Coastal Virginia Offshore Wind Commercial Project Biological Assessment

For National Marine Fisheries Service
March 2023

U.S. Department of the Interior

Bureau of Ocean Energy Management
Office of Renewable Energy Programs

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Abbreviations and Acronyms

°C	degrees Celsius
°F	degrees Fahrenheit
μPa	micropascal
μV/m	microvolts per meter
AIS	automatic identification system
AMAPPS	Atlantic Marine Assessment Program for Protected Species
ASSRT	Atlantic Sturgeon Status Review Team
BA	biological assessment
BMP	best management practice
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CHIRP	compressed high-intensity radiated pulse
COA	Corresponding Onshore Area
COP	Construction and Operations Plan
CTV	crew transfer vessel
CVOW	Coastal Virginia Offshore Wind
CVOW-C	Coastal Virginia Offshore Wind Commercial
dB	decibels
DBBC	double big bubble curtain
DMA	Dynamic Management Area
DP	dynamic positioning
DPS	distinct population segment
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMF	electromagnetic field
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FHWG	Fisheries Hydroacoustic Working Group
FR	Federal Register
GARFO	Greater Atlantic Regional Fisheries Office
HDD	horizontal directional drilling
HFC	high-frequency cetaceans
HLV	heavy lift vessel
HRG	high-resolution geophysical
Hz	hertz
in^3	cubic inch
IUCN	International Union for Conservation of Nature
J	joule
JPA	Joint Permit Application
kHz	kilohertz
kJ	kilojoule
km^2	square kilometers

kV	kilovolts
Lease Area	BOEM Renewable Energy Lease Area OCS-A 0483
LFC	low-frequency cetacean
Lpk	peak sound pressure level
LOA	Letter of Authorization
m/s	meters per second
MFC	mid-frequency cetacean
mG	milligauss
mg/L	milligrams per liter
MMPA	Marine Mammal Protection Act of 1972
mV/m	millivolts per meter
MW	megawatt
NARW	North Atlantic right whale
NLCD	National Land Cover Database
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
O&M	operations and maintenance
OCS	Outer Continental Shelf
OSS	offshore substation
Pa	pascals
PAM	passive acoustic monitoring
PARS	Port Access Route Study
PATON	Private Aids to Navigation
PBR	potential biological removal
PDE	project design envelope
PMT	Portsmouth Marine Terminal
POI	point of interconnection
ppt	parts per thousand
PRD	Protected Resources Division
Project	Coastal Virginia Offshore Wind Commercial Project
PSO	Protected Species Observer
PTS	permanent threshold shift
re	referenced to
ROSA	Responsible Offshore Science Alliance
ROW	right-of-way
SAP	site assessment plan
SAV	submerged aquatic vegetation
SEL	sound exposure level
SEL_{24h}	sound exposure level over 24 hours
SL	source level
SMA	Seasonal Management Area
SMR	State Military Reservation
SOV	service operations vessel
SPL	root-mean-square sound pressure level
TSS	total suspended sediment
TTS	temporary threshold shift

U.S.	United States
USACE	U.S. Army Corps of Engineers
USC	United States Code
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
UXO	unexploded ordnance
VA DWR	Virginia Department of Wildlife Resources
VACAPES	Virginia Capes
VADEQ	Virginia Department of Environmental Quality
VIMS	Virginia Institute of Marine Science
VMRC	Virginia Marine Resources Commission
VPA	Virginia Port Authority
WEA	Wind Energy Area
WTG	wind turbine generator
μV/m	microvolts per meter

1. Introduction

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

This Biological Assessment (BA) has been prepared pursuant to Section 7 of the Endangered Species Act (ESA) to evaluate potential effects of the Coastal Virginia Offshore Wind Commercial (CVOW-C) Project (Project, or Proposed Action) described herein on ESA-listed species under the jurisdiction of the National Marine Fisheries Service (NMFS) (50 CFR 402.14). Section 7(a)(2) of the ESA requires federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. "Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR §402.02). "Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of an ESA-listed species as a whole (50 CFR §402.02).

This BA provides a comprehensive description of the Proposed Action, defines the Action Area, describes those species potentially affected by the Proposed Action, and provides an analysis and determination of how the Proposed Action may affect listed species, their habitats, or both. The activities being considered include approving the Construction and Operations Plan (COP) for the construction, operations, maintenance, and eventual decommissioning of the proposed Project, which is an offshore wind energy facility on the OCS offshore of Virginia. Effects on ESA-listed species under the oversight of the U.S. Fish and Wildlife Service (USFWS) are analyzed under a separate BA document for consultation.

As detailed in the COP (Dominion Energy 2022), the Proposed Action would include the construction activities, operations, and maintenance (O&M), and eventual decommissioning of an up to 3,000 megawatt (MW) offshore wind energy facility, and associated submarine and upland cable interconnecting the wind facility to one cable landing location in Virginia Beach, Virginia (Figure 1-1). The Proposed Action would include 202 wind turbine generators (WTGs) within BOEM Renewable Energy Lease Area OCS-A 0483 (Lease Area), within the Virginia Wind Energy Area (WEA), located on the OCS approximately 27 miles (24 nautical miles, 44 kilometers) east off the Virginia Beach, Virginia coastline. The likely scenario would be to install 176 WTGs within the 202 potential sites. Accordingly, the Joint Permit Application (JPA) requests authorization from USACE and Virginia Marine Resources Commission (VMRC) to construct 176 offshore WTGs, scour protection around the base of the WTGs, three offshore substations (OSSs), inter-array cables connecting the WTGs to the OSSs, and offshore export cables. The cable route(s) would originate from the OSSs and would connect to the electric grid in Virginia Beach, Virginia.

This BA considers the potential effects of the Proposed Action on ESA-listed marine mammals, sea turtles, fish, and designated critical habitat in the Action Area. This BA describes the Proposed Action (Section 1.3, *Description of the Proposed Action*); describes avoidance, minimization, and mitigation measures applicable to all phases of the Proposed Action (Section 1.3.5, *Proposed Mitigation,* *Monitoring, and Reporting Measures*); defines the Action Area (Section 1.2, *Action Area*); describes the federally listed species potentially affected by the Proposed Action (Section 2.4, *Threatened and Endangered Species Considered for Further Analysis*); and provides an analysis and determination of how the Proposed Action may affect listed species or their habitats (Section 3, *Effects of the Proposed Action*). The ESA Section 7 effects analysis determinations are provided in Section 4, *Conclusions and Effects Determinations*.

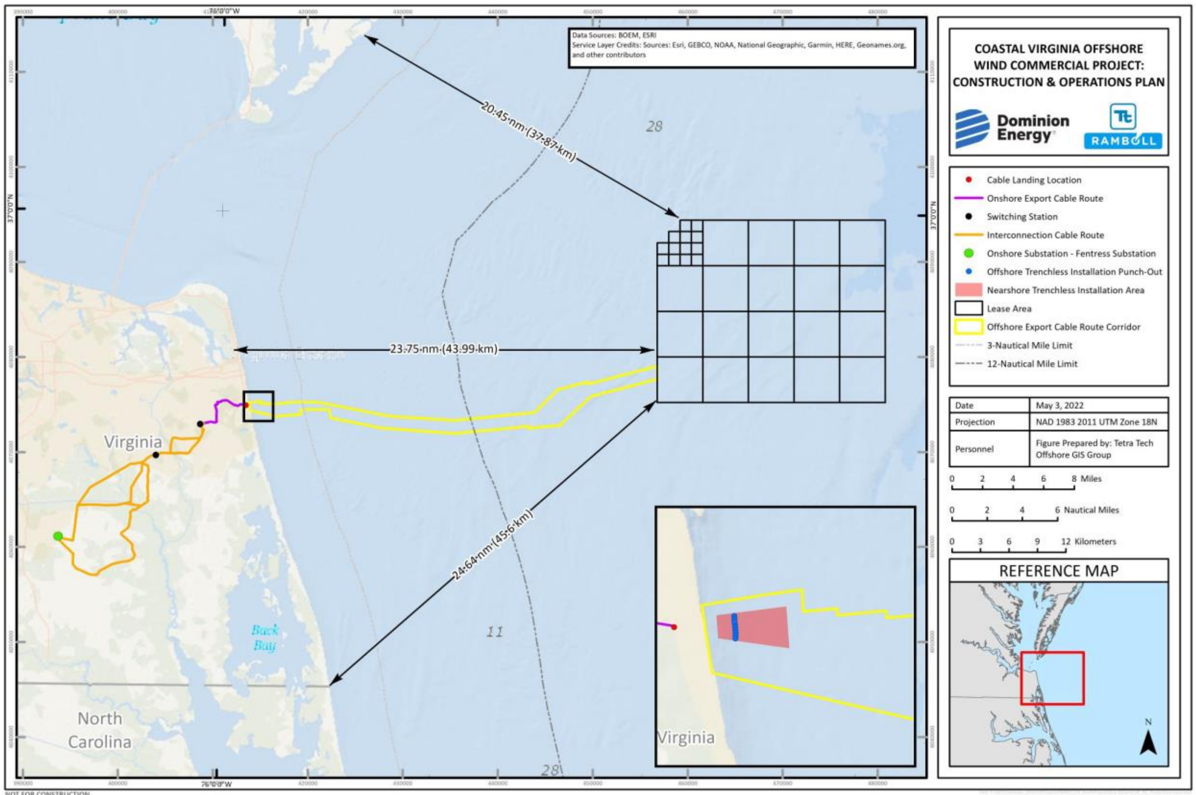

Figure 1-1 Coastal Virginia Offshore Wind Commercial Project location

1.1 Renewable Energy Process

Under BOEM's renewable energy regulations, the issuance of leases and subsequent approval of wind energy development on the OCS is a phased decision-making process. BOEM's wind energy program occurs in four distinct phases, defined as the following:

- **Phase 1**. Planning and Analysis (complete). The first phase of the renewable energy process is to identify suitable areas to be considered for wind energy leases through collaborative, consultative, and analytical processes using the state's task forces; public information meetings; and input from the states, Native American tribes, and other stakeholders.
- **Phase 2**. Lease Issuance (complete). The second phase is the issuance of a commercial wind energy lease. The competitive lease process is set forth at 30 CFR 585.210 to 585.225, and the noncompetitive process is set forth at 30 CFR 585.230 to 585.232. A commercial lease gives the lessee the exclusive right to subsequently seek BOEM's approval for the development of the leasehold. The lease does not grant the lessee the right to construct any facilities; rather, the lease grants the right to use the leased area to develop its plans, which must be approved by BOEM before the lessee can move on to the next phase of the process (30 CFR 585.600 and 585.601).

- **Phase 3**. Approval of site assessment plan (SAP) (complete). The third phase of the renewable energy development process is the submission of an SAP, which contains the lessee's detailed proposal for the construction of a meteorological tower, the installation of meteorological buoys, or both on the leasehold (30 CFR 585.605 to 585.618). The lessee's SAP must be approved by BOEM before these "site assessment" activities can be conducted on the leasehold. BOEM may approve, approve with modification, or disapprove a lessee's SAP (30 CFR 585.613). As a condition of SAP approval, meteorological towers will be required to have visibility sensors to collect data on climatic conditions above and beyond wind speed, direction, and other associated metrics generally collected at meteorological towers. These data will assist BOEM and the USFWS with evaluating the impacts of future offshore wind facilities on threatened and endangered birds, migratory birds, and bats.
- **Phase 4.** Approval of COP (Proposed Action). The fourth and final phase of the process is the submission of a COP, a detailed plan for the construction and operation of a wind energy farm on the Lease Area (30 CFR 585.620 to 585.638). BOEM's approval of a COP is a precondition of the construction of any wind energy facility on the OCS (30 CFR 585.628). As with an SAP, BOEM may approve, approve with modification, or disapprove a lessee's COP (30 CFR 585.628). This phase is the focus of the Proposed Action, including the CVOW-C Offshore Wind Farm Area and offshore export cables.

Phases 1 through 3 have already been completed for the CVOW-C Wind Farm Area and offshore export cables; the Proposed Action addressed in this consultation represents Phase 4 for the development.

The regulations also require that a lessee provide the results of surveys with its SAP or COP, including a shallow hazards survey (30 CFR 585.626 (a)(1)), geological survey (30 CFR 585.616(a)(2)), geotechnical survey (30 CFR 585.626(a)(4)), and archaeological resource survey (30 CFR 585.626(a)(5)). BOEM refers to these surveys as "site characterization" activities. Although BOEM does not issue permits or approvals for these site characterization activities, it will not consider approving a lessee's SAP or COP if the required survey information is not included (BOEM 2020).

The Proposed Action addresses Phase 4 of the renewable energy process. The Applicant has completed site characterization activities and has developed a COP in accordance with BOEM regulations. BOEM is consulting on the proposed approval of the COP for the CVOW-C Offshore Wind Farm Area and offshore export cables, as well as other permits and approvals from other agencies that are associated with the approval of the COP. BOEM is the lead federal agency for purposes of Section 7 consultation; the other action agencies are 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.

BOEM began evaluation for offshore wind development areas on the Atlantic OCS in 2009, which was authorized by the Energy Policy Act of 2005. The act, implemented by BOEM, provides a framework for issuing leases, easements, and ROW for OCS activities. BOEM's four-phase renewable energy program (planning and analysis, lease issuance, site assessment, and construction and operations) proceeded with this initiative on a state-by-state basis. The history of BOEM's planning and leasing activities offshore of Virginia includes the following:

- On February 3, 2012, BOEM published a "Call for Information and Nominations" in the *Federal Register* (*FR*) (77 *FR* 5545) to initiate the first step in the renewable energy leasing process for offshore Virginia. The purpose of the Call was to help BOEM determine whether competitive interest exists in the Call Area and also to request information from the public on issues relevant to BOEM's review of nominations for potential leasing in the area. The comment period closed on March 19, 2012. BOEM received eight public comment submissions and eight nominations of interest from companies expressing interest in obtaining a commercial lease for a wind energy project.

- On February 3, 2012, BOEM also published in the *Federal Register* (77 *FR* 5560) a Notice of Availability for the final Environmental Assessment (EA) and a Finding of No Significant Impact for commercial wind lease issuance and site assessment activities on the Atlantic OCS offshore New Jersey, Delaware, Maryland, and Virginia. Consultations ran concurrently with preparation of the EA and included consultations under the ESA, Magnuson-Stevens Fishery Conservation and Management Act, Section 106 of the National Historic Preservation Act, and the Coastal Zone Management Act.
- On December 3, 2012, BOEM published in the *Federal Register* (77 *FR* 71621) the Virginia Proposed Sale Notice, which provided the proposed lease terms and conditions as well as details on the lease sale. A 60-day public comment period accompanied the notice. A public information seminar was held on January 17, 2013, and the comment period closed on February 1, 2013. In response, 16 comments were received as well as two additional qualification packages from companies wanting to participate in the lease sale.
- On July 23, 2013, BOEM announced in the *Federal Register* (78 *FR* 44150) that it published a Final Sale Notice announcing the date of the commercial lease sale.
- On September 4, 2013, BOEM held the commercial lease sale (i.e., auction) for the WEA offshore Virginia. This auction was the second competitive lease sale for renewable energy on the OCS. The Virginia WEA was auctioned as one lease, with Virginia Electric and Power Company (doing business as Dominion Energy Virginia, hereafter referred to as Dominion Energy) as the winner of commercial wind lease OCS-A 0483.
- On November 1, 2013, the commercial wind energy lease with Dominion Energy went into effect.
- On March 2, 2016, Dominion Energy submitted a SAP for lease OCS-A 0483. The plan details methods and procedures to collect and analyze meteorological data and information on the conditions of the marine environment within the Lease Area. BOEM approved the SAP on October 12, 2017. Conditional to the terms of the Lease, Dominion Energy submitted semi-annual progress reports to BOEM throughout the duration of the site assessment term in May and October 2014, May and October 2015, April and November 2016, and May 2017. The SAP, Appendices, and semi-annual progress reports can be accessed on BOEM's website at https://www.boem.gov/CVOW-C.
- On February 14, 2020, Dominion Energy submitted a SAP and COP Survey Plan to BOEM, with modifications submitted on March 26, April 10, May 20, and September 8, 2020; and February 1 and March 29, 2021 to conduct high-resolution geophysical (HRG), geotechnical, benthic, and other survey activities in the Lease Area, Offshore Export Cable Corridor, and Onshore Project area. BOEM acknowledged that all comments had been addressed on June 12 and September 12, 2020, and April 13, 2021. Survey work commenced in Spring 2020 and continued through August 2021.
- On December 17, 2020, Dominion Energy submitted a COP to BOEM for the construction, operations, maintenance, and eventual decommissioning of the Project within the Lease Area. Updated COP versions were submitted on June 17, October 30, and December 3, 2021, and May 6, 2022. The CVOW-C Project COP and Appendices can be accessed on BOEM's website at https://www.boem.gov/CVOW-C.
- On July 1, 2021, BOEM published in the *Federal Register* (86 *FR* 35329) a Notice of Intent to Prepare an Environmental Impact Statement (EIS) for CVOW-C. A 30-day public comment period ended on August 2, 2021, during which three public, virtual scoping meetings were held.

USACE regulates work that is authorized or permitted through Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. On May 17, 2022, Dominion Energy submitted the JPA for federal and state permits to the VMRC and USACE (VMRC JPA No. 22-1183). The JPA requests authorization from USACE and VMRC to construct 176 offshore WTGs, scour protection around the base of the WTGs, up to three OSSs, inter-array cables connecting the WTGs to the OSSs, and offshore export cables. The cable route(s) would originate from the OSSs and would connect to the electric grid in Virginia Beach, Virginia.

As the lead federal agency, BOEM will be responsible for fulfilling the collective federal responsibilities under Section 7 of the ESA of 1973 (PL 93-205), Section 106 of the National Historic Preservation Act of 1966 (PL 89-665), and the Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (PL 104-267) (see Docket No. BOEM-2021-0040). The USACE Norfolk District regulates waters of the United States and wetlands under Section 10 of the Rivers and Harbors Act, and Section 404 of the Clean Water Act. The Virginia Department of Environmental Quality (VADEQ) regulates wetlands under Section 401 of the Clean Water Act. VMRC acts as the clearinghouse for distribution of JPAs to the appropriate agencies and regulates impacts and encroachments to activities in, on, under, or over state-owned submerged lands, tidal wetlands, and dunes/beaches (Code of Virginia Title 28.2 § 1200-1420). BOEM and BSEE will enforce COP conditions and ESA terms and conditions on the OCS that may be required under any resulting permit. On September 15, 2022, the USACE Norfolk District published a public notice for the JPA (USACE file number NOA-13-00418). USACE anticipates making a permit decision on or before August 30, 2023, 90 days after BOEM's target date of June 1, 2023 for Issuance of a Record of Decision. The "OCS Air Regulations," presented in 40 CFR 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; the EPA issues OCS air permits. Dominion Energy submitted an application to the EPA for the OCS Air Permit on March 15, 2022. Emissions from Project activities on the OCS would be permitted as part of an OCS air permit and must demonstrate compliance with National Ambient Air Quality Standards. In addition to the federal OCS air regulations, the OCS sources located within 25 nautical miles (46 kilometers) of the seaward boundary of a state are subject to the requirements applicable to the Corresponding Onshore Area (COA), as determined by EPA. The full extent of the Offshore Project area boundary is located within and beyond 25 nautical miles (46 kilometers) of the seaward boundary of Virginia. As such, any OCS air sources located within 25 nautical miles (46 kilometers) of the seaward boundary will also be subject to the state specific air permitting regulatory requirements of the COA, which has been determined to be Virginia. Since the Offshore Project area is within and beyond 25 nautical miles (46 kilometers) of seaward boundary, EPA will be the regulatory authority administering and issuing the OCS air permit, which will incorporate the applicable air permitting requirements of the COA for those OCS sources located within 25 nautical miles (46 kilometers) of seaward boundary.

The USCG administers the permits for Private Aids to Navigation (PATONs) located on structures positioned in or near navigable waters of the United States. PATONs and federal aids to navigation, including radar transponders, lights, sound signals, buoys, and lighthouses, are located throughout the Action Area. USCG approval of additional PATONs during construction of the WTGs and OSSs, and along the offshore export cable corridor, would be required. These aids serve as a visual reference to support safe maritime navigation. Federal regulations governing PATONs are presented in 33 CFR 66 and address the basic requirements and responsibilities. Dominion Energy would prepare the PATONs and Local Notice to Mariners for USCG authorization a minimum of 4 months prior to commencement of operations and a minimum of 2 weeks before commencing activities, respectively. Dominion Energy would comply with applicable requirements as specified by USCG.

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

NMFS received a request for authorization to take marine mammals incidental to construction activities related to the Project, which NMFS may authorize under the MMPA. NMFS's issuance of an MMPA incidental take authorization is a major federal action and, in relation to BOEM's action, is considered a connected action (40 CFR 1501.9I(1)). The purpose of the NMFS action—which is a direct outcome of Dominion Energy's request for authorization to take marine mammals incidental to specified activities associated with the Project (e.g., pile driving)—is to evaluate Dominion Energy's request under requirements of the MMPA (16 USC 1371(a)(5)(D)) and its implementing regulations administered by NMFS and to decide whether to issue the authorization.

On July 1, 2022, Dominion Energy submitted a request for a rulemaking and Letter of Authorization (LOA) pursuant to Section 101(a)(5) of the MMPA and 50 CFR § 216 Subpart I to allow for the incidental harassment of marine mammals resulting from the installation of WTGs and OSSs; installation of goal post piles for trenchless installation of the export cable; installation of cofferdams at locations of export cable route to landfall transitions; and performance of HRG site characterization surveys operating at less than 180 kilohertz (kHz) (Tetra Tech 2022a). Dominion Energy is including activities in the LOA request that could cause acoustic disturbance to marine mammals during construction of the Project area pursuant to 50 CFR § 216.104. The LOA application was deemed Adequate and Complete by NMFS on September 15, 2022. Dominion Energy subsequently submitted an addendum to the LOA application to NMFS on December 16, 2022 to document updates to the calculated and requested marine mammal takes. The addendum is currently under NMFS review.

1.1.1 Endangered Species Act Section 7 Consultation History

BOEM completed an EA on the issuance of leases for wind resource data collection on the OCS Offshore within the New Jersey, Delaware, Maryland, and Virginia Wind Energy Areas in 2012 and on associated site characterization and site assessment activities that could occur on those lease areas, including the Lease Area for the Project. On September 20, 2011, NMFS issued a programmatic informal consultation for the Mid-Atlantic WEAs (NMFS 2011). The 2011 consultation included site assessment and data collection activities and metocean buoy installation that occurred in preparation for submitting a COP, and was updated with a more recent programmatic consultation on these activities in September 2021 (Baker and Howsen 2021). However, these consultations do not include the construction, operations, maintenance, and eventual decommissioning of an offshore wind farm, which is the subject of this separate consultation. A similar consultation was conducted for the construction, operation, and decommissioning of the Virginia Offshore Wind Technology Advancement Project, and the biological opinion published by NMFS in 2015 (NMFS 2015). Since this biological opinion was published, the humpback whale population in the Northwestern Atlantic has been delisted; therefore, the species is not carried forward in this consultation (81 *FR* 62259).

1.2 Action Area

Under ESA Section 7 consultation regulations (50 CFR 402.02), the Action Area refers to the area affected by the Proposed Action and also includes the area where all consequences to listed species or critical habitat that are caused by the Proposed Action would occur, including actions that would occur outside the immediate area involved in the action (50 CFR 402.17). The Action Area, therefore, includes the Lease Area, export cable routes, and subsequent locations affected by underwater noise, electromagnetic fields (EMF), turbidity and water quality effects, habitat disturbance effects, vessel and survey operations, and other effects associated with the Proposed Action that may affect listed species, critical habitat, or both. The Action Area as defined also includes vessel transit routes between port locations, including ports outside of Virginia, necessary for completion of the Proposed Action. Potential vessel routes from port locations in Europe, eastern Canada, the Gulf of Mexico, and multiple ports in eastern Virginia (see Section 1.3, *Description of the Proposed Action*), are considered as part of the Action Area. The exact ports to be used will not be known until additional details are available when contracts are in place. Foreign ports are only anticipated to be utilized during construction; all O&M vessels are expected to come from ports in Virginia. The number of ports under consideration does not increase the number of vessel trips that are likely to occur but may affect the location and length of the transits. See Section 1.3, *Description of the Proposed Action* for a complete description of activities, including vessel transits, associated with the Proposed Action.

For the purposes of this BA, the Project area is considered the portion of the full Action Area where construction and eventual O&M of the Proposed Action will take place. The Project area, therefore, encompasses the Lease Area, all inter-array cable routes, and the transmission cable right-of-way to the onshore cable landing location in Virginia Beach, Virginia (Figure 1-1). Due to the difference in risk to ESA-listed species associated with Project activities within the Project area compared to activities within the Action Area, this portion of the Action Area is treated separately, where applicable, in Section 3, *Effects of the Proposed Action*.

1.3 Description of the Proposed Action

As detailed in Section 2.1 of the Draft EIS, the Proposed Action would allow Dominion Energy to construct, operate, maintain, and eventually decommission a wind energy facility up to 3,000 MW in scale on the OCS offshore Virginia within the range of design parameters outlined in Section 1 of the COP (Dominion Energy 2022). The Offshore Project Components, including the Offshore Substations, Inter-Array Cables, and WTGs, will be located in federal waters in the Lease Area, while the Offshore Export Cable Route Corridor will traverse both federal and state territorial waters of Virginia; the Offshore Trenchless Installation Punch-Out location will be in Virginia state waters. The onshore components of the Project, including the onshore substation, interconnection cables, switching station, onshore export cables, and the cable landing location will be located in Virginia Beach, Virginia. The construction stage of the Project will include temporary construction laydown area(s) and construction port(s) primarily at the existing Virginia Port Authority (VPA) Portsmouth Marine Terminal (PMT) in Portsmouth, Virginia. Ports in Europe and Novia Scotia, Canada may also be used during construction. Additional vessels supporting construction activities may also mobilize from port(s) in the Gulf of Mexico, though the number of Project vessels transiting from this region would be minimal and would only comprise smaller support vessels. Dominion Energy's wind turbine installation vessel (the "Charybdis") is currently being constructed in Brownsville, Texas, but will be deployed on Orsted-Eversource projects in the northeast before construction of the CVOW-C Project and will be homeported in Virginia during construction of the Proposed Action.

The O&M stage of the Project will include an onshore O&M facility with an associated Base Port, which will be in Lambert's Point, located on a brownfield site in Norfolk, Virginia, the VPA's PMT, or Newport News Marine Terminal in the Hampton Roads area of Virginia. Though Dominion Energy is considering all of these locations for the O&M facility, the preferred location is Lambert's Point in Norfolk, Virginia. The Onshore Substation is an existing substation currently owned by Dominion Energy called the Fentress Substation. Onshore export cables are anticipated to be constructed as underground transmission lines from the cable landing location to a common location, while the interconnection cables are expected to be constructed as overhead transmission lines or as a combination of overhead and underground (hybrid) transmission lines from the common location to the onshore substation. The key components of the Project are summarized in Table 1-1.

Table 1-1 Summary of Project components in the Proposed Action

Project Component	Proposed Action
Wind Turbine Generators (WTG)	Up to 16 megawatts (MW) (SG-14-222 DD) 14.7 MW (SG-14-222 DD) with power boost technology has been selected by Dominion Energy
WTG Layout	202 potential WTG foundation sites, with a likely scenario of 176 WTGs installed Spacing = 0.75 to 0.93 nautical miles in an offset grid pattern (east-west by northwest by southeast gridded layout)
Foundations	31-foot (9.5-meter) monopiles (WTG), 9.2-foot (2.8-meter) jacket pin piles (OSS)
Inter-Array Cables	66-kilovolt (kV) inter-array cables
Offshore Substations (OSSs)	Three OSSs comprising 12 jacket pin piles Actual capacity may vary depending on final capacity of the Project
Offshore Export Cables	Up to nine buried submarine high voltage alternating current cables located within the offshore export cable route corridor Cable landing location at the proposed parking lot, west of the firing range at State Military Reservation (SMR)
Onshore Export Cable Route (Cable Landing Location to Common Location north of Harpers Road)	Cable landing location at the proposed parking lot, west of the firing range at SMR to the common location north of Harpers Road
Switching Station	One switching station: Harpers Switching Station associated with Interconnection Cable Route Option 1
Interconnection Cable Route (Common Location north of Harpers Road to Onshore Substation/Point of Interconnection [POI])	Switching Station to the onshore substation/POI; one overhead interconnection cable route option, with one switching station
Onshore Substation	Fentress Substation

Source: COP Section 2, Table 2.3-1 (Dominion Energy 2022)

1.3.1 Construction and Installation

The Proposed Action would include the construction and installation of both onshore and offshore facilities. Construction and installation would begin in 2023 and be completed in 2027 (Figure 1-2). Dominion Energy anticipates beginning with land-based construction (onshore export and interconnection cable installation, switching station construction, and existing onshore substation upgrade construction) in the third quarter of 2023 and finishing in 2025. Construction of the offshore components would begin in the fourth quarter of 2023 with scour protection pre-installation (ending in 2025), offshore export cable installation (ending in 2026), and monopile and transition piece transport and onshore staging (ending in 2026). Monopile installation and offshore substation installation would occur from May 2024 through October 2025. Transition piece installation and scour protection post-installation would occur in 2024 through 2026. Inter-array cable installation and WTG pre-assembly and installation are planned to start in 2025 and end in 2026 and 2027, respectively. Commissioning is planned for 2024 through 2027. As per Dominion Energy's commitment to seasonal restrictions from November through April, no WTG or OSS foundation installation activities are planned for winter. Monopile and OSS pin pile installation is planned for part of spring (May), summer (June, July, August), and part of fall (September, October) annually. Dominion Energy anticipates that all WTG monopile and offshore substation jacket foundations will be installed by October 31, 2025. However, as a contingency to account for the potential for delays due to weather, other unanticipated events, or both, Dominion Energy has proposed installation of up to 15 foundations in 2026. If required to accommodate delays in the installation schedule, the 15 installations would occur between May 1 and September 30, 2026. Inter-array and offshore export cable emplacement associated with construction of the WTGs and OSSs would occur during two separate construction seasons, which would provide a recovery period for sand ridge habitats between the installation of the inter-array and offshore export cables. Additionally, there would be an approximate 1- to 2.5-month period between installation of each offshore export cable installation, with the potential for a longer period dependent on weather conditions and operational needs for cable resupply. There would be several months of seafloor rest following the completion of offshore export cable installation at one OSS prior to commencement of inter-array cable emplacement associated with the next OSS.

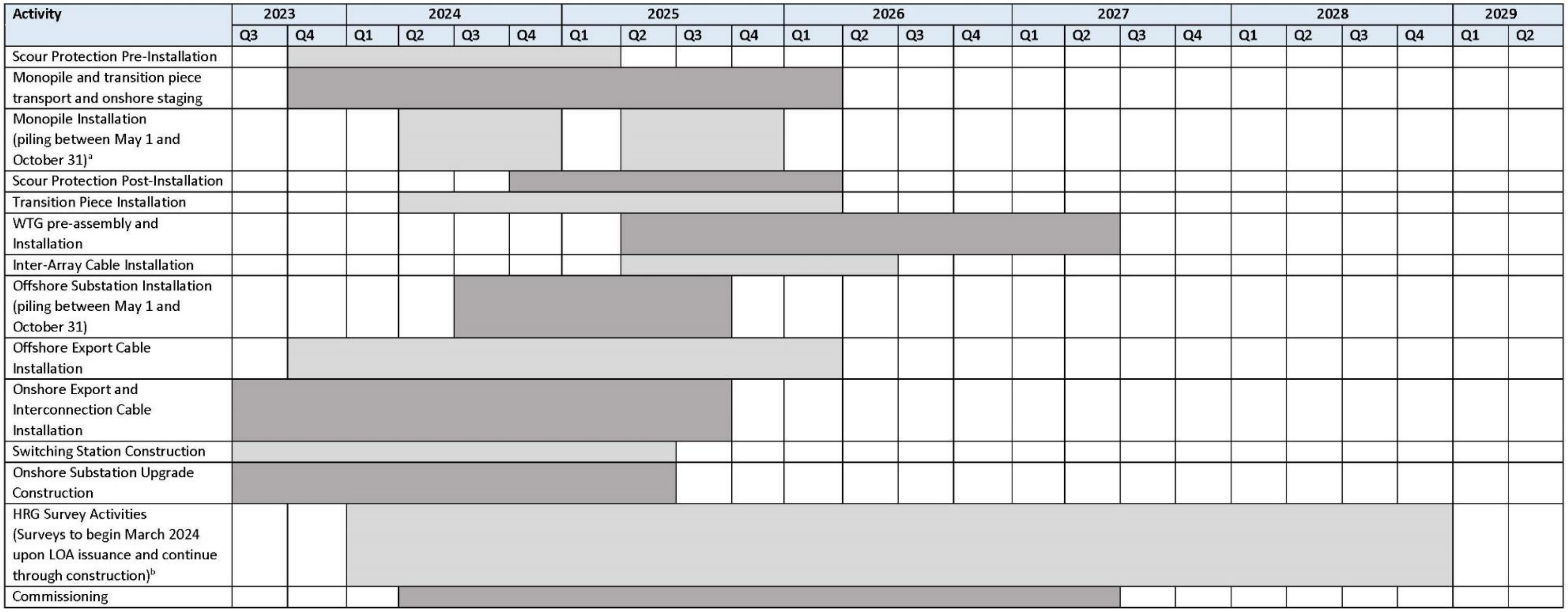

Figure 1-2 Indicative project schedule

Source: Construction and Operations Plan Table 1.1-3 (Dominion Energy 2022) and Letter of Authorization (LOA) Addendum #2 Table 1 (Tetra Tech 2022c)
HRG = high-resolution geophysical; WTG = wind turbine generator
[a] Dominion Energy anticipates that all WTG monopile and offshore substation jacket foundations will be installed by October 31, 2025. However, as a contingency to account for the potential for delays due to weather, other unanticipated events, or both, Dominion Energy has proposed installation of up to 15 foundations in 2026. If required to accommodate delays in the installation schedule, the 15 installations would occur between May 1 and September 30, 2026.
[b] Activities planned prior to March 2024 that could result in harassment of marine mammals include the unexploded ordance (UXO) identification HRG surveys covered in the authorized UXO Survey Incidental Harassment Authorization (IHA) (Authorized May 27, 2022 to May 26, 2023) and HRG surveys planned for December 2023 to March 2024 that would be covered under a separate IHA, which would terminate with the start of the LOA approval. HRG Surveys preceding the start date of the LOA in March 2024 are not included. As per the NOAA August 2021 webinar, the developer may need to cover pre-construction surveys under a separate IHA. Such permits have been authorized for Vineyard Wind and Ocean Wind.

1.3.1.1 Onshore Activities and Facilities

Proposed Onshore Project elements include the cable landing location, the onshore export cable route, the switching station, the onshore interconnection cable routes, and expansions/upgrades to the onshore substation that connects to the existing grid (Figure 1-3). These elements collectively compose the Onshore Project area.

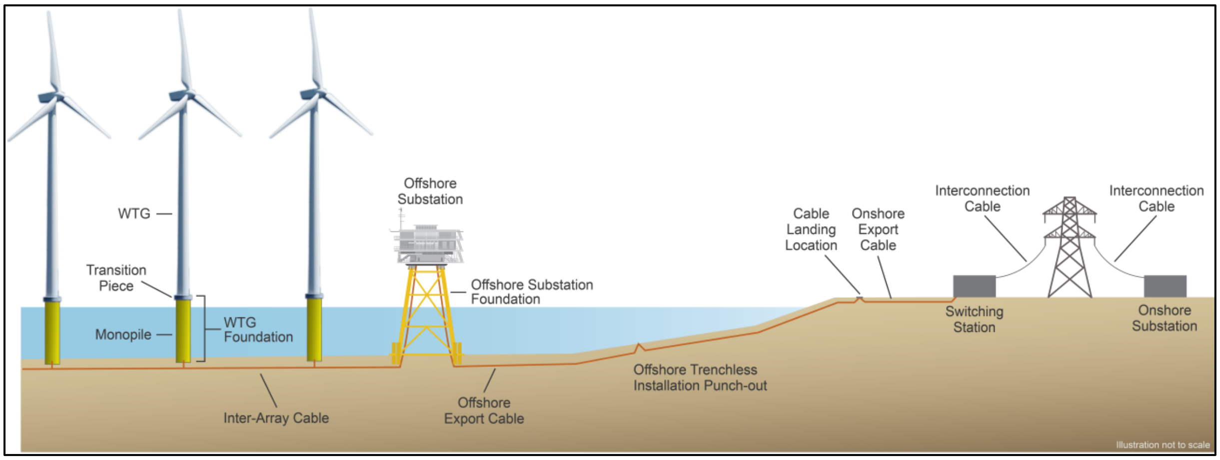

Figure 1-3 Overall Project operational concept

Note: The Interconnection Cable will begin before the Switching Station, at a Common Location north of Harpers Road.

The Proposed Action would include a cable landing location in Virginia Beach, Virginia as shown in Figure 1-4. The cable landing location would be located at the proposed parking lot west of the firing range at the State Military Reservation (SMR). Dominion Energy plans to use trenchless installation to install the offshore export cables under the beach and dune and bring them to shore through a series of conduits including horizontal directional drilling (HDD), direct steerable pipe thrusting, and microtunneling to avoid effects on the sensitive beach and dune habitats. HDD would create a pilot bore along the cable corridor, expand the bore to a diameter necessary for the cables, then pull the cables into the prepared borehole. Direct steerable pipe thrusting is similar, though the bore is created and expanded simultaneously. Upon exiting the conduits, the nine 230-kilovolt (kV) offshore export cables would be spliced in a series of nine separate single circuit vaults laid in a single ROW and transition to the onshore export cables at the cable landing location. The onshore export cables will be installed underground within vaults and duct banks to the Switching Station. Microtunneling is a trenchless construction method to install casing pipes from a jacking to a receiving shaft with minimal surface disturbance, through complex subsurface conditions ranging from soil to rock and typically below groundwater table. Generally, microtunneling is performed for casing pipe diameters ranging from 24 to 96 inches (i609.6 to 2,438.4 millimeters [mm]); however, installing casing pipe diameters outside of this range is possible depending on the project conditions. The product pipe(s) are subsequently installed inside the casing pipe to complete the installation. The installation methodology proposed would comply with local and state regulations and guidelines and has been determined to be the most appropriate installation technology that would avoid affecting a forested area on the SMR. Additional details on these installation methodologies are provided in Section 3.4.2.1 of the COP (Dominion Energy 2022). The maximum area of temporary disturbance for cable landing location is anticipated to be approximately 2.8 acres (1.1 hectares [hectares]) and the maximum temporary workspace at the nearshore trenchless installation area would be approximately 8.8 acres (3.6 hectares).

