swim speed of up to 35 kph. Sei whales swim at speeds of up to 55 kph. Assuming that a whale exposed to noise above the Level B harassment threshold takes a direct path to get outside of the noisy area, we would expect sperm, fin, and sei whales to be outside the noisy area (extending 4.1 km from a monopile and 3.2 k from a jacket) in less than an hour even if they did not swim at burst speed. Based on best available information that indicates whales resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013a; Melcon et al. 2012), we anticipate that exposed animals will be able to return normal behavioral patterns after this short duration activity ceases.

Goldbogen et al. (2013a) suggested that if the documented temporary behavioral responses interrupted feeding behavior, this could have impacts on individual fitness and eventually, population health. However, for this to be true, we would have to assume that an individual whale could not compensate for this lost feeding opportunity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding at a later time. There is no indication this is the case, particularly since unconsumed prey would still be available in the environment following the cessation of acoustic exposure (i.e., the pile driving is not expected to result in a reduction in prey). There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, we do not anticipate this movement to be consequential to the animal over the long-term (Southall et al 2007). Based on the estimated abundance of fin, sei, and sperm whales in the action area, and the number of instances of behavioral disruption expected, multiple exposures of the same animal are not anticipated. Therefore, we do anticipate repeat exposures, and based on the available literature that indicates infrequent exposures are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015b; NAS 2017; New et al. 2014; Southall et al. 2007d; Villegas-Amtmann et al. 2015), we do not expect this level of exposure to impact the fitness of exposed animals.

Given the frequency of pile driving noise, we do not anticipate any masking of sperm whale vocalizations. For fin and sei whales, little information exists on where they give birth as well as on mother-calf vocalizations. As such, it is difficult to assess whether or not masking could significantly interfere with mother-calf communication in a way that could result in fitness consequences. There is no indication that sperm whale calves occur in the action area. To be conservative, we assume here that some of the sei or fin whales exposed to pile driving noise are mother-calf pairs. Absent data on fin and sei whale mother-calf communication within the action area, we rely on our analysis of the effects of masking to North Atlantic right whales, which given their current status, are considered more vulnerable than fin or sei whales. Based on this analysis, we do not believe that TTS and or masking will affect fin whale mother-calf fitness.

Here, we carry out that four-step assessment to determine if the expected responses to exposure to noise above the behavioral disturbance threshold will result in harassment. For individual whales exposed to disturbing levels of noise, there will be a significant disruption of their behavior because they will need to abandon that activity for up to three hours while they swim to an alternate area to resume this behavior or they will avoid the area extending approximately 4 km from the pile being driven for the three hour duration of the pile driving. This means they will need to find an alternate migration route or alternate place for foraging. These whales will also experience masking and TTS, which would affect their ability to detect certain environmental cues for the duration of pile driving and may impact their ability to communicate. Based on this four-step analysis, we find that the 34 fin, 4 sei, and 5 sperm whales exposed to pile driving noise louder than 160 dB re 1uPa rms are likely to be adversely affected and that effect amounts to harassment. As such, we expect the harassment of 34 fin, 4 sei, and 5 sperm whales as a result of pile driving.

NMFS defines “harm” as “an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering.” Injury is limited to minor auditory injury, no serious injury or mortality will result from exposure to pile driving noise. Further, while exposure to pile driving noise will significantly disrupt behaviors of individual whales, it will not significantly impair any essential behavioral patterns. This is due to the short term, localized nature of the effects and because we expect these behaviors to resume once the whale is no longer exposed to the noise. The energetic consequences of the evasive behavior and delay in resting or foraging are expected to be minor and will not affect any individual’s ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in breeding or calving. Thus, the response of whales to pile driving noise does not meet the definition of “harm.”

Vessel Noise and Cable Installation

The frequency range for vessel noise (10 to 1000 Hz; MMS 2007) overlaps with the generalized hearing range for sei, fin, and right whales (7 Hz to 35 kHz) and sperm whales (150 Hz to 160 kHz) and would therefore be audible. As described in the BA, vessels without ducted propeller thrusters would produce levels of noise of 150 to 170 dB re 1 µPa-1 meter at frequencies below 1,000 Hz, while the expected sound-source level for vessels with ducted propeller thrusters level is 177 dB (RMS) at 1 meter. For ROVs, source levels may be as high as

160 dB. Given that the noise associated with the operation of project vessels is below the thresholds that could result in injury, no injury is expected. Noise produced during cable installation is dominated by the vessel noise; therefore, we consider these together.

Marine mammals may experience masking due to vessel noises. For example, right whales were observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007a) as well as increasing the amplitude (intensity) of their calls (Parks et al. 2011a; Parks et al. 2009). Right whales also had their communication space reduced by up to 84 percent in the presence of vessels (Clark et al. 2009a). Although humpback whales did not change the frequency or duration of their vocalizations in the presence of ship noise, their source levels were lower than expected, potentially indicating some signal masking (Dunlop 2016).

Vessel noise can potentially mask vocalizations and other biologically important sounds (e.g., sounds of prey or predators) that marine mammals may rely on. Potential masking can vary depending on the ambient noise level within the environment, the received level and frequency of the vessel noise, and the received level and frequency of the sound of biological interest. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 µPa in the band between 10 Hz and 10 kHz due to a combination of natural (e.g., wind) and anthropogenic sources (Urick 1983a), while inshore noise levels, especially around busy ports, can exceed 120 dB re 1 µPa. When the noise level is above the sound of interest, and in a similar frequency band, masking could occur. This analysis assumes that any sound that is above ambient noise levels and within an animal’s hearing range may potentially cause masking. However, the degree of masking increases with increasing noise levels; a noise that is just detectable over ambient levels is unlikely to cause any substantial masking.

Vessel noise has the potential to disturb marine mammals and elicit an alerting, avoidance, or other behavioral reaction. These reactions are anticipated to be short-term, likely lasting the amount of time the vessel and the whale are in close proximity (e.g., Magalhaes et al. 2002; Richardson et al. 1995d; Watkins 1981a), and not consequential to the animals. Additionally, short-term masking could occur. Masking by passing ships or other sound sources transiting the action area would be short term and intermittent, and therefore unlikely to result in any substantial costs or consequences to individual animals or populations. Areas with increased levels of ambient noise from anthropogenic noise sources such as areas around busy shipping lanes and near harbors and ports may cause sustained levels of masking for marine mammals, which could reduce an animal’s ability to find prey, find mates, socialize, avoid predators, or navigate.

Based on the best available information, ESA-listed marine mammals are either not likely to respond to vessel noise or are not likely to measurably respond in ways that would significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering. Therefore, the effects of vessel noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effect cannot be meaningfully evaluated or detected).

Operation of WTGs
Underwater noise associated with the operation of the WTGs is expected to be undetectable above ambient noise at a distance of 50 m from any wind turbine; based on data collected at wind farms in Europe peak underwater noise is expected to be 137 dB re 1uPa. NMFS considers 120 dB re uPa rms as the threshold above which exposure to continuous noise can result in behavioral disturbance. Given that operational noise will be undetectable above ambient noise at a distance of 50 m from the wind turbine, whales are likely to avoid approaching within 50 m of any WTGs. Given the very small area to be avoided, effects on ESA-listed whales are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated or detected).

Aircraft Noise
Whales at the surface may be exposed to noise from helicopters. North Atlantic right whale approach regulations (50 CFR 222.32) prohibit approaches to within 500 yards of a right whale with an aircraft. BOEM will require all aircraft operations to comply with current approach regulations for any sighted North Atlantic right whales or unidentified large whale. As noted above, source levels are expected between 149 to 151 dB re 1 μPa at 1 m (Richardson et al. 1995), with a received level of approximately 126 dB re 1 μPa (Patenaude et al. 2002). Any exposure of whales to aircraft noise will be brief and limited to the time of overflight (seconds). Due to the short-term nature of any exposures to aircraft and the brief responses that could follow such exposure, the effects of aircraft overflight noise on ESA-listed marine mammals are insignificant (i.e., so minor that the effects cannot be meaningfully evaluated or detected).

Survey Equipment to Support Decommissioning
The equipment that is described by BOEM for use for surveys to support decommissioning produces underwater noise that can be perceived by whales. Distances to the injury and behavioral disturbance thresholds from the loudest equipment is presented in the table below (7.15).

Table 7.15 Radius around noise source with noise above the Level A and Level B harassment thresholds

	Distance to Injury Threshold (m from source)	Distance to Behavioral Disturbance Threshold (m from source)**
LFC (baleen whales)	26	502
MFC (sperm whales)	1	502

It is extremely unlikely that any whales will be exposed to injurious levels of noise during any surveys. This conclusion is based on the very small distance from the source where noise above the injury threshold extends (26 m for right, fin, and sei whales and 1m for sperm whales). The proposed action includes a requirement for a minimum of two PSOs, each responsible for scanning no more than 180° per pile driving event. Additional observers will be required as necessary to maintain a 1,000 m exclusion zone for right whales and a 500 m exclusion zone for all whales (equivalent to the 160 dB re 1:uPa rms isopleth). Because we do not expect that a whale could be close enough to the sound source to be exposed to potentially injurious levels of noise (i.e., within 26 m of the source) without being detected by the observer in time for the noise producing survey equipment to be turned off in time to avoid exposure (even at night or in poor visibility), it is extremely unlikely that any whale would be exposed to underwater noise that could result in injury. The potential for behavioral effects is considered below.

Any time a whale is sighted within 500 m of the exclusion zone, HRG sources will be powered to off. Therefore, we do not expect the exposure of any fin, sei, right, or sperm whales to disturbing levels of noise during the surveys. It is important to note that even if a whale did get closer than 500 m before the equipment was shut off, effects of any short term noise exposure would be insignificant. This is because any exposure will be short (no more than a few seconds to a few minutes) and the reaction to exposure is expected to be limited to changing course and swimming away from the noise source only far/long enough to get out of the ensonified area (swimming less than 500 m which would take less than a few minutes), and because no animals are expected to be exposed to the noise source more than once, the effect of this exposure and resulting response will be so small that it will not be able to be meaningfully detected, measured or evaluated and, therefore, is insignificant. Because these behavioral changes are so minor, it is not reasonable to expect that, under the NMFS interim ESA definition of harassment, they are equivalent to an act that would "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering."

7.1.3 Effects of Project Noise on Sea Turtles

Background Information – Sea Turtles and Noise

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Bartol and Ketten 2006, Bartol et al. 1999, Lenhardt 1994, Lenhardt 2002, Ridgway et al. 1969). Below, we summarize the available information on expected responses of sea turtles to noise.

Stress caused by acoustic exposure has not been studied for sea turtles. As described for marine mammals, a stress response is a suite of physiological changes that are meant to help an organism mitigate the impact of a stressor. If the magnitude and duration of the stress response is too great or too long, it can have negative consequences to the animal such as low reproductive rates, decreased immune function, diminished foraging capacity, etc. Physiological stress is typically analyzed by measuring stress hormones (such as cortisol), other biochemical markers, and vital signs. To our knowledge, there is no direct evidence indicating that sea turtles will experience a stress response if exposed to acoustic stressors such as sounds from pile driving. However, physiological stress has been measured for sea turtles during nesting, capture and handling (Flower et al. 2015; Gregory and Schmid 2001; Jessop et al. 2003; Lance et al. 2004), and when caught in entangling nets and trawls (Hoopes et al. 2000; Snoddy et al. 2009). Therefore, based on their response to these other anthropogenic stressors, and including what is known about cetacean stress responses, we assume that some sea turtles will exhibit a stress response if exposed to a detectable sound stressor.

Marine animals often respond to anthropogenic stressors in a manner that resembles a predator response (Beale and Monaghan 2004b; Frid 2003; Frid and Dill 2002; Gill et al. 2001;

Harrington and Veitch 1992; Lima 1998; Romero 2004). As predators generally induce a stress response in their prey (Dwyer 2004; Lopez and Martin 2001; Mateo 2007), we assume that sea turtles may experience a stress response if exposed acoustic stressors, especially loud sounds. We expect breeding adult females may experience a lower stress response, as studies on loggerhead, hawksbill, and green turtles have demonstrated that females appear to have a physiological mechanism to reduce or eliminate hormonal response to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop 2001; Jessop et al. 2000; Jessop et al. 2004). We note that breeding females do not occur in the action area.

Due to the limited information about acoustically induced stress responses in sea turtles, we assume physiological stress responses would occur concurrently with any other response such as hearing impairment or behavioral disruptions. However, we expect such responses to be brief, with animals returning to a baseline state once exposure to the acoustic source ceases. As with cetaceans, such a short, low level stress response may in fact be adaptive and beneficial as it may result in sea turtles exhibiting avoidance behavior, thereby minimizing their exposure duration and risk from more deleterious, high sound levels.

Effects to Hearing

Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Clark et al. 2009b; Erbe et al. 2016). Masking can interfere with an individual’s ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options. Compared to other marine animals, such as marine mammals which are highly adapted to use sound in the marine environment, sea turtle hearing is limited to lower frequencies and is less sensitive. Because sea turtles likely use their hearing to detect broadband low-frequency sounds in their environment, the potential for masking would be limited to certain sound exposures. Only continuous anthropogenic sounds that have a significant low-frequency component, are not of brief duration, and are of sufficient received level could create a meaningful masking situation (e.g., long-duration vibratory pile extraction or long term exposure to vessel noise affecting natural background and ambient sounds); this type of noise exposure is not anticipated based on the characteristics of the sound sources considered here.

There is evidence that sea turtles may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al. 2013), magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015), and scent (Shine et al. 2004). Thus, any effect of masking on sea turtles could be mediated by their normal reliance on other environmental cues.

Behavioral Responses

To date, very little research has been done regarding sea turtle behavioral responses relative to underwater noise. Popper et al. (2014) describes relative risk (high, moderate, low) for sea turtles exposed to pile driving noise and concludes that risk of a behavioral response decreases with distance from the pile being driven. O'Hara and Wilcox (1990) and McCauley et al. (2000b), who experimentally examined behavioral responses of sea turtles in response to seismic airguns. O'Hara and Wilcox (1990) found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dB re: 1 µPa (rms) (or slightly less) in a shallow canal. Mccauley et al. (2000a) experimentally examined behavioral responses of sea turtles in response to seismic air guns. The authors found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dB rms (re: 1 μPa), or slightly less, in a shallow canal. Mccauley et al. (2000a) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB rms (re: 1 μPa). At 175 dB rms (re: one μPa), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (Mccauley et al. 2000a). Based on these data, NMFS assumes that sea turtles would exhibit a significant behavioral response in a manner that constitutes harassment or other adverse behavioral effects, when exposed to received levels of 175 dB rms (re: 1 μPa). This is the level at which sea turtles are expected to begin to exhibit avoidance behavior based on experimental observations of sea turtles exposed to multiple firings of nearby or approaching air guns.

Thresholds Used to Evaluate Effects of Project Noise on Sea Turtles

In order to evaluate the effects of exposure to noise by sea turtles that could result in physical effects, NMFS relies on the available literature related to the noise levels that would be expected to result in sound-induced hearing loss (i.e., TTS or PTS); we relied on acoustic thresholds for PTS and TTS for impulsive sounds developed by the U.S. Navy for Phase III of their programmatic approach to evaluating the environmental effects of their military readiness activities (U.S. Navy 2017a). At the time of this consultation, we consider these the best available data since they rely on all available information on sea turtle hearing and employ the same methodology to derive thresholds as in NMFS recently issued technical guidance for auditory injury of marine mammals (NMFS 2018). Below we briefly detail these thresholds and their derivation. More information can be found in the U.S. Navy's Technical report on the subject (U.S. Navy 2017a).

To estimate received levels from airguns and other impulsive sources expected to produce TTS in sea turtles, the U.S. Navy compiled all sea turtle audiograms available in the literature in an effort to create a composite audiogram for sea turtles as a hearing group. Since these data were insufficient to successfully model a composite audiogram via a fitted curve as was done for marine mammals, median audiogram values were used in forming the hearing group's composite audiogram. Based on this composite audiogram and data on the onset of TTS in fishes, an auditory weighting function was created to estimate the susceptibility of sea turtles to TTS. Data from fishes were used since there are currently no data on TTS for sea turtles and fishes are considered to have hearing range more similar to sea turtles than do marine mammals (Popper et al. 2014). Assuming a similar relationship between TTS onset and PTS onset as has been described for humans and the available data on marine mammals, an extrapolation to PTS susceptibility of sea turtles was made based on the methods proposed by (Navy 2017). From these data and analyses, dual metric thresholds were established similar to those for marine mammals: one threshold based on peak sound pressure level (0-pk SPL) that does not incorporate the auditory weighting function nor the duration of exposure, and another based on cumulative sound exposure level (SELcum) that incorporates both the auditory weighting function and the exposure duration (Table 7.16). The cumulative metric accumulates all sound exposure within a 24-hour period and is therefore different from a peak, or single exposure, metric.

Table 7.16. Acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for sea turtles exposed to impulsive sounds (U.S. Navy 2017a)

Hearing Group	Generalized Hearing Range	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Sea Turtles	30 Hz to 2 kHz	204 dB re: 1 Pa^2·s SEL$_{cum}$ 232 dB re: 1 µPa SPL (0-pk)	189 dB re: 1 µPa^2·s SEL$_{cum}$ 226 dB re: 1 µPa SPL (0-pk)

Based on the studies of behavioral responses of sea turtles to air gun noise summarized above, we expect that sea turtles would exhibit a behavioral response when exposed to received levels of 166 dB re: 1uPa rms and significant behavioral disruption and avoidance behavior when exposed to received levels of 175 dB re: 1 µPa (rms) and higher.

Effects of Project Noise on Sea Turtles

In the BA and in the acoustic models produced by Vineyard Wind to support the COP (Pyc et al. 2018), BOEM and Vineyard Wind rely on sound exposure guidelines from Popper at al. (2014) to estimate exposure to noise that could result in injury. Popper et al. (2014) present recommended criteria for exposure to pile driving noise for sea turtles based on the "levels for fish that do not hear well since it is likely these would be conservative for sea turtles." The recommended criteria (210 dB SELcum and >207 dB peak) are for mortality and potential mortal injury. The authors note, "because of their rigid external anatomy, it is possible that sea turtles are highly protected from impulsive sound effects, at least with regard to pile driving and seismic airguns."

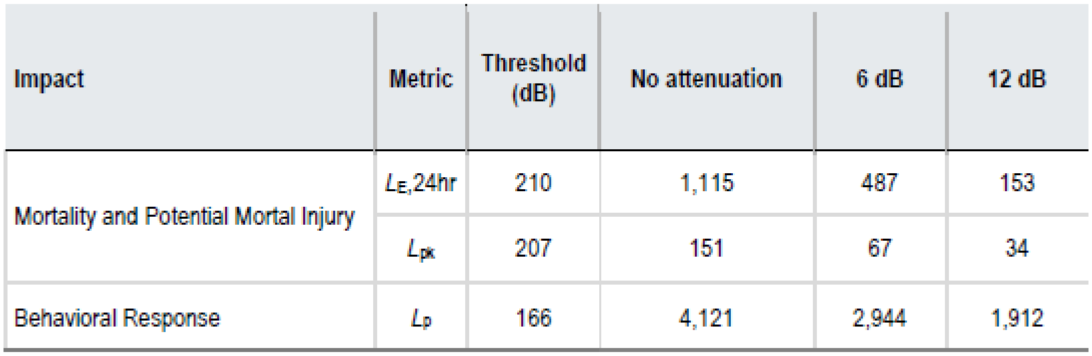
In comparing the Navy 2017 criteria (Table 7.16 above) and the Popper et al. (2014) criteria, it is important to consider that the thresholds are designed to evaluate different responses. The Navy 2017 thresholds, when exceeded, are likely to result in auditory injury (permanent or temporary threshold shift), while the Popper at al. (2014) criteria indicate the thresholds, when exceeded, are likely to result in mortality or potential mortal injury. However, based on the information that was used to develop the Navy 2017 thresholds, the Popper et al. 2014 thresholds are overly conservative; that is, use of these thresholds could result in predictions of mortality or mortal injury when the actual expected response would be auditory injury. For example, using the Popper et al. (2014) thresholds, you would expect that a sea turtle exposed to peak noise of 210 dB re 1 uPa would experience mortal injury. However, applying the Navy (2017) thresholds, you would expect that a sea turtle exposed to peak noise of 210 dB re 1uPa would not even experience a temporary disruption to their hearing (TTS). As NMFS has determined that the Navy (2017) thresholds represent the best available scientific information we consider the predicted responses of sea turtles to pile driving noise based on the Popper et al. (2014) thresholds to result in over-estimates of the severity of effects.

For assessing behavioral effects, BOEM and Vineyard Wind used a 166 dB re 1uPa RMS criteria based on McCauley et al. (2000b) which reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB rms re: 1 µPa SPL. As noted above, NMFS relies on a 175 dB rms re: 1 µPa SPL threshold for considering behavioral disturbance to sea turtles. This level is based upon work by Mccauley et al. (2000a), who experimentally examined behavioral responses of sea turtles in response to seismic air guns. The authors found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dB rms (re: 1 µPa), or slightly less, in a shallow canal. Mccauley et al. (2000a) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB rms (re: 1 µPa). At 175 dB rms (re: 1 µPa), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (Mccauley et al. 2000a). Based on these data, NMFS assumes that sea turtles would exhibit a significant behavioral response in a manner that may constitute harassment or other adverse behavioral effects, when exposed to received levels of 175 dB rms (re: 1 µPa). This is the level at which sea turtles are expected to begin to exhibit avoidance behavior based on experimental observations of sea turtles exposed to multiple firings of nearby or approaching air guns. Because data on sea turtle behavioral responses to pile driving is limited, the air gun data set is used to inform potential risk. BOEM's use of the 166 dB rms threshold represents an onset of potential behavioral responses by sea turtles to noise while the 175 dB rms threshold represents an onset of more significant reactions including disruption of behavior and active avoidance.

Pile Driving

Using the same methodology described above for marine mammals, Pyc et al. (2018) modeled radial distances to 207 dB peak and 210 dB SELcum for considering injury (based on Popper et al. 2014) and 166 dB re 1 uPa rms for behavioral disturbance (based on McCauley et al. 2000a). As explained above, the use of these injury thresholds is expected to overestimate the number of sea turtles exposed to noise that could result in injury and is expected to predict responses of exposed sea turtles that exceed actual responses. This is addressed in our assessment below.

Table 7.17. Radial distance (meters) to acoustic thresholds used to evaluate responses of sea turtles to pile driving noise resulting from modeling of 10.3 m monopile with various levels of attenuation. The values are calculated using the most conservative hammer energy radii, averaged over both modeling sites. Table from Pyc et al. (2018).



Impact	Metric	Threshold (dB)	No attenuation	6 dB	12 dB
Mortality and Potential Mortal Injury	$L_{E,24hr}$	210	1,115	487	153
	L_{pk}	207	151	67	34
Behavioral Response	L_p	166	4,121	2,944	1,912

The same animal movement modeling and exposure modeling procedures were used for sea turtles as were used for marine mammals incorporating movement parameters specific to the turtle species. There are limited density estimates for sea turtles in the WDA. For the exposure 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 (SERDP-SDSS) portal (DoN, 2007; DoN, 2012). These numbers were adjusted by the Sea Mammal Research Unit (SMRU, 2013), available in the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) (Halpin et al., 2009). In OBIS-SEAMAP, because density is provided as a range, the maximum density will always exceed zero, even though turtles are unlikely to be present in winter. These data are summarized seasonally (winter (December – February), spring (March – May), summer (June – August), and fall (September-November) and provided as a range of potential densities per square kilometer within each grid square (see table 7.18 below).

Table 7.18. Sea turtle density estimates for the project area used for the exposure analysis. Density estimates are derived from SERDP-SDSS NODE database.

Sea Turtle Species	Density (animals/100 km^2)			
	Spring	Summer	Fall	Winter
Leatherback	0.0274	0.0274	0.0274	0.0274
Loggerhead	0.1117	0.1192	0.1111	0.1111
Kemp’s ridley	0.0105	0.0105	0.0105	0.0105

Kraus et al. (2016) carried out surveys in the MA/RI and MA WEAs. In those surveys, leatherback and loggerhead sea turtles were the most commonly observed with an additional six identified Kemp’s ridley sightings over five years. Information from Kraus et al. (2016) does not provide density estimates for sea turtles, but rather provides effort-weighted average sightings rates (the number of animals per 1,000 km). A summary of sightings and the sightings rates from Kraus et al. (2016) is presented in table 7.19 below. No green sea turtles were identified by Kraus et al. (2016); however, as green sea turtles are at least occasionally present in the area surveyed it is possible that some of the unidentified sea turtles were green sea turtles.

Table 7.19. Effort-weighted average sighting rates (SR, the number of animals per 1000 km), numbers of sightings (S), and numbers of animals observed (A) for three sea turtle species (only *definite* and *probable* identifications) and all sea turtles combined, by season. Total effort (km) is shown below each season name

Species	**Autumn**			**Winter**			**Spring**			**Summer**		
	(13,298.08 km)			(11,846.17 km)			(23,348.20 km)			(18,683.15 km)		
	SR	**S**	**A**	**SR**	**S**	**A**	**SR**	**S**	**A**	**SR**	**S**	**A**
Leatherback	4.59	59	62	0	0	0	0.08	2	2	4.65	92	95
Loggerhead	3.97	45	45	0	0	0	0.07	2	2	1.52	31	31
Kemp’s Ridley	NA	4	4	NA	0	0	NA	0	0	NA	0	0
All turtles	10.46	133	140	0	0	0	0.19	5	5	8.66	146	165

As noted in BOEM’s BA, the Kraus et al. (2016) data suggest that the Pyc et al. (2018) modeling underestimates exposure of leatherback sea turtles. Kraus et al. (2016) data indicate that leatherbacks are the most abundant sea turtle species in the action area, which is consistent with our expectations based on available information on the use of the action area by sea turtles. Comparing the sightings rate of loggerhead and leatherback sea turtles in Kraus et al. (2016;

table 7.19 above), leatherbacks are 1.16 more abundant than loggerheads in the autumn, 1.14 times more abundant in the spring, and 3.06 times more abundant in the summer. To compensate for the underestimate of leatherback abundance in the Pyc et al. (2018) exposure estimates (below), we have multiplied the loggerhead estimates by the maximum difference in seasonal abundance (3.06) to predict exposure of leatherback sea turtles.

Table 7.20. Pyc et al. 2018 predicted exposures for the maximum design scenario (90 monopiles, 12 jacket foundations) with 6dB attenuation and no attenuation are presented in the table below (using the density estimates presented above). Note that while fractions of an animal cannot be taken, these tables are meant simply to show the modeled exposure numbers, versus the actual proposed take estimate.

No Attenuation

Sea Turtle Species	**Injury (207 dB re 1uPa peak**		**Injury (210 dB re 1 uPa SELcum)**		**Behavioral Disturbance (166 dB re 1 uPa rms)**	
	1 pile per day	**2 piles per day**	**1 pile per day**	**2 piles per day**	**1 pile per day**	**2 piles per day**
Kemp's Ridley	0.01	0.01	0.01	0.01	0.54	0.30
Leatherback	0.02	0.01	0.01	0.01	0.64	0.45
Loggerhead	0.07	0.09	0.07	0.13	2.94	3.34

6 dB Attenuation

Sea Turtle Species	**Injury (207 dB re 1uPa peak**		**Injury (210 dB re 1 uPa SELcum)**		**Behavioral Disturbance (166 dB re 1 uPa rms)**	
	1 pile per day	**2 piles per day**	**1 pile per day**	**2 piles per day**	**1 pile per day**	**2 piles per day**
Kemp's Ridley	0.01	0.01	0	0	0.31	0.19
Leatherback	0.02	0.01	0	0	0.38	0.29
Loggerhead	0.07	0.08	0	0.04	1.72	2.13

Because we know that green sea turtles occur in the WDA, we expect the potential to exist for exposure of green sea turtles to pile driving noise. In the action area, green sea turtles are the least abundant sea turtle species (Kraus et al. 2016). Therefore, we would not expect green sea turtle exposures to be greater than those modeled for Kemp's ridley sea turtles. The table below (7.21) modifies the modeled exposure estimates to consider the Kraus et al. (2016) information on leatherback abundance and our expectations regarding green sea turtle occurrence in the WDA.

Table 7.21. NMFS modified exposure estimates for the maximum design scenario (90 monopiles, 12 jacket foundations) with 6 dB attenuation are presented in the table below (using the density estimates presented above).

Sea Turtle Species	Injury (207 dB re 1uPa peak		Injury (210 dB re 1 uPa SELcum)		Behavioral Disturbance (166 dB re 1 uPa rms)	
	1 pile per day	2 piles per day	1 pile per day	2 piles per day	1 pile per day	2 piles per day
Kemp's Ridley	0.01	0.01	0	0	0.31	0.19
Green*	0.01	0.01	0	0	0.31	0.19
Leatherback**	0.21	0.24	0	0.12	5.16	6.52
Loggerhead	0.07	0.08	0	0.04	1.72	2.13

Proposed Measures to Minimize Exposure of Sea Turtles to Pile Driving Noise
Here, we consider the measures that are part of the proposed action, either because they are proposed by Vineyard Wind and reflected in the proposed action as described to us by BOEM in the BA, or are proposed to be required through the IHA, and how those measures will serve to minimize exposure of ESA listed sea turtles to pile driving noise. Details of these proposed measures are included in the Description of the Action section above. We do not consider use of PAM here; because sea turtles do not vocalize, PAM is not used to monitor sea turtle presence.

Seasonal Restriction on Pile Driving
No pile driving activities would occur between January 1 through April 30 to avoid the time of year with the highest densities of right whales in the project area. The January 1 – April 30 period overlaps with the period when we do not expect sea turtles to occur in the action area due to cold water temperatures. This seasonal restriction is factored into the acoustic modeling that supported the development of the amount of exposure estimates above. That is, the modeling does not consider any pile driving in the January 1 – April 30, period. Thus, the exposure estimates do not need to be adjusted to account for this seasonal restriction.

Sound Attenuation Devices
With the exception of a single monopile and a single jacket that may be installed without attenuation, Vineyard Wind would implement sound attenuation technology that would target at least a 12 dB reduction in pile driving noise, and that must achieve at least a 6 dB reduction in pile driving noise, as described above. The attainment of a 6 dB reduction in pile driving noise was incorporated into the exposure estimate calculations presented above. Thus, the exposure estimates do not need to be adjusted to account for the use of sound attenuation. If a reduction greater than 6 dB is achieved, the number of sea turtles exposed to pile driving noise could be lower as a result of resulting smaller distances to thresholds of concern.

Clearance Zones
As described in the BA, Vineyard Wind would use PSOs to establish clearance zones of 50 m around the pile driving equipment to ensure these zones are clear of sea turtles prior to the start of pile driving. If a sea turtle is observed approaching or entering the clearance zone prior to the

start of pile driving operations, pile driving activity will be delayed until either the sea turtle has voluntarily left the respective clearance zone and been visually confirmed beyond that clearance zone, or, 30 minutes have elapsed without re-detection of the animal.

Prior to the start of pile driving activity, the clearance zones will be monitored for 60 minutes for protected species including sea turtles. Pile driving would only commence once PSOs have declared the respective clearance zones clear of sea turtles for at least 30 minutes. Sea turtles observed within a clearance zone will be allowed to remain in the clearance zone (*i.e.*, must leave of their own volition), and their behavior will be monitored and documented. The clearance zones may only be declared clear, and pile driving started, when the entire clearance zones are visible (*i.e.*, when not obscured by dark, rain, fog, etc.) for a full 30 minutes prior to pile driving.

If a sea turtle is observed entering or within the clearance zone after pile driving has begun, the PSO will request a temporary cessation of pile driving as explained for marine mammals above. There will be at least two PSOs stationed at an elevated position at or near the pile being driven; given that PSOs are expected to reasonably be able to detect sea turtles at a distance of 500 m from their station , we expect that the PSOs will be able to effectively monitor the clearance zone which only extends 50 m from the pile. However, if we rely on the Popper et al. (2014) criteria to predict responses of sea turtles to pile driving noise, we would consider that a sea turtle within 67 m of the pile would be exposed to noise above the peak threshold (207 dB re 1uPa) or within 487 m of the pile to be exposed to noise above the cumulative threshold (210 dB re 1uPa) (both considering 6 dB attenuation). The distances to the peak and cumulative thresholds are larger for the unattenuated piles. Therefore, maintenance of the exclusion zone would not be effective at minimizing exposure of sea turtles to noise that could result in injury. We do not have modeled distances to the Navy (2017) thresholds to base any assessment of the effectiveness of the exclusion zones on reducing risk in the context of those criteria. Given this information, we do not adjust the exposure estimates to account for the 50 m clearance zone.

Soft Start

Soft start procedure is designed to provide a warning to animals or provide them with a chance to leave the area prior to the hammer operating at full capacity. As described above, before full energy pile driving begins, three sets of three strikes, separated by a minute each, will occur at less than 40 percent of total hammer energy. The result of the soft start will be an increase in underwater noise in an area radiating from the pile that is expected to exceed the Level B harassment threshold for whales (160 dB re 1uPa rms), but not exceed the Level A harassment (peak) threshold. We expect that any sea turtles close enough to the pile to be exposed to noise above 166 dB re 1uPa rms would experience behavioral disruption as a result of the soft start and expect that any sea turtles exposed to noise above 175 dB re 1uPa rms would exhibit evasive behaviors and swim away from the noise source. The use of the soft start gives sea turtles near enough to the piles to be exposed to the soft start noise a “head start” on escape or avoidance behavior by causing them to swim away from the source. It is possible that some sea turtles may swim out of the noisy area before full force pile driving begins; in this case, the number of sea turtles exposed to noise that may result in injury would be reduced. It is likely that by eliciting avoidance behavior prior to full power pile driving, the soft start will reduce the duration of exposure to noise that could result in behavioral disturbance. However, we are not able to predict the extent to which the soft start will reduce the number of sea turtles exposed to pile driving noise or the extent to which it will reduce the duration of exposure. Therefore, while the soft start is expected to reduce effects of pile driving we are not able to modify the estimated exposures to account for any benefit provided by the soft start.

Sound Source Verification
As described above, Vineyard Wind will also conduct hydroacoustic monitoring for a subset of impact-driven piles. The required sound source verification will provide information necessary to confirm that the sound source characteristics predicted by the modeling are reflective of actual sound source characteristics in the field. In the event that sound source verification indicates that characteristics in the field are such that the model is invalid or is determined to underestimate exposure of listed species, reinitiation of this consultation may be necessary.

Estimated Number of Sea Turtles Likely to be Exposed to Noise that May Result in Injury or Behavioral Disturbance
The exposure analysis conducted by Pyc et al. (2018) and reflected in the BA, as well as our modifications to that analysis, predicts exposure of fractions of sea turtles to noise that based on the Popper et al. (2014) criteria could result in injury (Table 7.21 above; 0.01 Kemp's ridley, 0.01 green, 0.24 leatherback, and 0.08 loggerhead) when considering piles installed with and without attenuation (i.e., the number of turtles exposed to noise above the injury criteria is the same if all piles were installed without attenuation or with 6 dB attenuation). As explained above, we expect that use of the Popper et al. (2014) criteria would both overestimate exposure (by considering larger areas) and effects of that exposure. Considering the small fractions of sea turtles expected to be exposed to noise that could result in injury using an injury criteria that overpredicts effects, we conclude that injury, including PTS which is an auditory injury, is extremely unlikely to occur.

The exposure analysis also predicts exposure of sea turtles to noise expected to elicit a behavioral response (166 dB re 1uPa rms) (Table 7.21, based on 6 dB attenuation). If we round the fractions up to whole numbers, we would expect exposure of 1 Kemp's ridley (rounded up from 0.31), 1 green (rounded up from 0.31), 3 loggerheads (rounded up from 2.13), and 7 leatherbacks (rounded up from 6.52) to noise that would elicit a behavioral response. We have also considered the installation of one monopile and one jacket foundation without attenuation; based on the modeled distance to the 166 dB re 1uPa rms threshold without attenuation we would expect exposure of fractions of sea turtles (0.005 Kemps ridley, 0.005 green, 0.063 loggerhead, and 0.019 leatherback) during installation of these unattenuated piles[23]. Adding these fractions to the fractions of sea turtles noted above does not change the rounded-up estimates, therefore these are inclusive of the driving of one unattenuated monopile and one unattenuated jacket foundation.

Exposure to noise above 175 dB re 1uPa rms is expected to result in disruption of behaviors and avoidance behavior. We do not have modeled exposures at the 175 dB re 1uPa rms threshold.

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[23] Calculated by multiplying the area ensonified above the behavioral disturbance threshold by the highest seasonal density anticipated for the respective species.

However, as noise dissipates at greater distances from the source, the predictions of exposure to the 166 dB re 1 uPa rms threshold would also capture sea turtles exposed to the 175 dB re 1uPa rms threshold. It is also expected to capture any sea turtles exposed to noise that could result in a temporary threshold shift (TTS), which is expected upon exposure to noise louder than 189 dB re: 1 μPa2·s SELcum or 226 dB re: 1 μPa SPL (0-pk) (Navy 2017). As such, we expect no more than 3 loggerheads, 7 leatherback, 1 Kemp's ridley, and 1 green sea turtle to be exposed to noise that could result in TTS or behavioral disruption.

These exposure estimates are based on the maximum impact scenario (installation of foundations to support 100 8W turbines); if fewer turbines are installed, the exposure will be proportionally reduced. For example, if 57 14 MW turbines were installed, we would expect the exposure of 43% fewer sea turtles or 2 loggerheads, 4 leatherbacks and no more than 1 Kemp's ridley and 1 green sea turtle to noise that could result in TTS or behavioral disruption.

Effects of Noise Exposure above 166 dB re 1uPa rms

TTS

Any sea turtles that experienced TTS would experience a temporary, recoverable, hearing loss manifested as a threshold shift around the frequency of the pile driving noise. Because sea turtles do not use noise to communicate, any TTS would not impact communications. We expect that this temporary hearing impairment would affect frequencies utilized by sea turtles for acoustic cues such as the sound of waves, coastline noise, or the presence of a vessel or predator. Sea turtles are not known to depend heavily on acoustic cues for vital biological functions (Nelms et al. 2016; Popper et al. 2014), and instead, may rely primarily on senses other than hearing for interacting with their environment, such as vision (Narazaki et al. 2013) and magnetic orientation (Avens and Lohmann 2003; Putman et al. 2015). As such, it is unlikely that the loss of hearing in a sea turtle would affect its fitness (i.e., survival or reproduction). That said, it is possible that sea turtles use acoustic cues such as waves crashing, wind, vessel and/or predator noise to perceive the environment around them. If such cues increase survivorship (e.g., aid in avoiding predators, navigation), hearing loss may have effects on individual sea turtle fitness. TTS of sea turtles is expect to only last for several days following the initial exposure (Moein et al. 1994). Given this short period of time, and that sea turtles are not known to rely heavily on acoustic cues, we do not anticipate that single TTSs would have any impacts on the fitness of individual sea turtles.

Masking

Sea turtle hearing abilities and known use of sound to detect environmental cues is discussed above. Sea turtles are thought capable of detecting nearby broadband sounds, such as would be produced by pile driving. Thus, environmental sounds, such as the sounds of waves crashing along coastal beaches or other important cues for sea turtles, could possibly be masked for a short duration during pile driving. However, any masking would not persist beyond the period it takes to complete pile driving each day (typically 3 hours but up to 6 hours on a day that two monopiles are installed and up to 14 hours on a day that a jacket foundation is installed), and could be decreased if there are suitable gaps of time between piles being driven in a given day to allow sea turtles to hear biologically-relevant sounds in between driven piles.

Behavioral response and stress
Based on prior observations of sea turtle reactions to sound, if a behavioral reaction were to occur, the responses could include increases in swim speed, change of position in the water column, or avoidance of the sound. The area where pile driving will occur is not known to be a breeding area and is over 600 km north of the nearest beach where sea turtle nesting has been documented (Virginia Beach, VA). Therefore, breeding adults and hatchlings are not expected in the area. The expected behavioral reactions would disrupt migration, feeding, or resting. However, that disruption will last for no longer than it takes the sea turtle to swim away from the noisy area or, at the longest, the duration of pile driving (three hours). There is no evidence to suggest that any behavioral response would persist beyond the duration of the sound exposure which in this case is the time it takes to drive a pile, approximately three hours. For migrating sea turtles, it is unlikely that this temporary disturbance, which would result in a change in swimming direction, would have any consequence to the animal. Resting sea turtles are expected to resume resting once they escape the noise. Foraging sea turtles would resume foraging once suitable forage is located outside the noisy area.

While in some instances, temporary displacement from an area may have significant consequences to individuals or populations this is not the case here. For example, if individual turtles were prevented from accessing nesting beaches and missed a nesting cue or were precluded from a foraging area for an extensive period, there could be impacts to reproduction and the health of individuals, respectively. However, the area where noise may be at disturbing levels is a small portion of the coastal area used for north-south and south-north migrations and is only a fraction of the project area used by foraging sea turtles. We have no information to indicate that any particular portion of the project area is more valuable to sea turtles than another and no information to indicate that resting, foraging and migrating can not take place in any portion of the project area or that any area is better suited for these activities than any other area. A disruption in migration, feeding, or resting for no more than three hours is not expected to result in any reduction in the health or fitness of any sea turtle. Additionally, significant behavioral responses that result in disruption of important life functions are more likely to occur from multiple exposures within a longer period of time, which are not expected to occur during the pile driving operations for the Vineyard Wind project.

Concurrent with the above responses, sea turtles are also expected to experience physiological stress responses. Stress is an adaptive response and does not normally place an animal at risk. Distress involves a chronic stress response resulting in a negative biological consequence to the individual. While all ESA-listed sea turtles that experience TTS and behavioral responses are also expected to also experience a stress response, such responses are expected to be short-term in nature given the duration of pile driving (three hours at a time) and because we do not expect any sea turtles to be exposed to pile driving noise on more than one day. As such, we do not anticipate stress responses would be chronic, involve distress, or have negative long-term impacts on any individual sea turtle's fitness.

All behavioral responses to a disturbance, such as those described above, will have an energetic or metabolic consequence to the individual reacting to the disturbance (e.g., adjustments in migratory movements or disruption/delays in foraging or resting). Short-term interruptions of normal behavior are likely to have little effect on the overall health, reproduction, and energy balance of an individual or population (Richardson *et al.* 1995). As the disturbance will occur for a portion of each day for a period of up to 102 days, with pile driving occurring for no more than 10% of the time in the May 1 – October 31 work window, this exposure and displacement will be temporary and not chronic. Therefore, any interruptions in behavior and associated metabolic or energetic consequences will similarly be temporary. Thus, we do not anticipate any impairment of the health, survivability, or reproduction of any individual sea turtle.

As explained above, the NMFS Interim Guidance on the ESA Term "Harass" (NMFS PD-02-111-XX) provides for a four-step process to determine if a response meets the definition of harassment. Here, we carry out those steps.

Sea turtles occur in the action area during the time of year when pile driving will occur. As explained above, we expect up to 1 Kemp's ridley, 1 green, 7 leatherback and 3 loggerhead sea turtles would be expected to be exposed to disturbing levels of noise. These turtles could experience TTS, masking, stress, and behavioral disturbance. With the exception of TTS which would take several days to recover from, the duration of the other responses are limited to the period of time the animal is exposed to pile driving noise (approximately three hours). This exposure is expected to result in disruption of migrating, resting and/or foraging behaviors and stopping their activity and swimming away from the noise source and avoiding the area with disturbing levels of noise.

For individual sea turtles exposed to disturbing levels of noise, there will be a significant disruption of their behavior because they will need to abandon that activity for up to three hours while they swim to an alternate area, to resume this behavior or they will avoid the area extending approximately 3 km from the pile being driven for the three hour duration of the pile driving. This means they will need to find an alternate migration route or alternate place for foraging or resting. These sea turtles will also experience masking and TTS which would affect their ability to detect certain environmental cues for the duration of pile driving (masking) or for up to several days after (TTS). Based on this four-step analysis, we find that the sea turtles exposed to disturbing levels of noise during pile driving are likely to be adversely affected and that effect is harassment. As such, we expect the harassment of 1 Kemp's ridley, 1 green, 7 leatherback, and 3 loggerhead sea turtles as a result of pile driving.

NMFS defines "harm" in the definition of "take" as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering" (50 CFR §222.102). No sea turtles will be injured or killed due to exposure to pile driving noise. Further, while exposure to pile driving noise will significantly disrupt behaviors of individual sea turtles, it will not significantly impair any essential behavioral patterns. This is due to the short term, localized nature of the effects and because we expect these behaviors to resume once the sea turtle is no longer exposed to the noise. The energetic consequences of the evasive behavior and delay in resting or foraging are not expected affect any individual's ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in breeding or nesting . TTS will resolve within a week of exposure and is not expected to affect the health of any sea turtle or its ability to migrate, forage, breed, or nest.

Thus, the response of sea turtles to pile driving noise does not meet the definition of "harm."

Vessel Noise and Cable Installation

The vessels used for the proposed project will produce low-frequency, broadband underwater sound below 1 kHz (for larger vessels), and higher-frequency sound between 1 kHz to 50 kHz (for smaller vessels), although the exact level of sound produced varies by vessel type. Noise produced during cable installation is dominated by the vessel noise; therefore, we consider these together.

ESA-listed turtles could be exposed to a range of vessel noises within their hearing abilities. Depending on the context of exposure, potential responses of green, Kemp's ridley, leatherback, and loggerhead sea turtles to vessel noise disturbance, would include startle responses, avoidance, or other behavioral reactions, and physiological stress responses. Very little research exists on sea turtle responses to vessel noise disturbance. Currently, there is nothing in the available literature specifically aimed at studying and quantifying sea turtle response to vessel noise. However, a study examining vessel strike risk to green sea turtles suggested that sea turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which turtles are responding, they only appear to show responses (avoidance behavior) at approximately 10 m or closer (Hazel et al. 2007).

Therefore, the noise from vessels is not likely to affect sea turtles from further distances, and disturbance may only occur if a sea turtle hears a vessel nearby or sees it as it approaches. These responses appear limited to non-injurious, minor changes in behavior based on the limited information available on sea turtle response to vessel noise.

For these reasons, vessel noise is expected to cause minimal disturbance to sea turtles. If a sea turtle detects a vessel and avoids it or has a stress response from the noise disturbance, these responses are expected to be temporary and only endure while the vessel transits through the area where the sea turtle encountered it. Therefore, sea turtle responses to vessel noise disturbance are considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated), and a sea turtle would be expected to return to normal behaviors and stress levels shortly after the vessel passes by.

Operation of WTGs

Underwater noise associated with the operation of the WTGs is expected to be undetectable above ambient noise at a distance of 50 m from any wind turbine; based on data collected at wind farms in Europe, peak underwater noise is expected to be 137 dB re 1uPa which is below the level when any behavioral response from sea turtles is expected (166 dB re 1 Pa rms). Underwater noise associated with the operation of the WTGs is below the thresholds for injury or behavioral disturbance for sea turtles; therefore, we do not expect any impacts to sea turtles due to noise associated with the operating turbines.

Aircraft Noise

As with vessel disturbance above, little information is available on how ESA-listed sea turtles respond to aircraft. For the purposes of this consultation, we assume all ESA-listed sea turtles may exhibit similar short-term behavioral responses such as diving, changes in swimming, etc., which is also consistent with those behaviors observed during aerial research surveys of sea turtles. We are unaware of any data on the physiological responses sea turtles exhibit to aircraft, but we conservatively assume a low-level, short-term stress response is possible.

The working group that developed the 2014 *ANSI Guidelines* for fishes and sea turtles did not consider this specific acoustic stressor for sea turtles in part because it is not considered to pose a great risk (Popper et al. 2014). Any low-flying altitude aircraft would only likely transmit low levels of sound within one meter into the water column. Sea turtles located at or near the water surface may exhibit startle reactions to certain aircraft overflights if the aircraft is flying at a low altitude and the turtle can see it or detect it through sound or water motion generated from wind currents on the surface. This would most likely occur when helicopters are hovering and might be visually detected by a sea turtle. The currents and waves the helicopter produces on the water's surface may also cause sea turtles to respond to the disturbance along with the sound. Aircraft overflight is brief, and does not persist in the action area for significant periods of time (not longer than a few hours), nor is the sound expected to be transmitted well into the water column. Thus, the risk of masking any biologically relevant sound to sea turtles is extremely low. Any startle reactions that occur, if any, are expected to be brief, with sea turtles resuming normal behaviors once the aircraft is no longer detectable or leaves the area. Due to the short-term nature of any exposures to aircrafts and the brief responses expected to the noise or visual disturbance produced, the effects of aircraft overflight noise on ESA-listed sea turtles is considered temporary and insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Survey Equipment to Support Decommissioning

Some of the equipment that is described by BOEM for use for surveys to support decommissioning produces underwater noise that can be perceived by sea turtles. This may include boomers, sparkers, bubble guns, and a chirp sub bottom profiler. The maximum distance to the injury threshold is 12 m and the maximum distance to the 175 dB re 1uPa behavioral disturbance threshold is 90 meters.

During all surveys, BOEM will require the use of PSOs to maintain an exclusion zone extending 50 m from the sound source for sea turtles and the shutdown of noise producing equipment operating in the hearing range of sea turtles if a sea turtle is at risk of being within 50 m of the sound source. Given the small size of the exclusion zone, we expect it can be effectively monitored and maintained by PSOs and that equipment will be shut down before a sea turtle is exposed to noise above the injury threshold. As such, exposure of any sea turtles to injurious levels of noise during the geophysical surveys is extremely unlikely to occur.

The largest possible disturbance distance for sea turtles is 90 m from an HRG vessel. In a scenario where a vessel is approaching a turtle at 90 m, it will reach the turtle in 39 seconds at a speed of 4.5 knots (2.315 m/sec). Subsequently, a vessel could pass a turtle and be beyond the 90 m disturbance distance in another 39 sec. Therefore, the largest potential disturbance time is likely to be no longer than 78 seconds. Given the very small area ensonified (radii of 90 m from the sound source) and the very short duration that any area will experience an increase in noise (less than two minutes), any effects to migrating, foraging, or resting sea turtles are expected to be limited to a startle response and associated very brief interruption of behavior. Effects are expected to be so small that they can not be evaluated, measured, or detected and are therefore insignificant.

7.1.4 Effects of Noise on Atlantic sturgeon

Background Information – Atlantic sturgeon and Noise
Impulsive sounds such as those produced by impact pile driving are known to affect fishes in a variety of ways, and have been shown to cause mortality, auditory injury, barotrauma, and behavioral changes. Impulsive sound sources produce brief, broadband signals that are atonal transients (e.g., high amplitude, short-duration sound at the beginning of a waveform; not a continuous waveform). They are generally characterized by a rapid rise from ambient sound pressures to a maximal pressure followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures. For these reasons, they generally have an increased capacity to induce physical injuries in fishes, especially those with swim bladders (Casper et al. 2013a; Halvorsen et al. 2012b; Popper et al. 2014). These types of sound pressures cause the swim bladder in a fish to rapidly and repeatedly expand and contract, and pound against the internal organs. This pneumatic pounding may result in hemorrhage and rupture of blood vessels and internal organs, including the swim bladder, spleen, liver, and kidneys. External damage has also been documented, evident with loss of scales, hematomas in the eyes, base of fins, etc. (e.g., Casper et al. 2012c; Gisiner 1998; Halvorsen et al. 2012b; Wiley et al. 1981; Yelverton et al. 1975a). Fishes can survive and recover from some injuries, but in other cases, death can be instantaneous, occur within minutes after exposure, or occur several days later.

Hearing impairment
Research is limited on the effects of impulsive noise on the hearing of fishes, however some research on seismic air gun exposure has demonstrated mortality and potential damage to the lateral line cells in fish larvae, fry, and embryos after exposure to single shots from a seismic air gun near the source (0.01 to 6 m; Booman et al. 1996; Cox et al. 2012). Popper et al. (2005a) examined the effects of a seismic air gun array on a fish with hearing specializations, the lake chub (*Couesius plumbeus*), and two species that lack notable hearing specializations, the northern pike (*Esox lucius*) and the broad whitefish (*Coregonus nasus*), a salmonid species. In this study, the average received exposure levels were a mean peak pressure level of 207 dB re 1 μPa; sound pressure level of 197 dB re 1 μPa; and single-shot sound exposure level of 177 dB re 1 μPa^2-s. The results showed temporary hearing loss for both lake chub and northern pike to both 5 and 20 air gun shots, but not for the broad whitefish. Hearing loss was approximately 20 to 25 dB at some frequencies for both the northern pike and lake chub, and full recovery of hearing took place within 18-24 hours after sound exposure. Examination of the sensory surfaces of the showed no damage to sensory hair cells in any of the fish from these exposures (Song et al. 2008). Popper et al. (2006) also indicated exposure of adult fish to a single shot from an air gun array (consisting of four air guns) within close range (six meters) did not result in any signs of mortality, seven days post-exposure. Although non-lethal injuries were observed, the researchers could not attribute them to air gun exposure as similar injuries were observed in controlled fishes. Other studies conducted on fishes with swim bladders did not show any

mortality or evidence of other injury (Hastings et al. 2008; McCauley and Kent 2012; Popper et al. 2014; Popper et al. 2007; Popper et al. 2005a).

McCauley et al. (2003) showed loss of a small percent of sensory hair cells in the inner ear of the pink snapper (*Pagrus auratus*) exposed to a moving air gun array for 1.5 hours. Maximum received levels exceeded 180 dB re 1 μPa^2-s for a few shots. The loss of sensory hair cells continued to increase for up to at least 58 days post-exposure to 2.7 percent of the total cells. It is not known if this hair cell loss would result in hearing loss since TTS was not examined. Therefore, it remains unclear why McCauley et al. (2003) found damage to sensory hair cells while Popper et al. (2005a) did not. However, there are many differences between the studies, including species, precise sound source, and spectrum of the sound that make it difficult speculate what the caused hair cell damage in one study and no the other.

Hastings et al. (2008) exposed the pinecone soldierfish (*Myripristis murdjan*), a fish with anatomical specializations to enhance their hearing and three species without notable specializations: the blue green damselfish (*Chromis viridis*), the saber squirrelfish (*Sargocentron spiniferum*), and the bluestripe seaperch (*Lutjanus kasmira*) to an air gun array. Fish in cages in 16 ft. (4.9 m) of water were exposed to multiple air gun shots with a cumulative sound exposure level of 190 dB re 1 μPa^2-s. The authors found no hearing loss in any fish following exposures. Based on the tests to date that indicated TTS in fishes from exposure to impulsive sound sources (air guns and pile driving) the recommended threshold for the onset of TTS in fishes is 186 dB $\mathrm{SEL_{cum}}$ re 1 μPa^2-s, as described in the 2014 *ANSI Guidelines*.

Physiological Stress

Physiological effects to fishes from exposure to anthropogenic sound are increases in stress hormones or changes to other biochemical stress indicators (e.g., D'amelio et al. 1999; Sverdrup et al. 1994; Wysocki et al. 2006). Fishes may have physiological stress reactions to sounds that they can detect. For example, a sudden increase in sound pressure level or an increase in overall background noise levels can increase hormone levels and alter other metabolic rates indicative of a stress response. Studies have demonstrated elevated hormones such as cortisol, or increased ventilation and oxygen consumption (Hastings and C. 2009; Pickering 1981; Simpson et al. 2015; Simpson et al. 2016; Smith et al. 2004a; Smith et al. 2004b). Although results from these studies have varied, it has been shown that chronic or long-term (days or weeks) exposures of continuous anthropogenic sounds can lead to a reduction in embryo viability (Sierra-Flores et al. 2015) and decreased growth rates (Nedelec et al. 2015).

Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources such as predator vocalizations or the sudden onset of loud and impulsive sound signals. Stress responses are typically considered brief (a few seconds to minutes) if the exposure is short or if fishes habituate or have previous experience with the sound**.** However, exposure to chronic noise sources may lead to more severe effects leading to fitness consequences such as reduced growth rates, decreased survival rates, reduced foraging success, etc. Although physiological stress responses may not be detectable on fishes during sound exposures, NMFS assumes a stress response occurs when other physiological impacts such as injury or hearing loss occur.

Some studies have been conducted that measure changes in cortisol levels in response to sound sources. Cortisol levels have been measured in fishes exposed to vessel noises, predator vocalizations, or other tones during playback experiments**.** Nichols et al. (2015a) exposed giant kelpfish (*Heterostichus rostratus*) to vessel playback sounds, and fish increased levels of cortisol were found with increased sound levels and intermittency of the playbacks. Sierra-Flores et al. (2015) demonstrated increased cortisol levels in fishes exposed to a short duration upsweep (a tone that sweeps upward across multiple frequencies) across 100 to 1,000 Hz. The levels returned to normal within one hour post-exposure, which supports the general assumption that spikes in stress hormones generally return to normal once the sound of concern ceases**.** Gulf toadfish (*Opsanus beta*) were found to have elevated cortisol levels when exposed to low-frequency dolphin vocalization playbacks (Remage-Healey et al. 2006). Interestingly, the researchers observed none of these effects in toadfish exposed to low frequency snapping shrimp "pops," indicating what sound the fish may detect and perceive as threats. Not all research has indicated stress responses resulting in increased hormone levels. Goldfish exposed to continuous (0.1 to 10 kHz) sound at a pressure level of 170 dB re 1 µPa for one month showed no increase in stress hormones (Smith et al. 2004b). Similarly, Wysocki et al. (2007b) exposed rainbow trout to continuous band-limited noise with a sound pressure level of about 150 dB re 1 µPa for nine months with no observed stress effects. Additionally, the researchers found no significant changes to growth rates or immune systems compared to control animals held at a sound pressure level of 110 dB re 1 µPa.

Masking

As described previously in this biological opinion, masking generally results from a sound impeding an animal's ability to hear other sounds of interest. The frequency of the received level and duration of the sound exposure determine the potential degree of auditory masking. Similar to hearing loss, the greater the degree of masking, the smaller the area becomes within which an animal can detect biologically relevant sounds such as those required to attract mates, avoid predators or find prey (Slabbekoorn et al. 2010). Because the ability to detect and process sound may be important for fish survival, anything that may significantly prevent or affect the ability of fish to detect, process or otherwise recognize a biologically or ecologically relevant sound could decrease chances of survival. For example, some studies on anthropogenic sound effects on fishes have shown that the temporal pattern of fish vocalizations (e.g., sciaenids and gobies) may be altered when fish are exposed to sound-masking (Parsons et al. 2009). This may indicate fish are able to react to noisy environments by exploiting "quiet windows" (e.g., Lugli and Fine 2003) or moving from affected areas and congregating in areas less disturbed by nuisance sound sources. In some cases, vocal compensations occur, such as increases in the number of individuals vocalizing in the area, or increases in the pulse/sound rates produced (Picciulin et al. 2012). Fish vocal compensations could have an energetic cost to the individual, which may lead to a fitness consequence such as affecting their reproductive success or increase detection by predators (Amorin et al. 2002; Bonacito et al. 2001).

Behavioral Responses

In general, NMFS assumes that most fish species would respond in similar manner to both air guns and impact pile driving. As with explosives, these reactions could include startle or alarm responses, quick bursts in swimming speeds, diving, or changes in swimming orientation. In other responses, fish may move from the area or stay and try to hide if they perceive the sound as potential threat. Other potential changes include reduced predator awareness and reduced feeding effort. The potential for adverse behavioral effects will depend on a number of factors, including the sensitivity to sound, the type and duration of the sound, as well as life stages of fish that are present in the areas affected.

Fish that detect an impulsive sound may respond in "alarm" detected by Fewtrell (2003), or other startle responses may also be exhibited. The startle response in fishes is a quick burst of swimming that may be involved in avoidance of predators. A fish that exhibits a startle response may not necessarily be injured, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment. However, fish do not exhibit a startle response every time they experience a strong hydroacoustic stimulus. A study in Puget Sound, Washington suggests that pile driving operations disrupt juvenile salmon behavior (Feist et al. 1992). Though no underwater sound measurements are available from that study, comparisons between juvenile salmon schooling behavior in areas subjected to pile driving/construction and other areas where there was no pile driving/construction indicate that there were fewer schools of fish in the pile-driving areas than in the non-pile driving areas. The results are not conclusive but there is a suggestion that pile-driving operations may result in a disruption in the normal migratory behavior of the salmon in that study, though the mechanisms salmon may use for avoiding the area are not understood at this time.

Because of the inherent difficulties with conducting fish behavioral studies in the wild, data on behavioral responses for fishes is largely limited to caged or confined fish studies, mostly limited to studies using caged fishes and the use of seismic air guns (Lokkeborg et al. 2012). In an effort to assess potential fish responses to anthropogenic sound, NMFS has historically applied an interim criteria for onset injury of fish from impact pile driving which was agreed to in 2008 by a coalition of federal and non-federal agencies along the West Coast (FHWG 2008). These criteria were also discussed in Stadler and Woodbury (2009), wherein the onset of physical injury for fishes would be expected if either the peak sound pressure level exceeds 206 dB (re 1 μPa), or the SEL_{cum}, (re 1 μPa^2-s) accumulated over all pile strikes occurring within a single day, exceeds 187 dB SEL_{cum} (re 1 μPa^2-s) for fish two grams or larger, or 183 dB re 1 μPa^2-s for fishes less than two grams. The more recent recommendations from the studies conducted by Halvorsen et al. (2011a), Halvorsen et al. (2012b), and Casper et al. (2012c), and summarized in the 2014 *ANSI Guidelines* are similar to these levels, but also establishes levels based upon fish hearing abilities, the presence of a swim bladder as well as severity of effects ranging from mortality, recoverable injury to TTS. The interim criteria developed in 2008 were developed primarily from air gun and explosive effects on fishes (and some pile driving) because limited information regarding impact pile driving effects on fishes was available at the time.

Criteria Used for Assessing Effects of Noise Exposure to Atlantic Sturgeon

There is no available information on the hearing capabilities of Atlantic sturgeon specifically, although the hearing of two species of sturgeon have been studied. While sturgeon have swimbladders, they are not known to be used for hearing, and thus sturgeon appear to only rely directly on their ears for hearing. Popper (2005) reported that studies measuring responses of the ear of European sturgeon (*Acipenser sturio*) using physiological methods suggest sturgeon are likely capable of detecting sounds from below 100 Hz to about 1 kHz, indicating that sturgeon should be able to localize or determine the direction of origin of sound. Meyer and Popper

(2002) recorded auditory evoked potentials of varying frequencies and intensities for lake sturgeon (*Acipenser fulvescens*) and found that lake sturgeon can detect pure tones from 100 Hz to 2 kHz, with best hearing sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for oscar (*Astronotus ocellatus*) and goldfish (*Carassius auratus*) and reported that the auditory brainstem responses for the lake sturgeon were more similar to goldfish (that can hear up to 5 kHz) than to the oscar (that can only detect sound up to 400 Hz); these authors, however, felt additional data were necessary before lake sturgeon could be considered specialized for hearing (Meyer and Popper 2002). Lovell et al. (2005) also studied sound reception and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon. Using a combination of morphological and physiological techniques, they determined that paddlefish and lake sturgeon were responsive to sounds ranging in frequency from 100 to 500 Hz, with the lowest hearing thresholds from frequencies in a bandwidth of between 200 and 300 Hz and higher thresholds at 100 and 500 Hz; lake sturgeon were not sensitive to sound pressure. We assume that the hearing sensitivities reported for these other species of sturgeon are representative of the hearing sensitivities of all Atlantic sturgeon DPSs.

The Fisheries Hydroacoustic Working Group (FHWG) was formed in 2004 and consists of biologists from NMFS, USFWS, FHWA, USACE, and the California, Washington and Oregon DOTs, supported by national experts on underwater sound producing activities that affect fish and wildlife species of concern. In June 2008, the agencies signed an MOA documenting criteria for assessing physiological effects of impact pile driving on fish. The criteria were developed for the acoustic levels at which physiological effects to fish could be expected. It should be noted, that these are onset of physiological effects (Stadler and Woodbury, 2009), and not levels at which fish are necessarily mortally damaged. These criteria were developed to apply to all fish species, including listed green sturgeon, which are biologically similar to shortnose and Atlantic sturgeon and for these purposes can be considered a surrogate. The interim criteria are:

- Peak SPL: 206 dB re 1 µPa
- SELcum: 187 B re 1µPa^2-s for fishes 2 grams or larger (0.07 ounces).
- SELcum: 183 dB re 1µPa^2-s for fishes less than 2 grams (0.07 ounces).

At this time, these criteria represent the best available information on the thresholds at which physiological effects to sturgeon are likely to occur. It is important to note that physiological effects may range from minor injuries from which individuals are anticipated to completely recover with no impact to fitness to significant injuries that will lead to death. The severity of injury is related to the distance from the pile being installed and the duration of exposure. The closer to the source and the greater the duration of the exposure, the higher likelihood of significant injury.

Popper et al. (2014) presents a series of proposed thresholds for onset of mortality and potential injury, recoverable injury, and temporary threshold shift for fish species exposed to pile driving noise. This assessment incorporates information from lake sturgeon and includes a category for fish that have a swim bladder that is not involved in hearing (such as Atlantic sturgeon). The criteria included in Popper et al. (2014) are:

  - Mortality and potential mortal injury: 210 dB SELcum or >207 dB peak
  - Recoverable injury: 203 dB SELcum or >207 dB peak

- TTS: >186 dB SELcum.

While these criteria are not exactly the same as the FHWG criteria, they are very similar. Based on the available information, for the purposes of this Opinion, we consider the potential for physiological effects upon exposure to 206 dB re 1 µPa peak and 187 dB re 1 µPa^{2}-s cSEL. Use of the 183 dB re 1 µPa^{2}-s cSEL threshold, is not appropriate for this consultation because all sturgeon in the action area will be larger than 2 grams. Physiological effects could range from minor injuries that a fish is expected to completely recover from with no impairment to survival to major injuries that increase the potential for mortality, or result in death.

We use 150 dB re: 1 µPa RMS as a threshold for examining the potential for behavioral responses by individual listed fish to noise with frequency less than 1 kHz. This is supported by information provided in a number of studies (Andersson et al. 2007, Purser and Radford 2011, Wysocki et al. 2007). Responses to temporary exposure of noise of this level is expected to be a range of responses indicating that a fish detects the sound, these can be brief startle responses or, in the worst case, we expect that listed fish would completely avoid the area ensonified above 150 dB re: 1 uPa rms. Popper et al. (2014) does not identify a behavioral threshold but notes that the potential for behavioral disturbance decreases with the distance from the source.

Effects of Project Noise on Atlantic sturgeon

Pile Driving
Using the same methodology described above for marine mammals and sea turtles, Pyc et al. (2018) modeled radial distances to 207 dB peak and 210 dB SELcum for considering injury based on Popper et al. 2014, 186 dB SELcum for considering TTS based on Popper et al. 2014.

Table 7.22. Radial distance (meters) to acoustic thresholds used to evaluate responses of sturgeon to pile driving noise resulting from modeling of 10.3 m monopile and jacket foundations with various levels of attenuation. The values are calculated using the most conservative hammer energy radii, averaged over both modeling sites. Table adapted from Pyc et al. (2018).

Threshold		**10.3 meter pile**			**four 3 meter piles**		
		distance (meters) by attenuation			**distance (meters) by attenuation**		
		0 dB	**6 dB**	**12 dB**	**0 dB**	**6 dB**	**12 dB**
Injury	210 dB SELcum	1,220	503	160	1,472	584	182
	207 peak	157	78	38	50	26	13
	186 SELcum	10,960	7,444	4,702	13,660	8,538	5,077

Pyc et al. (2018) also modeled the distances to the 150 dB re 1uPa rms threshold used for consideration of potential behavioral response. Maximum modeled distance for piles with the 6 dB attenuation was 9,229 m.

No density estimates are available for the action area or for any area that could be used to estimate density in the action area. Therefore, it was not possible to conduct an exposure analysis like was done for marine mammals and sea turtles.

Here, we consider the measures that are part of the proposed action, either because they are proposed by Vineyard Wind and reflected in the proposed action as described to us by BOEM in the BA, or are proposed to be required through the IHA, and how those measures may minimize exposure of Atlantic sturgeon to pile driving noise. Details of these proposed measures are included in the Description of the Action section above.

Atlantic sturgeon are not visible to PSOs because they occur near the bottom and depths in the WDA would preclude visual observation of fish near the bottom. Therefore, monitoring of clearance zones or areas beyond the clearance zones will not minimize exposure of Atlantic sturgeon to pile driving noise. Because Atlantic sturgeon do not vocalize, PAM can not be used to monitor Atlantic sturgeon presence; therefore, the use of PAM will not reduce exposure of Atlantic sturgeon to pile driving noise.

No pile driving activities would occur between January 1 through April 30 to avoid the time of year with the highest densities of right whales in the project area. The January 1 – April 30 period overlaps with the period when we expect the abundance of Atlantic sturgeon to be at its lowest, because we do not expect Atlantic sturgeon to overwinter in the WDA. Therefore, the seasonal restriction would not reduce the exposure of Atlantic sturgeon to pile driving noise.

Sound Attenuation Devices

Vineyard Wind would implement sound attenuation technology that would target at least a 12 dB reduction in pile driving noise, and that must achieve at least a 6 dB reduction in pile driving noise, as described above. The attainment of a 6 dB reduction in pile driving noise was incorporated into the estimates of the area where injury or behavioral disruption may occur as presented above. If a reduction greater than 6 dB is achieved, the size of the area of impact would be smaller which would likely result in a smaller number of Atlantic sturgeon exposed to pile driving noise.

Soft Start

Soft start procedure is designed to provide a warning to animals or provide them with a chance to leave the area prior to the hammer operating at full capacity. As described above, before full energy pile driving begins, three sets of three strikes, separated by a minute each, will occur at less than 40 percent of total hammer energy. The result of the soft start will be an increase in underwater noise in an area radiating from the pile that is expected to exceed the noise levels that would result in behavioral disturbance of Atlantic sturgeon (i.e., louder than 150 dB rms) but not exceed the threshold for injury. We expect that any Atlantic sturgeon close enough to the pile to be exposed to noise above 150 dB re 1uPa rms would experience behavioral disturbance as a result of the soft start and that these sturgeon would exhibit evasive behaviors and swim away from the noise source. The use of the soft start is expected to give Atlantic sturgeon near enough to the piles to be exposed to the soft start noise a “head start” on escape or avoidance behavior by causing them to swim away from the source. It is possible that some Atlantic sturgeon would swim out of the noisy area before full force pile driving begins; in this case, the number of

Atlantic sturgeon exposed to noise that may result in injury would be reduced. It is likely that by eliciting avoidance behavior prior to full power pile driving, the soft start will reduce the duration of exposure to noise that could result in behavioral disturbance. However, we are not able to predict the extent to which the soft start will reduce the extent of exposure.

Sound Source Verification

As described above, Vineyard Wind will also conduct hydroacoustic monitoring for a subset of impact-driven piles. The required sound source verification will provide information necessary to confirm that the sound source characteristics predicted by the modeling are reflective of actual sound source characteristics in the field. In the event that sound source verification indicates that characteristics in the field are such that the model is invalid or is determined to underestimate exposure of listed species, reinitiation of this consultation may be necessary.

Exposure of Atlantic sturgeon to Noise that May Result in Injury or Behavioral Disturbance

As described in the Environmental Baseline section of this Opinion, the WDA has not been systematically surveyed for Atlantic sturgeon; however, based on the best available information on use of the WDA by Atlantic sturgeon we expect use of the action area to be intermittent and limited to transient individuals moving through the WDA during the spring, summer and fall that may be foraging opportunistically in areas where benthic invertebrates are present. The area is not known to be a preferred foraging area and has not been identified as an aggregation area.

In the “most likely” scenario (100 monopiles, 2 jackets), over the course of the potential pile-installation window of May 1 – December 31, pile driving will occur for no more than 328 hours (3 hours per up to 100 monopiles and 14 hours each for two jacket foundations), or approximately 5.6% of the time (328 hours of pile driving/5,880 total hours). In the “maximum impact” scenario (90 monopiles, 12 jackets), over the course of the potential pile-installation window of May 1 – December 31, pile driving will occur for no more than 438 hours (3 hours per pile up to 90 monopiles and 14 hours each for 12 jacket foundations, up to 100 piles), or approximately 7.5% of the time (438 hours of pile driving/5,880 total hours).

In order to be exposed to pile driving noise that could result in injury, an Atlantic sturgeon would need to be within 26 m of a jacket pile or 78 m of a monopile for a single strike (based on the 207 dB peak threshold). Given the intermittent and dispersed use of the WDA by Atlantic sturgeon, the potential for co-occurrence in time and space is extremely unlikely given the small amount of time that pile driving will occur (approximately three hours at a time and no more than 7.5% of the time over the May 1 – December 31 pile driving window) and the small area where exposure to peak noise could occur (extending 26 or 78 m from the pile). This risk is further reduced by the soft-start, which we expect would result in a behavioral reaction and movement outside the area with the potential for exposure to the peak injury threshold.

Considering the 186 dB SELcum threshold, an Atlantic sturgeon would need to remain within 7,444 m of a monopile and 8,538 m of the four jacket piles for the full duration of pile driving during a 24-hour period (approximately three hours for a monopile and 14 hours for the jacket foundation). Downie and Kieffer (2017) reviewed available information on maximum sustained swimming ability (Ucrit) for a number of sturgeon species. No information was presented on Atlantic sturgeon. However, because all sturgeon species are physiologically similar, it is reasonable to expect that the maximum sustained swimming ability of Atlantic sturgeon is similar to the values reported for other sturgeon species in the review. Swimming speed increases with fish size; therefore, we have considered the available information on swimming speeds for sturgeon at least 50 cm as that is the smallest Atlantic sturgeon that could occur int eh action area. Information is available in that size range for Siberian, Shovelnose, and Green sturgeon. Reported swim speeds range from 79.2 to 106.3 cm/s (2.85 -3.8 km/h). Assuming a straight line escape and initial exposure within several meters of the pile and the slowest swim speed (2.85 km/h), a sturgeon would be able to escape from the noisy area surrounding a monopile within 2.5 hours and would be able to escape from the noisy area surrounding a jacket foundation within 3 hours. We expect that the soft-start will mean that the closest a sturgeon is to the pile being driven at the start of full power driving is several hundred meters away which further reduces the duration of exposure to noise that could accumulate to exceed the 186 dB SELcum threshold. Given that we expect any Atlantic sturgeon that are exposed to pile driving noise will be able to avoid exposure to noise above the levels that could result in exposure to the cumulative injury threshold.

Based on this analysis, it is extremely unlikely that any Atlantic sturgeon will be exposed to noise that will result in injury. Therefore, no injury of any Atlantic sturgeon is expected to occur.

Effects of Noise Exposure above 150 dB re 1uPa rms
We expect Atlantic sturgeon to exhibit a behavioral response upon exposure to noise louder than 150 dB re 1uPa RMS. This response could range from a startle with immediate resumption of normal behaviors to complete avoidance of the area. The area where pile driving will occur is used for migration of Atlantic sturgeon, with opportunistic foraging expected to occur where suitable benthic resources are present. The area is not an aggregation area, and sustained foraging is not known to occur in this area. During pile driving, the area that will have underwater noise above the 150 dB re 1uPa RMS threshold will extend approximately 9.3 km from the pile being installed. In the worst case, Atlantic sturgeon would avoid that entire area. The consequences for an individual sturgeon would be alteration of movements to avoid the noise and temporary cessation of opportunistic foraging.

While in some instances temporary displacement from an area may have significant consequences to individuals or populations, this is not the case here. For example, if individual Atlantic sturgeon were prevented or delayed from accessing spawning or overwintering grounds or were precluded from a foraging area for an extensive period, there could be impacts to reproduction and the health of individuals, respectively. However, as explained above the area where noise may be at disturbing levels is used only for movement between other more highly used portions of the coastal Atlantic Ocean and is used only for opportunistic, occasional foraging.

All behavioral responses to a disturbance, such as those described above, will have an energetic or metabolic consequence to the individual reacting to the disturbance (e.g., adjustments in migratory movements or disruption in opportunistic foraging). Short-term interruptions of normal behavior are likely to have little effect on the overall health, reproduction, and energy balance of an individual or population (Richardson *et al.* 1995). As the disturbance will occur for a portion of each day for a period of up to 102 days, with pile driving occurring for no more than 7.5% of the time in the May 1 – December 31 work window, this exposure and displacement will be temporary and not chronic. Therefore, any interruptions in behavior and associated metabolic or energetic consequences will similarly be temporary. Thus, we do not anticipate any impairment of the health, survivability, or reproduction of any individual Atlantic sturgeon.

Based on this analysis, we have determined that it is extremely unlikely that any Atlantic sturgeon will experience a significant disruption of migration or foraging, the two behaviors that occur in the action area. All effects to Atlantic sturgeon from exposure to pile driving noise are expected to be so small that they can not be meaningfully measured, detected, or evaluated and are, therefore, insignificant.

Vessel Noise and Cable Installation

The vessels used for the proposed project will produce low-frequency, broadband underwater sound below 1 kHz (for larger vessels), and higher-frequency sound between 1 kHz to 50 kHz (for smaller vessels), although the exact level of sound produced varies by vessel type. Noise produced during cable installation is dominated by the vessel noise; therefore, we consider these together.

In general, information regarding the effects of vessel noise on fish hearing and behaviors is limited. Some TTS has been observed in fishes exposed to elevated background noise and other white noise, a continuous sound source similar to noise produced from vessels. Caged studies on sound pressure sensitive fishes show some TTS after several days or weeks of exposure to increased background sounds, although the hearing loss appeared to recover (e.g., Scholik and Yan 2002; Smith et al. 2006; Smith et al. 2004b). Smith et al. (2004b) and Smith et al. (2006) exposed goldfish (a fish with hearing specializations, unlike any of the ESA-listed species considered in this opinion) to noise with a sound pressure level of 170 dB re 1 μPa and found a clear relationship between the amount of TTS and duration of exposure, until maximum hearing loss occurred at about 24 hours of exposure. A short duration (e.g., 10-minute) exposure resulted in 5 dB of TTS, whereas a three-week exposure resulted in a 28 dB TTS that took over two weeks to return to pre-exposure baseline levels (Smith et al. 2004b). Recovery times were not measured by researchers for shorter exposure durations, so recovery time for lower levels of TTS was not documented.

Vessel noise may also affect fish behavior by causing them to startle, swim away from an occupied area, change swimming direction and speed, or alter schooling behavior (Engas et al. 1998; Engas et al. 1995; Mitson and Knudsen 2003). Physiological responses have also been documented for fish exposed to increased boat noise. Nichols et al. (2015b) demonstrated physiological effects of increased noise (playback of boat noise) on coastal giant kelpfish. The fish exhibited acute stress responses when exposed to intermittent noise, but not to continuous noise. These results indicate variability in the acoustic environment may be more important than the period of noise exposure for inducing stress in fishes. However, other studies have also shown exposure to continuous or chronic vessel noise may elicit stress responses indicated by increased cortisol levels (Scholik and Yan 2001; Wysocki et al. 2006). These experiments demonstrate physiological and behavioral responses to various boat noises that have the potential to affect species' fitness and survival, but may also be influenced by the context and duration of exposure. It is important to note that most of these exposures were continuous, not intermittent, and the fish were unable to avoid the sound source for the duration of the experiment because this was a controlled study. In contrast, wild fish are not hindered from movement away from an irritating sound source, if detected, so are less likely to subjected to accumulation periods that lead to the onset of hearing damage as indicated in these studies. In other cases, fish may eventually become habituated to the changes in their soundscape and adjust to the ambient and background noises.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Because of the characteristics of vessel noise, sound produced from vessels is unlikely to result in direct injury, hearing impairment, or other trauma to Atlantic sturgeon. Plus, in the near field, fish are able to detect water motion as well as visually locate an oncoming vessel. In these cases, most fishes located in close proximity that detect the vessel either visually, via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away. These reactions may include physiological stress responses, or avoidance behaviors. Auditory masking due to vessel noise can potentially mask biologically important sounds that fish may rely on. However, impacts from vessel noise would be intermittent, temporary, and localized, and such responses would not be expected to compromise the general health or condition of individual fish from continuous exposures. Instead, the only impacts expected from exposure to project vessel noise for Atlantic sturgeon may include temporary auditory masking, physiological stress, or minor changes in behavior.

Therefore, similar to marine mammals and sea turtles, exposure to vessel noise for fishes could result in short-term behavioral or physiological responses (e.g., avoidance, stress). Vessel noise would only result in brief periods of exposure for fishes and would not be expected to accumulate to the levels that would lead to any injury, hearing impairment or long-term masking of biologically relevant cues. For these reasons, exposure to vessel noise is not expected to significantly disrupt normal behavior patterns of Atlantic sturgeon in the action area. Therefore, the effects of vessel noise on Atlantic sturgeon is considered insignificant (i.e., so minor that the effect cannot be meaningfully evaluated).

Operation of WTGs

Underwater noise associated with the operation of the WTGs is expected to be undetectable above ambient noise at a distance of 50 m from any wind turbine; based on data collected at wind farms in Europe, peak underwater noise is expected to be 137 dB re 1uPa which is below the level when behavioral response is expected (150 dB re 1 Pa rms). Underwater noise associated with the operation of the WTGs is below the thresholds for injury or behavioral disturbance for sea turtles; therefore, we do not expect any impacts to sea turtles due to noise associated with the operating turbines.

Aircraft Noise

Exposure of Atlantic sturgeon to aircraft noise is extremely unlikely given that any sound that transmits into the water column, would likely only be to a shallow depth and sound transmission into deep depths of the water column where Atlantic sturgeon occur is not likely. As only fish located at or near the surface of the water and within the limited area where transmission of aircraft noise is expected to occur have the potential to detect any noise produced from low-flying aircraft, and we do not expect Atlantic sturgeon in the action area to be at or near the surface, exposure of any Atlantic sturgeon to aircraft noise that could be potentially disturbing is extremely unlikely to occur.

Survey Equipment to Support Decommissioning
Some of the equipment that is described by BOEM for use for surveys to support decommissioning produces underwater noise that can be perceived by Atlantic sturgeon. This may include boomers, sparkers, bubble guns, and a chirp sub bottom profiler. The maximum distance to the injury threshold is 12 m and the maximum distance to the 150 dB re 1uPa behavioral disturbance threshold is 1.9 km for the loudest equipment.

In order to be exposed to noise louder than the injury threshold, a sturgeon would need to be within 12 meters of the source. This is extremely unlikely to occur given the dispersed nature of sturgeon distribution in the action area, the use of a ramp up procedure, which functions like a soft start and provides a warning before exposure to use of the survey equipment at full power, and the expectation that sturgeon will swim away, rather than towards the noise source. This risk is further reduced by the relatively narrow beam width of these sources, which reduces the area where underwater noise is experienced and therefore, reduces the potential for exposure. Based on this, no physical effects to any Atlantic sturgeon, including injury or mortality, is expected to result from the surveys to support decommissioning.

The area where underwater noise is above the behavioral disturbance threshold is transient and increased underwater noise will only be experienced in a particular area for seconds at a time; therefore, any effects to behavior will be minor and limited to a temporary disruption of normal behaviors, temporary avoidance of the ensonified area and minor additional energy expenditure spent while swimming away from the noisy area. If foraging or migrations are disrupted, we expect that they will quickly resume once the survey vessel has left the area (i.e., in seconds to minutes). No sturgeon will be displaced from a particular area for more than a few minutes. While the movements of individual Atlantic sturgeon will be affected by the sound associated with the survey, these effects will be temporary and localized, and there will be only a minimal impact on foraging, migrating, or resting sturgeon. Shifts in habitat use or distribution or reduction in foraging success are not expected. Effects to individual sturgeon from brief exposure to potentially disturbing levels of noise are expected to be limited to a brief startle or short displacement and will be so small that they cannot be meaningfully measured, detected, or evaluated; therefore, effects are insignificant.

7.2 Effects of Project Vessels

In this section we consider the effects of the operation of project vessels on listed species in the action area, by describing the existing vessel traffic in the action area, summarizing the anticipated increase in vessels associated with construction, operations, and decommissioning of the project, and then determining likely effects to sea turtles, whales, and Atlantic sturgeon. We also consider impacts to air quality from vessel emissions. Effects of vessel noise were considered in section 7.1, above, and are not repeated here.

There are a number of distinct areas that will be transited by project vessels. During the construction, operations, and decommissioning periods there will be daily vessel trips between a number of ports in Massachusetts and Rhode Island and the WDA (Table 7.23). There will be a limited amount of project related traffic between the WDA (the northeast portion of Lease Area OCS-A 0501 that will be developed) and three potential ports in Canada (Halifax, St. John, and Sheets Harbor) during the construction and decommissioning periods. Under the maximum design scenario, there will be a maximum of five trips per day (maximum of 50 trips per month) over a two-year construction schedule of relatively slow moving (13-18 knots) construction/installation vessels and cargo vessels transporting project components (COP (Volume 1, table 4.2-1)). Additionally, European-origin construction/installation vessels will be used over the course of the Project's offshore construction period. These vessels are expected to remain on site for the duration of the work that they are contracted to perform, which could range from two to twelve months. WTG components are also expected to be shipped to the WDA from one or more ports in Europe. This will consist of up to approximately 122 round trip vessel trips, based on the maximum design envelope installation of 100 WTGs. On average, vessels transporting components from Europe will make approximately five round trips per month over a two-year offshore construction schedule. Fewer installed WTGs would produce less trips as fewer components would be needed. It should be noted that the trips for the activities the vessels will be conducting in the Project Area might not necessarily occur within the same timeframe. The peak of vessel traffic will occur during the construction period and will consist of a mix of slower moving, larger construction and cargo vessels, and smaller, faster crew transport vessels. Once in the WDA, vessels may remain on station for weeks or months or remain for only a day.

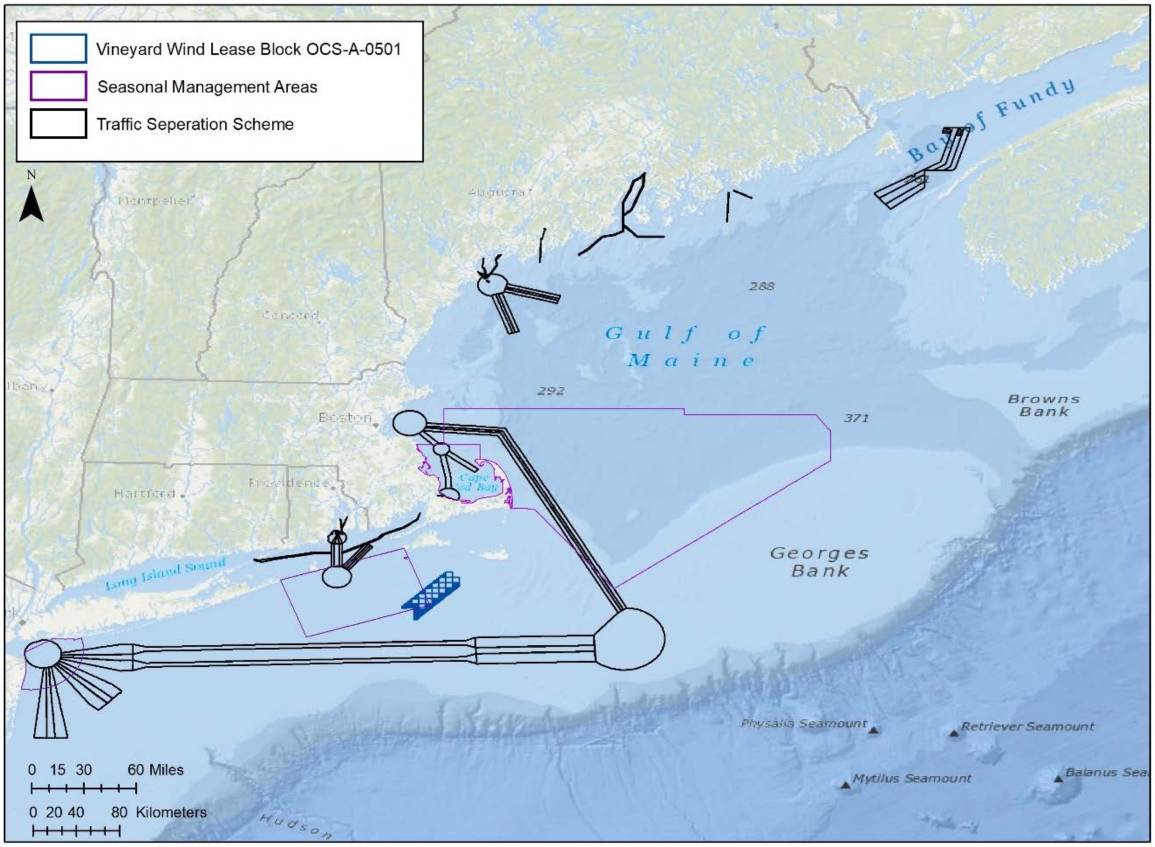
Table 7.23. Estimated maximum daily trips and trips per month during two-year project construction schedule, based on installation of 100 WTGs.

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

Source: Table 5.1-6 in Vineyard Wind BA, Vineyard Wind RFI

Approximate vessel transit routes from ports in the U.S. and Canada are largely known (Figures 7.2 and 7.3). Vessels transiting to the project area from Europe will include construction/installation vessels and cargo vessels transporting project components. At this time, the ports of origin in Europe are unknown and the exact vessel route from port facilities in Europe are unknown and will depend, on a trip-by-trip basis, on weather and sea-state conditions, other vessel traffic, and any maritime hazards. As described in the description of the action, these vessel trips would not occur but for the proposed action. Therefore, we consider if there are any effects of these trips in the area extending from the European countries along the North Atlantic coast from which vessels depart from to the WDA and/or ports in Canada, New Bedford, Brayton Point, Montaup, Providence, or Quonset. While we cannot predict the exact vessel routes that these vessels will take, we expect that based on a review of AIS data (see Figure 4 illustrating all AIS vessel tracks for 2019), it is reasonable to expect the vessel's track to approach the precautionary area at the intersection of the Boston Harbor Traffic Lanes and the Nantucket to Ambrose Traffic Lane and then track along the Nantucket to Ambrose Traffic Lane. At some point, the vessel will depart the Nantucket to Ambrose Traffic Lane and travel directly to the WDA or to the Narragansett Bay or Buzzards Bay traffic separation scheme.

Figure 7.1. Traffic Separation Schemes (TSSs), North Atlantic right whale Season Management Areas (SMAs), Vineyard Wind Lease Block (MA Lease OCS-A 0501 in the Action Area



7.2.1 *Existing Vessel Traffic in the Action Area*

Information from a number of sources including the DEIS, Navigational Risk Assessment (NRA) prepared to support the COP, and the USCG's 2020 MARI PARS study helps to establish the baseline vessel traffic in the WDA and surrounding area. Section 4 of the NRA characterizes the baseline vessel traffic within the Project region according to identified vessel types, their characteristics, operating areas/routes, separation zones, traffic density, and seasonal traffic variability over a 24-month period. The vessels operating within the WDA most frequently are commercial fishing vessels, followed by recreational vessels such as pleasure boats, charter fishing vessels, and sailboats. Research and underwater operations vessels, cargo vessels, tugboats and tankers, and military vessels/SAR vessels were also observed in the WDA, but less frequently. The OECC is mostly trafficked by pleasure craft, passenger ferries, high-speed craft, and commercial fishing vessels, in order of frequency. The WDA and OECC receive increased vessel traffic during the summer months. Overall, the WDA experiences moderate levels of commercial traffic, with approximately 1,300 unique trips recorded annually in 2016-2018 (Epsilon 2020). Commercial fishing vessels transit the WDA, primarily in the northern most portion with most traffic traveling in a northwest to southeast direction; some vessels also actively fish in the WDA. Vessel traffic between southern New England and the ports in Canada mainly consists of fishing vessels, tankers, container ships, and passenger vessels, and exhibits similar seasonal increases in vessel traffic to the Project Area. Trans-Atlantic vessel traffic mainly consists of tankers, container ships, and passenger vessels.

Table 3.4.7-1 in the COP Section 4.3, Appendix III-I (portions of which are replicated below in Table 7.24) summarizes the type and number of unique vessel counts recorded within 10 miles (16 kilometers) of the WDA based on AIS data from 2016 and 2017. Commercial fishing vessels and recreational vessels (pleasure craft and sailing vessels) comprised more than 70 percent all of the AIS tracks within 10 miles of the WDA recorded in 2016 and 2017. It is important to note that AIS is only required on commercial vessels with a length of 65 feet (19.8 meters) or longer, it is likely that vessel traffic is significantly more than described as many recreational vessels, as well as some fishing vessels are below the required length to have AIS. As reflected in the table, some smaller recreational and fishing vessels carry an AIS; however, the data likely excludes most vessels less than 65 feet (19.8 meters) long that traverse the WDA. Vessel Monitoring System reports collected by NMFS from 2011 to 2016 and recreational boating data surveys from 2010 and 2012 (Starbuck and Lipsky, 2013) were used to supplement the AIS data.

This table also does not reflect AIS crossings of the OECC (including Lewis Bay); however Figure 4.0-4 in the Navigational Risk Assessment shows AIS vessel tracks across the OECC. About 15 nautical miles offshore, the OECC route would cross a navigation route for tug-and-barge (shown as “towing”), tanker, and fishing vessels have also been commonly recorded throughout this area (COP Figure 4.0-4, -I; Epsilon 2020). The heaviest vessel traffic in the vicinity of the WDA occurs in four primary areas: Narragansett Bay, Buzzards Bay, Nantucket Sound, and the area between Woods Hole and Vineyard Haven. Additionally, high-volume passenger ferry traffic occurs between Hyannis and Nantucket and Martha’s Vineyard. This ferry traffic is a significant source of existing vessel traffic in the action area. Between Hyannis and Nantucket there are 7-12 roundtrips per day; approximately 6 round trips each day between Hyannis and Martha’s Vineyard, 14-19 round trips between Woods Hole and Martha’s Vineyard, and approximately 9 trips a day between Falmouth and Martha’s Vineyard. Additionally, the ferry between New Bedford and Martha’s Vineyard runs 7 roundtrips per day and the ferry between New Bedford and Nantucket runs 3 roundtrips per day. There were about 2,200 commercial cargo trips to the Port of New Bedford in 2016 and approximately 1,300 commercial cargo trips to the Port of Providence in 2016 (USACE 2016); all of these vessels would transit through a portion of the action area. The USCG's Port Access Study for Nantucket Sound indicates that there are 1,000s of trips through Nantucket Sound each year, including 22,000 annual ferry trips and 7-9,000 fishing vessel transits (USCG XXXX). A portion of these trips occur in the action area. As part of the Areas Offshore of Massachusetts and Rhode Island Port Access Route Study (MARIPARS), the USCG examined vessel traffic AIS density data for years 2015, 2016, 2017, and 2018 to identify current traffic characteristics, drawn from the USCG Navigation Center. Based on this data, annual vessel transits through the MA/RI WEA range from 13,000 to 46,900 transits (USCG 2020). AIS annual vessel traffic data shows that vessel activity and vessel density quadruples during the summer months compared to the colder months of January and February (USCG 2020).

Table 7.24. 2016 and 2017 AIS Vessel Traffic Data within the WDA 10-mile Analysis Area

Vessel Type [a]	**Vessel Dimensions (maximum-minimum)**					**Number of Unique Vessels**	
	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

Source: Table 3.4.7-1 COP Section 4.3, Appendix III-I

AIS = Automatic Identification System; ft. = feet; m = meter; na = data not available

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

[b] Displacement based on example vessels

To help assess the potential increase in risk of vessel strike on listed species that may result from an increase in vessel traffic in the action area, we calculated the percent increase of vessel traffic due to the project from baseline vessel traffic in the WDA and along the OECC by considering the available information on annual vessel transits in the WDA and across the OECC. We were not able to generate an accurate estimate of total annual non-Project transits of the action area as a whole. However, as project vessel traffic will be concentrated in the WDA and along the OECC, we determined this was a reasonable approach; nonetheless, as explained below, this results in an underestimate of total baseline vessel activity for the entire action area, but captures where all project vessels will be operating during construction. An underestimate of baseline (non-project) vessel traffic in the area means that any calculation of the increase in vessel traffic attributable to the project is likely to be an overestimate. However, at this time, this is the best available information and we do not have any information on how much of an underestimate the determination of baseline traffic may be so we are not able to make any adjustments to that number. According to section 4.3 of the Navigational Risk Assessment, the traffic within the OECC analysis area (analysis area of the Offshore Export Cable Corridor including a 500-m zone around it) accounts for 19-22% of the overall traffic in Nantucket Sound. On average, 145 - 156 vessels are traversing this area daily, or approximately 52,925 annually. The Supplementary Analysis for Navigational Risk Assessment (COP Volume III, Appendix III-I, Table 2.2; Epsilon 2020) provides a summary of AIS data from vessel traffic transiting the Vineyard Wind WDA from 2016-2018. For this three-year period there were 591 unique vessels, and 4,139 unique vessel tracks recorded, or approximately 1,380 unique tracks a year. For the purposes of this section, a unique vessel track is assumed to be equivalent to a vessel trip. To determine the total annual vessel trips through the OECC and WDA, we added the two annual trip estimates to get a total of 54,305 annual trips. Through the rest of this section, 54,305 annual vessel trips will be used as the baseline of vessel activity in the OECC and WDA. However, as explained above, the data collected to inform this estimate underrepresents smaller (less than 65 feet) vessels using the area, and also does not include traffic in the Ambrose-Nantucket TSS (unless those vessels crossed the WDA or OECC) and does not account for all vessels transiting along all routes that will be used by project vessels and thus, is an underestimate of the total baseline vessel traffic in the area.

The DEIS, BA, and COP prepared for the Vineyard Wind project all present various statistics on the vessel traffic related to the project activities during construction, operation, and decommissioning. The trips listed in these documents (COP Volume I – Section 4.2.4, Volume III – Section 7.8, and Navigational Risk Assessment in Appendix III-I; Epsilon 2020) include vessel activity occurring in the Project Area, and describes vessel operations for all phases of the project. For all three phases of the project an average and maximum count of vessel trips over various temporal domains is listed. As the maximum is for an extreme case and does not represent vessel traffic during all times, the average for each phase was determined to better represent a reasonable estimate of the sustained increase in vessel traffic over the life of the project. To determine the percent increase in annual vessel traffic due to the project we divided the annual project-related vessel trips by phase by the baseline annual vessel trips (54,305 trips) (Table 7.25). Note that the percent increase in annual vessel traffic due to the project is just calculated for the OECC and the WDA, which are the two areas vessels will be transiting to/from during construction, operation, and decommissioning. As explained above, existing vessel traffic in the greater southern New England area is currently very high, for a review of vessel characteristics in the area see the Navigational Risk Assessment (COP Volume III, Appendix III-I; Epsilon 2020) and the USCG MARIPARS.

Table 7.25. Percent Increase Above Baseline Vessel Traffic in the WDA and OECC Due to Project Vessels

Phase	Annual Project-Related Vessel Trips (average daily trips x 365 days)	Phase Duration	% Increase in Annual Vessel Trips in the OECC and WDA
Construction	2,555 [a]	2 years	+ 4.7%
Operation	887 [b]	30 years	+ 1.6%
Decommissioning	2,190 [c]	2 years	+ 4.0%

[a] Source: Vineyard Wind Biological Assessment, 2019, pg. 81
[b] Source: Vineyard Wind COP Volume I Table 4.3-2, Epsilon 2020
[c] Source: Vineyard Wind Biological Assessment, 2019, pg. 80

7.2.2 Vessel Operations for Construction, Operations and Maintenance and Decommissioning

COP Table 4.2-1 (Volume I, Section 4.2.4; Epsilon 2020) summarizes vessel details including type/class, number of each type, length, and speed for each proposed Project activity during construction, parts of the table are replicated below (Table 7.4). The maximum transit speed of these vessels while traveling to/from various ports to the WDA and OECC varies from 6 to 30 knots, with operational speeds being somewhat slower.