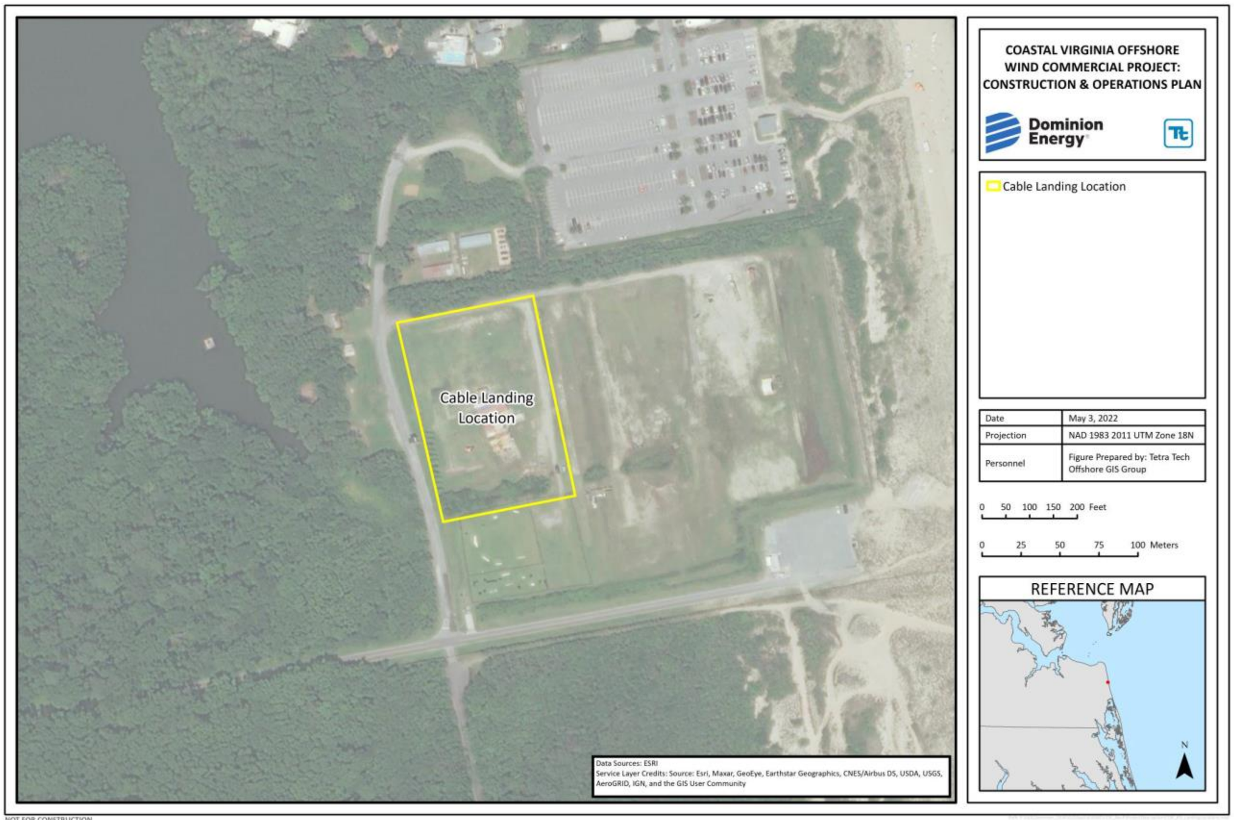

Figure 1-4 Onshore Project components—cable landing location

Onshore export cables would transfer the electricity from the cable landing location to a common location at the Harpers Switching Station north of Harpers Road and would comprise 27 single-phase 230-kV onshore export cables installed underground within the onshore export cable route corridor. The proposed Project currently includes a single onshore export cable route that plans to use HDD below Lake Christine. The onshore export cable route (Figure 1-5) would be 4.41 miles (7.10 kilometers) long, and the operational corridor would be approximately 51 acres (20.5 hectares). Land cover classes following classifications from the National Land Cover Database (NLCD) for the onshore export cable route between the cable landing location and the Harpers Switching Station include Developed open space; Developed land, low intensity; Developed land, medium intensity; cultivated crops; Developed land, high intensity; woody wetlands; evergreen forest; deciduous forest; and mixed forest (COP Table 4.2-7; Dominion Energy 2022). It is estimated that a total of 39.24 acres (15.88 hectares) of all land cover classes may be temporarily disturbed during cable installation, and 12.07 acres (4.88 hectares) will be altered during O&M (COP Table 4.2-7; Dominion Energy 2022).

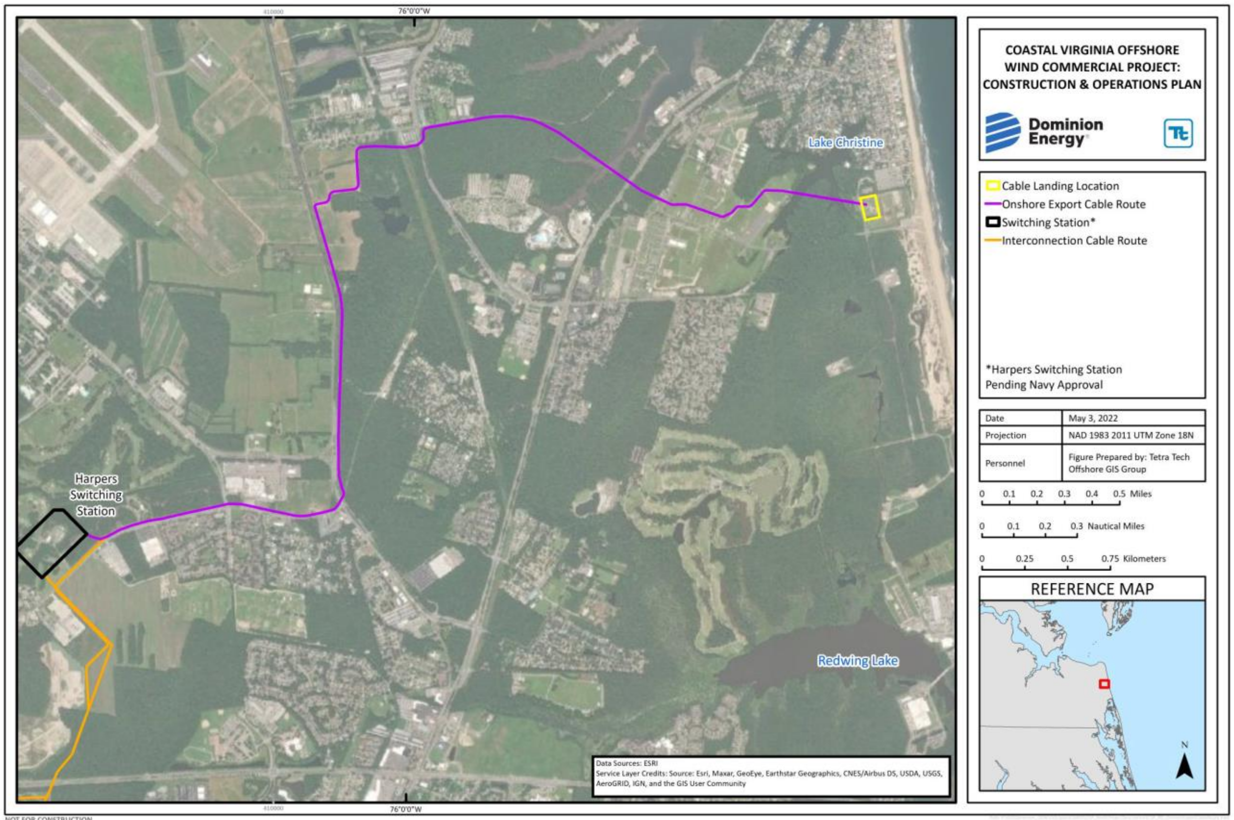

Figure 1-5 Onshore Project components—onshore export cable route

The switching station would be constructed north of Harpers Road (Harpers Switching Station, preferred). The switching station would collect power and convert an underground cable configuration to an overhead configuration. The power would then be transmitted to the existing onshore substation for distribution to the grid. The switching station would be an aboveground, fenced facility and would generally have the appearance of a typical larger Dominion Energy substation. Construction of the Switching Station would involve site clearing and grading, foundation and equipment construction, and site mitigation and restoration. Prior to construction, Dominion Energy will conduct land and other surveys including geophysical, geotechnical, environmental, and cultural studies to support permits and approvals for construction of the switching station. Construction activities will include backhoes, excavators, bulldozers, skid-steer loaders, dump trucks, cranes, and temporary generators. NLCD land cover classes within the construction footprint of the Harpers Switching Station include Developed open space; Developed land, medium intensity; Developed land, low intensity; woody wetlands; and mixed forest (COP Table 4.2-7; Dominion Energy 2022). A maximum area of 21 acres (8.49 hectares) of all land classes would be temporarily disturbed during construction, and up to 12.38 acres (5.01 hectares) of land will be altered during O&M (COP Table 4.2-7; Dominion Energy 2022). The switching station would serve as a transition point where the power transmitted through 27 230-kV onshore export cables would be collected to three 230-kV interconnection cables.

A triple-circuit 230-kV transmission line would be constructed from Harpers Road along an interconnection cable route corridor to the expanded/upgraded onshore substation at Fentress. The interconnection cable (Interconnection Cable Route Option 1) would be installed as overhead transmission facilities, and a maximum construction and installation corridor area of 254.4 acres (103.0 hectares) would be needed for overhead cables. Existing ROWs would be used to the extent practical. Installation of the interconnection cable may require trimming of tree limbs either along the edge of the upland ROW, or trees outside the ROW that have potential to come within 10 feet (3 meters) of the transmission wires or structures if they were to fall. Danger tree removal will be accomplished by hand in wetland areas and within 100 feet (31 meters) of streams, if applicable. Care will be taken not to leave debris in streams or wetland areas and matting may be used for heavy equipment in these areas. Erosion control devices will also be used on an ongoing basis during all clearing and construction activities until the ROW has been restored. Upon completion of Interconnection Cable construction, Dominion Energy will restore the ROW utilizing site rehabilitation procedures outlined in Dominion Energy's Standards and Specifications for Erosion and Sediment Control and Stormwater Management for Construction and Maintenance of Linear Electric Transmission Facilities that was approved by the VADEQ. Construction and installation activities will include backhoes, excavators, bulldozers, skid-steer loaders, dump trucks, cranes, and temporary generators.

Interconnection Cable Route Option 1 will cross over the various NLCD land cover classes including: cultivated crops; Developed open space; Developed land, low intensity; Developed land, medium intensity; open water; Developed land, high intensity; emergent herbaceous wetlands; woody wetlands; deciduous forest; mixed forest; and shrub/scrub (COP Table 4.2-7; Dominion Energy 2022). A maximum area of 71.17 acres (28.8 hectares) of all land classes would be temporarily disturbed during construction, and up to 120.70 acres (48.84 hectares) of land will be altered during O&M (COP Table 4.2-7; Dominion Energy 2022).

The cable landing location would be located at the proposed parking lot west of the firing range at the SMR. The existing onshore substation (Fentress Substation) that would be expanded/upgraded to accommodate the electricity from the Project is located in Chesapeake, Virginia. The Fentress Substation would serve as the final Point of Interconnection (POI) for power distribution to the Pennsylvania–New Jersey–Maryland interconnection grid. Expansions/upgrades to the Onshore Substation will include:

- Safety fencing installed along the perimeter of the expansion;
- Erosion controls implemented in accordance with the Dominion Energy's Erosion and Sediment Control Plan, which will be prepared based on the requirements at 9 VAC §25-840 and 9 VAC §25-870-55, respectively, as applicable;
- Preparation of the site, including clearing, filling, excavation, and grading as necessary;
- A stormwater management system installed in accordance with Dominion Energy's Stormwater Pollution Prevention Plan, which will be prepared based on the requirements at 9 VAC §25-840 and 9 VAC §25-870-55, respectively, as applicable;
- Installation of foundations and sumps;
- Heavy-load vehicles used to deliver and place equipment;
- Completion of cable installation, including connection of the onshore export cables;
- Testing and commissioning of the new equipment; and
- Landscaping installed, restored, or both as required by applicable regulations.

The maximum area of land disturbance associated with the construction activities for the Fentress Substation would be approximately 6.2 to 21.4 acres (2.5 to 8.7 hectares). NLCD land cover classes within the Fentress Substation construction footprint include mixed forest; woody wetlands; evergreen forest; Developed land, medium intensity; emergent herbaceous wetlands; Developed land, low intensity; and Developed land, high intensity (COP Table 4.2-7; Dominion Energy 2022). The onshore substation expansions/upgrades would serve as the POI for the three 230/500-kV auto-transformers for connection into the grid. The existing equipment at the onshore substation affected by this Project would include one 500-kV transmission line, two 230/500-kV transformer banks, and a security fence. The onshore substation expansion/upgrades would include the addition of three 230/500-kV transformer banks, a

500-kV gas-insulated switchgear building, static poles, and other ancillary equipment. The facility is planned to be surrounded by a security fence approximately 20 feet (6.1 meters) high.

On August 15, 2022, BOEM was notified by Dominion Energy that the Virginia State Corporation Commission approved, by issuance of a certificate of public convenience and need, Dominion's preferred cable route alternative (Route 1) for the Virginia facilities, which includes all of the transmission interconnection lines and stations starting 3 miles offshore, the single proposed underground lines and route from the SMR to the Harpers Switching Station, and Route 1 for the overhead lines from Harpers Switching Station to Fentress Substation. Route 1 is Dominion Energy's preferred route in the BOEM process, and the route for which Dominion Energy seeks a Clean Water Act permit from USACE. Through its issuance of a certificate of public convenience and need for the Virginia facilities and Route 1, that route becomes the only Virginia state-authorized route Dominion Energy can use for the Proposed Action.

1.3.1.2 Offshore Activities and Facilities

The Offshore Project components within the Proposed Action include WTGs and their foundations, OSSs and their foundations, scour protection for foundations, inter-array cables, and offshore export cables (these elements collectively compose the Offshore Project area). All Offshore Project elements would be on the OCS, except for a portion of the offshore export cables, which will be within state waters. WTGs and OSSs would be, at minimum, 27 miles (24 nautical miles, 44 kilometers) offshore (Figure 1-1). HRG survey activities will be conducted, and activities include pre-lay surveys prior to construction, as-built surveys during construction, and post-construction surveys. All surveys would use typical HRG sources including multibeam echosounders, single beam depth sounders, sidescan sonar, compressed high-intensity radiated pulse (CHIRPs), parametric sub-bottom profilers, boomers, and sparkers. Potential detonation of unexploded ordnances (UXOs) is not included under the Proposed Action and is not anticipated. Preliminary survey data and analysis of available information indicates potential UXO can be avoided through micrositing and other non-detonation measures (Tetra Tech 2022a) which are described later in this section.

Dominion Energy's Proposed Action includes the construction and installation of 202 14- to 16-MW WTGs. Of the 202 WTG sites, 26 are considered spare locations to provide the flexibility to switch positions if any sites are determined unfavorable for monopile foundation installation. The majority of spare WTG locations are located along the northwestern and northeastern boundaries of the Lease Area and within an area referred to as the fish haven area[a] (Figure 1-6). A likely scenario of 176 WTGs is anticipated. The final WTG layout, regardless of the number of WTGs, would be arranged in a grid pattern oriented at 35 degrees to minimize wake losses within the wind farm (Figure 1-6). WTGs would be spaced approximately 0.75 nautical mile (1.39 kilometers) in an east-west direction and 0.93 nautical mile (1.72 kilometers) in a north–south direction. However, the distances between some turbines in the final WTG layout may be slightly larger or smaller, subject to micrositing; some WTG foundation installation locations may shift up to 500 feet (152 meters) to avoid obstructions, sensitive cultural and natural resources, and due to local site condition variations. Turbine tip height as measured from mean seal level would be between 804 feet (245 meters) and 869 feet (265 meters). The distance from the bottom of the turbine tip to the highest astronomical tide would be between 82 feet (25 meters) and

a The Fish Haven is an area of documented recreational fisheries uses within the northern border of the Lease Area known as the *Triangle Wrecks* and *Triangle Reef*. The area consists of several large, scuttled World War II-era ships, tires, cable spools, and other materials deposited since the 1970s to facilitate an artificial reef development (COP Sections 2.1.1 and 4.2.4.2; Dominion Energy 2022).

115 feet (35 meters). Refer to Figure 1-7 for a simplified elevation drawing of Dominion's proposed WTG layout. Dominion Energy would mount the WTGs on monopile foundations consisting of two parts: a lower foundation pile (monopile) driven into the seabed and an upper transition piece mounted on top of the monopile (together referred to as the WTG foundation), which have a maximum diameter of 31 feet (9.5 meters).

The WTG foundations would have scour protection Installed around the base of the monopile. The final need, type, and method for installing scour protection for the WTG foundations would be determined in consultation and coordination with relevant jurisdictional agencies prior to construction and installation, and environmental conditions at the WTG construction and installation location will further determine the design of the scour protection. Scour protection will consist of small and large rocks sourced from the United States (U.S.), Canada, or both and will be installed with a dynamic positioning (DP) vessel equipped with a fallpipe. Currently, Dominion Energy proposes to install two layers of scour protection; both installed prior to installation of the WTG monopile foundation. On specific sites, the second layer might be installed after installation of the WTG monopile foundation, depending on the need for large-sized stones at some locations. The total area of disturbance for the WTG foundations and associated scour protection ranges from 152.4 acres (61.7 hectares) under the likely scenario to 179.3 acres (72.6 hectares) under the Proposed Action (COP Table 4.2-17; Dominion Energy 2022).

During installation, the monopile foundations will be lifted off by the on-board crane of the installation vessel with a dedicated lifting tool and placed on the seabed atop the pre-installed scour protection layers. It is estimated that a maximum of 55.7 acres (22.5 hectares) of seafloor will be temporarily disturbed by the jack-up vessels during WTG foundation installation. Each foundation will be initially installed to the target penetration depth via vibratory pile driving to reduce the risk of pile run, followed by impact pile driving using a maximum 4,000-kilojoule (kJ) impact hammer to complete the installation. Monopiles will be installed by either one or more DP heavy lift vessels (HLVs) or jack-up vessels with sufficient crane capacity. Monopiles would be installed in one or more years between May 1 and October 31 to avoid the North Atlantic right whale (NARW) migration season (Section 3.2.2, *North Atlantic Right Whale*). All WTGs would be installed using 31-foot (9.5-meter) monopile foundations, which would require a piling schedule under one of the three following scenarios, using comparable hammer energies for all scenarios:

- **Scenario 1 (Standard Driving Schedule)**: One monopile foundation is installed in a 24-hour period using a vibratory pile driving for a duration of 60 minutes o followed by 85 minutes of impact pile driving.
- **Scenario 2 (Hard-to-Drive Schedule)**: One monopile foundation is installed in a 24-hour period using a "hard-to-drive" schedule where additional time is required to reach the target penetration requiring up to 30 minutes of vibratory pile driving followed by 99 minutes of impact pile driving.
- **Scenario 3 (One Standard and One Hard-to-Drive Schedule)**: Two monopile foundations are installed in a 24-hour period, one using the Standard Driving Schedule, and the other following the Hard-to-Drive Schedule which totals up to 90 minutes of vibratory pile driving followed by 184 minutes of impact pile driving for both foundations. The primary indicator between the Standard Driving Schedule and Hard-to-Drive Schedule would be the local substrate conditions at the foundation installation which may require additional pile strikes with the impact hammer to reach pile stability and the target penetration depth. The number of strikes at each associated hammer energy are provided in Table 1-2.

Table 1-2 Summary of pile strikes, piling progression, and pile strikes for the three WTG foundation installation scenarios

Piling Scenario	Hammer Energy (%)	Hammer Energy (J)	Duration (minutes)	Strikes per Minute	Total Number of Strikes
Scenario 1 (Standard Driving Schedule)	20	800	8	42	324
	40	1,600	32	40	1,296
	80	3,200	36	36	1,296
	100	4,000	9	36	324
Scenario 2 (Hard-to-Drive Schedule)	20	800	13	42	558
	40	1,600	19	40	744
	80	3,200	31	36	1,116
	100	4,000	36	36	1,302
Scenario 3 (One Standard and One Hard-to-Drive Schedule)	20	800	21	42	882
	40	1,600	51	40	2,040
	80	3,200	67	36	2,412
	100	4,000	45	36	1,626

Source: COP Appendix Z, Table Z-8 (Dominion Energy 2022).

The exact number of WTG foundations requiring the piling schedule in each scenario is not known at this time, however, for the purposes of the modeling conducted for the COP (Appendix Z; Dominion Energy 2022) and the LOA application (Tetra Tech 2022a), a proposed pile installation schedule was developed using preliminary seabed data available for the wind farm area. The anticipated pile installation schedule, which includes the number of foundations installed under each of the three scenarios previously stated is provided in Table 1-3.

Table 1-3 Proposed pile-driving installation for Project construction under the Proposed Action

Year	Month	Total Number of Foundations Installed	Number Standard WTG Installations	Number Hard-to-Drive WTG Installations	Number of Days with Two WTGs Installed
2024	May	18	5	13	1
	June	25	6	19	6
	July	26	7	19	6
	August	2 WTGs, 12 OSSs	1	1	1
	September	13	3	10	0
	October	11	1	10	0
2024 Total		**95 WTGs, 12 OSSs**	**23**	**72**	**14**
2025	May	16	6	10	1
	June	24	8	14	6
	July	26	8	16	6
	August	20	6	14	6
	September	5	2	3	0
	October	1	1	0	0
2025 Total		**88 WTG**	**31**	**57**	**19**

Source: Tetra Tech 2022c.
OSS = offshore substation; WTG = wind turbine generator.

Dominion Energy proposes using near-to-pile noise mitigation systems such as the Hydro Sound Damper, the Noise Mitigation Sleeve, or the AdBm Noise Mitigation System; far-from-pile noise mitigation systems, or both such as a double big bubble curtain (DBBC), to achieve, at minimum, acoustic isopleth ranges that meet the modeled scenario using 10 dB noise mitigation (Bellmann et al. 2020). A bubble curtain system is a compressed air system (air bubble barrier) for sound absorption in water. Sound stimulation of air bubbles at or close to their resonance frequency effectively reduces the loudness of the radiated sound wave (i.e., the noise produced during pile driving) by means of scattering and absorption effects. The DBBC hoses will be deployed before the foundation installation vessel is in position. Two air hoses would be placed in a circular or elliptical shape at radii of approximately 591 feet (180 meters) and 755 feet (230 meters) from the monopile installation location. DBBCs will be pre-deployed at two to three foundation installation locations and would be recovered as soon as the piling is completed and re-deployed at another foundation installation location. Approximately 125.9 to 148.1 acres (50.9 to 59.9 hectares) of seafloor will be temporarily disturbed by the platform supply vessel during DBBC installation.

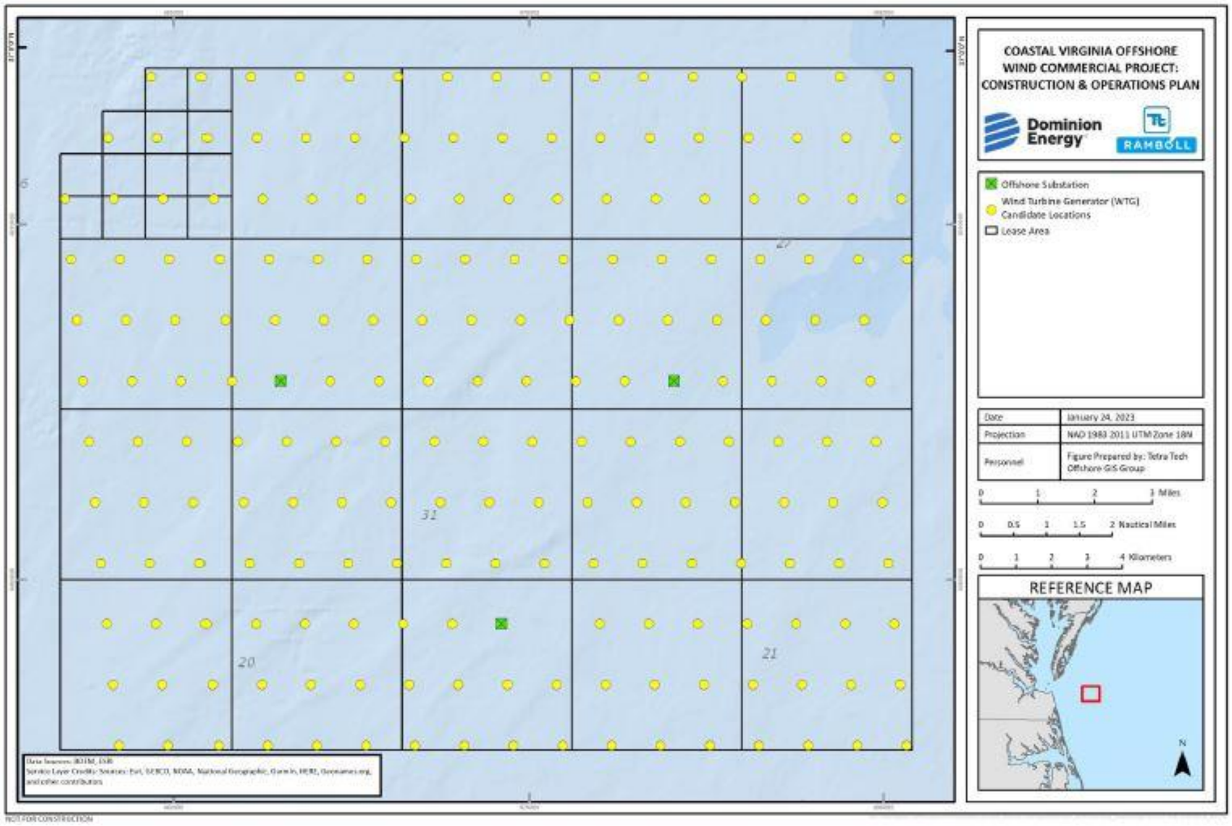

Figure 1-6 CVOW-C WTG and offshore substation layout

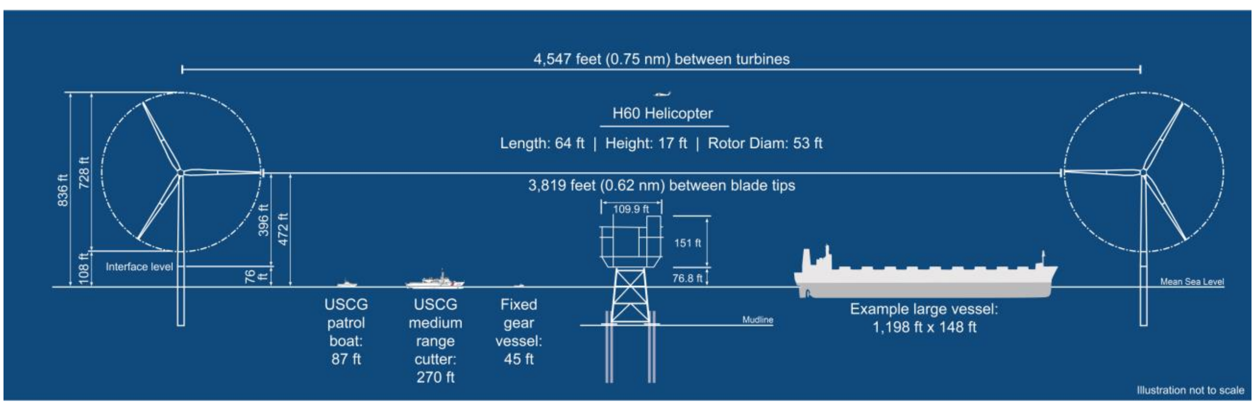

Figure 1-7 Scaled representation of Dominion Energy's proposed Offshore Project components and common vessel types relative to WTG rotor diameter and 0.75 nautical mile turbine spacing

Dominion Energy proposes to construct three OSSs. The OSSs would comprise two main components: a foundation attached to the seafloor and a topside to contain the decks holding the main electrical and support equipment. Dominion Energy is also considering adding a helideck to support monitoring and maintenance to each of the OSSs for normal and emergency access by helicopters. Dominion Energy is proposing to use pre-installed, piled, jacket foundations, which comprise four pin piles each with a maximum diameter of 9.2 feet (2.8 meters) to support the OSSs. Prior to construction and installation of the piled jacket foundations, an area of up to 656 feet (200 meters) around the center of each OSS location will be checked and cleared for debris, large boulders, and UXO. Based on no encounters with boulders/rocks in either the course of the extensive survey activities for the CVOW Pilot or Commercial Projects, Dominion Energy does not anticipate the need for boulder removal but has included the possibility that it may be needed following further detailed engineering and installation planning. Furthermore, route clearance (e.g., by means of pre-lay grapnel runs) will be performed along the offshore export cable route corridor and inter-array cable routes prior to any installation activity.

Once the construction and installation location has been prepared, the jacket will be brought to the site using a feeder barge or vessel. The jacket will be lifted and placed in the designated target position via a floating DP HLV, which may temporarily disturb up to 3.6 acres (1.5 hectares) of seafloor during installation. The offshore substation jacket foundation piles will be installed before the jacket is placed on the seabed (i.e., pre-installed), so a piling template will be lowered onto the location where the jacket will be installed. It is estimated that a total of 1.9 acres (0.8 hectare) of seafloor will be temporarily disturbed by the pin pile template during installation. The OSS jacket foundations will be placed into the template and then will first be installed via vibratory pile driving to reduce the risk of pile run, followed by impact pile driving using a maximum 3,000-kJ impact hammer to complete the installation. The piling schedule scenario for the OSS includes up to two pin piles installed per day, requiring up to 120 minutes of vibratory pile driving followed by 410 minutes of impact pile driving for both pin piles (COP Appendix Z; Dominion Energy 2022). The number of strikes and associated hammer energies are provided in Table 1-4.

Table 1-4 Summary of pile strikes, piling progression, and pile strikes for the Offshore Substation Foundation Installation Scenario

Piling Scenario	Hammer Energy (%)	Hammer Energy (J)	Duration (minutes)	Strikes per Minute	Total Number of Strikes
Scenario 4 (OSS Piled Jacket Foundation)	20	600	36	42	1,512
	40	1,200	38	40	1,512
	80	2,400	84	36	3,024
	100	3,000	252	36	9,072

Source: COP Appendix Z, Table Z-8 (Dominion Energy 2022).

It is currently proposed that all 12 jacket pin piles for the OSS will be installed during August 2024. However, like the WTG monopile foundations, any changes to the schedule would remain between May and October of each year to avoid the time of the year NARWs have an increased presence in the region (Dominion Energy 2022).

The OSS foundations are not foreseen to have scour protection installed around the base of the piled jackets. However, if detailed engineering indicates the need for scour protection, the type and method for installing scour protection for the OSS foundations would be determined in consultation and coordination with relevant jurisdictional agencies prior to construction and installation. If necessary, Dominion Energy currently estimates that up to 2.86 acres (1.16 hectares) of scour protection would be installed for the OSS foundations (COP Table 4.2-17; Dominion Energy 2022). Dominion Energy believes that it is possible to design and install the 9.2-foot (2.8-meter) pin piles for the piled jacket foundations to the desired target penetration depth of 230 to 269 feet (70 to 82 meters). The distance of the OSS topside substructure base above the highest astronomical tide would be between 56 and 151 feet (17 and 46 meters).

The inter-array cable system would be composed of a series of cable “strings” that interconnect a small grouping of WTGs to the offshore substations. The inter-array cables would consist of strings of three-core copper, aluminum conductor, or both, with a rated voltage of 72.5 kV and an operating voltage of 66 kV, connecting up to six WTGs per string. The WTG strings would be connected to each other via link/switch, and each OSS would be tied to a WTG string. Dominion Energy anticipates approximately 12 WTG strings would be connected to each OSS, for a total of 36 WTG strings. However, the number of WTGs per string, the number of WTG strings, or both connecting to each OSS may be modified given the final layout of WTGs. Prior to the installation of the inter-array cable, Dominion Energy will complete route clearance, including UXO surveys, and pre-lay grapnel activities to identify and remove as appropriate any obstructions within the proposed 82-foot (25-meter) wide inter-array cable installation corridors. UXO identification surveys, in particular, will be completed in a wider corridor of 164 feet (50 meters) to allow for rerouting of the cable as necessary to avoid identified features where clearance is not possible. Dominion Energy intends to microsite around all UXOs to the maximum extent practicable. Should micrositing not be feasible, the UXO will be relocated to a safe location (COP Section 3; Dominion Energy 2023). Before any manipulation of UXO is done, onboard UXO experts will confirm that the UXO is "safe to handle," meaning the risk of accidental detonation is as low as reasonably possible given that industry standard handling procedures are followed. In any case, confirmed UXO will not be brought to the water surface, since exposure to the environment could raise the potential for accidental detonation. The seabed disturbance footprint for UXO mitigation, which will entail relocation of UXO that cannot be avoided by micrositing, is anticipated to be approximately 161.5 square feet (15 square meters) per mitigation of one UXO. Relocation of UXO will be done by first using a suction pump to uncover and reconfirm the classification of the UXO, then using the WROV's articulated arm to place slings underneath the UXO, and finally lifting it and shifting it to a safe location. The actual quantity of UXO relocation will be determined following UXO investigation and identification surveys. Investigation surveys were initiated in 2022 and are ongoing. Identification surveys will commence in April 2023 and continue throughout 2023.

Boulder clearance or relocation is not currently anticipated under the Proposed Action; however, if determined to be necessary, the following would occur:

- At least 90 days prior to inter-array cable corridor preparation and cable installation (e.g., boulder relocation, pre-cut trenching, cable crossing installation, cable lay and burial) and foundation site preparation (e.g., scour protection installation), the Lessee must provide DOI with a boulder relocation plan.
- The plan shall include the following:
  - Identification of areas of active (within the last 5 years) bottom trawl fishing, areas where boulders >6.6 feet (>2 meters) in diameter are anticipated to occur, and areas where boulders are expected to be relocated for project purposes.
  - Methods to minimize the quantity of seafloor obstructions from relocated boulders in areas of active bottom trawl fishing as identified in #1.

Dominion Energy must submit its boulder relocation plan to BOEM (at renewable_reporting@boem.gov) and BSEE (at OSWSubmittals@bsee.gov). BOEM and BSEE will review the boulder relocation plan and provide comments, if any, on the plan within 45 days, but no later than 90 days, after the plan's submittal. Dominion Energy must resolve all comments on the plan to BOEM's and BSEE's satisfaction before implementation of the plan. If BOEM or BSEE does not provide comments on the plan within 90 calendar days of its submittal, Dominion Energy may conclude that the plan is not accepted and should not implement the plan.

Once the pre-installation activities are complete, the inter-array cables will be loaded onto a cable lay vessel at the cable fabrication facility, the location of which is still to be determined, and brought to the Lease Area for lay and burial. Based on recent input from Dominion Energy, sandwave removal methods are not currently anticipated to occur prior to cable installation; and are therefore, not discussed further under the Proposed Action.[b] Therefore, cable installation in sand wave areas do not require separate burial methods or tools and cables will be installed using the same cable installation methods described below.

The offshore export cables would transfer the electricity from the OSS to the cable landing location in Virginia Beach, Virginia. Electricity would be transferred from each of the three OSSs to the cable landing location via three three-core copper, aluminum-conductor 230-kV subsea cables, or both, for a total of nine offshore export cables. The offshore export cable route corridor width associated with the three cables originating from each OSS would be 1,280 feet (390 meters). Upon exiting the Lease Area, the three offshore export cable route corridors originating at the OSS would merge to become one overall offshore export cable route corridor containing all nine offshore export cables. The offshore export cable route corridor between the western edge of the Lease Area and the cable landing location would range in width from 1,970 feet (600 meters) to 9,400 feet (2,865 meters). Variability in the offshore export cable route corridor width would be driven by several external constraints, including existing telecommunications cable and transmission cable crossings; the U.S. Department of Defense exclusion area to the south; the vessel traffic lane and proposed Atlantic Coast Port Access Study safety fairway to the north; the Dam Neck Ocean Disposal Site; obstructions, exclusion areas, and seabed conditions identified from existing data and ongoing surveys; potential risks due to the use of the area by third parties; and the approach to the HDD at the cable landing location. Within the offshore export cable route corridor, the nine offshore export cables would generally be spaced approximately 164 to 2,716 feet (50 to 828 meters) apart and constrained at times to be spaced 164 to 328 feet (50 to 100 meters) apart.

Dominion Energy has proposed several cable installation methods for the inter-array and offshore export cables. The most likely cable burial methods being considered as part of the project design envelope (PDE) include jet plow, jet trenching, hydroplow (simultaneous lay and burial), mechanical plowing (simultaneous lay and burial), other technologies, or both available at the time of installation. Final installation methods would be determined by the final engineering design process that is informed by detailed geotechnical data, risk assessments, and coordination with regulatory agencies and stakeholders. For all the proposed installation methods, a narrow temporary trench is created into which the cable is bed while the equipment is towed along the seabed. Inter-array cables would be buried to a depth of between 3.9 and 9.8 feet (1.2 and 3 meters); however, the exact depth would be dependent on the substrate encountered along the route. The offshore export cables would be buried to a target depth of between 3.3 and 16.4 feet (1 and 5 meters) (COP Section 3.4.1.4; Dominion Energy 2022), which is consistent with the recommendations from the preliminary Cable Burial Risk Assessment (COP Appendix W; Dominion Energy 2022). Post-lay surveys will be conducted using a remotely operated vehicle or burial assessment sled to determine the need for secondary cable protection measures such as rocks, geotextile sand containers, basalt sand containers, or concrete mattresses (COP Section 3.4.2.1; Dominion Energy 2022). For the purposes of the effects assessment, it was assumed the offshore export cables would require additional protection at the three fiber optic cable crossing locations and at the Omega joint location between mile posts 13 and 17 (kilometer posts 21 and 28).

Dominion Energy has identified three in-service telecommunications cables within the offshore export cable route corridor that would be crossed by the offshore export cables. At cable crossings, both the existing infrastructure and the offshore export cables must be protected. The protection and crossing method would be determined on a case-by-case basis. At a minimum, it is expected that each asset crossing would include two layers of cable protection installed prior to and post offshore export cable installation, and a potential third layer of protection if stabilization and scour protection is deemed

[b] Email from Mitchell Jabs, Dominion Energy to BOEM Re: Dominion CVOW-C EIS Coordination – ICF & BOEM. Dated September 12, 2022.

necessary.

The construction and installation phase of the proposed Project would make use of both construction and support vessels to complete tasks in the Offshore Project area. Table 1-5 provides details and specifications on vessels expected to be used during construction based on the information in COP Section 3.4.1.5 (Dominion Energy 2022). Daily estimated vessel trips would be dependent on the construction period and activity range. Vessel transits under the Proposed Action would average 46 trips per day through the duration of construction activities; daily estimated vessel trips would be dependent on the construction period and activity and range from a minimum of three trips per day to a maximum of 95 trips per day. Vessel transits under the likely scenario may be reduced overall by 15 percent, though daily estimated vessel trips would still likely range from a minimum of three trips per day to a maximum of 95 trips per day. Construction vessels would travel between the Offshore Project area and various ports identified in Table 1-5, depending on the vessel role. Dominion Energy and the Port of Virginia have executed a lease agreement for a portion of the existing PMT facility in the city of Portsmouth, Virginia to serve as a construction port for the majority of construction vessels. The port would be used to store monopile and transition pieces and to store and pre-assemble WTG components. Table 1-5 presents the best available information of vessels and transits that are currently anticipated for the Proposed Action.

Section 3 of the COP provides additional details on construction and installation methods for offshore activities and facilities (Dominion Energy 2022).

Table 1-5 Summary of offshore vessels for construction in the Proposed Action

Vessel Role	Vessel Class	# of Vessels	Width (feet)	Length (feet)	Draft (feet)	Most Likely Operation Period	Frequency of Transit	Transit Destination
Scour Protection Installation	Fall Pipe Vessel	1	106	507	25	10/2023 to 12/2024 and 02/2025 to 10/2025	Weekly	Canada/USA
Transport monopile/transition pieces from U.S. port to installation site	U.S. barge	2	105	400	20	04/2024 to 12/2025	(188+17)/2 = 103 cycles in total for all barges	Portsmouth, VA
Tugs for MP/TP transport barges	U.S. ocean-going tug	3	41	132	18	04/2024 to 12/2025	103 + 52 = 155 cycles in total	Portsmouth, VA
Monopile/transition piece/Offshore Substation Installation	HLV	1	161	711	36	04/2024 to 12/2025	Monthly	Europe/ Hampton Roads, VA
Noise Monitoring	CTV	2	34	84	7	05/2024 to 10/2024 and 05/2025 to 10/2025	Daily	Portsmouth, VA

Vessel Role	Vessel Class	# of Vessels	Width (feet)	Length (feet)	Draft (feet)	Most Likely Operation Period	Frequency of Transit	Transit Destination
Noise Mitigation	Platform Support Vessel	1	100	454	29	05/2024 to 10/2024 and 05/2025 to 10/2025	2 cycles in total + X due to bad weather	Portsmouth, VA
Crew Transfer	CTV	1	23	65	6	04/2024 to 12/2025	Every 2nd day	Portsmouth, VA
Jacket Installation	DP HLV	1	161	710	36	N/A	Monthly	Europe/ Hampton Roads, VA
Noise Monitoring for Jacket Installation	CTV	2	34	84	7	N/A	Daily	Portsmouth, VA
Noise Mitigation for Jacket Installation	Platform Support Vessel	1	100	454	29	N/A	Daily	Portsmouth, VA
Transport jackets/topsides from EU port to installation site	HLV	1	138	568	35	11/2024 to 04/2025	3 cycles in total	Europe
Assist tugboat for topside installation	U.S. ocean-going tug	1	35	112	19	N/A	Daily	Hampton Roads, VA
Offshore Cable Commissioning (CONTINGENCY VESSEL)	DP2 JUV	2	230	132	20	11/2024 to 07/2025	N/A	N/A
Nearshore Trenchless Installation	Drill Rig spread	2	40	9	N/A	09/2023 to 02/2024	N/A (Staged at the direct pipe punchout locations)	Hampton Roads, VA
Nearshore Marine assistance	U.S. Multi-Purpose Support Vessel (Multicat)	2	40	92	14	09/2023 to 02/2024	Weekly	Portsmouth, VA
Nearshore Marine assistance	U.S. tug (small)	1	35	112	19	09/2023 to 02/2024	Weekly	Portsmouth, VA

Vessel Role	Vessel Class	# of Vessels	Width (feet)	Length (feet)	Draft (feet)	Most Likely Operation Period	Frequency of Transit	Transit Destination
Landfall	Landfall Beach spread	1	N/A	N/A	N/A	01/2023 to 04/2024 and 07/2024 to 09/2025	Weekly	Hampton Roads, VA
Shore pull-in	U.S. Pull-in support barge	1	105	400	20	01/2023 to 04/2024 and 07/2024 to 09/2025	Weekly	Portsmouth, VA
Shore pull-in	U.S. workboat (tug)	4	41	132	18	01/2023 to 04/2024 and 07/2024 to 09/2025	Weekly	Portsmouth, VA
Cable Lift Jack-Up Installation Vessel – CONTINGENCY VESSEL	JUV	1	105	144	13	01/2023 to 04/2024 and 07/2024 to 09/2025	N/A	N/A
Pre-lay Grapnel Run	Multipurpose Support Vessel	1	59	266	19	01/2023 to 04/2024 and 07/2024 to 09/2025	Weekly	Portsmouth, VA
Pre-Installation Survey	Survey Vessel	1	34	87	10	01/2023 to 04/2024 and 07/2024 to 09/2025	Weekly	Portsmouth, VA

Vessel Role	Vessel Class	# of Vessels	Width (feet)	Length (feet)	Draft (feet)	Most Likely Operation Period	Frequency of Transit	Transit Destination
Cable Laying and Burial	Shallow-draft Cable Lay Vessel	1	110	401	18	01/2023 to 04/2024 and 07/2024 to 09/2025	Monthly	Europe/Hampton Roads, VA
Anchor handling	Multi-Purpose Support Vessel (Multicat)	2	40	92	14	01/2023 to 04/2024 and 07/2024 to 09/2025	Daily	Hampton Roads, VA
Transport Cable	Multipurpose Support Vessel	3	79	289	15	01/2023 to 04/2024 and 07/2024 to 09/2025	Single Trip	Europe/Hampton Roads, VA
Cable Burial	Hydro-plow (Jetting)	1	20	53	14	01/2023 to 04/2024 and 07/2024 to 09/2025	N/A	Europe/Hampton Roads, VA
Crew Transfer	CTV	1	34	87	10	01/2023 to 04/2024 and 07/2024 to 09/2025	Every 2nd day	Portsmouth, VA
As-built Survey	Survey Vessel	1	34	87	10	01/2023 to 04/2024 and 07/2024 to 09/2025	Weekly	Portsmouth, VA

Vessel Role	Vessel Class	# of Vessels	Width (feet)	Length (feet)	Draft (feet)	Most Likely Operation Period	Frequency of Transit	Transit Destination
Pre-lay Survey (Offshore Export Cable)	Survey Vessel	1	34	87	10	01/2023 to 04/2024 and 07/2024 to 09/2025	Weekly	Portsmouth, VA
Cable Laying and burial (Offshore Export Cable)	Deep-draft Cable Lay Vessel	1	106	528	22	01/2023 to 04/2024 and 07/2024 to 09/2025	Monthly	Hampton Roads, VA
Cable Laying and burial (Offshore Export Cable)	Deep-draft Cable Lay Vessel	1	39	110	9	01/2023 to 04/2024 and 07/2024 to 09/2025	Monthly	Europe/Hampton Roads, VA
Cable Burial (Offshore Export Cable)	Trenching Support or cable laying Vessel	1	105	529	25	01/2023 to 04/2024 and 07/2024 to 09/2025	Monthly	Europe/ Hampton Roads, VA
Cable Burial (Offshore Export Cable)	Trenching Support Vessel or Cable laying Vessel	1	112	561	28	01/2023 to 04/2024 and 07/2024 to 09/2025	Monthly	Europe/ Hampton Roads, VA
Cable Burial (Offshore Export Cable)	Burial tool (Post-lay Jetting)	2	25	46	19	01/2023 to 04/2024 and 07/2024 to 09/2025	Monthly	Europe/ Hampton Roads, VA

Vessel Role	Vessel Class	# of Vessels	Width (feet)	Length (feet)	Draft (feet)	Most Likely Operation Period	Frequency of Transit	Transit Destination
Offshore Jointing Vessel (Offshore Export Cable)		1	23	565	6	01/2023 to 04/2024 and 07/2024 to 09/2025	Monthly	Europe/ Hampton Roads, VA
Pre-lay Grapnel Run (Inter-Array Cable)	Multipurpose Support Vessel	1	26	92	9	01/2023 to 04/2024 and 11/2024 to 05/2026	Weekly	Portsmouth, VA
Pre-lay Survey (Inter-Array Cable)	Survey Vessel	1	23	85	5	01/2023 to 04/2024 and 11/2024 to 05/2026	Weekly	Portsmouth, VA
Cable Laying and burial (Inter-Array Cable)	Deep-draft Cable Lay Vessel	1	106	528	25	01/2023 to 04/2024 and 11/2024 to 05/2026	Every 60 days	Europe/ Hampton Roads, VA
Multipurpose Service Vessel (Inter-Array Cable)	W2W	2	76	292	18	01/2023 to 04/2024 and 11/2024 to 05/2026	Monthly	Hampton Roads, VA
Crew Transfer (Inter-Array Cable)	CTV	2	23	65	6	01/2023 to 04/2024 and 11/2024 to 05/2026	Every 2nd day	Portsmouth, VA
Cable Burial (Inter-Array Cable)	Trenching Support Vessel or Cable Laying Vessel	1	105	529	37	01/2023 to 04/2024 and 11/2024 to 05/2026	Every 60 days	Hampton Roads, VA

Vessel Role	Vessel Class	# of Vessels	Width (feet)	Length (feet)	Draft (feet)	Most Likely Operation Period	Frequency of Transit	Transit Destination
Cable Burial (Inter-Array Cable)	Burial tool (Post-lay Jetting)	1	25	46	19	01/2023 to 04/2024 and 11/2024 to 05/2026	Every 60 days	Hampton Roads, VA
As-built Survey (Inter- Array Cable)	Deep-draft Cable Lay Vessel	1	106	528	25	01/2023 to 04/2024 and 11/2024 to 05/2026	Weekly	Portsmouth, VA
WTG Installation	JUV	1	184	472	23	08/2025 to 02/2027	Every 10-14 days	Portsmouth, VA
Transport WTGs from U.S. port to installation site	U.S. barge	2	100	400	20	08/2025 to 02/2027	Approximately every 3 days	Portsmouth, VA
Transport WTGs from U.S. port to installation site	U.S. ocean going tug	2	41	132	18	08/2025 to 02/2027	Approximately every 3 days	Portsmouth, VA
Assist tugboat	U.S. ocean going tug	1	35	112	19	08/2025 to 02/2027	Approximately every 3 days	Hampton Roads, VA
Commissioning spread	Multirole subsea Support Vessel with W2W	1	52	354	18	08/2025 to 04/2027	Bi-weekly	Portsmouth, VA
Site Security	Safety vessel, Nearshore Trenchless Installation	1	var	var	var	09/2023 to 08/2027	Bi-weekly	Portsmouth, VA
Sand wave removal (CONTINGENCY VESSEL)	Trailer Suction Hopper Dredger	1	92	480	30	2023	Daily	Portsmouth, VA
Boulder Picking (CONTINGENY VESSEL)	Anchor Handling Tug + crane barge	2	46	146	21	2023	Weekly	Portsmouth, VA
Boulder Ploughing	Anchor Handling Tug + towed plough	1	36	190	11	2023	Weekly	Portsmouth, VA

Vessel Role	Vessel Class	# of Vessels	Width (feet)	Length (feet)	Draft (feet)	Most Likely Operation Period	Frequency of Transit	Transit Destination
Crossing Protection (concrete mattresses)	Fall Pipe Vessel or Deep Draft Cable Lay Vessel	1	46	146	21	2024 to 2026	Between 3 and 27 cycles	Portsmouth, VA

AHT = anchor handling tug; CTV = crew transfer vessel; HLV = heavy lift vessel; JUV = jack-up vessel; N/A/ = not applicable; VA = Virginia, W2W = walk-to-work vessel

1.3.2 Operations and Maintenance

The Proposed Action is anticipated to have an operating period of 33 years[c]. Dominion Energy intends to lease an existing O&M facility with the preferred location at Lambert's Point, located on a brownfield site in Norfolk, Virginia. Dominion Energy is also evaluating leasing options in VPA's PMT and Newport News Marine Terminal near Hampton Roads, Virginia. The O&M facility would monitor operations and would include office space, a control room, warehouse, shop, and pier space.

The proposed Project would include an O&M plan to be finalized as a component of the required Facility Design Report/Fabrication Installation Report, and planned and unplanned inspections, including preventive maintenance based on statutory requirements, original equipment manufacturers' guidelines, and industry best practices. Dominion Energy would maintain an Oil Spill Response Plan and Safety Management System that would be developed and implemented prior to construction and installation activities in coordination with BOEM and the Bureau of Safety and Environmental Enforcement (COP, Appendices A and Q; Dominion Energy 2022).

1.3.2.1 Onshore Activities and Facilities

The switching station and onshore substation would be equipped with monitoring equipment and would be regularly inspected during the operational lifespan. Onshore maintenance activities could include routine maintenance, including the replacement or upgrade of electrical components and equipment. The onshore export cables and interconnection cables would require periodic testing; however, maintenance should not be required outside of occasional repair activities as a result of damage due to unanticipated events. Overhead lines would be inspected prior to being energized and routinely inspected by vegetation management crews every three years for woody vegetation and hazard trees, with additional inspections following localized storm events.

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c Dominion Energy's lease with BOEM (Lease OCS-A 0483) has an operations term of 25 years that commences on the date of COP approval. See https://www.boem.gov/sites/default/files/uploadedFiles/BOEM/Renewable_Energy_Program/State_Activities/Commercial%20Lease%20OCS-A%200483.pdf; see also 30 CFR § 585.235(a)(3).) Dominion Energy would need to request an extension of its operations term from BOEM to operate the proposed Project for 33 years. For the purposes of maximum-case scenario and to ensure National Environmental Policy Act coverage if BOEM grants such an extension, the BA analyzes a 33-year operations term.

1.3.2.2 Offshore Activities and Facilities

Primary offshore O&M activities will include:

- Inspections of Offshore Project components for signs of corrosion, quality of coatings, and structural integrity of the WTG components.
- Inspections and maintenance of the WTG and OSS electrical components/equipment.
- Surveys of the offshore export cable and inter-array cable routes, to confirm the cables have not become exposed or that any cable protection measures have not worn away. Dominion Energy anticipates that post-installation cable surveys will occur once per year. However, the final frequency and schedule of these surveys will be determined in coordination with the applicable agencies.
- Sampling and testing (of lubricating oils, etc.).
- Replacement of consumable items (such as filters and hydraulic oils).
- Repair or replacement of worn, failed, or defective systems (such as WTG blades, bolts, corrosion protection systems, protective coatings, cables, etc.), including cleaning off subsea marine growth, realigning machinery, renewing cable protection using additional rock dumping or mattress placement, etc.
- Updating or improving systems (such as control systems, sensors, etc.).
- Disposal of waste materials and parts (in line with best practice and regulatory requirements).

Crew transfer vessels and service operation vessels would be used to support O&M activities offshore. Helicopters are also being considered to support the Project's O&M activities, with an estimated 50 round trips each year required.

Dominion Energy anticipates 365 operating days for a single service operations vessel (SOV), with 26 annual round trips to the O&M port, and 365 operating days for each of two crew transfer vessels (CTVs), with 75 annual round trips to the O&M port per vessel. Dominion Energy anticipates approximately 25 annual round trips for additional vessels to conduct routine surveys. Additionally, the SOV will also have a daughter craft which will be used for in-field support and personnel transfers, with an estimated 26 round trips to port per year for the daughter craft. In total, Dominion Energy estimates approximately 253 annual round trips to port during O&M.

Ports used during O&M would either be located at Lambert's Point in Norfolk, Virginia, or VPA's PMT and Newport News Marine Terminal near Hampton Roads, Virginia (COP Section 3.5; Dominion Energy 2022). However, conflicting information regarding the number of round trips expected to be completed by CTVs, SOVs, or both during O&M is presented in the COP and the draft EIS. Additionally, the estimated number does not comport with O&M service trip estimates for other U.S. East Coast wind farm projects with published COPs, which estimate several hundred to thousands of annual service round trips; however, this is the vessel transit data available for analysis in this BA.

The WTGs would be monitored through a supervisory control and data acquisition system and offshore export cables and inter-array cables would be monitored through distributed temperature sensing equipment to provide real-time detection of possible faults. In the event of a fault or failure of an Offshore Project component, Dominion Energy would repair and replace it in a timely manner.

Appropriate safety systems would be included on all WTGs, including fire detection and an audible and visible warning system, painting and marking, lightning protection, aids to navigation in accordance with USCG requirements, and appropriate lighting for the aviation and maritime industries.

1.3.3 Decommissioning

In accordance with 30 CFR 585 and other BOEM requirements, Dominion Energy would be required to remove or decommission all Project infrastructure and clear the seabed of all obstructions following the end of the Project's O&M activities. Unless otherwise authorized by BOEM, Dominion Energy will achieve complete decommissioning within two years of termination of the lease and either reuse, recycle, or responsibly dispose of all materials removed. Table 1-6 provides additional details on removal methods and assumptions that would likely be applicable based on present-day understanding of available decommissioning approaches (COP Section 3, Table 3.6-1; Dominion Energy 2022). Dominion Energy would also perform site clearance surveys after the Project material is removed to confirm all components have been properly removed and the Project area is cleared of obstructions (COP, Section 3.6; Dominion Energy 2022). Although the Proposed Action has a designated lifespan of 33 years, some installations and components may remain fit for continued service after this time. Dominion Energy would have to apply for an extension to operate the Proposed Action for more than the operations term.

Table 1-6 Summary of decommissioning methods and assumptions

Project Component	Removal Method	Comments and Assumptions
Wind Turbine Generator (WTG)	Removal of the WTGs is done using a reversed construction and installation method. Decommissioning of the turbines and towers is assumed to include removal of the rotor, nacelle, blades and tower to be removed in the reverse construction and installation order.	• Materials brought onshore to U.S. port for recycling and disposal; • Steel in the tower is assumed to be recycled; and • The blades are assumed to be recycled.
WTG Monopile Foundation	Removal of the monopiles is done using a reversed construction and installation method. Removal of the monopile is assumed to be cut off below the mud line and be lifted off by a heavy lift vessel (HLV) to a barge prior to decommissioning.	• Monopile to be cut at or just below mudline and transported to U.S. port for recycling; and • Steel is assumed to be recycled.
Offshore Substation topside	Removal of the Offshore Substation topside is done using a reversed construction and installation method. The Offshore Substation topside is assumed to be lifted off by a HLV to a barge prior to decommissioning.	• Transported to U.S. port for recycling and disposal; and • Steel from the topside is assumed to be recycled.
Offshore Substation Jacket Foundation	The Offshore Substation Jacket Foundation piles are assumed to be cut below the mud line, before the jacket is lifted off in one section by a HLV to a barge prior to decommissioning.	• Cut below mudline and transported to U.S. port for recycling; and • Steel from the jacket and piles is assumed to be recycled.
Cables	The Offshore Export Cables and Inter-Array Cables are assumed to be lifted out and cut into pieces or reeled in.	• Total removal of cable and transported to U.S. port for recycling; and • Core material to be recycled.

Project Component	Removal Method	Comments and Assumptions
Onshore Substation	Removal of all buildings and equipment, unless suitable for future use.	• Materials to be recycled; and • To be demolished and recycled unless suitable for future use. Site to be prepared for future use.
Onshore Export and Interconnection Cables	Removal of the Onshore Export Cable and Interconnection Cable is assumed to be limited to disconnecting and cutting at the fence line below ground level, this on both side.	• Remaining cable capped off and earthed; and • Removal of termination points and cut of cable 3 feet (0.9 meter) below ground level.
Scour protection and rock filling	Alternatives: • Removal of scour protection and rock filling; and • Leave scour protection in place, as undisturbed as possible.	• Assumed to be removed unless leaving in place is deemed appropriate through consultation with the appropriate authorities.

BOEM would require Dominion Energy to submit a decommissioning application upon the earliest of the following dates: two years before the expiration of the lease, 90 days after completion of the commercial activities on the commercial lease, or 90 days after cancellation, relinquishment, or other termination of the lease (see 30 CFR 585.905). Upon completion of the technical and environmental reviews, BOEM may approve, approve with conditions, or disapprove the lessee's decommissioning application. This process would include an opportunity for public comment and consultation with municipal, state, and federal management agencies. Dominion Energy would need to obtain separate and subsequent approval from BOEM to retire in place any portion of the proposed Project. Approval of such activities would require compliance under the National Environmental Policy Act and other federal statutes and implementing regulations.

If the COP is approved or approved with modifications, Dominion Energy would have to submit a bond that would be held by the U.S. government to cover the cost of decommissioning the entire facility if Dominion Energy would not otherwise be able to decommission the facility.

1.3.3.1 Onshore Activities and Facilities

At the time of decommissioning, some components of the onshore electrical infrastructure may still have substantial life expectancies. Dominion Energy anticipates removing the onshore substation buildings and equipment unless it is suitable for future use. Materials would be recycled as appropriate. Removal of the onshore export cable and interconnection cable is assumed by Dominion Energy to be limited to disconnecting and cutting at the fence line below ground level at both sides. The termination points would be removed, the cable would be cut 3 feet (0.9 meter) below ground level, and remaining cable would be capped off and earthed.

1.3.3.2 Offshore Activities and Facilities

The decommissioning process for the WTGs and OSSs is anticipated to the be the reverse of construction and installation, with turbine components or the OSS topside structure removed prior to foundation removal. Decommissioning of the topside structures for WTGs and OSSs is assumed by Dominion Energy to include removal of all WTG components including removal of the rotor, nacelle, blades, and tower and removal of the OSS topside structure. Materials would be brought onshore for recycling and disposal. WTG monopile foundations and the OSS piled jacket foundations would be removed by cutting below the mud line and lifting the foundation off by a heavy lift vessel to a barge. All foundations would need to be removed to 15 feet (4.6 meters) below the mudline (30 CFR 585.910(a)). The steel used in the foundations and towers would be recycled. The scour protection placed around the base of each foundation, if used, would be removed unless leaving in place is deemed appropriate through consultation with appropriate authorities. Offshore export cables and inter-array cables would be retired in place or removed in accordance with the decommissioning plan. If removed, the offshore export cables and inter-array cables would be lifted out and cut into pieces or reeled in, and the cable would be recycled as appropriate. Although exact details regarding vessel types, ports, and transit estimates are not known at this time, decommissioning vessel activities are expected to be similar to or slightly less than those anticipated for construction.

1.3.4 Fisheries Monitoring Plans

This section outlines the surveys proposed for the COP Fisheries Monitoring Plan prior to construction. These plans have been developed with consideration of both BOEM's guidelines for providing information on fisheries for offshore wind projects (BOEM 2019a) and Responsible Offshore Science Alliance (ROSA) guidance for overarching principals and recommended elements for experimental protocols in the design and implementation of offshore wind monitoring projects (ROSA 2021). In addition to Sections 1.3.4.1, *Welk Surveys* and 1.3.4.2, *Black Sea Bass Surveys*, Dominion Energy is developing an Atlantic surf clam survey plan that will be provided to BOEM and NMFS when completed.

1.3.4.1 Welk Surveys

The overall objective of these surveys is to develop a sampling framework in support of acquiring 2 years of pre-construction data at the Project Lease Area with a focus on whelk. Welk surveys will occur at roughly 3-day intervals using welk pots which is a common gear type in the *Busycon* fisheries. Sampling will occur twice a month during times of traditionally high fishing activity (November to March) and once a month during times of traditionally low fishing activity (April to October) (21 cruises [4 in year one and 17 in year two]). Baited pots are weighted allowing them to remain on the seafloor. Typically, this fishery deploys single pots along the seafloor. At the end of each string, there is a static vertical buoy line that is attached to mark the gears position at the surface. To reduce the number of vertical lines and reduce entanglement potential, these pots will be deployed in strings (or trawls) of multiple pots along the seafloor, which are connected by groundlines. Pots are deployed and left at the fishing location and are hauled at intervals (approximately 3 days), then re-baited and set again. It is anticipated to construct 8 strings of 12 pots for deployment. The approximate length of each trawl will be 1,800 feet (149 meters) with 150 feet (45 meters) spacing between the pots. Buoy lines will have the required whale release (weak link/swivel) and colored markings (yellow and black marking scheme using paint or woven tracer).

Some elements of the proposed welk survey plan will be dependent upon existing information and data collected during the first phase of the project, and the existing knowledge of the Project Lease Area will be leveraged to assist in the design of the sampling area. Two subareas within the Project Lease Area, composed of three turbines each, will be targeted throughout the welk sampling study. These areas will be chosen based on examining relevant fishery, oceanographic and biological data, and consultation with Dominion Energy and stakeholders. The two subareas will be stratified by depth, with one area less than 30 meters and the second area greater than 30 meters (Figure 1-8, panel A). Each lease block within the identified sampling area will be divided into subareas (aliquots). Aliquots will be designated into one of the four distance strata from the turbine. For each sampling event, one turbine within each of the two subareas will be randomly selected, and pots will be deployed within one of the randomly chosen aliquots within each of the distance strata (Figure 1-8, panel B). The first three distance strata will be informed by the literature. The fourth distance strata will be sufficiently far from the turbine outside the Project Lease Area and function similarly to a control site where no turbine effect is anticipated.

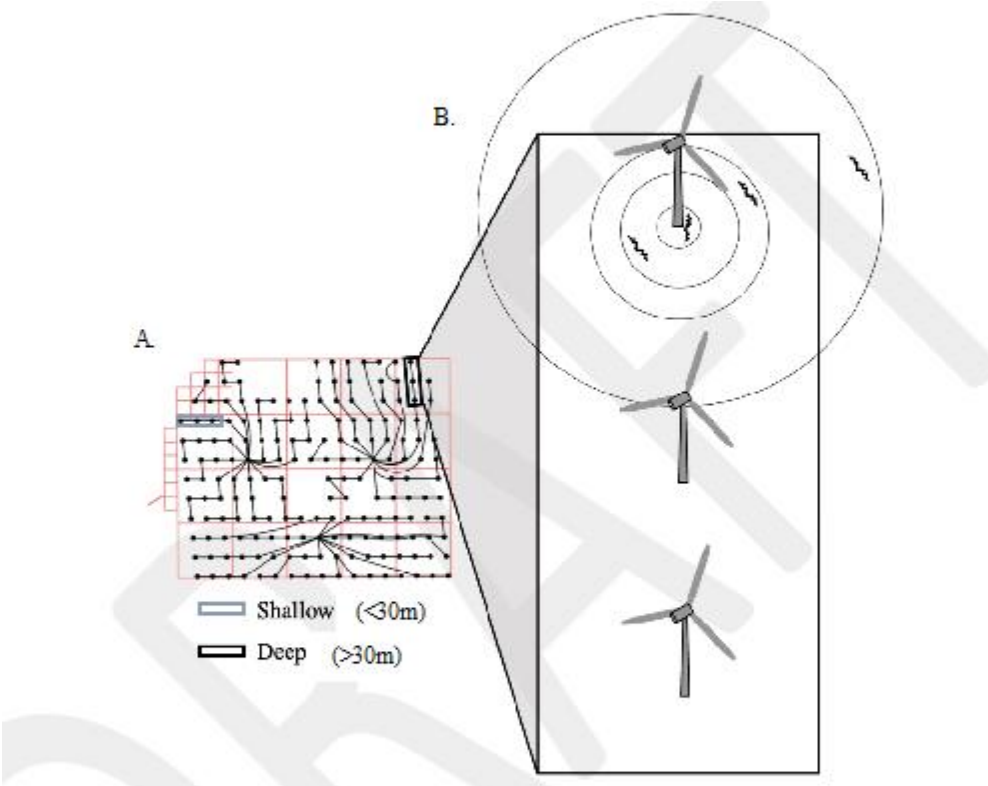


Figure 1-8 Hypothetical Project Lease Area with turbine and cable array shown in A. Example of subareas (stratified by depth) which would be used for the welk survey study shown in B. Four distance strata surround a randomly selected at a turbine within the deep subarea. A string of pots is randomly placed within an aliquot which falls within the specified subarea. The fourth distance strata will fall outside of the lease area and function similar to a control

1.3.4.2 Black Sea Bass Surveys

The proposed monitoring plan will consist of a survey design supporting acquisition of 2 years of pre-construction data at the Project Lease Area sampled with fish pots, a common gear type in the black sea bass fishery. Typically, this fishery deploys strings (or trawls) of multiple pots along the seafloor, which are connected by groundlines. At the end of each string, there is a static vertical buoy line that is attached to mark the gear's position at the surface. To mitigate the entanglement potential of a variety of nontarget species (i.e., marine mammals, sharks, and sea turtles) some of the following methods may be used: instead of using a vertical line with a buoy for gear marking, the section of rope between the anchor and the first pot in the string will consist of an elongated section of sinking ground line. To distinguish this gear the end of sinking ground line (top 12 feet [4 meters]) the rope will be marked in a yellow and black marking scheme using paint or woven tracers. GPS locations will be used to mark gear. During year two of this project, it is intended to test other on-demand fishing systems as they are available. These fishing methods eliminate the use of vertical lines and should provide equal levels of mitigation.

Pots will be constructed so as to be consistent with regional efforts with respect to design elements of the gear (i.e., trap material, volume, entrance funnels, escape vent configuration). It is anticipated to construct eight strings of six pots for deployment. The approximate length of each trawl will be 480 feet (146 meters) with 60 feet (18 meters) spacing between the pots and a 180 feet (55 meters) anchor line. In an effort to characterize both the underlying population demographics of the sampled black sea bass resource and the catches of the commercial fishery, a combination of ventless and vented (consistent with current regulatory requirements) pots randomly placed within a string will be utilized. The sampling locations will be selected such that the relative effect of the Project will be assessed as a function of the distance from turbine structures.

Two subareas within the Project Lease Area, composed of three turbines each, will be targeted throughout the study. These areas will be chosen based on examining relevant fishery, oceanographic and biological data, and consultation with Dominion Energy and stakeholders. The two subareas will be stratified by depth, with one area less than 30 meters and the second area greater than 30 meters (Figure 1-9, panel A). Each lease block within the identified sampling area will be divided into subareas (aliquots). Aliquots will be designated into one of the four distance strata from the turbine. For each sampling event, a turbine within each of the two subareas will be randomly selected, and pots will be deployed within one of the randomly chosen aliquots within each of the distance strata (Figure 1-9, panel B). The first three distance strata will be informed by the literature and other fishery monitoring studies for black sea bass in the region. The fourth distance strata will be sufficiently far from the turbine (outside of the Project Lease Area) and function similarly to a control site where no turbine effect is anticipated.

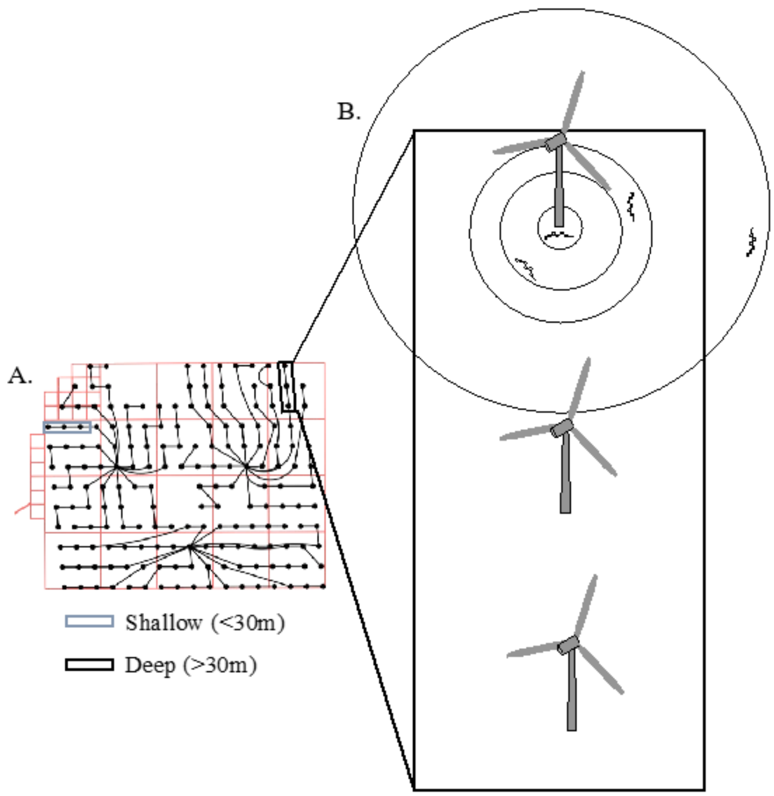


Figure 1-9 Hypothetical Project Lease Area with turbine and cable array shown in A. Example of subareas (stratified by depth) which would be used for the black sea bass surveys is shown in B. Four distance strata surround a randomly selected turbine within the deep subarea. A string of pots is randomly placed within an aliquot which falls within the specified subarea. The fourth distance strata will fall outside of the Project Lease Area and function similar to a control.

1.3.4.3 Atlantic Surf Clam Surveys

The proposed monitoring plan will consist of a sampling framework that will collect one year of pre-construction data at the Project area with a focus on estimating Atlantic surf clam abundance, spatial distribution and population structure to establish baseline resource conditions and characterize the resource in and near the Project Lease Area. Data will be collected for within the Project Lease Area and at a control site via a dredge survey designed to collect a wider range of Atlantic surf clam sizes than a commercial dredge.

Commercial fishermen harvest surf clams with hydraulic clam dredges with heavy sleds pulled along the sea floor and utilizing high-pressure jets that allows a steel blade to pass through the first few inches of substrate and scoop the clams onto the dredge, where they are captured in a cage made of steel bars. The bars on commercial clam dredges are spaced several inches apart so they do not collect anything but the targeted surf clams. The survey tows conducted with these fisheries survey dredging approach will be much shorter than typical commercial tows, and the dredge will be fished using a moderately sized vessel that can safely maneuver within a wind farm lease area. The clam survey will be performed during the late spring/early summer of 2023 contingent upon the commercial vessel's availability. It is anticipated that this experiment will require 3 days at sea to complete, plus 2 days for mobilization and 2 days for demobilization. Standardized survey tows utilizing the novel dredge will be made on board the *F/V Joey D*, a 99-foot (30-meter) clam fishing vessel built in 2020. The novel dredge has been specially designed for research sampling and contains reduced bar spacing that allows for the sampling of a wider size range of clams relative to a standard commercial clam dredge. An additional advantage of this novel dredge over a lined commercial dredge is that it does not clog with sediment and therefore catches are cleaner and easier to process. This novel dredge has also been used to survey within wind lease areas in New Jersey, thereby ensuring the regional integration of information completed by this and other surveys. Work has been completed in New Jersey to calibrate the novel dredge against the federal survey dredge, facilitating inclusion of data collected in wind farm related surveys with existing, long-term data collected by the federal survey.

A total of twenty stations will be sampled from within the Project Lease Area, and another twenty from the control site outside the Project Lease Area for a total of 40 stations. Turbine locations provided by Dominion Energy will be used to simulate wind farm infrastructure. The station selection and tows will use simulated wind farm infrastructure for samples taken prior to construction to ensure before and after samples can be compared in terms of efficiency and other aspects of sample collection that might be impaired by infrastructure. A similar study completed by Rutgers University at the Ocean Wind 1 lease where stations were stratified by depth within and outside of the lease site. A similar stratification by depth could be employed in this survey if appropriate.

Each dredge tow will sample the bottom for 5 minutes at a vessel speed of 1.5 knots. Sensors on the dredge will be used to estimate bottom contact engagement, and the location (latitude/longitude) of the beginning and end of each tow will be recorded. The tow start/end locations, and the dredge width will be used to calculate the area of bottom that was sampled for a given tow. Any tows that are retrieved with a full dredge will be discarded and the tow repeated for a shorter duration because a full dredge will not allow the gear to continue fishing. The catch from each tow will be sorted and deposited in bushel baskets to measure the volume of the entire clam catch for each tow.

Demographic indices of Atlantic surf clam in the subsample will be collected, including counts, measurements, shells for aging, tissue samples, and weights. Approximately twenty shells per station from the subsample will be retained and returned to the laboratory for aging. Additionally, tissue samples will be taken from a subset of clams for genetic analysis. These protocols follow those used in the federal Atlantic surf clam survey. Catching horseshoe crabs, scallops, goosefish (market name monkfish) and whelk (market name conch) in clam dredges is common. Thus, all other animals in each of the subsamples will be identified to species and counted. A benthic sediment sampler (Peterson grab sampler) will also collect samples of the seabed sediment and benthic macroinvertebrates at each station to characterize the existing environmental conditions within and near the Project Lease Area.

1.3.5 Proposed Mitigation, Monitoring, and Reporting Measures

This section outlines the proposed mitigation, monitoring, and reporting conditions that are intended to minimize or avoid potential effects on ESA-listed species. Mitigation measures committed to by Dominion Energy in the COP are considered as a part of the Proposed Action and are binding. For construction activities, NMFS is a co-action agency who will issue an LOA under the MMPA for the Proposed Action as described by Dominion Energy in their LOA application. Any conditions required under the LOA would be consistent with and be required under the ESA consultation process. The conditions of the final LOA for listed species of marine mammals that apply to activities under the authorities of the co-action agencies described in Section 1, *Introduction* will be implemented in any associated permits and authorizations, as applicable. Notably, the temporal scope of ESA consultation is broader than the LOA and covers the life of the Project, whereas the LOA regulations are valid for a duration of five years for construction and some O&M of the Project. Therefore, some measures proposed in Table 1-7 are in addition to those that may be required by NMFS under the LOA. The final LOA conditions that apply to ESA-listed marine mammals will also be included as a condition in the final record of decision.

A full description of mitigation measures under the Proposed Action ©s provided in Tables 1-8 and 1-9. During the development of this draft BA, and in coordination with cooperating agencies, BOEM considered additional mitigation measures that could further avoid, minimize, or mitigate impacts on the physical, biological, socioeconomic, and cultural resources assessed in this document. These potential additional mitigation measures are described in Table 1-8. Some or all of these BOEM proposed mitigation measures may be required as a result of consultation completed under Section 7 of the ESA, or through the Magnuson Stevens Act. Mitigation imposed through consultations will be included in the Final BA. The additional mitigation measures presented in Table 1-8 may not all be within BOEM’s statutory and regulatory authority to require; however, other jurisdictional governmental agencies may require them. BOEM may choose to incorporate one or more additional measures in the record of decision and adopt those measures as conditions of COP approval. As previously discussed, all CVOW-C committed measures are part of the Proposed Action (Table 1-7).

Table 1-7 Mitigation, monitoring, and reporting measures committed to by the Applicant

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
1	General	Agency & Consultation Conditions	The Applicant will adhere to any additional requirements for the Proposed Action set forth by MMPA and ESA consultations as well as BOEM PDCs/BMPs, and ROD conditions.	Construction, O&M, Decommissioning	Measures will be developed that reduce effects analyzed under agency consultations.
2	General	PSO standards and responsibilities	• PSOs must be provided by a third-party provider. • PSO and PAM operators will have completed NMFS-approved PSO training, and have team leads with experience in the northwestern Atlantic Ocean on similar projects; remaining PSOs and PAM operators will have previous experience on similar projects and the ability to work with the relevant software; PSOs and PAM operators will complete a Permits and Environmental Compliance training and a two-day training and refresher session with the PSO provider and the Project compliance representatives before the anticipated start of Project activities. • PSOs will check the NOAA Fisheries website daily for DMA locations. • PSOs will work in shifts such that no one monitor will work more than 4 consecutive hours without a consecutive 2-hour break or longer than 12 hours during any 24-hour period. • PSOs will be responsible for visually monitoring and identifying ESA-listed species approaching or entering the established clearance and shutdown zones during Project activities. • PSOs will be equipped with reticule binoculars and have the ability to estimate distances to ESA-listed species located in proximity to their established zones. Range finders will also be available for PSOs to use as appropriate. Digital single-lens reflex camera equipment will be used to record sightings and verify species identity. • Observations will take place from the highest available vantage point. • General 360-degree scanning will occur during the monitoring periods, and target scanning by PSOs will occur when alerted of an ESA-listed species presence. • All data will be recorded using industry-standard software. • Data recorded will include information related to ongoing operations, observation methods and effort, visibility conditions, protected species detections, and any mitigation actions requested and enacted.	Construction, O&M, Decommissioning	This measure ensures that PSOs are qualified and effective at monitoring for marine wildlife and that the appropriate agencies are contacted in the event of a NARW sighting. Collectively these measures minimize the potential for adverse effects on ESA-listed species by providing timely action for any mitigation or reporting.

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
3	General	Vessel strike avoidance policy	• The Project will implement a vessel strike avoidance policy for all vessels under contract to Dominion Energy to reduce the risk of vessel strikes, and the likelihood of death, serious injury, or both to marine mammals, sea turtles, or ESA-listed fish that may result from collisions with vessels. • Vessel operators and crews shall receive site-specific training on marine mammal, sea turtle, and ESA-listed fish sighting/reporting and vessel strike avoidance measures. • All attempts shall be made to remain parallel to the animal's course when a travelling marine mammal is sighted in proximity to the vessel in transit. All attempts shall be made to reduce any abrupt changes in vessel direction until the marine mammal has moved beyond its associated separation distance. • If an animal or group of animals is sighted in the vessel's path or in proximity to it, or if the animals are behaving in an unpredictable manner, all attempts shall be made to divert away from the animals or, if unable due to restricted movements, reduce speed and shift gears into neutral until the animal(s) has moved beyond the associated separation distance (except for voluntary approach and bow riding dolphin species). • All vessels will employ a dedicated lookout during all operations (will be filled by PSOs when PSOs are required for specified mitigation and monitoring activities). • All vessels will comply with NMFS regulations and speed restrictions and state regulations as applicable for NARW. • All vessels regardless of size operating from November 1 through April 30 will operate at speeds of 10 knots or less when transiting from port to port within the Lease Area and export cable route, or within the boundaries of any DMA, slow zone, or SMA.	Construction, O&M, Decommissioning	This measure reduces the potential for adverse effects on ESA-listed species by increasing the effectiveness of mitigation and monitoring measures through educational and training materials and through avoiding vessel interactions with ESA-listed species. The measure would minimize the potential for adverse effects on marine mammals and sea turtles resulting from vessel interactions.
4	General	Vessel separation distances	• Vessels will maintain, to the extent practicable, separation distances of: • >1,640-foot (500-meter) distance from any sighted ESA-listed whale, including the NARW and unidentified large whale; • >328 feet (100 meters) from sperm whales and non-ESA listed baleen whales; • >164 feet (50 meters) for dolphins, porpoises, seals, and sea turtles.	Construction, O&M, Decommissioning	The measure would minimize the potential for adverse effects on marine mammals and sea turtles resulting from vessel interactions.