Table 7.26. Vessels to Be Used During the Construction Phase (from Table 4.2-1 in COP Volume I)

Role	Vessel Type	Max # of Vessels
Foundation Installation		
Marine Mammal Observers and Environmental Monitors	Fishing Vessel/ Crew Transfer Vessel	2-6
Scour Protection Installation	Fall Pipe Vessel	1
Overseas Foundation Transport	Heavy Cargo Vessel, Deck Carrier, and/or Semi-submersible Vessel	2-4
Foundation Installation (Possibly Including Grouting	Jack-up, Heavy Lift Vessel, or Semi- submersible Vessel	1-2
Noise Mitigation Vessel	DP-2 Support Vessel or Anchor Handling Tug Supply Vessel	1
Acoustic Monitoring	Multipurpose Support Vessel or Tug Boat	1
Secondary Work, Snagging, and Possibly Grouting	DP-2 Support Vessel or Tug Boat	1
Crew Transfer	Crew Transfer Vessel	3
Transport of Foundations to WDA	Barge	2-5
Transport of Foundations to WDA	Tugs	3-4
Tugboat to Support Main Foundation Installation Vessel(s)	Site Tug	1
ESP Installation		
ESP Installation	Floating Crane vessel or Semi- submersible Vessel	1

ESP Transport	Heavy Cargo Vessel, Deck Carrier, and/or Semi-submersible Vessel	1-2
ESP Transport (if required)	Tugs	2-4
Crew Transfer	Crew Transfer Vessel	1
Service Boat	Crew Transfer Vessel	1
Refueling Operations to ESP	Crew Transfer Vessel	1
Crew Hotel Vessel During Commissioning	Jack-up or Floatel Vessel	1
Offshore Export Cable Installation		
Pre-Lay Grapnel Run	Multipurpose Support Vessels	1
Pre-Installation Surveys	Multi-role survey vessel or Smaller Support Vessels	1
Laying of the Cables (and potentially burial)	Cable Laying Vessel	1
Boulder Clearance	Cable Laying Support Vessel	1
Support Main Vessel with Anchor Handling	Anchor Handling Tug Supply Vessel	1
Trenching Vessel	Purpose Built Offshore Construction/ROV/Survey Vessel	1
Crew Transfer	Crew Transfer Vessel	1
Place Rock or Concrete Mattresses	Rock/Mattress Placement Vessels	1
Dredging	Dredging Vessels	1
Inter-Array Cable Installation		
Pre-Lay Grapnel Run	Multipurpose Support Vessel	1
Pre-Installation Surveys	Multi-role survey vessel or Smaller Support Vessels	1
Laying of the Cables (and potentially burial)	Cable Laying Vessel	1
Burial Support Vessel	Cable Laying Support vessel	1
Crew Transfer	Crew Transfer Vessel	2
Cable Termination and Commissioning	Cable Laying Support vessel	1
Trenching Vessel	Purpose Built Offshore Construction/ROV/ Survey Vessel	1
Place Rock or Concrete Mattresses	Rock/Mattress Placement Vessels	1
WTG Installation		
Nacelle and Tower Transport	Heavy Lift Vessels	1-4
Blade Transport	Heavy Cargo Vessel	1-5
Feeding WTG Components from Harbor to WDA	Jack-up Vessels/Feeder Barges	2-6
Vessel and Feeder Concept Assistance	Harbor Tug	1-6
WTG Installation	Jack-up Crane Vessel	1-2
Crew Transfer	Crew Transfer Vessel	3
WTG Commissioning		

Crew Transfer	Crew Transfer Vessel	1-4
Main Commissioning Vessel	Service Operation Vessel	1
Miscellaneous Construction Activities		
Refueling Vessels	Crew Transfer Vessel or Multipurpose Support Vessel	1
Guard Vessels	Crew Transfer Vessel	1
Geophysical and Geotechnical Survey Operations	Multi-role survey vessel or Smaller Support Vessels	1

COP Tables 3.2-1 and 3.2-2 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 Massachusetts and Rhode Island ports (e.g., Brayton Point and Quonset) may also be used. Canadian ports (e.g., Sheets Port, St. John, and Halifax) may be used during construction or decommissioning; BOEM has indicated that during the two-year construction period up to five vessels could transit between the WDA and ports in Canada to transport project components per day, with a maximum of 50 trips per month (Table 7.23). One-way distance from each of the potential ports to the WDA as delineated in Figure 7.2 (New Bedford routes) and Figure 7.3 (Canadian routes) 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]). BOEM estimates that up to 16 unique European construction/installation vessels would be used over the course of the Project's offshore construction period. These vessels are expected to remain on site for the duration of the work that they are contracted to perform, which could range from two to twelve months. The ports of origin of these vessels are unknown at this time. It is also anticipated that monopiles, transition pieces, wind turbine generator components, electrical service platform components, and offshore cables will be shipped from overseas ports in Europe, either directly to the WDA or first to a US port before being transported to the WDA. This will result in a total of approximately 122 round trips to transport project components from Europe. The trips for the five activities listed above might not necessarily occur within the same timeframe. On average, vessels transporting components from Europe will make ~5 round trips per month over a two-year offshore construction schedule. As with the construction vessels described above, the ports of origin are unknown. All of these vessels traveling from Europe are large slow moving construction/installation or cargo vessels that travel at slow speeds of approximately 10-18 knots.

Figure 7.2. Potential Vessel Routes between WDA and New Bedford

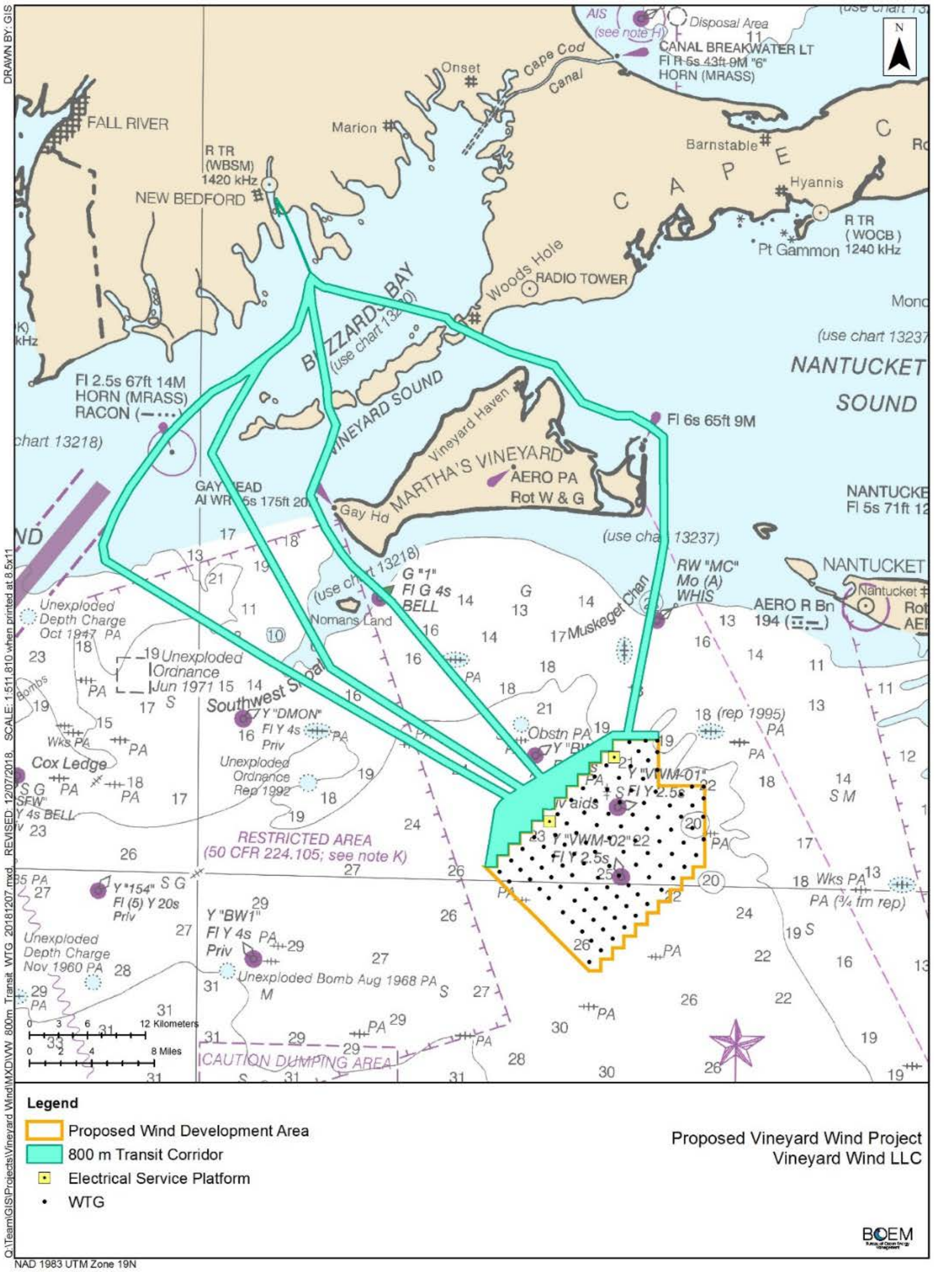
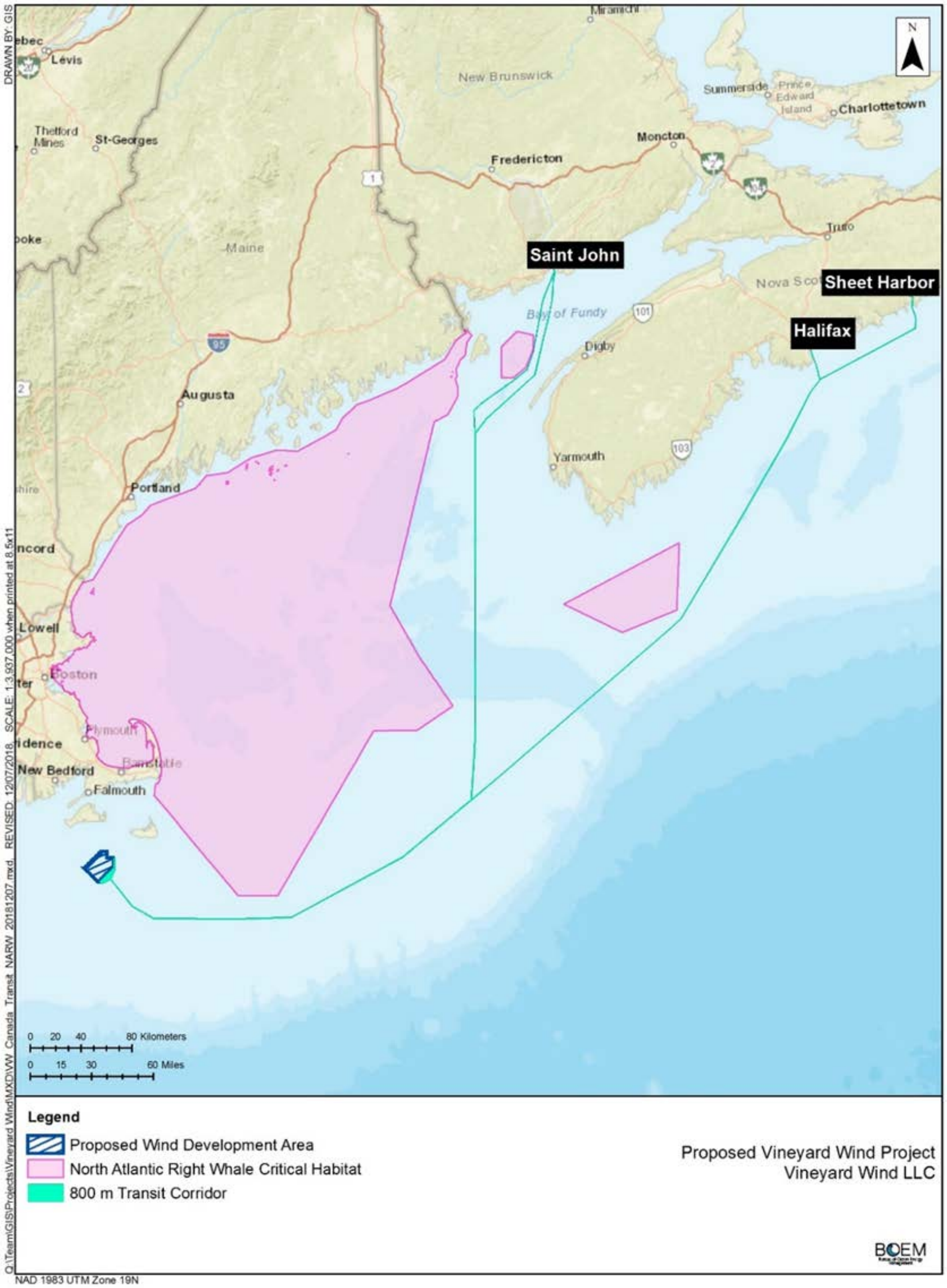


Figure 7.3. Vessel Traffic Routes from Canadian Ports



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 46 vessels could be on-site (at the WDA or along the OECC) at any given time (Table 7.26). Many of these vessels will remain in the WDA or OECC for days or weeks at a time, potentially making only infrequent trips to port for bunkering and provisioning, if needed. Therefore, although an average of 25 vessels will be involved in construction activities on any given day, on average only 7 vessels will transit to and from ports each day. However, the maximum number of vessels involved in the Project at one time is highly dependent on the Project's final schedule, the final design of the Project's components, and the logistics solution used to achieve compliance with the Jones Act. The peak level of construction is expected to occur during pile driving activities from May through December. However, mobilization to and from the WDA would occur before and after this period (COP Volume III Section 7.8.2.1). 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 (Figure 7.2).

As noted above, in addition to one time trips from Europe of specialized construction vessels that will stay at the project site for two to twelve months, many project components will be transported to the project site from Europe (with the potential for stops in one of the Canadian or U.S. ports mentioned). While we do not know where in Europe these vessels will originate from, we expect they will take the most direct route available. Vessels coming from Europe to the project site or one of the MA or RI ports are expected to approach the precautionary area at the intersection of the Boston Harbor Traffic Lanes and the Nantucket to Ambrose Traffic Lane and then track along the Nantucket to Ambrose Traffic Lane. At some point, the vessel will depart the Nantucket to Ambrose Traffic Lane and travel directly to the WDA or to the Narragansett Bay or Buzzards Bay traffic separation scheme.

During operations and maintenance, and as described in Section 7.8.2.2 of Volume III of the COP (Epsilon 2020), 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, on average we expect there to be ~2.5 daily trips during the operational phase (~30 years) of the project (Table 7.23 and 7.27) (Vineyard Wind COP; Volume I, Section 4.3.4; Epsilon 2020). CTVs will be homeported in New Bedford, or other southern New England ports, however additional vessels used for maintenance may have to travel to the project area from domestic and international ports.

Table 7.27. Vessels to Be Used During the Operational and Maintenance Phase (from Table 4.3-2 in COP Volume I)

Role	Vessel Type	Description of Anticipated Vessel Activities	Annual Round Trips
Scour Protection Repairs			
Scour Protection Repair	Fall Pipe Vessel	One trip every 1.5 years, 2 days per trip	0.7
ESP O&M			
Refueling Operations to ESP	Crew Transfer Vessel or Multipurpose Support Vessel	One trip per year, 1 day per trip	1
WTG O&M			
WTG Transport	Heavy Cargo Vessel and/or Deck Carrier	One trip every 3 years	0.3
Main Repair Vessel	Jack-up Vessel	One trip every 1.5 years, 5 days per trip	0.7
Gearbox Oil Change	Crew Transfer Vessel or Multipurpose Support Vessel	Approximately one trip per WTG (In years 5, 13 and 21)	110
Ad Hoc Survey Work	Multi-role Survey Vessel	Up to 100 surveys over the Project's lifespan, 2 days per trip	3.3
Cable Inspection/Repairs			
Cable Inspection/Repair	Multi-role Survey Vessel	Eight surveys over the Project's lifespan, 20 days per trip (Years 1,2,3,6,9,12,15, and 20)	1
Daily and Miscellaneous O&M Scenario 1 (CTV Concept)			
Daily Crew Transfer	Crew Transfer Vessel	One trip per day for approximately 70% of the year (~256 days)	256
Daily Crew Transfer	Crew Transfer Vessel	One trip per day for approximately 70% of the year (~256 days)	256
Daily Crew Transfer	Crew Transfer Vessel	One trip per day for approximately 70% of the year (~256 days)	256
Miscellaneous Repairs	Multipurpose Support Vessel	One trip every 3 years, 10 days per trip	0.3
Marine Mammal Observations	Crew Transfer Vessel/Fishing Vessel	One trip per year, 5 days per trip	1
Guard Vessels	Crew Transfer Vessel/Fishing Vessel	One trip every 1.5 years, 7 days per trip	0.7
Daily and Miscellaneous O&M Scenario 2 (SOV Concept)			
Service Operation Vessel (SOV)	Multipurpose Support Vessel	One round trip every two weeks, lasting approximately two weeks each	26
Daily Crew Transfer from SOV	Crew Transfer Vessel	One trip per day for approximately 70% of the year (~256 days))	256
Marine Mammal Observations	Crew Transfer Vessel/Fishing Vessel	One trip per year, 5 days per trip	1

Guard Vessels	Crew Transfer Vessel/Fishing Vessel	One trip every 1.5 years, 7 days per trip	0.7

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 2,190 trips per year. Assuming that decommissioning also lasts two years, this equates to approximately six vessel trips per day. Vessels used during the decommissioning phase will likely be similar to the vessels used during construction (Table 7.27). As these vessels are not all currently in the southern New England area, they will have to travel to the project area from domestic and international ports. While most of the vessels operating during construction and decommissioning will travel at relatively low speeds (i.e., 12 knots or less), some vessels are capable of transiting at up to 30 knots. There are a number of measures designed to decrease the risk of interactions between project vessels and listed species that are part of the proposed action, as highlighted below. In addition to these measures, all vessel operators are required to abide by the right whale ship strike reduction rule (78 FR 73726) and the right whale approach regulations (62 FR 6729).

7.2.3 Minimization and Monitoring Measures for Vessel Operations

There are a number of measures that Vineyard Wind is proposing to take and/or BOEM is proposing to require as conditions of COP approval that are designed to avoid, minimize, or monitor effects of the action on ESA-listed species during construction, operation, and decommissioning of the project. These are considered part of the proposed action. More information on these measures is included in COP Volume III Attachment-M and BOEM's March 2019 BA. These include the following measures, which will be implemented year-round:

- 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 below in seasonal measures.
    - CTVs in DMAs: All vessels must travel at 10 knots or less within any NMFS-designated DMA, with the exception of crew transfer vessels (CTVs). CTVs traveling within any 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, CTVs 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.
- Any project vessel that will travel at speeds over 10 knots will have an observer who has undergone PSO training who will be in communication with the captain to report any

protected species sightings. Speeds will immediately be reduced to 10 knots or less if any listed species are sighted by the observer or otherwise reported to the captain.

- All Project vessels, irrespective of size, will be required to operate AIS.
- PSOs will record the vessel's position and speed, water depth, sea state, and visibility will be recorded at the start and end of each observation period, and whenever there is a change in any of those variables that materially affects sighting conditions.
- Real-time PAM system will be used to monitor for protected species within the entire transit corridor used by project vessels during the construction, operation and maintenance, and decommissioning phases of the Project. Information will be relayed to all vessels transiting to, from, or within the WDA as soon as possible following detection of a right whale.
- Vessel operators will use all available sources of information on right whale presence, including at least daily monitoring of the Right Whale Sightings Advisory System, and monitoring of Coast Guard VHF Channel 16 throughout the day to receive notifications of any sightings and consideration of information associated with any Dynamic Management Areas to plan vessel routes to minimize the potential for co-occurrence with any right whales.
- All vessels greater than or equal to 65 ft. (19.8 m) in overall length must slow to speeds of 10 knots or less in Seasonal Management Areas as per the Right Whale Ship Strike Reduction Rule (50 CFR 224.105)
- All vessels will comply with State (322 CMR 12.07) and Federal regulations (50 CFR part 222.32) that prohibit approaching a right whale within a 500 yard (1500 ft.) buffer zone. Any vessel finding itself within the 500 yard (1500 ft.) buffer zone created by a surfacing right whale must depart immediately at a safe, slow speed.

Additionally, during the November 1 to May 14 period, which coincides to the time of year with the greatest abundance of right whales in the action area, the following measures will be required:

- Project vessels, transiting to/from or within the WDA, except within Nantucket Sound (unless an active DMA is in place), would travel at less than 10 knots within the WDA. Exceptions are provided for crew transfer vessels and crew transfer vessels operating in a DMA as long as the enhanced mitigation described below are followed.
    - Crew Transfer Vessels: From November 1 through May 14, CTVs 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.

7.2.4 Assessment of Risk of Vessel Strike – Construction, Operations and Maintenance and Decommissioning

Here, we consider the risk of vessel strike to ESA listed species. This assessment incorporates the strike avoidance measures identified above because they are considered part of the proposed action or are otherwise required by regulation. This analysis is organized by species group (i.e., whales, sea turtles, Atlantic sturgeon) because the risk factors and effectiveness of strike avoidance measures are different for the different species groups.

7.2.4.1 Atlantic sturgeon

The distribution of Atlantic sturgeon does not overlap with the entirety of the action area. The marine range of Atlantic sturgeon extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida with distribution largely from shore to the 50m depth contour (ASMFC 2006; Stein et al. 2004). Thus, Atlantic sturgeon only occur along a portion of the vessel routes described above and are absent from much of the vessel routes from Canada and Europe given the deep-water offshore routes that will be transited by these vessels.

While Atlantic sturgeon are known to be struck and killed by vessels in rivers and estuaries located adjacent to spawning rivers (i.e., Delaware Bay), we have no reports of vessel strikes in the marine environment. The risk of strike is expected to be considerably less in the Atlantic Ocean, including the action area for this consultation, than in rivers. This is because of the greater water depth which increases the space between bottom oriented sturgeon and propellers and hulls of vessels, lack of obstructions or constrictions that would otherwise restrict the movement of sturgeon, and the more disperse nature of vessel traffic and more disperse distribution of individual sturgeon which reduces the potential for co-occurrence of individual sturgeon with individual vessels. All of these factors are expected to decrease the likelihood of an encounter between an individual sturgeon and a vessel and also increase the likelihood that a sturgeon would be able to avoid any vessel. While we cannot quantify the risk of vessel strike in the portions of the Atlantic Ocean that overlap with the action area, based on these factors and the lack of any information to suggest that Atlantic sturgeon are struck and killed by vessels in the marine environment we expect the risk to be extremely low.

We have considered whether Atlantic sturgeon are likely to be struck by project vessels or if the increase in vessel traffic is likely to otherwise increase the risk of strike for Atlantic sturgeon in the action area. As established elsewhere in this Opinion, Atlantic sturgeon use of the action area is intermittent and disperse; there are no aggregation areas in the action area and the action area is not adjacent to any spawning rivers, which would increase the number and concentration of migrating Atlantic sturgeon. The disperse nature of Atlantic sturgeon in the action area means that the potential for co-occurrence between a project vessel and an Atlantic sturgeon is extremely low. In order to be struck by a vessel, an Atlantic sturgeon needs to co-occur with the vessel hull or propeller in the water column. Given the depths in the vast majority of the action area (with the exception of near shore areas where vessels will dock) and that sturgeon occur at or near the bottom while in the action area, the potential for co-occurrence of a vessel and a sturgeon in the water column is extremely low even if a sturgeon and vessel co-occurred generally. The areas to be transited by the barges are free flowing with no obstructions; therefore, even in the event that a sturgeon was up in the water column such that it could be vulnerable to strike, there is ample room for a sturgeon swim deeper to avoid a vessel or to swim away from it which further reduces the potential for strike. None of the nearshore port areas where vessels will potentially enter shallower water and dock, including New Bedford, are known to be used by Atlantic sturgeon; as such, co-occurrence between any Atlantic sturgeon and any project vessels in areas with shallow water or constricted waterways where the risk of vessel strike is theoretically higher, is extremely unlikely to occur. Considering this analysis, it is extremely unlikely that any project vessels will strike an Atlantic sturgeon during any phase of the proposed project. We have also considered whether avoiding these project vessels increases the risk of being struck by non-project vessels operating in the action area. In order for this to occur, another vessel would have to be close enough to the project vessel such that the animal's evasive movements made it such that it was less likely to avoid the nearby vessel. Given common navigational safety practices (i.e., not traveling too close to other vessels to minimize the risk of collisions), it is extremely unlikely that another vessel would be close enough such that a sturgeon avoiding a project vessel would not be able to avoid another non-project vessel or that the risk of being struck by another non-project vessel would otherwise increase. Based on this analysis, it is extremely unlikely that any Atlantic sturgeon will be struck by project vessels.

7.2.4.2 ESA Listed Whales

Background Information on the Risk of Vessel Strike to ESA Listed Whales

Vessel strikes from commercial, recreational, and military vessels are known to affect large whales and have resulted in serious injury and occasional fatalities to cetaceans (Lammers et al. 2003, Douglas et al. 2008, Laggner 2009, Berman-Kowalewski et al. 2010, Calambokidis 2012). Records of collisions date back to the early 17th century, and the worldwide number of collisions appears to have increased steadily during recent decades (Laist et al. 2001, Ritter 2012).
The most vulnerable marine mammals are those that spend extended periods of time at the surface feeding or in order to restore oxygen levels within their tissues after deep dives. Baleen whales, such as the North Atlantic right whale, seem generally unresponsive to vessel sound, making them more susceptible to vessel collisions (Nowacek et al. 2004). In an effort to reduce the likelihood and severity of fatal collisions with right whales, NMFS established vessel speed restrictions in specific locations, primarily at key port entrances, and in certain times in SMAs. The restrictions apply to vessels 65 feet and greater in length (73 FR 60173, October 10, 2008). NMFS also established a DMA program whereby vessels are requested, but not required, to either travel at 10 knots or less or route around locations when certain aggregations of right whales are detected outside SMAs. These temporary protection zones are triggered when three or more whales are sighted within 2-3 miles of each other outside of active SMAs. The size of a DMA is larger if more whales are present. A DMA is a rectangular area centered over whale sighting locations and encompasses a 15-nautical mile buffer surrounding the sightings' core area to accommodate the whales' movements over the DMA's 15-day lifespan. The DMA lifespan is extended if three or more whales are sighted within 2-3 miles of each other within its bounds during the second week the DMA is active. Only verified sightings are used to trigger or extend DMAs; however DMAs can be triggered by a variety of sources, including dedicated surveys, or reports from mariners. In an analysis of the effectiveness of the ship strike rule, Conn and Silber (2013) estimated that the speed restrictions required by the ship strike rule reduced total ship strike mortality by 80 to 90%. In the Vineyard Wind action area, the Block Island SMA, which is in effect from November 1 - April 30 each year, overlaps with a portion of the Vineyard Wind Lease block (MA Lease OCS-A 0501) (Figure 7.4). Additionally, many DMAs have been established in response to aggregations of right whales in the waters of southern New England, and overlap the action area (Table 7.28 and Figure 7.5)

Figure 7.4. Traffic Separation Schemes (TSSs), Season Management Areas (SMAs), Vineyard Wind Lease block (MA Lease OCS-A 0501) in the Project Area in southern New England

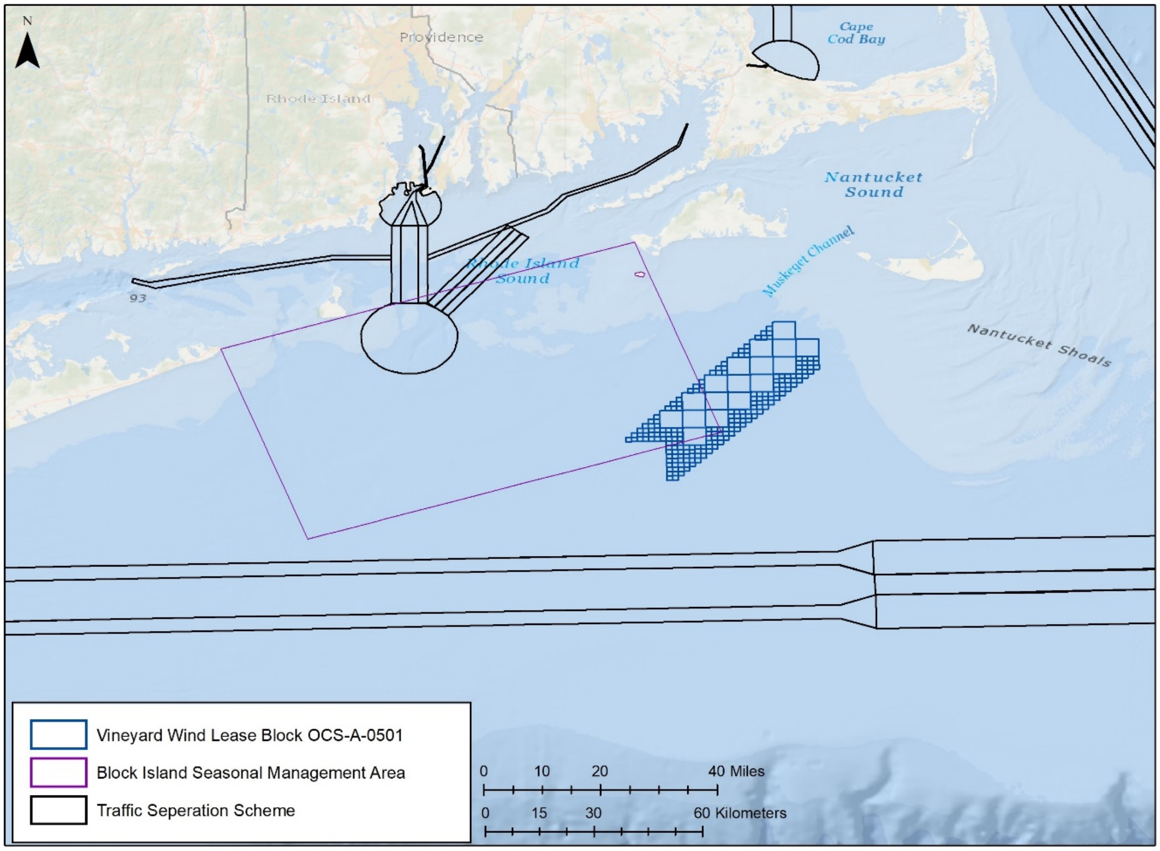


Table 7.28. Dynamic Management Areas (DMAs) established in the past five years in the waters of southern New England

Trigger Date (date of RW sightings)	**Number of Right Whales**	**General Location**	**Boundaries**	**Days in Effect**
1/15/2014	3	South of Nantucket	41 04N 40 24N 070 26W 069 33W	14
3/1/2014	3	South of Nantucket	41 13N 40 33N 070 36W 069 44W	13

3/5/2014	11	South of Cape Cod	41 38N 40 50N 070 50W 069 46W	14
4/2/2014	8	South of Nantucket	41 12N 40 29N 070 41W 069 45W	14
4/7/2014	7	North of Nantucket	41 55N 41 11N 070 21W 069 21W	14
12/13/2014	10	Southeast of Nantucket	41 35N 40 56N 069 56W 070 46W	13
12/27/2014	8	Southeast of Nantucket	41 35N 40 56N 069 56W 070 46W	13
1/21/2015	6	South of Nantucket	41 12N 40 28N 070 251W 069 28W	14
2/24/2015	10	Southwest of Nantucket	41 29N 40 43N 070 51W 069 52W	14
3/13/2015	6	South of Martha's Vineyard	41 24N 40 41N 071 13W 070 11W	13
4/1/2015	4	RI Sound	41 37N 40 56N 071 39W 070 44W	15
4/16/2015	5	Southwest of Nantucket	41 26N 40 44N 070 47W 069 51W	12
5/28/2015	3	35 nm east southeast of Nantucket	41 25 N 40 46 N 069 41 W 068 48 W	12
8/1/2015	3	13 nm east southeast of Boston	42 38 N 41 58 N 071 15 W 070 21 W	14

8/23/2016	6 to 9	55 nm southeast of Nantucket	40 49 N 40 05 N 070 02 W 069 04 W	14
2/21/2017	10	16 nm south of Marthas Vineyard	41 26N 40 43N 071 05W 070 09W	15
3/6/2017	14	16 nm south of Marthas Vineyard	41 26N 40 43N 071 05W 070 09W	15
3/21/2017	4	22 nm southwest of Nantucket	41 14N 40 33N 070 47W 069 52W	15
4/9/2017	7	19 nm south southeast of Nantucket	41 19N 40 35N 070 51W 069 52W	14
4/19/2017	20	15 nm south southwest of Nantucket	41 19N 40 35N 070 51W 069 52W	14
5/4/2017	8	15 nm south southwest of Block Island	41 24N 40 38N 071 47W 070 47W	14
5/19/2017	8	80 nm east of New York	40 32 N 39 51 N 072 46 W 071 49 W	15
6/15/2017	3	13 nm south of Nantucket	41 17N 40 47N 069 44W 070 24W	10
7/3/2017	3	2 nm South of Nantucket	41 32N 40 53N 070 29W 069 36W	14
7/16/2017	3	2 nm South of Nantucket	41.32N 40.53N 070.29W 069.36W	14
7/29/2017	4	South of Nantucket	41.33 N 40.54 N 070.35 W 069.42 W	14

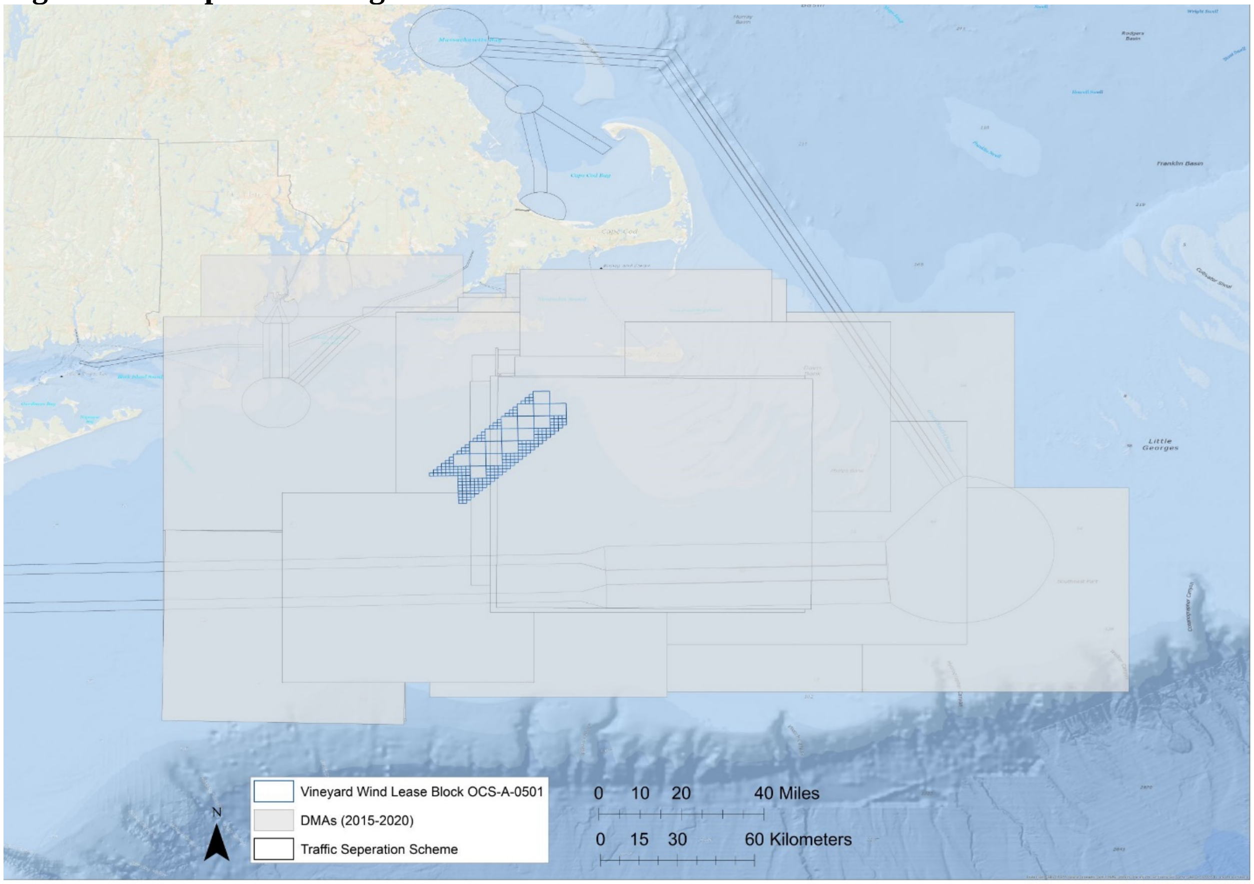
1/21/2018	22	30 nm south of Nantucket	41.15N 40.22N 070.51W 069.37W	14
2/9/2018	6	29 nm south of Nantucket	41 10 N 40 24 N 070 40 W 069 43 W	15
3/20/2018	6	11 nm southwest of Nantucket	41 28N 40 47N 070 45W 069 46W	15
3/29/2018	8	20 nm south southwest of Nantucket	41 28N 40 47N 070 45W 069 46W	8
4/24/2018	3	19 nm south of Martha's Vineyard	41 25 N 40 46 N 070 58 W 070 06 W	15
6/30/2018	4	2 nm south of Nantucket	41 32 N 40 54 N 070 29 W 069 34 W	13
11/18/2018	4	21 nm south of Nantucket	41 16 N 40 37 N 070 42 W 069 47 W	15
11/26/2018	17	21 nm south of Nantucket	41 22 N 40 29 N 070 39 W 069 29 W	15
11/26/2018	17	21 nm south of Nantucket	41 16 N 40 37 N 070 42 W 069 47 W	15
12/15/2018	33	26 nm south of Nantucket	41 17 N 40 24 N 070 37 W 069 25 W	14
12/15/2018	33	26 nm south of Nantucket	41 12 N 40 28 N 070 36 W 069 31 W	10

1/2/2019	53	South of Nantucket	41 12 N 40 28 N 070 36 W 069 31 W	NA
1/15/2019	100	South of Nantucket	41 12 N 40 28 N 070 36 W 069 31 W	15
1/27/2019	20	South of Nantucket	41 12 N 40 28 N 070 36 W 069 31 W	14
2/4/2019	11	South of Nantucket	41 12 N 40 28 N 070 36 W 069 31 W	15
2/17/2019	19	South of Nantucket	41 12 N 40 28 N 070 36 W 069 31 W	15
3/1/2019	10	South of Nantucket	41 12 N 40 28 N 070 36 W 069 31 W	15
3/13/2019	15	South of Nantucket	41 12 N 40 28 N 070 36 W 069 31 W	15
3/28/2019	6	South of Nantucket	41 12 N 40 28 N 070 36 W 069 31 W	15
4/7/2019	15	South of Nantucket	41 12 N 40 28 N 070 36 W 069 31 W	15
4/23/2019	3	Southwest Martha's Vineyard	40 39 N 39 59 N 070 56 W 071 47 W	15
4/29/2019	3	South of Martha's Vineyard	40 47 N 40 07 N 070 29 W 071 22 W	15
5/7/2019	4	Southwest of Martha's Vineyard	40 39 N 39 59 N 070 56 W 071 47 W	15

5/14/2019	4	South of Martha's Vineyard	40 47 N 40 07 N 070 29 W 071 22 W	10
5/16/2019	5	Southeast of Nantucket	40 48 N 40 05 N 068 24 W 069 20 W	15
5/15/2019,	4	South of Nantucket	40 44 N 40 04 N 070 01 W 070 51 W	15
5/22/2019	15	Southwest Martha's Vineyard	40 39 N 39 59 N 070 56 W 071 47 W	14
5/22/2019	15	South Martha's Vineyard	40 47 N 40 07 N 070 29 W 071 22 W	14
5/25/2019	9	South of Nantucket	40 44 N 40 04 N 070 01 W 070 51 W	13
7/15/2019	3	South of Nantucket	41 34 N 40 54 N 70 32 W 69 39 W	14
7/25/2019	7	South of Nantucket	41 14 N 40 29 N 069 32 W 070 32 W	14
8/3/2019	10	South of Nantucket	41 14 N 40 29 N 069 32 W 070 32 W	14
8/12/2019	9	South of Nantucket	41 14 N 40 29 N 069 32 W 070 32 W	15
8/30/2019	19	Southeast of Nantucket	41 23 N 40 43 N 068 14 W 070 10 W	12
9/9/2019	7	Southeast of Nantucket	41 23 N 40 43 N 068 14 W 070 10 W	15

11/9/2019	3	Southeast of Nantucket	41 01 N 40 25 N 069 10 W 069 56 W	13
11/19/2019	?	Southeast of Nantucket	41 01 N 40 25 N 069 10 W 069 56 W	15
12/12/2019	8	South of Nantucket	41 10 N 40 28 N 069 42 W 070 43 W	14
12/29/2019	14	4nm south of Nantucket	41 35 N 40 52 N 069 35 W 070 37 W	15
1/22/2020	58	31 nm south of Nantucket	41 11 N 40 22 N 069 32 W 070 37 W	15
1/31/2020	50	31 nm south of Nantucket	41 11 N 40 22 N 069 32 W 070 37 W	15
2/9/2020	14	31 nm south of Nantucket	41 11 N 40 22 N 069 32 W 070 37 W	15
2/20/2020	8	31 nm south of Nantucket	41 11 N 40 22 N 069 32 W 070 37 W	15
3/2/2020	66	Extended 31 nm south of Nantucket and 47 nm southeast Nantucket	41 11 N 40 22 N 069 32 W 070 37 W and 41 02 N 40 15 N 068 58 W 070 01 W	15
3/12/2020	13	31 nm south of Nantucket and 47 nm southeast Nantucket	41 11 N 40 22 N 069 32 W 070 37 W and 41 02 N 40 15 N 068 58 W 070 01 W	14

Figure 7.5 Map Illustrating DMAs identified in Table 7.28



Evidence suggests that a greater rate of mortality and serious injury to marine mammals correlates with greater vessel speed at the time of a ship strike (Laist et al. 2001, Vanderlaan and Taggart 2007 as cited in (Aerts and Richardson 2008)). Vessels transiting at speeds >10 knots present the greatest potential hazard of collisions (Jensen and Silber 2004, Silber et al. 2009). Vanderlann and Taggart (2007) demonstrated that between vessel speeds of 8.6 and 15 knots, the probability that a vessel strike is lethal increases from 0.21 to 0.79. Most lethal and severe injuries resulting from ship strikes have occurred from vessels travelling at 14 knots or greater (Laist et al. 2001). Large whales also do not have to be at the water's surface to be struck. In a study that used scale models of a container ship and a right whale in experimental flow tanks designed to characterize the hydrodynamic effects near a moving hull that may cause a whale to be drawn to or repelled from the hull, Silber et al. (2010) found when a whale is below the surface (about one to two times the vessel draft), there is likely to be a pronounced propeller suction effect. This modeling suggests that in certain circumstances, particularly with large, fast moving ships and whales submerged near the ship, t, this suction effect may draw the whale closer to the propeller, increasing the probability of propeller strikes.

7.2.4.2.1 Exposure Analysis – ESA-Listed Large Whales

We consider vessel strike of ESA-listed large whales in context of specific project phases, as a result of all Vineyard Wind vessel movement within the action area, because the characteristics and volume of vessel traffic is distinctly different during the three phases of the project. The construction, operation, and decommissioning phases will all have varying frequencies of vessel transits in the nearshore and offshore waters of the action area in southern New England. Further, trips from Europe will only occur during the construction phase.

All portions of the action area are presently used year-round by a variety of vessels ranging from small recreational fishing vessels to large commercial cargo ships. Additionally, ESA-listed whales occur in the Project area throughout the year. North Atlantic right whales transit and feed in the Project area year-round, while fin, sperm, and sei whales transit and feed in the area seasonally. Current vessel strike reduction measures that overlap the action area include the Block Island and Great South Channel SMAs which requires that vessels greater than or equal to 65 ft. (19.8 m) in length travel at less than or equal to 10 knots between November 1st and April 30th every year (Figure 7.4).

From the marine mammal stock assessment reports and serious injury and mortality reports produced by NMFS, for the period of 2000-2017 (the most recent period available) there were a total of five ESA-listed whale strikes in southern New England (Rhode Island and Massachusetts, south and east of Cape Cod) which is the best representation of the Project area from the available information. Of the reported strikes, three were to North Atlantic right whales and two were to fin whales (2017 injury and mortality data – In Press, 2007-2016 injury data - NMFS SARs, SI/M, 2000-2006 injury data – NMFS unpub. data). A review of available information for 2018 and through July 2019, did not reveal any additional reports of vessel strikes for right whales in the action area (https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2019-north-atlantic-right-whale-unusual-mortality-event).

Though this is a relatively small number of vessel strikes for the time period, detection of carcasses is very difficult given the large open ocean, which means that this could be an underestimate. Estimates of unobserved mortality by year are included in Figure 4 of the 2018 North Atlantic right whale stock assessment report (NMFS 2019). Conversely, the location of a recovered carcass is where it was first detected, not necessarily where the incident occurred, and some of the incidents detected in this area may be whales that were struck outside of the area, which would result in an overestimate of the strikes that occurred in the area. Additionally, depending on cetacean species carcasses may be more likely to float or sink, they may be carried from where they were struck on the bow of a vessel and only noticed in port, or carried away from the ship strike location by wind, currents, and waves. All of these factors contribute to the difficulty in detecting carcasses, in particular from ship strike (Rockwood et al. 2017).

A number of studies have estimated carcass recovery rates for different cetacean species, including 17% for right whales, 6.5% for killer whales, <5% for grey whales, and 3.4% for sperm whales (Kraus et al. 2005). These rates are largely related to how buoyant a species is, thus affecting how likely it will be detected. Right whales are the most buoyant species due to their thick blubber layer, and are most likely to be detected, thus providing a conservative estimate for extrapolation. Though no recovery rate exists for blue whales, they are thought to be negatively buoyant at or near the surface. Sperm whale buoyancy depends on lung inflation at mortality; near the surface they have positive buoyancy, but overall negative tissue buoyancy (Rockwood et al. 2017). To determine an improved recovery rate estimate for other whale species relative to right whales, Rockwood et al. 2017 used an average of the sperm, grey, and killer whale rates. Available literature suggests that the buoyancy of fin whales is similar to blue whales, and thus less than the species with known recovery rates, therefore providing a reasonable proxy. Using the rate of 17% rate for right whales, the 5% rate (mean of sperm, grey, and killer whales) for fin whales, we extrapolated ship strike mortality from the 2000-2017 serious injury/mortality data to produce an estimate of the total number of right and fin whales struck in Southern New England annually as shown below.

To estimate the annual average vessel strike mortalities corrected for unobserved vessel strike mortalities, we divided the number of observed vessel strike ESA-listed whale mortalities by 0.17 for right whales and 0.05 fin whales. The resulting, corrected number of vessel strike mortalities of each species within the action area are below. Based on these calculations, we would anticipate that an average of 1 right whale and 2 fin whales are struck in the action area (excluding the Canadian and European transit routes), each year.

Number of ESA-Listed Large Whales Struck by Vessels in the Action Area (excluding the Canadian and European transit routes), accounting for Cryptic Mortality

Right whales: 3 (total whales detected struck)/ 0.17 (percent of total struck) = 18 whales struck /18 (years of SI/M data) = 1 whale struck per year

Fin whales: 2 (total whales detected struck)/ 0.05 (percent of total struck) = 40 whales struck / 18 (years of SI/M data) = 2.2 whales struck per year

In spite of being one of the primary known sources of direct anthropogenic mortality to whales, ship strikes remain relatively rare, stochastic events. If we assume that an increase in vessel trips results in a proportional increase in risk of vessel strike, we can then use the calculated percent increase in vessel traffic attributable to the project, to calculate the increase in risk of vessel strike due to project activity (construction, operations, and decommissioning). It is important to note that our ability to predict the increase in vessel traffic is limited to the WDA and OECC as this is the only portion of the action area that we have an estimate of baseline trips (albeit an underestimate as noted above). However, given that non-project vessel traffic is high in the greater MA/RI WEA, this risk assessment can be considered a worst-case representation of the increased risk in the southern New England portion of the action area as a whole (i.e., the entirety of the action area minus the transit routes to Canada and Europe). As illustrated in Table 7.25, we expect a 4.7% increase in vessel trips during the two-year construction period over baseline conditions, a 1.6% increase in traffic during the 30-year operations period, and a 4.0% increase in traffic during the two-year decommissioning period. As such, assuming that linear relationship in vessel traffic and whales struck, we could predict a proportional increase in the number of right and fin whales struck in the action area over this period, as illustrated below:

Hypothetical Estimates of ESA-Listed Large Whale Vessel Strikes in the Action Area Considering Increase in Vessel Traffic Due to Proposed Action

Construction = 4.7% increase in traffic for 2 years
Right whales: 0.047 (increase in vessel traffic) * 1 (baseline vessel strike rate per year) = 0.047 (*2 years, length of phase) = 0.090 whales
Fin whales: 0.047 (increase in vessel traffic) * 2.2 (baseline vessel strike rate per year) = 0.103 (*2 years, length of phase) = 0.21 whales

Operation = 1.6% increase in traffic for 30 years
Right whales: 0.016 * 1 = 0.016 (*30) = 0.48 whales
Fin whales: 0.016 * 2.2 = 0.035 (*30) = 1.06 whales

Decommissioning = 4.0% increase in traffic for 2 years
Right whales: 0.04 * 1 = 0.04 (*2) = 0.08 whales
Fin whales: 0.04 * 2.2 = 0.088 (*2) = 0.18 whales

As mentioned above, it is likely that these calculations overestimate the increased risk as they are based on the portion of the action area that will experience the maximum increase in vessel traffic (i.e., within the WDA and OECC) when most vessels once in the WDA will be stationary or moving extremely slowly (i.e., 3 knots or less). Regardless, there are a number of factors that result in us determining that this hypothetical increase in vessel strike will not occur. As described above in section 7.2.3, Vineyard Wind is proposing to take and/or BOEM is proposing to require measures to reduce the likelihood of striking marine mammals, including, ESA-listed large whales, particularly North Atlantic right whales. These measures include seasonal speed restrictions and enhanced monitoring via PSOs, PAM, and/or aerial surveys.