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
5	General	Vessel speed restrictions	• All vessels 65 feet (20 meters) or larger operating from November 1 through April 30 will operate at speeds of 10 knots or less. • All vessels will comply with NMFS regulations and speed restrictions and state regulations as applicable for NARW. • All Project-related vessels will comply with 10 knot speed restrictions in any SMA, DMA, or Slow Zone. • All Project-related vessels will reduce vessel speed to 10 knots or less when mother/calf pairs, pods, or larger assemblages of whales are observed near an underway vessel. • If an animal is sighted within their respective separation distance, vessels must steer a course away from the animal at 10 knots or less until the minimum separate distance is established	Construction, O&M, decommissioning	This measure would minimize the potential for ship strikes and effects on marine mammals, and secondarily on sea turtles by slowing speeds. Communication between project vessels would further reduce potentially adverse effects by alerting vessels to the presence of marine mammals in the area.
6	General	Situational Awareness System/Common Operating Picture	CVOW-C Monitoring and Coordination Center (MCC) will establish and maintain a Common Operating Procedure detailing the monitoring, project communication and external reporting requirements associated with marine mammal and sea turtle detections. Members of the MCC monitoring team will consult with NMF'' NARW reporting system for the presence of NARW in Project area and vessel transit routes. Monitoring activities will include a combination of the following: • Minimum of daily monitoring of sighting communication tools such as Mysticetus, Whale Alert, WhaleMap, WhaleAlert during project construction, operation and maintenance activities. • Regular monitoring of the USCG VHF Channel 16 to receive notifications of any DMA, SMA, or Slow Zone. • Monitoring of any real-time acoustic networks. • Platform for communicating sighting information to all Project vessels. • Process for reporting sightings to appropriate external parties and regulatory agencies. • Identification of responsible positions for monitoring and reporting responsibilities. • During pile installation, in the two days prior to and daily throughout construction, the lead of the PSO monitoring team will consult with NMFS NARW reporting systems for the presence of NARW. • If a NARW is confirmed through any of the above-mentioned monitoring tools or alerts, then the vessel captain, Lead PSO onboard, or the MCC will notify the Right Whale Sighting Advisory System hotline immediately and no later than within 24 hours.	Construction, O&M, decommissioning	This measure ensures that ESA-listed species detections in the area are known about as early as possible which could lead to mitigation measures if necessary, thus improving readiness for mitigation implementation.

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
7	Foundation Installation	Foundation installation: Pile-driving time-of-year restriction	Pile driving of foundations and pile driving associated with installation of the goal post piles for Trenchless Installation will not occur from November 1 through April 30.	Construction	Time-of-year restrictions for impact pile-driving activities would minimize and avoid potential adverse effects on ESA-listed species, such as the NARW, that are more likely to occur in the area during that time period.
8		Foundation installation: Noise mitigation systems	The Project will use a noise mitigation system for all impact and vibratory piling events for foundation installation. Dominion Energy will achieve the sound levels at the ranges that correspond to the isopleths modeled using the 10 dB reduction and will verify these ranges in field measurements.	Construction	The reduction in sound pressure levels would reduce the area of underwater noise effects on ESA-listed whales, sea turtles, fish, and the prey they feed upon during impact pile driving.
9	Foundation Installation	Sound field verification (SFV) measurement plan	An SFV measurement plan will be submitted to NMFS and BOEM for review and approval at least 120 days prior to the planned start of pile driving. The plan will describe how Dominion Energy will ensure the location selected is representative of the rest of the piles of that type to be installed. The plan will also describe how the effectiveness of the sound attenuation methodology will be evaluated based on the results.	Construction	This measure ensures that noise level data collected in the SFV are consistently collected at the highest possible standard using up-to-date methodology to minimize noise effects on marine mammal, sea turtle and ESA-listed fish species.

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
10	Foundation Installation	Sound measurements and Level A / B harassment distance verification	Dominion Energy will conduct field verification measurements of impact and vibratory pile driving during installation of the WTG foundations for model validation purposes and to further determine the effectiveness of the mitigation measures employed. • SFV measurements will be conducted during installation of the first three monopiles installed over the course of the Project. • If pile driving occurs across different seasons, SFV measurements will also be conducted during installation of a monopile in a season that differs from the season of the first monopile measured for comparison purposes (i.e., if the first monopile is installed in the spring and pile driving also occurs in the fall, SFV measurements will occur on a pile installed in the fall). • If Dominion Energy receives technical information that indicates a subsequent monopile is likely to produce larger sound fields than modeled or previously measured, they will conduct measurements on that monopile with the potentially larger sound field. • Dominion Energy will provide initial results of the SFV measurements to NMFS as soon as they are processed. • Measurements will be conducted at distances of approximately 2,460 feet (750 meters), 8,202 feet (2,500 meters), and 16,404 feet (5,000 meters) from the pile being installed as well as the extent of the Level B harassment zones to verify the accuracy of the modeled zones. • Recordings will be continuous throughout the duration of all impact hammering of each pile monitored. • The measurement systems will have a sensitivity appropriate for the expected sound levels received from pile driving at the nominal ranges through the installation of the pile. • The dynamic range of the system will be sufficient such that at each location, pile-driving signals are not clipped and are not masked by noise floor.	Construction	This measure can be used to evaluate the potential for A and B harassment levels to be achieved during impact pile driving as accurately as possible and to highlight potential for changes to shutdown zones if necessary.

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
11	Foundation Installation	Adaptive management of SFV measurements	• If the initial SFV measurements indicate distances to the isopleths corresponding to the Level A and B harassment zones are less than the distances predicted by modeling assuming 10 dB noise attenuation, Dominion Energy may request a modification of the clearance and shutdown zones for impact pile driving. • For the modification request to be considered by NMFS, Dominion Energy must have conducted SFV measurement on a least three piles to verify that the zone sizes are consistently smaller than predicted by modeling. • The adjusted clearance zones will be based on the maximum Level A harassment distance measured for that hearing group. • If the SFV measurements indicated the need for extended clearance and shutdown zones, a plan outlining a combination of enhanced PAM and visual monitoring will be developed and implemented, including the potential addition of dedicated PSO vessels.	Construction	This measure allows for the shutdown zones to be modified to better represent actual risks to marine wildlife from noise-generating activities once sufficient evidence is present to permit such a change.
12	Foundation Installation	Time of day restrictions for pile driving	• Pile driving of the foundations will commence only during daylight hours no earlier than 1 hour after civil sunrise. • Pile driving of foundations will not be initiated later than 1.5 hours before civil sunset. • Pile driving of the foundations may continue after dark when the installation of the same pile began during daylight, when visual clearance zones were fully visible for the 60 minutes immediately prior to civil sunset, and pile driving must proceed for human safety or installation feasibility reasons. • Pile driving will not be initiated in times of low visibility when visual clearance zones cannot be visually monitored, as determined by the Lead PSO.	Construction	This measure will maximize visibility and detection probability for ESA-listed species so that mitigation measures may be implemented to reduce adverse effects from pile driving noise.

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
13	Foundation Installation	Daytime visual monitoring (*Daytime is defined by the period between nautical twilight rise and set for the region)*	• A minimum of two PSOs will be on active duty at the foundation pile driving vessel/platform from 60 minutes before and during, and for 30 minutes after pile installation activity. • Each PSO will use big eye (25x) binoculars and that are spaced 180 degrees apart to maximize coverage of clearance and shutdown zones for all protected species. The big eye binoculars will be placed at a deck height expected to achieve monitoring of minimum distances. • PSOs will continuously scan from 90 degrees right to 90 degrees left for full coverage of their half of the monitoring zone. • Any dedicated PSO vessel(s) will be located at the best vantage point (distance from the pile driving vessel) to observe and document ESA-listed species in proximity to the clearance, shutdown zones, or both. • PSOs on the dedicated PSO vessel will have reticle binoculars, and if deemed appropriate and effective for the PSO vessel, big eye binoculars. • Should more than one dedicated PSO vessel be in operation, the PSO vessels will operate in positions directly opposite each other to ensure coverage of the clearance, shutdown zones, or both.	Construction	This measure will increase detection probability of ESA-listed species and increase implementation probability of mitigation actions to reduce effects from pile driving noise.
14	Foundation Installation	Daytime visual monitoring during periods of reduced visibility	• If the clearance and shutdown zones are visually obscured, the PSOs on watch will continue to monitor the zones using reduced visibility monitoring tools such as night vision devices, infrared, thermal camera systems, or both. • All visual PSOs on duty will be in contact (through the Lead PSO) with the on-duty PAM operator who will monitor the PAM systems for acoustic detections of marine mammals that are vocalizing in the area.	Construction	Enhanced detection methods would increase visibility of ESA-listed species under periods of reduced visibility to help minimize and avoid potential adverse effects during impact pile driving.
15	Foundation Installation	Nighttime visual monitoring (if required)	Pile driving during nighttime hours could potentially occur when a pile installation is started during daylight and, due to unforeseen circumstances, would need to be finished after dark. New piles will not be initiated after dark. If piling extends into nighttime periods, the following actions will be taken: • Visual PSOs will rotate in pairs: one observing with a handheld night vision devices (NVD) and one monitoring an infrared/thermal imaging camera system. Deck lights will be extinguished or dimmed during night observations when using night-vision devices; however, if the deck lights must remain on for safety reasons, the PSO will attempt to use the NVD in areas away from potential interference by these lights. If a PSO is unable to monitor the visual clearance or shutdown zones with available NVDs. Piling will be halted (as safe to do so). • A PAM operator will monitor the PAM systems for acoustic detections of ESA-listed marine mammals vocalizing in the area.	Construction	Time-of-day observing requirements would ensure that shutdown zones are effectively monitored to minimize and avoid potential adverse effects on ESA-listed species.

<table>
<tr><th></th><th>Activity</th><th>Measure</th><th>Description</th><th>Project Phase</th><th>Expected Effects Avoided or Minimized</th></tr>
<tr><td>16</td><td>Foundation Installation</td><td>PAM for pile driving</td><td>
PAM will occur during all foundation installation activities and will supplement the visual monitoring program during all pre-start clearance periods, piling, and post-piling monitoring periods.
PAM will be designed and established such that detection capability extends to at least 3 miles (5 kilometers) from the pile-driving location (though it will extend farther if available technology at the time of construction allows) for all foundations.
The NARW acoustic clearance zone is ‘at any distance’ and Dominion Energy will monitor out to at least 5 kilometers.
The selected PAM system will transmit real time data to PAM monitoring stations on the vessels, a shore side monitoring station, or both.
PAM will begin 60 minutes prior to the initiation of the soft-start, throughout foundation installation, and for 30 minutes after pile driving has been completed.
PAM will be conducted by a dedicated, qualified, and NMFS-approved PAM operator(s).
PAM operator(s) will monitor the hydrophone signal in real time both aurally (using headphones) and visually (via the monitor screen displays).
PAM operators will communicate detections of any marine mammals to the Lead PSO who will ensure the implementation of the appropriate mitigation measures
A PAM detection alone (i.e., in the absence of visual confirmation by a PSO) will not trigger mitigation measures, with the exception of a confirmed PAM detection of NARW at any distance.
</td><td>Construction</td><td>This measure increases the scope of monitoring for NARW, and other ESA-listed marine mammal species. Early detection will improve mitigation implementation which will reduce effects of pile driving.</td></tr>
<tr><td>17</td><td>Foundation Installation</td><td>Clearance and shutdown zones for impact pile driving</td><td>Clearance and shutdown zones for Impact Pile Driving of Foundations

Table 4. Clearance and Shutdown Zones for Impact Pile Driving
<table>
<tr><th rowspan="2">Species</th><th colspan="2">Clearance Zone (m)</th><th colspan="2">Shutdown Zone (m)</th></tr>
<tr><th>One per Day</th><th>Two per Day</th><th>One per Day</th><th>Two per Day</th></tr>
<tr><td>North Atlantic right whale – PAM</td><td>at any distance</td><td>at any distance</td><td>at any distance</td><td>at any distance</td></tr>
<tr><td>North Atlantic right whale – visual detection</td><td>at any distance, minimum 1,750</td><td>at any distance, minimum 1,750</td><td>at any distance, minimum 1,750</td><td>at any distance, minimum 1,750</td></tr>
<tr><td>All other Mysticetes and sperm whales</td><td>5,100</td><td>6,500</td><td>1,750</td><td>1,750</td></tr>
<tr><td>Harbor porpoise</td><td>750</td><td>750</td><td>750</td><td>750</td></tr>
<tr><td>Dolphins and pilot whales</td><td>500</td><td>500</td><td>500</td><td>500</td></tr>
<tr><td>Seals</td><td>500</td><td>500</td><td>500</td><td>500</td></tr>
<tr><td>Sea Turtles</td><td>1,000</td><td>1,000</td><td>100</td><td>100</td></tr>
</table>
Notes:
Clearance and shutdown zones account for practicality concerns, including the functional effective distances for visual monitoring as based on experiences from the CVOW Pilot Project. Note for high frequency cetaceans, the peak PTS distance was used given the small size of harbor porpoises and the likely visible identification range. In general, if the modeled PTS distance was less than 100 m, the clearance zone was set at 250 m; whereas if the modeled zone was greater than 100 m but less than 500 m, it was set at 500 m.</td><td>Construction</td><td>The establishment of clearance and shutdown zones would minimize the potential for adverse effects on marine mammals, sea turtles resulting from pile driving by ensuring that marine mammals and sea turtles are not within or near threshold ranges at the start of pile driving and by reducing the occurrence, exposure levels and exposure times that an animal might encounter during pile driving.</td></tr>
</table>

<table>
<tr><th></th><th>Activity</th><th>Measure</th><th>Description</th><th>Project Phase</th><th>Expected Effects Avoided or Minimized</th></tr>
<tr><td>18</td><td>Foundation Installation</td><td>Clearance and shutdown zones for vibratory</td><td>Clearance and shutdown zones during vibratory pile driving of foundations
Table 5. Clearance and Shutdown Zones (Vibratory Pile Driving for Foundations)
<table>
<tr><th rowspan="2">Species</th><th colspan="2">Clearance zone (m)</th><th colspan="2">Shutdown zone (m)</th></tr>
<tr><th>One Per Day</th><th>Two per Day</th><th>One Per Day</th><th>Two per Day</th></tr>
<tr><td>North Atlantic right whale – PAM</td><td>at any distance</td><td>at any distance</td><td>at any distance</td><td>at any distance</td></tr>
<tr><td>North Atlantic right whale – visual detection</td><td>at any distance, minimum 1,750</td><td>at any distance, minimum 1,750</td><td>at any distance, minimum 1,750</td><td>at any distance, minimum 1,750</td></tr>
<tr><td>All other Mysticetes and sperm whales</td><td>1,000</td><td>1,000</td><td>1,000</td><td>1,000</td></tr>
<tr><td>Harbor porpoise</td><td>500</td><td>500</td><td>500</td><td>500</td></tr>
<tr><td>Dolphins and pilot whales</td><td>250</td><td>250</td><td>250</td><td>250</td></tr>
<tr><td>Seals</td><td>250</td><td>250</td><td>250</td><td>250</td></tr>
<tr><td>Sea Turtles</td><td>1,000</td><td>1,000</td><td>100</td><td>100</td></tr>
</table>
Notes:
Clearance and shutdown zones account for practicality concerns, including the functional effective distances for visual monitoring as based on experiences from the CVOW Pilot Project.
In general, if the modeled PTS distance was less than 100 m, the clearance zone was set at 250 m; whereas if the modeled zone was greater than 100 m but less than 500 m, it was set at 500 m.</td><td>Construction</td><td>The establishment of clearance and shutdown zones would minimize the potential for adverse effects on marine mammals, sea turtles resulting from pile driving by ensuring that marine mammals and sea turtles are not within or near threshold ranges at the start of pile driving and by reducing the occurrence, exposure levels and exposure times that an animal might encounter during pile driving.</td></tr>
<tr><td>19</td><td>Foundation Installation</td><td>Pre-start clearance</td><td>• Dominion Energy will implement a 60-minute clearance period of the clearance zones prior to impact pile driving for the foundations.
• If a marine mammal or sea turtle is observed entering or within the relevant shutdown zones prior to the initiation of pile driving activity, pile driving activity will be delayed and will not begin until either the marine mammal(s) or sea turtle(s) has voluntarily left the respective clearance zones and been visually or acoustically confirmed beyond that shutdown zone, or when the additional time period has elapsed with no further sighting or acoustic detection (i.e., 15 minutes for small odontocetes and 30 minutes for all other marine mammal species, 60 minutes for sea turtles).
• PSOs will apply a clearance zone of 3,.280 feet (1,000 meters) for all species of sea turtle, however the shutdown zone for sea turtles remains at 328 feet (100 meters).</td><td>Construction</td><td>This measure decreases the effects of pile driving noise by ensuring that marine mammals and sea turtles are not within or near threshold ranges at the start of pile driving.</td></tr>
</table>

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
20	Foundation Installation	Soft-start (ramp up) for impact pile driving	• A soft-start will occur at the beginning of the impact pile driving of each pile and at any time following the cessation of impact pile driving of 30 minutes or longer. The soft-start requires an initial 30 minutes using a reduced hammer energy for pile driving. • An Operating Procedure will be developed to document the soft-start process incorporating final project design including specific hammer energies. • Soft-start procedure will not begin until the marine mammal and sea turtle clearance zones have been cleared by the visual PSOs and PAM operators. • If a marine mammal or sea turtle is detected within or about to enter the applicable clearance zone, prior to or during the soft-start procedure, pile driving will be delayed until the animal has been observed exiting the clearance zone or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and 30 minutes for all other marine mammal species, and 60 minutes for sea turtles). • Soft-starts are not feasible for vibratory pile driving and will not be implement for vibratory piling. All remaining pre-start clearance protocols will be followed prior to initiating vibratory piling	Construction	The establishment of soft-start protocols would minimize the potential for adverse effects for animals close to the activity at the start of piling, allowing them to leave before full hammer energy is reached.
21	Foundation Installation	Shutdowns	• If a marine mammal or sea turtle is detected entering or within the respective shutdown zones after pile driving has commenced, an immediate shutdown of pile driving will be implemented when practicable as determined by the lead engineer on duty who will determine if a shutdown is safe and practicable. • If shutdown is called for but it is determined that shutdown is not feasible due to risk of injury or loss of life, there will be a reduction of hammer energy. • Following shutdown, pile driving will only be initiated once the animal has been observed exiting its respective clearance zone within 30 minutes of the shutdown, or if an additional time period has elapsed with no further sightings (i.e., 15 minutes for small odontocetes, 30 minutes for all other marine mammal species, and 30 minutes for sea turtles). • The shutdown zone and clearance zone will be continually monitored by PSOs and PAM operators during any pauses in pile driving. • If pile driving shuts down for reasons other than mitigation (e.g., mechanical difficulty) for periods less than 30 minutes, pile driving may restart without soft-start if PSOs have maintained constant observations and no detections of any marine mammal or sea turtles in the clearance zone have occurred.	Construction	This measure would minimize the potential for adverse effects on ESA-listed marine mammals and sea turtles by minimizing the time exposed and the sound levels they are expose to if an ESA-listed species is detected within a shutdown zone

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
22	Foundation Installation	Post-impact piling monitoring	PSOs will continue to survey the clearance and shutdown zones and surrounding waters throughout the duration of pile installation and for a minimum of 30 minutes after piling has been completed.	Construction	This measure would not minimize adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for impact pile driving.
23	Trenchless Installation of Export Cable	Time of day restrictions for pile driving during trenchless installations	• Pile driving for any trenchless installation will commence only during daylight hours no earlier than 1 hour after civil sunrise and will be completed no later than 1 hour before civil sunset. • Pile driving of goal posts or cofferdams may continue after dark when the installation of the same pile began during daylight, when visual clearance zones were fully visible for the 30 minutes immediately prior to civil sunset, and pile driving must proceed for human safety or installation feasibility reasons. • Pile driving will not be initiated in times of low visibility when visual clearance zones cannot be visually monitored.	Construction	This measure will minimize the potential for adverse effects by maximizing the ability to detect species and implement the required mitigation measures
24	Trenchless Installation of Export Cable	Daytime visual monitoring *(Daytime is defined by the period between nautical twilight rise and set for the region)*	• A minimum of two PSOs will be on active duty at the goal post or cofferdam pile driving platform, or on a vessel nearby the construction vessel, from 30 minutes before, during, and 30 minutes after pile driving. • Any additional PSO vessels will remain in contact with the Lead PSO. • Each PSO on watch will use reticle binoculars and, if deemed feasible and effective for the vessel, Big Eye binoculars.	Construction	This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures that, in turn will reduce noise exposures.
25	Trenchless Installation of Export Cable	Daytime visual monitoring during periods of reduced visibility	If the clearance and shutdown zones are visually obscured, the PSOs on watch will continue to monitor the zones using reduced visibility monitoring tools such as night vision devices, infrared, thermal camera systems, or both.	Construction	Enhanced detection methods would increase visibility of ESA-listed species under periods of reduced visibility to help minimize and avoid potential adverse effects during impact pile driving.

<table>
<tr><th></th><th>Activity</th><th>Measure</th><th>Description</th><th>Project Phase</th><th>Expected Effects Avoided or Minimized</th></tr>
<tr><td>26</td><td></td><td>Nighttime visual monitoring (if required)</td><td>While not expected, pile driving during nighttime hours could potentially occur when a pile installation is started during daylight and, due to unforeseen circumstances, would need to be finished after dark.
New piles will not be initiated after dark.
Visual PSOs will rotate in pairs: one observing with a handheld NVD and one monitoring an infrared/thermal imaging camera system.
Deck lights will be extinguished or dimmed during night observations when using night-vision devices; however, if the deck lights must remain on for safety reasons, the PSO will attempt to use the NVD in areas away from potential interference by these lights.
If a PSO is unable to monitor the visual clearance or shutdown zones with available tools, piling will not commence or will be halted (as safe to do so).
No PAM monitoring will be conducted for trenchless installations</td><td>Construction</td><td>Time-of-day observing requirements would ensure that shutdown zones are effectively monitored to minimize and avoid potential adverse effects on ESA-listed species.</td></tr>
<tr><td>27</td><td>Trenchless Installation of Export Cable</td><td>Clearance and shutdown zones for impact pile driving during trenchless installations</td><td>Clearance and shutdown zones for Project impact pile driving during trenchless installations (i.e., goal post piles)

Table 7. Clearance and Shutdown Zones for Goal Post Installation<table><tr><th>Species</th><th>Clearance zone (m)</th><th>Shutdown zone (m)</th></tr><tr><td>North Atlantic right whale – visual detection</td><td>at any distance</td><td>at any distance</td></tr><tr><td>All other Mysticetes, sperm whales, and pilot whales</td><td>1,000</td><td>1,000</td></tr><tr><td>Harbor porpoise</td><td>750</td><td>100</td></tr><tr><td>Dolphins and pilot whales</td><td>250</td><td>100</td></tr><tr><td>Seals</td><td>500</td><td>100</td></tr><tr><td>Sea Turtles</td><td>1,000</td><td>100</td></tr></table>Note:
Clearance and shutdown zones proposed based on distances to NOAA Fisheries harassment criteria (NOAA Fisheries 2018a).</td><td>Construction</td><td>This measure decreases the effects of pile driving noise by ensuring that marine mammals and sea turtles are not within or near threshold ranges at the start of pile driving and reduces effects by minimizing the time exposed to threshold level noise.</td></tr>
</table>

<table>
<tr><th></th><th>Activity</th><th>Measure</th><th>Description</th><th>Project Phase</th><th>Expected Effects Avoided or Minimized</th></tr>
<tr><td>28</td><td>Trenchless Installation of Export Cable</td><td>Clearance and shutdown zones for vibratory pile driving during trenchless installations</td><td>Clearance and shutdown zones during vibratory pile driving of cofferdams

Table 6. Clearance and Shutdown Zones for (Vibratory Pile Driving for Cofferdam Installation)
<table>
<tr><th>Species</th><th>Clearance zone (m)</th><th>Shutdown zone (m)</th></tr>
<tr><td>North Atlantic right whale – visual detection</td><td>at any distance</td><td>at any distance</td></tr>
<tr><td>All other Mysticetes, sperm whales, and pilot whales</td><td>1,000</td><td>1,000</td></tr>
<tr><td>Harbor porpoise</td><td>250</td><td>100</td></tr>
<tr><td>Dolphins</td><td>250</td><td>100</td></tr>
<tr><td>Seals</td><td>250</td><td>100</td></tr>
<tr><td>Sea Turtles</td><td>1,000</td><td>100</td></tr>
</table>Notes:
In general, if the modeled PTS distance was less than 100 m, the clearance zone was set at 250 m; whereas if the modeled zone was greater than 100 m but less than 500 m, it was set at 500 m. Shutdown zones have been set at 100 m for non-mysticetes to prevent direct interactions with equipment.</td><td>Construction</td><td>This measure decreases the effects of pile driving noise by ensuring that marine mammals and sea turtles are not within or near threshold ranges at the start of pile driving and reduces effects by minimizing the time exposed to threshold level noise.</td></tr>
<tr><td>29</td><td>Trenchless Installation of Export Cable</td><td>Pre-start clearance for pile driving</td><td>• A 30-minute pre-start clearance period will be implemented prior to impact pile driving of goal post piles or vibratory piling of the temporary cofferdam. During this period, the clearance zone and surrounding waters out the maximum visual extent will be continuously monitored.
• The ESA-listed large whale shutdown zone will be fully visible for at least 30 minutes prior to commencing piling.
• If a marine mammal or sea turtle is observed entering or within the relevant shutdown zones prior to the initiation of pile driving activity, pile driving activity will be delayed and will not begin until either the marine mammal(s) or sea turtle(s) has voluntarily left the respective and been visually confirmed beyond that clearance zone, or when the additional time period has elapsed with no further sighting or acoustic detection (i.e., 15 minutes for small odontocetes and 30 minutes for all other marine mammals and sea turtles).</td><td>Construction</td><td>This measure decreases the effects of pile driving noise by ensuring that marine mammals and sea turtles are not within or near threshold ranges at the start of pile driving.</td></tr>
</table>

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
30	Trenchless Installation of Export Cable	Soft-start (ramp up) for impact pile driving (goal post piles)	• A soft-start will occur at the beginning of the impact pile driving of each goal post and at any time following the cessation of impact pile driving of 30 minutes or longer • The soft-start requires an initial 30 minutes using a reduced hammer energy for pile driving. An Operating Procedure will be developed to document the soft-start process incorporating final project design including specific hammer energies. • Soft-start procedure will not begin until the clearance zones have been cleared by the visual PSOs. • If a marine mammal is detected within or about to enter the applicable clearance zone, prior to or during the soft-start procedure, pile driving will be delayed until the animal has been observed exiting the shutdown zone or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and 30 minutes for all other marine mammal species and sea turtles). • Soft-starts are not feasible for vibratory pile driving and will not be implement for vibratory piling. All remaining pre-start clearance protocols will be followed prior to initiating vibratory piling	Construction	The establishment of soft-start protocols would minimize the potential for adverse effects for animals close to the activity at the start of piling, allowing them to leave before full hammer energy is reached.
31	Trenchless Installation of Export Cable	Shutdowns	• If a marine mammal or sea turtle is detected entering or within the respective shutdown zones after pile driving has commenced, an immediate shutdown of pile driving will be implemented when practicable as determined by the lead engineer on duty who will determine if a shutdown is safe and practicable. • If shutdown is called for but it is determined that shutdown is not feasible due to risk of injury or loss of life, there will be a reduction of hammer energy • Following shutdown, pile driving will only be initiated once the animal has been observed exiting its respective clearance zone within 30 minutes of the shutdown, or if an additional time period has elapsed with no further sightings (i.e., 15 minutes for small odontocetes, 30 minutes for all other marine mammal species, and 30 minutes for sea turtles). • The shutdown zone and clearance zone will be continually monitored by PSOs and PAM operators during any pauses in pile driving. • If pile driving shuts down for reasons other than mitigation (e.g., mechanical difficulty) for periods less than 30 minutes, pile driving may restart without soft-start if PSOs have maintained constant observations and no detections of any marine mammal or sea turtles in the clearance zone have occurred.	Construction	This measure would minimize the potential for adverse effects on marine mammals, sea turtles by minimizing the time exposed and the sound levels they are expose to if an ESA-listed species is detected within a shutdown zone

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
32	Trenchless Installation of Export Cable	Post-impact piling monitoring	PSOs will continue to survey the clearance and shutdown zones and surrounding waters throughout the duration of pile installation and for a minimum of 30 minutes after piling has been completed.	Construction	This measure would not minimize adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for impact pile driving.
33	HRG Surveys	Daytime visual monitoring	• During daylight hours, one PSO will be on active duty and PSOs will rotate in shifts of one on and three off. • PSOs will monitor the clearance and shutdown zones beginning 30 minutes before HRG equipment operation begins, throughout the survey operation, and 30 minutes after the end of the operation of active sources below 180 kHz. • Applicant will follow all NMFS LOA requirements and BOEM PDC/BMPs for HRG surveys. If conflicting requirements are presented, the most protective measures will be followed.	Construction, O&M	This measure would ensure the effectiveness of the required mitigation and monitoring measures for HRG surveys.
34		Visual monitoring during low visibility conditions, including nighttime.	• PSOs will work in shifts such that PSOs are working pairs during nighttime HRG survey operations. • PSOs will use night vision equipment (e.g., night vision goggles with thermal clip-ons), infrared technology, and PAM. • The PAM system will consist of an array of hydrophones with three broadband and three low-frequency hydrophones. • The PAM operator(s) will monitor the hydrophone signals in real time both aurally (using headphones) and visually (via the monitor screen displays).	Construction, O&M	Time-of-day, visibility, and weather restrictions would minimize the potential for adverse effects on ESA-listed species resulting from HRG surveys.
35	HRG Surveys	Clearance and shutdown zones	The following clearance and shutdown zones will be implemented during HRG surveys: • 1,640-foot (500-meter) clearance and shutdown zone for NARW. • 1,640-foot (500-meter) clearance zone and shutdown zone for all ESA-listed marine mammal species. • 328-foot (100-meter) clearance and shutdown zone for all other marine mammal except delphinids from the genera *Delphinus, Lagenorhynchus, Stenella* or *Tursiops*; and seals. • 3,280-foot (1,000-meter) clearance zone and a 328-foot (100-meter) shutdown zone for sea turtles.	Construction, O&M	This measure decreases the effects of HRG noise by ensuring that marine mammals and sea turtles are not within or near threshold ranges at the start of the survey and reduces effects by minimizing the time exposed and the sound levels they are expose to if an ESA-listed species is detected within a shutdown zone

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
36	HRG Surveys	Pre-start clearance	• PSOs will implement a 30-minute clearance period of the applicable clearance prior to the initiation of soft-start using the appropriate visual technology for the duration. • Soft-start of HRG survey equipment may not be initiated if any ESA-listed animal is within its respective clearance zone. • If an animal is observed within its respective clearance zone, soft-start will be delayed until the animal is observed exiting the zone or an additional time has elapsed with no further sighting (i.e., 15 minutes for small odontocetes, 30 minutes for all other marine mammals, and 30 minutes for sea turtles).	Construction, O&M	The establishment of a shutdown zone may decrease the potential for effects on ESA-listed species during HRG surveys.
37	HRG Surveys	Soft-start of HRG survey equipment	Where technically feasible, HRG equipment will be activated starting with the smallest acoustic source at its lowest practical power output appropriate for the survey, and then gradually turned up and other sources added in such a way that the source level increases gradually.	Construction, O&M	The establishment of soft-start protocols would minimize the potential for adverse effects for animals close to the activity at the start of the survey, allowing them to leave before full acoustic power is reached.
38	HRG Surveys	Shutdowns	• If an animal is observed within its respective shutdown zone (described above) an immediate shutdown of HRG equipment will be required. • The clearance zone must be continually monitored by PSOs during any pauses in HRG survey activity, activities will be delayed until the animal(s) has been observed leaving the clearance zone within 30 minutes of the shutdown, or after an additional time period has elapsed with no further sightings (i.e., 15 minutes for small odontocetes, 30 minutes for all other marine mammals, and 30 minutes for sea turtles.	Construction, O&M	This measure reduces effects by minimizing the time exposed to threshold level noise.
39	All Activities: Reporting	PSO Reporting	• All PSOs will use a standardized data entry format. • Operations, monitoring conditions, observation effort, all marine mammal, sea turtle, and ESA-listed fish detections, and any mitigation actions will be recorded.	Construction	This monitoring measure would ensure monitoring of mitigation effectiveness and compliance. The data gathered could be used to evaluate effects and potentially lead to additional mitigation measures, if required.

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
40	All Activities: Reporting	Injured protected species reporting	Any potential takes, strikes, stranded, entangled, or dead/injured protected species regardless of cause, will be reported by the vessel captain or the PSO onboard to the Greater Atlantic (Northeast) Region Marine Mammal and Sea Turtle Stranding and Entanglement Hotline (866-755-NOAA [6622]) within 24 hours of a sighting. In addition, if the injury or death was caused by a collision with a Project-related vessel, Dominion Energy will ensure that NMFS is notified of the strike within 24 hours. The notification will include date and location (latitude and longitude) of the strike, name of the vessel involved, and the species identification or a description of the animal, if possible. If the Project activity is responsible for the injury or death, Dominion Energy will supply a vessel to assist in any salvage effort as requested by NMFS.	Construction, O&M, decommissioning	This monitoring measure would ensure monitoring of mitigation effectiveness and compliance. The data gathered could be used to evaluate effects and potentially lead to additional mitigation measures, if required.
41	All Activities: Reporting	Reporting observed impacts on species	• PSOs/PAM operators will report any observations concerning impacts on marine mammals, sea turtles, and ESA-listed fish to NMFS within 48 hours. • BOEM and NMFS will be notified within 24 hours if any evidence of a fish kill during construction activity is observed.	Construction, O&M, decommissioning	This monitoring measure would ensure monitoring of mitigation effectiveness and compliance. The data gathered could be used to evaluate effects and potentially lead to additional mitigation measures, if required.
42	All Activities: Reporting	Report of activities and observations	Dominion Energy will provide NMFS with a report within 90 calendar days following the completion of construction and HRG surveys, including a summary of the activities and an estimate of the number of marine mammals taken.	Construction, O&M, decommissioning	This monitoring measure would ensure monitoring of mitigation effectiveness and compliance. The data gathered could be used to evaluate effects and potentially lead to additional mitigation measures, if required.

	Activity	Measure	Description	Project Phase	Expected Effects Avoided or Minimized
42	All Activities: Reporting	Report information	• Data on all marine mammal, sea turtle, and ESA-listed fish observations will be recorded and based on standards of protected species observer collection data by the PSOs. This information will include dates, times, and locations of survey operations; time of observation, location and weather; details of animal sightings (e.g., species, numbers, behavior); and details of any observed taking (e.g., behavioral disturbances or injury). • A quality assured/quality controlled database of all sightings and associated details (e.g., distance from vessel, behavior, species, group size/composition) within and outside of the designated shutdown zones, monitoring effort, environmental conditions, and Project-related activity will be provided after field operations and reporting are complete. This database will undergo thorough quality checks and include all variables required by the NMFS-issued Incidental Take Authorization and BOEM ROD requirements, and ESA consultation and will be included for the Final Technical Report due to BOEM and NMFS. • During construction, weekly reports briefly summarizing sightings, detections and activities will be provided to NMFS and BOEM on the Wednesday following a Sunday-Saturday period. • Final reports will follow a standardized format for PSO reporting from activities requiring protected species mitigation and monitoring • An annual report summarizing the prior year's activities will be provided to NMFS and to BOEM on April 1 every calendar year summarizing the prior year's activities.	Construction, O&M, decommissioning	This monitoring measure would ensure monitoring of mitigation effectiveness and compliance. The data gathered could be used to evaluate effects and potentially lead to additional mitigation measures, if required.

BMP = best management practice; BOEM = Bureau of Ocean Energy Management; CVOW-C = Coastal Virginia Offshore Wind Commercial; DMA = Dynamic Management Area; ESA = Endangered Species Act; HRG = high-resolution geophysical; MMPA = Marine Mammal Protection Act; NARW = North Atlantic right whale; NMFS = National Marine Fisheries Service; NOAA = National Oceanic and Atmospheric Administration; O&M = operations and maintenance;
PAM = passive acoustic monitoring; PDC = project design criteria; PSO = protected species observer; ROD = Record of Decision; SMA = Seasonal Management Area; SFV = sound field verification; VHF = very high-frequency.
Source: Dominion Energy 2022; Tetra Tech 2022a.

Table 1-8 Additional proposed mitigation, monitoring, and reporting measures proposed by BOEM

No.	Activity	Measure	Description	Project Phase	Expected Effects
1	General	Vessel strike avoidance procedures	Applicant proposed measures plus: • As part of vessel strike avoidance, a training program will be implemented. The training program will be provided to NMFS for review and approval prior to the start of surveys. Confirmation of the training and understanding of the requirements will be documented on a training course log sheet. Signing the log sheet will certify that the crew members understand and will comply with the necessary requirements throughout the survey event. • Vessel operators and crew must maintain a vigilant watch for marine mammals and sea turtles by slowing down or stopping their vessels to avoid striking these protected species. Vessel crew members responsible for navigation duties will receive site-specific training on marine mammal sighting/reporting and vessel strike avoidance measures. Vessel strike avoidance measures will include, but are not limited to the following, except under extraordinary circumstances when complying with these measures would put the safety of the vessel or the crew at risk: ○ If underway, vessels must steer a course away from any sighted NARW at 10 knots (18.5 km/hr) or less until the 1,640 feet (500 meters) minimum separation distance has been established. If a NARW is sighted in a vessel's path, or within 330 feet (100 meters) of an underway vessel, the underway vessel must reduce speed and shift the engine to neutral. Engines will not be engaged until the NARW has moved outside of the vessel's path and beyond 330 feet (100 meters). If stationary, the vessel must not engage engines until the NARW has moved beyond 330 feet (100 meters); ○ All vessels will maintain a separation distance of 330 feet (100 meters) or greater of any sighted whales. If sighted, the vessel underway must reduce speed and shift the engine to neutral and must not engage the engines until the whale has moved outside the vessel's path and beyond 330 feet (100 meters). If a survey vessel is stationary, the vessel will not engage engines until the whale has moved out of the vessel's path and beyond 330 feet (100 meters); ○ Vessel operators will use all available sources of information of NARW presence, including daily monitoring of the Right Whale Sightings Advisory System, WhaleAlert app, and monitoring of USCG VHF Channel 16 to receive notifications of right whale detections, SMAs, DMAs, and Slow Zones to plan vessel routes to minimize the potential for co-occurrence with right whales.	All phases	**Maintains safe operating distances**

No.	Activity	Measure	Description	Project Phase	Expected Effects
2	General	Incorporate LOA requirements	The measures required by the final MMPA LOA would be incorporated into COP approval, and BOEM, BSEE, or both would monitor compliance with these measures.	Years 1–5 construction	Incorporation of mitigation measures designed to reduce effects on listed and non-listed marine mammals
3	General	BOEM PDCs and BMPs	BOEM will require Dominion Energy comply with all the Project Design Criteria and BMP for Protected Species at https://www.boem.gov/sites/default/files/documents//PDCs%20and%20BMPs%20for%20Atlantic%20Data%20Collection%2011222021.pdf, that implement the integrated requirements for threatened and endangered species resulting from the June 29, 2021, programmatic consultation under the ESA, revised September 1, 2021. This requirement also applies to non-ESA-listed marine mammals that are found in that document. Consultation conditions occurring in State waters outside of BOEM jurisdiction may apply to co-action agencies issuing permits and authorizations under this consultation	All phases	Ensure the PDE includes preventative mitigation measures to avoid potential effects on ESA-listed species, in addition to external mitigation implemented during Project activities
4	General	Look out for sea turtles and reporting	a. For all vessels operating north of the Virginia/North Carolina border, between June 1 and November 30, Dominion Energy would have a trained lookout posted on all vessel transits during all phases of the project to observe for sea turtles. The trained lookout would communicate any sightings, in real time, to the captain so that the requirements in I below can be implemented. b. For all vessels operating south of the Virginia/North Carolina border, year-round, Dominion Energy would have a trained lookout posted on all vessel transits during all phases of the project to observe for sea turtles. The trained lookout would communicate any sightings, in real time, to the captain so that the requirements II below can be implemented. This requirement is in place year-round for any vessels transiting south of Virginia, as sea turtles are present year-round in those waters. c. The trained lookout would monitor https://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.	All phases	Minimize risk of vessel strikes to sea turtles

No.	Activity	Measure	Description	Project Phase	Expected Effects
4 (cont'd)	General	Look out for sea turtles and reporting	d. If a sea turtle is sighted within 330 feet (100 meters) or less of the operating vessel's forward path, the vessel operator would slow down to 4 knots (unless unsafe 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 330 feet (100 meters), at which time the vessel may resume normal operations. If a sea turtle is sighted within 164 feet (50 meters) of the forward path of the operating vessel, the vessel operator would shift to neutral when safe to do so and then proceed away from the turtle at a speed of 4 knots. The vessel may resume normal operations once it has passed the turtle. e. Vessel captains/operators would 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 would slow to 4 knots while transiting through such areas. f. All vessel crew members would be briefed in the identification of sea turtles and in regulations and best practices for avoiding vessel collisions. Reference materials would 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) would 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. g. The only exception is when the safety of the vessel or crew necessitates deviation from these requirements on an emergency basis. If any such incidents occur, they would be reported to NMFS within 24 hours. h. If a vessel is carrying a PSO or trained lookout for the purposes of maintaining watch for NARWs, an additional lookout is not required and this PSO or trained lookout would maintain watch for marine mammals and sea turtles. Vessel transits to and from the Offshore Project area, that require PSOs will maintain a speed commensurate with weather conditions and effectively detecting sea turtles prior to reaching the 330 feet (100 meters) avoidance measure.	All phases	Minimize risk of vessel strikes to sea turtles

No.	Activity	Measure	Description	Project Phase	Expected Effects
5	General	Marine debris awareness training	Dominion Energy would ensure that vessel operators, employees, and contractors engaged in offshore activities pursuant to the approved COP complete marine trash and debris awareness training annually. The training consists of two parts: (1) viewing a marine trash and debris training video or slide show (described below); and (2) receiving an explanation from management personnel that emphasizes their commitment to the requirements. The marine trash and debris training videos, training slide packs, and other marine debris related educational material may be obtained at https://www.bsee.gov/debris or by contacting BSEE. The training videos, slides, and related material may be downloaded directly from the website. Operators engaged in marine survey activities would continue to develop and use a marine trash and debris awareness training and certification process that reasonably assures that their employees and contractors are in fact trained. The training process would include the following elements: • Viewing of either a video or slide show by the personnel specified above; • An explanation from management personnel that emphasizes their commitment to the requirements; • Attendance measures (initial and annual); and • Record keeping and the availability of records for inspection by DOI. By January 31 of each year, Dominion Energy would submit to DOI an annual report that describes its marine trash and debris awareness training process and certifies that the training process has been followed for the previous calendar year. Dominion Energy would send the reports via email to BOEM (at renewable_reporting@boem.gov) and to BSEE (at marinedebris@bsee.gov).	All phases	Decrease the loss of marine debris, which may represent entanglement and/ or ingestions risk
6	General	BOEM/NMFS meeting requirements for sea turtle take documentation	To facilitate monitoring of the incidental take exemption for sea turtles, through the first year of operations, BOEM and NMFS would meet twice annually to review sea turtle observation records. These meetings/conference calls would be bi-annually) and would 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. These meetings would continue on an annual basis following year one of operations. Upon mutual agreement of NMFS and BOEM, the frequency of these meetings can be changed.	Construction and year 1 of operations	Establish process for monitoring of IT exemption for sea turtles

No.	Activity	Measure	Description	Project Phase	Expected Effects
7	General	Data Collection BA BMPs	BOEM would ensure that all PDC and BMPs incorporated in the Atlantic Data Collection consultation for Offshore Wind Activities (June 2021) shall be applied to activities associated with the construction, maintenance and operations of the Dominion Energy project as applicable.	All phases	Incorporate previously determined best management practices to reduce the likelihood of take of listed species during surveys, vessel operations, and maintenance in the Atlantic OCS
8	General	BOEM COP PDCs and BMPs	Use standard underwater cables that have electrical shielding to control the intensity of electromagnetic fields (EMF).	Construction, O&M	Decrease area of EMF effects on marine mammals, sea turtles, and ESA-listed fish.
			Lessees and grantees should evaluate marine mammal use of the proposed Action Area and should design the project to minimize and mitigate the potential for mortality or disturbance. The amount and extent of ecological baseline data required should be determined on a project basis.	Pre-Construction	Avoid effects with early planning.
			Vessels related to project planning, construction, and operation should travel at reduced speeds when assemblages of cetaceans are observed. Vessels also should maintain a reasonable distance from whales, small cetaceans, and sea turtles, and these should be determined during site-specific consultations.	All phases	Minimize the potential for ESA-listed species strikes from vessels
			Lessees and grantees should minimize potential vessel effects on marine mammals and sea turtles by having project-related vessels follow the NMFS Regional Viewing Guidelines while in transit. Operators should undergo training on applicable vessel guidelines.	All phases	Minimize the potential for ESA-listed species strikes from vessels with ESA-listed species.
			Lessees and grantees should take efforts to minimize disruption and disturbance to marine life from sound emissions, such as pile driving, during construction activities.	All phases	minimize the potential and severity of noise effects
			Lessees and grantees should avoid and minimize effects on marine species and habitats in the Action Area by posting a qualified observer on site during construction activities. This observer should be approved by BOEM and NMFS.	Construction	ensure the effectiveness of mitigation and monitoring measures

No.	Activity	Measure	Description	Project Phase	Expected Effects
9	General	Periodic Underwater Surveys, Reporting of Monofilament and Other Fishing Gear Around WTG Foundations	Dominion Energy must monitor indirect effects associated with charter and recreational fishing gear lost from expected increases in fishing around WTG foundations by surveying at least 10 of the WTGs located closest to shore in the Dominion Energy Lease Area (OCS-A 0483) annually. Survey design and effort may be modified with review and concurrence by DOI. Dominion Energy may conduct surveys by remotely operated vehicles, divers, or other means to determine the frequency and locations of marine debris. Dominion Energy must report the results of the surveys to BOEM (at renewable_reporting@boem.gov) and BSEE (at marinedebris@bsee.gov) in an annual report, submitted by April 30, for the preceding calendar year. Annual reports must be submitted in Word format. Photographic and videographic materials must be provided on a portable drive in a lossless format such as TIFF or Motion JPEG 2000. Annual reports must include survey reports that include: the survey date; contact information of the operator; the location and pile identification number; photographic, video documentation, or both of the survey and debris encountered; any animals sighted; and the disposition of any located debris (i.e., removed or left in place). Annual reports must also include claim data attributable to the Project from Dominion Energy corporate gear loss compensation policy and procedures. Required data and reports may be archived, analyzed, published, and disseminated by BOEM.	Operations	Establish requirement for monitoring and reporting of lost monofilament and other fishing gear around WTGs
10	Foundation Installation	PAM Plan	BOEM and USACE would ensure that Dominion Energy prepares a PAM Plan that describes all proposed equipment, deployment locations, detection review methodology and other procedures, and protocols related to the proposed uses of PAM for mitigation and long-term monitoring. This plan would be submitted to NMFS and BOEM for review and concurrence at least 120 days prior to the planned start of activities requiring PAM.	Construction and post-construction monitoring	Ensure the efficacy of PAM placement for appropriate monitoring
11	Foundation Installation	Pile driving monitoring plan	BOEM would ensure that Dominion Energy prepare and submit a Pile Driving Monitoring Plan to BOEM, BSEE, and NMFS for review and concurrence at least 90 days before start of pile driving. The plan would detail all plans and procedures for sound attenuation as well as for monitoring ESA-listed whales and sea turtles during all impact and vibratory pile driving. The plan would also describe how BOEM and Dominion Energy would determine the number of whales exposed to noise above the Level B harassment threshold during pile driving with the vibratory hammer to install the cofferdam at the sea to shore transition. Dominion Energy would obtain NMFS' concurrence with this plan prior to starting any pile driving.	Construction	Ensure adequate monitoring and mitigation is in place during pile driving

No.	Activity	Measure	Description	Project Phase	Expected Effects
12	Foundation Installation	PSO Coverage	BOEM and USACE would ensure that PSO coverage is sufficient to reliably detect marine mammals and sea turtles at the surface in the identified clearance and shutdown zones to execute any pile driving delays or shutdown requirements. This will include a PSO/ PAM team on the construction vessel and two additional PSO vessels each with a visual monitoring team. The following equipment and personnel will be on each associated vessel: ***Construction Vessel:*** • 2, visual PSOs on watch • 2, (7x) or (10x) reticle binoculars calibrated for observer height off the water. • 2 (25x or similar) mounted "big eye" binoculars if vessel is deemed appropriate to provide a platform in which use of the big eye binoculars would be effective. • 1, PAM operator on duty • 1, mounted thermal/IR camera system • 2, (25x or similar) "big eye" binoculars mounted 180 deg apart • 1, monitoring station for real-time PAM system • 2, handheld or wearable NVDs with IR spotlights • 1, Data collection software system • 2, PSO-dedicated VHF radios • 1, digital single lens reflex camera equipped with a 300-mm lens **Each Additional PSO Vessels (2):** • 2, visual PSOs on watch • 2, (7x) or (10x) reticle binoculars calibrated for observer height off the water. • 1, (25x or similar) mounted "big eye" binoculars if vessel is deemed appropriate to provide a platform in which use of the big eye binoculars would be effective. • 1, mounted thermal/IR camera system • 1, handheld or wearable NVD with IR spotlight • 1, Data collection software system • 2, PSO-dedicated VHF radios • 1, digital single lens reflex camera equipped with a 300-mm lens If, at any point prior to or during construction, the PSO coverage that is included as part of the Proposed Action is determined not to be sufficient to reliably detect ESA-listed whales and sea turtles within the clearance and shutdown zones, additional PSOs, platforms, or both would be deployed. Determinations prior to construction would be based on review of the Pile Driving Monitoring Plan. Determinations during construction would be based on review of the weekly pile driving reports and other information, as appropriate.	Construction	Ensure adequate monitoring of zones

No.	Activity	Measure	Description	Project Phase	Expected Effects
13	Foundation Installation	Sound Field Verification Plan	BOEM would require Dominion Energy to develop an operational sound field verification plan to determine the operational noises emitted from the Offshore Project area. The plan would be reviewed and approved by BOEM and NMFS. • The plan will include measurement procedures and results reporting that meet ISO standard 18406:2017 (Underwater acoustics – Measurement of radiated underwater sound from percussive pile driving)	Operations	Establish requirement for operational noise monitoring
14	Foundation Installation	Sound field verification	Applicant proposed measures plus: • BOEM and USACE would ensure that if the clearance, shutdown zones, or both are expanded due to the verification of sound fields from Project activities, PSO coverage is sufficient to reliably monitor the expanded clearance, shutdown zones, or both. Additional observers would be deployed on additional platforms for every 4,921 feet (1,500 meters) that a clearance or shutdown zone is expanded beyond the distances modeled prior to verification.	Construction	Ensure adequate monitoring of clearance zones
15	Foundation Installation	Adaptive shutdown zones	BOEM and USACE may consider reductions in the shutdown zones for sei, fin or sperm whales based on sound field verification of a minimum of 3 piles; however, BOEM/USACE would ensure that the shutdown zone for sei whales, fin whales, blue whales, and sperm whales is not reduced to less than 3,280 feet (1,000 meters), or 1,640 feet (500 meters) for sea turtles. No reductions in the clearance or shutdown zones for NARWs would be considered regardless of the results of sound field verification of a minimum of three piles.	Construction	Ensure that shut down zones are sufficiently conservative
16	Foundation Installation and Trenchless Installation of Export Cable	Minimum visibility requirement	• In order to commence pile driving at foundations, PSOs must be able to visually monitor a 5,741-foot (1,750-meter) radius from their observation points for at least 60 minutes immediately prior to piling commencement. • In order to commence pile driving at trenchless installation sites, PSOs must be able to visually monitor a 3,280-foot (1,000-meter) from their observation points for at least 30 minutes immediately prior to piling commencement. Acceptable visibility will be determined by the Lead PSO.	Construction	Ensure adequate monitoring of zones
17	Foundation Installation and Trenchless	Monitoring zone for sea turtles	Applicant proposed measures plus: • BOEM and USACE would ensure that Dominion Energy monitors the full extent of the area where noise would exceed the root-mean-square sound pressure level (SPL) 175 dB re 1 µPa behavioral disturbance threshold for turtles for the full duration of all pile driving activities and for 30 minutes following the cessation of pile driving activities and record all observations in order to ensure that all take that occurs is documented.	Construction	Ensure accurate monitoring of sea turtle take

No.	Activity	Measure	Description	Project Phase	Expected Effects
18	Foundation installation and Trenchless Installation of Export Cable	Alternative Monitoring Plan (AMP) for Pile Driving	Dominion Energy must not conduct pile driving operations at any time when lighting or weather conditions (e.g., darkness, rain, fog, sea state) prevent visual monitoring of the full extent of the clearance and shutdown zones. • Dominion Energy must submit an AMP to BOEM and NMFS for review and approval at least 6 months prior to the planned start of pile-driving. This plan may include deploying additional observers, alternative monitoring technologies such as night vision, thermal, and infrared technologies, or use of PAM and must demonstrate the ability and effectiveness to maintain all clearance and shutdown zones during daytime as outlined below in Part 1 and nighttime as outlined in Part 2 to BOEM's and NMFS's satisfaction. • The AMP must include two stand-alone components as described below: ○ Part 1 – Daytime when lighting or weather (e.g., fog, rain, sea state) conditions prevent visual monitoring of the full extent of the clearance and shutdown zones. Daytime being defined as 1 hour after civil sunrise to 1.5 hours before civil sunset. ○ Part 2 – Nighttime inclusive of weather conditions (e.g., fog, rain, sea state). Nighttime being defined as 1.5 hours before civil sunset to 1 hour after civil sunrise. • If a protected marine mammal or sea turtle is observed entering or found within the shutdown zones after impact pile-driving has commenced, Dominion Energy would follow the shutdown procedures outlined in Table 1-7 of this Biological Assessment. Dominion Energy would notify BOEM and NMFS of any shutdown occurrence during piling driving operations with 24 hours of the occurrence unless otherwise authorized by BOEM and NMFS.	Construction	Establish requirement for nighttime impact pile driving approval

No.	Activity	Measure	Description	Project Phase	Expected Effects
18 (cont'd)	Foundation installation and Trenchless Installation of Export Cable	Alternative Monitoring Plan (AMP) for Pile Driving	• The AMP should include, but is not limited to the following information: ○ Identification of night vision devices (e.g., mounted thermal/infrared camera systems, hand-held or wearable NVDs, infrared spotlights), if proposed for use to detect protected marine mammal and sea turtle species. ○ The AMP must demonstrate (through empirical evidence) the capability of the proposed monitoring methodology to detect marine mammals and sea turtles within the full extent of the established clearance and shutdown zones (i.e., species can be detected at the same distances and with similar confidence) with the same effectiveness as daytime visual monitoring (i.e., same detection probability). Only devices and methods demonstrated as being capable of detecting marine mammals and sea turtles to the maximum extent of the clearance and shutdown zones will be acceptable. ○ Evidence and discussion of the efficacy (range and accuracy) of each device proposed for low visibility monitoring must include an assessment of the results of field studies (e.g., Thayer Mahan demonstration), as well as supporting documentation regarding the efficacy of all proposed alternative monitoring methods (e.g., best scientific data available). ○ Reporting procedures, contacts and timeframes. BOEM may request additional information, when appropriate, to assess the efficacy of the AMP.		
19	Fisheries Sampling	Sampling gear	All sampling gear would be hauled at least once every 30 days, and all gear would be removed from the water and stored on land between survey seasons to minimize risk of entanglement.	All fisheries surveys	Minimize risk of entanglement
20	Fisheries Sampling	Gear identification	To facilitate identification of gear on any entangled animals, all trap/pot gear used in the surveys would be uniquely marked to distinguish it from other commercial or recreational gear. Using black and yellow striped duct tape, place a 3-foot-long mark within 2 fathoms of a buoy. In addition, using black and white paint or duct tape, place 3 additional marks on the top, middle and bottom of the line. These gear marking colors are proposed as they are not gear markings used in other fisheries and are, therefore, distinct. Any changes in marking would not be made without notification and approval from NMFS.	Pot/trap surveys	Distinguish survey gear from other commercial or recreational gear
21	Fisheries Sampling	Lost survey gear	If any survey gear is lost, all reasonable efforts that do not compromise human safety would be undertaken to recover the gear. All lost gear would be reported to NMFS (mailto:nmfs.gar.incidental-take@noaa.gov) within 24 hours of the documented time of missing or lost gear. This report would include information on any markings on the gear and any efforts undertaken or planned to recover the gear.	All fisheries surveys	Promote recovery of lost gear

No.	Activity	Measure	Description	Project Phase	Expected Effects
22	Fisheries Sampling	Training	At least one of the survey staff onboard the trawl surveys and ventless trap surveys would have completed NEFOP observer training (within the last 5 years) or other training in protected species identification and safe handling (inclusive of taking genetic samples from Atlantic sturgeon). Reference materials for identification, disentanglement, safe handling, and genetic sampling procedures would be available on board each survey vessel. BOEM would ensure that Dominion Energy prepares a training plan that addresses how this requirement would be met and that the plan is submitted to NMFS in advance of any trawl or trap surveys. This requirement is in place for any trips where gear is set or hauled.	Trawl and ventless trap surveys	Promote safe handling and release of Atlantic sturgeon
23	Fisheries Sampling	Sea turtle disentanglement	Vessels deploying fixed gear (e.g., pots/traps) would have adequate disentanglement equipment (i.e., knife and boathook) onboard. Any disentanglement would occur consistent with the Northeast Atlantic Coast STDN Disentanglement Guidelines at https://www.reginfo.gov/public/do/DownloadDocument?objectID=102486501 and the procedures described in "Careful Release Protocols for Sea Turtle Release with Minimal Injury" (NOAA Technical Memorandum 580; https://repository.library.noaa.gov/view/noaa/3773).	Pot/trap surveys	Require disentanglement of sea turtles caught in gear
24	Fisheries Sampling	Sea turtle/ESA-fish identification and data collection	Any sea turtles or ESA-fish caught, retrieved, or both in any fisheries survey gear would first be identified to species or species group. Each ESA-listed species caught, retrieved, or both would then be properly documented using appropriate equipment and data collection forms. Biological data, samples, and tagging would occur as outlined below. Live, uninjured animals should be returned to the water as quickly as possible after completing the required handling and documentation. a. The Sturgeon and Sea Turtle Take Standard Operating Procedures would be followed (download at: https://media.fisheries.noaa.gov/2021-11/Sturgeon%20%26%20Sea%20Turtle%20Take%20SOPs_external_11032021.pdf). b. Survey vessels would have a passive integrated transponder (PIT) tag reader onboard capable of reading 134.2 kHz and 125 kHz encrypted tags (e.g., Biomark GPR Plus Handheld PIT Tag Reader) and this reader be used to scan any captured sea turtles and sturgeon for tags. Any recorded tags would be recorded on the take reporting form (see below).	All fisheries surveys	Require standard data collection and documentation of any sea turtle/Atlantic sturgeon caught during surveys

No.	Activity	Measure	Description	Project Phase	Expected Effects
24 (cont'd)	Fisheries Sampling	Sea turtle/ESA-fish identification and data collection	c. Genetic samples would be taken from all captured ESA-fish (alive or dead) to allow for identification of the DPS of origin of captured individuals and tracking of the amount of incidental take. This would be done in accordance with the Procedures for Obtaining Sturgeon Fin Clips (download at: https://media.fisheries.noaa.gov/2021-11/Sturgeon%20%26%20Sea%20Turtle%20Take%20SOPs_external_11032021.pdf). ○ Fin clips would be sent to a NMFS approved laboratory capable of performing genetic analysis and assignment to DPS of origin. To the extent authorized by law, BOEM is responsible for the cost of the genetic analysis. Arrangements would be made for shipping and analysis in advance of submission of any samples; these arrangements would be confirmed in writing to NMFS within 60 days of the receipt of this ITS. Results of genetic analysis, including assigned DPS of origin would be submitted to NMFS within 6 months of the sample collection. ○ Subsamples of all fin clips and accompanying metadata forms would be held and submitted to a tissue repository (e.g., the Atlantic Coast Sturgeon Tissue Research Repository) on a quarterly basis. The Sturgeon Genetic Sample Submission Form is available for download at: https://media.fisheries.noaa.gov/2021-02/Sturgeon%20Genetic%20Sample%20Submission%20sheet%20for%20S7_v1.1_Form%20to%20Use.xlsx?null. d. All captured sea turtles and ESA-fish would be documented with required measurements and photographs. The animal's condition and any marks or injuries would be described. This information would be entered as part of the record for each incidental take. A NMFS Take Report Form would be filled out for each individual sturgeon and sea turtle (download at: https://media.fisheries.noaa.gov/2021-07/Take%20Report%20Form%2007162021.pdf?null) and submitted to NMFS as described below.	All fisheries surveys	Require standard data collection and documentation of any sea turtle/Atlantic sturgeon caught during surveys

No.	Activity	Measure	Description	Project Phase	Expected Effects
25	Fisheries Sampling	Sea turtle/ESA-fish handling and resuscitation guidelines	Any sea turtles or ESA-fish caught and retrieved in gear used in fisheries surveys would be handled and resuscitated (if unresponsive) according to established protocols and whenever at-sea conditions are safe for those handling and resuscitating the animal(s) to do so. Specifically: a. Priority would be given to the handling and resuscitation of any sea turtles or ESA-fish that are captured in the gear being used, if conditions at sea are safe to do so. Handling times for these species should be minimized (i.e., kept to 15 minutes or less) to limit the amount of stress placed on the animals. b. All survey vessels would have copies of the sea turtle handling and resuscitation requirements found at 50 CFR 223.206(d)(1) prior to the commencement of any on-water activity (download at: https://media.fisheries.noaa.gov/dam-migration/sea_turtle_handling_and_resuscitation_measures.pdf). These handling and resuscitation procedures would be carried out any time a sea turtle is incidentally captured and brought onboard the vessel during the Proposed Actions. c. If any sea turtles that appear injured, sick, or distressed, are caught and retrieved in fisheries survey gear, survey staff would immediately contact the Greater Atlantic Region Marine Animal Hotline at 866-755-6622 for further instructions and guidance on handling the animal, and potential coordination of transfer to a rehabilitation facility. If unable to contact the hotline (e.g., due to distance from shore or lack of ability to communicate via phone), the USCG should be contacted via VHF marine radio on Channel 16. If required, hard-shelled sea turtles (i.e., non-leatherbacks) may be held on board for up to 24 hours following handling instructions provided by the Hotline, prior to transfer to a rehabilitation facility. d. Attempts would be made to resuscitate any ESA-fish that are unresponsive or comatose by providing a running source of water over the gills as described in the Sturgeon Resuscitation Guidelines (download at: https://media.fisheries.noaa.gov/dam-migration/sturgeon_resuscitation_card_06122020_508.pdf). e. Provided that appropriate cold storage facilities are available on the survey vessel, following the report of a dead sea turtle or sturgeon to NMFS, and if NMFS requests, any dead sea turtle or ESA-fish would be retained on board the survey vessel for transfer to an appropriately permitted partner or facility on shore as safe to do so. f. Any live sea turtles or ESA-fish caught and retrieved in gear used in any fisheries survey would ultimately be released according to established protocols and whenever at-sea conditions are safe for those releasing the animal(s) to do so.	All fisheries surveys	Ensure the safe handling and resuscitation of sea turtles and Atlantic sturgeon following established protocols

No.	Activity	Measure	Description	Project Phase	Expected Effects
26	Fisheries sampling	Take notification	GARFO PRD would be notified as soon as possible of all observed takes of sea turtles and ESA-fish occurring as a result of any fisheries survey. Specifically: a. GARFO PRD would be notified within 24 hours of any interaction with a sea turtle or ESA-fish (nmfs.gar.incidental-take@noaa.gov). The report would include at a minimum: (1) survey name and applicable information (e.g., vessel name, station number); (2) GPS coordinates describing the location of the interaction (in decimal degrees); (3) gear type involved (e.g., bottom trawl, gillnet, longline); (4) soak time, gear configuration and any other pertinent gear information; (5) time and date of the interaction; and (6) identification of the animal to the species level. Additionally, the email would transmit a copy of the NMFS Take Report Form (download at: https://media.fisheries.noaa.gov/2021-07/Take%20Report%20Form%2007162021.pdf?null) and a link to or acknowledgement that a clear photograph or video of the animal was taken (multiple photographs are suggested, including at least one photograph of the head scutes). If reporting within 24 hours is not possible due to distance from shore or lack of ability to communicate via phone, fax, or email, reports would be submitted as soon as possible; late reports would be submitted with an explanation for the delay. b. At the end of each survey season, a report would be sent to NMFS that compiles all information on any observations and interactions with ESA-listed species. This report would also contain information on all survey activities that took place during the season including location of gear set, duration of soak/trawl, and total effort. The report on survey activities would be comprehensive of all activities, regardless of whether ESA-listed species were observed.	All fishery surveys	Establish procedures for immediate reporting of sea turtle/Atlantic sturgeon take

No.	Activity	Measure	Description	Project Phase	Expected Effects
27	Reporting	Monthly / annual reporting	Applicant proposed measures plus: BOEM would ensure that Dominion Energy implements the following reporting requirements necessary to document the amount or extent of take that occurs during all phases of the Proposed Action: a. All reports would be sent to: nmfs.gar.incidental-take@noaa.gov. b. During the construction phase and for the first year of operations, Dominion Energy would 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 ESA-listed species. Monthly reports are due on the 15th of the month for the previous month. c. Beginning in year two of operations, Dominion Energy would compile and submit annual reports that include a summary of all project activities carried out in the previous year, including vessel transits (number, type of vessel, and route), repair and maintenance activities, survey activities, and all observations of ESA-listed species. These reports are due by April 1 of each year (i.e., the 2026 report is due by April 1, 2027). Upon mutual agreement of NMFS and BOEM, the frequency of reports can be changed.	Construction and operations	Establish reporting requirements and timing to document take and operator activities
28	Special Conditions	Special Conditions	Dominion Energy will comply with any special conditions and required mitigation associated with work authorized or permitted through Section 10 of the Rivers and Harbors Act of 1899, Section 404 of the Clean Water Act, and ESA terms and conditions landward of the Submerged Lands Act boundary.	All Phases	Establish requirement for avoidance, minimization, mitigation of impacts pursuant to Section 10, Section 404 and Submerge Lands Act

BMP = best management practice; BOEM = Bureau of Ocean Energy Management; BSEE = Bureau of Safety and Environmental Enforcement; COP = Construction and Operations Plan; DMA = Dynamic Management Area; DOI = Department of the Interior; DPS = distinct population segment; ESA = Endangered Species Act; GARFO PRD = Greater Atlantic Regional Fisheries Office Protected Resources Division; IR = infrared; ITS = incidental take statement; LOA = Letter of Authorization; MMPA = Marine Mammal Protection Act; NARW = North Atlantic right whale; NEFOP = Northeast Fisheries Observer Program; NMFS = National Marine Fisheries Service; NVD = night vision device; O&M = operations and maintenance; PAM = passive acoustic monitoring; PDC = project design criteria; PDE = project design envelope; PSO = protected species observer; SMA = Seasonal Management Area; USACE = U.S. Army Corps of Engineers; VHF = very high-frequency; WTG = wind turbine generator.

2. Environmental Baseline

2.1 Physical Environment

2.1.1 Seabed and Physical Oceanographic Conditions

2.1.1.1 Seabed Conditions

The seabed characteristics of the Action Area are consistent with the larger Mid-Atlantic Bight region; soft-bottom sediments characterized by fine sand punctuated by gravel and silt/sand mixes with the primary morphological feature consisting of shoal massifs, scarps, sand ridges, and swales (Dominion Energy 2022). Water depths in the Lease Area range from 57 to 139 feet (18 to 42 meters) mean lower low water and water depths along the offshore export cable route corridor range from 9.5 to 95.1 feet (2.9 to 29 meters) mean lower low water (Dominion Energy 2022). The seabed generally slopes west to east towards the OCS edge, with the shallowest waters in the western portion of the Action Area, and the deepest in the eastern portion. The sand ridges and swales, which make up the seabed in the Action Area are thought to be the result of storm activity and hydrodynamic interactions, typically spaced 4,900 to 13,000 feet (1,500 to 4,000 meters) apart with crests standing 13 to 20 feet (4 to 6 meters) above the swales (Dominion Energy 2022). The topographic variability of these ridges lessens towards the northeastern portion of the Action Area where the water depths increase. Within the Lease Area, the seafloor sediment consists predominantly of sand with silt to silty clay (Dominion Energy 2022).

2.1.1.2 Physical Oceanographic Conditions

Sea surface temperatures in the Lease Area reported by the EPA released in their National Coastal Condition Report IV (EPA 2012) ranged from 32°F to 88°F (0°C to 31°C), which corresponds to a depth-averaged annual water temperature of 56.39°F (13.55°C) (Dominion Energy 2022). Within Virginian state waters, mean water temperatures from the Naval Air Station Oceana, Dam Neck Annex range from 43.34°F to 76.64°F (6.3°C to 24.8°C), varying due to seasons and water depth (Dominion Energy 2022).

The Mid-Atlantic Bight is characterized by a cross-shelf salinity gradient due to freshwater runoff from the Hudson-Raritan Estuary System, Delaware Bay, and Chesapeake Bay (Castelao et al. 2010; Dominion Energy 2022). This stratification typically starts in early June and persists through October. Salinity in the Lease Area ranges from 31.9 to 32.8 parts per thousand (ppt), and in Virginian state waters near the Nearshore Trenchless Installation Area salinity ranged from 23.4 to 36.6 ppt (COP Table 4.1-7; Dominion Energy 2022).

2.1.1.3 Water Quality

For the purpose of the Section 7 consultation, the total suspended solids (TSS) metric is the pertinent water quality parameter likely to be measurably affected by the proposed Project activities. Ocean waters within the Mid-Atlantic Bight typically have low concentrations of suspended particles and low turbidity. Waters along this region average 5.6 milligrams per liter (mg/L) of TSS with near bottom concentrations of 6.9 mg/L, which is considered low (Dominion Energy 2022). Water quality sampling conducted nearshore and offshore areas of the Naval Air Station Oceana Dam Neck Annex in Virginia Beach, Virginia indicated TSS concentrations ranging from 0.03 to 0.11 mg/L (Dominion Energy 2022).

2.1.2 Electromagnetic Fields

The marine environment continuously generates additional ambient EMF effects. The motion of electrically conductive seawater through the earth's magnetic field induces voltage potential, thereby creating electrical currents. Surface and internal waves, tides, and coastal ocean currents all create weak induced EMF effects. Their magnitude at a given time and location depends on the strength of the prevailing magnetic field, site, and time-specific ocean conditions. Other external factors like electrical storms and solar events can also generate variable EMF effects. The estimated EMF level in the Action Area is approximately 500 milligauss (mG; 50 µT) (NOAA 2022a). The strength of the Earth's direct current magnetic field is approximately 516 mG (51.6 µT) along the southern New England coast (CSA Ocean Sciences Inc. and Exponent 2019). As ocean currents and organisms move through this direct current magnetic field, a weak direct current electric field is produced. For example, the electric field generated by the movement of the ocean currents through the Earth's magnetic field is reported to be approximately 0.075 millivolts per meter (mV/m) or less (CSA Ocean Sciences Inc. and Exponent 2019). Other external factors like electrical storms and solar events can also generate variable EMF effects. Following the methods described by Slater et al. (2010), a uniform current of 1 meter per second (m/s) flowing at right angles to the natural magnetic field in the action area could induce a steady-state electrical field on the order of 51.5 microvolts per meter (µV/m). Wave action would also induce electrical and magnetic fields at the water surface on the order of 10 to 100 uV/m and 1 to 10 mG, respectively, depending on wave height, period, and other factors. Although these effects dissipate with depth, wave action would likely produce detectable EMF effects up to 185 feet (56 meters) below the surface (Slater et al. 2010).

Though no submarine transmission or communication cables have been identified in the Action Area, these can also contribute to EMF levels in an area. Electrical telecommunications cables are likely to induce a weak EMF in the immediate area along the cable path. Gill et al. (2005) observed electrical fields on the order of 1 to 6.3 µV/m within 1 meter of a typical cable of this type. The heat effects of communication and transmission cables on surrounding sediments are likely to be negligible given the limited transmission power levels involved (Taormina et al. 2018). Fiber-optic cables with optical repeaters would not produce EMF or significant heat effects.

2.1.3 Anthropogenic Conditions

2.1.3.1 Artificial Light

Vessel traffic and navigational safety lights on buoys and meteorological towers are the only artificial lighting sources in the open-water portion of the Action Area. Land-based artificial light sources become more predominant approaching the Virginia Beach shoreline.

2.1.3.2 Vessel Traffic

There are several routing measures that regulate vessel traffic to help ships avoid navigational hazards in the vicinity of the Action Area. Vessel traffic in and out of Chesapeake Bay is regulated by a Traffic Separation Scheme that is 5.8 miles (5 nautical miles, 9.3 kilometers) west of the Lease Area and approximately 1.2 miles (1 nautical mile, 1.9 kilometers) north of the export cable corridor route (Anatec Limited 2022). The Traffic Separation Scheme within the approach to Chesapeake Bay consists of three parts: an Eastern Approach, a Southern Approach, and a Precautionary Area. The Southern Approach consists of a two-way, deep-water route for vessels with drafts exceeding 42 feet (12.8 meters) (Anatec Limited 2022). There is also a pilotage boarding area located off Cape Henry where the Southern and Eastern Approaches converge.

The Lease Area is located partially within the "Chesapeake Bay to Delaware Bay: Eastern Approach

Cutoff Fairway," proposed by the USCG Atlantic Coast Port Access Route Study (PARS) (USCG 2021). The potential fairway is about 200 miles (322 kilometers) long, approximately 10 nautical miles (18.5 kilometers) wide; however, the width narrows to approximately 4 nautical miles (7.4 kilometers) wide adjacent to the Lease Area and includes the customary route taken by vessels transiting between the Port of Virginia; the Port of Baltimore, Maryland; the Port of Philadelphia, Pennsylvania; and the Port of Wilmington, Delaware (USCG 2020). The proposed Chesapeake Bay to Delaware Bay: Eastern Approach Cutoff Fairway occupies a small portion of three of the northwesternmost Lease Area aliquots. The intersection of the Chesapeake Bay to Delaware Bay: Eastern Approach Cutoff Fairway and the Lease Area is approximately 135 acres (55 hectares; 0.5 km^2), which is approximately 0.1 percent of the Lease Area. In addition, on June 16, 2021, the USCG announced a PARS for the Approaches to Chesapeake Bay, Virginia. The purpose of this study was to examine the east-west traffic that merges into the Atlantic Coast PARS Safety Fairways.

The *Port Access Route Study: Approaches to the Chesapeake Bay Final Report* (USCG 2021) was reviewed in COP Appendix S: Navigation Safety Risk Assessment (Anatec Limited 2022) and it is considered that the Atlantic Coast PARS scenario represents a worst case from an assessment perspective. Figure 4.4-45 (p. 4-652) of the COP Section 4.4 (Dominion Energy 2022) shows the outputs of the Port Access Route Study: Approaches to the Chesapeake Bay Final Report (USCG 2021) for reference.

According to automatic identification system (AIS) data, the vicinity surrounding the Action Area is heavily trafficked by vessels entering and exiting the Chesapeake Bay and transiting along the coast of the U.S. (Anatec Limited 2022). Throughout 2019, there was an average of approximately 22 to 23 unique vessels per day recorded within the Navigation Safety Risk Assessment offshore study area, which includes the Lease Area and surrounding 10 nautical miles (18.5 kilometers). Cargo vessels accounted for 73 percent of all recorded traffic, followed by military vessels (ten percent) and tankers (six percent) (Anatec Limited 2022). Vessel activity within the export cable corridor study area (inclusive of the export cable route corridor and 2-nautical mile [3.7-kilometer] buffer) was notably higher than in offshore areas, with an average of 36 unique vessels per day recorded in 2019 (Anatec Limited 2022). The highest vessel densities were recorded half-way between coastal Virginia and the Lease Area, mostly composed of cargo vessels converging on the southern approach to Chesapeake Bay. Coastal regions within the study area also exhibit moderate to high vessel densities, primarily due to recreational vessels. Potential future growth in commercial shipping traffic volume is conservatively estimated to increase between 10 percent and 20 percent, though there is considerable uncertainty associated with long-term forecasting of vessel traffic activity (Anatec Limited 2022).

Importantly, recreational vessels and commercial fishing vessels less than 65 feet (19.8 meters) in length are not required to broadcast via AIS; activity of these vessel classes in the Navigation Safety Risk Assessment study area is, therefore, likely underrepresented in the data. Additionally, AIS data in the Navigation Safety Risk Assessment presents the average number of unique vessels recorded per day for each month of 2019 within the study area and lease area; these data can inform overall vessel activity, but are not necessarily analogous to the discrete number of vessel transits that occur in the region. Given these limitations of the data, the baseline vessel activity described in this BA is considered an underestimate of total vessel activity for the region.

2.1.4 Underwater Noise

There is limited publicly available site-specific ambient sound information collected within the Action Area. NOAA's SoundMap (NOAA 2022b), which is a mapping tool that provides maps of the temporal, spatial, and frequency characteristics of man-made underwater noise resulting from various activities, provides some information for an area encompassing the Action Area. Pressure fields associated with different contributors of underwater sound (i.e., shipping and passenger vessels) were summed and the sound pressure level values at frequencies ranging from 50 to 800 Hz were presented for various water column depths. Within the lower 50 Hz frequency range, underwater sound pressure levels were greatest, varying between approximately 80 to 100 decibels (dB) depending on water depth and proximity to the coastline. The sound contribution and magnitude decreases with increasing frequency, indicating that the noise from shipping and passenger vessels is largely focused within the low-frequency range.

The underwater sound speed is influenced by the temperature, salinity, and depth as described using sound velocity profiles. For the proposed Project, sound speed profiles were obtained in COP Appendix Z, Underwater Acoustic Assessment (Dominion Energy 2022) from the NOAA Sound Speed Manager software for May to October when the proposed offshore construction activities will occur. Modeled impact ranges used the average sound velocity profile of these months, but further discussion of these profiles can be found in Appendix Z of the COP (Dominion Energy 2022).

2.2 Climate Change

NMFS and USFWS lists the long-term changes in climate change as a threat for almost all marine species (Hayes et al. 2020, 2022; NMFS 2022h,i; USFWS 2022a,b,c,d). Climate change is known to increase temperatures, alter ocean acidity, raise sea levels, and increase numbers and intensity of storms. Increased temperatures can alter habitat, modify species' use of existing habitats, change precipitation patterns, and increase storm intensity (Love et al. 2013; EPA 2022; NASA 2023).