Here, we explain how these measures will reduce the risk of any project vessel striking a whale. Many of these measures are centered on vessel speed restrictions and increased monitoring. To avoid a vessel strike, a vessel operator both needs to be able to detect a whale and be able to slow down or move out of the way in time to avoid collision. The speed limits and monitoring measures that are part of the proposed action maximize the opportunity for detection and avoidance.

The measures proposed by Vineyard Wind and BOEM are in accordance with measures outlined in NMFS Ship Strike Reduction Strategy as the best available means of reducing ship strikes of right whales. Most ship strikes have occurred at vessel speeds of 13-15 knots or greater (Jensen and Silber 2003; Laist et al. 2001). An analysis by Vanderlaan and Taggart (2006) showed that at speeds greater than 15 knots, the probability of a ship strike resulting in death increases asymptotically to 100%. At speeds below 11.8 knots, the probability decreases to less than 50%, and at ten knots or less, the probability is further reduced to approximately 30%. In rulemaking, NMFS has concluded, based on the best available scientific evidence, that a maximum speed of 10 knots, as measured as “speed over ground”, in certain times and locations (of which only the Block Island SMA overlaps with the action area), is the most effective and practical approach to reducing the threat of ship strikes to right whales. Absent any information to the contrary, we assume that a 10-knot speed restriction similarly reduces the risk to other whale species.

Substantial evidence (Laist et al., 2001; Jensen and Silber, 2003; Vanderlaan and Taggart, 2007) indicates that vessel speed is an important factor affecting the likelihood and lethality of whale/vessel collisions. In a compilation of ship strikes of all large whale species that assessed ship speed as a factor in ship strikes, Laist et al. (2001) concluded that a direct relationship existed between the occurrence of a whale strike and the speed of the vessel. These authors indicated that most deaths occurred when a vessel was traveling at speeds of 14 knots or greater and that, as speeds declined below 14 knots, whales apparently had a greater opportunity to avoid oncoming vessels. Adding to the Laist et al. (2001) study, Jensen and Silber (2003) compiled 292 records of known or probable ship strikes of all large whale species from 1975 to 2002. Vessel speed at the time of the collision was reported for 58 of those cases; 85.5 percent of these strikes occurred at vessel speeds of 10 knots or greater. Effects of vessel speed on collision risks also have been studied using computer simulation models to assess hydrodynamic forces vessels have on a large whale (Knowlton et al., 1995; Knowlton et al., 1998). These studies found that, in certain instances, hydrodynamic forces around a vessel can act to pull a whale toward a ship. These forces increase with increasing speed and thus a whale's ability to avoid a ship in close quarters may be reduced with increasing vessel speed. Related studies by Clyne (1999) found that the number of simulated strikes with passing ships decreased with increasing vessel speeds, but that the number of strikes that occurred in the bow region increased with increasing vessel speeds. The speed reduction alone provides a significant reduction in risk of vessel strike as it both provides for greater opportunity for a whale to evade the vessel but also ensures that vessels are operating at such a speed that they can make evasive maneuvers in time to avoid a collision.

A number of measures will be in place to maximize the likelihood that if whale is in the vicinity of a project vessel, the captain can be notified and measures taken to avoid a strike (such as slowing down further and/or altering course). All vessels that operate at speeds above 10 knots will carry a PSO who will constantly monitor the area around the vessel to look for whales. We expect that a PSO will be able to detect whales at least 1 km away from the vessel in good daylight conditions, which provides ample opportunity for notification to the captain and for the captain to make changes in course. The detection of whales will be enhanced by the use of PAM during the time of year when right whales are at the highest density in the action area will allow for detection of vocalizing whales at a greater distance than an observer can detect visually. This allows for significantly earlier notification of whale presence and further increases time available to avoid a strike. Awareness of any whales in the area will also be enhanced through monitoring of reports on USCG Channel 16, communication between multiple project vessel operators or any sightings, and monitoring of the right whale sightings advisory system.

Although these measures have been developed specifically with right whales in mind, the speed reduction and enhanced monitoring measures are expected to provide protection for other large whales as well, as these species are generally faster swimmers and are more likely to be able to avoid oncoming vessels.

Our quantitative ESA-listed whale vessel strike estimates do not include sei nor sperm whales because there are no records of vessel strike for either species in the action area from 2000-2017. There are records of vessel strike mortality of both species in the greater New England area, however both species tend to occupy deeper waters of the continental shelf, and are likely to exist in small numbers in the action area due to the relatively shallower water depths. In aerial surveys conducted from 2011-2015 in the project area only four sightings of sperm whales occurred, three in summer and one in autumn (Kraus et al., 2016). While sightings of sei whales occurred between March and June, with the greatest number of sightings in May (*n* = 8) and June (*n* = 13), and no sightings from July through January (Kraus et al., 2016).

In summary, we expect that despite the increase in vessel traffic that will result from the proposed action, the measures that will be required of all project vessel operations will ensure that the opportunity for detection of any ESA-listed whale that could co-occur with a vessel's transit route will be maximized as will the opportunity for operators to avoid any such whales. Combined with the requirements for vessel speed restrictions, we expect that these measures will make it extremely unlikely that a project vessel will collide with a whale.

Effects of Foreign Vessel Transits

BOEM has indicated that during the two-year construction period up to five vessels could transit between the WDA and ports in Canada to transport project components per day, with a maximum of 50 trips per month. At this point it is unknown if project vessels will travel to and from Canada during the operations phase. During decommissioning, a similar amount of traffic to the constructions phase could occur. These vessel trips would be limited to slow moving barges and/or cargo ships that travel at speeds at 10 knots or less. The Port of Halifax receives approximately 1,500 cargo vessels a year while the Port of St. John receives approximately 950. Vessels traveling to and from these ports travel to several ports in the United States as well as Europe and Asia. Project vessels will represent an extremely small portion of the vessel traffic traveling to and from these ports in Canada. Given that these vessels will be in compliance with measures that NMFS has determined minimize the potential for ship strike and given the extremely small increase in vessel traffic in this portion of the action area that these vessels will represent, it is extremely unlikely that one of these ships will strike an ESA-listed whale.

Additionally, during the construction phase BOEM estimates that up to 16 unique European construction/installation vessels would be used over the course of the Project's offshore construction period. It is also anticipated that WTG components will be shipped from overseas ports in Europe, either directly to the WDA or first to a US port before being transported to the WDA. This will result in a total of approximately 122 round trips to transport project components from Europe. The trips for the five activities listed above might not necessarily occur within the same timeframe. On average, vessels transporting components from Europe will make ~5 round trips per month over a two-year offshore construction schedule. As with the construction vessels described above, the ports of origin are unknown. All of these vessels are large slow moving construction/installation or cargo vessels, which travel at slow speeds of approximately 10 knots. Current vessel traffic between the U.S. and Europe is predominantly tankers, container ships, and passenger vessels, which are similar ships in size and speed to the ones that will be used during the construction phase of the project. In this portion of the action area, co-occurrence of project vessels and individual whales is expected to be extremely unlikely; this is due to the dispersed nature of whales in the open ocean and the only intermittent presence of project vessels. Given that these vessels will be in compliance with measures that NMFS has determined minimize the potential for ship strike and given the extremely small increase in vessel traffic in this portion of the action area that these vessels will represent.

Together, this makes it extremely unlikely that any ESA-listed whales will be struck by a project vessel.

In summary, while there is a hypothetical increase in risk of vessel strike during all phases of the proposed project due to the increase in vessel traffic, the measures that will be in place, particularly the reduction in speed to 10 knots or less, and use of enhanced monitoring measures for any vessels larger than 65 feet that may operate at speeds above 10 knots, we do not expect that this hypothetical increase in risk will be realized. Based on the best available information on the risk factors associated with vessel strikes of large whales (i.e., vessel size and vessel speed), and the measures required to reduce risk, it is extremely unlikely that any project vessel will strike a right, fin, sei, or sperm whale during any phase of the proposed project.

7.2.4.3 Sea Turtles

Background Information on the Risk of Vessel Strike to Sea Turtles

Within the action area, project vessel traffic will be heaviest in the nearshore waters of southern New England, and the offshore WDA. Vessel traffic will be heaviest during the construction and decommissioning phases, while transits will be fewer but consistent during operation. Baseline vessel traffic in the region is described in detail in section 7.2.1, and vessel traffic related to the proposed project is described in section 7.2.2.

Sea turtles are vulnerable to vessel collisions because they regularly surface to breathe, and often rest at or near the surface. Sea turtles often congregate close to shorelines during the breeding season, where boat traffic is denser (Schofield et al. 2007; Schofield et al. 2010); however, the lack of nesting beaches in the action area makes this factor irrelevant for this analysis. Sea turtles, with the exception of hatchlings and pre-recruitment juveniles, spend a majority of their time submerged (Renaud and Carpenter 1994; Sasso and Witzell 2006). Although, Hazel et al. (2007) demonstrated sea turtles preferred to stay within the three meters of the water's surface, despite deeper water being available. Any of the sea turtle species found in the action area can occur at or near the surface in open-ocean and coastal areas, whether resting, feeding or periodically surfacing to breathe. Therefore, all ESA-listed sea turtles considered in the biological opinion are at risk of vessel strikes.

While research is limited on the relationship between sea turtles, ship collisions and ship speeds, sea turtles are at risk of vessel strike where they co-occur with vessels. Sea turtle detection is likely based primarily on the animal's ability to see the oncoming vessel, which would provide less time to react to vessels traveling at speeds at or above 10 knots (Hazel et al. 2007). Hazel et al. (2007) examined vessel strike risk to green sea turtles and suggested that sea turtles may habituate to vessel sound and are more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in eliciting responses (Hazel et al. 2007). Regardless of what specific stressor associated with vessels turtles are responding to, they only appear to show responses (avoidance behavior) at approximately 10 m or closer (Hazel et al. 2007). This is a concern because faster vessel speeds also have the potential to result in more serious injuries (Work et al. 2010). Although sea turtles can move quickly, Hazel et al. (2007) concluded that at vessel speeds above 4 km/hour (2.1 knots) vessel operators cannot rely on turtles to actively avoid being struck. Thus, sea turtles are not considered reliably capable of moving out of the way of vessels moving at speeds greater than 2.1 knots.

Stranding networks that keep track of sea turtles that wash up dead or injured have consistently recorded vessel propeller strikes, skeg strikes, and blunt force trauma as a cause or possible cause of death (Chaloupka et al. 2008). Vessel strikes can cause permanent injury or death from bleeding or other trauma, paralysis and subsequent drowning, infection, or inability to feed. Apart from the severity of the physical strike, the likelihood and rate of a turtle's recovery from a strike may be influenced by its age, reproductive state, and general condition at the time of injury. Much of what has been documented about recovery from vessel strikes on sea turtles has been inferred from observation of individual animals for some duration of time after a strike occurs (Hazel et al. 2007; Lutcavage et al. 1997). In the U.S., the percentage of strandings that were attributed to vessel strikes increased from approximately 10 percent in the 1980s to a record high of 20.5 percent in 2004 (USFWS 2007). In 1990, the National Research Council estimated that 50-500 loggerhead and 5-50 Kemp's ridley sea turtles were struck and killed by boats annually in waters of the U.S. (NRC 1990). The report indicates that this estimate is highly uncertain and could be a large overestimate or underestimate. As described in the Recovery Plan for loggerhead sea turtles (NMFS and USFWS 2008), propeller and collision injuries from boats and ships are common in sea turtles. From 1997 to 2005, 14.9% of all stranded loggerheads in the U.S. Atlantic and Gulf of Mexico were documented as having sustained some type of propeller or collision injuries although it is not known what proportion of these injuries were post or ante-mortem. The proportion of vessel-struck sea turtles that survive is unknown. In some cases, it is not possible to determine whether documented injuries on stranded animals resulted in death or were post-mortem injuries. However, the available data indicate that post-mortem vessel strike injuries are uncommon in stranded sea turtles. Based on data from off the coast of Florida, there is good evidence that when vessel strike injuries are observed as the principle finding for a stranded turtle, the injuries were both ante-mortem and the cause of death (Foley et al 2019). Foley et al. (2019) found that the cause of death was vessel strike or probable vessel strike in approximately 93% of stranded turtles with vessel strike injuries. Sea turtles found alive with concussive or propeller injuries are frequently brought to rehabilitation facilities; some are later released and others are deemed unfit to return to the wild and remain in captivity. Sea turtles in the wild have been documented with healed injuries so at least some sea turtles survive without human intervention. As noted in NRC 1990, the regions of greatest concern for vessel strike are outside the action area and include areas with high concentrations of recreational-boat traffic such as the eastern Florida coast, the Florida Keys, and the shallow coastal bays in the Gulf of Mexico. In general, the overall risk of strike for sea turtles in the Northwest Atlantic is considered greatest in areas with high densities of sea turtles and small, fast moving vessels such as recreational vessels (NRC 1990); none of the areas documented as highest risk for sea turtle vessel strikes occur in the action area.

Vessel use for the Vineyard Wind project could result in physical disturbance and strikes to sea turtles, and would most likely occur in areas that overlap sea turtle habitats, especially in areas with high densities of sea turtles and high-speed vessel transits. In the action area, the species and age classes most likely to be impacted are adults, sub-adults, and juveniles of leatherback sea turtles, the North Atlantic DPS of green sea turtles, Northwest Atlantic Ocean DPS of loggerhead sea turtles, and Kemp's ridley sea turtles. In particular, the leatherback sea turtle is abundant in the southern New England region and may be found in open-ocean habitats and foraging at the surface and throughout the water column (Dodge et al. 2014). Within the action area, coastal foraging habitats exist for all the above sea turtle species over the continental shelf and within inshore waters

7.2.4.3.1 Exposure Analysis – Sea Turtles

We consider vessel strike of ESA-listed sea turtles in context of specific project phases, as a result of all Vineyard Wind vessel movement within the action area, as opposed to in the aggregate. The construction, operation, and decommissioning phases will all have varying frequencies of vessel transits in the nearshore and offshore waters of the action area in southern New England. Additionally, offshore vessel movements from Canada, Europe, and other ports in the United States will vary considerably by phase of the project. Large vessel traffic (≥ 65 ft.) will primarily be transiting from international ports or between ports in southern New England and the WDA and/or the OECC, while small vessel traffic (<65 ft.) will almost be solely transiting from ports in southern New England to and from the WDA and/or OECC.

To estimate the number of vessel strikes of sea turtles due to the proposed action, we relied on 2016-2018 data (the most recent period available) from NMFS' Sea Turtle Stranding and Salvage Network (STSSN) to first establish the annual average number of sea turtles detected struck by vessels in the action area. We queried the STSSN database for records of stranded sea turtles with evidence of vessel strike throughout the waters of Rhode Island and Massachusetts, south and east of Cape Cod, as a best reasonable representation of the action area. While we recognize that some vessel strikes may be post-mortem, the available data indicate that post-mortem vessel strike injuries are uncommon in stranded sea turtles. Based on data from off the coast of Florida, there is good evidence that when vessel strike injuries are observed as the principle finding for a stranded turtle, the injuries were both ante-mortem and the cause of death (Foley et al. 2019). Out of the 118 recovered stranded sea turtles in the southern New England region during the three year time period of data, there were a total of 33 records of sea turtles recovered with evidence of vessel strikes (Table 7.29). Recovered sea turtles included 18 leatherbacks, 14 loggerheads, and one green sea turtle, and primarily occurred between the months of August and November, which is consistent with the time period when sea turtle abundance is greatest in the region. Though no Kemp's ridley sea turtles were recovered with evidence of vessel strike injuries in this time period, they are in the same size class as green sea turtles in this area and occur in the area at the same time. For this analysis, we assume that Kemp's ridley sea turtles are at no higher risk to vessel strike than green turtles and thus have the same likelihood of being vulnerable to vessel strike.

Table 7.29. Preliminary STSSN cases from July 2016 to October 2018 with evidence of propeller strike or probable vessel collision

	Leatherback		**Green**		**Loggerhead**		**Total**
	Alive	Dead	Alive	Dead	Alive	Dead	
Massachusetts	2	15		1		13	**31**
Rhode Island		1				1	**2**
Total	**2**	**16**		**1**		**14**	**33**

Based on the findings of Foley et al. (2019) that found vessel strike was the cause of death in 93% of strandings with indications of vessel strike, we took 93% of the strandings where the animal was dead and had evidence of propeller strike or probable vessel collision (Table 7.29) to estimate the number of interactions where vessel strike was the cause of death. There were approximately 31 strandings from 2016 to 2018 combined where cause of death was due to propeller strike or probable vessel collision (Table 7.30).

Table 7.30. Preliminary STSSN cases from July 2016 to October 2018 where cause of death was due to propeller strike or probable vessel collision adjusted based on Foley et al. (2019)

	Leatherback	**Green**	**Loggerhead**	**Total**
Massachusetts	13.95	0.93	12.09	**26.97**
Rhode Island	0.93		0.93	**1.86**
Total	**14.88**	**0.93**	**13.02**	**28.83**

Importantly, the data in Table 7.29 and adjusted in Table 7.30 are only based on observed stranding records, which represent only a portion of the total at-sea mortalities of sea turtles within the action area. Sea turtle carcasses typically sink upon death, and float to the surface only when enough accumulation of decomposition gases causes the body to bloat (Epperly et al., 1996). Though floating, the body is still partially submerged and acts as a drifting object. The drift of a sea turtle carcass depends on the direction and intensity of local currents and winds. As sea turtles are vulnerable to human interactions such as fisheries bycatch and vessel strike, a number of studies have estimated at-sea mortality of marine turtles and the influence of nearshore physical oceanographic and wind regimes on sea turtle strandings. Although sea turtle stranding rates are variable, they usually do not exceed 20 percent of total mortality, as predators, scavengers, wind, and currents prevent carcasses from reaching the shore (Koch et al. 2013). Strandings may represent as low as five percent of total mortalities in some areas (Koch et al. 2013). Strandings of dead sea turtles from fishery interaction have been reported to represent as low as seven percent of total mortalities caused at sea (Epperly et al. 1996). Remote or difficult to access areas may further limit the amount of strandings that are observed. Because of the low probability of stranding under different conditions, determining total vessel strikes directly from raw numbers of stranded sea turtle data would vary between regions, seasons, and other factors such as currents.

To determine unobserved vessel strike mortalities, we relied on available estimates from the literature. Based on data reviewed in Murphy and Hopkins-Murphy (1989), only six of 22 loggerhead sea turtle carcasses tagged within the South Atlantic and Gulf of Mexico region were reported in stranding records, indicating that stranding data represent approximately 27 percent of at-sea mortalities. In comparing estimates of at-sea fisheries induced mortalities to estimates of stranded sea turtle mortalities due to fisheries, Epperly et al. (1996) estimated that strandings represented 7-13 percent of all at-sea mortalities.

Based on these two studies, both of which occurred on the U.S. East Coast, stranding data likely represent 7-27 percent of all at-sea mortalities. While there are additional estimates of the percent of at-sea mortalities likely to be observed in stranding data for locations outside the action area (e.g., Peckham et al. 2008, Koch et al. 2013), we did not rely on these since stranding rates depend heavily on beach survey effort, current patterns, weather, and seasonal factors among others, and these factors vary greatly with geographic location (Hart et al. 2006). Thus, based on the mid-point between the lower estimate provided by Epperly et al. (1996) of seven percent, and the upper estimate provided by Murphy and Hopkins-Murphy (1989) of 27 percent, we assume that the STSSN stranding data represent approximately 17 percent of all at sea mortalities. This estimate closely aligns with an analysis of drift bottle data from the Atlantic Ocean by Hart et al. (2006), which estimated that the upper limit of the proportion of sea turtle carcasses that strand is approximately 20 percent.

To estimate the annual average vessel strike mortalities corrected for unobserved vessel strike mortalities, we corrected the observed number with the detection value of 17%. The resulting, corrected number of vessel strike mortalities of each species within the action area are below. In using the 17 percent correction factor, we assume that all sea turtle species and at-sea mortalities are equally likely to be represented in the STSSN dataset. That is, sea turtles killed by vessel strikes are just as likely to strand and be recorded in the STSSN database (i.e., 17 percent) as those killed by other activities, such as interactions with fisheries, and the likelihood of stranding once injured or killed does not vary by species.

<u>Number of ESA-listed Sea Turtles Struck and Killed by Vessels in the Action Area (excluding the Canadian and European transit routes) adjusted based on Foley et al. (2019), accounting for Unobserved Mortality</u>

Leatherback sea turtles: 14.88 (93% of those documented by STSSN)/ 0.17 (percent documented) = 87.52 leatherback sea turtles struck /3 (years of STSSN data) = 29.17 leatherback sea turtles struck per year

Loggerhead sea turtles: 13.02 (93% of those documented by STSSN)/ 0.17 (percent documented) = 76.58 loggerhead sea turtles struck / 3 (years of STSSN data) = 25.52 loggerhead sea turtles struck per year

Green sea turtles: 0.93 (93% of those documented by STSSN)/ 0.17 (percent documented) = 5.47 green sea turtles struck / 3 (years of STSSN data) = 1.82 green sea turtles struck per year

Finally, assuming a proportional relationship between vessel strikes and vessel traffic, we considered the phase-specific increase in vessel traffic and increased the number of baseline strikes to account for the increase in project vessel traffic

<u>Hypothetical Estimates of ESA-Listed Sea Turtle Vessel Strikes in the Action Area Considering Increase in Vessel Traffic Due to the Proposed Action</u>

Construction = 4.7% increase in traffic for 2 years

> Leatherback sea turtles: 0.047 (increase in vessel traffic) * 29.17 (vessel strike rate per year) = 1.37 (*2 years, length of phase) = 2.74 leatherback sea turtles
>
> Loggerhead sea turtles: 0.047 (increase in vessel traffic) * 25.52 (vessel strike rate per year) = 1.19 (*2 years, length of phase) = 2.39 loggerhead sea turtles

Green sea turtles: 0.047 (increase in vessel traffic) * 1.82 (vessel strike rate per year) = 0.08 (*2 years, length of phase) = 0.17 green sea turtles

Operation = 1.6% increase in traffic for 30 years
Leatherback sea turtles: 0.016 * 29.17 = 0.46 (*30) = 14.00 leatherback sea turtles
Loggerhead sea turtles: 0.016 * 25.52 = 0.40 (*30) = 12.24 loggerhead sea turtles
Green sea turtles: 0.016 * 1.82 = 0.029 (*30) = 0.87 green sea turtles

Decommissioning = 4% increase in traffic for 2 years
Leatherback sea turtles: 0.04 * 29.17 = 1.16 (*2) = 2.33 leatherback sea turtles
Loggerhead sea turtles: 0.04 * 25.52 = 1.02 (*2) = 2.04 loggerhead sea turtles
Green sea turtles: 0.04 * 1.82 = 0.07 (*2) = 0.14 green sea turtles

As explained above in section 7.2.3, Vineyard Wind is proposing to take and/or BOEM is proposing to require a number of measures designed to minimize the potential for strike of a protected species that will be implemented over the life of the project. These include reductions in speed in certain areas, including certain times of the year to minimize the risk of vessel strike of right whales, vessel operators must reduce vessel speed to 10 knots or less when sea turtles are observed in the path of an underway vessel, and to use lookouts to spot protected species and direct vessel captains to slow down or alter course to avoid strike (BA Section 5.2.1.2). While we expect that these measures will help to reduce the risk of vessel strike of sea turtles, individual sea turtles can be difficult to spot from a moving vessel at a sufficient distance to avoid strike due to their low-lying appearance. We also expect that waiting until a turtle is within 50 m to take steps to avoid a strike would limit the opportunity to act in time to avoid a collision. Further, the available information indicates that the speed necessary to avoid a strike is below 4 knots. It is not clear that a vessel detecting a turtle at a distance of 50 m could slow down to below 4 knots in time to avoid collision. Also, even vessels transiting at speeds of 10 knots are likely not traveling slow enough to avoid all collisions. With this information in mind, we expect that the risk reduction measures that are part of the proposed action will reduce collision risk overall but will not eliminate that risk. We are not able to quantify any reduction in risk that may be realized and expect that any reduction in risk may be small.

No estimate was calculated for Kemp’s ridley sea turtles as none were documented in the three-year period of data, however as they are in the same size class and occur in the same area as green turtles, we assume their risk to vessel strike is equal to green sea turtles. To determine the likely total number of sea turtles that will be struck by project vessels, we have rounded up to whole animals the numbers calculated above. As such, based on our analysis, the proposed action is expected to result in no more than 18 vessel strikes of leatherback sea turtles during construction/operation/decommissioning, 17 vessel strikes of loggerhead sea turtles during construction/operation/decommissioning, 2 vessel strike of a green sea turtle, and 2 vessel strike of a Kemp’s ridley sea turtle during construction/operation/decommissioning.

While not all strikes of sea turtles are lethal, we have no way of predicting what proportion of strikes will be lethal and what proportion will result in recoverable injury. As such, for the purposes of this analysis, we are assuming that all strikes will result in serious injury or mortality.

Effects of Foreign Vessel Transits

BOEM has indicated that during the two-year construction period up to five vessels could transit between the WDA and ports in Canada to transport project components per day, with a maximum of 50 trips per month. At this point it is unknown if project vessels will travel to and from Canada during the operations phase. During decommissioning, a similar amount of traffic to the constructions phase could occur. These vessel trips would be limited to slow moving barges and/or cargo ships that travel at speeds at 10 knots or less. Additionally, during the construction phase BOEM estimates that up to ~16 unique European construction/installation vessels would be used over the course of the Project's offshore construction period. It is also anticipated that WTG components will be shipped from overseas ports in Europe, either directly to the WDA or first to a US port before being transported to the WDA. This will result in a total of approximately 122 round trips to transport project components from Europe. The trips for the five activities listed above might not necessarily occur within the same timeframe. On average, vessels transporting components from Europe will make ~5 round trips per month over a two-year offshore construction schedule. As with the construction vessels described above, the ports of origin are unknown. All of these vessels are large slow moving construction/installation or cargo vessels, which travel at slow speeds of approximately 10 knots. In this portion of the action area, co-occurrence of project vessels and individual sea turtles is expected to be extremely unlikely; this is due to the dispersed nature of sea turtles in the open ocean and the only intermittent presence of project vessels. Together, this makes it extremely unlikely that any ESA-listed sea turtles will be struck by a project vessel.

7.2.4.4 Consideration of Potential Shifts in Vessel Traffic

Here, we consider how the proposed project may result in shifts or displacement of existing vessel traffic. Any shifts or displacement of vessel traffic are expected to primarily occur in the WDA due to the presence of the WTGs and ESPs during the operational phase of the proposed Project. However, as stated in the Navigational Risk Assessment (COP Volume III), the proposed WTG spacing is sufficient to allow the passage of vessels between the WTGs, and the directional trends of the vessel data are roughly in-line with the direction of the rows of WTGs as currently designed. However, transit through the WDA is a matter of risk tolerance, and up to the individual vessel operators. Therefore, while the presence of the WTGs and ESP(s) is not expected to result in any required re-routing or other shift or displacement in vessel traffic it is possible that it will result in changes to vessel operator preferences and habitats. Currently, vessel traffic in the WDA is primarily fishing vessels which transit the northern portion of the lease area. Larger vessels such as cargo, tug, or cruise vessels transit the WDA very infrequently as these larger vessels primarily transit the Nantucket to Ambrose TSS and TSS routes into New Bedford and Buzzards Bay. As part of the NEPA review, there is an alternative under consideration that would remove several potential turbine locations in the northern portion of the WDA to better accommodate the primary fishing vessel traffic. Depending on final layout, existing vessel traffic may transit within the turbines in the WDA, or operators may avoid the WDA and transit around it. However, this potential shift in traffic does not increase the risk of interaction with listed species as densities of listed species are not incrementally higher outside the WDA such that risk of ship strike would increase. As such, even if there is a shift in vessel traffic outside of the WDA or any other change in traffic patterns due to the construction and operation of the project, any effects to listed species would be so small that they would not be able to be meaningfully measured, evaluated, or detected and are therefore, insignificant.

7.2.5 Air Emissions Regulated by the OCS Air Permit

The proposed OCS Air Permit considers effects of air emissions from sources that meet the definitions for coverage under the permit as described in the Fact Sheet. In the Fact Sheet, EPA notes its finding that it is appropriate and reasonable to aggregate the estimated 106 WTGs, ESP, and OCS vessels being constructed and/or operating within the WDA as a single source for the purposes of the permit. They also note that once the WDA facility meets the definition of an OCS source, emissions from vessels servicing or associated with any part of the WDA facility are included in the potential emissions from the WDA facility while traveling to and from any part of the WDA facility when within 25 miles of the centroid of the WDA facility. The proposed OCS Air Permit considers emissions only during the construction and operations/maintenance phases of the project. As explained in the Fact Sheet, EPA states, "due to the fact that the decommissioning phase of the windfarm will occur well into the future, the EPA is unable to determine best achievable control technology (BACT) and lowest achievable emissions reductions (LAER) for the decommissioning phase and will not be permitting this phase at this time." Therefore, the effects of air emissions during decommissioning are not considered in this consultation; reinitiation may be necessary in the future to consider these effects once there is sufficient information to determine what effects to listed species and/or critical habitat are reasonably certain to occur.

EPA has determined that the air quality analysis done in support of the proposed OCS Air Permit shows that the impact from the WDA facility operation will not cause or contribute to a violation of applicable national ambient air quality standards (NAAQS) or prevention of significant deterioration (PSD) increments. The analysis also shows that construction phase emissions for both the WDA facility and OECLA will not cause significant impacts for the PSD increments at any Class I area (national parks and wilderness areas). The NAAQS are health-based standards that the EPA sets to protect public health with an adequate margin of safety. The PSD increments are designed to ensure that air quality in an area that meets the NAAQS does not significantly deteriorate from baseline levels. The WDA facility consumes a maximum of 99.7% of the 24- hr. PM2.5 and 61.5% of the 24-hr PM10 PSD increment within 1.5 km from the WDA. In addition, the air quality impact analysis demonstrated that operation of the WDA facility will not adversely cause impairment to soils, vegetation, or visibility at Class I areas.

Based on the analysis presented by EPA in the Fact Sheet, any effects to air quality from the proposed action are likely to be insignificant. At this time, there is no information on the effects of air quality on listed species that may occur in the action area. However, as the PSD increments are designed to ensure that air quality in the area regulated by the permit do not significantly deteriorate from baseline levels, it is reasonable to conclude that any effects to listed species from these emissions will be so small that they can not be meaningfully measured, detected, or evaluated and therefore are insignificant.

7.3 Effects to Habitat and Environmental Conditions

7.3.1 Cable Installation

Two offshore export cables in one cable corridor would connect the offshore components 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. A single primary offshore export cable corridor (OECC) with two potential routes through Muskeget Channel was analyzed in the BA. 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). Two potential landfall sites were considered in the BA, Covell's Beach in Barnstable, Massachusetts, and New Hampshire Avenue in Yarmouth, Massachusetts. In June 2020, Vineyard Wind notified BOEM that the New Hampshire Avenue route was no longer being considered; in July 2020 BOEM requested that we remove consideration of the New Hampshire Avenue route from consideration in the consultation, as it is no longer part of the proposed action. As the offshore export cable approaches Cape Cod, the final route would be contingent on the choice of landfall site. 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 2020).

Vineyard Wind is proposing to lay most of the inter-array cable and offshore export cable using simultaneous lay and bury via jet embedment. 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 2020). 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 any sand waves. More information on dredging methodology is presented below.

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.[24] Vineyard Wind has conservatively estimated up to 10 percent of the inter-array and offshore export cables would require one of these protective measures.

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[24] 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 2020)

7.3.1.1 Pre-lay Grapnel Run

Prior to installation of the cables, a pre-lay grapnel run would be performed to locate and clear obstructions such as abandoned fishing gear and other marine debris. The pre-lay grapnel run will involve towing a grapnel, via the main cable laying vessel, along the benthos of the cable burial route. During the pre-lay grapnel run, the cable-lay vessel will tow the grapnel at slow speeds (i.e., approximately 1 knot or less) to ensure all debris is removed. Given the very slow speed of the operation, any listed species in the vicinity are expected to be able to avoid the device and avoid an interaction. Additionally, as the cable of the grapnel run will remain taught as it is pulled along the benthos, there is no risk for any listed species to become entangled in the cable. For these reasons, any interaction between the pre-lay grapnel run and listed species is extremely unlikely to occur.

7.3.1.2 Dredging

Following the pre-lay grapnel run, dredging within the OECC would occur where necessary to allow for effective cable laying through any identified sand waves. As described in the COP (Volume III), at isolated locations where large sand waves exhibit greater than 1.5 m (4.9 ft.) of relief above the bedform troughs to either side, dredging of the top portion of the sand wave may be necessary to allow the cable installation tool to reach the stable sediment layer under the base of the mobile sand wave. Dredging is expected to be limited to areas of large sand waves, which are mobile features. Because sand waves are transient, BOEM and Vineyard Wind can not predict exactly where dredging will be required. However, Vineyard Wind has identified the areas along the OECC that are prone to developing large sand waves (see COP Volume II-A, Figure 2.1-13); dredging is expected to be limited to those areas. 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. For the installation of the two cables, total dredging could occur over up to 69 acres (279,400 m^2) and could remove up to 214,500 cubic yards (164,000 cubic meters) of dredged material. A trailing suction hopper dredge (TSHD) is expected to be used. Dredged material would be sidecast along the seafloor. Information provided to us by BOEM indicates that any required dredging associated with the nearshore segments of the cable installation is expected to occur in August/September 2021 and any required dredging associated with the mid-section and offshore section of the cables is expected to occur in early March/April 2022.

The dredge is a shallow-draft seagoing vessel. The hull design is similar to that of a hopper dredge; however, sidecasting dredges do not usually have hopper bins. Instead of collecting the material in hoppers onboard the vessel, the side-casting dredge pumps the dredged material directly overboard through an elevated discharge boom. The sidecasting dredge picks up the bottom material through two dragarms and pumps it through a discharge pipe supported by a discharge boom. During the dredging process, the vessel travels along the entire length of the shoaled area casting material away from and beyond the dredge prism.

A typical sequence of events in a sidecasting operation is as follows: the dredge moves to the work site; the dragarms are lowered to the desired depth; then, the pumps are started to take the material from the channel bottom and pump it through the discharge boom as the dredge moves along a designated line in the dredge prism. The dredge is self-propelled so there is no associated tugboat, barge, or support vessel.

Atlantic sturgeon and green, loggerhead, and Kemp's ridley can be vulnerable to impingement or entrainment in hydraulic cutterhead dredges. Whales and leatherback sea turtles are too big for there to be a risk of impingement or entrainment. Here, we consider the risk of impingement and entrainment in the proposed dredging operations. The effects of dredging on prey and water quality are considered in other sections of this Opinion. As noted above, dredging may occur in March, April, August, and September. Sea turtles do not occur in the action area in March and April; therefore, any dredging in that time period would not pose any risk of impingement or entrainment to sea turtles.

Most sea turtles and sturgeon are able to escape from the oncoming draghead of a hydraulic dredge due to the slow speed that the draghead advances (up to 3mph or 4.4 feet/second). Interactions with a hopper dredge result primarily from crushing when the draghead is placed on the bottom or when an animal is unable to escape from the suction of the dredge and becomes stuck on the draghead (impingement). Entrainment occurs when organisms are sucked through the draghead into the hopper. Mortality most often occurs when animals are sucked into the dredge draghead, pumped through the intake pipe, and then killed as they cycle through the centrifugal pump and into the hopper.

Interactions with the draghead can also occur if the suction is turned on while the draghead is in the water column (i.e., not seated on the bottom). For any dredging that occurs to support cable installation, procedures will be required to minimize the operation of suction when the draghead is not properly seated on the bottom sediments, which reduces the risk of these types of interactions.

There is some evidence to indicate that turtles can become entrained in trunions or other water intakes (see Nelson and Shafer 1996). For example, a large piece of a loggerhead sea turtle was found in a UXO screening basket on Virginia Beach in 2013. The hopper dredge was operated with UXO screens on the draghead designed to prevent entrainment of any material with a diameter greater than 1.25". The pieces of turtle found were significantly larger. Because an inspection of the UXO screens revealed no damage, it is suspected that the sea turtle was entrained in another water intake port. There are also several examples of relatively large sturgeon (2-3' length) detected in inflow screening alive and relatively uninjured. Given the damage anticipated from passing through the pumps, it is possible that these sturgeon were entrained somewhere other than the draghead.

Impingement/Entrainment in Hopper Dredges – Sea Turtles

Sea turtles have been killed in hopper dredge operations along the East and Gulf coasts of the United States. Documented turtle mortalities during dredging operations in the USACE South Atlantic Division (SAD; i.e., south of the Virginia/North Carolina border) are more common than in the USACE North Atlantic Division (NAD; Virginia-Maine) presumably due to the greater abundance of turtles in these waters and the greater frequency of hopper dredge operations. For example, in the USACE SAD, over 480 sea turtles have been entrained in hopper dredges since 1980 and in the Gulf Region over 200 sea turtles have been killed since 1995. Records of sea turtle entrainment in the USACE NAD began in 1994. Through 2018, 88 sea turtles deaths (see Table 7.31) related to hopper dredge activities have been recorded in waters north of the North Carolina/Virginia border (USACE Sea Turtle Database[25]); 79 of these turtles have been entrained in dredges operating in Chesapeake Bay.

Interactions are likely to be most numerous in areas where sea turtles are resting or foraging on the bottom. When sea turtles are at the surface, or within the water column, they are not likely to interact with the dredge because there is little, if any, suction force in the water column. Sea turtles have been found resting in deeper waters, which could increase the likelihood of interactions from dredging activities. In 1981, observers documented the take of 71 loggerheads by a hopper dredge at the Port Canaveral Ship Channel, Florida (Slay and Richardson 1988). This channel is a deep, low productivity environment in the Southeast Atlantic where sea turtles are known to rest on the bottom, making them extremely vulnerable to entrainment. The large number of turtle mortalities at the Port Canaveral Ship Channel in the early 1980s resulted in part from turtles being buried in the soft bottom mud, a behavior known as brumation. Since 1981, 77 loggerhead sea turtles have been taken by hopper dredge operations in the Port Canaveral Ship Channel, Florida. Chelonid turtles have been found to make use of deeper, less productive channels as resting areas that afford protection from predators because of the low energy, deep water conditions. Habitat in the action area is not consistent with areas where sea turtle brumation has been documented; therefore, we do not anticipate any sea turtle brumation in the action area.

As noted above, in the North Atlantic Division area, nearly all interactions with sea turtles have been recorded in nearshore bays and estuaries where sea turtles are known to concentrate for foraging (i.e., Chesapeake Bay and Delaware Bay). Very few interactions have been recorded at offshore dredge sites such as the ones considered in this Opinion. This may be because the area where the dredge is operating is more wide-open providing more opportunities for escape from the dredge as compared to a narrow river or harbor entrance. Sea turtles may also be less likely to be resting or foraging at the bottom while in open ocean areas, which would further reduce the potential for interactions.

Before 1994, endangered species observers were not required on board hopper dredges and dredge baskets were not inspected for sea turtles or sea turtle parts. The majority of sea turtle takes in the NAD have occurred in the Norfolk district. This is largely a function of the large number of loggerhead and Kemp's ridley sea turtles that occur in the Chesapeake Bay each summer and the intense dredging operations that are conducted to maintain the Chesapeake Bay entrance channels and for beach nourishment projects at Virginia Beach. Since 1992, the take of nine sea turtles (all loggerheads) has been recorded during hopper dredge operations in the Philadelphia, Baltimore, and New York Districts. Hopper dredging is relatively rare in New England waters where sea turtles are known to occur, with most hopper dredge operations being completed by the specialized Government owned dredge Currituck which operates at low suction and has been demonstrated to have a very low likelihood of entraining or impinging sea turtles. To date, no hopper dredge operations (other than the Currituck) have occurred in the New England District in areas or at times when sea turtles are likely to be present.

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[25] The USACE Sea Turtle Data Warehouse is maintained by the USACE's Environmental Laboratory and contains information on USACE dredging projects conducted since 1980 with a focus on information on interactions with sea turtles.

Table 7.31. Recorded Sea Turtle Takes in USACE NAD Dredging Operations

Project Location	Year of Operation	Cubic Yardage Removed	Observed Takes
Cape Henry Channel	2018	2,500,000	1 loggerhead
Thimble Shoals Channel	2016	1,098,514	1 loggerhead
York Spit Channel	2015	815,979	6 loggerheads
Cape Henry Channel	2014	2,165,425	3 loggerheads 1 Kemp's ridley
Sandbridge Shoal	2013	815,842	1 loggerhead[26]
Cape Henry Channel	2012	1,190,004	1 loggerhead
York Spit	2012	145,332	1 Loggerhead
Thimble Shoal Channel	2009	473,900	3 Loggerheads
York Spit	2007	608,000	1 Kemp's Ridley
Cape Henry	2006	447,238	3 Loggerheads
Thimble Shoal Channel	2006	300,000	1 loggerhead
Delaware Bay	2005	50,000	2 Loggerheads
Thimble Shoal Channel	2003	1,828,312	7 Loggerheads 1 Kemp's ridley 1 unknown
Cape Henry	2002	1,407,814	6 Loggerheads 1 Kemp's ridley 1 green
VA Beach Hurricane Protection Project (Cape Henry)	2002	1,407,814	1 Loggerhead
York Spit Channel	2002	911,406	8 Loggerheads 1 Kemp's ridley
Cape Henry	2001	1,641,140	2 loggerheads 1 Kemp's ridley
VA Beach Hurricane Protection Project (Thimble Shoals)	2001	4,000,000	5 loggerheads 1 unknown
Thimble Shoal Channel	2000	831,761	2 loggerheads 1 unknown
York River Entrance Channel	1998	672,536	6 loggerheads

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[26] Sea turtle observed in cage on beach (material pumped directly to beach from dredge).

Atlantic Coast of NJ	1997	1,000,000	1 Loggerhead
Thimble Shoal Channel	1996	529,301	1 loggerhead
Delaware Bay	1995	218,151	1 Loggerhead
Cape Henry	1994	552,671	4 loggerheads 1 unknown
York Spit Channel	1994	61,299	4 loggerheads
Delaware Bay	1994	NA	1 Loggerhead
Cape May NJ	1993	NA	1 Loggerhead
Off Ocean City MD	1992	1,592,262	3 Loggerheads
			TOTAL = 88 Turtles

Typically, endangered species observers are required to observe at least 50% of the dredge activity (i.e., 6 hours on watch, 6 hours off watch). To address concerns that some loads would be unobserved, procedures have been in place since at least 2002 to insure that inflow cages were only inspected and cleaned by observers. This maximizes the potential that any entrained sea turtles were observed and reported.

It is possible that not all sea turtles killed by dredges are observed onboard the hopper dredge. Several sea turtles stranded on Virginia shores with crushing type injuries from May 25 to October 15, 2002. The Virginia Marine Science Museum (VMSM) found 10 loggerheads, 2 Kemp's ridleys, and 1 leatherback exhibiting injuries and structural damage consistent with what they have seen in animals that were known dredge takes. While it cannot be conclusively determined that these strandings were the result of dredge interactions, it is reasonable to conclude that the death of these sea turtles was attributable to dredging operations given the location of the strandings (e.g., in the southern Chesapeake Bay near ongoing dredging activity), the time of the documented strandings in relation to dredge operations, the lack of other ongoing activities which may have caused such damage, and the nature of the injuries (e.g., crushed or shattered carapaces and/or flipper bones, black mud in mouth). In 1992, three dead sea turtles were found on an Ocean City, Maryland beach while dredging operations were ongoing at a borrow area located 3 miles offshore. Necropsy results indicate that the deaths of all three turtles were dredge related. Because there were no observers on board the dredge, it is unknown if turtles observed on the beach with these types of injuries were crushed by the dredge and subsequently stranded on shore or whether they were entrained in the dredge, entered the hopper and then were discharged onto the beach with the dredge spoils. Further analyses need to be conducted to better understand the link between crushed strandings and dredging activities, and if those strandings need to be factored into an incidental take level. Regardless, it is possible that dredges are taking animals that are not observed on the dredge, which may result in strandings on nearby beaches. However, there is not enough information at this time to determine the number of injuries or mortalities that are not detected.

The number of interactions between dredge equipment and sea turtles seems to be best associated with the volume of material removed, which is closely correlated to the length of time dredging takes, with a greater number of interactions associated with a greater volume of material removed and a longer duration of dredging. The number of interactions is also heavily influenced by the time of year dredging occurs (with more interactions correlated to times of year when more sea turtles are present in the action area) and the type of dredge plant used (sea turtles are apparently capable of avoiding pipeline and mechanical dredges as no takes of sea turtles have been reported with these types of dredges). The number of interactions may also be influenced by the terrain in the area being dredged, with interactions more likely when the draghead is moving up and off the bottom frequently. Interactions are also more likely at times and in areas when sea turtle forage items are concentrated in the area being dredged, as sea turtles are more likely to be spending time on the bottom while foraging.

We are not aware of any hopper dredging that has occurred in the action area. The concentration of sea turtles in Chesapeake Bay is much higher than we anticipate for the action area; therefore, using these projects to calculate an entrainment rate (i.e., sea turtles entrained per dredge volume) would result in a significant overestimate of the likelihood of interactions in the action area. We have calculated an entrainment rate by combining hopper dredge projects operating in Delaware Bay, in borrow areas on the Mid-Atlantic OCS, and mid-Atlantic navigation channels that have not used screening for unexploded ordinance (such screening decreases the ability of observers to detect entrained turtles) but have utilized endangered species observers for monitoring. These projects are combined in the table 7.32 below. Using these projects to calculate an entrainment rate would still likely overestimate sea turtle interactions given greater sea turtle numbers and density off Delaware compared to the action area; however, it would likely be less of an overestimate than using Chesapeake Bay projects. The entrainment rate calculated for the projects listed in Table 7.31 indicates that entrainment of a sea turtle is likely to occur for every 3.8 million cubic yards of material removed with a hopper dredge (calculated by dividing the total cubic yards removed by the number of sea turtles entrained: 15,280,061 CY / 4 sea turtles = 3,820,015) .

Table 7.32. Hopper dredging projects in the Mid-Atlantic without UXO screens and with endangered species observers.

Project Name	Year	CY Removed	Sea Turtle Interactions
Wallops Island, VA (OCS Borrow Area)	2013	1,000,000	0
Delaware Bay (Reach D)	2013	1,149,946	0
Wallops Island, VA (OCS Borrow Area)	2012	3,200,000	0
LBI Surf City	2006-2007	880,000	0
Delaware Bay - Channel Maintenance	2006	390,000	0

Delaware Bay - Channel Maintenance	2005	50,000	1
Delaware Bay - Channel Maintenance	2005	167,982	0
Delaware Bay	2005	162,682	0
Fenwick Island	2005	833,000	0
Cape May	2004	290,145	0
Delaware Bay - Channel Maintenance	2004	50,000	0
Cape May Meadows	2004	1,406,000	0
Cape May	2002	267,000	0
Delaware Bay - Channel Maintenance	2002	50,000	0 (bone)
Delaware Bay - Channel Maintenance	2001	50,000	0
Cape May City	1999	400,000	0
Delaware Bay - Channel Maintenance	1995	218,151	1
Bethany Beach and South Bethany Beach	1994	184,451	0
Delaware Bay - Channel Maintenance	1994	2,830,000	1
Dewey Beach	1994	624,869	0
Cape May	2005	300,000	0
Fenwick Island*	1998	141,100	0
Delaware Bay - Channel Maintenance (Brandywine)	1993	415,000	1

Bethany Beach*	1992	219,735	0
		15,280,061	**4**

Dredging associated with the installation of the OECC will remove no more than 214,500 cubic yards of dredged material with only a portion of the dredging occurring at a time of year when sea turtles are present in the action area. Considering the entrainment rate calculated above, we would predict entrainment of no more than 0.056 sea turtles during dredging for the proposed OECC installation. Considering that only a portion of the proposed dredging would occur when sea turtles are present in the action area the risk is even lower. Based on this, interactions between the dredge and sea turtles are extremely unlikely to occur.

Hopper Dredge Interactions – Atlantic Sturgeon

Sturgeon are vulnerable to interactions with hopper dredges. The risk of interactions is related to both the amount of time sturgeon spend on the bottom and the behavior the fish are engaged in (i.e., whether the fish are overwintering, foraging, resting or migrating) as well as the intake velocity and swimming abilities of sturgeon in the area (Clarke 2011). Intake velocities at a typical large self-propelled hopper dredge are 11 feet per second. As noted above, exposure to the suction of the draghead intake is minimized by not turning on the suction until the draghead is properly seated on the bottom sediments and by maintaining contact between the draghead and the bottom.

A significant factor influencing potential entrainment is based upon the swimming stamina and size of the individual fish at risk (Boysen and Hoover, 2009). Swimming stamina is positively correlated with total fish length. Entrainment of larger sturgeon such as the ones in the action area is less likely due to the increased swimming performance and the relatively small size of the draghead opening. Juvenile entrainment is possible depending on the location of the dredging operations and the time of year in which the dredging occurs. Typically, major concerns of juvenile entrainment relate to fish below 200 mm (Hoover et al., 2005; Boysen and Hoover, 2009). Juvenile sturgeon are not powerful swimmers and they are prone to bottom-holding behaviors, which make them vulnerable to entrainment when in close proximity to dragheads (Hoover et al., 2011). Juvenile sturgeon do not occur in the action area. The estimated minimum size for sturgeon that out-migrate from their natal river is greater than 50cm; therefore, that is the minimum size of sturgeon anticipated in the action area.