Increase of the ocean's acidity has numerous effects on ecosystems including reducing available calcium carbonate that organisms use to build shells, which can cause effects on marine mammal and sea turtle prey items and result in feeding shifts within food webs (Love et al. 2013; EPA 2022; NASA 2023). These effects have the potential to alter the distribution and abundance of marine mammal and sea turtle prey. For example, between 1982 and 2018 the average center of biomass for 140 marine fish and invertebrate species along U.S. coasts shifted approximately 20 miles (32 kilometers) north. These species also migrated an average of 21 feet (6.4 meters) deeper (EPA 2022).

Climate change has the potential to affect marine mammals as a result increased storm severity and frequency; increased erosion and sediment deposition; ocean acidification; and altered habitat, ecology, and migration patterns. Climate change could potentially affect the incidence or prevalence of infection, the frequency or magnitude of epizootics, the severity, or both or presence of clinical disease in infected individuals (Burge et al. 2014). Over time climate change and coastal development would alter existing habitats, rendering some areas unsuitable for certain species and more suitable for others. For example, shifts in NARW distribution patterns are likely in response to changes in prey densities related to climate change (O'Brien et al. 2022; Reygondeau and Beaugrand 2011; Meyer-Gutbrod et al. 2015). These long-term, high-consequence impacts could include increased energetic costs associated with altered migration routes, reduction of suitable breeding, foraging habitat, or both, and reduced individual fitness.

Available data also suggests that changing ocean temperatures and sea level rise may lead to changes in the sex ratio of sea turtle populations (e.g., green sea turtle [*Chelonia mydas*] population feminization predicted under Intergovernmental Panel on Climate Change scenarios by 2120); loss of nesting area; and a decline in population growth due to incubation temperature reaching lethal levels (Patrício et al. 2019; Varela et al. 2019). In addition to affecting nesting activity, increased sea surface temperatures could have physiological effects on sea turtles during migration (Marn et al. 2017). Higher temperatures in migratory corridors would be especially risky for metabolic rates of female sea turtles post-nesting, as they do not generally forage during breeding periods, and their body condition would not be expected to be optimal to withstand unexpected changes in water temperature in their migratory habitat (Hays et al. 2014).

Finfish and invertebrate migration patterns can be influenced by warmer waters, as can the frequency or magnitude of disease (Hare et al. 2016). Regional water temperatures that increasingly exceed the thermal stress threshold may affect the recovery of the American lobster fishery off the East Coast of the U.S. (Rheuban et al. 2017). Ocean acidification driven by climate change is contributing to reduced growth, and, in some cases, decline of invertebrate species with calcareous shells. Increased freshwater input into nearshore estuarine habitats can result in water quality changes and subsequent effects on invertebrate species (Hare et al. 2016). Based on a recent study, marine, estuarine, and riverine habitat types were found to be moderately to highly vulnerable to stressors resulting from climate change (Farr et al. 2021). In general, rocky and mud bottom, intertidal, special areas of conservation, kelp, coral, and sponge habitats were considered the most vulnerable habitats to climate change in marine ecosystems (Farr et al. 2021). Similarly, estuarine habitats considered most vulnerable to climate change include intertidal mud and rocky bottom, shellfish, kelp, submerged aquatic vegetation, and native wetland habitats (Farr et al. 2021). Riverine habitats found to be most vulnerable to climate change include native wetland, sandy bottom, water column, and submerged aquatic vegetation habitats (Farr et al. 2021). As invertebrate habitat, finfish habitat, and Essential Fish Habitat may overlap with these habitat types, the Farr et al. (2021) environmental study suggests that marine life and habitats could experience dramatic changes and decline over time as impacts from climate change continue.

The extent of these effects is unknown; however, it is likely that ESA-listed populations already stressed by other factors will likely be the most affected by the repercussions of climate change. The current effects from climate change are likely to result in long-term consequences to individuals or populations that are detectable and measurable and have the potential to result in population-level effects that could compromise the viability of some species.

2.3 Species and Critical Habitat Considered, but Discounted from Further Analysis

Several species have broad ranges, which may include the Action Area but are not likely to be affected by the Proposed Action. During vessel transits through the Gulf of Mexico some ESA-listed species are present and include smalltooth sawfish, Gulf sturgeon, Nassau grouper, and various ESA-listed coral species in the Gulf of Mexico which include the boulder star coral, elkhorn coral, lobed star coral, mountainous star coral, pillar coral, rough cactus coral, and staghorn coral (79 *FR* 53851). However, the only activity under the Proposed Action that would occur in the Gulf of Mexico are possible vessel transits for support vessels during construction which would not involve anchoring on the seafloor. Because these are primarily benthic species or have a limited range in the Gulf of Mexico; and therefore, a low risk of vessel encounters, it was determined there would be “no effect” for any of these species and they are therefore excluded from further analysis. All other ESA-listed species that may be encountered are evaluated below.

2.3.1 Blue Whale – Endangered

In the North Atlantic Ocean, the range of blue whales (*Balaenoptera musculus*) extends from the subtropics to the Greenland Sea. As described in 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 (Hayes et al. 2020). Blue whales do not commonly occur within the shelf waters of the U.S. East Coast as they typically occur further offshore in areas with depths of 328 feet (100 meters) or more (Hayes et al. 2020). Migration patterns for blue whales in the eastern North Atlantic Ocean are poorly understood, but blue whales have been documented in winter months off Mauritania in northwest Africa (Baines and 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 deepwater areas near the shelf break west of the British Isles (Charif and Clark 2009). Data suggest blue whales are rare in the U.S. Mid-Atlantic shelf waters given their preference for high-latitude feeding areas (Pike et al. 2009; Lesage et al. 2017, 2018; Hayes et al. 2020). Blue whales could be encountered by Project vessels originating from ports in Europe or eastern Canada. Due to only a limited number of Project vessels transiting from Europe to the wind farm area and all Project vessels would adhere to the vessel strike avoidance measures outlined in Tables 1-8 and 1-9 to further reduce the likelihood of a vessel strike occurring or resulting in a serious injury or mortality, the potential for vessel strikes occurring that result in serious injury or mortality is low. Therefore, the potential for adverse effects from the Proposed Action to occur is **discountable.**

2.3.2 Humpback Whale Cape Verde/Northwest Africa Distinct Population Segment – Endangered

The humpback whale (*Megaptera novaeangliae*) can be found worldwide in all major oceans from the equator to sub-polar latitudes. In the summer, humpbacks are found in high-latitude feeding grounds while during the winter months, individuals migrate to tropical or subtropical breeding grounds to mate and give birth (Hayes et al. 2020). North Atlantic humpback whales feed during the summer in various locations in cooler, temperate regions, including the Gulf of Maine, Newfoundland/Labrador, the Gulf of St. Lawrence, Greenland, Iceland, and Norway, including Svalbard (Wenzel et al. 2020). Available photo-identification and genotyping data indicate humpbacks from all these feeding grounds migrate to the primary winter breeding ground in the Dominican Republic (Wenzel et al. 2020). However, smaller numbers have been observed wintering around the Cape Verde Islands (Wenzel et al. 2020; Cooke 2018a). The designation of the Cape Verde/Northwest Africa distinct population segment (DPS) was based on genetic evidence indicating a second breeding ground occupied by humpback whales feeding primarily off Norway and Iceland (Bettridge et al. 2015; Wenzel et al. 2020). Surveys conducted between 2010 and 2018 estimated 272 non-calf whales in the Cape Verde/Northwest Africa DPS using photo-identification survey methods (Wenzel et al. 2020). Although the population abundance for this DPS remains unknown, resighting rates suggest a small population size (Wenzel et al. 2020). Humpback whales were subject to significant removals by pre-modern whalers especially in their wintering grounds in the West Indies and Cape Verde Islands (Smith and Reeves 2003). Whaling in the Cape Verde Islands occurred primarily during 1850 to 1912 with a total estimated kill of about 3,000 animals (Reeves et al. 2002). Humpback whales from the Cape Verde/Northwest Africa DPS potentially occurring in the Action Area would be limited to those individuals located within or around the summer feeding grounds off Norway and Iceland where they may encounter Project vessels originating from ports in Europe. However, given this DPS is primarily present in European waters in the summer, interactions with Project vessels in Europe would be uncommon and limited to the whales migration to and from feeding/breeding grounds. Given the small size of this DPS and their limited presence in European waters, potential for adverse effects from the Proposed Action to occur is **discountable.**

2.3.3 Rice's Whale – Endangered

The Rice's whale (*Balaenoptera ricei*) has been consistently located in the northeastern Gulf of Mexico and they are the only resident baleen whale in the Gulf of Mexico. In 2021, scientists determined that the Rice's whale was a unique species, genetically and morphologically distinct from Bryde's whales (*Balaenoptera brydei*) and in response NMFS revised the common and scientific name of the ESA-listed entity originally designated for the Gulf of Mexico Bryde's whale in 2019 to Rice's whale and classification to species to reflect the new scientifically accepted taxonomy and nomenclature of the species (NMFS 2022a). NMFS most recent abundance estimate from 2017 to 2018 surveys in the northeastern Gulf of Mexico is approximately 50 individual Rice's whales (NMFS 2022a). Rice's whales in U.S. waters of the Gulf of Mexico are primarily located in the northeastern Gulf of Mexico along the OCS between roughly 100- and 400-meter depth. A single Rice's whale was observed in the western Gulf of Mexico off the coast of Texas, suggesting that their distribution may occasionally include waters elsewhere in the Gulf of Mexico. The Rice's whale is one of the few types of baleen whales to prefer warmer, tropical waters and that does not make long-distance migrations. They remain in the Gulf of Mexico year-round. Given their limited distribution, the only overlap with the Action Area would be with any potential Project vessel transits that occur from ports in the Gulf of Mexico to the Project area. However, as discussed in Section 1.3, *Description of Proposed Action*, Project vessels originating from the Gulf of Mexico would be limited to smaller support vessels, not vessels transporting project components. It is anticipated that these support vessels would only mobilize from the Gulf of Mexico to the project location; therefore, transits would be minimal during Project construction. Additionally, all Project vessels originating from the Gulf of Mexico would adhere to the vessel strike avoidance measures outlined in Tables 1-8 and 1-9 to further reduce the likelihood of a vessel strike occurring or resulting in a serious injury or mortality. Therefore, the potential for adverse effects from the Proposed Action to occur is **discountable**.

2.3.4 Atlantic Salmon Gulf of Maine DPS – Endangered

The Gulf of Maine DPS of Atlantic salmon (*Salmo salar*) is the only DPS listed under the ESA that may occur in the Action Area. They were originally listed in December 2000 (65 FR 69459), and the listing was then updated in June 2009 to expand the range of the Gulf of Maine DPS listed under the ESA (74 FR 29343). The geographic range of the Gulf of Maine DPS is the Dennys River watershed to the Androscoggin River (74 FR 29343). Freshwater habitats in the Gulf of Maine provide spawning habitat and thermal refuge for adults; overwintering and rearing areas for eggs, fry, and parr; and migration corridors for smolts and adults (Bardonnet and Bagliniere 2000). Atlantic salmon in the Gulf of Maine are known to migrate far distances in the open ocean to feeding areas in the Davis Strait between Labrador and Greenland, which is approximately 4,000 kilometers from their natal rivers (Danie et al. 1984; Meister 1984). Most Atlantic salmon (about 90 percent) from the Gulf of Maine return after spending two winters at sea; usually less than 10 percent return after spending one winter at sea and approximately 1 percent of returning salmon are either repeat spawners or have spent three winters at sea (Baum 1997). Atlantic salmon in the Action Area would only be encountered during vessel transits from ports in Novia Scotia, Canada which would be limited to the scour protection installation vessels. The likelihood of Project vessels encountering Atlantic salmon in the Gulf of Maine during transits, however, is low as vessel strikes are not often reported for this species and vessel transits would not disturb any freshwater habitats where spawning occurs. Therefore, the potential for adverse effects from the Proposed Action to occur is **discountable**.

2.3.5 Oceanic Whitetip Shark – Threatened

The oceanic whitetip shark (*Carcharhinus longimanus*) can be found globally in tropical and warm-temperate waters. It is a pelagic species with a preference for open ocean waters but can also be found on the OCS or around oceanic islands in deeper waters (NMFS 2023a). The species is typically found in water temperatures between 59°F and 82°F (15°C and 28°C), though is most common in waters above 68°F (20°C) (Bonfil et al. 2008; Carlson and Gulak 2012; Tolotti et al. 2015; NMFS 2023a). In the Northwest Atlantic, the oceanic whitetip shark is most commonly observed south of Virginia, though records of occurrence do include the Mid-Atlantic and northeast U.S. (Kohler et al. 1998; Young and Carlson 2020; Vaudo et al. 2022). The overall range of the shark in the North Atlantic expands northward during the summer and fall in response to seasonally warming temperatures and prey availability (Vaudo et al. 2022). Oceanic whitetip sharks may, therefore, be encountered in the proposed Action Area; however, these occurrences would be rare. Due to the low probability of this species occurring in the Action Area, the potential for adverse effects from the Proposed Action to occur is **discountable**.

2.3.6 Scalloped Hammerhead Shark – Endangered

Scalloped hammerhead sharks (*Sphyrna lewini*) are moderately large sharks with a global distribution.

Animals from the Eastern Atlantic DPS, which occur in the Eastern Atlantic and Mediterranean Sea (79 FR 38213), and the Central and Southwest Atlantic DPS, which range as far north as central Florida, may occur in the Action Area but are not expected within the Project area. The primary factors responsible for the decline of the listed scalloped hammerhead shark DPSs are overutilization, due to both catch and bycatch of these sharks in fisheries, and inadequate regulatory mechanisms for protecting these sharks, with illegal fishing identified as a significant problem (79 FR 38213). ESA-listed scalloped hammerhead sharks in the Action Area would only be encountered by Project vessels transiting from ports in Europe or the Gulf of Mexico. Because only a limited number of Project vessels would transit from Europe or the Gulf of Mexico to the wind farm area and reported vessel strikes for this species are low, the potential for vessel strikes occurring that result in serious injury or mortality is low and the potential for adverse effects from the Proposed Action to occur is **discountable.**

2.3.7 Shortnose Sturgeon – Endangered

The shortnose sturgeon (*Acipenser brevirostrum*) is anadromous, spawning and growing in freshwater and foraging in both the estuary of its natal river and shallow marine habitats close to the estuary (Bain 1997; Fernandes et al. 2010). Shortnose sturgeon occur in the Northwest Atlantic but are typically found in freshwater or estuarine environments. Historically, the species was found in coastal rivers along the entire east coast of North America. Because of threats such as habitat degradation, water pollution, dredging, water withdrawals, fishery bycatch, and habitat impediments (e.g., dams), the species is now listed as Endangered throughout the entire population range. Within the Mid-Atlantic Region, shortnose sturgeon are found in Chesapeake Bay, though there is little to no evidence of any spawning populations in this area (Kynard et al. 2016). The only rivers in the Mid-Atlantic with evidence of shortnose sturgeon populations are the Delaware River and the Potomac River, both of which are outside the Action Area (Kynard et al. 2016). Movement of shortnose sturgeon between rivers is rare, and the individuals that are known to occur in Chesapeake Bay are likely transients from the Delaware River or remnants of the Potomac River population (NMFS 2015; Kynard et al. 2016). In addition, they are a primarily benthic species that are rarely known to leave their natal freshwater rivers (Kieffer and Kynard 1993; NMFS 2015); therefore, their presence in the marine environment is uncommon (Baker and Howsen 2021). The species is expected to be rare in the Action Area, limited to Chesapeake Bay, the potential for adverse effects from the Proposed Action to occur is **discountable**.

2.3.8 Hawksbill Sea Turtle – Endangered

Only two records of Atlantic hawksbill sea turtles (*Eretmochelys imbricata*) have been reported offshore Virginia. Hawksbill sea turtle typically prefers tropical habitats and occurrence in Virginia's offshore waters is considered extralimital (Ocean Biodiversity Information System 2022; Virginia Institute of Marine Science [VIMS] 2022a; Dominion Energy 2022). Two sightings of one individual each occurred during the Atlantic Marine Assessment Program for Protected Species (AMAPPS) study in 2019 off central Florida, but no other sightings were recorded prior to 2019 or in 2020 (Palka et al. 2017; Northeast Fisheries Science Center and Southeast Fisheries Science Center 2020, 2021). Given the low density of hawksbill sea turtles in the Mid-Atlantic, the species is more likely to be encountered in the Action Area by vessels transiting from ports in the Gulf of Mexico. Hawksbill sea turtles regularly occur in Gulf of Mexico waters off the southern Florida coast and in the northern Gulf, especially in Texas coastal waters (NMFS and USFWS 1993). They have been recorded in waters of all Gulf Coast states and are regularly observed in the Florida Keys (Lund 1985; NMFS and USFWS 1993; Meylan and Redlow 2006). However, as discussed previously, Project vessels originating from the Gulf of Mexico would be limited to smaller support vessels and only a minimal number of transits would be expected to occur throughout the life of the Project. Therefore, the likelihood of a vessel strike occurring or resulting in a serious injury or mortality would be low, and the potential for adverse effects from the Proposed Action to occur is **discountable**.

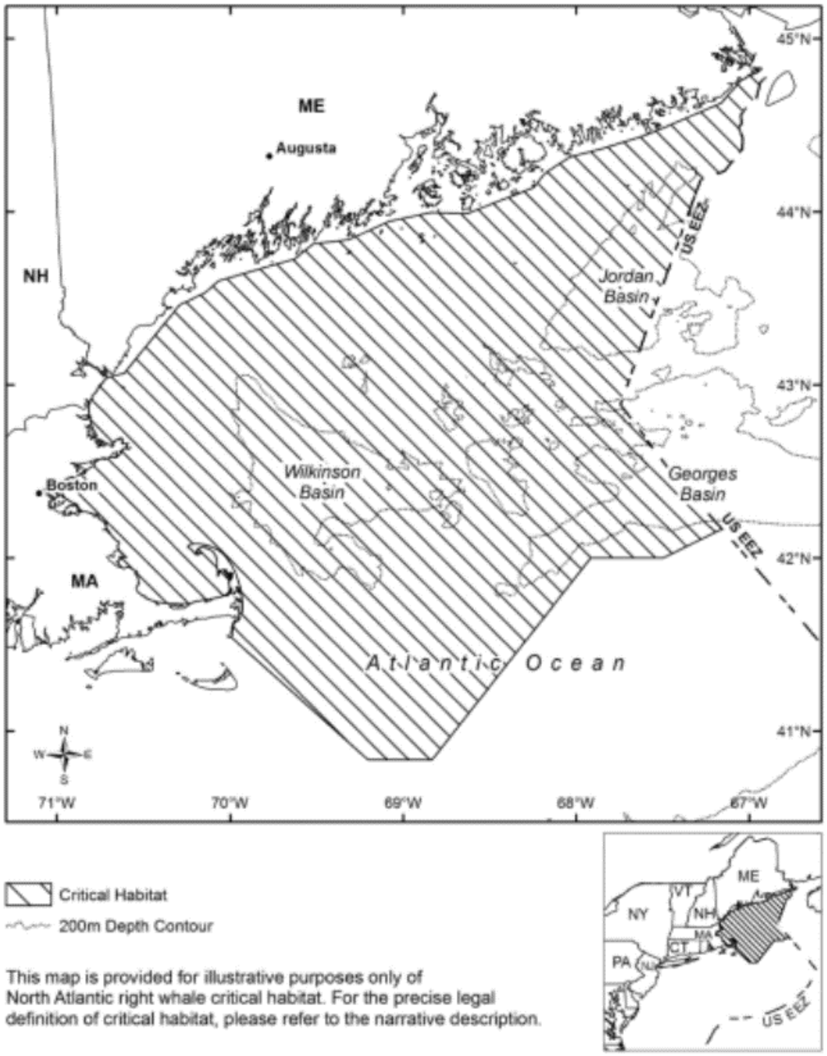
2.3.9 Critical Habitat Designated for the North Atlantic Right Whale

In 1994, NMFS designated critical habitat for the NARW population in the North Atlantic Ocean (59 FR 28805). This critical habitat designation included portions of Cape Cod Bay and Stellwagen Bank, the Great South Channel (each off the coast of Massachusetts), and waters adjacent to the coasts of South Carolina, Georgia, and the east coast of Florida. These areas were determined to provide critical feeding, nursery, and calving habitat for the North Atlantic population of NARWs.

In 2016, NMFS revised designated critical habitat for the NARW with two new expanded areas. The areas designated as critical habitat contains approximately 29,763 nm2 (102,084.2 km2) of marine habitat in the Gulf of Maine and Georges Bank region (Unit 1) (Figure 2-1) and off the Southeast U.S. coast (Unit 2) (Figure 2-2). Units 1 and 2 are both outside of the Project area; however, Project vessels may transit through Unit 1 depending on the route that is taken from ports in Nova Scotia, Canada (Dominion Energy 2022). Unit 2, which contains the physical and biological features essential to NARW calving habitat, occurs outside of the Project area and though a minimal number of Project vessels may transit from the Gulf of Mexico, they are not likely to transit through the coastal habitat of Unit 2; therefore, it is not discussed further.

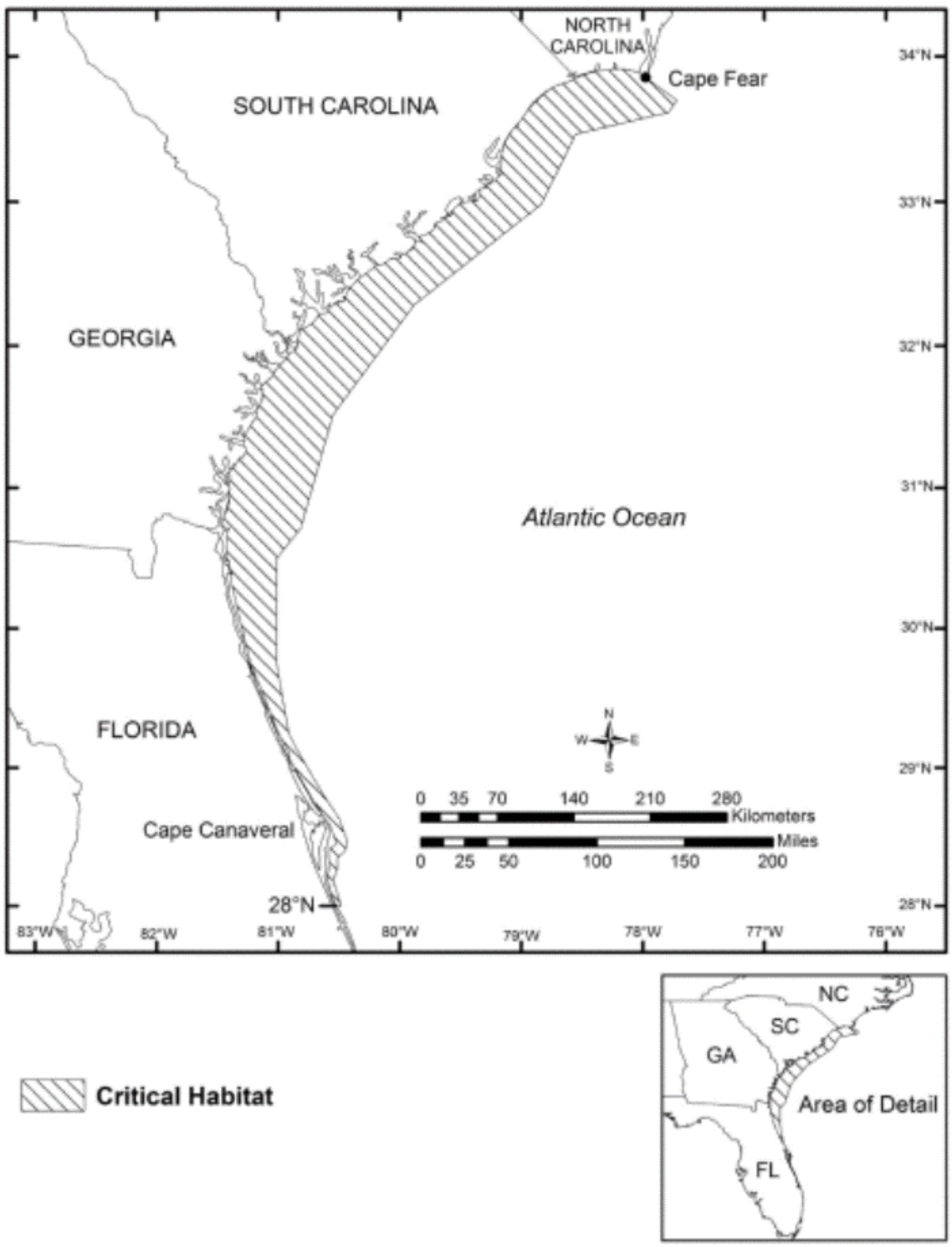
The physical and biological features essential to the conservation of NARW foraging habitat in Unit 1 are (1) the physical oceanographic conditions and structures of the Gulf of Maine and Georges Bank region that combine to distribute and aggregate the zooplankton, *Calanus finmarchicus*, for NARW foraging, namely prevailing currents and circulation patterns, bathymetric features (basins, banks, and channels), oceanic fronts, density gradients, and temperature regimes; (2) 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; (3) late stage *C. finmarchicus* in dense aggregations in the Gulf of Maine and Georges Bank region; and (4) diapausing *C. finmarchicus* in aggregations in the Gulf of Maine and Georges Bank region. When these features are available, they provide the combined features of foraging habitat that are essential to the conservation of NARW (81 FR 4837).

Both areas (Unit 1 and Unit 2) are outside of the Project area, though vessel transits through Unit 1 may occur. However, vessel transits through Unit 1 as a result of the Proposed Action will not affect the physical oceanographic conditions or modify the oceanographic features associated with foraging area functions (distribution and aggregations of *C. finmarchicus*, low flow velocities) when they occur in the spring and summer. No effects of the Proposed Action were identified that would affect that ability of NARWs to select an area with these features, when they co-occur, within the ranges specified that would substantially influence NARW ability to forage. The presence of a small number of vessels is not expected to affect the selection of these critically important features by NARWs. As a precaution, and required by federal regulations, all vessels must maintain 1,640 feet (500 meters) or greater from any sighted NARW. Compliance with this regulation aids in ensuring no adverse effects on the ability of whales to select an area with the co-occurrence of these features. Therefore, it was determined that the potential for adverse effects from the Proposed Action to occur to Unit 1 of NARW critical is **discountable** and is not considered further.



Source: 81 FR 4837

Figure 2-1 **Map identifying designated critical habitat in the northeastern foraging area for the endangered North Atlantic right whale**



Source: 81 FR 4837

Figure 2-2 Map identifying designated critical habitat (Unit 2) in the southeastern calving area for the endangered North Atlantic right whale

2.3.10 Critical Habitat for All Listed Distinct Population Segments of Atlantic Sturgeon

The final rule for Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) critical habitat (all listed DPSs) was issued on August 17, 2017 (82 FR 39160). This rule includes 31 units, all rivers, occurring from Maine to Florida. No marine habitats were identified as critical habitat because the physical and biological features in these habitats essential for the conservation of Atlantic sturgeon could not be identified.

Critical habitat designations for the Atlantic sturgeon Gulf of Maine DPS encompasses seven rivers of Maine, New Hampshire, and Massachusetts. Chesapeake Bay Atlantic sturgeon DPS critical habitat includes five main tributaries to the bay: the Potomac, Rappahannock, York, James, and Nanticoke Rivers. The South Atlantic DPS Atlantic sturgeon critical habitat is composed of nine rivers of South Carolina, Georgia, and Florida. The Project area is a significant distance from the tributaries of the Gulf of Maine and South Atlantic DPSs, and though it is closer to the Chesapeake Bay DPS tributaries, no construction, O&M, or decommissioning activities would occur within or adjacent to the tributary. The only Project activity that may affect Atlantic sturgeon critical habitat are Project vessel transits within the Action Area. Project vessel transits throughout the Action Area do not include the rivers identified for the Gulf of Maine, New York Bight, Carolina, or South Atlantic DPS critical habitats as these vessels would only transit offshore waters in these areas and are not discussed further. Project vessels transiting between the wind farm area and Europe, Portsmouth, Virginia, and Norfolk, Virginia would not travel through critical habitat of any Chesapeake Bay Atlantic sturgeon DPS. Although Portsmouth, Virginia, and Norfolk, Virginia are close to the James River critical habitat boundary (82 FR 39253), any ports used in this area would be east of and outside the critical habitat boundary (Figure 2-3).

The primary physical and biological features identified as being essential for conservation of Atlantic sturgeon include: (1) hard-bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0 to 0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages; (2) aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development; (3) water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support unimpeded movements of adults to and from spawning sites, seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary, and staging, resting, or holding of subadults or spawning condition adults; and (4) water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support spawning, annual and interannual adult, subadult, larval, and juvenile survival, and larval, juvenile, and subadult growth, development, and recruitment (82 FR 39160). Because no Project vessels would transit within the James River where critical habitat is designated, and no anchoring would occur in the critical habitat, vessel activities would not affect any essential physical and biological features in this critical habitat. Therefore, the potential for adverse effects from the Proposed Action to occur is **discountable.**

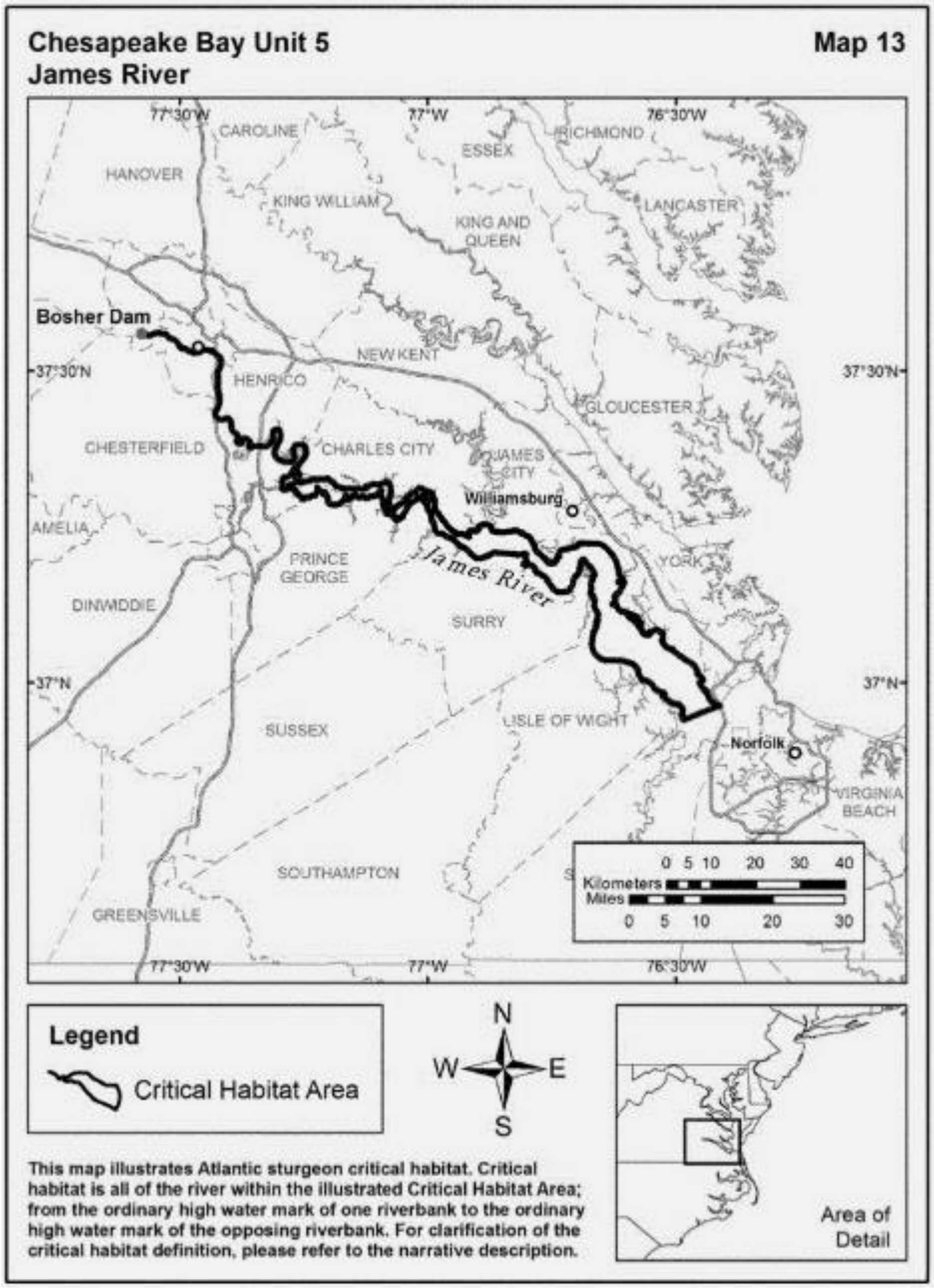


Figure 2-3 Map identifying designated critical habitat in the James River for the Chesapeake Bay distinct population segment of Atlantic sturgeon

2.3.11 Critical Habitat in the Gulf of Mexico

Critical habitat within the U.S. Gulf of Mexico includes: (1) Gulf sturgeon (*Acipenser oxyrinchus desotoi*) critical habitat (68 FR 13370) which comprises 14 geographic areas including freshwater rivers and tributaries and nearshore marine and estuarine habitats between the mouth of the Mississippi to the Suwannee River in Florida; (2) smalltooth sawfish (*Pristis ectinatea*) critical habitat designated in two coastal areas of south Florida in the Charlotte Harbor Estuary and the Ten Thousand Islands/Everglades (74 FR 45353); and (3) breeding, overwintering, nearshore reproductive, and sargassum habitat for the northwest Atlantic Ocean DPS of loggerhead sea turtles (*Caretta caretta*) (79 FR 9855). The only potential Project activities that would occur in the Gulf of Mexico would be vessel transits, and though exact ports in the Gulf of Mexico that may be used are currently unknown, Project vessels in the Gulf of Mexico would be limited to smaller support vessels and only a minimal number of transits would be expected to occur throughout the life of the Project (Section 1.3, *Description of the Proposed Action*). Additionally, no anchoring or other activities that could disturb the seafloor are likely to occur in the Gulf of Mexico, and no activities would occur that would disturb any essential physical or biological features within the designated critical habitats. Therefore, the potential for adverse effects from the Proposed Action to occur is **discountable**.

2.4 Threatened and Endangered Species Considered for Further Analysis

Eight ESA-listed species under NMFS jurisdiction are considered for further analysis; these include two large whale species, four sea turtle species, and two fish species. These species and their potential occurrence in the Action Area are summarized in Table 2-1. General information about these species, current status and threats, use of the Action Area and Project area, and additional information about habitat use that is pertinent to this consultation are described in the following sections.

Table 2-1 ESA-listed species considered for further analysis

Common Name	Stock (NMFS) or Distinct Population Segment	ESA Status	Occurrence within Action Area [a]	Critical Habitat Occurs in Action Area	Critical Habitat Occurs in Project Area	Recovery Plan
Marine Mammals						
Fin whale (*Balaenoptera physalus*)	Western North Atlantic	Endangered 35 FR 18319	Regular	No designated habitat	No designated habitat	75 FR 47538 07/2010
North Atlantic right whale (*Eubalaena glacialis)*	Western North Atlantic	Endangered 73 FR 12024	Regular	Yes. 81 FR 4837	No. Nearest critical habitat is approximately 251 miles (403.9 kilometers) southwest of the Project area. 81 FR 4837	70 FR 32293 08/2004
Sei whale (*Balaenoptera borealis*)	Nova Scotia	Endangered 35 FR 18319	Rare	No designated habitat	No designated habitat	FR Not Available [b] 12/2011
Sperm whale (*Physeter macrocephalus*)	North Atlantic	Endangered 35 FR 18319	Uncommon	No designated habitat	No designated habitat	75 FR 81584 12/2010

Common Name	Stock (NMFS) or Distinct Population Segment	ESA Status	Occurrence within Action Area [a]	Critical Habitat Occurs in Action Area	Critical Habitat Occurs in Project Area	Recovery Plan
Sea Turtles						
Green sea turtle (*Chelonia mydas)*	North Atlantic	Threatened 81 FR 20057	Regular	Yes 63 FR 46693	No. Nearest critical habitat is approximately 1,414 miles (2,276 kilometers) southeast of the Project area. 63 FR 46693	FR Not Available 10/1991 – U.S. Atlantic [c]
Leatherback sea turtle (*Dermochelys coriacea)*	N/A	Endangered 35 FR 8491	Regular	Yes 44 FR 17710 and 77 FR 4170	No. Nearest critical habitat is approximately 1,470 miles (2,366 kilometers) southeast of the Action Area. 44 FR 17710 and 77 FR 4170	FR Not Available 10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico [d]
Loggerhead sea turtle (*Caretta caretta)*	Northwest Atlantic	Threatened 76 FR 58868	Common	Yes 79 FR 39856	No. Nearest critical habitat is approximately 59 miles (95 kilometers) southeast of the Project area. 79 FR 39856	74 FR 2995 10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 01/2009 – Northwest Atlantic
Kemp's ridley sea turtle (*Lepidochelys kempii)*	N/A	Endangered 35 FR 18319	Common	No designated habitat	No designated habitat	FR Not Available 09/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 09/2011[e]

Common Name	Stock (NMFS) or Distinct Population Segment	ESA Status	Occurrence within Action Area [a]	Critical Habitat Occurs in Action Area	Critical Habitat Occurs in Project Area	Recovery Plan
Marine Fish						
Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*)	All DPSs	Endangered 77 FR 5913	Regular	Yes 82 FR 39160	No. Nearest critical habitat is in the James River which is adjacent to vessel ports included in the Proposed Action (Portsmouth and Norfolk, Virginia) but no vessel or other Project activities would occur in the James River. 82 FR 39160	N/A
Giant manta ray (*Mobula birostris)*	N/A	Threatened 83 FR 2916	Regular	No designated habitat 84 FR 66652	No designated habitat 84 FR 66652	N/A

DPS = distinct population segment; ESA = Endangered Species Act; FR = Federal Register; N/A = not applicable; NMFS = National Marine Fisheries Service.

Notes:
[a] Potential occurrence of species evaluated based on five categories:
- Common – Occurring consistently in moderate to large numbers;
- Regular – Occurring in low to moderate numbers on a regular basis or seasonally;
- Uncommon – Occurring in low numbers or on an irregular basis;
- Rare – Records for some years but limited; and
- Not expected – Range includes the Action Area, but due to habitat preferences and distribution information, species are not expected to occur in the Action Area although records may exist for adjacent waters.

[b] Final Recovery Plan for the sei whale is available on NMFS website: https://repository.library.noaa.gov/view/noaa/15977\.
[c] Recovery Plan for the U.S. population of green sea turtles is available on NMFS website: https://repository.library.noaa.gov/view/noaa/15995.
[d] Recovery Plan for leatherback sea turtles in the U.S. Caribbean, Atlantic, and Gulf of Mexico is available on NMFS website: https://repository.library.noaa.gov/view/noaa/15994.
[e] The Bi-national Recovery Plan for Kemp's ridley sea turtles is available on NMFS website: https://repository.library.noaa.gov/view/noaa/4368.

Information about species occurrence was drawn from several available sources. Previous assessments conducted by BOEM (Waring et al. 2012; BOEM 2012; Baker and Howsen 2021); the AMAPPS, which coordinates data collection and analysis to assess the abundance, distribution, ecology, and behavior of marine mammals in the U.S. Atlantic (Palka et al. 2017; Palka 2020; Palka et al. 2021); habitat-based cetacean density models for the U.S. East Coast developed by the Duke University Marine Geospatial Ecology Lab in 2016 (Roberts et al. 2022); the most current marine mammal stock assessments (Hayes et al. 2020, 2021, 2022); Section 7 mappers available online (Greater Atlantic Regional Fisheries Office [GARFO] 2022); and other applicable research available for this region or these species (e.g., Davis et al. 2020; Farmer et al. 2022). Additional species-specific sources of information are cited where appropriate.

3. Effects of the Proposed Action

Effects of the action are evaluated for the potential to result in harm to listed species. If a Project-related activity may affect a listed species, the exposure level and duration of effects are evaluated further for the potential for those effects to harass or injure listed species. The following sections present the potential Project-related effects on ESA-listed species of marine mammals, sea turtles, and fish from the construction/installation, O&M, and decommissioning stages over the lifetime of the Project. Within each section, the effects of the Proposed Action are presented for 202 WTG sites and a likely scenario of 176 WTGs to ensure analysis of the range of expected effects. For quantifiable effects (e.g., acoustic exposures, bottom disturbance) produced by 202 WTGs, a 15 percent reduction was applied to estimate effects associated with 176 WTGs.

3.1 Determination of Effects

Based on the analysis of the methods described in this section, potential effects from the proposed Project were determined using the criterion described as follows:

The term “consequences,” was introduced to the ESA to replace “direct” and “indirect” effects in 2019. Consequences are a result or effect of an action on ESA species. NMFS uses two criteria to identify the ESA-listed species and designated critical habitat that are **not likely to be adversely affected** by the Proposed Action.

The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If NMFS concludes that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, they must also conclude that the species or designated critical habitat is **not likely to be adversely affected** by those activities.

The second criterion is the probability of a response given exposure. An ESA-listed species or designated critical habitat that co-occurs with a stressor of the action but is not likely to respond to the stressor is also **not likely to be adversely affected** by the Proposed Action.

A determination for each species and designated critical habitat was made based on an analysis of potential consequences from each identified stressor. One of the following three determinations, as defined by the ESA, has been applied for listed species and critical habitat that have potential to be affected by the Project: No effect; may affect, not likely to adversely affect; may affect, likely to adversely affect.

The probability of an effect on a species or designated critical habitat is a function of exposure intensity and susceptibility of a species to a stressor’s effects (i.e., probability of response).

No effect – This determination indicates that the proposed Project would have no effects, positive or negative, on species or designated critical habitat. Generally, this means that the species or critical habitat would not be exposed to the proposed Project and its environmental consequences.

A **may affect, not likely to adversely affect** determination would be given if the Project's effects are wholly beneficial, insignificant, or discountable.

1. *Beneficial* effects have an immediate positive effect without any adverse effects on the species or habitat.
2. *Insignificant* effects relate to the size or severity of the effect and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. *Insignificant* is the appropriate effect conclusion when plausible effects are going to happen but will not rise to the level of constituting an adverse effect.
3. *Discountable*[4] effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did affect a listed species), but it is extremely unlikely to occur (USFWS and NMFS 1998).

A *may affect, likely to adversely affect* determination occurs when the proposed Project may result in any adverse effect on a species or its designated critical habitat. In the event that the Project may have beneficial effects on listed species or critical habitat, but is also likely to cause some adverse effects, then the proposed Project **may affect, likely to adversely affect**, the listed species.

Table 3-1 depicts the effects determinations for each ESA-listed species analyzed in this assessment by stressor that were not already discounted in Section 2.3, *Species and Critical Habitat Considered, but Discounted from Further Analysis*. The subsections below provide a description of the existing conditions for each species of ESA-listed marine mammal, sea turtle, and fish in the Action Area, accompanied by the detailed effects assessment for each stressor on these ESA-listed species.

[4] When the terms "discountable" or "discountable effects" appear in this document, they refer to potential effects that are found to support a "not likely to adversely affect" conclusion because they are extremely unlikely to occur. The use of these terms should not be interpreted as having any meaning inconsistent with the ESA regulatory definition of "effects of the action."

Table 3-1 Effects determination by stressor

Stressor		Marine Mammals				Sea Turtles				Marine Fish	
		Fin Whale	**North Atlantic Right Whale**	**Sei Whale**	**Sperm Whale**	**Green Sea Turtle (North Atlantic DPS)**	**Leatherback Sea Turtle**	**Loggerhead Sea Turtle (Northwest Atlantic DPS)**	**Kemp's Ridley Sea Turtle**	**Atlantic Sturgeon**	**Giant Manta Ray**
Underwater Noise	WTG and OSS Foundation Installation Impact and Vibratory Pile Driving	LAA	NLAA for PTS LAA for BD	LAA for PTS NLAA for BD	NLAA	LAA	LAA	LAA	LAA	NLAA	NLAA
Underwater Noise	Goal Post Pile Installation	NLAA	NLAA	NLAA	NLAA	LAA	LAA	LAA	LAA	NLAA	NLAA
Underwater Noise	Cofferdam Installation	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Underwater Noise	HRG Surveys	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Underwater Noise	Vessel Noise	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Underwater Noise	Cable Laying or Trenching Noise	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Underwater Noise	WTG Operations	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Habitat Disturbance	Physical Disturbance of Sediment	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Habitat Disturbance	Structure Presence	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Habitat Disturbance	Changes in Oceanographic and Hydrological Conditions	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Habitat Disturbance	Changes in Prey	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Water Quality	Turbidity	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Water Quality	Oil Spills/Chemical Release	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
	Secondary Entanglement from Increased Recreational Fishing Due to Reef Effect	NLAA	NLAA	NLAA	NLAA	NLAA	LAA	LAA	NLAA	NLAA	NLAA
	Vessel Traffic	NLAA	NLAA	NLAA	NLAA	LAA	LAA	LAA	LAA	NLAA	NLAA
	EMF	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
	Fishery Monitoring Plan	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
	Overall Effects Determination	LAA	LAA	LAA	LAA	LAA	LAA	LAA	LAA	NLAA	NLAA

-- = not applicable for resource; BD = behavioral disturbance; DPS = distinct population segment; EMF = electromagnetic field; HRG = high-resolution geophysical; LAA = likely to adversely affect; NLAA = not likely to adversely affect; OSS = offshore substation; PTS = permanent threshold shift; WTG = wind turbine generator.

3.2 Marine Mammals

Four marine mammal species listed under the ESA are likely to occur in the Project area, all of which are large whales: the fin whale (*Balaenoptera physalus*), NARW (*Eubalaena glacialis*), sei whale (*Balaenoptera borealis*), and sperm whale (*Physeter macrocephalus*). Species descriptions, status, likelihood, and timing of occurrence in the Project area, and information about feeding habits and hearing ability relevant to this effects analysis, are provided in the following sections.

3.2.1 Fin Whale

Fin whales have a wide distribution and can be found in temperate to polar regions in all ocean basins (Edwards et al. 2015). The Northern Hemisphere population is separated by ocean basin, but recent evidence suggests fin whales in the North Atlantic and North Pacific are genetically distinct and, therefore, should be recognized as separate subspecies (Archer et al. 2019). Bérubé et al. (1998) further suggests the presence of multiple fin whale subpopulations within the North Atlantic based on genetic analyses, though stock boundaries in the North Atlantic remain uncertain. Fin whales off the east coast of the US constitute a single stock, with a distribution range that extends from the Mid-Atlantic coast to southern Newfoundland and Labrador, Canada (Hayes et al. 2022). They have been observed in every season throughout most of their range, though densities do vary seasonally (Edwards et al. 2015). Fin whales are the most commonly sighted large whale species in OCS waters from the Mid-Atlantic coast to Nova Scotia and accounted for 47% of all large whale sightings during aerial surveys (Cetacean and Turtle Assessment Program [CETAP] 1982; BOEM 2012). Their broad distribution throughout the Western North Atlantic is further corroborated by acoustic detections made in both coastal and deep offshore areas year-round (Watkins et al. 1987; Davis et al. 2020).

Fin whales are the second largest cetacean, with adults in the North Atlantic reaching lengths up to 78.7 feet (24 meters) and featuring a streamlined body and pointed head. In field surveys, fin whales are often confused with other balaenopterid whales such as the blue and sei whale, but can be distinguished by the white, v-shaped chevron patterns on their right side behind the head and extending to their back (Jefferson et al. 1993). Primary prey for fin whales include krill, squid, and small schooling fish such as sand lance, herring, and capelin. Waters off New England and within the Gulf of St. Lawrence represent main feeding grounds for fin whales, and some level of site fidelity among females at their feeding grounds likely exist (Clapham and Seipt 1991; Agler et al. 1993; Schleimer et al. 2019). While fin whales likely migrate into Canadian waters, deep offshore areas, or tropical latitudes, distinct, population-wide large-scale annual migrations are unlikely (Hayes et al. 2022). Data suggests that calving may take place from October through January in the Mid-Atlantic region (Hain et al. 1992), though calving, mating, and wintering patterns for the majority of the population remain unknown. The fin whale's ecological role and influence on ecosystem processes surpasses that of all other cetacean species in the Western North Atlantic due to their large stock size and prey requirements (Hain et al. 1992; Kenney et al. 1997).

Fin whales also produce characteristic vocalizations that can be distinguished during passive acoustic monitoring (PAM) surveys (BOEM 2012; Erbe et al. 2017). The primary call type is the "20-Hz signals," a short downsweep falling from 30 to 15 Hz over a 1-second period. Fin whale song structure is composed of repetitive sequences of these 20-Hz pulses, which exhibit geographic variation and appear to be associated with reproductive behaviors (Watkins et al. 1987; Delarue et al. 2009; Van Parijs et al. 2021). Fin whales can also produce higher frequency sounds up to 310 Hz, and source levels (SLs) (expressed as root-mean-square sound pressure level [SPL]) as high as 195 dB re 1 µPa m have been reported, making it one of the most powerful biological sounds in the ocean (Erbe et al. 2017). Anatomical modeling based on fin whale ear morphology suggests their greatest hearing sensitivity is between 20 Hz and 20 kHz (Cranford and Krysl 2015; Southall et al. 2019).

3.2.1.1 Current Status

Fin whales are listed as Endangered under the ESA and Vulnerable by the International Union for Conservation of Nature (IUCN) Red List (Cooke 2018b; Hayes et al. 2022). The species is also listed as Endangered by the Virginia Department of Wildlife Resources (VA DWR 2022). The Western North Atlantic stock is listed as strategic and depleted under the MMPA due to its Endangered status (Hayes et al. 2022). The best abundance estimate available for the Western North Atlantic stock is 6,802 based on data from 2016 NOAA shipboard and aerial surveys and the 2016 Canadian Northwest Atlantic International Sightings Survey that extended from Newfoundland to Florida (Hayes et al. 2022). A population trend analysis does not currently exist for this species because of insufficient data; however, based on photographic identification, the gross annual reproduction rate is 8 percent with a mean calving interval of 2.7 years (Agler et al. 1993; Hayes et al. 2022). Potential biological removal (PBR) for this stock is 11, and annual human-caused mortality and serious injury for the period between 2015 and 2019 was estimated to be 1.85 per year. This estimate includes incidental fishery interactions (i.e., bycatch/entanglement) and vessel collisions, but other threats to fin whales include contaminants in their habitat and potential climate-related shifts in distribution of prey species (Hayes et al. 2022). There is no designated critical habitat for this species in or near the Action Area.

3.2.1.2 Potential Habitat Surrounding and within the Project Area

Fin whales are one of the most commonly sighted large whales in OCS waters from the Mid-Atlantic coast of the U.S. to Nova Scotia, principally from Cape Hatteras and northward (Sergeant 1977; Sutcliffe and Brodie 1977; CETAP 1982, Hain et al. 1992; NMFS 2019a). Fin whales are present in the Mid-Atlantic OCS region during all four seasons, although sighting data indicate that they are more prevalent during winter, spring, and summer (Hayes et al. 2022). While fall is the season of lowest overall abundance off Virginia, fin whales do not depart the area entirely. Fin whales, much like humpback whales, seem to exhibit habitat fidelity to feeding areas (Hayes et al. 2022). While fin whales typically feed in the Gulf of Maine and the waters surrounding New England, mating and calving (and general wintering) areas are largely unknown (Hayes et al. 2022). Strandings data indicate that calving may take place in the Mid-Atlantic OCS region during October to January for this species (Hain et al. 1992). AMAPPS data indicate fin whales are likely to be present within the Project area year-round, with a greater presence in the Lease Area versus the nearshore areas of the export cable route corridor (Palka et al. 2021). Sightings data from the U.S. Navy's Virginia Capes (VACAPES) Operating Area off Virginia Beach, Virginia showed 15 detections in 2019 and nine detections in 2020 (Engelhaupt et al. 2020, 2021). Passive acoustic data analyzed by Davis et al. (2020) show a similar presence offshore Virginia, with the greatest number of acoustic detections in the late fall and winter. Protected Species Observers (PSOs) during past surveys in the Project area reported one fin whale sighting in July 2020 and 13 sightings in February 2021 (Dominion Energy 2022).

3.2.2 North Atlantic Right Whale

The NARW occurs in the North Atlantic Ocean from temperate to subpolar latitudes. The primary habitat for this species is coastal or OCS waters ranging from calving grounds off the Southeastern U.S. to feeding grounds off the Northeastern U.S. (NMFS 2023b). Important feeding habitats include coastal waters off Massachusetts, Georges Bank, the Great South Channel, Gulf of Maine, Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence. There are two critical habitat areas for NARWs in Canadian waters (Brown et al. 2009) and two in U.S. waters: all U.S. waters within the Gulf of Maine are designated as a Foraging Area Critical Habitat while waters off the Southeastern US are designated as a Calving Area Critical Habitat (81 *FR* 4837; NMFS 2023b). The Mid-Atlantic OCS between the two critical habitat areas has been identified as a principal migratory corridor and thus an important habitat for NARWs as they travel between breeding and feeding grounds (NMFS 2023b; CETAP 1982). This migratory pathway is considered a Biologically Important Area for the species (LaBrecque et al. 2015). Increasingly important NARW foraging habitat exists on and in the vicinity of Nantucket Shoals off southern Massachusetts (Hayes 2022 O'Brien et al. 2022; Meyer-Gutbrod et al. 2021; Quintana-Rizzo et al. 2021). This region, however, is located approximately 400 miles (642 kilometers) northeast of the proposed Project area and would not be affected by Project activities.

While some individuals undergo yearly migrations between spending summer months at their northern feeding grounds and winter months at their southern breeding grounds, the location of most individuals throughout much of the year is poorly understood. Year-round presence in all habitat areas has been recorded, including off the Mid-Atlantic (Bailey et al. 2018; Davis et al. 2017). In addition, long-range movements are also apparent, with some individuals being identified in the eastern North Atlantic and others covering long distances over short time periods (NMFS 2023b).

The NARW is a large, relatively stock whale that can range in length from 55.8 to 59 feet (17 to 18 meters). One of the most distinguishing features of the right whale is their prominently curved jawline and whitish callosities, or areas of roughened skin, covering the top of their rostrum and head, which can be up to one-third of their body length (Jefferson et al. 1993). The callosities form a unique pattern on the animal's head, enabling individual identification similar to a fingerprint and fundamental to demographic and movement studies. Foraging habits of NARWs show a clear preference for the zooplanktonic copepod, *Calanus finmarchicus* (Mayo et al. 2001). The NARW distribution and movement patterns within their foraging grounds is highly correlated with concentrations and distributions of their prey, which exhibit high variability within and between years (Pendleton et al. 2012). Due to the heightened energetic requirements of pregnant and nursing females, yearly reproductive success of the population is directly related to foraging success and the abundance of *C. finmarchicus* (Meyer-Gutbrod et al. 2015), which in turn is correlated with decadal-scale variability in climate and ocean patterns (Greene and Pershing 2000).

Skim feeding is an important activity identified in effects assessments because it demonstrates a critical behavior (feeding) that could be disrupted by introduced noise. Similarly, right whales spend extended periods of time at the water's surface actively socializing in what are known as surface active groups; surface active groups have been documented in all habitat regions, during all seasons, involve all age classes, and include mating behaviors, play, and the maintenance of social bonds (Parks et al. 2007a). The extensive and biologically critical surface behaviors of NARWs, such as surface skim feeding and surface active groups, represent a vulnerable time for right whales as they are exposed to an increased risk for ship strike when active at or near the surface.

Right whale vocalizations most frequently observed during PAM studies include upsweeps rising from 30 to 450 Hz, often referred to as "upcalls," and broadband (30 to 8,400 Hz) pulses, or "gunshots," with SLs between 172 and 187 dB re 1 µPa m (Erbe et al. 2017). However, recent studies have shown that mother-calf pairs reduce the amplitude of their calls in the calving grounds, possibly to avoid detection by predators (Parks et al. 2019). Modeling conducted using right whale ear morphology suggest that the best hearing sensitivity for this species is between 16 Hz and 25 kHz (Ketten et al. 2014; Southall et al. 2019).

3.2.2.1 Current Status

The NARW is listed as Endangered under the ESA and Critically Endangered by the IUCN Red List (Cooke 2020; NMFS 2023b). The species is also listed as Endangered by the VA DWR (2022). Right whales are considered to be one of the most critically endangered large whale species in the world (NMFS 2023b). The Western North Atlantic population size was estimated to be 338 individuals in the most recent draft 2022 SAR, which used a hierarchical, state-space Bayesian open population model of sighting histories from the photo-identification recapture database through November 2022 (NMFS 2023b). Between 2011 and 2020, the population has declined in overall abundance by 29.7 percent, further evidenced by the decrease in the abundance estimate from 451 in 2018 (NMFS 2023a) to the current 2021 estimate of 338 individuals (NMFS 2023b). This decline in abundance follows a previous positive population trend from 1990 to 2011 that saw an increase of approximately 2.8 percent per year from an initial abundance estimate of 270 individuals in 1998 (NMFS 2023b). Over time, there have been periodic swings of per capita birth rates (NMFS 2023b), although current birth rates continue to remain below expectations (Pettis et al. 2022), with an approximately 40 percent decline in reproductive output for the species since 2010 (Kraus et al. 2016).

Net productivity rates do not exist as the Western North Atlantic stock lacks any definitive population trend (NMFS 2023b). The average annual human-related mortality/injury rate exceeds that of the calculated PBR of 0.7, and due to its listing as Endangered under the ESA this population is classified as strategic and depleted under the MMPA (NMFS 2023b). Estimated human-caused mortality and serious injury between 2016 and 2020 was 8.1 whales per year (NMFS 2023b). However, it is likely that not all mortalities are documented, and modeling suggests that the mortality rate for the period from 2014 to 2018 may be up to 27.4 animals (NMFS 2023b; Pace 2021). Based on the mortalities for which the carcasses could be examined, preliminary analyses indicate that all mortalities are likely to be human-caused, predominantly from entanglement in fishing gear or vessel collisions (NMFS 2023b). There have been elevated numbers of mortalities reported since 2017, which prompted NMFS to designate an Unusual Mortality Event for NARWs (NMFS 2023c). These elevated mortalities have continued into 2023, totaling 36 mortalities, 33 serious injuries, and 29 sublethal injuries or illness (NMFS 2023c). Although the majority of the mortalities occurred in Canadian waters, the U.S. population is not separated from those in Canada; therefore, the effects of mortality affect the population considered in the assessment process. While vessel strikes and entanglements in fishing gear represent the most significant threat to NARWs, other risks to the population include acoustic disturbance and masking, climate change, and climate-driven shifts in prey species (NMFS 2023b).

There are two designated critical habitat areas for NARWs: the Northeastern U.S. Foraging Area (Unit 1), which includes the Gulf of Maine, George’s Bank, and the Great South Channel; and the Southeastern U.S. Calving Area (Unit 2) off the Southeast U.S., which includes coastal waters from Cape Fear, North Carolina to south of Cape Canaveral, Florida (81 *FR* 4837). While the Project area is located between Unit 1 and Unit 2, there is no critical habitat located within the Project area itself (Section 2.3.9, *Critical Habitat Designated for the North Atlantic Right Whale*). Seasonal Management Areas (SMAs) for the NARW have been designated in the U.S. and Canada for reducing ship strikes in heavily trafficked areas of their migratory corridor. All vessels greater than 65 feet (19.8 meters) in overall length must operate at speeds of 10 knots or less within these areas during specified time periods. The closest SMA to the Project area is at the entrance to Delaware Bay and is in effect seasonally from November 1 to April 30.

3.2.2.2 Potential Habitat Surrounding and within the Project Area

The offshore waters of Virginia, including waters within the Project area, are used as a migration corridor for NARW and are considered a Biologically Important Area for migration (NOAA 2022c). NARW occur offshore Virginia during seasonal movements north or south between important feeding and breeding grounds (Knowlton et al. 2002; Firestone et al. 2008; NMFS 2023b). NARW have been observed in coastal Atlantic waters year-round, however the likelihood of occurrence of NARWs is highest during the late winter and early spring. They have been acoustically detected off Georgia and North Carolina in 7 of 11 months monitored (Hodge et al. 2015), offshore Virginia predominantly in the winter and early spring (Davis et al. 2017), and other recent passive acoustic studies of right whales off the Virginia coast demonstrate their year-round presence in Virginia (Salisbury et al. 2016, 2018), where increased detections in fall and late winter/early spring have been documented. They are typically most common in the spring (late March and April) when they are migrating north, and in the fall (i.e., October and November) when they are migrating south (Kenney and Vigness-Raposa 2010; Davis et al. 2017).

Previous surveys reported sightings of up to eight right whales on two separate days in coastal Virginia in April 2019 (Cotter 2019). Three sightings of NARW were reported by PSOs during previous surveys in the Lease Area and export cable route corridor between February and March 2021 (Dominion Energy 2022).

3.2.3 Sei Whale

The sei whale is a large baleen whale species found in subtropical, temperate, and subpolar waters around the globe, most commonly observed in temperate waters at mid-latitudes. Sei whales are often associated with deeper waters and areas along the OCS edge (Hain et al. 1985); however, this general offshore pattern of sei whale distribution is disrupted during occasional incursions into more shallow and inshore waters (Waring et al. 2004). Sightings in U.S. Atlantic waters are typically centered on mid-shelf and the shelf edge and slope (Olsen et al. 2009). The species is notable for its unpredictable distribution, concentrating in specific areas in large numbers for a period and then abandoning those habitats for years or even decades. The breeding and calving areas used by this species are unknown (Hayes et al. 2020).

Sei whales usually travel alone or in small groups of two to five animals, occasionally in groups as large as 10 (Hayes et al. 2020). Potential species occurrence in the Project area is likely to be closely tied to feeding behavior and seasonal availability of preferred prey resources. Sei whales in the North Atlantic preferentially prey on calanoid copepods, particularly *Calanus finmarchicus*, over all other zooplankton species (NMFS 2011; Prieto et al. 2014), demonstrating a clear preference for copepods between June and October, with euphausiids constituting a larger part of the diet in May and November (NMFS 2011; Prieto et al. 2014). The prey preferences of sei whales closely resemble those of NARW (Hayes et al. 2020), particularly where the two species overlap, though sei whales also forage on small schooling fish, and cephalopods (including squid). Although uncertainties still exist with distinguishing sei whale vocalizations during PAM surveys, they are known to produce short duration (0.7 to 2.2 seconds) upsweeps and downsweeps between 20 and 600 Hz. SLs for these calls can range from 147 to 183 dB re 1 µPa m (Erbe et al. 2017). Their primary call type, the downsweep, likely serves both social and reproductive functions (Baumgartner et al. 2008; Tremblay et al. 2019; Van Parijs et al. 2021). No auditory sensitivity data are available for this species (Southall et al. 2019), though they are part of the low-frequency cetaceans (LFC) hearing group, which have a generalized hearing range from 7 Hz to 35 kHz (NMFS 2018).

3.2.3.1 Current Status

Sei whales are listed as Endangered under the ESA and by the IUCN Red List (Cooke 2018c; Hayes et al. 2022). The species is also listed as Endangered by the VA DWR (2022). The stock is considered strategic under the MMPA due to its ESA status. Prior to 1999, sei whales in the Western North Atlantic were considered a single stock but following the suggestion of the Scientific Committee of the International Whaling Commission, two separate stocks were identified for this species (Nova Scotia stock and Labrador Sea stock). Only the Nova Scotia stock can be found in U.S. waters, and the current abundance estimate for this population is 6,292 derived from recent surveys conducted between Halifax, Nova Scotia and Florida (Hayes et al. 2022). Population trends are not available for this stock because of insufficient data (Hayes et al. 2022). This stock is listed as strategic and depleted under the MMPA due to its Endangered status (Hayes et al. 2022). The PBR for this stock is 6.2, and annual human-caused mortality and serious injury from 2015 to 2010 was estimated to be 0.8 per year (Hayes et al. 2022).

Sei whales are occasionally killed in collisions with vessels. Of three sei whales that stranded along the U.S. Atlantic coast between 1975 and 1996, two showed evidence of collisions with ships (Laist et al. 2001). Between 1999 and 2005, there were three reports of sei whales being struck by vessels along the Atlantic coast of the U.S. and the maritime provinces of Canada (Cole et al. 2005; Nelson et al. 2007). Two of these vessel strikes were reported as having resulted in the death of the sei whale. There have been three sei whale strandings reported in Virginia since 2010; one in Sandbridge in 2011 (King 2011), one in Norfolk in 2012 (Nealon 2012), and one in the St. Julien's Creek annex of Elizabeth River in 2014 (Knight and Jasek 2014). The stranding in Norfolk was believed to be the result of a vessel strike (Nealon 2012) and the stranding in Elizabeth River showed evidence of blunt for trauma as well as plastic debris in its stomach that may have caused damage, preventing the animal from feeding normally (Knight and Jasek 2014). There is no designated critical habitat for this species in or near the Project area.

3.2.3.2 Potential Habitat Surrounding and within the Project Area

Sei whales occur in deep water characteristic of the OCS edge throughout their range (Hain et al. 1992; Hayes et al. 2022). In the waters off Virginia, sei whales are rarely sighted; however, this may be an artifact of being keyed (i.e., identified using standard identification parameters) as fin whales during surveys since it is difficult to distinguish between the two. However, a 2018 aerial survey conducted by the Navy recorded sei whales in the area surrounding Norfolk Canyon (DoN 2022). Sei whales are present seasonally in Virginia's offshore waters, especially along the continental slope (Palka et al. 2021). The relative abundance and density of sei whales is greatest in the spring, according to predictive density mapping based on long-term survey data (Roberts et al. 2022). Specifically, annual peaks in occurrence are in May and annual lows occur from January to March according to biogeographic information data (Ocean Biodiversity Information System 2020; see Figure 4.2-20). The AMAPPS Marine Mammal Model for sei whales indicates low presence throughout the Project area offshore Virginia in spring, summer, and fall when the majority of Project construction activities would occur (Palka et al. 2021).

3.2.4 Sperm Whale

Sperm whales occur throughout the world's oceans. They can be found near the edge of the ice pack in both hemispheres and are also common along the equator. The North Atlantic stock is distributed mainly along the OCS-edge, over the continental slope, and mid-ocean regions, where they prefer water depths of 1,969 feet (600 meters) or more and are less common in waters less than 984 feet (300 meters) deep (Perry et al. 1999; Hayes et al. 2020). The stock exhibits a distinct seasonal cycle in U.S. Atlantic exclusive economic zone waters (Perry et al. 1999; Stanistreet et al. 2018). During the winter, sperm whales are observed east and northeast of Cape Hatteras, predominantly past the OCS edge (Hayes et al. 2020). In the spring, sperm whale distribution shifts north and they are more widely distributed throughout the Mid-Atlantic Bight and southern portions of George's Bank (Hayes et al. 2020). Their summer distribution is similar to the spring, but with heightened occurrence inshore of the 328-foot (100-meter) isobath south of New England and in the Mid-Atlantic (Hayes et al. 2020). Sperm whale occurrence on the OCS in areas south of New England is at its highest in the fall, while occurrence in the Mid-Atlantic Bight is along the shelf edge (Hayes et al. 2020). The observed seasonality is likely driven by the distributions of their preferred prey (cephalopods), which may aggregate along distinct oceanographic features such Gulf Stream eddies and temperature fronts in association with bathymetric features of the shelf edge (Waring et al. 1993; Jaquet and Whitehead 1996; Griffin 1999).

Sperm whales are the largest odontocete (toothed whale) species, with adults ranging from 39 to 59 feet (12 to 18 meters) in length. They can easily be distinguished during visual surveys by their large, blunt head, narrow underslung jaw, and characteristic blow shape resulting from the S-shaped blowhole set at the front-left of the head (Jefferson et al. 1993).

Sperm whales belong to the mid-frequency cetacean (MFC) marine mammal hearing group, which has a generalized hearing range of 150 Hz to 160 kHz (NMFS 2018a). Peak hearing sensitivity of sperm whales ranges from 5 to 20 kHz based on auditory brainstem response to recorded stimuli completed on a stranded neonate (Ridgway and Carder 2001).

Unlike mysticete whales that produce various types of calls used solely for communication, sperm whales produce clicks that are used for echolocation and foraging as well as communication (Erbe et al. 2017). Sperm whale clicks have been grouped into five classes based on the click rate, or number of clicks per second; these include “squeals,” “creaks,” “usual clicks,” “slow clicks,” and “codas.” In general, these clicks are broadband sounds ranging from 100 Hz to 30 kHz with peak energy centered around 15 kHz. Depending on the class, SLs for sperm whale calls range between approximately 166 and 236 dB re 1 µPa m (Erbe et al. 2017). Sperm whales communicate and search for prey using broadband transient signals between 500 and 24 kHz, with most sound energy focused in the 2- and 9-kHz range (Lohrasbipeydeh et al. 2012).

3.2.4.1 Current Status

The Western North Atlantic stock is considered strategic under the MMPA due to its listing as Endangered under the ESA, and the global population is listed as Vulnerable on the IUCN Red List (Taylor et al. 2019; Hayes et al. 2020). The species is also listed as Endangered by the VA DWR (2022). The best and most recent abundance estimate based on 2016 surveys conducted between the lower Bay of Fundy and Florida is 4,349 (Hayes et al. 2020). No population trend analysis is available for this stock. Historically, thousands of sperm whales were killed during the early 18th Century. A moratorium on sperm whale hunting was adopted in 1986 and currently no hunting is allowed for any purposes in the North Atlantic. Occasionally, sperm whales will become entangled in fishing gear or be struck by ships off the U.S. East Coast. However, this rate of mortality is not believed to have biologically significant effects. The current PBR for this stock is 6.9, and because the total estimated human-caused mortality and serious injury is less than 10 percent of this calculated PBR, it is considered insignificant (Hayes et al. 2020). Between 2013 and 2017, 12 sperm whale strandings were documented along the U.S. East Coast, but none of the strandings showed evidence of human interactions (Hayes et al. 2020). Other threats to sperm whales include contaminants, climate-related changes in prey distribution, and anthropogenic noise, although the severity of these threats on sperm whales is currently unknown (Hayes et al. 2020). There is no designated critical habitat for this population in the Project area.

3.2.4.2 Potential Habitat Surrounding and within the Project Area

Off the coast of Virginia, sperm whales have recently been observed spending a significant amount of time near Norfolk Canyon and in waters over 6,000 feet (1,800 meters) deep (DoN 2017). Sperm whale migrations are not as well known, nor stereotypic as exhibited by most of the baleen whale species. Sperm whales have been known to concentrate off Cape Hatteras during winter months, with a northward migration to Delaware and Virginia (Costidis et al. 2017). In the North Atlantic, there appears to be a general shift northward during the summer, but there is no clear migration direction in some temperate areas (Whitehead 2003). AMAPPS data indicate they may be present throughout the Lease Area, particularly in the spring and summer in deeper waters, and low relative occurrence in the nearshore waters within the export cable route corridor (Palka et al. 2021). Sightings data from the U.S. Navy’s VACAPES Operating Area off Virginia Beach, Virginia showed seven detections in 2019 and three detections in 2020 (Engelhaupt et al. 2020, 2021). Only one sperm whale sighting was reported by PSOs during previous surveys in the Lease Area and export cable route corridor in August 2020 (Dominion Energy 2022).

3.2.5 Effects Analysis for Marine Mammals

3.2.5.1 Definition of Take, Harm, and Harass

Section 3 of the ESA defines take as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. For the purposes of this effects analysis, two forms of take were considered: lethal and sublethal take. Lethal take is expected to result in immediate, imminent, or delayed but likely mortality. Sublethal take is when effects of the action are below the level expected to cause death, but are still expected to cause injury, harm, or harassment. Harm, as defined by regulation (50 CFR §222.102), includes acts that actually kill or injure wildlife and acts that may cause significant habitat modification or degradation that actually kill or injure fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering. Thus, for sublethal take NMFS is concerned with harm that does not result in mortality but is still likely to injure an animal.

NMFS has not defined "harass" under the ESA by regulation. However, on October 21, 2016, NMFS 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 2016a). For this consultation, this definition of "harass" will be relied on when assessing effects on all ESA-listed species except marine mammals.

For marine mammal species, prior to the issuance of the October 21, 2016, guidance, consultations that involved NMFS Permits and Conservation Division's authorization under the MMPA relied on the MMPA definition of harassment. Under the MMPA, harassment is defined as any act of pursuit, torment, or annoyance that:

1. *has the potential to injure a marine mammal or marine mammal stock in the wild (Level A Harassment); or*
2. *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). Under NMFS regulation, Level B harassment does not include an act that has the potential to injure a marine mammal or marine mammal stock in the wild.*

NMFS October 21, 2016, guidance states that the "interim ESA harass interpretation does not specifically equate to MMPA Level A or Level B harassment but shares some similarities with both levels in the use of the terms 'injury/injure' and a focus on a disruption of behavior patterns. NMFS has not defined 'injure' for purposes of interpreting Level A and Level B harassment but in practice has applied a physical test for Level A harassment" (NMFS 2016a). However, the modeling used to estimate ESA-level take numbers for marine mammals, specifically regarding underwater noise stressors, do correspond to MMPA definitions of Level A and B harassment. Therefore, any Level A harassment has been considered for this analysis to be instances of potential harm via permanent threshold shift (PTS)/auditory injury under the ESA. Level B harassment as applied in this consultation may involve a wide range of behavioral responses, including, but not limited to, avoidance, changes in vocalizations or dive patterns, or disruption of feeding, migrating, or reproductive behaviors. Level B harassment may or may not constitute harm under the ESA definition of "significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering," depending on the nature of the effects.

3.2.5.2 Underwater Noise

BOEM recognizes that underwater noise can result in take by harassment for ESA-listed marine mammal species. The Proposed Action would produce temporary construction-related underwater noise and long-term operational underwater noise above levels that may affect listed species. Underwater noise generated by Project construction and operations include vibratory and impact pile driving for the installation of monopiles and pin piles, impact pile driving of goal post piles for trenchless cable landing installation, vibratory pile driving for the installation and removal of sheet piles for the cofferdams, HRG surveys, vessel activity, WTG operations, and dredging. These activities would temporarily increase sound levels in the marine receiving environment and may result in potential adverse effects on ESA-listed marine mammals in the Action Area. Potential adverse effects include PTS, behavioral disturbance, or both. No harm as defined by the ESA (Section 3.2.5.1, *Definition of Take, Harm, and Harass*) is expected to result from any underwater noise generated by the Proposed Action.

Potential auditory injury (i.e., PTS) and harassment (behavioral disruption) takes of ESA-listed species from Project activities would be restricted to this area, with the extent and severity of effects dependent on the timing of activities relative to species occurrence, the type of noise effect, and species-specific sensitivity. The Applicant conducted Project-specific modeling to characterize the area affected by underwater noise from installation of the WTG and OSS foundations using impact and vibratory pile driving methods; installation of temporary cofferdams using vibratory pile driving methods; and installation of goal post piles used for trenchless installation offshore of the cable landing location using impact pile driving methods (COP, Appendix Z; Dominion Energy 2022). Full details of these activities were provided in Section 1.3, *Description of the Proposed Action*, and are summarized in the following subsections. For these sources, modeling was also completed to estimate the number of each ESA-listed species likely to be exposed to underwater noise levels above auditory injury (i.e., PTS) and behavioral thresholds. The results of this modeling effort were used to develop the effects analysis presented in this BA. Exposure modeling was conducted using a 205 WTG and 3 OSS scenario. Given the very small difference between the modeling scenario and the Proposed Action (202 WTGs and 3 OSSs), PTS and behavioral exposures estimated for the Proposed Action are considered equivalent to the modeled scenario. Additionally, the likely scenario (176 WTGs and 3 OSSs) is represented by a 15 percent reduction from the Proposed Action, applied across all construction years with conservative rounding. Although piling may be completed in 2025 for the likely scenario, this BA still considers the effects of piling through 2026 for consistency with the LOA and to maintain construction flexibility. For sound sources where no Project-specific modeling was completed, information available in the literature was used to develop the effects analysis.

3.2.5.2.1 Overview of Underwater Noise

Two primary components of underwater noise important for effects assessment include pressure and particle motion. Pressure can be characterized as the compression and rarefaction of the water as the noise wave propagates through it. Particle motion is the displacement, or back and forth motion, of the water molecules that create the compression and rarefaction. Both factors contribute to the potential for effects on affected resources from underwater noise. However, marine mammal and sea turtle hearing is based on the detection of sound pressure, and there is no evidence to suggest either group is able to detect particle motion for the purposes of hearing and noise detection (Bartol and Bartol 2012; Nedelec et al. 2016). All discussions of particle motion in this BA are, therefore, focused on fish and invertebrate species.

Underwater sound can be described through a source-path-receiver model. An acoustic source emits sound energy that radiates outward and travels through the water and the seafloor as pressure waves. The sound level decreases with increasing distance from the acoustic source as the sound pressure waves spread out under the influence of the surrounding receiving environment. The amount by which the sound levels decrease between a source and a receiver is called transmission loss. The amount of transmission loss that occurs depends on the source-receiver separation, the frequency of the sound, the properties of the water column, and the properties of the seafloor. Underwater sound levels are expressed in dB, which is a logarithmic ratio relative to a fixed reference pressure of 1 micropascal (μPa).

The efficiency of underwater sound propagation allows marine mammals to use underwater sound as a method of communication, navigation, and prey detection and predator avoidance (Richardson et al. 1995; Southall et al. 2007). Anthropogenic (i.e., human-introduced) noise has gained recognition as a potential stressor for marine mammals because of their reliance on underwater hearing for maintenance of these critical biological functions (Richardson et al. 1995; Ketten 1998). Underwater noise generated by human activities can often be detected by marine animals many kilometers from the source. The potential for negative effects decreases with increasing distance from a noise source. Potential acoustic effects can range from physiological injury to permanent or temporary hearing loss to behavioral changes, and acoustic masking (i.e., communication interference). All the above effects have the potential to induce stress on marine animals in their receiving environment (OSPAR Commission 2009; Erbe 2013).

Anthropogenic noise sources can be categorized generally as impulsive (e.g., impact pile driving, sparkers/boomers) or non-impulsive (e.g., vibratory pile-driving, vessel noise, CHIRP systems). Non-impulsive sources can be further characterized as continuous or intermittent. Sounds from moving sources such as ships are continuous noise sources, although transient relative to the receivers. Impulsive sound is characterized by a distinct energy pulse that has a rapid rise time and high zero-to-peak sound pressure level (Lpk). Most impulsive sounds are broadband and are generated by sources such as impact pile driving, commercial and recreational echosounders, and sub-bottom profilers. Non-impulsive sounds tend to be tonal, narrowband and do not have the rapid rise times seen in impulsive sources (Southall et al. 2007). Some non-impulsive sources can be broadband and like impulsive sounds may be generated from stationary or moving sources over a specified period, duty cycle, or both.

Underwater noise is less likely to disturb or injure an animal if it occurs at frequencies outside of an animals generalized hearing sensitivity. The importance of sound components at particular frequencies can be scaled by frequency weighting relative to an animal’s sensitivity to those frequencies (Nedwell and Turnpenny 1998; Nedwell et al. 2007; Finneran 2016). Thresholds used for the purpose of predicting the extent of potential noise effects on marine mammals and subsequent management of these effects have recently been revised to account for the duration of exposure and the differences in hearing acuity in various marine mammal species (Finneran 2016; NMFS 2018).