In general, entrainment of large mobile animals, such as the Atlantic sturgeon in the action area, is relatively rare. Several factors are thought to contribute to the likelihood of entrainment. In areas where animals are present in high density, the risk of an interaction is greater because more animals are exposed to the potential for entrainment. The risk of entrainment is likely to be higher in areas where the movements of animals are restricted (e.g., in narrow rivers or confined bays) where there is limited opportunity for animals to move away from the dredge than in unconfined areas such as wide rivers or open bays. The hopper dredge draghead operates on the bottom and is typically at least partially buried in the sediment. Sturgeon are benthic feeders and are often found at or near the bottom while foraging or while moving within rivers. Sturgeon at or near the bottom could be vulnerable to entrainment if they were unable to swim away from the draghead. Atlantic sturgeon are not anticipated to be foraging in the sediment in the areas to be dredged given that they are areas of dynamic sand waves that would not support benthic invertebrates that sturgeon would forage on. As such, sturgeon are not anticipated to be so close to the sediment to be vulnerable to entrainment in the hopper dredge. If Atlantic sturgeon are up off the bottom while in offshore areas, such as the action area, the potential for interactions with the dredge are further reduced. Based on this information, the likelihood of an interaction of an Atlantic sturgeon with a hopper dredge operating in the action area is expected to be low.

Nearly all recorded entrainment of sturgeon during hopper dredging operations has been during maintenance or deepening of navigation channels within rivers with spawning populations of Atlantic sturgeon. We have records of three Atlantic sturgeon entrainments outside of such river channels. Two of these are from York Spit Channel, Virginia and based on the state of decomposition of one of these it was not killed interacting with the dredge. The other record is from the Sandy Hook Channel in New Jersey. To calculate an entrainment rate for Atlantic sturgeon that would be a reasonable estimate for the action area, we have considered projects where hopper dredges operated without UXO screens and with endangered species observers and where we expect the observers would have reported any observations of sturgeon. We have limited the projects considered to those that are outside of rivers or other inland areas as the size class of sturgeon present in those areas would be different from the action area and we expect behavior of sturgeon to be different in those areas. As such, the level of entrainment in these areas would not be comparable to the level of interactions that may occur in the action area.

Table 7.33: Hopper Dredging Operations in areas within the USACE NAD similar to the action area (only projects that operated without UXO screens, and carried observers and complete records available are included)

Project Location	Year of Operation	Cubic Yards Removed	Observed Entrainment
Wallops Island offshore VA borrow area	2013	1,000,000	0
Wallops Island offshore VA borrow area	2012	3,200,000	0
York Spit Channel, VA	2011	1,630,713	1
Cape Henry Channel, VA	2011	2,472,000	0
York Spit Channel, VA	2009	372,533	0
Sandy Hook Channel, NJ	2008	23,500	1
York Spit Channel, VA	2007	608,000	0
Atlantic Ocean Channel, VA	2006	1,118,749	0

Thimble Shoal Channel, VA	2006	300,000	0
Cape May	2004	290,145	0
Thimble Shoal Channel, VA	2004	139,200	0
VA Beach Hurricane Protection Project	2004	844,968	0
Thimble Shoal Channel	2003	1,828,312	0
Cape May	2002	267,000	0
Cape Henry Channel, VA	2002	1,407,814	0
York Spit Channel, VA	2002	911,406	0
East Rockaway Inlet, NY	2002	140,000	0
Cape Henry Channel, VA	2001	1,641,140	0
Thimble Shoal Channel, VA	2000	831,761	0
Cape Henry Channel, VA	2000	759,986	0
Cape May City	1999	400,000	0
York Spit Channel, VA	1998	296,140	0
Cape Henry Channel, VA	1998	740,674	0
Thimble Shoal Channel, VA	1996	529,301	0
East Rockaway Inlet, NY	1996	2,685,000	0
Cape Henry Channel, VA	1995	485,885	0
East Rockaway Inlet, NY	1995	412,000	0
York Spit Channel, VA	1994	61,299	0
Cape Henry Channel , VA	1994	552,671	0
	TOTAL	25,950,197	2

In the absence of any dredging in the action area to base an entrainment estimate, we consider other projects that have been conducted in a comparable environment to that of the action area (see Table 7.33). As noted above, based on what we know about Atlantic sturgeon behavior in environments comparable to the action area, we consider the risk of entrainment at this site is similar to that of the projects identified in Table 7.33. At this time, this is the best available information on the potential for interactions with Atlantic sturgeon.

Using this method, and using the dataset presented in Table 7.33, we have calculated an interaction rate indicating that for every 12.98 million cubic yards of material removed, one Atlantic sturgeon is likely to be injured or killed. This calculation is based on a number of assumptions including the following: that Atlantic sturgeon are evenly distributed throughout the action area, that all hopper dredges will have the same entrainment rate, and that Atlantic sturgeon are equally likely to be encountered throughout the time period when dredging will occur. While this estimate is based on several assumptions, it is reasonable because it uses the best available information on entrainment of Atlantic sturgeon from past dredging operations, including dredging operations in the vicinity of the action area, it includes multiple projects over several years, and all of the projects have had observers present which we expect would have documented any entrainment of Atlantic sturgeon.

Dredging associated with the installation of the OECC will remove no more than 214,500 cubic yards of dredged material. Considering the entrainment rate calculated above, we would predict entrainment of no more than 0.016 Atlantic sturgeon during dredging for the proposed OECC installation. Based on this, interactions between the dredge and Atlantic sturgeon are extremely unlikely to occur.

7.3.1.3 Turbidity from Cable Installation

Installation of the OECC and inter-array cable would disrupt bottom habitat and suspend sediment in the water column. BOEM indicates in the BA that 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 of turbidity 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 2020).

Dredging will only occur along a portion of the route (no more than 10%) and only in areas with sand waves that would disrupt the ability to successfully lay the cable. As described in the BA, modeling indicates that the sediment plume associated with dredging would be mostly confined to the bottom 1 foot (3 meters) of the water column. 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).

Because the dredge will be moving along the cable route, the plume will be temporary and localized.

Simulation of the typical (non-dredging) cable installation for the OECC suggest plumes of greater than 10 mg/L total suspended solids (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 indicates 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. According to modeling presented in the BA, the sediment plume is confined to the bottom 9.8 feet (3 meters) of the water column. As the cable laying will be moving along the cable route, the associated turbidity plume will also be transient and will not last in any particular area for more than a few hours.

Atlantic sturgeon

Atlantic sturgeon are adapted to natural fluctuations in water turbidity through repeated exposure (e.g., high water runoff in riverine habitat, storm events) and are adapted to living in turbid environments (Hastings 1983, ECOPR Consulting 2009). Atlantic sturgeon forage at the bottom by rooting in soft sediments meaning that they are routinely exposed to high levels of suspended sediments. Few data have been published reporting the effects of suspended sediment on sturgeon. Garakouei et al. (2009) calculated Maximum Allowable Concentrations (MAC) for total suspended solids in a laboratory study with *Acipenser stellatus* and *A. persicus* fingerlings (7-10 cm TL). The MAC value for suspended sediments was calculated as 853.9 mg/L for *A. stellatus* and 1,536.7 mg/L for *A. persicus*. All stellate sturgeon exposed to 1,000 and 2,320 mg/L TSS for 48 hours survived. All Persian sturgeon exposed to TSS of 5,000, 7,440, and 11,310 mg/L for 48 hours survived. Given that Atlantic sturgeon occupy similar habitats as these sturgeon species we expect them to be a reasonable surrogate for Atlantic sturgeon. Wilkens et al. (2015) contained young of the year Atlantic sturgeon (100-175 mm TL) for a 3-day period in flow-through aquaria, with limited opportunity for movement, in sediment of varying concentrations (100, 250 and 500 mg L−1 total suspended solids [TSS]) mimicking prolonged exposure to suspended sediment plumes near an operating dredge. Four-percent of the test fish died; one was exposed to 250 TSS and three to 500 TSS for the full three-day period. The authors concluded that the impacts of sediment plumes associated with dredging are minimal where fish have the ability to move or escape. As tolerance to environmental stressors, including suspended sediment, increases with size and age (ASMFC 2012), we expect that the subadult and adults in the action area would be less sensitive to TSS than the test fish used in both of these studies.

Any Atlantic sturgeon within 5 km of the operating dredge would be exposed to TSS of up to 750 mg/L; an Atlantic sturgeon within 2 km of the cable laying operation would be exposed to TSS of up to 100 mg/L. These elevated TSS levels are not expected to persist for more than 3 hours in any particular location. Based on the information summarized above, any exposure to TSS would be below levels that would be expected to result in any effects to the subadult or adult Atlantic sturgeon occurring in the action area. As such, Atlantic sturgeon are extremely unlikely to experience any physiological or behavioral responses to exposure to increased TSS. Effects to Atlantic sturgeon prey are addressed below.

Whales

In a review of dredging impacts to marine mammals, Todd et al. (2015) found that direct effects from turbidity have not been documented in the available scientific literature. Because whales breathe air, some of the concerns about impacts of TSS on fish (i.e., gill clogging or abrasion) are not relevant. Cronin et al. (2017) suggest that vision may be used by North Atlantic right whale to find copepod aggregations, particularly if they locate prey concentrations by looking upwards. However, Fasick et al. (2017) indicate that North Atlantic right whales 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). Because ESA listed whales often forage at depths deeper than light penetration (i.e., it is dark), which suggests that vision is not relied on exclusively for foraging, TSS that reduces visibility would not be expected to affect foraging ability. 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 and frequently occur at depths without light penetration, significant impacts from turbidity are not likely. As such, any effects to ESA listed whales from exposure to increased turbidity during dredging or cable installation are likely to be so small that they cannot be meaningfully measured, evaluated, or detected and are therefore, insignificant. Effects on prey are considered below.

Sea Turtles

Similar to whales, because sea turtles breathe air, some of the concerns about impacts of TSS on fish (i.e., gill clogging or abrasion) are not relevant. There is no scientific literature available on the effects of exposure of sea turtles to increased TSS. Michel et al. (2013) indicates that since sea turtles feed in water that varies in turbidity levels, changes in such conditions are unlikely to inhibit sea turtle foraging even if they use vision to forage. Based on the available information, we expect that any effects to sea turtles from exposure to increased turbidity during dredging or cable installation are likely to be so small that they cannot be meaningfully measured, evaluated, or detected and are therefore, insignificant. Effects on prey are considered below.

7.3.1.4 Potential for Entanglement during Cable Laying

The jet plow uses jets of water to liquefy the sediment, creating a trench in which the cable is laid. Cable laying operations proceed at speeds of <1 knot. At these speeds, any sturgeon, sea turtle, or whale is expected to be able to avoid any interactions with the cable laying operation. Additionally, as the cable will be taut as it is unrolled and laid in the trench, there is no risk of entanglement. Based on this information, entanglement of any species during the cable laying operation is extremely unlikely to occur.

7.3.1.4 Impacts of Cable Installation on Prey

Cable installation could affect prey of Atlantic sturgeon, sea turtles, and whales due to impacts of sediment disturbance during dredging or cable laying; exposure to increased TSS; burial during dredged material disposition; or direct removal during dredging. Here, we provide a brief summary of the prey that the various listed species forage on and then consider the effects of cable installation on prey, with the analysis organized by prey type.

Summary of Information on Feeding of Listed Species

Right whales
Right whales feed almost exclusively on copepods, a type of zooplankton. Of the different kinds of copepods, North Atlantic right whales feed especially on late stage *Calanus finmarchicus*, a large calanoid copepod (Baumgartner *et al.*. 2007), as well as Pseudocalanus spp. and Centropages spp. (Pace and Merrick 2008). Because a right whale's mass is ten or eleven orders of magnitude larger than that of its prey (late stage *C. finmarchicus* is approximately the size of a small grain of rice), right whales are very specialized and restricted in their habitat requirements – they must locate and exploit feeding areas where copepods are concentrated into high-density patches (Pace and Merrick 2008).

Fin whales
Fin whales in the North Atlantic eat pelagic crustaceans (mainly euphausiids or krill, including *Meganyctiphanes norvegica* and *Thysanoessa inerrnis*) and schooling fish such as capelin (*Mallotus villosus*), herring (*Clupea harengus*), and sand lance (*Ammodytes spp*.) (NMFS 2010). Fin whales feed by lunging into schools of prey with their mouth open, using their 50 to 100 accordion-like throat pleats to gulp large amounts of food and water. A fin whale eats up to 2 tons of food every day during the summer months.

Sei whales
An average sei whale eats about 2,000 pounds of food per day. They can dive 5 to 20 minutes to feed on plankton (including copepods and krill), small schooling fish, and cephalopods (including squid) by both gulping and skimming.

Sperm whales
Sperm whales hunt for food during deep dives with feeding occurring at depths of 500– 1000 m depths (NMFS 2010 [note: recovery plan]). Deepwater squid make up the majority of their diet (NMFS 2010). Given the shallow depths of the area where the cable will be installed (less than 50 m), it is extremely unlikely that any sperm whales would be foraging in the area affected by the cable installation and extremely unlikely that any potential sperm whale prey would be affected by cable installation.

Green sea turtles
Green sea turtles feed primarily on sea grasses and may feed on algae. The cable route is designed to avoid areas with sea grasses; therefore, no effects to sea turtle forage are anticipated.

Loggerhead and Kemp's ridley sea turtles
Loggerhead turtles feed on benthic invertebrates such as gastropods, mollusks, and crustaceans. Diet studies focused on North Atlantic juvenile stage loggerheads indicate that benthic invertebrates, notably mollusks and benthic crabs, are the primary food items (Burke et al. 1993, Youngkin 2001, Seney 2003). Limited studies of adult loggerheads indicate that mollusks and benthic crabs make up their primary diet, similar to the more thoroughly studied neritic juvenile stage (Youngkin 2001). Kemp's ridleys primarily feed on crabs, with a preference for portunid crabs including blue crabs; crabs make up the bulk of the Kemp's ridley diet (NMFS et al. 2011 [note: recovery plan]).

Leatherback sea turtles

Leatherback sea turtles feed exclusively on jellyfish. A study of the foraging ecology of leatherbacks off the coast of Massachusetts indicates that leatherbacks foraging off Massachusetts primarily consume the scyphozoan jellyfishes, *Cyanea capillata* and *Chrysaora quinquecirrha*, and ctenophores, while a smaller proportion of their diet comes from holoplanktonic salps and sea butterflies (*Cymbuliidae*) (Dodge et al. 2011).

Atlantic sturgeon

Atlantic sturgeon are opportunistic benthivores that feed primarily on mollusks, polychaete worms, amphipods, isopods, shrimps and small bottom-dwelling fishes (Smith 1985, Dadswell 2006). A stomach content analysis of Atlantic sturgeon captured off the coast of New Jersey indicates that polycheates were the primary prey group consumed; although the isopod *Politolana concharum* was the most important individual prey eaten (Johnson et al. 2008). The authors determined that mollusks and fish contributed little to the diet and that some prey taxa (i.e., polychaetes, isopods, amphipods) exhibited seasonal variation in importance in the diet of Atlantic sturgeon. Novak et al. (2017) examined stomach contents from Atlantic sturgeon captured at the mouth of the Saco River, Maine and determined that American Sand Lance *Ammodytes americanus* was the most common and most important prey.

Effects of Cable Installation on the Prey Base of ESA Listed Species in the Action Area

Copepods

Copepods exhibit diel vertical migration; that is, they migrate downward out of the euphotic zone at dawn, presumably to avoid being eaten by visual predators, and they migrate upward into surface waters at dusk to graze on phytoplankton at night (Baumgartner and Fratantoni 2008; Baumgartner et al. 2011). Baugmartner et al. (2011) concludes that there is considerable variability in this behavior and that it may be related to stratification and presence of phytoplankton prey with some copepods in the Gulf of Maine remaining at the surface and some remaining at depth. Because copepods even at depth are not in contact with the substrate, we do not expect any entrainment of copepods as a result of dredging and do not anticipate any burial or loss of copepods during dredged material placement or installation of the cable. We were unable to identify any scientific literature that evaluated the effects to marine copepods of exposure to TSS. Based on what we know about effects of TSS on other aquatic life, it is possible that high concentrations of TSS could negatively affect copepods. However, given that: the expected TSS levels are below those that are expected to result in effects to even the most sensitive species evaluated; the sediment plume will be transient and temporary (i.e., persisting in any one area for no more than three hours); elevated TSS is limited to the bottom 3 meters of the water column; and will occupy only a small portion of the WDA at any given time, any effects to copepod availability, distribution, or abundance on foraging whales would be so small that they could not be evaluated, measured, or detected. Therefore, effects are insignificant.

Fish

Of the fish species that fin and sei whales and Atlantic sturgeon may feed on in the action area, only sand lance are expected to be vulnerable to entrainment and mortality in the hopper dredge (Michel et al. 2013); their vulnerability is due to their behavior of burrowing into the sand. Sand lance are strongly associated with bottom habitats comprised of clean sandy sediments located in relatively shallow water depths of less than 100 m. This suggests that sand lance may be present in the sand waves where dredging will occur. As described in Reine and Clarke (1998), not all fish entrained in a hydraulic dredge are expected to die. Studies summarized in Reine and Clarke (1998) indicate a mortality rate of 37.6% for entrained fish. We expect that dredging in sand waves to allow for cable installation will result in the entrainment and mortality of some sand lance. However, given the size of the area where dredging will occur, the short duration of dredging, and the expectation that most entrained sand lance will survive, and that sand lance are only one of several species available for fin and sei whales and Atlantic sturgeon to forage on while in the action area, we expect any impact of the loss of sand lance on these species to be so small that it can not be meaningfully measured, evaluated, or detected.

As explained above, elevated TSS will be experienced along the cable corridor during cable installation. Anticipated TSS levels are below the levels expected to result in the mortality of fish that are preyed upon by fin or sei whales or Atlantic sturgeon. In general, fish can tolerate at least short term exposure to high levels of TSS. Wilber and Clarke (2001) reviews available information on the effects of exposure of estuarine fish and shellfish to suspended sediment. In an assessment of available information on sublethal effects to non-salmonids, they report that the lowest observed concentration–duration combination eliciting a sublethal response in white perch was 650 mg/L for 5 d, which increased blood hematocrit (Sherk et al. 1974 in Wilber and Clarke 2001). Regarding lethal effects, Atlantic silversides and white perch were among the estuarine fish with the most sensitive lethal responses to suspended sediment exposures, exhibiting 10% mortality at sediment concentrations less than 1,000 mg/L for durations of 1 and 2 days, respectively (Wilber and Clarke 2001). Forage fish in the action area will be exposed to maximum TSS concentration-duration combinations far less than those demonstrated to result in sublethal or lethal effects of the most sensitive non-salmonids for which information is available. Based on this, we do not anticipate the mortality of any forage fish; therefore we do not anticipate any reduction in fish as prey for fin or sei whales or Atlantic sturgeon.

Dredged material will be sidecast. This could result in the burial of sand lance in areas where dredged material is deposited. However, sand lance routinely bury themselves several inches into the substrate so we do not expect any loss of sand lance due to sidecast disposal. Modeling presented in the BA indicates that as suspended sediment settles out of the water column following cable installation, maximum deposition will be less than 0.2 inches (5 mm) of sediment with deposition greater than 0.04 inch (1 millimeter) only within 328 feet to 492 feet (100 meters to 150 meters) of the trench centerline. Given the thin layer of deposition we do not anticipate any effects to sand lance.

Benthic Invertebrates

Benthic invertebrates that are present within the sand being dredged, including polychaete worms that Atlantic sturgeon forage on would be removed along with the sand. These organisms may survive entrainment and if so would be deposited alive adjacent the areas being dredged. Some motile organisms, such as crabs, may avoid the dredge. However, entrainment of crabs does occur (Reine et al. 1998) and we expect that most small benthic invertebrates in the path of the dredge would be entrained. We do not have any information to base a mortality rate on. We expect that dredging in sand waves to allow for cable installation will result in the entrainment and mortality of some benthic invertebrates. However, given the size of the area where dredging will occur and the short duration of dredging, the loss of benthic invertebrates will be small, temporary, and localized. Similarly, the burial and mortality of any benthic invertebrates during dredge material deposition will be small, temporary, and localized. In the BA, BOEM indicates that an area approximately 6-feet wide will be disturbed during cable installation; this is likely to result in the mortality of some benthic invertebrates in the path of the jet plow. Immediately following cable installation, this area will likely be devoid of any benthic invertebrates. However, given the narrow area, we expect recolonization to occur from adjacent areas that were not disturbed; therefore, this reduction in potential forage will be temporary.

As explained above, elevated TSS will be experienced along the cable corridor during cable installation. Because polychaete worms live in the sediment, we do not expect any effects due to exposure to elevated TSS in the water column. Wilbur and Clarke (2001) reviewed available information on effects of TSS exposure on crustacean and report that in experiments shorter than 2 weeks, nearly all mortality of crustaceans occurred with exposure to concentrations of suspended sediments exceeding 10,000 mg/L and that the majority of these mortality levels were less than 25%, even at very high concentrations. Wilbur and Clarke (2001) also noted that none of the crustaceans tested exhibited detrimental responses at dosages within the realm of TSS exposure anticipated in association with dredging. Based on this information, we do not anticipate any effects to crustaceans resulting from exposure to TSS associated with cable installation. Given the thin layer of deposition associated with the settling of TSS out of the water column following cable installation we do not anticipate any effects to benthic invertebrates. Based on this analysis, we expect any impact of the loss of benthic invertebrates to foraging Kemp's ridley and loggerhead sea turtles and Atlantic sturgeon due to cable installation to be so small that they can not be meaningfully measured, evaluated, or detected.

Jellyfish

Jellyfish occur in the water column and therefore are not vulnerable to entrainment in the hopper dredge. Therefore, we do not expect any loss of jellyfish due to dredging. We also do not expect the deposition of dredged material or the settling of sediment onto the bottom to affect jellyfish. A literature search revealed no information on the effects of exposure to elevated TSS on jellyfish. However, given the location of jellyfish in the water column and the information presented in the BA that indicates that any sediment plume associated with cable installation will be limited to the bottom 3 meters of the water column, we expect any exposure of jellyfish to TSS to be minimal. Based on this analysis, effects to leatherback sea turtles resulting from effects to their jellyfish prey are extremely unlikely to occur.

7.3.1.5 On Shore Cable Connections

The proposed landfall location is Covell's Beach in Barnstable. 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. The HDD rig would be setup in a parking lot or other previously disturbed area, and the drill would be advanced seaward. The length of the drill or bore would depend on the width of the dune and beach area, any nearshore sensitive resources, such as eelgrass, as well as bathymetry and geologic conditions. Two bores would be needed, one for each offshore cable. At the offshore end of each bore site, a temporary cofferdam or other method (e.g., gravity cell) may be used to facilitate cable pull-in. Once the bores are completed, each offshore cable is pulled though a bore to an underground concrete vault. In the vault, the three-core submarine cable is separated and jointed to the single core onshore export cable (three single core cables per circuit).

HDD allows the cable to transition from the onshore to marine environment under the sediments. The only in-water work would be at the transition site where a temporary cofferdam will be installed. Given the shallow, nearshore location of the transition site, we do not expect any whales, sea turtles, or Atlantic sturgeon to be exposed to any effects of the cofferdam installation or cable pull-in.

7.3.2 WTG and ESP Installation

Pile driving for WTG and ESP installation as well as the deposition of rock for scour protection at the base of these foundations may result in a minor and temporary increase in suspended sediment in the area immediately surrounding the foundation or scour protection being installed. The amount of sediment disturbed during these activities is minimal; thus, any associated increase in TSS will be small and significantly lower than the TSS associated with cable installation addressed above. Given the very small increase in TSS associated with foundation installation and placement of scour protection, any physiological or behavioral responses by ESA listed species from exposure to TSS are extremely unlikely to occur.

7.3.3 EMF and Heat During Cable Operation

Electromagnetic fields (EMF) are generated by current flow passing through power cables during operation and can be divided into electric fields (called E-fields, measured in volts per meter, V/m) and magnetic fields (called B-fields, measured in μT) (Taormina et al. 2018). Buried cables reduce, but do not entirely eliminate, EMF (Taormina et al. 2018). When electric energy is transported, a certain amount is lost as heat by the Joule effect, leading to an increase in temperature at the cable surface and a subsequent warming of the sediments immediately surrounding the cable; for buried cables, thermal radiation can warm the surrounding sediment in direct contact with the cable, even at several tens of centimeters away from it (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). The metallic shielding and sediments used for burial are expected to completely contain the electrical field (Bevelhimer et al. 2013). However, magnetic field emissions cannot be reduced by shielding, although multiple-stranded cables can be designed so that the individual strands cancel out a portion of the fields emitted by the other strands. Normandeau et al. (2011) compiled data from a number of existing sources, including 19 undersea cable systems in the U.S., to characterize EMF associated with cables consistent with those proposed for wind farms. The dataset considers cables consistent with those proposed by Vineyard Wind (i.e., 66 kV and 220 kV). In the paper, the authors present information indicating that the maximum anticipated magnetic field would be experienced directly above the cable (i.e., 0 m above the cable and 0 m lateral distance), with the strength of the magnetic field dissipating with distance. Based on this data, the maximum anticipated magnetic field would be 7.85 µT at the source, dissipating to 0.08 µT at a distance of 10 m above the source and 10 m lateral distance. By comparison, the Earth's geomagnetic field strength ranges from approximately 20 to 75 µT (Bochert and Zettler 2006).

When electric energy is transported, a certain amount gets lost as heat, leading to an increased temperature of the cable surface and subsequent warming of the surrounding environment (OSPAR 2009). As described in Taormina et al. (2018), the only published field measurement study results are from the 166 MW Nysted wind energy project in the Baltic Sea (maximal production capacity of about 166 MW), in the proximity of two 33 and 132 kV AC cables buried approximately 1 m deep in a medium sand area. In situ monitoring showed a maximal temperature increase of about 2.5 ºC at 50 cm directly below the cable and did not exceed 1.4°C in 20 cm depth above the cable (Meißner et al., 2007). Taormina et al. caution that application of these results to other locations is difficult, considering the large number of factors impacting thermal radiation including cable voltage, sediment type, burial depth, and shielding. The authors note that the expected impacts of submarine cables would be a change in benthic community makeup with species that have higher temperature tolerances becoming more common. Taormina et al. conclude at the end of their review of available information on thermal effects of submarine cables that considering the narrowness of cable corridors and the expected weakness of thermal radiation, impacts are not considered to be significant. Based on the available information summarized here, and lacking any site-specific predictions of thermal radiation from the Vineyard Wind cables, we expect that any impacts will be limited to a change in species composition of the infaunal benthic invertebrates immediately surrounding the cable corridor. As such, we do not anticipate thermal radiation to change the abundance, distribution, or availability of potential prey for any species. As any increase in temperature will be limited to areas within the sediment around the cable where listed species do not occur, we do not anticipate any exposure of listed species to an increase in temperature associated with the cable.

7.3.3.1 Atlantic sturgeon

Sturgeons are electrosensitive and use electric signals to locate prey. Information on the impacts of magnetic fields on fish is limited. A number of fish species, including sturgeon, are suspected of being sensitive to such fields because they have magnetosensitive or electrosensitive tissues, have been observed to use electrical signals in seeking prey, or use the Earth's magnetic field for navigation during migration (EPRI 2013). Bevelhimer *et al*. 2013 examined the behavioral responses of Lake Sturgeon to electromagnetic fields. The authors also report on a number of studies, which examined magnetic fields associated with AC cables consistent with the characteristics of the cables proposed by Vineyard Wind and report that in all cases magnetic field strengths are predicted to decrease to near-background levels at a distance of 10 m from the cable. Like Atlantic sturgeon, Lake Sturgeon are benthic oriented species that can utilize electroreceptor senses to locate prey; therefore, they are a reasonable surrogate for Atlantic sturgeon in this context. Bevelhimer et al. 2013 carried out lab experiments examining behavior of individual lake sturgeon while in tanks with a continuous exposure to an electromagnetic source mimicking an AC cable and examining behavior with intermittent exposure (i.e., turning the magnetic field on and off). Lake sturgeon consistently displayed altered swimming behavior when exposed to the variable magnetic field. By gradually decreasing the magnet strength, the authors were able to identify a threshold level (average strength ~ 1,000–2,000 µT) below which short-term responses disappeared. The anticipated maximum exposure of an Atlantic sturgeon to the proposed cable would be 7.85 µT at the source, dissipating to 0.08 µT at a distance of 10 m above the source and 10 m lateral distance. This is several orders of magnitude below the levels that elicited a behavioral response in the Bevelhimer et al. (2013) study. As such, it is extremely unlikely that there will be any effects to Atlantic sturgeon due to exposure to the magnetic field from the proposed cable.

7.3.3.2 ESA Listed Whales

The current literature suggests that cetaceans can sense the Earth's geomagnetic field and use it to navigate during migrations but not for directional information (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). 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). Information presented in the BA describes modeled and measured magnetic field levels from various existing submarine power cables indicating 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. Given that the cables will be buried at depths of 3 to 8 feet this represents a "worst case" scenario for exposure and establishes that ESA listed whales may detect the magnetic field associated with the cables at a distance of 25 m above the cable and within 24 meters horizontally from the cable.

As described in Normandeau et al. (2011), there is no scientific evidence as to what the response to exposures to the detectable magnetic field would be. However, based on the evidence that magnetic fields have a role in navigation it is reasonable to expect that any effects would be related to migration and movement. Given the limited distance from the cable that the magnetic field will be detectable, the potential for effects is extremely limited. Even if listed whales did avoid the 48m wide corridor along the cable route that the magnetic field is detectable, the effects would be limited to minor deviations from normal movements. As such, any effects are likely to be so small that they can not be meaningfully measured, detected, or evaluated and are therefore insignificant.

7.3.2.3 Sea Turtles

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 hemap-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. For purposes of this analysis, we will assume that leatherback and Kemp's ridley sea turtles are as sensitive as loggerhead sea turtles.

Sea turtles are known to use multiple cues (both geomagnetic and nonmagnetic) for navigation and migration. However, conclusions about the effects of magnetic fields from power cables are still hypothetical as it is not known how sea turtles detect or process fluctuations in the earth's magnetic field. In addition, some experiments have shown an ability to compensate for "miscues," so the absolute importance of the geomagnetic field is unclear.

Based on the demonstrated and assumed magneto sensitivity of sea turtle species that occur in the action area, we expect that loggerhead, leatherback, and Kemp's ridley sea turtles will be able to detect the magnetic field. As described in Normandeau et al. (2011), there is no scientific evidence as to what the response to exposures to the detectable magnetic field would be. However, based on the evidence that magnetic fields have a role in navigation it is reasonable to expect that effects would be related to migration and movement; however, the available information indicates that any such impact would be very limited in scope. As noted in Normandeau (2011), while a localized perturbation in the geomagnetic field caused by a power cable could alter the course of a turtle, it is likely that the maximum response would be some, probably minor, deviation from a direct route to their destination. Based on the available information, effects to sea turtles from the magnetic field associated with the Vineyard Wind cables are expected to be so small that they can not be measured or detected and are therefore, insignificant.

7.3.2.4 Effects to Prey

Magnetic fields associated with the operation of the transmission line could impact benthic organisms that serve as sturgeon and sea turtle prey. Effects to forage fish, jellyfish, copepods, and krill are extremely unlikely to occur given the limited distance into the water column that any magnetic field associated with the transmission line is detectable. Information presented in the BA summarizes a number of studies on the effects of exposure of benthic resources to magnetic fields. According to these studies, the survival and reproduction of benthic organisms are not thought to be affected by long-term exposure to static magnetic fields (Bochert and Zettler 2004, Normandeau *et al*. 2011). Results from the 30-month post-installation monitoring for the Cross Sound Cable Project in Long Island Sound indicated that the benthos within the transmission line corridor for this project continues to return to pre-installation conditions. The presence of amphipod and worm tube mats at a number of stations within the transmission line corridor suggest construction and operation of the transmission line did not have a long-term negative effect on the potential for benthic recruitment to surface sediments (Ocean Surveys 2005). Therefore, no impacts (short-term or long-term) of magnetic fields on sturgeon or sea turtle prey are expected.

7.3.4 Lighting

Most construction activities (pile driving, WTG assembly) will be limited to daylight hours. However, cable laying operations would take place 24 hours per day, 7 days a week during installation. Construction and support vessels would be required to display lights when operating at night and deck lights would be required to illuminate work areas. However, lights would be down shielded to illuminate the deck, and would not intentionally illuminate surrounding waters. If sea turtles, Atlantic sturgeon, whales, or their prey are attracted to the lights, it could increase the potential for interaction with equipment or associated turbidity. However, due to the nature of project activities and associated seafloor disturbance, turbidity, and noise, listed species and their prey are not likely to be attracted by lighting because they are disturbed by these other factors. As such, we have determined that any effects of project lighting on sea turtles, sturgeon, or whales are extremely unlikely.

In addition to vessel lighting, the WTGs will be lit for navigational and aeronautical safety. Lighting may also be required at on shore areas, such as where the cables will make landfall. Sea turtle hatchlings are known to be attracted to lights and artificial beach lighting is known to disrupt proper orientation towards the sea. However, due to the distance from the nearest nesting beach to the project area (the straight line distance through the Atlantic Ocean from Virginia Beach, VA, the northernmost area where successful nesting has occurred, and the WDA is more than 600 km), there is no potential for project lighting to impact the orientation of any sea turtle hatchlings.

7.3.5 Physical Changes to the Environment During the Operational Period

7.3.5.1 Temporary and Permanent Loss of Benthic Habitat and Habitat Conversion

As described in the BA, long-term habitat alteration would result from the installation of the foundations, scour protection around the WTG and ESP foundations, as well as cable protection along any portions of the inter-array and export cables that could not be buried to depth. 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 up to an additional 63 acres (0.26 km^2) of 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). The addition of the WTGs and ESPs, spaced from 0.76 to 1.0 nautical miles apart, is expected to result in a 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. Overall, construction of the WTGs, ESPs, and scour protection would transform 152 acres (0.61 km^2) of soft bottom habitat into coarse, hard bottom habitat. Over time (weeks to months), the areas with scour protection are likely to be colonized by sessile or highly mobile organisms (e.g., sponges, hydroids, crustaceans). This results in a modification of the benthic community in these areas from primarily infaunal organisms (e.g., amphipods, polychaetes, bivalves).

Hard-bottom and vertical structures in a soft-bottom habitat can create artificial reefs, thus inducing the ‘reef’ effect (Taormina et al. 2018). The reef effect is usually considered a beneficial impact, associated with higher densities and biomass of fish and decapod crustaceans (Taormina et al. 2018) which may provide a potential increase in available forage items for sea turtles compared to the surrounding soft-bottoms. In the North Sea, Coolen et al. (2018) sampled epifouling organisms at offshore oil and gas platforms and compared data to samples from the Princess Amalia Wind Farm (PAWF) and natural rocky reef areas. The 60 PAWF monopile turbine foundations with rock scour protection were deployed between November 2006 and March 2007 and surveys were carried out in October 2011 and July 2013. This study demonstrated that the WTG foundations and rocky scour protection acted as artificial reef with a rich abundance and diversity of epibenthic species, comparable to that of a natural rocky reef.

Stenburg et al. (2015) studied the long-term effects of the Horns Rev 1 offshore wind farm (North Sea) on fish abundance, diversity, and spatial distribution. Gillnet surveys were conducted in September 2001, before the WTGs were installed, and again in September 2009, 7 years post-construction at the wind farm site and at a control site 6 km away. The three most abundant species in the surveys were whiting (*Merlangius merlangus*), dab (*Limanda limanda*), and sand lance (*Ammodytidae spp*.). Overall fish abundance increased slightly in the area where the wind farm was established but declined in the control area 6 km away. None of the key fish species or functional fish groups showed signs of negative long-term effects due to the wind farm. Whiting and the fish group associated with rocky habitats showed different distributions relative to the distance to the artificial reef structures introduced by the turbines. Rocky habitat fishes were most abundant close to the turbines while whiting was most abundant away from them. The authors also note that the wind farm development did not appear to affect the sand-dwelling species dab and sand lance, suggesting that that the direct loss of habitat (<1% of the area around the wind farm) and indirect effects (e.g. sediment composition) were too low to influence their abundance. Species diversity was significantly higher close to the turbines. The authors conclude that the results indicate that the WTG foundations were large enough to attract fish species with a preference for rocky habitats, but not large enough to have adverse negative effects on species inhabiting the original sand bottom between the turbines.

Methartta and Dardick (2019) carried out a meta-analysis of studies that examined finfish abundance inside windfarms compared to nearby reference sites. The overall effect size was positive and significantly different from zero, indicating greater abundance of fish inside of wind farms.

For the Vineyard Wind project, effects to listed species from the loss of soft bottom habitat (53 acres) and conversion of soft bottom habitat to hard bottom habitat (99 acres) may occur if this habitat shift resulted in changes in use of the area (considered below) by listed species or resulted in changes in the availability, abundance, or distribution of forage species. The only forage fish species we expect to be impacted by these habitat alterations would be sand lance. As sand lance are strongly associated with sandy substrate, and the project would result in a loss of such soft bottom, there would be a reduction in availability of habitat for sand lance that theoretically could result in a localized reduction in the abundance of sand lance in the action area. However, even just considering the WDA, which is dominated by sandy substrate, the loss or conversion of soft bottom habitat is very small, approximately 0.2% of the WDA (calculated as 112 acres of 75,614 acre size of the WDA), and an even smaller portion of the action area as a whole. The results from Stenburg et al. (2015; summarized above) suggest that this loss of habitat is not great enough to impact abundance in the area and that there may be an increase in abundance of sand lance despite this small loss of habitat. However, even in a worst case scenario assuming that the reduction in the abundance of sand lance in the action area is directly proportional to the amount of soft substrate lost, we would expect a 0.2% reduction in the sand lance available as forage for fin and sei whales and Atlantic sturgeon in the action area. Given this small, localized reduction in sand lance and that sand lance are only one of many species the fin and sei whales and Atlantic sturgeon may feed on in the action area, any effects to these species are expected to be so small that they can not be meaningfully measured, evaluated, or detected and are therefore, insignificant.

Atlantic sturgeon would experience a reduction in infaunal benthic organisms, such as polychaete worms, in areas where soft substrate is lost or converted to hard substrate. As explained above, the action area is not an aggregation area or otherwise known to be a high use area for foraging. Any foraging by Atlantic sturgeon is expected to be limited to opportunistic occurrences. Similar to the anticipated reduction in sand lance, the conversion of soft substrate to hard substrate may result in a proportional reduction in infaunal benthic organisms that could serve as forage for Atlantic sturgeon. Assuming that the reduction in the abundance of infanual benthic organisms in the action area is directly proportional to the amount of soft substrate lost, we would expect a 0.2% reduction in the abundance of these species as forage for Atlantic sturgeon in the action area. Given this small, localized, patchy reduction in infaunal benthic organisms, and that the action area is not an area that sturgeon are expected to be dependent on for foraging, any effects to Atlantic sturgeon are expected to be so small that they can not be meaningfully measured, evaluated, or detected and are therefore, insignificant. Also, to the extent that epifaunal species richness is increased in the WDA due to the reef effect of the WTGs and their scour protection, and to the extent that sturgeon may feed on some of these benthic invertebrates, any negative effects may be offset.

The available information suggests that the prey base for Kemp's ridley and loggerhead sea turtles may increase in the action area due to the reef effect of the WTGs and associated scour protection and an increase in crustaceans and other forage species. However, given the small size of the area impacted and any potential resulting increase in available forage, any effects are likely to be so small that they can not be meaningfully measured, evaluated, or detected. No effects to the forage base of green sea turtles are anticipated as no effects on sea grasses are anticipated. Also based on the available information, we expect that there may be an increase in abundance of schooling fish that sei or fin whales may prey on but that this increase will be so small that the effects to sei or fin whales can not be meaningfully measured, evaluated or detected. A similar effect is anticipated for the jellyfish prey of leatherback sea turtles. Because we do not expect sperm whales to forage in the WDA (due to the shallow depths), we do not expect any impacts to the forage base for sperm whales.

None of the available studies examined distribution or abundance of copepods in association with wind farms built to date. In section 7.3.4 below, we explain how the physical presence of the foundations may affect the distribution, abundance, or availability of copepods due to the distance between the foundations and that these effects to right whales will be insignificant.

7.3.6 Effects to Oceanic and Atmospheric Conditions of WTG Installation and Operations

As explained in section 4.9 of the Environmental Baseline, the proposed Project area is located within the Southern New England sub-region of the U.S. Northeast Shelf Large Marine Ecosystem, and the northern end of the Mid-Atlantic Bight. The region is a dynamic area between southward flowing cool arctic waters and northward flowing warm tropical waters, with complex seasonal physical dynamics, which support a diverse marine ecosystem. The physical oceanography of this region is influenced by local bathymetry, freshwater input from multiple rivers and estuaries, large-scale atmospheric patterns, and tropical and winter coastal storm events. Weather-driven surface currents, fronts, upwelling, tidal mixing, and estuarine outflow all contribute to driving water movement both at local and regional scales (Kaplan 2011). These dynamic regional ocean properties support a diverse and productive ecosystem that undergoes variability across multiple time scales. Here, we consider the best available information on how the operation of the Vineyard Wind project may affect the oceanographic and atmospheric conditions in the action area and whether there will be any consequences to listed species.

A variety of existing oceanographic research and monitoring is conducted in the region by state and federal agencies, academic institutions, and non-governmental organizations using an array of platforms including ships, autonomous vehicles, buoys, moorings, and satellites. Research and monitoring efforts include measuring the physical and biological structure of the ocean environment including variables such as temperature, chlorophyll, and salinity at a range of depths as well as long-term shelf-wide surveys that provide data used to estimate spawning stock biomass, overall fish biodiversity, zooplankton abundance, information on the timing and location of spawning events, and insight to detect changes in the environment.

In the waters of the Project area and further south along the continental shelf, the broad, year-round pattern of currents are generally understood. Water flows south along the western margins of the Gulf of Maine due to a cyclonic gyre before splitting at the northern part of the Great South Channel (east of Cape Cod), and flowing northeast towards Georges Bank, and west over Nantucket Shoals and the continental shelf region of southern New England. This westward non-tidal circulation flow is constant with little variability between seasons (Bigelow 1927, OSW Framework). On a seasonal scale, the greater Mid-Atlantic Bight region experiences one of the largest transitions in stratification. Starting in the late spring, a strong thermocline develops at approximately 20 m depth across the middle to outer shelf, and forms a thermally isolated body of water known as the “cold pool” which shifts annually but generally extends from the waters of southern New England (in some years, the WDA is on the northern edge of the cold pool) to Cape Hatteras. Starting in the fall, the cold pool breaks down and transitions to cold and well-mixed conditions that last through the winter (Houghton et al. 1982). The cold pool is particularly important to a number of demersal and pelagic fish and shellfish species in the region, but also influences regional biological oceanography as wind-assisted transport and stratification have been documented to be important components of plankton transport in the region (Checkley et al. 1988, Cowen at al. 1993, Hare et al. 1996, Grothues et al. 2002, Sullivan et al. 2006, Narvaez et al. 2015, Munroe et al. 2016). The region also experiences upwelling in the summer driven by southwest winds associated with the Bermuda High (Glenn & Schofield 2003; Glenn et al. 2004). Cold nutrient-rich water from the cold pool can be transported by upwelling events to surface and nearshore waters. At the surface, this cold water can form large phytoplankton blooms, which support many higher trophic species (Sha et al. 2015). The cold pool supports prey species for ESA-listed species of whales and sea turtles, both directly through providing habitat and indirectly through its influence on regional biological oceanography, which supports a productive ecosystem (Kane 2005, Chen et al. 2018, Winton et al. 2018).

Lower-trophic plankton species are well adapted to take advantage of the variable seasonality of the regional ecosystem, and support the upper food web for species such as pelagic fish, sea turtles, and marine mammals (Kenney and Vigness-Raposa 2010, Pershing and Stamieszkin 2019). Though plankton exhibit movement behavior, physical and oceanographic features (e.g. tidal mixing fronts, thermal fronts, freshwater plumes, internal waves, stratification, horizontal and vertical currents, and bathymetry) are the primary drivers that control aggregations and concentrate them by orders of magnitude (Pershing and Stamieszkin 2019, Kraus et al. 2019).

Many marine species including sea turtles and marine mammals forage around these physical and oceanographic features where prey is concentrated. Many protected species have been observed foraging in the entire southern New England WEAs, including the area where the Vineyard Wind project will be constructed, with higher densities of North Atlantic right whales and leatherback sea turtles observed outside of the Vineyard Wind project area around Nantucket Shoals, a bathymetric feature that may support frontal zones and trap prey (Dodge et al. 2014, Kraus et al. 2016, Leiter et al. 2017, Stone et al. 2017). Listed whales were most often observed during the spring and summer throughout the WEAs, with feeding behavior observed during both periods. However, North Atlantic right whales have been increasingly sighted in the eastern portion of the WEA near the western edge of Nantucket Shoals during winter months, and shift their distribution to the northern portion of the MA WEA and southern portion of the MA/RI WEA in the spring, with observations including feeding behavior and surface active groups throughout (Kraus et al. 2016, Leiter et al. 2017). These high use areas are nearby, but outside, the footprint of the Vineyard Wind project. A species distribution model which incorporated the primary prey of North Atlantic right whales (*Calanus finmarchicus*) and environmental covariates predicted areas of high foraging habitat suitability for right whales in southern New England waters (Pendelton et al. 2012). As mentioned above, currents flow into southern New England waters from the Gulf of Maine, likely transporting *Calanus sp.* especially in the spring. However, it is not clear what is driving *Calanus sp.* in winter months. (Record et al. 2019). Little is known about the specific oceanographic processes driving right whale feeding habitat in the southern New England region, but their movement within the area may be linked to the movement and availability of prey based on currents and oceanographic conditions.

A number of modeling and in-situ studies have been conducted to help inform the potential impact offshore wind farms may have on the oceanic and atmospheric environment; summaries of these studies are described in this paragraph. In general, most of these studies have occurred in Europe where offshore wind farms are already in operation. The only information from the U.S. is a recent modeling study conducted in the Great Lakes region of the U.S. to simulate the impact of 432 offshore wind turbines on Lake Erie’s dynamic and thermal structure. Model results showed that the turbines did have an impact on the area they were built in by reducing wind speed and wind stress, which led to less mixing, lower current speeds and higher surface water temperature (Afsharian et al. 2020). Abroad, a study on the effect of large offshore wind farms on the local wind climate using satellite synthetic aperture radar (SAR) found that a decrease of the mean wind speed is found as the wind flows through the wind farms, leaving a velocity deficit of 8–9% on average, immediately downstream of the wind turbine arrays. Wind speed was found to recover to within 2% of the free stream velocity over a distance of 5–20 km past the wind farm, depending on the ambient wind speed, the atmospheric stability, and the number of turbines in operation (Christiansen & Hasager 2005). The disturbance of wind speed and wind wakes from wind farms can also cause oceanic responses. According to Broström (2008), a windfarm can cause a divergence/convergence in the upper ocean due to a strong horizontal shear in the wind stress and resulting curl of the wind stress. Utilizing analytical models to determine wind farm effects, experts expect to find a circulation and an associated upwelling pattern when the size of the wind farm is comparable in size to the 'Rossby radius of deformation', defined as the length scale at which rotational effects become as important as buoyancy or gravity wave effects in the evolution of the flow about some disturbance (Broström 2008). We note here that the footprint of the Vineyard Wind project is nowhere near the size of the Rossby radius of deformation (estimated at 200-300 km) and therefore is not large enough to cause such disruption. Upwelling can have significant impacts on local ecosystems due to the influx of nutrient rich, cold, deep, water which increases biological productivity and forms the basis of the lower trophic level. The upwelling induced by a wind farm will likely increase primary production, which may affect the local ecosystem (Broström 2008).

As tidal currents move past wind turbine foundations they generate a turbulent wake that will contribute to a mixing of the stratified water column. In a study evaluating the impacts of wind turbine foundations using a 3D unstructured grid model, localized areas of decreased water velocity were found to extend up to 250 times the monopole diameter away from the monopile (Cazenave et al. 2016). The introduction of monopiles also had an impact on the M2 amplitude (semidiurnal tidal component due to the moon) and phase duration, from the model the amplitude increased between 0.5-7% depending on the preexisting amphidrome, defined as the geographical location which has zero tidal amplitude for one harmonic constituent of the tide. Changes in the tidal amplitude may increase the chances of coastal flooding in low-lying areas. The M2 tidal constituent in the Project area has relatively high amplitudes thus coastal flooding is not a potential impact (Irish and Signell 1992). The monopiles were also found to increase localized vertical mixing due to the turbulence from the monopiles, which in turn could decrease seasonal stratification. The horizontal extent of this disturbance is significantly larger than the sum of the footprint of the foundations, and the authors concluded the introduction of monopiles offshore may affect stratification and nutrient cycling. Additionally, the authors suggested that if wind farms are constructed in areas of tidal fronts, the physical structure of wind turbine foundations may alter the structure of fronts and subsequently the marine vertebrates that use these oceanic structures for foraging (Cazenave et al. 2016). As areas of frontal activity are often pelagic biodiversity hotspots, altering their structure may decrease efficient foraging opportunities for listed species

A number of studies have investigated the impacts of offshore wind farms on seasonal stratification (Carpenter et al. 2016, Schultz et al. 2020). Carpenter et al. (2016) used a combination of numerical models and in situ measurements from two windfarms (Bard 1 and Global Tech 1) to conduct an analysis of the impact of increased mixing in the water column due to the presence of offshore wind structures on the seasonal stratification of the North Sea. Based off the model results and field measurements, estimates of the time scale for how long a complete mixing of the stratification takes, was found to be longer, though comparable to, the summer stratification period in the North Sea and that it is unlikely the two windfarms would alter seasonal stratification dynamics in the region. The estimates of mixing was found to be influenced by the pycnocline thickness and drag of the foundations of the wind turbines. For there to be a significant impact on stratification, large regions (length of 100 km) of the North Sea would need to be covered with wind farms; however the actual threshold was not defined (Carpenter et al. 2016). Schultz et al. 2020 found similar results in the same area of the German Bight of the North Sea. Impacts on stratification could lead to changes in the structure, productivity, and circulation of the oceanic regions. In an empirical bio-physical study, Floeter et al. (2017) used a remotely operated vehicle to record conductivity, temperature, depth, oxygen, and chlorophyll-a measurements of an offshore wind farm. Vertical mixing was found to be increased within the wind farm, leading to a doming of the thermocline and a subsequent transport of nutrients into the surface mixed layer. Though discerning a wind farm-induced relationship from natural variability is difficult, wind farms may cause enhanced mixing, and due to the interaction between turbulence levels and the growth of phytoplankton, this could have cascading effects on nutrient levels, ecosystems, and marine vertebrates (Carpenter et al. 2016, Floeter et al. 2017). In general, these studies described varying scales of impacts on the oceanographic and atmospheric processes as a resultant effect of offshore wind turbine development. Oceanographic and atmospheric effects are possible at a range of temporal and spatial scales, based on regional and local oceanographic and atmospheric conditions as well as the size and locations of wind farms.

When applying studies conducted outside the Mid-Atlantic Bight region to our consideration of the potential effects of the Vineyard Wind project on environmental conditions, it should be noted that the seasonal stratification over the summer, particularly in the studies conducted in the North Sea is much less than the peak stratification seen in the summer over the Mid-Atlantic Bight. The conditions in the North Sea are more representative of weaker stratification, similar to conditions seen in the Mid-Atlantic Bight during the spring or fall. However, during this time the ecosystem may be more susceptible to changes in hydrodynamics due to the presence of structures than during highly stratified conditions in the summer. Increased stratification could affect the timing and rate of breakdown of the cold pool in the fall, which could have cascading effects on species in the region. Offshore wind energy development has the potential to alter the atmospheric and the physical and biological oceanographic environment due to the influence of the wind turbines on the wind stress at the ocean surface and the physical presence of the in-water turbine foundations which could influence the flow and mixing of water. However, for foundations like those proposed by Vineyard Wind, any effects to stratification would be limited to an area within a few hundred meters from each monopile foundations and thus we do not expect these localized disruptions to effect the formation and function of the cold pool. Due to the linkages between oceanography and food webs, lower-tropic level prey species that support protected species may also be affected, which in turn may impact protected species. Information on which to base an assessment of the degree that the proposed project will result in any such impacts is limited. No utility scale offshore wind farms exist in the region nor along either coast of the United States to evaluate potential impacts of the proposed Project, thus we primarily have results from research conducted on offshore wind projects in other countries available to evaluate potential impacts on the oceanographic and atmospheric environment, and potential subsequent effects on protected species and their prey.

ESA-listed species in the proposed Project area primarily feed on four prey resources - zooplankton, pelagic fish, gelatinous organisms, and benthic mollusks. Of the listed species in the area, North Atlantic right whales are the only obligate zooplanktivores. Through in-situ research and modeling and simulation studies, results did show that offshore wind farms can reduce wind speed and wind stress which can lead to less mixing, lower current speeds, and higher surface water temperature (Afsharian et al. 2020), cause wakes that will result in detectable changes in vertical motion and/or structure in the water column (e.g. Christiansen & Hasager 2005, Broström 2008), as well as detectable wakes downstream from a wind farm by increased turbidity (Vanhellemont and Ruddick, 2014). It is possible these factors could result in disruption of prey aggregations, primarily of zooplankton, which are transported by currents. This possible effect is primarily relevant to North Atlantic right whales and leatherback sea turtles as their planktonic prey (Calanus sp. and gelatinous organisms) are the only listed species' prey in the region whose aggregations are driven by hydrodynamic processes. We note that as the scale of offshore wind development in the Mid-Atlantic Bight increases and the area occupied by wind turbines increases, the scope and scale of potential impacts may also increase and this issue may require additional research and analysis to support future assessments. However, this consultation only considers the effects of the proposed Vineyard Wind project.

Relative to the southern New England region and Mid-Atlantic Bight as a whole, the scale of the proposed Project (no more than 100 turbines) and the small footprint of the WDA (75,614 acres, with project foundations occupying only a small fraction of that) is small. Based on the available information, we do not expect the scope of hydrodynamic effects to be large enough to influence regional conditions that could affect the distribution of prey, mainly zooplankton, or conditions that aggregate prey in the local southern New England region or broader Mid-Atlantic Bight. This is because any effects to hydrodynamics that could result in disruptions to the distribution of zooplankton are expected to be limited to an area within a few hundred meters of individual turbines. For foundations like those proposed by Vineyard Wind, any effects to the distribution and abundance of prey would be limited to an area within a few hundred meters from each monopile foundation. These localized changes at the WDA and waters within a few hundred meters downcurrent of the foundations of the wind turbines could result in localized changes in zooplankton distribution and abundance. Based on the spacing of the turbines, these areas will not interact or overlap. Thus, the disruption of zooplankton distribution will be limited spatially and will be patchy throughout the project footprint. This disruption in distribution will not result in a reduction in overall abundance of zooplankton in the project area. Thus, we do not anticipate any higher trophic level impacts; that is, we do not anticipate any reductions in gelatinous organisms, pelagic fish, or benthic invertebrates that depend on zooplankton as forage. Therefore, we do not expect any reduction in the abundance or changes in distribution of prey for whales and turtles that forage on these species. Right whales are the only listed obligate zooplanktivores, feeding exclusively on copepods. The monopiles could disrupt the distribution of copepods in the project footprint; however, there would not be a reduction in abundance and disruptions to distribution would be limited to small areas extending no more than a few hundred meters from each foundation. Given the small, localized, and patchy effects anticipated to the distribution and aggregation of prey and that we do not expect any overall reduction in the amount of prey in the action area, any effects to foraging individual right whales or leatherback sea turtles are expected to be so small that they cannot be meaningfully measured, evaluated, or detected and are therefore, insignificant. Additionally, as Atlantic sturgeon in the marine environment primarily feed on benthic invertebrates and small fish such as sand lance, hydrodynamic effects are not likely to impact the distribution or availability of their prey and any effects to Atlantic sturgeon are extremely unlikely to occur.

7.3.7 Effects of Physical Presence of the WTGs on Listed Species

The WTGs are proposed to be 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: North Atlantic right whale (59 feet [18 meters]), fin whale (79 feet [24 meters]), sei whale (59 feet [18 meters]), and sperm whales (59 feet [18 meters]). As noted in the BA, for reference, about 103, 59-ft long North Atlantic right whales (large females) would fit end-to-end between two foundations spaced at 1 nm. Based on a simple assessment of spacing, it does not appear that the WTGs would be a barrier to the movement of any listed species through the area.

The only wind turbines currently in operation in U.S. waters are the five WTGs that make up the Block Island Wind Farm. We have no information to indicate that the presence of these WTGs has resulted in any change in distribution of any marine species; however, the available information is very limited. It is also not clear whether any monitoring results from such a small project in more nearshore waters may be used to predict responses to the larger scale project currently under consideration here.

Because Atlantic sturgeon carry out portions of their life history in rivers, they are frequently exposed to structures in the water such as bridge piers and pilings. There is ample evidence demonstrating that sturgeon routinely swim around and past large and small structures in waterways, often placed significantly closer together than even the minimum distance of the closest WTGs (e.g., AKRF 2012). As such, we do not anticipate that the presence of the WTGs or ESP will affect the distribution of Atlantic sturgeon in the action area or their ability to move through the action area.

Given their distribution largely in the open ocean, whales and sea turtles may rarely encounter large fixed structures in the water column such as the turbine foundations; thus, there is little information to use to evaluate the effects that these structures will have on the use of the area by these species. Given their large size (10.3 meter diameter) and presence above and below water, we expect that whales and sea turtles will be able to visually detect the structures and we do not expect whales or sea turtles to collide with the stationary foundations.

Data is available for monitoring of harbor porpoises before, during, and after construction of three offshore wind projects in Europe. Monitoring of harbor porpoises occurred before, during and after construction of the Horns Rev offshore wind project in the North Sea. Horns Rev 1 consists of 80 WTGs laid out as an oblique rectangle of 5 km x 3.8 km (8 horizontal and 10 vertical rows). The distance between turbines is 560 m in both directions. The project was installed in 2002 (Tougaard et al. 2006). The project is of similar size (80 foundations) to the Vineyard Wind project, but turbine spacing is closer together (0.5 km compared to at least 1.4 km). Pre-construction baseline data was collected with acoustic recorders and with ship surveys beginning in 1999; post-construction acoustic and ship surveys continued until the spring of 2006. In total, there were seven years of visual/ship surveys and five years of acoustic data. Both sets of data indicate a weak negative effect on harbor porpoise abundance and activity during construction, which has been tied to localized avoidance behavior during pile driving, and no effects on activity or abundance linked to the operating wind farm (Tougaard et al. 2006). Teilmann et al. (2007) reports on continuous acoustic harbor porpoise monitoring at the Nysted wind project before, during, and after construction. The results show that echolocation activity significantly declined inside Nysted Offshore Wind Farm since the pre-construction baseline during and immediately after construction. Teilmann and Carstensen (2012) update the dataset to indicate that echolocation activity continued to increase as time went by after operations began. Scheidat et al. (2011) reported results of acoustic monitoring of harbor porpoise activity for one year prior to construction and for two years during operation of the Dutch offshore wind farm Egmond aan Zee. The results show an overall increase in acoustic activity from baseline to operation, which the authors note is in line with a general increase in porpoise abundance in Dutch waters over that period. The authors also note that acoustic activity was significantly higher inside the wind farm than in the reference areas, indicating that the occurrence of porpoises in the wind farm area increased during the operational period, possibly due to an increase in abundance of prey in this area or as refuge from heavy vessel traffic outside of the wind farm area. Teilmann and Carstensen (2012) discuss the results of these three studies and are not able to determine why harbor porpoises reacted differently to the Nysted project. One suggestion is that as the area where the Nysted facility occurs is not particularly important to harbor porpoises, animals may be less tolerant of disturbance associated with the operations of the wind farm.

Absent any information on the effects of wind farms or other foundational structures on the local abundance or distribution of whales and sea turtles, and given the conflicting results from studies of harbor porpoises, it is difficult to predict how listed whales and sea turtles will respond to the presence of the turbines. However, given the spacing between the turbines and our determination that operational noise will not disturb or displace whales or sea turtles, we do not expect that the physical presence of the foundations will affect the distribution of whales or sea turtles in the action area or affect how these animals move through the area. If prey abundance increases in the WDA due to the reef effect it is possible that there could be an increase in use of the WDA by listed whales and sea turtles; however, given the degree of effect anticipated for prey species we do not expect that to result in a significant increase in the use of the WDA by foraging whales or sea turtles.

7.4 Repair and Maintenance Activities

Vineyard Wind would design WTGs and ESPs to operate by remote control, so personnel would not be required to be present except to inspect equipment and conduct repairs. Effects of vessel traffic associated with repairs and maintenance during the operations phase is considered in the Effects of Project Vessels section above. Effects of noise associated with project vessels and aircraft are addressed in the acoustics section above; these effects were determined to be insignificant.

Project components would be inspected regularly; these visual inspections would have no effects on listed species. Bathymetric and other surveys would be undertaken to monitor cable exposure and/or depth of burial; the effects of acoustic surveys of the cable corridor were considered in the acoustics analysis; no other effects are anticipated. Minor underwater work, associated with minor repairs of the metalwork of the foundations may involve welding by divers; no effects to listed species are anticipated from these activities. Periodic cleaning of the foundations will involve using a brush to break down the marine growth (where required) followed by high-pressure jet wash (seawater only). More significant repairs would be necessary if there was a major component failure (i.e., gearbox, blades, transformer). However, no in-water work is anticipated (other than vessels) to carry out these repairs; therefore, we do not anticipate any effects to listed species. Scour Protection Repair is expected to occur over two days every 18 months. This will involve using a fall pipe vessel to deploy additional rock scour protection as needed. This would not increase the footprint of the scour protection and thus would not introduce any new effects not already considered in our assessment of the loss of soft substrate and habitat conversion. Vineyard Wind would change WTG gearbox oil after years 5, 13, and 21 of service; the risk of spills is addressed in section 7.5 of this Opinion.

BOEM has indicated that given the burial depth of the cable, displacement, or damage by vessel anchors or fishing gear is unlikely. In the event that cable repair was necessary due to such an event or some other unexpected maintenance issue, it could be necessary to remove a portion of the cable and splice in a new section. We determined that acoustic and habitat based effects of cable installation would be insignificant or extremely unlikely to occur; as any cable repair will essentially follow the same process as cable installation except in only a small portion of the cable route and for a shorter period of time, we expect that the effects will be the same or less and therefore would also be insignificant.

Based on our review of the planned repair and maintenance activities described in the BA, DEIS and COP (Volume 1, Section 4.3), no additional effects beyond those considered in the acoustics and vessel strike sections of this Opinion are anticipated to result from repair and maintenance activities over the life of the project.

7.5 Unexpected/Unanticipated Events

In this section, we consider the “low probability events” that were identified by Vineyard Wind in the COP (Volume III, section 8). These events, while not part of the proposed action, include collisions between vessels, allisions (defined as a strike of a moving vessel against a stationary object) between vessels and WTGs or ESPs, and accidental spills.

7.5.1 Vessel Collision/Allision with Foundation

A vessel striking a wind turbine theoretically could result in a spill or catastrophic failure/collapse of the turbine. However, there are several measures in place that ensure such an event is extremely unlikely to occur. These include: inclusion of project components on nautical charts which would limit the likelihood of a vessel operator being unaware of the project components while navigating in the area; compliance with lighting and marking required by the USCG which is designed to allow for detection of the project components by vessels in the area; and, spacing of turbines to allow for safe navigation through the project area. Because of these measures, a vessel striking a turbine or ESP is extremely unlikely to occur. The Navigational Risk Assessment prepared for the project reaches similar conclusions and determined that it is highly unlikely that a vessel will strike a foundation and even in the unlikely event that such a strike did occur, the collapse of the foundation is highly unlikely even considering the largest/heaviest vessels that could transit the WDA. Therefore, based on this information, any effects to listed species that could theoretically result from a vessel collision/allision are extremely unlikely to occur.

7.5.2 Failure of WTGs due to Weather Event

As explained in the COP and DEIS, Vineyard Wind designed the proposed Project components to withstand severe weather events. The WTGs and ESPs are designed to endure sustained wind speeds of up to 112 mph (97.3 knots) and gusts of 157 mph (136.4 knots). WTGs would also automatically shut down when wind speeds exceed 69 mph (60 knots). In addition, the structures are designed for maximum wave heights greater than 60 feet (18.3 meters) (Vineyard

Wind 2018e). As described in the Navigational Risk Assessment (NRA), significant waves of up to 11.5 m (~38 ft.) have been measured at the Nantucket Shoals weather monitoring buoy (Station 44008) (available data from 1982 to 2008). The maximum significant wave height of 11.5 meters (37.73 ft.) was observed during the months of September in 1999, while the maximum wave period of 15.9 seconds occurred in February of 2004 (NDBC, 2017). Maximum wind gusts are also described in the NRA based on data collected from Station 44008 from 2007 to 2017. The maximum observed wind speed from 2007 to 2017 was 50.9 knots and occurred November 3-4, 2007 during extratropical storm Noel; Noel was observed to have wind speeds of 70 to 75 knots while traveling near the WDA (NOAA, 2017d as cited in NRA).

BOEM has indicated that the proposed WTGs will meet design criteria to withstand extreme weather conditions that may be faced in the future and include consideration of 50 and 100-year 10 minute wind speed values and ocean forces. The 50-year 10 minute wind speed is estimated to be 96 knots and the 100-year 10 minute wind speed is estimated to be 105 knots. (A 100-year 10-minute wind speed means there is a 1-percent chance of that event occurring in any given year.). The design will also be in accordance with various standards including International Electrotechnical Commission (IEC) 61400-1 and 61400-3. These standards require designs to withstand forces based on a 50-year return interval for the turbines, and 100-year return interval for electrical substation platforms. The requirements for extreme metocean loading are based on 50-yr return interval site-specific conditions for most operating load cases with a 500-yr abnormal "robustness" load case check (a 500-year event has a 0.2% chance of occurring in any given year).

Given that the project components are designed to endure wind and wave conditions that are far above the maximum wind and wave conditions recorded at the nearest weather monitoring buoy to the project, and exceed the conditions that are not expected to occur more than once every 100 years, it is not reasonable to anticipate that project components will experience a catastrophic failure due to a weather event over the next thirty years. Again, this is because the components have been designed to withstand conditions that are only likely to occur once every 50, 100, or even 500-years, any event more severe than that is not reasonably certain to occur. As a catastrophic failure is not reasonably certain to occur, any associated potential impacts to listed species are not reasonably certain to occur and therefore, are not considered consequences of the proposed action.

7.5.3 Oil Spill/Chemical Release

Several measures will be implemented to minimize the potential for any chemical or oil spills or accidental releases. Vineyard Wind is required to comply with USCG and Bureau of Safety and Environmental Enforcement regulations relating to prevention and control of oil spills and will adhere to the Oil Spill Response Plan included in COP Appendix I-A (Volume III; Epsilon 2020). Vineyard Wind would conduct refueling and lubrication of stationary equipment in a manner that is designed to minimize the risk of accidental spills. Additionally, a Construction Spill Prevention, Control, and Countermeasure Plan would be prepared in accordance with applicable requirements, and would outline spill prevention plans.

The toppling of a WTG or ESP could hypothetically result in a release of transformer oil, lubrication oil, and/or general oil. The ESPs would contain the greatest volumes of oils, with a maximum of approximately 123,210 gallons (466,400.6 liters) of transformer oil, 15 gallons (56.8 liters) of lubrication oil, and 348.7 gallons (1,320 liters) of general oil. The risk of a spill in the unlikely event of a collapse is limited by the containment built into the structures. As explained above, catastrophic loss of any of the structures in not reasonably certain to occur; therefore, the spill of oil from these structures is also not reasonably certain to occur. Modeling presented by BOEM in the BA (from Bejarano et al. 2013) indicates that the probability of a "catastrophic release" of oil from the wind facility is one time in 1,000 or more years. Given the 30-year life of this project, the modeling supports our determination that such a release is not reasonably certain to occur.

The Bejarano et al. (2013) modeling indicates the only incidents calculated to occur within the life of the Proposed Action are spills of up to 90 to 440 gallons (340.7 to 1,665.6 liters) of WTG fluid or a diesel fuel spill of up to 2,000 gallons (7,570.8) with model results suggesting that such spills would occur no more frequently than once in 10 years and once in 10-50 years, respectively. However, this modeling assessment does not account for any of the spill prevention plans that will be in place for the project which are designed to reduce risk of accidental spills/releases. Considering the predicted frequency of such events (i.e., no more than 3 WTG fluid spills over the 30-year life of the WTGs and no more than one diesel spill over the life of the project), and the reduction in risk provided by adherence to USCG and BSEE requirements as well as adherence to the spill prevention plan both of which are designed to eliminate the risk of a spill of any substance to the marine environment, we have determined that any fuel or WTG fluid spill is extremely unlikely to occur; as such, any exposure of listed species to any such spill is also extremely unlikely to occur.

We also note that in the unlikely event that there was a spill, if a response was required by the US EPA or the USCG, there would be an opportunity for NMFS to conduct a consultation with the lead Federal agency on the oil spill response which would allow NMFS to consider the effects of any oil spill response on listed species in the action area.

7.6 Consideration of Potential Shifts or Displacement of Fishing Activity

As described in section 7.2 (Effects of Project Vessels) the WDA and OECC support moderate levels of commercial and recreational fishing activity throughout the year. Fishing activity includes a variety of fixed gear and mobile gear fisheries, including squid, lobster, black sea bass, Atlantic herring, Atlantic sea scallop, Atlantic surf clam/ocean quahog, monkfish, Northeast multispecies, shark species, summer flounder, tilefish, and tuna. Effort is highly variable due to factors including target species distribution and abundance, environmental conditions, season, and market value. As addressed in the Status of the Species and Environmental Baseline sections of the Opinion, interactions between fishing gear and listed whales, sea turtles, and Atlantic sturgeon occur throughout their range and may occur in the action area.

Here, we consider how the potential shift or displacement of fishing activity from the WDA, as a result of the proposed project, may affect ESA listed species. As described in section 3.4.5 of the DEIS, potential impacts to fishing activities in the WDA and OECC during the construction phase of the proposed project primarily are related to accessibility of the WDA and OECC. Potential effects include displacement of vessel transit routes, shift in fishing effort due to disruption in access to fishing grounds in the WDA and OECC due to the presence of Project vessels and construction activities, and changes to the distribution and abundance of target species due to environmental and construction impacts (e.g., sediment dispersion, noise, and vibration). Impacts during the decommissioning phase of the Project are expected to be similar. Due to these potential impacts, displacement of fishing vessels and shifts in effort during the construction and decommissioning phases are expected; though the magnitude of the shifts is unknown due to the naturally variability of the fisheries it is likely to be small given the small geographic area impacted by construction or decommissioning at any one time.

During the operational phase of the project, the potential impacts to fishing activity primarily relate to potential accessibility issues due to the presence and spacing of WTGs and ESPs. While there are no restrictions proposed for fishing activity in the WDA, the presence and spacing of structures may impede fishing operations for certain gear types. Additionally, as explained above, the structures will provide new hard bottom habitat in the WDA and an ensuing "reef effect" that may attract fish and, as a result, fishermen.

The potential for shifts in fishing effort is expected to vary by gear type. Of the gear types that fish within the WDA, bottom tending mobile gear is more likely to be displaced than fixed gear, with larger fishing vessels using small mesh bottom-trawl gear and mid-water trawl gear more likely to be displaced, compared to smaller fishing vessels using similar gear types that may be easier to maneuver. However, even without any use restrictions, there may be different risk tolerances among vessel captains that could lead to at least a temporary reduction in fishing effort in the WDA. Space use conflicts due to displacement of fishing activity from the WDA to surrounding waters could cause a temporary or permanent reduction in fishing activities within the WDA, but an increase in fishing activities elsewhere. Additionally, there could be increased potential for gear conflicts within the WDA as commercial fisheries and for-hire recreational fishing compete for space between turbines, especially if there is an increase in recreational fishing for structure-affiliated species attracted to the foundations (e.g. black sea bass). Fixed gear fisheries, such as lobster and black sea bass pot fisheries may resume or even increase fishing activity in the WDA and along the OECC shortly after construction because these fisheries are relatively static and target species with an affinity for new structure that would be created by WTGs and ESPs, though there may be small shifts in gear placement to avoid areas very close to project infrastructure. Mobile fisheries, such as sea scallop and squid trawl fisheries may take longer to resume fishing activity within the WDA or OECC as the physical presence of the new Project infrastructure may alter the behavior of fishing vessels. However, for all fisheries, any changes in fishing location are expected to be limited to moves to nearby, geographically-adjacent areas given the relatively small footprint of the project, the distribution of target species, and distance from home ports, all of which limit the potential for significant geographic shifts in distribution of fishing effort. For example, if fishing effort were to shift for longfin squid, effort may shift north and west outside of the WDA to other areas of similar squid availability south of Long Island.

Fishing vessel activity (transit and active fishing) is high throughout the southern New England region and Mid-Atlantic Bight as a whole, with higher levels of effort occurring outside of the WDA than within the WDA. The scale of the proposed Project (no more than 100 turbines) and the footprint of the WDA (75,614 acres, with project foundations occupying only a small fraction of that) relative to the size of available fishing area are small. Fishing activity will not be restricted within the WDA and the proposed spacing of the turbines could allow for fishing activity to occur, depending on the risk tolerance of the operator and weather conditions. Any reduction in fishing effort in the WDA would reduce the potential for interactions between listed species and fishing gear in the WDA. However, any effects to listed species from shifts of fishing effort to areas outside of the WDA is expected to be so small that it cannot be meaningfully measured, evaluated, or detected. This is because any potential shifts are expected to be limited to small changes in geographic area where the risk of interaction between fishing gear and listed species is not any different than it is in the WDA.

As explained in Section 7.3 above, the presence of new structures (e.g. WTG and ESP foundations) may also act as artificial reefs and attract schooling fish and shellfish. This increase in biomass could result in an increase in recreational fishing around the WTGs. As explained in section 7.3, any changes in biomass around the foundations are expected to insignificant effects on the distribution, abundance, and use of the WDA by listed species. If there is an increase in recreational fishing in the WDA, it is likely that this will represent a shift in fishing effort from areas outside the WDA to within the WDA. While interactions between listed species and recreational fishing do occur (see for example Rudloe and Rudloe 2005, Swingle et al. 2017), the risk of co-occurrence or interactions will not change with any potential shift in distribution of that fishing effort. That is because such interactions remain rare events and because any effects to the distribution or abundance of listed species in the WDA is expected to be insignificant

In summary, we do not expect the risk of entanglement or bycatch to increase due to any potential shifts or displacement of fishing activity due to the proposed Project.

7.7 Project 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)). The portion buried below 15 feet (4.6 meters) would remain, and the depression refilled with the temporarily removed sediment. BOEM expects that WTGs and ESPs would be disassembled and the piles cut below the mudline. Offshore cables may be retired in place or removed. All scour protection is anticipated to be removed.

Information on the proposed decommissioning is very limited and the information available to us in the BA, DEIS, and COP lacks adequate detail to carry out a thorough assessment of effects on listed species. Here, we evaluate the information that is available on the decommissioning. We note that prior to decommissioning, Vineyard Wind would be required to submit a decommissioning plan to BOEM. According to BOEM, this would be subject to an approval process that is independent of the proposed COP approval. BOEM indicates in the DEIS that the approval process will include an opportunity for public comment and consultation with municipal, state, and federal management agencies. Vineyard Wind would need to obtain separate and subsequent approval from BOEM to retire any portion of the Proposed Action in place. Given that approval of the decommissioning plan will be a discretionary Federal action, albeit one related to the present action, we anticipate that a determination will be made based on the best available information at that time whether reinitiation of this consultation is necessary to consider effects of decommissioning that are different from those considered here.

As described in section 4.4 of the COP, it is anticipated that the equipment and vessels used during decommissioning will likely be similar to those used during construction and installation. For offshore work, vessels would likely include cable laying vessels, crane barges, jack-up barges, larger support vessels, tugboats, crew transfer vessels, and possibly a vessel specifically built for erecting WTG structures. Effects of the vessel traffic anticipated for decommissioning are addressed in the vessel effects section of this Opinion. As described below, we have determined that all other effects of decommissioning will be insignificant.

As described in the COP (Volume 1, Section 4.4), if cable removal is required, the first step of the decommissioning process would involve disconnecting the inter-array 66kV cables from the WTGs. Next, the inter-array cables would be pulled out of the J-tubes or similar connection and extracted from their embedded position in the seabed. In some places, in order to remove the cables, it may be necessary to jet plow the cable trench to fluidize the sandy sediments covering the cables. Then, the cables will be reeled up onto barges. Lastly, the cable reels will then be transported to the port area for further handling and recycling. The same general process will likely be followed for the 220 kV offshore export cables. If protective concrete mattresses or rocks were used for portions of the cable run, they will be removed prior to recovering the cable. We determined that acoustic and habitat based effects of cable installation would be insignificant or extremely unlikely to occur; as the cable removal will essentially follow the same process as cable installation except in reverse, we expect that the effects will be the same and therefore would also be insignificant.

Prior to dismantling the WTGs, they would be properly drained of all lubricating fluids, according to the established operations and maintenance procedures and the OSRP. Removed fluids would be brought to the port area for proper disposal and / or recycling. Next, the WTGs would be deconstructed (down to the transition piece at the base of the tower) in a manner closely resembling the installation process. The blades, rotor, nacelle, and tower would be sequentially disassembled and removed to port for recycling using vessels and cranes similar to those used during construction. It is anticipated that almost all of the WTG will be recyclable, except possibly for any fiberglass components. After removing the WTGs, the steel transition pieces and foundation components would be decommissioned.

Sediments inside the monopile could be suctioned out and temporarily stored on a barge to allow access for cutting. Because this sediment removal would occur within the hollow base of the monopile, no listed species would be exposed to effects of this operation. The foundation and transition piece assembly is expected to be cut below the seabed in accordance with the BOEM's removal standards (30 C.F.R. 250.913). The portion of the foundation below the cut will likely remain in place. Depending upon the available crane's capacity, the foundation/transition piece assembly above the cut may be further cut into several more manageable sections to facilitate handling. Then, the cut piece(s) would be lifted out of the water and placed on a barge for transport to an appropriate port area for recycling.

The steel foundations would likely be cut below the mudline using one or a combination of: underwater acetylene cutting torches, mechanical cutting, or a high pressure water jet. The ESP foundation piles will likely be removed according to the same procedures used in the removal of the WTG foundations.

BOEM did not provide any estimates of underwater noise associated with pile cutting, and we did not identify any reports of underwater noise monitoring of pile cutting with the proposed methods. Hinzmann et al. (2017) reports on acoustic monitoring of removal of a met-tower monopile associated with the Amrumbank West offshore wind project in the North Sea off the coast of Germany. Internal jet cutting (i.e., the cutter was deployed from inside the monopile) was used to cut the monopile approximately 2.5 below the mudline. The authors report that the highest sound levels were between 250 and 1,000 Hz. Frequent stopping and starting of the noise suggests that this is an intermittent, rather than continuous noise source. The authors state that values of 160 dB SELcum and 190 dB Peak were not exceeded during the jet cutting process. At a distance of 750 m from the pile, noise attenuated to 150.6 dB rms. For purposes of this consultation, and absent any other information to rely on, we assume that these results are predictive of the underwater noise that can be expected during pile removal during project decommissioning. As such, using these numbers, we would not expect any injury to any listed species because the expected noise levels are below the injury thresholds for whales, sea turtles, and Atlantic sturgeon. We also do not expect any exposure to noise that could result in behavioral disturbance of sea turtles or whales because the noise is below the levels that may result in behavioral disturbance.

Any Atlantic sturgeon within 750 m of the pile being cut would be exposed to underwater noise that is expected to elicit a behavioral response. Exposure to that noise could result in short-term behavioral or physiological responses (e.g., avoidance, stress). Exposure would be brief, just long enough to detect and swim away from the noise, and consequences limited to avoidance of the area within 750 m of the pile during. As such, effects to Atlantic sturgeon will be so small that they can not be meaningfully measured, evaluated, or detected, and would be insignificant.

The sediments previously removed from the inner space of the pile would be returned to the depression left once the pile is removed. To minimize sediment disturbance and turbidity, a vacuum pump and diver or ROV-assisted hoses would likely be used. This, in combination with the removal of the stones used for scour protection and any concrete mattresses used along the cable route, would reverse the conversion of soft bottom habitat to hard bottom habitat that would occur as a result of project construction. Removal of the foundations would remove the potential for reef effects in the WDA. As we determined that effects of habitat conversion due to construction would be insignificant, we expect the reverse to also be true and would expect that effects of habitat conversion back to pre-construction conditions would also be insignificant.

7.8 Consideration of the Effects of the Action in the Context of Predicted Climate Change due to Past, Present, and Future Activities

Climate change is relevant to the Status of the Species, Environmental Baseline, Effects of the Action and Cumulative Effects sections of this Opinion. In the Status of the Species section, climate change as it relates to the status of particular species is addressed. Rather than include partial discussion in several sections of this Opinion, we are synthesizing our consideration of the effects of the proposed action in the context of anticipated climate change here.

In general, waters in the Northeast are warming and are expected to continue to warm over the 34-year life of the Vineyard Wind project. Globally averaged surface ocean temperatures are projected to increase by approximately 0.7 °C by 2030 and 1.4 °C by 2060 compared to the 1986-2005 average (IPCC 2014), with increases of closer to 2°C predicted for the geographic area that includes the WDA. Data from the two NOAA weather buoys closest to the WDA (44020 and 44097) collected from 2009-2016 indicate a mean temperature range from a low of 5.9°C in the winter to a high of 21.8°C in the summer. Based on current predictions (IPCC 2014[27]), this could shift to a range of 7.9°C in the winter to 23.8°C in the summer. Ocean acidification is also expected to increase over the life of the project (Hare et. al 2016).

We have considered whether it is reasonable to expect ESA listed species whose northern distribution does not currently overlap with the action area to occur in the action area over the project life due to a northward shift in distribution. We have determined that it is not reasonable to expect this to occur. This is largely because water temperature is only one factor that influences species distribution. Even with warming waters we do not expect hawksbill sea turtles to occur in the action area because there will still not be any sponge beds or coral reefs that hawksbills depend on and are key to their distribution (NMFS and USFWS 2013). We also do not expect giant manta ray or oceanic whitetip shark to occur in the action area. Oceanic whitetip shark are a deep-water species (typically greater than 184 m) that occurs beyond the shelf edge on the high seas (Young et al. 2018). Giant manta ray also occur in deeper, offshore waters and occurrence in shallower nearshore waters is coincident with the presence of coral reefs that they rely on for important life history functions (Miller et al. 2016). Smalltooth sawfish do not occur north of Florida. Their life history depends on shallow estuarine habitats fringed with vegetation, usually red mangroves (Norton et al. 2012); such habitat does not occur in the action area and would not occur even with ocean warming over the course of the proposed action. As such, regardless of the extent of ocean warming that may be reasonably expected in the action area over the life of the project, the habitat will remain inconsistent with habitats used by ESA listed species that currently occur south of the action area. Therefore, we do not anticipate that any of these species will occur in the action area over the life of the proposed action.

We have also considered whether climate change will result in changes in the use of the action area by Atlantic sturgeon or the ESA listed turtles and whales considered in this consultation. In a climate vulnerability analysis, Hare et al. (2016) concluded that Atlantic sturgeon are relatively invulnerable to distribution shifts. Given the extensive range of the species along nearly the entire U.S. Atlantic Coast and into Canada, it is unlikely that Atlantic sturgeon would shift out of the action area over the life of the project. If there were shifts in the abundance or distribution of sturgeon prey, it is possible that use of WDA by foraging sturgeon could become more or less common. However, even if the frequency and abundance of use of the WDA by Atlantic sturgeon increased over time, we would not expect any different effects to Atlantic sturgeon than

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[27] IPCC 2014 is used as a reference here consistent with NMFS 2016 Revised Guidance for Treatment of Climate Change in NMFS Endangered Species Act Decisions (Available at: https://www.fisheries.noaa.gov/national/endangered-species-conservation/endangered-species-act-guidance-policies-and-regulations, last accessed September 2, 2020).

those considered based on the current distribution and abundance of Atlantic sturgeon in the action area.

Use of the action area by sea turtles is driven at least in part by sea surface temperature, with sea turtles absent from the WDA from the late fall through mid-spring due to colder water temperatures. An increase in water temperature could result in an expansion of the time of year that sea turtles are present in the action area and could also increase the frequency and abundance of sea turtles in the action area. However, even with a 2°C increase in water temperatures, winter and early spring mean sea surface temperatures in the WDA are still too cold to support sea turtles. Therefore, any expansion in annual temporal distribution in the action area is expected to be small and on the order of days or potentially weeks, but not months. Any changes in distribution of prey would also be expected to affect distribution and abundance of sea turtles and that could be a negative or positive change. It has been speculated that the nesting range of some sea turtle species may shift northward as water temperatures warm. Currently, nesting in the mid-Atlantic is extremely rare, and no nesting has ever been documented in New England. In order for nesting to be successful, fall and winter temperatures need to be warm enough to support the successful rearing of eggs and sea temperatures must be warm enough for hatchlings to survive when they enter the water. Predicted increases in water temperatures over the life of the project are not great enough to allow successful rearing of sea turtle hatchlings in the action area. Therefore, we do not expect that over the time-period considered here, that there would be any nesting activity or hatchlings in the action area. Based on the available information, we expect that any increase in the frequency and abundance of use of the WDA by sea turtles due to increases in mean sea surface temperature would be small. Regardless of this, we would not expect any different effects to sea turtles than those considered based on the current distribution and abundance of sea turtles in the action area. Further, given that any increase in frequency or abundance of sea turtles in the action area is expected to be small we do not expect there to be an increase in risk of vessel strike above what has been considered based on current known distribution and abundance.

The distribution, abundance and migration of baleen whales reflects the distribution, abundance and movements of dense prey patches (e.g., copepods, euphausiids or krill, amphipods, shrimp), which have in turn been linked to oceanographic features affected by climate change (Learmonth et al. 2006). Changes in plankton distribution, abundance, and composition are closely related to ocean climate, including temperature. Changes in conditions may directly alter where foraging occurs by disrupting conditions in areas typically used by species and can result in shifts to areas not traditionally used that have lower quality or lower abundance of prey.

Climate change is unlikely to affect the frequency or abundance of sperm whales in the action area. The species rarity in the WDA is expected to continue over the life of the project due to the depths in the area being shallower than the open ocean deep-water areas typically frequented by sperm whales and their prey. Two of the significant potential prey species for fin whales in the WDA are sand lance and Atlantic herring. Hare et al. (2016) concluded that climate change is likely to negatively impact sand lance and Atlantic herring but noted that there was a high degree of uncertainty in this conclusion. The authors noted that higher temperatures may decrease productivity and limit habitat availability. A reduction in small schooling fish such as sand lance and Atlantic herring in the WDA could result in a decrease in the use of the area by foraging fin whales. The distribution of copepods in the North Atlantic, including in the WDA is driven by a number of factors that may be impacted by climate change. Record et al. (2019) suggests that recent changes in the distribution of North Atlantic right whales are related to recent rapid changes in climate and prey and notes that while right whales may be able to shift their distribution in response to changing oceanic conditions, the ability to forage successfully in those new habitats is also critically important. Warming in the deep waters of the Gulf of Maine is negatively impacting the abundance of *Calanus finmarchicus*, a primary prey for right whales. *C. finmarchicus* is vulnerable to the effects of global warming, particularly on the Northeast U.S. Shelf, which is in the southern portion of its range (Grieve et al. 2017). Grieve et al. (2017) used models to project *C. finmarchicus* densities into the future under different climate scenarios considering predicted changes in water temperature and salinity. Based on their results, by the 2041–2060 period, 22 – 25% decreases in *C. finmarchicus* density are predicted across all regions of the Northeast U.S. shelf. A decrease in abundance of right whale prey in the WDA could be expected to result in a similar decrease in abundance of right whales in the WDA over the same time scale; however, whether the predicted decline in density in *C. finmarchicus* density is great enough to result in a decrease in right whale presence in the action area over the life of the project is unknown.

Right whale calving occurs off the coast of the Southeastern U.S. In the final rule designating critical habitat, the following features were identified as essential to successful calving: (1) calm sea surface conditions associated with Force 4 or less on the Beaufort Scale, (2) sea surface temperatures from 7 °C through 17 °C; and, (3) water depths of 6 to 28 meters where these features simultaneously co-occur over contiguous areas of at least 231 km^2 during the months of November through April. Even with a 2°C shift in mean sea surface temperature, waters off of New England in the November to April period will not be warm enough to support calving. While there could be a northward shift in calving over this period, it is not reasonable to expect that over the life of the project that calving would occur in the WDA. Further, given the thermal tolerances of young calves (Garrison 2007) we do not expect that the distribution of young calves would shift northward into the action area such that there would be more or younger calves in the action area.

Based on the available information, it is difficult to predict how the use of the action area by large whales may change over the operational life of the project. However, we do not expect changes in use by sperm whales. Changes in use by sei, fin, and right whales may be related to a northward shift in distribution due to warming waters and a decreased abundance of prey. However, it is also possible that reductions in prey in other areas, including the Gulf of Maine, result in persistence of foraging in the WDA over time. Based on the information available at this time, it seems most likely that the use of the WDA by large whales will decrease or remain stable. As such, we do not expect any changes in abundance or distribution that would result in different effects of the action than those considered in the Effects of the Action section of this Opinion.

8.0 CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. It is important to note that the ESA definition of cumulative effects is not equivalent to the definition of “cumulative impacts” under the National Environmental Policy Act (NEPA). The NEPA definition is considerably more broad.

We reviewed the list of cumulative impacts identified by BOEM in the DEIS and determined that most (other offshore wind energy development activities; undersea transmission lines, gas pipelines, and other submarine cables (e.g., telecommunications); tidal energy projects; marine minerals use and ocean-dredged material disposal; military use; Federal fisheries use and management, and, oil and gas activities) do not meet the ESA definition of cumulative effects because we expect that if any of these activities were proposed in the action area, or proposed elsewhere yet were to have future effects inside the action area, they would require at least one Federal authorization or permit and would therefore require their own ESA section 7 consultation. BOEM identifies global climate change as a cumulative impact in the DEIS. Because global climate change is not a future state or private activity, we do not consider it a cumulative effect for the purposes of this consultation. Rather, future state or private activities reasonably certain to occur and contribute to climate change’s effects in the action area are relevant. However, given the difficulty of parsing out climate change effects due to past and present activities from those of future state and private activities, we discussed the effects of the action in the context of climate change due to past, present, and future activities in the Effects of the Action section above. The remaining cumulative impacts identified in the DEIS (marine transportation, coastal development, and state and private fisheries use and management) are addressed below.

In the SDEIS, BOEM presented a cumulative activities scenario that identified the possible extent of reasonably foreseeable offshore wind development on the Atlantic OCS. As a result of this process, BOEM has assumed that approximately 22 gigawatts of Atlantic offshore wind development are reasonably foreseeable along the east coast. As defined by BOEM in the SDEIS, reasonably foreseeable development includes 17 active wind energy lease areas (16 commercial and 1 research). The level of development expected to fulfill 22 gigawatts of offshore wind energy would result in the construction of about 2,000 wind turbines over a 10-year period on the Atlantic OCS, with currently available technology. It is important to note that because any future offshore wind project will require section 7 consultation, these future wind projects do not fit within the ESA definition of cumulative effects and none of them are considered in this Opinion. However, in each successive consultation, the effects on listed species of other offshore wind projects under construction or completed would be considered to the extent they influence the status of the species and/or environmental baseline according to the best available scientific information.

During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions reasonably certain to occur in the action area or have effects in the action area. We did not find any information about non-Federal actions other than what has already been described in the *Environmental Baseline*. The primary non-Federal activities that will continue to have effects in the action area are: Recreational fisheries, fisheries authorized by states, use of the action area by private vessels, discharge of wastewater and associated pollutants, and coastal development authorized by state and local governments. Any coastal development that requires a Federal authorization, inclusive of a permit from the USACE, would require future section 7 consultation and would not be considered a cumulative effect. We do not have any information to indicate that effects of these activities over the life of the proposed action will have different effects than those considered in the Status of the Species and Environmental Baseline sections of this Opinion, inclusive of how those activities may contribute to climate change.

9.0 INTEGRATION AND SYNTHESIS OF EFFECTS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 7) to the *Environmental Baseline* (Section 6) and the *Cumulative Effects* (Section 8), while also considering effects in context of climate change, to formulate the agency's biological opinion as to whether the proposed action is likely to reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution. The purpose of this analysis is to determine whether the action, in the context established by the status of the species, environmental baseline, and cumulative effects, is likely to jeopardize the continued existence of North Atlantic right whales, fin, sei or sperm whales, five DPSs of Atlantic sturgeon, the Northwest Atlantic DPS of loggerhead sea turtles, North Atlantic DPS of green sea turtles, or leatherback or Kemp's ridley sea turtles.

Below, for the listed species that may be affected by the action, we summarize the status of the species and consider whether the action will result in reductions in reproduction, numbers or distribution of these species and then consider whether any reductions in reproduction, numbers or distribution resulting from the action would reduce appreciably the likelihood of both the survival and recovery of these species, as those terms are defined for purposes of the federal Endangered Species Act. In making those assessments we consider the effects of the action in the context of the Status of the Species, Environmental Baseline, Cumulative Effects and climate change.

In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter." Recovery is defined as, "Improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act."

9.1 Atlantic sturgeon

Atlantic sturgeon from any of the five DPSs may be present in the action area and exposed to effects of the proposed action. We have determined that all effects of the proposed action on Atlantic sturgeon will be insignificant or extremely unlikely to occur. While exposure to pile driving noise may result in a behavioral response from individuals close enough to the pile to be disturbed, that response will not significantly disrupt normal behavior patterns. We determined that all effects to habitat and prey will be insignificant or extremely unlikely to occur and determined that vessel strike was extremely unlikely to occur. No harassment, harm, injury, or mortality is expected to result from the proposed action. These conclusions were made in consideration of the threatened and endangered status of Atlantic sturgeon in the action area, other stressors that individuals are exposed to within the action area as described in the Environmental Baseline and Cumulative Effects sections of this Opinion, and any anticipated effects of climate change on the abundance and distribution of Atlantic sturgeon in the action area. As all effects will be insignificant or extremely unlikely to occur, the proposed action is not likely to adversely affect Atlantic sturgeon from the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, or Southeast DPSs.

9.2 Marine Mammals

Our effects analysis determined that pile driving is likely to adversely affect ESA-listed marine mammals in the action area and cause temporary threshold shift, behavioral response, and stress in a small number of individual North Atlantic right, fin, sei, and sperm whales. Pile driving is also likely to result in permanent threshold shift in a small number of fin and sei whales. No non-auditory injury, serious injury of any kind, or mortality is anticipated. We determined that exposure to other project noise will have effects that are insignificant or are extremely unlikely to occur. We also determined that effects to habitat and prey are also insignificant or extremely unlikely to occur and concluded that with the incorporation of vessel strike risk reduction measures that are part of the proposed action, strike of an ESA listed whale by a project vessel is extremely unlikely to occur. In this section, we discuss the likely consequences of these effects to the individual whales that have been exposed, the populations those individuals represent, and the species those populations comprise.

Our analyses identified the likely effects of the Vineyard Wind project, which requires authorizations from BOEM, BSEE, EPA, USACE, and USCG, and issuance of an MMPA take authorization (IHA) by NMFS, on the ESA- listed individuals that will be exposed to these actions. We measure effects to individuals of endangered or threatened marine mammals using changes in the individual’s “fitness” or the individual’s growth, survival, annual reproductive success, and lifetime reproductive success. When we do not expect listed marine mammals exposed to an action’s effects to experience reductions in fitness, we would not expect the action to impact that animal’s health or future reproductive success. Therefore, we would not expect adverse consequences on the overall reproduction, abundance, or distribution of the populations those individuals represent or the species those populations comprise. As a result, if we conclude that listed animals are not likely to experience reductions in their fitness, we would conclude our assessment. If, however, we conclude that listed animals are likely to experience reductions in their fitness, we would assess the consequences of those fitness reductions for the population or populations the individuals in an action area represent.

As documented previously, the adverse effects resulting from the proposed action are from sounds produced during pile driving in the action area. While this opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the basic hearing capabilities of some marine mammals; how these animals use sounds as environmental cues; how they perceive acoustic features of their environment; the importance of sound to the normal behavioral and social ecology of species; the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of exposed individuals; and the circumstances that could produce outcomes that have adverse consequences for individuals and populations of exposed species. Based on the best available information, we expect most exposures and potential responses of ESA-listed cetaceans to acoustic stressors associated with the Vineyard Wind project to have little effect on the exposed animals. As is evident from the available literature cited herein, responses are expected to be short-term, with the animal returning to normal behavior patterns shortly after the exposure is over (e.g., Goldbogen et al. 2013a; Silve et al. 2015). However, Southall et al. (2016) suggested that even minor, sub-lethal behavioral changes may still have significant energetic and physiological consequences given sustained or repeated exposure. We do not expect such sustained or repeated exposure of any individuals in this case. As described in further detail in Section 7.1, we would expect an increased likelihood of consequential effects when exposures and associated effects are long- term and repeated, occur in locations where the animals are conducting critical activities, and when the animal affected is in a compromised state.

9.2.1 North Atlantic Right Whales

As described in the Status of the Species, the endangered North Atlantic right whale is currently in decline in the western North Atlantic (Pace et al. 2017b) and experiencing an unusual mortality event (Daoust et al. 2017). Based on data available as of August 2020, there are estimated to be approximately 400 right whales in the western North Atlantic. Modeling indicates that low female survival, a male-biased sex ratio, and low calving success are contributing to the population’s current decline (Pace et al. 2017b). Due to the declining status of North Atlantic right whales, the resilience of this population to stressors that would impact the distribution, abundance, and reproductive potential of the population is low. Entanglement in fishing gear and vessel strikes are currently understood to be the most significant threats to the species and, as described in the *Environmental Baseline*, may occur in the action area over the life of the proposed action. As noted in the Cumulative Effects section of this Opinion, we have not identified any cumulative effects different than those considered in the Status of the Species and Environmental Baseline sections of this Opinion, inclusive of how those activities may contribute to climate change. As described in section 7.8, climate change is expected to negatively affect right whales throughout their range, including in the action area, over the life of this project; however, we have not identified any different or exacerbated effects of the action in the context of anticipated climate change.

Right whales may co-occur with project vessels in the project area periodically through the 34-year life of the project. A number of measures designed to reduce the risk of vessel strike, including traveling at reduced speeds and deploying lookouts, are part of the proposed action. As explained above, we have determined that strike of a right whale by a project vessel is extremely unlikely to occur. No injury (auditory or other) or mortality is expected due to exposure to any aspect of the proposed action during the construction, operations, or decommissioning phases of the project.

A number of measures that are part of the proposed action, including a seasonal restriction of pile driving and enhanced clearance measures in May, November, and December, reduce the potential for exposure of right whales to pile driving noise. No right whales are expected to be exposed to pile driving noise that could result in PTS or any other injury. However, even with these minimization measures in place, we expect up to 20 North Atlantic right whales to experience TTS, behavioral disturbance, and physiological stress in the action area during the construction period due to exposure to pile driving noise. As explained in the Effects of the Action section, all of these impacts are expected to be temporary and resolve within hours. Exposure to potentially disturbing levels of noise will only occur during pile driving; the effects of exposure to WTG operational noise and noise associated with other project activities is expected to be insignificant.

When in the WDA, one of the primary activities North Atlantic right whales are expected to be engaged in is migration (that is, we expect that right whales will be in the project area while migrating along the Atlantic coast). However, we also expect the animals to perform other behaviors, including opportunistic foraging and resting. Based on the best available information that indicates whales resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013a; Melcon et al. 2012), we anticipate that the up to 20 right whales exposed to harassing levels of pile driving noise will be able to return to normal behavioral patterns after the exposure ends. A single pile driving event will take no more than three hours; therefore, even in the event that a right whale was exposed to disturbing levels of noise for the entirety of a pile driving event, that disturbance would last no more than three hours. If an animal exhibits an avoidance response, it would experience a cost in terms of the energy associated with traveling away from the acoustic source. There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, which we do not expect, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al. 2007a). The energetic consequences of the evasive behavior and delay in resting or foraging are not expected affect any individual's ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in future breeding or calving. TTS will resolve within a week of exposure and is not expected to affect the health of any whale or its ability to migrate, forage, breed, or calve. These conclusions also apply to any mother-calf pairs that may be exposed to pile driving noise. Pile driving noise may mask right whale calls and could have effects on mother-calf communication and behavior. However, we do not anticipate that such effects would result in fitness consequences given their short-term nature. As noted in the Effects of the Action section, when calves leave the foraging grounds off the coast of the southeastern U.S. at around four months of age, they are expected to be more robust and less susceptible to a missed or delayed nursing opportunity. Any masking of communications or any delays in nursing due to swimming away from the pile driving noise would only last for the duration of the exposure to pile driving noise, which in all cases would be no more than three hours. This temporary disruption is not expected to have any health consequences to the calf or mother due to its short-term duration and the ability to resume normal behaviors as soon as they are out of range of the disturbance.

Stress responses are also anticipated with each of these instances of disruption. However, the available literature suggests these acoustically induced stress responses will be of short duration (similar to the duration of exposure), and not result in a chronic increase is stress that could result in physiological consequences to the animal. We do not anticipate long duration exposures to occur and we do not anticipate the associated stress of exposure to result in significant costs to affected individuals**.**

As described in section 7.1, up to 20 right whales are expected to be exposed to pile driving noise and respond in a way that meets NMFS' interim definition of harassment under the ESA (inclusive of TTS, behavioral disturbance, and stress). Because we do not expect the same animal to be exposed more than once, we expect there to be harassment of 20 different whales. We do not anticipate harassment to result from exposure to any other noise source. No harm, injury, or mortality is expected. No vessel strikes of North Atlantic right whales are anticipated.

As described in greater detail in Section 7.1, we do not anticipate these instances of TTS and behavioral harassment to result in fitness consequences to individual North Atlantic right whales. Our analysis considered the overall number of exposures to acoustic stressors that are expected to result in harassment, inclusive of behavioral responses, TTS, and stress, the duration and scope of the proposed activities expected to result in such impacts, the expected behavioral state of the animals at the time of exposure, and the expected condition of those animals. Instances of North Atlantic right whale exposure to acoustic stressors are expected to be short-term, not exceeding three hours, with the animal returning to its previous behavioral state shortly thereafter. As described previously, information is not available to conduct a quantitative analysis to determine the likely fitness consequences of these exposures and associated responses because we do not have information from wild cetaceans that links short-term behavioral responses to vital rates and animal health. Harris et al. (2017a) summarized the research efforts conducted to date that have attempted to understand the ways in which behavioral responses may result in long-term consequences to individuals and populations. Efforts have been made to try to quantify the potential consequences of such responses, and frameworks have been developed for this assessment (e.g., Population Consequences of Disturbance). However, models that have been developed to date to address this question require many input parameters and, for most species, there are insufficient data for parameterization (Harris et al. 2017a). Nearly all studies and experts agree that infrequent exposures of a single day or less are unlikely to impact an individual's overall energy budget (Farmer et al. 2018; Harris et al. 2017b; King et al. 2015b; NAS 2017; New et al. 2014; Southall et al. 2007d; Villegas-Amtmann et al. 2015). Based on best available information, we expect this to be the case for North Atlantic right whales exposed to acoustic stressors associated with this project even for animals that may already be in a stressed or compromised state due to factors unrelated to the Vineyard Wind project.

We do not expect any serious injury or mortality of any right whale to result from the proposed action. We also do not anticipate fitness consequences to any individual North Atlantic right whales. Because we do not anticipate any reduction in fitness, we do not anticipate any future effects on reproductive success. While many right whales in the action area are in a stressed state that is thought to contribute to a decreased calving interval, the short-term (no more than three hours) exposure to pile driving noise experienced by a single individual is not anticipated to have any lingering effects and is not expected to have any effect on future reproductive output. As such, we do not expect any reductions in reproduction. Any effects to distribution will be limited to short-term alterations to normal movements by individuals to avoid disturbing levels of noise. Pile driving noise will be short-term (3 hours at a time) and intermittent (occurring only on 57 to 102 days). Operational noise is not expected to impact the distribution of right whales and neither is the existence of the turbine foundations. Effects to distribution will be limited to avoiding the area with disturbing levels of noise during pile driving. There will be no change to the overall distribution of right whales in the action area or throughout their range.

The proposed action is not likely to affect the recovery potential of North Atlantic right whales. The 2005 Recovery Plan states that North Atlantic right whales may be considered for reclassifying to threatened when all of the following have been met: 1) The population ecology (range, distribution, age structure, and gender ratios, etc.) and vital rates (age-specific survival, age-specific reproduction, and lifetime reproductive success) of right whales are indicative of an increasing population; 2) The population has increased for a period of 35 years at an average rate of increase equal to or greater than 2% per year; 3) None of the known threats to Northern right whales (summarized in the five listing factors) are known to limit the population's growth rate; and, 4) Given current and projected threats and environmental conditions, the right whale population has no more than a 1% chance of quasi-extinction in 100 years. The proposed action will not result in any condition that impacts the time it will take to reach these goals or the likelihood that these goals will be met. This is because the proposed action will not affect the trend of the species or prevent or delay it from achieving an increasing population or otherwise affect its growth rate and will not affect the chance of quasi-extinction.

For these reasons, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of North Atlantic right whales in the wild. These conclusions were made in consideration of the endangered status of North Atlantic right whales, other stressors that individuals are exposed to within the action area as described in the Environmental Baseline and Cumulative Effects section of this Opinion, and any anticipated effects of climate change on the abundance and distribution of right whales in the action area.

9.2.2 Fin Whales

As described in further detail in the Status of the Species, of the three to seven stocks thought to occur in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in U.S. waters, where NMFS' best estimate of abundance is 1,618 individuals (Hayes et al. 2019). However, this may be an underestimate as the entire range of the stock was not surveyed (Palka 2012). According to the latest NMFS stock assessment report for fin whales in the Western North Atlantic, information is not available to conduct a trend analysis for this population (Hayes et al. 2019). Rangewide, there are over 100,000 fin whales occurring primarily in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. Entanglement in fishing gear and vessel strikes as described in the *Environmental Baseline*, may occur in the action area over the life of the proposed action. As noted in the Cumulative Effects section of this Opinion, we have not identified any cumulative effects different from those considered in the Status of the Species and Environmental Baseline sections of this Opinion, inclusive of how those activities may contribute to climate change. As described in section 7.8, climate change may result in changes in the distribution or abundance of fin whales in the action area over the life of this project; however, we have not identified any different or exacerbated effects of the action in the context of anticipated climate change.

Up to 34 fin whales are expected to experience harassment (inclusive of TTS, behavioral disturbance, and stress) over the construction period due to exposure to pile driving noise. Up to five Fin whales are also expected to experience PTS during the construction period due to exposure to pile driving noise. Based on the best available information as detailed in Section 7, no harm, non-auditory injury or mortality to fin whales is reasonably certain to occur. No vessel strikes of fin whales are anticipated.

As described in greater detail in Section 7.1, we do not anticipate that instances of TTS and behavioral harassment will result in fitness consequences to individual fin whales. When in the WDA, one of the primary activity fin whales are expected to be engaged in is migration. However, we also expect the animals to perform other behaviors, including opportunistic foraging and resting. Based on best available information that indicates whales resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013a; Melcon et al. 2012), we anticipate that exposed animals will be able to return to normal behavioral patterns after the exposure ends. If an animal exhibits an avoidance response, it would experience a cost in terms of the energy associated with traveling away from the acoustic source. There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, which we do not expect, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al. 2007a). The energetic consequences of the evasive behavior and delay in resting or foraging are not expected affect any individual's ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in breeding or calving. TTS will resolve within a week of exposure and is not expected to affect the health of any whale or its ability to migrate, forage, breed, or calve. Pile driving noise may mask fin whale calls and could have effects on mother-calf communication and behavior. However, we do not anticipate that such effects would result in fitness consequences given their short-term nature. Because we do not anticipate fitness consequences to individual fin whales to result from instances of TTS and behavioral harassment due to acoustic stressors, we do not expect these stressors to cause reductions in overall reproduction, abundance, or distribution of the fin whale population in the North Atlantic or rangewide.

Unlike TTS, PTS is permanent meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to affect aspects of affected animal's life functions that do not overlap in time and space with the proposed action. This slight PTS will be a minor degradation of hearing capabilities within regions of hearing that align most completely with the energy produced by pile driving (i.e. the low-frequency region below 2 kHz) and not severe hearing impairment. We expect this hearing impairment to mean that the affected animal would lose a few decibels in its hearing sensitivity, which is not likely to meaningfully affect its ability to forage, communicate with conspecifics, or detect and react to threats. No severe hearing impairment or serious injury is expected because of the received levels of noise anticipated and the short duration of exposure. The PTS anticipated is considered a minor auditory injury. As discussed previously in Section 7.1, permanent hearing impairment has the potential to affect individual whale survival and reproduction, although data are not readily available to evaluate how permanent hearing threshold shifts directly relate to individual whale fitness. Our exposure and response analyses indicate that some fin whales would experience PTS, but this PTS is expected to be minor. With this minor degree of PTS, even though several individual whales are expected to experience a minor reduction in fitness, we would not expect such impacts to have meaningful effects at the population level given what is known about the current status of the fin whale population that will be exposed. That is, a few individual fin whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, but these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. For this reason, we do not anticipate that instances of PTS will result in changes in the number, distribution, or reproductive potential of fin whales in the North Atlantic.

The proposed action will not result in any reduction in the abundance or reproduction of fin whales. Any effects to distribution will be limited to short-term alterations to normal movements by individuals to avoid disturbing levels of noise. Pile driving noise will be short-term (3 hours at a time) and intermittent (occurring only on 57 to 102 days). Operational noise is not expected to impact the distribution of fin whales and neither is the existence of the turbine foundations. Effects to distribution will be limited to avoiding the area with disturbing levels of noise during pile driving. There will be no change to the overall distribution of fin whales in the action area or throughout their range.

The proposed action is not likely to affect the recovery potential of fin whales. The 2010 Recovery Plan for fin whales included two criteria for consideration for reclassifying the species from endangered to threatened: 1. Given current and projected threats and environmental conditions, the fin whale population in each ocean basin in which it occurs (North Atlantic, North Pacific and Southern Hemisphere) satisfies the risk analysis standard for threatened status (has no more than a 1% chance of extinction in 100 years) and has at least 500 mature, reproductive individuals (consisting of at least 250 mature females and at least 250 mature males) in each ocean basin. Mature is defined as the number of individuals known, estimated, or inferred to be capable of reproduction. Any factors or circumstances that are thought to substantially contribute to a real risk of extinction that cannot be incorporated into a Population Viability Analysis will be carefully considered before downlisting takes place.; and, 2. None of the known threats to fin whales are known to limit the continued growth of populations. Specifically, the factors in 4(a)(l) of the ESA are being or have been addressed: A) the present or threatened destruction, modification or curtailment of a species' habitat or range; B) overutilization for commercial, recreational or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors. The proposed action will not result in any condition that impacts the time it will take to reach these goals or the likelihood that these goals will be met. This is because the proposed action will not affect the trend of the species or prevent or delay it from achieving an increasing population or otherwise affect the number of individuals or the species growth rate and will not affect the chance of extinction.

Based on this analysis, the proposed action is not likely to result in an appreciable reduction in the likelihood of survival and recovery of fin whales in the wild. These conclusions were made in consideration of the endangered status of fin whales, other stressors that individuals are exposed to within the action area as described in the Environmental Baseline and Cumulative

Effects, and any anticipated effects of climate change on the abundance and distribution of fin whales in the action area.

9.2.3 Sei Whales

As described in the Status of the Species, the most recent abundance estimate we are aware of for sei whales is 25,000 individuals worldwide (Braham 1991). According to the latest NMFS stock assessment report for sei whales in the western North Atlantic, there are insufficient data to determine population trends for sei whales (Hayes et al. 2017). The best abundance estimate for the Nova Scotia stock of sei whales is 357 animals, though the abundance survey from which this estimate was derived excluded waters off the Scotian Shelf, an area encompassing a large portion of the stock's range. For this reason, this abundance estimate is considered a minimum (Hayes et al. 2017). Outside of U.S. waters in the North Atlantic, a shipboard sighting survey of Icelandic and Faroese waters produced an estimate of about 10,300 sei whales (Cattanach et al. 1993). Additionally, Macleod et al. (2005) reported an estimated 1,011 sei whales in waters off Scotland. Entanglement in fishing gear and vessel strikes as described in the *Environmental Baseline*, may occur in the action area over the life of the proposed action. As noted in the Cumulative Effects section of this Opinion, we have not identified any cumulative effects different than those considered in the Status of the Species and Environmental Baseline sections of this Opinion, inclusive of how those activities may contribute to climate change. As described in section 7.8, climate change may result in changes in the distribution or abundance of sei whales in the action area over the life of this project; however, we have not identified any different or exacerbated effects of the action in the context of anticipated climate change.

Sei whales exposed to pile driving noise are expected to experience TTS, behavioral disturbance, and physiological stress. As described in the Effects of the Action section, up to four instances of harassment (inclusive of TTS, significant behavioral disturbance, and stress) are reasonably certain to occur over the construction period. Additionally, up to two instances of PTS are anticipated due to exposure to pile driving noise. This PTS will result in minor auditory injury. No vessel strikes of sei whales are anticipated.

As described in greater detail in Section 7.1, we do not anticipate that instances of TTS and behavioral harassment will result in fitness consequences to individual sei whales. When in the WDA, one of the primary activities sei whales are expected to be engaged in is migration. However, we also expect the animals to perform other behaviors, including opportunistic foraging and resting. Based on best available information that indicates whales resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013a; Melcon et al. 2012), we anticipate that exposed animals will be able to return to normal behavioral patterns after the exposure ends. If an animal exhibits an avoidance response, it would experience a cost in terms of the energy associated with traveling away from the acoustic source. There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, which we do not expect, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al. 2007a). The energetic consequences of the evasive behavior and delay in resting or foraging are not expected affect any individual's ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in breeding or calving. TTS will resolve within a week of exposure and is not expected to affect the health of any whale or its ability to migrate, forage, breed, or calve. Pile driving noise may mask sei whale calls and could have effects on mother-calf communication and behavior. However, we do not anticipate that such effects would result in fitness consequences given their short-term nature.

Stress responses are also anticipated with each of these instances of disruption. However, the available literature suggests these acoustically induced stress responses will be of short duration (similar to the duration of exposure), and not result in a chronic increase is stress that could result in physiological consequences to the animal. We do not anticipate long duration exposures to occur and we do not anticipate the associated stress of exposure to result in significant costs to affected individuals**.**

Because we do not anticipate fitness consequences to individual sei whales to result from instances of TTS and behavioral harassment due to acoustic stressors, we do not expect these stressors to cause reductions in overall reproduction, abundance, or distribution of the sei whale population in the North Atlantic or rangewide.

Unlike TTS, PTS is permanent meaning the effects of PTS last well beyond the duration of the proposed action and outside of the action area as animals migrate. As such, PTS has the potential to effect aspects of the affected animal’s life functions that do not overlap in time and space with the proposed action. This slight PTS will be a minor degradation of hearing capabilities within regions of hearing that align most completely with the energy produced by pile driving (i.e. the low-frequency region below 2 kHz) and not severe hearing impairment. We expect this hearing impairment to mean that the affected animal would lose a few decibels in its hearing sensitivity, which is not likely to meaningfully affect its ability to forage, communicate with conspecifics, or detect and react to threats. Our exposure and response analyses indicate that two sei whales would experience PTS, but this PTS is expected to be minor. With this minor degree of PTS, even though several individual whales are expected to experience a minor reduction in fitness (e.g., less efficient ability to locate conspecifics; decreased ability to detect threats at long distance); we would not expect such impacts to have meaningful effects at the population level. That is, while two sei whales could be less efficient at locating conspecifics or have decreased ability to detect threats at long distances, these animals are still expected to be able to locate conspecifics to socialize and reproduce, and will still be able to detect threats with enough time to avoid injury. For this reason, we do not anticipate that instances of PTS will result in changes in the number, distribution, or reproductive potential of sei whales in the North Atlantic.

The proposed action will not result in any reduction in the abundance or reproduction of sei whales. Any effects to distribution will be limited to short-term alterations to normal movements by individuals to avoid disturbing levels of noise. Pile driving noise will be short-term (3 hours at a time) and intermittent (occurring only on 57 to 102 days). Operational noise is not expected to impact the distribution of sei whales and neither is the existence of the turbine foundations. Effects to distribution will be limited to avoiding the area with disturbing levels of noise during pile driving. There will be no change to the overall distribution of sei whales in the action area or throughout their range.

The proposed action is not likely to affect the recovery potential of sei whales. The 2011 Recovery Plan for sei whales included two criteria for consideration for reclassifying the species from endangered to threatened: 1. Given current and projected threats and environmental conditions, the sei whale population in each ocean basin in which it occurs (North Atlantic, North Pacific and Southern Hemisphere) satisfies the risk analysis standard for threatened status (has no more than a 1% chance of extinction in 100 years) and the global population has at least 1,500 mature, reproductive individuals (consisting of at least 250 mature females and at least 250 mature males in each ocean basin). Mature is defined as the number of individuals known, estimated, or inferred to be capable of reproduction. Any factors or circumstances that are thought to substantially contribute to a real risk of extinction that cannot be incorporated into a Population Viability Analysis will be carefully considered before downlisting takes place. And 2. None of the known threats to sei whales are known to limit the continued growth of populations. Specifically, the factors in 4(a)(l) of the ESA are being or have been addressed: A) the present or threatened destruction, modification or curtailment of a species' habitat or range; B) overutilization for commercial, recreational or educational purposes; D) the inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors (there are no criteria for Factor C, disease or predation). The proposed action will not result in any condition that impacts the time it will take to reach these goals or the likelihood that these goals will be met. This is because the proposed action will not affect the trend of the species or prevent or delay it from achieving an increasing population or otherwise affect the number of individuals or the species growth rate and will not affect the chance of extinction.

In summary, the impacts expected to occur and affect sei whales are not anticipated to result in reductions in overall reproduction, abundance, or distribution of the sei whale population in the North Atlantic. Because we do not anticipate impacts to the sei whale population in the North Atlantic, we also do not anticipate reductions in overall reproduction, abundance, or distribution of the sei whale population rangewide. For this reason, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of sei whales in the wild. These conclusions were made in consideration of the endangered status of sei whales, other stressors that individuals are exposed to within the action area as described in the Environmental Baseline and Cumulative Effects sections of this Opinion, and any anticipated effects of climate change on the abundance and distribution of fin whales in the action area.

9.2.4 Sperm Whales

As described in further detail in the Status of the Species, the most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA listing. No other more recent rangewide abundance estimates are available for this species (Waring et al. 2015). There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for the North Atlantic stock, underestimated to consist of 2,288 individuals (N_{min}=1,815). Entanglement in fishing gear and vessel strikes as described in the *Environmental Baseline*, may occur in the action area over the life of the proposed action. As noted in the Cumulative Effects section of this Opinion, we have not identified any cumulative effects different than those considered in the Status of the Species and Environmental Baseline sections of this Opinion, inclusive of how those activities may contribute to climate change. As described in section 7.8, climate change may result in changes in the distribution or abundance of sei whales in the action area over the life of this project; however, we have not identified any different or exacerbated effects of the action in the context of anticipated climate change.

As described in the Effects of the Action section, up to five sperm whales are likely to experience harassment (inclusive of TTS, significant behavioral disturbance, and stress) over the construction period due to exposure to pile driving noise. When in the WDA, one of the primary activity sperm whales are expected to be engaged in is migration. However, we also expect the animals to perform other behaviors, including opportunistic foraging and resting. Based on best available information that indicates whales resume normal behavior quickly after the cessation of sound exposure (e.g., Goldbogen et al. 2013a; Melcon et al. 2012), we anticipate that exposed animals will be able to return to normal behavioral patterns after the exposure ends. If an animal exhibits an avoidance response, it would experience a cost in terms of the energy associated with traveling away from the acoustic source. There would likely be an energetic cost associated with any temporary habitat displacement to find alternative locations for foraging, but unless disruptions occur over long durations or over subsequent days, which we do not expect, we do not anticipate this movement to be consequential to the animal over the long term (Southall et al. 2007a). The energetic consequences of the evasive behavior and delay in resting or foraging are not expected affect any individual's ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in breeding or calving . TTS will resolve within a week of exposure and is not expected to affect the health of any whale or its ability to migrate, forage, breed, or calve. Pile driving noise is not expected to mask sperm whale calls.

Stress responses are also anticipated with each of these instances of disruption. However, the available literature suggests these acoustically induced stress responses will be of short duration (similar to the duration of exposure), and not result in a chronic increase is stress that could result in physiological consequences to the animal. We do not anticipate long duration exposures to occur and we do not anticipate the associated stress of exposure to result in significant costs to affected individuals**.**

We do not expect any serious injury or mortality of any sperm whale to result from the proposed action. We also do not anticipate fitness consequences to any individual sperm whales. Because we do not anticipate any reduction in fitness, we do not anticipate any future effects on reproductive success. Any effects to distribution will be limited to short-term alterations to normal movements by individuals to avoid disturbing levels of noise. Pile driving noise will be short-term (3 hours at a time) and intermittent (occurring only on 57 to 102 days). Operational noise is not expected to impact the distribution of sperm whales and neither is the existence of the turbine foundations. Effects to distribution will be limited to avoiding the area with disturbing levels of noise during pile driving. There will be no change to the overall distribution of sperm whales in the action area or throughout their range.

The proposed action is not likely to affect the recovery potential of sperm whales. The 2010 Recovery Plan states that sperm whales may be considered for reclassifying to threatened when all of the following have been met: 1. Given current and projected threats and environmental conditions, the sperm whale population in each ocean basin in which it occurs (Atlantic

Ocean/Mediterranean Sea, Pacific Ocean, and Indian Ocean) satisfies the risk analysis standard for threatened status (has no more than a 1% chance of extinction in 100 years) and the global population has at least 1,500 mature, reproductive individuals (consisting of at least 250 mature females and at least 250 mature males in each ocean basin). Mature is defined as the number of individuals known, estimated, or inferred to be capable of reproduction. Any factors or circumstances that are thought to substantially contribute to a real risk of extinction that cannot be incorporated into a Population Viability Analysis will be carefully considered before downlisting takes place; and, 2. None of the known threats to sperm whales is known to limit the continued growth of populations. Specifically, the factors in 4(a)(l) of the ESA are being or have been addressed: A) the present or threatened destruction, modification or curtailment of a species' habitat or range; B) overutilization for commercial, recreational or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors. The proposed action will not result in any condition that impacts the time it will take to reach these goals or the likelihood that these goals will be met. This is because the proposed action will not affect the trend of the species or prevent or delay it from achieving an increasing population or otherwise affect its growth rate and will not affect the chance of extinction

For these reasons, the effects of the proposed action are not expected to cause an appreciable reduction in the likelihood of survival and recovery of sperm whales in the wild. These conclusions were made in consideration of the endangered status of sperm whales, other stressors that individuals are exposed to within the action area as described in the Environmental Baseline and Cumulative Effects, and any anticipated effects of climate change on the abundance and distribution of fin whales in the action area.

9.3 Sea Turtles

Our effects analysis determined that pile driving is likely to adversely affect a number of individual ESA-listed sea turtles in the action area and cause temporary and permanent threshold shift, behavioral response, and stress but that no serious injury or mortality is anticipated. We determined that exposure to other project noise will have effects that are insignificant or extremely unlikely to occur. We also determined that effects to habitat and prey are also insignificant or extremely unlikely to occur. We expect that project vessels will strike and kill no more than 18 leatherback, 17 loggerhead, 2 green, and 2 Kemp's ridley sea turtles over the life of the project, inclusive of the construction, operation, and decommissioning period. In this section, we discuss the likely consequences of these effects to the sea turtles that have been exposed, the populations those individuals represent, and the species those populations comprise.

While this biological opinion relies on the best available scientific and commercial information, our analysis and conclusions include uncertainty about the basic hearing capabilities of sea turtles, such as how they use sound to perceive and respond to environmental cues, and how temporary changes to their acoustic soundscape could affect the normal physiology and behavioral ecology of these species. Vessel strikes are expected to result in more significant effects on individuals than other stressors considered in this opinion because these strikes are expected to result in serious injury or mortality. Those that are killed and removed from the population would decrease reproductive rates, and those that sustain non-lethal injuries and permanent hearing impairment could have fitness consequences during the time it takes to fully recover, or have long lasting impacts if permanently harmed. Temporary hearing impairment and significant behavioral disruption from harassment could have similar effects, but given the duration of exposures, these impacts are expected to be temporary and a sea turtle's hearing is expected to return back to normal shortly after the exposure ends. Therefore, these temporary effects are expected to exert significantly less adverse effects on any individual than severe injuries and permanent non-lethal injuries.

In this, section we assess the likely consequences of these effects to the sea turtles that have been exposed, the populations those individuals represent, and the species those populations comprise. Section 5.2 described current sea turtle population statuses and the threats to their survival and recovery. Most sea turtle populations have undergone significant to severe reduction by human harvesting of both eggs and sea turtles, loss of beach nesting habitats, as well as severe bycatch pressure in worldwide fishing industries. The Environmental Baseline identified actions expected to generally continue for the foreseeable future for each of these species of sea turtle that may affect sea turtles in the action area. As described in section 7.8, climate change may result in a northward distribution of sea turtles, which could result in a small change in the abundance, and seasonal distribution of sea turtles in the action area over the 34-year life of the Vineyard Wind project. However, as described there, given the cool winter water temperatures in the action area and considering the amount of warming that is anticipated, any shift in seasonal distribution is expected to be small (potential additional weeks per year, not months) and any increase in abundance in the action area is expected to be small. As noted in the Cumulative Effects section of this Opinion, we have not identified any cumulative effects different than those considered in the Status of the Species and Environmental Baseline sections of this Opinion, inclusive of how those activities may contribute to climate change.

9.3.1 Northwest Atlantic DPS of loggerhead sea turtles

As described in the Status of the Species, nesting trends for each of the loggerhead sea turtle recovery units in the Northwest Atlantic Ocean DPS are variable. A preliminary regional abundance survey of loggerheads within the northwestern Atlantic continental shelf, corrected for unidentified turtles in proportion to the ratio of identified turtles, estimates about 801,000 loggerheads (NMFS-NEFSC 2011). More recent nesting data indicate that nesting in Georgia, South Carolina, and North Carolina is now on an upward trend. Recent data from Florida index nesting beaches, which comprise most of the nesting in the DPS, indicate a 19% increase in nesting from 1989 to 2018. Ceriani and Meylan (2017) report a positive trend for this DPS. The primary threat to sea turtles in the Northwest Atlantic is fishery bycatch. Fisheries bycatch is the highest threat to the loggerhead sea turtles globally (Conant et al. 2009); as noted in the Environmental Baseline, bycatch in fisheries operating in the action area is likely to occur over the life of the proposed action. Other threats include boat strikes, marine debris, coastal development, habitat loss, contaminants, disease, and climate change; as noted in the Environmental Baseline, Cumulative Effects and in our consideration of climate change, all of these threats are a factor in the action area.

The impacts to loggerhead sea turtles from the proposed action are expected to result in the serious injury or mortality of 17 individuals due to ship strike over the construction, operations and decommissioning period and the harassment of 3 individuals due to exposure to pile driving noise. We determined that all other effects of the action would be insignificant or extremely unlikely to occur.

The 3 loggerhead sea turtles that experience harassment could suffer temporary hearing impairment (TTS), and we also assume these turtles would have physiological stress. These temporary conditions are expected to return to normal over a short period of time. TTS will resolve within one week while behavioral disturbance and stress will cease after exposure to pile driving noise ends (no more than three hours). These temporary alterations in behavior are not likely to reduce the overall fitness of individual turtles. The energetic consequences of the evasive behavior and delay in resting or foraging are not expected to affect any individual's ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in breeding or nesting. In general, based upon what we know about sound effects on sea turtles, we do not anticipate exposure to these acoustic stressors to have long-term effects on an individual nor alter critical life functions. Therefore, we do not anticipate loggerhead sea turtles to have population level consequences from acoustic stressors.

The mortality of 17 loggerhead sea turtles in the action area over the 34 year life of the project (inclusive of 2 years of construction, 30 years of operations, and 2 years of decommissioning) would reduce the number of loggerhead sea turtles from the recovery unit of which they originated as compared to the number of loggerheads that would have been present in the absence of the proposed actions (assuming all other variables remained the same). We expect that the majority of loggerheads in the action area originated from the Northern Recovery Unit (NRU) or the Peninsular Florida Recovery Unit (PFRU). Annual nest totals for the PFRU averaged 64,513 nests from 1989-2007, representing approximately 15,735 females per year (NMFS and USFWS 2008). Nest counts taken at index beaches in Peninsular Florida showed a significant decline in loggerhead nesting from 1989 to 2007, most likely attributed to mortality of oceanic-stage loggerheads caused by fisheries bycatch (Witherington et al. 2009). In the trend analysis by Ceriani and Meylan (2017), a 2% decrease for this Recovery Unit was reported.

The Northern Recovery Unit, from the Florida-Georgia border through southern Virginia, is the second largest nesting aggregation in the DPS, with an average of 5,215 nests from 1989-2008, and approximately 1,272 nesting females (NMFS and U.S. FWS 2008). For the Northern recovery unit, nest counts at loggerhead nesting beaches in North Carolina, South Carolina, and Georgia declined at 1.9% annually from 1983 to 2005 (NMFS and U.S. FWS 2007a). In the trend analysis by Ceriani and Meylan (2017), a 35% increase for this Recovery Unit was reported. In 2019, record numbers of loggerhead nests have been reported in Georgia and the Carolinas (https://www.cbsnews.com/news/rare-sea-turtles-smash-nesting-records-in-parts-of-southeast-georgia-south-carolina-north-carolina/; July 14, 2019).

The loss of 17 loggerheads over the 34 years of the project, at a rate of no more than 1 per year represents an extremely small percentage of the number of sea turtles in the PFRU or NRU. Even if the total population of the PFRU was limited to 15,735 loggerheads (the number of nesting females), the loss of 17 individuals would represent approximately 0.1% of the population. On an annual basis, the loss represents approximately 0.003% of the minimum population size. If the total NRU population was limited to 1,272 sea turtles (the number of nesting females), the loss of 17 individuals would represent approximately 1.3% of the population or approximately 0.004% on annual basis. Even just considering the number of adult nesting females this loss is extremely small and would be even smaller when considered for the total recovery unit and represents an even smaller percentage of the DPS as a whole.

As noted in the Environmental Baseline, the status of loggerhead sea turtles in the action area is expected to be the same as that of each recovery unit over the life of the project. The loss of such a small percentage of the individuals from any of these recovery units represents an even smaller percentage of the DPS as a whole. Considering the extremely small percentage of the populations that will be killed, it is unlikely that these deaths will have a detectable effect on the numbers and population trends of loggerheads in these recovery units or the number of loggerheads in the Northwest Atlantic DPS. We make this conclusion in consideration of the status of the species as a whole, the status of loggerhead sea turtles in the action area, and in consideration of the threats experienced by loggerheads in the action area as described in the Environmental Baseline and Cumulative Effects sections of this Opinion. As described in section 7.8, climate change may result in changes in the distribution or abundance of loggerheads in the action area over the life of this project; however, we have not identified any different or exacerbated effects of the action in the context of anticipated climate change.

Any effects on reproduction are limited to the future reproductive output of the individuals that die. Even assuming that all of these losses were reproductive female (which is unlikely given the expected even sex ratio in the action area), given the number of nesting adults in each of these populations, it is unlikely that the expected loss of loggerheads would affect the success of nesting in any year. Additionally, this extremely small reduction in potential nesters is expected to result in a similarly small reduction in the number of eggs laid or hatchlings produced in future years and similarly, an extremely small effect on the strength of subsequent year classes with no detectable effect on the trend of any recovery unit or the DPS as a whole. The proposed actions will not affect nesting beaches in any way or disrupt migratory movements in a way that hinders access to nesting beaches or otherwise delays nesting. Additionally, given the small percentage of the species that will be killed as a result of the proposed actions, there is not likely to be any loss of unique genetic haplotypes and no loss of genetic diversity.

The proposed action is not likely to reduce distribution because while the action will temporarily affect the distribution of individual loggerheads through behavioral disturbance changes in distribution will be temporary and limited to movements to nearby areas in the WDA. As explained in section 7, we expect the project to have insignificant effects on use of the action area by loggerheads.

While generally speaking, the loss of a small number of individuals from a subpopulation or species may have an appreciable reduction on the numbers, reproduction and distribution of the species this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range or the species has extremely low levels of genetic diversity. This situation is not likely in the case of loggerheads because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity, there are several thousand individuals in the population and the number of loggerheads is likely to be stable or increasing over the time period considered here.

Based on the information provided above, the death of 17 loggerheads over the 34 year life span of the project will not appreciably reduce the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for recovery and eventual delisting). The actions will not affect loggerheads in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment which would prevent loggerheads from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of 17 loggerheads represents an extremely small percentage of the species as a whole; (2) the death of 17 loggerheads will not change the status or trends of any recovery unit or the DPS as a whole; (3) the loss of 17 loggerheads is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of 17 loggerheads is likely to have an extremely small effect on reproductive output that will be insignificant at the recovery unit or DPS level; (5) the actions will have only a minor and temporary effect on the distribution of loggerheads in the action area and no effect on the distribution of the species throughout its range; and, (6) the actions will have no effect on the ability of loggerheads to shelter and only an insignificant effect on individual foraging loggerheads.

In certain instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that loggerhead sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the NWA DPS of loggerheads can rebuild to a point where listing is no longer appropriate. In 2008, NMFS and the USFWS issued a recovery plan for the Northwest Atlantic population of loggerheads (NMFS and USFWS 2008). The plan includes demographic recovery criteria as well as a list of tasks that must be accomplished. Demographic recovery criteria are included for each of the five recovery units. These criteria focus on sustained increases in the number of nests laid and the number of nesting females in each recovery unit, an increase in abundance on foraging grounds, and ensuring that trends in neritic strandings are not increasing at a rate greater than trends in in-water abundance. The recovery tasks focus on protecting habitats, minimizing and managing predation and disease, and minimizing anthropogenic mortalities.

Loggerheads have a stable trend; as explained above, the loss of 17 loggerheads over the life span of the proposed actions will not affect the population trend. The number of loggerheads likely to die as a result of the proposed actions is an extremely small percentage of any recovery unit or the DPS as a whole. This loss will not affect the likelihood that the population will reach the size necessary for recovery or the rate at which recovery will occur. As such, the proposed actions will not affect the likelihood that the demographic criteria will be achieved or the timeline on which they will be achieved. The action area does not include nesting beaches; all effects to habitat will be insignificant or extremely unlikely to occur; therefore, the proposed actions will have no effect on the likelihood that habitat based recovery criteria will be achieved.

The proposed actions will also not affect the ability of any of the recovery tasks to be accomplished.

The effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction; further, the actions will not prevent the species from growing in a way that leads to recovery and the actions will not change the rate at which recovery can occur. This is the case because while the actions may result in a small reduction in the number of loggerheads and a small reduction in the amount of potential reproduction due to the loss of this individual, these effects will be undetectable over the long-term and the actions are not expected to have long term impacts on the future growth of the DPS or its potential for recovery. Therefore, based on the analysis presented above, the proposed actions will not appreciably reduce the likelihood that the NWA DPS of loggerhead sea turtles can be brought to the point at which they are no longer listed as threatened.

Based on the analysis presented herein, the proposed actions are not likely to appreciably reduce the survival and recovery of the NWA DPS of loggerhead sea turtles. These conclusions were made in consideration of the threatened status of NWA DPS loggerhead sea turtles, other stressors that individuals are exposed to within the action area as described in the Environmental Baseline and Cumulative Effects, and any anticipated effects of climate change on the abundance and distribution of loggerhead sea turtles in the action area.

9.3.2 North Atlantic DPS of green sea turtles

As described in the Status of the Species, the North Atlantic DPS of green sea turtles is the largest of the 11 green turtle DPSs with an estimated abundance of over 167,000 adult females from 73 nesting sites. All major nesting populations demonstrate long-term increases in abundance (Seminoff et al. 2015b). While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue for this DPS, they appear to be somewhat resilient to future perturbations. As described in the Environmental Baseline and Cumulative Effects, green sea turtles in the action area are exposed to pollution and experience vessel strike and fisheries bycatch. As noted in the Cumulative Effects section of this Opinion, we have not identified any cumulative effects different than those considered in the Status of the Species and Environmental Baseline sections of this Opinion, inclusive of how those activities may contribute to climate change. As described in section 7.8, climate change may result in changes in the distribution or abundance of green sea turtles in the action area over the life of this project; however, we have not identified any different or exacerbated effects of the action in the context of anticipated climate change.

The impacts to green sea turtles from the proposed action are expected to result in the harassment of one individual due to exposure to pile driving noise and the serious injury or mortality of two individuals over the 34-year life of the project inclusive of construction, operations, and decommissioning. We determined that all other effects of the action would be insignificant or extremely unlikely.

The one green sea turtle that experience harassment could suffer temporary hearing impairment (TTS), and we also assume these turtles would have physiological stress. These temporary conditions are expected to return to normal over a short period of time. TTS will resolve within one week while behavioral disturbance and stress will cease after exposure to pile driving noise ends (no more than three hours). These temporary alterations in behavior are not likely to reduce the overall fitness of individual turtles. The energetic consequences of the evasive behavior and delay in resting or foraging are not expected to affect any individual's ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in breeding or nesting.

The death of two green sea turtles, whether males or females, immature or mature, would reduce the number of green sea turtles as compared to the number of green that would have been present in the absence of the proposed actions assuming all other variables remained the same. The loss of two green sea turtles represents a very small percentage of the species as a whole. Even compared to the number of nesting females (17,000-37,000), which represent only a portion of the number of greens worldwide, the mortality of two green represents less than 0.006% of the nesting population. The loss of these sea turtles would be expected to reduce the reproduction of green sea turtles as compared to the reproductive output of green sea turtles in the absence of the proposed action. As described in the "Status of the Species" section above, we consider the trend for green sea turtles to be stable. As noted in the Environmental Baseline, the status of loggerhead sea turtles in the action area is expected to be the same as that of each recovery unit over the life of the project. As explained below, the death of these green sea turtles will not appreciably reduce the likelihood of survival for the species for the reasons outlined below. We make this conclusion in consideration of the status of the species as a whole, the status of green sea turtles in the action area, and in consideration of the threats experienced by loggerheads in the action area as described in the Environmental Baseline and Cumulative Effects sections of this Opinion.

While generally speaking, the loss of a small number of individuals from a subpopulation or species may have an appreciable reduction on the numbers, reproduction and distribution of the species this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range or the species has extremely low levels of genetic diversity. This situation is not likely in the case of greens because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity, there are several thousand individuals in the population and the number of greens is likely to be increasing and at worst is stable. These actions are not likely to reduce distribution of greens because the actions will not cause more than a temporary disruption to foraging and migratory behaviors.

Based on the information provided above, the death of two green sea turtles over the 34 year life of the project, will not appreciably reduce the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect green sea turtles in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment which would prevent green sea turtles from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the species' nesting trend is increasing; (2) the death of 2 green sea turtles represents an extremely small percentage of the species as a whole; (3) the loss of 2 green sea turtles will not change the status or trends of the species as a whole; (4) the loss of 2 green sea turtles is not likely to have an effect on the levels of genetic heterogeneity in the population; (5) the loss of 2 green sea turtles is likely to have an undetectable effect on reproductive output of the species as a whole; (6) the action will have insignificant and temporary effects on the distribution of greens in the action area and no effect on its distribution throughout its range; and (7) the action will have no effect on the ability of green sea turtles to shelter and only an insignificant effect on individual foraging green sea turtles.

In rare instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that green sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the species can rebuild to a point where listing is no longer appropriate. A Recovery Plan for Green sea turtles was published by NMFS and USFWS in 1991. The plan outlines the steps necessary for recovery and the criteria, which, once met, would ensure recovery. In order to be delisted, green sea turtles must experience sustained population growth, as measured in the number of nests laid per year, over time. Additionally, “priority one” recovery tasks must be achieved and nesting habitat must be protected (through public ownership of nesting beaches) and stage class mortality must be reduced. Here, we consider whether this proposed actions will affect the population size and/or trend in a way that would affect the likelihood of recovery.

The proposed actions will not appreciably reduce the likelihood of survival of green sea turtles. Also, it is not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of green sea turtles in any geographic area and since it will not affect the overall distribution of green sea turtles other than to cause minor temporary adjustments in movements in the action area. As explained above, the proposed actions are likely to result in the mortality of two green sea turtles; however, as explained above, the loss of these individuals over this time period is not expected to affect the persistence of green sea turtles or the species trend. The actions will not affect nesting habitat and will have only an extremely small effect on mortality. The effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction; further, the actions will not prevent the species from growing in a way that leads to recovery and the actions will not change the rate at which recovery can occur. This is the case because while the actions may result in a small reduction in the number of greens and a small reduction in the amount of potential reproduction due to the loss of one individual, these effects will be undetectable over the long-term and the actions is not expected to have long term impacts on the future growth of the population or its potential for recovery. Therefore, based on the analysis presented above, the proposed actions will not appreciably reduce the likelihood that green sea turtles can be brought to the point at which they are no longer listed as endangered or threatened.

Despite the threats faced by individual green sea turtles inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions in light of the status of the species rangewide and in the action area, the environmental baseline, cumulative effects explained above, including climate change, and has concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed actions, resulting in the mortality of 2 green sea turtles over 34 years, is not likely to appreciably reduce the survival and recovery of this species.

9.3.3 Leatherback Sea Turtles

As described in the Status of the Species, the leatherback Turtle Expert Working Group estimates there are between 34,000 – 95,000 total adults (20,000 – 56,000 adult females; 10,000 – 21,000 nesting females) in the North Atlantic. The review by NMFS USFWS (2013) suggests the leatherback nesting population is stable in most nesting regions of the Atlantic Ocean. However, more recent information suggests that leatherback turtle nesting in the Northwest Atlantic is showing an overall negative trend, with the most notable decrease occurring during the most recent time frame of 2008 to 2017 (NW Atlantic Leatherback Working Group 2018). The primary threats to leatherback sea turtles include fisheries bycatch, harvest of nesting females, and egg harvesting; of these, as described in the Environmental Baseline and Cumulative Effects, fisheries bycatch occurs in the action area. Leatherback sea turtles in the action area are also at risk of vessel strike. As noted in the Cumulative Effects section of this Opinion, we have not identified any cumulative effects different than those considered in the Status of the Species and Environmental Baseline sections of this Opinion, inclusive of how those activities may contribute to climate change. As described in section 7.8, climate change may result in changes in the distribution or abundance of leatherback sea turtles in the action area over the life of this project; however, we have not identified any different or exacerbated effects of the action in the context of anticipated climate change.

The impacts to leatherback sea turtles from the proposed action are expected to result in the harassment of seven individual due to exposure to pile driving noise. We also expect that 18 leatherbacks will be struck and seriously injured or killed by a project vessel over the 34-year life of the project inclusive of construction, operations, and decommissioning. We determined that all other effects of the action would be insignificant or extremely unlikely to occur.

The seven leatherback sea turtles that experience harassment would experience behavioral disturbance and could suffer temporary hearing impairment (TTS); we also assume these turtles would have physiological stress. These temporary conditions are expected to return to normal over a short period of time. TTS will resolve within one week while behavioral disturbance and stress will cease after exposure to pile driving noise ends (no more than three hours). These temporary alterations in behavior are not likely to reduce the overall fitness of individual turtles. The energetic consequences of the evasive behavior and delay in resting or foraging are not expected to affect any individual’s ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in breeding or nesting.

The death of 18 leatherbacks over the life span of the project represents an extremely small percentage of the number of leatherbacks in the North Atlantic, just 0.05% even considering the lowest population estimate (34,000) and an even smaller percentage of the species as a whole.

Considering the extremely small percentage of the population that will be killed, it is unlikely that these deaths will have a detectable effect on the numbers and population trends of leatherbacks in the North Atlantic or the species as a whole.

Any effects on reproduction are limited to the future reproductive output of this individual. Even assuming that this loss was a reproductive female, given the number of nesting adults in each of this population (10,000-21,000), it is unlikely that the expected loss of no more than one leatherback per year would affect the success of nesting in any year. Additionally, this extremely small reduction in potential nesters is expected to result in a similarly small reduction in the number of eggs laid or hatchlings produced in future years and similarly, an extremely small effect on the strength of subsequent year classes with no detectable effect on the trend of any nesting beach or the population as a whole. The proposed action will not affect nesting beaches in any way or disrupt migratory movements in a way that hinders access to nesting beaches or otherwise delays nesting. Additionally, given the small percentage of the species that will be killed as a result of the proposed action, there is not likely to be any loss of unique genetic haplotypes and no loss of genetic diversity.

The proposed action is not likely to reduce distribution because while the action will temporarily affect the distribution of individual leatherbacks through behavioral disturbance, changes in distribution will be temporary and limited to movements to nearby areas in the WDA. As explained in section 7, we expect the project to have insignificant effects on use of the action area by leatherbacks.

While generally speaking, the loss of a small number of individuals from a subpopulation or species may have an appreciable reduction on the numbers, reproduction and distribution of the species this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range or the species has extremely low levels of genetic diversity. This situation is not likely in the case of leatherbacks because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity, there are several thousand individuals in the population and the number of leatherbacks is likely to be stable or increasing over the period considered here.

Based on the information provided above, the death of 18 leatherbacks over the 34-year life of the project will not appreciably reduce the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for recovery and eventual delisting). The actions will not affect leatherbacks in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment which would prevent leatherbacks from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of 18 leatherbacks represents an extremely small percentage of the Northwest Atlantic population and an even smaller percentage of the species as a whole; (2) the death of 18 leatherbacks will not change the status or trends of any nesting beach, the Northwest Atlantic population or the species as a whole; (3) the loss of 18 leatherbacks is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of 18 leatherbacks is likely to have an extremely small effect on reproductive output that will be insignificant at the nesting beach, population, or species level; (5) the actions will have only a minor and temporary effect on the distribution of leatherbacks in the action area and no effect on the distribution of the species throughout its range; and, (6) the actions will have no effect on the ability of leatherbacks to shelter and only an insignificant effect on individual foraging leatherbacks.

In certain instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that leatherback sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that leatherbacks can rebuild to a point where listing is no longer appropriate. In 1992, NMFS and the USFWS issued a recovery plan for leatherbacks in the U.S. Caribbean, Atlantic, and Gulf of Mexico (NMFS and USFWS 1992). The plan includes three recovery objectives:

1) The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico, St. Croix, USVI, and along the east coast of Florida.
2) Nesting habitat encompassing at least 75 percent of nesting activity in USVI, Puerto Rico and Florida is in public ownership.
3) All priority one tasks have been successfully implemented.

The recovery tasks focus on protecting habitats, minimizing and managing predation and disease, and minimizing anthropogenic mortalities.

Because the death of 18 leatherbacks over the 34-year life of the project is such a small percentage of the population and is not expected to affect the status or trend of the species, it will not affect the likelihood that the adult female population of loggerheads increases over time. This loss will not affect the likelihood that the population will reach the size necessary for recovery or the rate at which recovery will occur. As such, the proposed actions will not affect the likelihood that the demographic criteria will be achieved or the timeline on which they will be achieved. The action area does not include nesting beaches; all effects to habitat will be insignificant or extremely unlikely to occur; therefore, the proposed actions will have no effect on the likelihood that habitat based recovery criteria will be achieved. The proposed actions will also not affect the ability of any of the recovery tasks to be accomplished.

The effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction; further, the actions will not prevent the species from growing in a way that leads to recovery and the actions will not change the rate at which recovery can occur. This is the case because while the actions may result in a small reduction in the number of leatherbacks and a small reduction in the amount of potential reproduction due to the loss of tis individual, these effects will be undetectable over the long-term and the actions are not expected to have long term impacts on the future growth of the species or its potential for recovery. Therefore, based on the analysis presented above, the proposed actions will not appreciably reduce the likelihood that leatherback sea turtles can be brought to the point at which they are no longer listed as endangered Despite the threats faced by individual leatherback sea turtles inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions in light of the status of the species rangewide and in the action area, the environmental baseline, cumulative effects explained above, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached here do not change.

Based on the analysis presented herein, the proposed actions are not likely to appreciably reduce the survival and recovery of leatherback sea turtles. These conclusions were made in consideration of the endangered status of leatherback sea turtles, other stressors that individuals are exposed to within the action area as described in the Environmental Baseline and Cumulative Effects, and any anticipated effects of climate change on the abundance and distribution of leatherback sea turtles in the action area.

9.3.4 Kemp's ridley sea turtles

As described in the Status of the Species, of the sea turtles species in the world, the Kemp's ridley has declined to the lowest population level. Fishery interactions are the main threat to the species. While the species is steadily increasing, the species' limited range and low global abundance make its resilience to future perturbation low. The status of Kemp's ridley sea turtles in the action area is the same as described in the Status of the Species. As described in the Environmental Baseline and Cumulative Effects, fisheries bycatch and vessel strike are likely to continue to occur in the action area over the life of the project. As noted in the Cumulative Effects section of this Opinion, we have not identified any cumulative effects different than those considered in the Status of the Species and Environmental Baseline sections of this Opinion, inclusive of how those activities may contribute to climate change. As described in section 7.8, climate change may result in changes in the distribution or abundance of Kemp's ridley sea turtles in the action area over the life of this project; however, we have not identified any different or exacerbated effects of the action in the context of anticipated climate change.

The impacts to Kemp's ridley sea turtles from the proposed action are expected to result in the harassment of one individual due to exposure to pile driving noise and two serious injuries or mortalities resulting from vessel strike. We determined that all other effects of the action would be insignificant or extremely unlikely to occur.

The one Kemp's ridley sea turtle that experience harassment could suffer temporary hearing impairment (TTS), and we also assume these turtles would have physiological stress. These temporary conditions are expected to return to normal over a short period of time. TTS will resolve within one week while behavioral disturbance and stress will cease after exposure to pile driving noise ends (no more than three hours). These temporary alterations in behavior are not likely to reduce the overall fitness of individual turtles. The energetic consequences of the evasive behavior and delay in resting or foraging are not expected to affect any individual's ability to successfully obtain enough food to maintain their health, or impact the ability of any individual to make seasonal migrations or participate in breeding or nesting.

The mortality of two Kemp's ridleys over a 34 year time period represents a very small percentage of the Kemp's ridleys worldwide. Even taking into account just nesting females (7-8,000), the death of two Kemp's ridley represents less than 0.028% of the population. While the death of two Kemp's ridley will reduce the number of Kemp's ridleys compared to the number that would have been present absent the proposed actions, it is not likely that this reduction in numbers will change the status of this species or its stable to increasing trend as this loss represents a very small percentage of the population. Reproductive potential of Kemp's ridleys is not expected to be affected in any other way other than through a reduction in numbers of individuals.

A reduction in the number of Kemp's ridleys would have the effect of reducing the amount of potential reproduction as any dead Kemp's ridleys would have no potential for future reproduction. In 2006, the most recent year for which data is available, there were an estimated 7-8,000 nesting females. While the species is thought to be female biased, there are likely to be several thousand adult males as well. Given the number of nesting adults, it is unlikely that the loss of two Kemp's ridley over 34 years would affect the success of nesting in any year. Additionally, this small reduction in potential nesters is expected to result in a small reduction in the number of eggs laid or hatchlings produced in future years and similarly, a very small effect on the strength of subsequent year classes. Even considering the potential future nesters that would be produced by the individuals that would be killed as a result of the proposed actions, any effect to future year classes is anticipated to be very small and would not change the stable to increasing trend of this species. Additionally, the proposed actions will not affect nesting beaches in any way or disrupt migratory movements in a way that hinders access to nesting beaches or otherwise delays nesting.

The proposed actions are not likely to reduce distribution because the actions will not impede Kemp's ridleys from accessing foraging grounds or cause more than a temporary disruption to other migratory behaviors. Additionally, given the small percentage of the species that will be killed as a result of the proposed actions, there is not likely to be any loss of unique genetic haplotypes and no loss of genetic diversity.

While generally speaking, the loss of a small number of individuals from a subpopulation or species may have an appreciable reduction on the numbers, reproduction and distribution of the species this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range or the species has extremely low levels of genetic diversity. This situation is not likely in the case of Kemp's ridleys because: the species is widely geographically distributed, it is not known to have low levels of genetic diversity, there are several thousand individuals in the population and the number of Kemp's ridleys is likely to be increasing and at worst is stable.

Based on the information provided above, the death of two Kemp's ridley sea turtles over 34 years will not appreciably reduce the likelihood of survival (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The actions will not affect Kemp's ridleys in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment which would prevent Kemp's ridleys from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the species' nesting trend is increasing; (2) the death of two Kemp's ridleys represents an extremely small percentage of the species as a whole; (3) the death of two Kemp's ridleys will not change the status or trends of the species as a whole; (4) the loss of these Kemp's ridleys is not likely to have an effect on the levels of genetic heterogeneity in the population; (5) the loss of these Kemp's ridleys is likely to have such a small effect on reproductive output that the loss of this individual will not change the status or trends of the species; (5) the actions will have only a minor and temporary effect on the distribution of Kemp's ridleys in the action area and no effect on the distribution of the species throughout its range; and, (6) the actions will have no effect on the ability of Kemp's ridleys to shelter and only an insignificant effect on individual foraging Kemp's ridleys.

In rare instances, an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that Kemp's ridley sea turtles will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that Kemp's ridleys can rebuild to a point where listing is no longer appropriate. In 2011, NMFS and the USFWS issued a recovery plan for Kemp's ridleys (NMFS et al. 2011). The plan includes a list of criteria necessary for recovery. These include:

1. An increase in the population size, specifically in relation to nesting females[28];
2. An increase in the recruitment of hatchlings[29];
3. An increase in the number of nests at the nesting beaches;
4. Preservation and maintenance of nesting beaches (i.e. Rancho Nuevo, Tepehuajes, and Playa Dos); and,
5. Maintenance of sufficient foraging, migratory, and inter-nesting habitat.

Kemp's ridleys have an increasing trend; as explained above, the loss of two Kemp's ridleys over the 34-year life of the project will not affect the population trend. The number of Kemp's ridleys likely to die as a result of the proposed actions is an extremely small percentage of the species. This loss will not affect the likelihood that the population will reach the size necessary for recovery or the rate at which recovery will occur. As such, the proposed actions will not affect the likelihood that criteria one, two or three will be achieved or the timeline on which they will be achieved. The action area does not include nesting beaches; therefore, the proposed actions will have no effect on the likelihood that recovery criteria four will be met. All effects to

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[28] A population of at least 10,000 nesting females in a season (as measured by clutch frequency per female per season) distributed at the primary nesting beaches in Mexico (Rancho Nuevo, Tepehuajes, and Playa Dos) is attained in order for downlisting to occur; an average of 40,000 nesting females per season over a 6-year period by 2024 for delisting to occur

[29] Recruitment of at least 300,000 hatchlings to the marine environment per season at the three primary nesting beaches in Mexico (Rancho Nuevo, Tepehuajes, and Playa Dos).

habitat will be insignificant or extremely unlikely to occur; therefore, the proposed actions will have no effect on the likelihood that criteria five will be met.

The effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction. Further, the actions will not prevent the species from growing in a way that leads to recovery and the actions will not change the rate at which recovery can occur. This is the case because while the actions may result in a small reduction in the number of Kemp’s ridleys and a small reduction in the amount of potential reproduction due to the average loss of one individual per year, these effects will be undetectable over the long-term and the actions are not expected to have long term impacts on the future growth of the population or its potential for recovery. Therefore, based on the analysis presented above, the proposed actions will not appreciably reduce the likelihood that Kemp’s ridley sea turtles can be brought to the point at which they are no longer listed as endangered or threatened.

Despite the threats faced by individual Kemp’s ridley sea turtles inside and outside of the actions area, the proposed actions will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed actions in light of the status of the species, Environmental Baseline and cumulative effects explained above, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed actions, resulting in the mortality of two Kemp’s ridleys, is not likely to appreciably reduce the survival and recovery of this species. These conclusions were made in consideration of the endangered status of Kemp’s ridley sea turtles, other stressors that individuals are exposed to within the action area as described in the Environmental Baseline and Cumulative Effects, and any anticipated effects of climate change on the abundance and distribution of Kemp’s ridleys in the action area.

10.0 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of fin, sei, sperm, or North Atlantic right whales or the Northwest Atlantic DPS of loggerhead sea turtles, North Atlantic DPS of green sea turtles, Kemp’s ridley or leatherback sea turtles. We find that the proposed action is not likely to adversely affect blue whales, the Northeast Atlantic DPS of loggerhead sea turtles, or any DPS of Atlantic sturgeon; thus, it is also not likely to jeopardize the continued existence of these species. We find that the proposed action will have no effect on critical habitat designated for the North Atlantic right whale.

11.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. In the case of threatened species, section 4(d) of the ESA leaves it to the Secretary’s discretion whether and to what extent to extend the statutory 9(a) ‘‘take’’ prohibitions, and directs the agency to issue regulations it considers necessary and advisable for the conservation of the species.

“Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. NMFS has not yet defined “harass” under the ESA in regulation, but has issued interim guidance on the term “harass,” defining it as to “create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering” (NMFS PD 02-110-19) We considered NMFS’ interim definition of harassment in evaluating whether the proposed activities are likely to result in harassment of ESA-listed species. Incidental take statements serve a number of functions, including providing reinitiation triggers for all anticipated take, providing exemptions from the Section 9 prohibitions against take, and identifying reasonable and prudent measures that will minimize the impact of anticipated incidental take and monitor incidental take that occurs.

When an action will result in incidental take of ESA-listed marine mammals, ESA section 7(b)(4) requires that such taking be authorized under the MMPA section 101(a)(5) before the Secretary can issue an Incidental Take Statement (ITS) for ESA-listed marine mammals and that an ITS specify those measures that are necessary to comply with Section 101(a)(5) of the MMPA. Section 7(b)(4), section 7(o)(2), and ESA regulations provide that taking that is incidental to an otherwise lawful activity conducted by an action agency or applicant is not considered to be prohibited taking under the ESA if that activity is performed in compliance with the terms and conditions of this ITS, including those specified as necessary to comply with the MMPA, Section 101(a)(5). Accordingly, the terms of this ITS and the exemption from Section 9 of the ESA become effective only upon the issuance of MMPA authorization to take the marine mammals identified here. Absent such authorization, this ITS is inoperative for ESA-listed marine mammals.

The measures described below are non-discretionary, and must be undertaken by the action agency so that they become binding conditions for the exemption in section 7(o)(2) to apply. BOEM has a continuing duty to regulate the activity covered by this ITS. If BOEM (1) fails to assume and implement the terms and conditions or (2) fails to require the project sponsor or their contractors to adhere to the terms and conditions of the ITS through enforceable terms that are added to grants, permits and/or contracts as appropriate, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, BOEM or Vineyard Wind must report the progress of the action and its impact on the species to us as specified in the ITS [50 CFR §402.14(i)(3)] (See U.S. Fish and Wildlife Service and National Marine Fisheries Service’s Joint Endangered Species Act Section 7 Consultation Handbook (1998) at 4-49).

11.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). As explained in the Effects of the Action section, we anticipate pile driving during construction to result in the harassment of North Atlantic right, fin, sperm, and sei whales and NWA DPS loggerhead, NA DPS green, Kemp’s ridley, and leatherback sea turtles. We also anticipate pile driving during construction to result in the injury (PTS) of fin and sei whales. We anticipate the serious injury or mortality of NWA DPS loggerhead, NA DPS green, Kemp's ridley, and leatherback sea turtles due to vessel strikes during construction, operation, and decommissioning phases of the project. No other sources of incidental take are anticipated. There is no incidental take anticipated to result from EPA's proposed issuance of a National Pollutant Discharge Elimination System (NPDES) General Permit for construction activities or the Outer Continental Shelf Air Permit or the USCG's proposed issuance of a Private Aids to Navigation (PATON) authorization. We anticipate no more than the amount and type of take described below to result from the construction, operation, and decommissioning of the Vineyard Wind project as proposed for approval by BOEM and pursuant to other permits, authorizations, and approvals by BSEE, USACE, and NMFS' Office of Protected Resources.

Vessel Strike

We calculated the number of sea turtles likely to be struck by project vessels based on the anticipated increase in vessel traffic during the construction, operations, and decommissioning phases of the project. The following amount of incidental take is exempted over the life of the project, inclusive of all three phases:

Species	Vessel Strike
	Serious Injury or Mortality
NWA DPS Loggerhead sea turtle	17
NA DPS green sea turtle	2
Kemp's ridley sea turtle	2
Leatherback sea turtle	18

Pile Driving

We calculated the number of whales and sea turtles likely to be injured or harassed due to exposure to pile driving noise based on the maximum impact scenario (i.e., the pile driving scenario that could be approved by BOEM and authorized by the IHA that would result in the maximum amount of take). The numbers below are the amount of take anticipated in consideration of that maximum impact scenario (one pile per day, 6 dB attenuation, 90 monopiles, 12 jackets). This represents the maximum amount of take that is anticipated and is consistent with the amount of Level A and Level B harassment NMFS is proposing to authorize through the MMPA IHA:

Species	Take due to Exposure to Pile Driving Noise – 90 monopiles, 12 jackets, one pile per day, 6 dB attenuation	
	Harassment (TTS/Behavior)	Injury (PTS)
North Atlantic right whale	20	None anticipated (NA)_
Fin whale	34	5
Sperm whale	5	NA
Sei Whale	4	2
NWA DPS Loggerhead sea turtle	3	NA
NA DPS green sea turtle	1	NA
Kemp's ridley sea turtle	1	NA
Leatherback sea turtle	7	NA

As explained in the Effects of the Action section of this Opinion, Vineyard Wind may install fewer turbines of larger capacity if such turbines are available and may install only one ESP (supported by jacket foundation). The amount of take of whales and sea turtles is proportional to the amount of pile driving. Installing fewer piles requires less pile driving; therefore, the number of whales and/or sea turtles that will be exposed to pile driving noise will be reduced proportionally. As such, the amount of take exempted is proportional to the number of piles installed (rounded up to a whole animal). If 84 9.5 MW turbines are installed, the project would require 84 WTG foundations. In this scenario if 84 monopiles and 2 ESPs (jackets) are installed, this would represent a 16% reduction in pile driving and the amount of take exempted by this ITS would be 16% less than shown in the table above and would be:

Species	Take due to Exposure to Pile Driving Noise -84 monopiles, 2 ESPs (jackets)	
	Harassment (TTS/Behavior)	Injury (PTS)
North Atlantic right whale	17	NA
Fin whale	29	5
Sperm whale	5	NA
Sei Whale	4	2
NWA DPS Loggerhead sea turtle	3	NA
NA DPS green sea turtle	1	NA
Kemp's ridley sea turtle	1	NA
Leatherback sea turtle	6	NA

For the low end of the design envelope, which is installing 57 14 MW turbines, we would expect a 43% reduction in exposure and this ITS would exempt take as follows:

Species	Take due to Exposure to Pile Driving Noise -57 monopiles, 2 ESPs (jackets)	
	Harassment (TTS/Behavior)	Injury (PTS)
North Atlantic right whale	12	NA
Fin whale	20	3
Sperm whale	3	NA
Sei Whale	3	2
NWA DPS Loggerhead sea turtle	2	NA
NA DPS green sea turtle	1	NA
Kemp's ridley sea turtle	1	NA
Leatherback sea turtle	4	NA

As noted in the Effects of the Action section of this Opinion, if sound attenuation of greater than 6 dB is achieved, fewer animals may be exposed to pile driving noise that would result in injury or harassment. However, as that reduction would need to be modeled based on the particular amount of attenuation achieved, we are not able to predict the extent of any potential reduction in the number of animals exposed to injurious or harassing levels of noise.

Following BOEM's approval of the Construction and Operations Plan, BOEM and BSEE review the applicant's Facility Design Report (FDR) and Fabrication and Installation Report (FIR). At that time, the number of piles to be installed will be known and confirmation of the amount or extent of exempted incidental take will be provided by us to BOEM. Within 5 days of approving the FIR (but at least 30 days prior to the initiation of pile driving), BOEM must notify us of the total number of foundations and ESPs to be installed. If at that time it is determined that the amount or extent of incidental take is likely to exceed the maximum amount for each source and type of take considered in this ITS, consultation may need to be reinitiated.

11.2 Effects of the Take

In this opinion, we determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to jeopardize the continued existence of any ESA-listed species under NMFS' jurisdiction.

11.2 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action is likely to incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and terms and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the ITS are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

Reasonable and prudent measures are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). The reasonable and prudent measures and terms and conditions are specified as required by 50 CFR 402.14 (i)(1)(ii) and (iv) to document the incidental take by the proposed action and minimize the impact of that take on ESA-listed species. The reasonable and prudent measures are nondiscretionary, and must be undertaken by the appropriate Federal agency so that they become binding conditions for the exemption in section 7(o)(2) to apply.

The reasonable and prudent measures identified here are necessary and appropriate to minimize impacts of incidental take that might otherwise result from the proposed action and to document incidental take that does occur. Specifically, these RPMs and their implementing terms and conditions will minimize the exposure of ESA listed whales and sea turtles to pile driving noise or reduce the extent of that exposure and will minimize the risk to sea turtles of vessel strike. These RPMs and terms and conditions also require that all incidental take that occurs is documented and reported to NMFS in a timely manner. Please note that these reasonable and prudent measures and terms and conditions are in addition to the measures that Vineyard Wind has committed to, the additional measures that BOEM has indicated they will require, and the mitigation measures identified in the proposed IHA issued by NMFS as all these are considered part of the proposed action (see section 3 above). For example, the prohibition on pile driving from January 1 – April 30 is considered part of the proposed action and it is not repeated here as an RPM or term and condition. We consider that a failure to implement the measures identified as part of the proposed action in section 3 of this Opinion would be a change in the action that may necessitate reinitiation of consultation and may render the take exemption inapplicable to the activities that are carried out.

All of the RPMs and Terms and Conditions are reasonable and prudent and necessary and appropriate to minimize or document the level of incidental take associated with the proposed action. None of the RPMs and the terms and conditions that implement them alter the basic design, location, scope, duration, or timing of the action and all of them involve only minor changes (50 CFR§ 402. 14(i)(2)).

We have determined the following reasonable and prudent measures are necessary and appropriate to minimize and document the impacts of incidental take of threatened and endangered species during the proposed action:

1. Effects to ESA-listed whales and sea turtles must be minimized during pile driving. This includes adherence to the mitigation measures specified in the final MMPA IHA.

2. Effects to ESA-listed sea turtles must be minimized during vessel transits throughout the construction, operations, and decommissioning period.

3. Effects to ESA-listed whales and sea turtles must be documented during all phases of the proposed action and all incidental take must be reported to NMFS

11.3 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, BOEM, BSEE, USACE, and NMFS Office of Protected Resources must comply with the relevant terms and conditions, which implement the reasonable and prudent measures above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)).

These terms and conditions are non-discretionary. If BOEM, USACE, and NMFS Office of Protected Resources fail to ensure compliance with these terms and conditions and the reasonable and prudent measures they implement, the protective coverage of section 7(o)(2) may lapse.

1) To implement the requirements of reasonable and prudent measure 1 (RPM 1), the measures required by the final MMPA IHA must be incorporated into any project authorizations/approvals and the relevant Federal agency must monitor their compliance:
   a) BOEM must require, through an enforceable condition of their approval of Vineyard Wind's Construction and Operations Plan, that Vineyard Wind comply with any measures in the final MMPA IHA that are revised from, or in addition to, measures included in the proposed IHA, which have been incorporated into the proposed action.
   b) NMFS' OPR must ensure that all mitigation measures as prescribed in the final IHA are implemented by Vineyard Wind.
   c) The USACE must require, through an enforceable condition of any permit issued to Vineyard Wind, compliance with any measures in the final MMPA IHA that are revised from, or in addition to, measures included in the proposed IHA, which have been incorporated into the proposed action.

2) To implement the requirements of RPM 1, BOEM and USACE must ensure that pile driving operations are carried out in a way that will minimize exposure of listed sea turtles to noise that may result in injury or behavioral disturbance by extending the exclusion zone for sea turtles from 50 m (as described in the proposed action) to 500 m for all pile driving operations.

3) To implement the requirements of RPM 1, BOEM and USACE must ensure that the following measures are implemented to minimize the likelihood of exposure of right whales to pile driving noise:
   a) At all times of year that pile driving takes place, for purposes of monitoring the exclusion zone, any large whale sighted by a PSO within 1,000 m of the pile that cannot be identified to species must be treated as if it were a North Atlantic right whale.
   b) At all times of year that pile driving takes place, any PAM detection of a right whale within the clearance/exclusion zone (May 1 - May 14: radius 10,000 m; May 15-May 31: 2,000 m for monopiles, 1,600 m for jacket; June 1 - October 31: radius 1,000 m with the exceptions noted in 3(e) below; November 1- December 31: radius 10,000 m) surrounding a pile must be treated the same as a visual observation and trigger any required delays in pile installation.
   c) At all times of year that pile driving takes place, a North Atlantic right whale observed by a PSO located on the pile driving vessel at any distance from the pile must be treated as a visual observation within the exclusion zone and trigger any required delays or shutdowns in pile installation.

   d) Vineyard Wind must continue to deploy the PAM system that is in place for May 1- May 14 through May 31 and implement an extended PAM monitoring zone of 10 km around any pile to be driven with all detections of right whales provided to the visual PSO to increase situational awareness and to be considered as pile driving is planned. For any piles driven May 15-May 31, the exclusion zone must be extended from 1,000 m to 2,000 m for monopiles and 1,600 m for jacket (i.e., half distance to Level B threshold) to minimize the extent of any take of North Atlantic right whales.
   e) Between June 1 and October 31, if a DMA or Right Whale Slow Zone is designated that overlaps with a predicted Level B harassment zone (monopile foundation: 4,121 m, jacket foundation: 3,220 m) from a pile to be installed, the PAM system in place during this period must be extended to the largest practicable detection zone to increase situational awareness of the visual PSOs and for purposes of planning pile installation. For any pile driving June 1 – October 31, where the predicted Level B harassment zone would overlap with a DMA or Right Whale Slow Zone, the exclusion zone must be extended from 1,000 m to 2,000 m for monopiles and 1,600 m for jacket piles (i.e., half distance to Level B threshold) to minimize the extent of any take of North Atlantic right whales.
   f) Vineyard Wind must prepare a *Passive Acoustic Monitoring Plan* that describes all equipment, procedures, and protocols related to the required use of PAM for monitoring. This plan must be submitted to NMFS and BOEM for review and approval at least 90 days prior to the planned start of pile driving.

4) To implement the requirements of RPM 1, BOEM and USACE must ensure that measures are implemented to maximize detection of a whale or sea turtle in the exclusion or monitoring zone:
   a) To minimize the effects of sun glare on visibility, no pile driving may begin until at least one hour after (civil) sunrise to ensure effective visual monitoring can be accomplished in all directions.
   b) To minimize the effects of sun glare on visibility and to minimize the potential for pile driving to continue after sunset when visibility would be impaired, no pile driving may begin within 1.5 hours of (civil) sunset.
   c) BOEM must ensure that Vineyard Wind develops and implements measures for enhanced monitoring in the event that poor visibility conditions unexpectedly arise and pile driving cannot be stopped due to safety or operational feasibility. Vineyard Wind must prepare and submit an *Alternative Monitoring Plan* to NMFS and BOEM for NMFS' review and approval at least 90 days prior to the planned start of pile driving. This plan may include deploying additional observers, alternative monitoring technologies (i.e. night vision, thermal, infrared), and/or use of PAM with the goal of ensuring the ability to maintain all exclusion zones for all ESA-listed species in the event of unexpected poor visibility conditions.

5) To implement reasonable and prudent measure 2, BOEM must ensure that between June 1 and November 30, Vineyard Wind has a trained lookout posted on all vessel transits during all phases of the project to observe for sea turtles and communicate with the captain to take avoidance measures as soon as possible if one is sighted as detailed below. If a vessel is carrying a visual observer for the purposes of maintaining watch for North Atlantic right whales, an additional lookout is not required and this visual observer must maintain watch for whales and sea turtles. If the trained lookout is a vessel crew member, this must be their designated role and primary responsibility while the vessel is transiting. Any designated crew lookouts must receive training on protected species identification, vessel strike minimization procedures, how and when to communicate with the vessel captain, and reporting requirements. These following avoidance measures must be implemented between June 1 and November 30:

    a) The trained lookout must monitor *seaturtlesightings.org* prior to each trip and report any observations of sea turtles in the vicinity of the planned transit to all vessel operators/captains and lookouts on duty that day.

    b) If a sea turtle is sighted within 100 m of the operating vessel's forward path, the vessel operator must slow down to 4 knots (unless unsafe to do so) and may resume normal vessel operations once the vessel has passed the sea turtle. If a sea turtle is sighted within 50 m of the forward path of the operating vessel, the vessel operator must shift to neutral when safe to do so and then proceed away from the turtle at a speed of 4 knots or less until there is a separation distance of at least 100 m at which time normal vessel operations may be resumed.

    c) Between June 1 and November 30, vessels must avoid transiting through areas of visible jellyfish aggregations or floating sargassum lines or mats. In the event that operational safety prevents avoidance of such areas, vessels must slow to 4 knots while transiting through such areas.

    d) All vessel crew members must be briefed in the identification of sea turtles and in regulations and best practices for avoiding vessel collisions. Reference materials must be available aboard all project vessels for identification of sea turtles. The expectation and process for reporting of sea turtles (including live, entangled, and dead individuals) must be clearly communicated and posted in highly visible locations aboard all project vessels, so that there is an expectation for reporting to the designated vessel contact (such as the lookout or the vessel captain), as well as a communication channel and process for crew members to do so.

6) To implement reasonable and prudent measure 3, BOEM and USACE must ensure that Vineyard Wind monitors in-water noise levels and sound propagation during pile driving, in accordance with the following measures:

    a) Vineyard Wind must carry out field measurements as described in the requirements for the sound source verification plan below (6c) for the first monopile and first jacket foundation to be installed. The purpose of these measurements is to validate the accuracy of the modeled distances described in the Effects of the Action section of this Opinion to isopleths of concerns as detailed below in 6(c).

b) In the event that future piles are installed that have a larger diameter or are installed with a larger hammer or stronger hammer energy, Vineyard Wind must carry out field measurements for those additional piles.

c) Vineyard Wind must prepare and submit a *Sound Source Verification Plan* to NMFS, USACE, and BOEM for review and NMFS' approval at least 90 days prior to the planned start of pile driving. This plan must describe how Vineyard Wind will ensure that the location selected is representative of the rest of the piles of that type to be installed and, in the case that it is not, how additional sites will be selected for sound source verification or how the results from the first pile can be used to predict actual installation noise propagation for subsequent piles. The plan must describe how the effectiveness of the sound attenuation methodology will be evaluated based on the results. The plan must be sufficient to document sound at the source as well as to document propagation and distances to isopleths of concern to allow for comparison to the distances assessed in the Effects of the Action section of this Opinion (i.e., to the Level A and Level B harassment zones for marine mammals and the injury and behavioral disturbance zones for sea turtles and Atlantic sturgeon).

d) Before driving any additional piles, Vineyard Wind must review the initial field measurement results and make any necessary adjustments to the sound attenuation system and/or the exclusion or monitoring zones as detailed below. If the initial field measurements indicate that the isopleths of concern are larger than those considered in this Opinion (see table X), BOEM and USACE must ensure that additional sound attenuation measures are put in place before additional piles are installed. Additionally, the exclusion and monitoring zones must be expanded to match the actual distances to the isopleths of concern. If the exclusion zones are expanded beyond 1,500 m, additional observers must be deployed on additional platforms, with each observer responsible for maintaining watch in no more than 180° an area with a radius no greater than 1,500 m. The exclusion zones established in the proposed action must be considered minimum exclusion zones and may not be reduced based on sound source verification results. Vineyard Wind must provide the initial results of the field measurements to NMFS, USACE, and BOEM as soon as they are available; NMFS, USACE, and BOEM will discuss these as soon as feasible with a target for that discussion within two business days of receiving the results. BOEM and NMFS will provide direction to Vineyard Wind on whether any additional modifications to the sound attenuation system or changes to the exclusion or monitoring zones are required. BOEM must also discuss with NMFS the potential need for reinitiation of consultation if appropriate.

7) To implement RPM 3, BOEM and USACE must ensure that Vineyard Wind monitors the full extent of the area where noise will exceed the Level A (cumulative) and Level B harassment thresholds for ESA-listed whales and the full extent of the area where noise will exceed the 175 dB rms threshold for turtles for the full duration of all pile driving activities and record all observations in order to ensure that all take that occurs is documented. Vineyard Wind must prepare and submit a *Pile Driving Monitoring Plan* to NMFS for review and approval at least 90 days before start of pile driving. The plan may involve enhanced visual observations (i.e., multiple platforms) and/or PAM (for whales).

8) To implement RPM 3, BOEM must ensure that Vineyard Wind implements the following reporting requirements necessary to document the amount or extent of take that occurs during all phases of the proposed action:

    a) If a North Atlantic right whale is observed at any time by PSOs or personnel on any project vessels, during any project-related activity or during vessel transit, Vineyard Wind must immediately report sighting information to NMFS (866-755-6622), the U.S. Coast Guard via channel 16 and through the WhaleAlert app (http://www.whalealert.org/).

    b) In the event of a suspected or confirmed vessel strike of a sea turtle by any project vessel, Vineyard Wind must report the incident to NMFS (NMFS Protected Resources Division, incidental.take@noaa.gov; and NMFS New England/Mid-Atlantic Regional Stranding Hotline (866-755-6622)) as soon as feasible. The report must include the following information: (A) Time, date, and location (latitude/longitude) of the incident; (B) Species identification (if known) or description of the animal(s) involved; (C) Vessel's speed during and leading up to the incident; (D) Vessel's course/heading and what operations were being conducted (if applicable); (E) Status of all sound sources in use; (F) Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike; (G) Environmental conditions (e.g., wind speed and direction, Beaufort scale, cloud cover, visibility) immediately preceding the strike; (H) Estimated size and length of animal that was struck; (I) Description of the behavior of the animal immediately preceding and following the strike; (J) Estimated fate of the animal (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and (K) To the extent practicable, photographs or video footage of the animal(s).

    c) In the event that an injured or dead marine mammal or sea turtle is sighted, Vineyard Wind must report the incident to NMFS (Protected Resources Division, incidental.take@noaa.gov; and NMFS New England/Mid-Atlantic Regional Stranding Hotline (866-755-6622)) as soon as feasible, but no later than 24 hours from the sighting. The report must include the following information: (A) Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable); (B) Species identification (if known) or description of the animal(s) involved; (C) Condition of the animal(s) (including carcass condition if the animal is dead); (D) Observed behaviors of the animal(s), if alive; (E) If available, photographs or video footage of the animal(s); and (F) General circumstances under which the animal was discovered. Staff responding to the hotline call will provide any instructions for handling or disposing of any injured or dead animals, which may include coordination of transport to shore, particularly for injured sea turtles.

    d) Vineyard Wind must compile and submit weekly reports during pile driving that document the start and stop of all pile driving daily, the start and stop of associated observation periods by the PSOs, details on the deployment of PSOs, and a record of all observations of marine mammals and sea turtles. These weekly reports may be submitted to NMFS (incidental.take@noaa.gov) and BOEM directly from the PSO providers and can consist of raw data. Weekly reports are due on Wednesday for the previous week (Sunday – Saturday).

e) Vineyard Wind must compile and submit monthly reports that include a summary of all project activities carried out in the previous month, including vessel transits (number, type of vessel, and route) and piles installed, and all observations of listed whales and sea turtles. Monthly reports are due on the 15th of the month for the previous month.

9) To implement RPM 3 and to facilitate monitoring of the incidental take exemption for sea turtles, BOEM and NMFS must meet twice annually to review sea turtle observation records. These meetings/conference calls will be held in September (to review observations through August of that year) and December (to review observations from September to November) and will use the best available information on sea turtle presence, distribution, and abundance, project vessel activity, and observations to estimate the total number of sea turtle vessel strikes in the action area that are attributable to project operations.

As explained above, reasonable and prudent measures are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). The reasonable and prudent measures and terms and conditions are specified as required by 50 CFR 402.14 (i)(1)(ii), (iii) and (iv) to document the incidental take by the proposed action, minimize the impact of that take on ESA-listed species and, in the case of marine mammals, specify those measures that are necessary to comply with section 101(a)(5) of the Marine Mammal Protection Act of 1972 and applicable regulations with regard to such taking. We document our consideration of these requirements for reasonable and prudent measures and terms and conditions here. As discussed below, we have determined that all of these RPMs and associated terms and conditions are reasonable, and necessary or appropriate, to minimize or document take and that they all comply with the minor change rule. That is, none of these RPMs or their implementing terms and conditions alter the basic design, location, scope, duration, or timing of the action, and all involve only minor changes.

RPM 1/Term and Condition 1

The proposed IHA includes a number of general conditions and specific mitigation measures that are considered part of the proposed action. The final IHA issued under the MMPA may have modified or additional measures that clarify or enhance the measures identified in the proposed IHA. Compliance with those measures is necessary and appropriate to minimize and document incidental take of North Atlantic right, sperm, sei, and fin whales. As such, the terms and conditions that require BOEM, USACE, and NMFS to ensure compliance with the conditions and mitigation measures of the final IHA are necessary and appropriate to minimize the extent of take of these species due to exposure to pile driving noise and to ensure that take is documented.

RPM 1/Term and Condition 2

The proposed action includes a requirement for maintenance of an exclusion zone of 50m for all pile driving activities. As explained in the Effects of the Action section of this Opinion, this is expected to minimize the potential for exposure of sea turtles to noise that could result in harassment. We are requiring extension of that exclusion zone to 500 m for all pile driving activities. This is expected to reduce exposure of sea turtles to noise that would result in behavioral disturbance by expanding the area around the pile that will need to be clear of sea turtles before pile driving will begin. This requirement is reasonable because the PSOs will already be in place to maintain exclusion zones and an area with a radius of 500 m can be visually monitored for sea turtles.

RPM 1/Term and Condition 3

The proposed action includes a number of measures designed to reduce the number of right whales exposed to pile driving noise. The additional requirements of Term and Condition 3 are designed to further minimize the extent of take of North Atlantic right whales. The proposed action includes a requirement to maintain exclusion zones for sperm, sei and fin whales of 500 m from the pile being driven and 1,000 or 10,000 m for right whales dependent on the time of year. We expect that PSOs will be able to detect whales within approximately 1,750 m from the pile being driven; however, we recognize that at greater distances it may not always be possible to identify the particular species of whale. As such, requiring that any large whale that can not be identified to species be treated as a right whale for purposes of maintenance of the exclusion zone is reasonable and appropriate to minimize the potential for a case of mistaken identity leading to unanticipated exposure. Similarly, if a PSO stationed at the pile driving vessel is able to detect and identify a right whale outside of the identified exclusion zone we require that to trigger the same delays in pile installation that would be triggered by the whale being sighted within the exclusion zone (e.g., if a 1,000m exclusion zone is in place and the PSO spots a right whale at 1,500 m, pile driving will not begin until that whale has departed the area). This would minimize the potential for pile driving to begin when a right whale is nearby the pile or potentially swimming towards the pile and would further minimize the number of right whales exposed to pile driving noise.

The proposed action includes the use of Passive Acoustic Monitoring (PAM), which can detect vocalizing whales and provide notification that whales are present in the area of detection. The PAM system provides an important supplement to the PSO’s visual observations of visible whales. The requirement to treat detections by PAM of vocalizing right whales the same way that visual detections of right whales are treated will maximize the effectiveness of the measures designed to avoid exposure of right whales to pile driving noise and therefore minimize the potential of take. We also require that Vineyard Wind prepare a *Passive Acoustic Monitoring Plan* that describes all equipment, procedures, and protocols related to the required use of PAM for monitoring. This will ensure that the PAM protocols are appropriate to achieve the stated goals of PAM.

While right whales occur in the action area year round, there are seasonal differences in abundance. Several of the measures that are incorporated into the proposed action that are designed to minimize exposure of right whales to pile driving noise are designed in recognition of these seasonal differences (e.g., the January – April prohibition on pile driving and the enhanced mitigation measures required for early May and November-December). In July 2020, Roberts et al. published updated right whale density estimates that are appropriate for consideration of seasonal distribution of right whales in the action area (Roberts et al. 2020) and incorporate sightings data from 2010-2018. The patterns in seasonal abundance are consistent with those considered in the development of the seasonal restrictions and enhanced mitigation measures. However, a review of right whale sightings in the action area over the last five years (Right Whale Sightings Advisory System) in the early May (May 1 – May 15) and late May (May 16 – May 31) do not appear to be significantly different. In 2019, distribution and abundance of right whales in the action area appear to be the same in early and late May and in 2018, there were more sightings of right whales in late May than early May. In 2015 there were more right whales in early May than late May and in 2016 and 2014 there were no recorded sightings in May. Based on this review, we expect that the risk of exposure to pile driving noise in late May is the same as in early May and that enhanced monitoring and mitigation measures from May 15 – May 31 will minimize the extent of take of right whales due to exposure to pile driving noise. Vineyard Wind will have a PAM system in place from May 1 – May 14 capable of detecting vocalizing right whales located within 10km of any pile to be driven. Requiring that this system be used during the May 15 – May 31 period will increase situational awareness of PSOs and project personnel so that pile driving can be scheduled in consideration of the presence of right whales in an area beyond what the PSO can observe visually. Requiring a larger exclusion zone during this period (2,000 m for monopiles and 1,600 m for jackets) will minimize the extent of take of right whales in this period by ensuring that right whales are further from the pile when pile driving begins. Any right whales that are in the Level B harassment zone (i.e., within approximately 4,000 m from a monopile and 3,200 m for jackets) when pile driving begins will have a smaller distance to swim in order to avoid the noise, thus reducing the time that they are harassed.

The enhanced mitigation measures that are part of the proposed action for May 1 – May 15 and November 1 – December 31 are designed to enhance the detection of right whales in areas that may be impacted by pile driving noise and reduce the potential for exposure of right whales to pile driving noise. These time periods were identified as having higher densities of right whales than other times of year. The density of right whales in the WDA is lower from June – October than at other times of year. We have considered whether there are appropriate and available triggers for enhanced mitigation during the June – October period. Dynamic Management Areas (DMA) are a component of the 2008 NOAA Ship Strike Rule (73 FR 60173) to minimize lethal ship strikes of North Atlantic right whales. DMAs are temporary protection zones that are triggered when three or more whales are sighted within 2-3 miles of each other outside of active Seasonal Management Areas (SMAs). The size of a DMA is larger if more whales are present. A DMA is a rectangular area centered over whale sighting locations and encompasses a 15-nautical mile buffer surrounding the sightings' core area to accommodate the whales' movements over the DMA's 15-day lifespan. The DMA lifespan is extended if three or more whales are sighted within 2-3 miles of each other within its bounds during the second week the DMA is active. Only verified sightings are used to trigger or extend DMAs. The trigger of three or more whales is taken from a NOAA NEFSC analysis of sightings data from Cape Cod Bay and Stellwagen Bank from 1980 to 1996 (Clapham & Pace 2001). This analysis found that an initial sighting of three or more right whales was a reasonably good indicator that whales would persist in the area, and the average duration of the whale's presence based on these sightings data was two weeks. Recently, NMFS enacted a complementary program, the "Right Whale Slow Zones" that will trigger a Slow Zone designation establishing a rectangular area encompassing a circle with a radius of 20 nautical miles around an acoustic detection point (i.e., detection of a vocalizing right whale from a passive or active acoustic monitoring source)[30]. For acoustically triggered Slow Zones, notifications will be released when right whale detections are received from an acoustic monitoring system that meets criteria established by acoustic experts; criteria for acoustic monitoring systems ensure the acoustic system's evaluation process has undergone peer review and has a low false detection rate as well as a relatively low missed detection rate for right whales. We are requiring that if there is a DMA or Slow Zone that overlaps the area where noise above the Level B harassment threshold is anticipated (i.e., approximately 4 km from a monopile and 3.2 km from a jacket) surrounding a pile to be driven during that 15-day period that the DMA or Slow Zone is in effect, that PAM be used to monitor for vocalizing right whales and that an extended exclusion zone of 2,000 m for monopiles and 1,600 m for jackets will be required. This is expected to minimize take of right whales as it will require enhanced mitigation measures when there is an indication that right whales are present in the area and that they are likely to persist in the area. Requiring a larger exclusion zone during this period (2,000 m for monopiles and 1,600 m for jackets) will minimize the extent of take of right whales in this period by ensuring that right whales are further from the pile when pile driving begins. Any right whales that are in the Level B harassment zone (i.e., within approximately 4,000 m from a monopile and 3,200 m for jackets) when pile driving begins will have a smaller distance to swim in order to avoid the noise, thus reducing the time that they are harassed.

RPM 1/Term and Condition 4

Vineyard Wind intends to carry out all pile driving (hammering) during daylight hours. In order to maintain the required exclusion zones it is important that the required pre-clearance periods occur only in good visibility conditions. The proposed action includes measures designed to meet this requirement including a requirement that pile driving shall not be initiated at night or when the clearance zone cannot be visually monitored, as determined by the lead PSO on duty. Pile driving may continue after dark only if the action began during the day and must proceed for human safety or installation feasibility reasons. Sun glare can impair visibility around sunset and sunrise; therefore, we are requiring measures that ensure that the pre-clearance period for pile driving activities does not occur when sun glare would impair visibility. This will minimize take of whales and sea turtles by minimizing the potential for insufficient clearance of the exclusion zones due to poor visibility. Further, it limits the extent of pile driving that could occur after sunset when the ability to visually monitor for sea turtles and whales is limited. BOEM and Vineyard Wind have indicated that once installation of a pile begins it may be operationally unsafe to stop that installation; as such, given that conditions can rapidly change in the marine environment (i.e., fog or low clouds could unexpectedly arise) and that conditions could unexpectedly arise that impair visibility, we are requiring the development of an alternative monitoring plan to be implemented when visibility in unexpectedly reduced and pile driving cannot be safely stopped. This will ensure that take of whales and sea turtles can be documented in poor visibility conditions.

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[30] https://www.fisheries.noaa.gov/feature-story/help-endangered-whales-slow-down-slow-zones; last accessed September 11, 2020

RPM 2/Term and Condition 5
We anticipate that sea turtles will be struck and killed by project vessels. We are requiring a number of measures designed to minimize the risk of vessel strike; while detection of sea turtles from a moving vessel may not always be possible, the use of a trained lookout on all vessel transits during the June to November period when sea turtles occur in the project area is expected to increase detectability and provide an alert to the vessel operator that could facilitate avoidance of the individual and reduce the potential for strike. Requiring vessel operators to slow down when a sea turtle is sighted reduces the likelihood that the vessel will strike that turtle by increasing the likelihood that the vessel operator or the turtle can avoid the collision. Sea turtles are seasonally present in the action area; certain habitat features, including concentrations of jellyfish and the presence of floating sargassum lines or mats, can serve as indicators of an increased potential of sea turtle presence. By requiring that vessel operators avoid such areas, or if they are unavoidable slow down while transiting through them, we expect to reduce the likelihood of vessel strike.

RPM 3/Term and Conditions 6-9
Documenting take that occurs is essential to ensure that reinitiation of consultation occurs if the amount or extent of take identified in the ITS is exceeded. Incidental take of right, fin, sei, and sperm whales is expected to result from exposure to pile driving noise. Incidental take of sea turtles is expected to result from exposure to pile driving noise and from being struck by project vessels.

The estimates of the amount of take expected as a result of exposure to pile driving noise are tied to the intensity of noise produced during pile driving and the propagation of that noise in the environment. As such, obtaining accurate information on the actual noise associated with the project's pile driving activities is critical to checking the assumptions that went into calculating the amount of take anticipated and for documenting the take that occurs. The exclusion zones that are included as part of the proposed action were based on the modeled sound sources. Verification of the extent of underwater noise produced during pile driving is essential to determining if those exclusion zones need to be larger in order to provide the same degree of protection to whales and sea turtles.

Documentation and timely reporting of observations of whales and sea turtles is also important to monitoring the amount or extent of actual take compared to the amount or extent of take exempted. As such, it is necessary to identify whales and sea turtles exposed not only to injurious levels of noise, but also to harassing levels of noise. Thus, we are requiring BOEM and Vineyard Wind to document exposure of whales and sea turtles to noise that is expected to result in behavioral disturbance. We are not dictating a specific methodology for monitoring those larger areas around the piles, rather we are providing the standards for what that monitoring must achieve which will provide BOEM and Vineyard Wind flexibility to design a monitoring protocol that is feasible and appropriate to meet those standards. The reporting requirements included here will allow us to track the progress of the action and associated take.

We recognize that documenting sea turtles that were struck by project vessels may be difficult given their small size and the factors that contribute to cryptic mortality addressed in the Effects of the Action section of this Opinion. Therefore, we are requiring that BOEM and Vineyard

Wind document any and all observations of dead or injured sea turtles over the course of the project and that we meet twice annually to review that data and determine which, if any, of those sea turtles have a cause of death that is attributable to project operations. We expect that we will consider the factors reported with the particular turtle (i.e., did the lookout suspect the vessel struck the turtle), the state of decomposition, any observable injuries, and the extent to which project vessel traffic contributed to overall traffic in the area at the time of detection.

12.0 CONSERVATION RECOMMENDATIONS

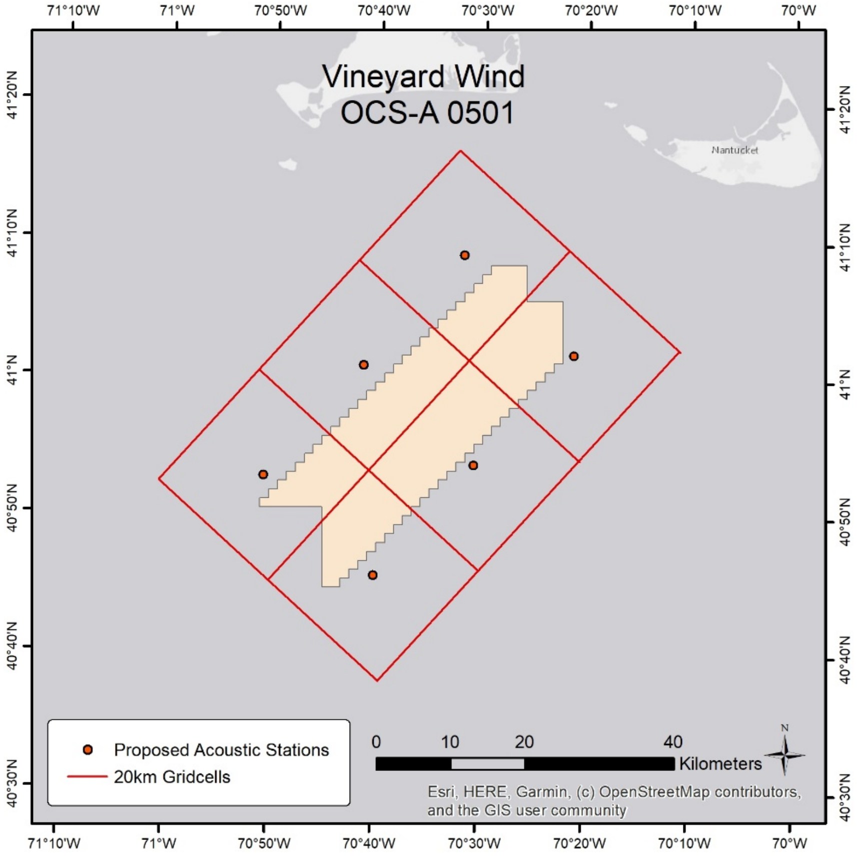
Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

We make the following conservation recommendations, which would provide information for future consultations related to offshore wind that may affect ESA-listed species or would minimize or avoid adverse effects of the proposed action. BOEM, USACE, USCG, U.S. EPA, and/or BSEE should use their authorities to:

- Support research and development to aid in minimization of risk of vessel strikes on marine mammals and sea turtles.
- Support development of regional monitoring of cumulative impacts of this and future projects through the Regional Wildlife Science Entity (RWSE).
- Work with the NEFSC to support robust monitoring and study design with adequate sample sizes, appropriate spatial and temporal coverage, and proper design allowing the detection of potential impacts of offshore wind projects on a wide range of environmental conditions including species distribution and habitat usage.
- Conduct research to monitor noise levels during construction and operation to understand how wind farms influence the acoustic soundscape.
- Conduct research regarding the abundance and distribution of Atlantic sturgeon in the wind lease area and surrounding region in order to understand the distribution and habitat use and aid in density modeling efforts, including the use of acoustic telemetry networks to monitor for tagged fish.
- Support research into understanding and modeling effects of offshore wind on regional oceanic and atmospheric conditions and potential impacts on protected species and habitats.
- Support the continuation of aerial surveys for post-construction monitoring of listed species in the lease area.
- Conduct monitoring pre/during/post construction, including long-term monitoring, to understand any changes in sea turtle distribution and habitat use in MA/RI WEA/southern New England, including deploying acoustic tags on sea turtles and utilizing acoustic telemetry network.
- Conduct long-term ecological monitoring to document the changes to the ecological communities on, around, and between WTG foundations and other benthic areas disturbed by the proposed Project.
- Support research on construction impacts to protected species distribution, particularly the North Atlantic right whale and other listed whales.

- Develop PAM array in WEA (wind energy area) to monitor use of the area by baleen whales during the life of the Project, including construction, and to detect small scale changes at the scale of the WEA. Bottom mounted recorders should be deployed at a maximum of 20 km distance from each other throughout the given study area in order to ensure near to complete coverage of the area over which North Atlantic right whale and other baleen whales can be heard (see Figure 1 for example in lease area OCS-A-0501).
- Support the development of a regional PAM network across lease areas to monitor long-term changes in baleen whale distribution and habitat use. A regional PAM network should consider adequate array/hydrophone design, equipment, and data evaluation to understand changes over the spatial scales that are relevant to these species for the duration of these projects, as well as the storage and dissemination of these data.

Figure 12.1: Example of 20 km array of bottom mounted recorders in lease area OCS-A-0501.



13.0 REINITIATION NOTICE

This concludes formal consultation for the proposed authorizations associated listed herein for the Vineyard Wind offshore energy project. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

(1) The amount or extent of taking specified in the ITS is exceeded.
(2) New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
(3) The identified action is subsequently modified in a manner that causes an effect to ESA- listed species or designated critical habitat that was not considered in this opinion.
(4) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

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