3.2.5.2.2 Auditory Criteria for Marine Mammals

Assessment of the potential effects of underwater noise on marine mammals requires acoustic thresholds against which received sound levels can be compared. Auditory thresholds from underwater noise are expressed using two common metrics: sound pressure level, measured in dB reference to (re) 1 μPa, and sound exposure level (SEL), a measure of energy in dB re 1 μPa^2 s. SPL is an instantaneous value represented as either root-mean-square sound pressure level (SPL) or Lpk, whereas SEL is the total noise energy to which an organism is exposed over a given time period, typically 1 second for pulse sources, and up to 24-hours for assessing effects using NMFS threshold criteria. The sound exposure level over 24 hours (SEL_{24h}) NMFS threshold criteria for PTS are frequency-weighted metrics, which account for the susceptibility of a hearing group to noise-induced hearing loss (NMFS 2018).

For marine mammals, recommended acoustic criteria for hearing injury (i.e., PTS) and behavioral disturbance are recognized by NMFS and have recently been updated in terms of PTS thresholds (NMFS 2018). The revised PTS thresholds apply dual criteria based on an unweighted Lpk and a SEL_{24h} based on updated frequency weighting functions for five functional marine mammal hearing groups described by Finneran and Jenkins (2012). Behavioral disturbance thresholds for marine mammals are based on an SPL of 160 dB re 1 μPa for impulsive and non-impulsive, intermittent sounds and 120 dB re 1 μPa for non-impulsive, continuous sounds for all marine mammal species (NMFS 2022b). Although these disturbance thresholds remain current (in the sense that they have not been formally superseded by newer directives), they are not frequency weighted to account for different hearing abilities by the five marine mammal hearing groups. Current weighting for PTS (and temporary threshold shifts [TTS]) relies on an animal’s hearing sensitivities and an animal’s susceptibility to noise-induced hearing loss based on empirical, modeled TTS data, or both. Because behavior is not grounded in the potential for hearing loss, these weighting criteria are not applied for behavioral disturbance thresholds. There has been some work conducted to group animals into categories based on their susceptibility to, or severity of reaction to, acoustic disturbance which has resulted in step or dose response functions (Southall et al. 2019; Harris et al. 2017; Moretti et al. 2014; Wood et al. 2012); however, effects analysis in this document was based on the current SPL behavioral disturbance criteria of 120 dB re 1 μPa and 160 dB re 1 μPa applied equally to all species. Southall et al. (2019) conducted a broad, structured assessment of the audiometric and physiological basis for the categorization of marine mammal hearing groups. Southall et al. (2019) kept the same frequency responses (i.e., hearing sensitivities) but re-categorized the LFC, MFC, and high-frequency cetaceans (HFC) hearing groups to LFC, HFC (previously MFC), and very high-frequency (previously HFC) hearing groups, and distinguished between phocid carnivores (i.e., pinnipeds) in water and in air. They thus proposed retaining the thresholds and functions developed by Finneran (2016) and adopted by NMFS (2018). The results of Southall et al. (2019) remain congruent with the current existing regulatory guidance (NMFS 2018); therefore, this BA maintains the nomenclature from NMFS (2018) for this analysis. In addition, the three species of marine mammals listed under the ESA that are likely to occur in the Project area (Sections 3.2.1, *Fin Whale*, 3.2.2, *North Atlantic Right Whale*, 3.2.3, *Sei Whale*, and 3.2.4, *Sperm Whale*) belong to the LFC and MFC hearing groups so only these will be carried forward in this assessment as shown in Table 3-2.

Table 3-2 Marine mammal functional hearing groups

Functional Hearing Groups	Taxonomic Group	Hearing Range
Low-frequency cetaceans (LFC)	Baleen whales (e.g., humpback whale, blue whale)	7 Hz to 35 kHz
Mid-frequency cetaceans (MFC)	Most dolphin species, beaked whales, sperm whale	150 Hz to 160 kHz

Source: NMFS 2018
Hz = hertz; kHz = kilohertz

The potential for underwater noise exposures to result in adverse effects on marine mammals depends on the received sound level, the frequency content of the sound relative to the hearing ability of the animal, an animal's susceptibility to noise-induced hearing loss, and the level of natural background noise. Potential effects range from subtle changes in behavior at low received levels to strong disturbance effects or potential injury, mortality, or both at high received levels.

Sound reaching the receiver with ample duration and noise level can result in a loss of hearing sensitivity in marine animals termed a noise-induced threshold shift. This may consist of TTS or PTS. TTS is a relatively short-term, reversible loss of hearing following exposure (Southall et al. 2007; Le Prell 2012), often resulting from cellular fatigue and metabolic changes (Saunders et al. 1985; Yost 2000). While experiencing TTS, the hearing threshold rises, and subsequent sounds must be louder to be detected. PTS is an irreversible loss of hearing (permanent damage) following exposure that commonly results from inner ear hair cell loss or structural damage to auditory tissues (Saunders et al. 1985; Henderson et al. 2008). While the only direct evidence of PTS occurring in marine mammals has been observed for harbor seals in a laboratory setting to a 4.1-kHz tone (Reichmuth et al. 2019), it has been estimated using TTS responses demonstrated in many species in response to exposure to impulsive and non-impulsive noise sources (a full review is provided in Southall et al. 2007, 2019; Finneran 2016; Finneran et al. 2017). Prolonged or repeated exposures to sound levels sufficient to induce TTS without recovery time can lead to PTS (Southall et al. 2007, 2019).

Table 3-3 outlines the acoustic thresholds for onset of auditory effects (PTS and behavioral disruption) for marine mammals for both impulsive and non-impulsive noise sources. Acoustic thresholds are only provided for LFC and MFC hearing groups as these are the only ESA-listed marine mammal species likely to occur in the Project area. Impulsive noise sources for the Project includes impact pile driving and certain HRG equipment (i.e., boomers and sparkers). Non-impulsive noise sources associated with the Project include vibratory pile driving associated with installation and removal of the cofferdam, certain HRG equipment (i.e., CHIRP systems), vessel activities, and dredging.

Table 3-3 Acoustic thresholds for onset of acoustic impacts (PTS and behavioral disturbance) for ESA-listed cetaceans

Marine Mammal Functional Hearing Group	Impulsive Sources			Non-impulsive Sources	
	PTS		Behavioral Disturbance	PTS	Behavioral Disturbance
	Lpk	SEL_{24h}[1]	SPL	SEL_{24h}[a]	SPL
LFC (North Atlantic right whale, fin whale)	219	183	160	199	120–continuous 160–intermittent
MFC (sperm whale)	230	185	160	198	120–continuous 160–intermittent

Source: National Marine Fisheries Service 2018, 2022b
LFC = low-frequency cetacean; Lpk = peak sound pressure level in units of decibels referenced to 1 micropascal; MFC = mid-frequency cetacean; PTS = permanent threshold shift; SEL_{24h} = sound exposure level over 24 hours in units of decibels referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of decibels referenced to 1 micropascal.
[a] SEL_{24h} thresholds including frequency weighting for each hearing group.

Marine mammals show varying levels of disturbance in response to underwater noise sources. Observed behavioral responses include displacement and avoidance, decreases in vocal activity, and habituation. Behavioral responses can consist of disruption in foraging patterns, increases in physiological stress, and reduced breeding opportunities, among other responses. To better understand and categorize the potential effects of behavioral responses, Southall et al. (2007) developed a behavioral response severity scale of low, moderate, or high (Southall et al. 2007; Finneran et al. 2017). This scale was recently updated in Southall et al. (2021a). The revised report updated the single severity response criteria defined in Southall et al. (2007) into three parallel severity tracks that score behavioral responses from 0 to 9. The three severity tracks are (1) survival, (2) reproduction, and (3) foraging. This approach is acknowledged as being relevant to vital rates, defining behaviors that may affect individual fitness, which may ultimately affect population parameters. It is noted that not all the responses within a given category need to be observed but that a score is assigned for a severity category if any of the responses in that category are displayed. To be conservative, the highest (or most severe) score is to be assigned for instances when several responses are observed from different categories. In addition, the authors acknowledge that it is no longer appropriate to relate "simple all-or-nothing thresholds" to specific received sound levels and behavioral responses across broad taxonomic groupings and sound types due to the high degree of variability within and between species and noise types. The new criteria also move away from distinguishing noise effects from impulsive vs. non-impulsive sound types into considering the specific type of noise (e.g., pile driving, seismic, vessels).

Auditory masking occurs when sound signals used by marine mammal overlap in time, space, and frequency with another sound source (Richardson et al. 1995). Masking can reduce communication space, limit the detection of relevant biological cues and reduce echolocation effectiveness. A growing body of literature is focused on improving the framework for assessing the potential for masking of animal communication by anthropogenic noise and understand the resulting effects. More research is needed to understand the process of masking, the risk of masking by anthropogenic activities, the ecological significance of masking, and what anti-masking strategies are used by marine animals and their degree of effectiveness before masking can be incorporated into regulation strategies or mitigation approaches (Erbe et al. 2016). For the current assessment, masking was considered possible if the frequency of the sound source overlaps with the hearing range of the marine mammal (Table 3-3).

3.2.5.2.3 Assessment of Underwater Noise Effects

The main sources of proposed Project-generated underwater noise considered in the present assessment include installation of the WTG and OSS foundations using both impact and vibratory pile driving methods; installation of the temporary cofferdams using vibratory pile driving methods; installation of goal post piles using impact pile driving methods to support cable installation; HRG survey equipment; vessel traffic; and WTG operations. Acoustic propagation modeling exposure modeling of the various foundation installation scenarios; cofferdam installation scenarios; and goal post pile installation scenarios was undertaken by Tetra Tech and Marine Acoustics, Inc. to determine distances to the established PTS and behavioral disturbance thresholds for marine mammals and the number of individuals potentially exposed to above-threshold noise (Dominion Energy 2022; Tetra Tech 2022a,b) as described further in the following subsections. Potential effects associated with impulsive underwater noise sources include PTS and behavioral disruptions. A description of the modeling is provided in Section 3.2.5.2.3.1, *WTG and OSS Foundations (C)* with a summary of the results.

3.2.5.2.3.1 WTG and OSS Foundations (C)

Noise produced during installation of the WTGs and OSS foundations would occur intermittently during the installation of offshore structures. Under the Proposed Action, installation of 176 foundations was identified as the most likely scenario with seven spare locations identified (COP Section 1.2; Dominion Energy 2023). However, should the seven spare locations be required, the modeling conducted for the Project included the assessment of all 183 foundation locations being used and requiring piling to meet the needs of the proposed Project. All WTG would be installed using 31-foot (9.5-meter) monopile foundations and would first be installed using vibratory pile-driving methods (non-impulsive noise) prior to impact pile driving (impulsive noise) to reduce the risk of pile run (Tetra Tech 2022a). The modeling assumed installation of a single pile would require the piling schedule under one of the three following scenarios, using comparable hammer energies for all scenarios:

- Scenario 1 (Standard Driving Schedule): One monopile foundation is installed in a 24-hour period using a duration 60 minutes of vibratory pile driving followed by 85 minutes of impact pile driving.
- Scenario 2 (Hard-to-Drive Schedule): One monopile foundation is installed in a 24-hour period using a “hard-to-drive” schedule where additional time is required to reach the target penetration requiring up to 30 minutes of vibratory pile driving followed by 99 minutes of impact pile driving.
- Scenario 3 (One Standard and One Hard-to-Drive Schedule): Two monopile foundations are installed in a 24-hour period, one using the Standard Driving Schedule, and the other following the Hard-to-Drive Schedule which totals up to 90 minutes of vibratory pile driving followed by 184 minutes of impact pile driving for both foundations.

All OSS would be installed using piled jacket foundations each with up to four 9.2-foot (2.8-meter) pin piles. Like the WTG foundations, the OSS foundations will be installed using vibratory pile driving methods prior to impact pile driving to reduce the risk of pile run. The modeling assumed up to two pin piles would be installed per day, requiring up to 120 minutes of vibratory pile driving followed by 410 minutes of impact pile driving for both pin piles (Tetra Tech 2022a). Installation of both foundation types would occur between 2024 and 2026 between May and October of each year to avoid the time of the year NARWs have an increased presence in the region (Tetra Tech 2022a,c).

Impact hammer installation of the monopile foundations would produce the most intense underwater noise effects with the greatest potential to cause PTS effects on marine mammals. Sound fields for the WTG were modeled at two representative locations (a shallow and deep location) in the Lease Area and sounds fields for the OSS foundations were modeled at the location where the greatest sound propagation was expected out of the three proposed OSS locations. Soft start procedures (Table 1-7) were incorporated into the modeling for all WTG scenarios and the OSS scenario using the piling schedules in

Tables 1-3 and 1-5. Inclusion of the soft-start procedure in the modeling accounts for the acoustic propagation and overall sound field produced from the entire pile driving effort; however, the modeling does not use any aversion or fleeing behavior in the animal movement model to account for any potential mitigative effects that the soft-start procedure would have on marine mammals, or other species.

The resulting values represent a radius extending around each pile where potential PTS-level or behavioral effects could occur. The cumulative PTS distances consider total estimated daily exposure, meaning a marine mammal would have to remain within that threshold distance over an entire day of exposure to experience temporary or permanent auditory changes in hearing. The exposure distances for behavioral effects are instantaneous values, meaning that any animal within the effect radius is assumed to have experienced behavioral effects. The maximum modeled ranges for each pile type and scenario are summarized in Table 3-4 for the species included in this BA. These maximum ranges assume the deeper water location will apply to all WTG foundations for both impact and vibratory pile driving methods. The underwater sound propagation will vary depending on the location of the WTG, but assuming a deeper water depth for all WTG foundations provides the maximum potential for effects on marine mammals from the Proposed Action.

The modeled ranges represent the total area over which noise produced by the Project activity may exceed a given threshold following a single impact hammer strike or 1 second of vibratory hammering (for Lpk and SPL metrics) and for 24-hours of pile driving activity based on pre-defined piling schedules (for SEL_{24h} metric). The ranges only account for source characteristics and environmental parameters within the Project area, which contribute to how sound may propagate through the water. They do not incorporate animal movement or behavior to account for how any animal may respond to noise or how their movement would influence their total duration of exposure to the noise. This is accomplished through estimates of exposure.

Table 3-4 Maximum ranges (meters) to PTS and behavioral thresholds for installation of the WTG and OSS foundation scenarios using both vibratory and impact pile-driving methods with 10 dB noise mitigation

Scenario	Installation Method	Marine Mammal Hearing Group					
		LFC			MFC		
		PTS (SEL_{24h})	PTS (Lpk)	Behavior (SPL)	PTS (SEL_{24h})	PTS (Lpk)	Behavior (SPL)
WTG Monopile 1 – Standard Installation	Impact	4,396	132	6,182	170	29	6,182
	Vibratory	141	NA	8,866	0	NA	8,866
WTG Monopile 2 – Hard-to-drive Installation	Impact	4,980	132	6,182	187	29	6,182
	Vibratory	113	NA	8,866	0	NA	8,866
WTG Monopile 3 – One Standard and One Hard-to-drive	Impact	5,663	132	6,182	226	29	6,182
	Vibratory	158	NA	8,866	0	NA	8,866
OSS Foundation	Impact	2,680	0	2,172	48	0	2,172
	Vibratory	75	NA	3,601	0	NA	3,601

Source: Dominion Energy 2022
dB = decibel; LFC = low-frequency cetacean; Lpk = peak sound pressure level in units of dB referenced to 1 micropascal; MFC = mid-frequency cetacean; NA = not applicable for this installation method; OSS = offshore substation; PTS = permanent threshold shift; SEL_{24h} = sound exposure level over 24 hours in units of dB referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of dB referenced to 1 micropascal; WTG = wind turbine generator.

To estimate the number of marine mammals likely to be exposed above the acoustic thresholds shown in Table 3-3, the modeling assumed a construction schedule that included a combination of all possible foundation installation scenarios. The construction schedule used to estimate the number of exposures throughout the entire construction period is provided in Table 3-5.

Table 3-5 Proposed pile-driving schedule used to estimate the number of marine mammals potentially exposed to above-threshold noise during Project construction under the Proposed Action

Year	Month	Total Number of Foundations Installed	Number Standard WTG Installations	Number Hard-to-Drive WTG Installations	Number of Days with Two WTGs Installed
2024	May	18	5	13	1
	June	25	6	19	6
	July	26	7	19	6
	August	2 WTGs, 12 OSSs	1	1	1
	September	13	3	10	0
	October	11	1	10	0
	2024 Total	**95 WTGs, 12 OSSs**	**23**	**72**	**14**
2025	May	16	6	10	1
	June	24	8	14	6
	July	26	8	16	6
	August	20	6	14	6
	September	5	2	3	0
	October	1	1	0	0
	2025 Total	**88 WTG**	**31**	**57**	**19**

Source: Tetra Tech 2022c.
OSS = offshore substation; WTG = wind turbine generator.

To estimate the number of animals expected to receive sound levels above established thresholds, Marine Acoustics, Inc. conducted exposure modeling, which combines animal movement modeling with the sound fields produced by each pile type and scenario using their Acoustic Integration Model© (Tetra Tech 2022a). Different simulations were run in Acoustic Integration Model© for each species, modeling scenario, and modeled location in which simulated animals (i.e., animats) were randomly distributed throughout the modeling environment and the predicted received level was recorded every 30 seconds for each animat to create a sound exposure history. Animats move throughout the simulated environment following known behavioral rules for each species based on available studies (Tetra Tech 2022a). The sound exposure histories are then subsampled based on the expected duration of the activity (e.g., a monopile foundation may take up to 3 hours to install so 3-hour exposure histories were extracted from each scenario for each species), and then normalized using the ratio of real-world density estimates (Table 3-6) to the animat simulation densities for each species modeled (Tetra Tech 2022b). The resulting estimated number of ESA-listed marine mammal species exposed to PTS or behavioral-level noise effects from construction activities are summarized in Table 3-7. Dominion Energy has committed to achieving the ranges modeled using 10 dB noise mitigation for WTG foundation installation (Table 3-4).

Table 3-6 Mean seasonal density estimates (animals/km^2) for the potentially occurring marine mammal species in the Project-buffered (8.9 km) Lease Area

Species	Spring (May)	Summer (June–August)	Fall (September–October)
Fin whale	0.00069	0.00036	0.00019
North Atlantic right whale	0.00015	0.00004	0.00005
Sei whale	0.00021	0.00001	0.00004
Sperm whale	0.00003	0.00000	0.00000

Source: Tetra Tech 2022b.
km = kilometers

Table 3-7 Annual estimated number of ESA–listed marine mammals exposed to PTS and behavioral threshold noise during installation of 183 WTG and OSS foundations installed using both impact and vibratory pile driving (with 10 dB noise mitigation) for the Proposed Action and likely scenario

Species	Construction Year	PTS Exposures	Behavioral Exposures
Fin whale	2024	4	112
	2025	3	90
Total		**7**	**202**
North Atlantic right whale	2024	0 [a]	6
	2025	0 [a]	6
Total		**0**	**12**
Sei Whale	2024	1	3
	2025	1	2
Total		**2**	**5**
Sperm whale	2024	0	3
	2025	0	3
Total		**0**	**6**

dB = decibels; ESA = Endangered Species Act; OSS = offshore substation; PTS = permanent threshold shift; WTG = wind turbine generator
Source: Tetra Tech 2022c.
[a] One PTS exposure was estimated for North Atlantic right whales, but due to mitigation measures proposed by the Applicant, no PTS (Level A takes) exposures are expected and no Level A takes have been requested for these species. PTS and behavioral exposures are based on the number of Level A and Level B takes requested in the Letter of Authorization application addendum (Tetra Tech 2022b).

Effects of Exposure to Noise Above the PTS Thresholds

Modeling indicates that up to nine fin whales and three sei whales may be exposed to underwater noise levels above PTS thresholds from impact pile-driving noise. The potential for serious injury is minimized by the implementation of pre-clearance, shutdown zones, and soft-starts for impact pile-driving operations 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. These measures also make it unlikely that any ESA-listed cetacean will be exposed to pile driving that would result in severe hearing impairment or serious injury and would more likely have the potential to result in slight PTS (i.e., minor degradation of hearing capabilities at some hearing thresholds). In addition, soft-starts could be effective in deterring marine mammals from impact pile-driving activities prior to exposure resulting in a serious injury. However, few empirical studies have been conducted that test how effective soft-start procedures are for moving marine mammals, particularly baleen whales, out of acoustic injury ranges. Studies on soft starts of deep penetration seismic surveys (i.e., airgun arrays) have shown mixed results for efficacy and seem to be highly contextual (Dunlop et. al. 2016; Barkaszi et. al. 2012; Barkaszi and Kelly 2019). Recent studies by Graham et al. (2023) showed that combined use of acoustic deterrent devices and soft start procedures resulted in a strong directional response by harbor porpoise away from the sound source. Therefore, in the effects analysis of all impact pile driving, soft-start procedures are assumed to be reasonably effective in reducing high-level exposure but is not considered to be fully effective, particularly at further distances where noise accumulation leading to PTS may still occur. The potential for serious injury is largely minimized through clearance zone and using a noise mitigation system during all impact pile driving operations. The proposed requirement that impact pile driving can only commence when the pre-clearance zones (Table 3-7) are fully visible to PSOs allows a high marine mammal detection capability, and enables a high rate of success in implementing these zones to avoid serious injury. However, exposures leading to PTS are still possible. Therefore, the effects of noise exposure above PTS thresholds resulting from Project pile driving during foundation installation **may affect, likely to adversely affect** fin and sei whales.

No PTS exposures were modeled for sperm whales; PTS exposures for sperm whales are highly unlikely to occur and are, therefore, considered **discountable**.

One PTS exposure per year was modeled for NARWs during foundation installation (Tetra Tech 2022b). However, no Level A take is requested for NARWs because the potential for PTS exposures to NARW can be reduced to zero given the mitigation measures outlined in Tables 1-8 and 1-9. Specifically, the following measures will be used to eliminate NARW PTS exposures:

- Foundation installation would only occur between May and October, in order to avoid the winter and spring seasons when NARW presence is greatest (Section 3.2.2, *North Atlantic Right Whale*);
- Pre-clearance monitoring and shutdowns during foundation installation will occur at any distance from the source if a NARW is detected visually or acoustically;
- PSOs will visually monitor from the foundation construction vessel and a minimum of two PSO monitoring vessels will be required to fully monitor the maximum 6-kilometer PTS range estimated for LFC (Table 3-4);
- A real-time PAM system will be designed and deployed to supplement visual monitoring such that NARW detection capabilities extend to a minimum of 5 kilometers from all foundation installation activities;
- No foundation installation activities will occur during nighttime except under specified safety and engineering conditions defined in Table 1-7, and all PSOs will be equipped with night vision equipment and infrared technology should monitoring be required during nighttime or low visibility conditions;
- A minimum visibility range of 5,741 feet (1,750 meters) will be maintained during all foundation installations, and no piling will commence if this visibility range is not met; and
- A soft-start procedure will be implemented.

These combined measures optimize the opportunity for visual and acoustic PSOs to detect NARWs around the foundation installation activities. These measures would help reduce the amount of time an animal is receiving acoustic energy above the PTS onset thresholds which lower the risk of PTS being realized. With full implementation of these measures, the potential for PTS exposure to NARW is considered unlikely to occur and **discountable**.

Therefore, the effects of noise exposure above PTS thresholds resulting from pile driving during foundation installation **may affect, not likely to adversely affect** NARWs and sperm whales.

Effects of Exposure to Noise Above the Behavioral Thresholds

Considering foundation installation pile driving activities, up to 202 fin whales, 12 NARWs, 5 sei whales, and 6 sperm whales could be exposed to noise that meets or exceeds the behavioral thresholds during installation of the WTG monopile and OSS jacket foundations over the construction period (Table 3-7). Although behavioral thresholds may be reached, how species react and the consequences of these reactions are relatively unknown. This is due to the lack of species-specific studies that outline the behavioral responses of ESA-listed marine mammal species likely to be present in the Project area to Project activities (i.e., impact pile-driving activities or vibratory pile-driving activities). Some avoidance and displacement of LFCs has been documented during other impulsive noise activities (seismic exploration), which may be used as a proxy to determine the potential behavioral reactions of LFC to other impulsive activities such as impact pile driving. However, recent reports assessing the severity of behavioral reactions to underwater noise sources indicate that applying behavioral responses across broad sound categories (e.g., impact pile driving, and seismic exploration are both impulsive) can lead to significant errors in predicting effects (Southall et al. 2021a). Hearing group-specific analyses are presented in the following subsections.

Low-frequency Cetaceans (LFC)

Behavioral and masking effects are more difficult to mitigate and are, therefore, still considered likely for activities with large acoustic disturbance areas such as impact pile driving. The most commonly reported behavioral effect of pile-driving activity on marine mammals has been short-term avoidance or displacement from the pile-driving site, although studies that examine the behavioral responses of baleen whales to pile driving are absent from the literature. Since there are no studies that have directly examined the behavioral responses of baleen whales to pile-driving, studies using other impulsive sound sources such as seismic airguns serve as the best available proxies. With seismic airguns, the distance at which responses occur depends on many factors, including the volume of the airgun (and consequently source level), as well as the hearing sensitivity, behavioral state, and even life stage of the animal (Southall et al. 2021b). Malme et al. (1986) observed that gray whales exposed to received levels of about 173 dB re 1 μPa, had a 50 percent probability of stopping feeding and leaving the area. Some whales ceased to feed but remained in the area at received levels of 163 dB re 1 μPa. Individual gray whale responses were highly variable. Other studies have documented baleen whales initiating avoidance behaviors to full-scale seismic surveys at distances as short as 1.8 miles (3 kilometers) away (McCauley et al. 1998, Johnson 2002, Richardson et al. 1986) and as far away as 12 miles (20 kilometers) (Richardson et al. 1999). Bowhead whales have exhibited other behavioral changes, including reduced surface intervals and dive durations, at received SPL between 125 to 133 dB re 1 μPa (Malme et al. 1988). A more recent study by Dunlop et al. (2017) compared the migratory behavior of humpback whales exposed to a 3,130 in^3 airgun array with those that were not. There was no gross change in behavior observed (including respiration rates), although whales exposed to the seismic survey made a slower progression southward along their migratory route compared to the control group. This was largely seen in female-calf groups, suggesting there may be differences in vulnerability to underwater sound based on life-stage (Dunlop et al. 2017). The researchers produced a dose-response model which suggested behavioral change was most likely to occur within 2 miles (4 kilometers) of the seismic survey vessel at SELs greater than 135 dB re 1 μPa^2 s (Dunlop et al. 2017).

Though the Project Lease Area, where impact pile driving will occur, does not overlap with any critical habitat (Section 2.3, *Species and Critical Habitat Considered, but Discounted from Further Analysis*), it does overlap with a Biologically Important Area for migrating NARWs. Timing of migrations includes a northward migration during March to April and a southward migration during October and November between summer feeding and winter calving grounds. During this migration period, adults may be accompanied by calves and periodically feed and rest along their migration route (Hayes et al. 2022). Fin and sei whales generally prefer the deeper waters of the continental slope and more often can be found in water >295 feet (90 meters) deep (Hain et al. 1985; Waring et al. 2011; Hayes et al. 2022). Based on the literature previously identified, behavioral responses of LFCs to impact pile driving could include ceasing feeding and avoiding the ensonified area. To limit potential effects to NARWs, impact pile driving will not occur during January 1 through April 30, avoiding the times of year when NARWs are present in higher densities. In addition, both the visual and PAM clearance and shutdown zones will extend to any distance from the pile at which a NARW is detected (Table 1-7), which will limit the potential for behavioral disturbance to NARWs and any other species present when the NARW detection occurs by reducing the amount of time an animal is receiving acoustic energy above the behavioral threshold. If animals are exposed to underwater noise above behavioral thresholds, it could result in displacement of individuals from a localized area around a pile (maximum 8.7 kilometers for installation of two piles per day; Table 3-4). However, this displacement would be temporary for the duration of activity, which would be a maximum of 5 hours per 24-hour period for both vibratory and impact pile driving of two piles per day. NARWs (and any LFCs) would be expected to resume their previous behavior after an unknown period of time following the cessation of active pile driving. In addition, the behavioral disturbance area would not be expected to impede the migration of NARWs to critical habitats located to the north and south of the Project area as animals would still be able to pass along coastal areas and areas offshore of the Lease Area (Figure 1-1).

Acoustic masking can occur if the frequencies of the activity overlap with the communication frequencies used by marine mammals. Modeling results indicate that dominant frequencies of impact pile-driving activities for the Proposed Action were concentrated below 1 kHz (Appendix Z; Dominion Energy 2022) which overlaps with the hearing sensitivity of LFC species (Sections 3.2.1, *Fin Whale*, 3.2.2, *North Atlantic Right Whale*, and 3.2.3, *Sei Whale*). Additionally, low frequency sound can propagate greater distances than higher frequencies, meaning masking may occur over larger distances than masking related to higher frequency noise. There is evidence that some marine mammals can compensate for the effects of acoustic masking by changing their vocalization rates (Blackwell et al. 2013; Di Iorio and Clark 2010; Cerchio et al. 2014), increasing call amplitude (Scheifele et al. 2004; Holt et al. 2009), or shifting the dominant frequencies of their calls (Lesage et al. 1999; Parks et al. 2007b). When effects of masking cannot be compensated for, increasing noise could affect the ability to locate and communicate with other individuals. NARWs appear to be particularly sensitive to the effects of masking as a result of underwater noise and have faced significant reductions in their communication space due to anthropogenic noise. For example, vocalizing NARWs in the Stellwagen Bank National Marine Sanctuary were exposed to noise levels greater than 120 dB for 20 percent of their peak feeding month and were estimated to have lost 63 to 67 percent of their communication space (Hatch et al. 2012). Reduced communication space caused by anthropogenic noise could potentially contribute to the population fragmentation and dispersal of the critically endangered NARW (Hatch et al. 2012; Brakes and Dall 2016). However, given that pile-driving occurs intermittently, and would only occur up to 5 hours per day under the Proposed Action, it is unlikely that complete auditory masking would occur.

Mid-frequency Cetaceans (MFC)

MFCs also show varying levels of sensitivity to mid-frequency impulsive noise sources (i.e., impact pile driving), with observed responses ranging from displacement (Maybaum 1993) to avoidance behavior (animals moving rapidly away from the source) (Watkins et al. 1993; Hatakeyama et al. 1995), decreased vocal activity, and disruption in foraging patterns (Goldbogen et al. 2013). Würsig et al. (2000) studied the response of Indo-Pacific hump-backed dolphins to impact pile driving in the seabed in water depths of 20 to 26 feet (6 to 8 meters). No overt behavioral changes were observed in response to the pile-driving activities, but the animals' speed of travel increased, and some dolphins remained in the vicinity while others temporarily abandoned the area. Once pile-driving ceased, dolphin abundance and behavioral activities returned to pre-pile-driving levels. One study conducted during wind farm construction in Cromarty Firth, Scotland, the effect of impact and vibratory pile-driving on the vocal presence of both bottlenose dolphins and harbor porpoises was compared both in and outside the Cromarty Firth area (Graham et al. 2017). The researchers found a similar level of response of both species to both impact and vibratory piling, likely due to the similarly low received SELs from the two approaches, which were measured at 129 dB re 1 μPa^2 s for vibratory and 133 dB re 1 μPa^2 s for impact, both at 2,664 feet (812 meters) from the pile. There were no statistically significant responses attributable to either type of pile driving activity in the presence/absence of a species or the duration over which individuals were encountered, except for bottlenose dolphins on days with impact pile driving. The duration of bottlenose dolphin acoustic encounters decreased by an average of approximately 4 minutes at sites within the Cromarty Firth (closest to pile-driving activity) in comparison to areas outside the Cromarty Firth (Graham et al. 2017). The authors hypothesized that the lack of a strong response was because the received levels were very low in this particularly shallow environment, despite similar size piles and hammer energy to other studies. In another playback study, trained dolphins were asked to perform a target detection exercise during increasing levels of vibratory pile driver playback SPL up to 140 dB re 1 µPa (Branstetter et al. 2018). Three of the five dolphins exhibited either a decrease in their ability to detect targets in the water, or a near complete secession of echolocation activity, suggesting the animals became distracted from the task by the vibratory pile-driving sound (Branstetter et al. 2018).

Sperm whales are rarely seen in shallower waters of the OCS (less than 1,000 feet [305 meters] deep) and frequent the continental slope in water depths greater than 2,000 feet (609 meters) (NMFS 2010). They prefer deeper waters to hunt for squid and are generally found in the Mid-Atlantic Bight during the spring. Near the wind farm area, the density of sperm whales is expected to be low (Table 3-6). Based on the available literature, behavioral responses of sperm whales to impact pile driving could include ceasing feeding and avoiding the ensonified area. However, due to the expected low density of sperm whales in the wind farm area (Table 3-6), and the low number of behavioral exposures estimated (Table 3-7) the potential for exposure to underwater noises above behavioral thresholds is considered unlikely. Additionally, the clearance and shutdown zones for sperm whales extend to a maximum of 6,500 and 1,750 meters, respectively. While this will help limit exposures to the higher noise isopleths for sperm whales, it will not eliminate all exposure an individual is receiving to acoustic energy above the behavioral threshold. If animals are exposed to underwater noise above behavioral thresholds, it would likely result temporary displacement out to maximum 8.7 kilometers from the pile for installation of two piles per day (Table 3-4). This displacement would be temporary for the duration of activity, which would be a maximum of 5 hours a day for both vibratory and impact pile driving of two piles per day. MFCs (specifically sperm whales) would be expected to resume pre-construction behaviors following the approximate 5-hour installation period or once they move out of the disturbance zone.

As previously outlined for LFCs, modeling results indicate that dominant frequencies of impact pile-driving activities for the Proposed Action will be concentrated below 1 kHz (Appendix Z; Dominion Energy 2022). Though this does overlap with the frequency range of sperm whale hearing and vocalizations (Section 3.2.4, *Sperm Whale*), it is not within their peak sensitivity range so the effects of masking would be less severe for MFC as they are better attuned to noise outside the range of pile driving. Therefore, piling noise would not impede their ability to echolocate prey or navigate. Additionally, given that pile-driving occurs intermittently, and would only occur up to 5 hours a day under the Proposed Action, it is unlikely that complete auditory masking would occur.

WTG and OSS Foundation Installation – Behavioral Effect Summary

Based on the mitigation and monitoring measures included in the Proposed Action or proposed by BOEM (Tables 1-8 and 1-9) and temporary, intermittent nature of pile driving noise under the Proposed Action, the potential for exposure of these ESA-listed species to noise levels leading to behavioral disruption would be reduced at the level of the individual animal and would not be expected to have population-level effects. As described in the modeling scenarios (Section 3.2.5.2.3.1, *WTG and OSS Foundations [C]*), the soft-start procedure was modeled to account for the sound field and ranges to thresholds, but animal aversion (i.e., moving away from the source) which is the anticipated reaction to the soft-start procedures, were not modeled. Therefore, the behavioral exposure estimates should be considered a conservative estimate. As discussed above, up to 202 fin whales and 12 NARWs, 5 sei whales, and 6 sperm whales may be exposed to noise above the behavioral threshold (Table 3-7). Due to the large behavioral disturbance range, behavioral exposures cannot be completely avoided with mitigation.

Fin whales are expected to utilize the Project area year-round and demonstrate some feeding site fidelity that may include waters offshore Virginia (Section 3.2.1.2, *Potential Habitat Surrounding and within the Project Area*); therefore, behavioral changes resulting from disturbance have the potential to interrupt critical functions. Likewise, as described in Section 3.2.2.2, *Potential Habitat Surrounding and within the Project Area*, the NARW uses the Project area as a migratory corridor, often with calves, and can be present year-round. The migratory corridor is a considered Biologically Important Area; as such, behavioral disturbance in this area for a critically endangered species may result in affecting critical functions. Therefore, the behavioral disturbance resulting from foundation installation cannot be discounted.

As detailed in Section 3.2.3.2, *Potential Habitat Surrounding and within the Project Area* and Section 3.2.4.2, *Potential Habitat Surrounding and within the Project Area*, sei and sperm whales are most likely to occur in deeper water slope and canyon environments. Although these species may occur year-round in the Project area, their predictability and use of the Project area is likely ancillary to deeper water habitats. It is unlikely that any behavioral reactions to noise exposures above the behavioral thresholds would interrupt critical functions for these species and any effects would be **insignificant**.

Therefore, the effects of exposure to noise above behavioral thresholds resulting from pile driving for foundation installation **may affect, likely to adversely affect** fin whales and NARWs; and **may affect not likely to adversely affect** sei and sperm whales.

3.2.5.2.3.2 Goal Post Piles (C)

Up to 12 goal posts consisting of nine 42-inch (1.07-meter) steel pipe piles for a total of 108 piles would be installed using impact pile driving (impulsive source) to support trenchless installation of the export cable offshore of the cable landing location. Sound fields were modeled at one representative location assuming two posts would be installed per day requiring up to 130 minutes to install both piles (Dominion Energy 2022). For the goal posts, up to 260 strikes per pile were assumed for installation. All goal post piles would be installed between May 1 and October 31 in 2024 and would occur over a total of 24 days for all 108 piles, assuming up to two piles are installed per day. No noise mitigation will be used during this activity. The ranges to the PTS and behavioral thresholds for all species included in this BA are provided in Table 3-8.

Table 3-8 Maximum ranges (meters) to PTS and behavioral thresholds during installation of up to two goal post piles per day using impact pile driving to support trenchless installation of the export cable with no noise mitigation

LFC			MFC		
PTS (Lpk)	PTS (SEL_{24h})	Behavior (SPL)	PTS (Lpk)	PTS (SEL_{24h})	Behavior (SPL)
2	591	1,450	0	21	1,450

LFC = low-frequency cetacean; Lpk = peak sound pressure level in units of dB referenced to 1 micropascal; MFC = mid-frequency cetacean; PTS = permanent threshold shift; SEL_{24h} = sound exposure level over 24 hours in units of dB referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of dB referenced to 1 micropascal
Source: Tetra Tech 2022a

The number of marine mammals potentially exposed to above threshold noise during installation of the goal post piles was estimated by multiplying the average seasonal density for each species by the harassment zone by the number of days of pile driving (Tetra Tech 2022b). The harassment zone represents maximum ensonified area calculated as πr^2 where r is the threshold range from Table 3-8. Densities were obtained from Duke University's Marine Geospatial Ecology Lab and the Marine-life Data and Analysis Team (Roberts et al. 2022). The density data were selected based on where they overlapped with the Project area (Figure 1-1), and the maximum densities for each month were averaged by season for the construction period (shown in Table 3-9). Results of the exposure estimates during goal post pile installation are provided in Table 3-9. However, it is worth noting that while the propagation modeling included noise mitigation, noise mitigation systems are not as commonly applied during nearshore installation activities such as the goal post pile installations, and the exposure estimates assume that no noise mitigation is applied during construction (Tetra Tech 2022b).

Table 3-9 Total estimated number of ESA-listed marine mammals exposed to noise above PTS or behavioral-level thresholds from impact pile driving during installation of the goal post piles to support trenchless installation of the export cable

Species	Average Seasonal Density (animals/100 km²) [a]	PTS and Behavioral Exposures [b]
Fin whale	0.041	0
North Atlantic right whale	0.024	0
Sei whale	0.015	0
Sperm whale	0.001	0

Source: Tetra Tech 2022b.
ESA = Endangered Species Act
[a] Densities estimated using data from Roberts et al. (2022).
[b] Estimated exposures under the Proposed Action are equivalent to estimated exposures under the likely scenario of 176 WTGs and 3 OSSs.
km^2 = square kilometers

Effects of Exposure to Noise Above the PTS Thresholds

No PTS exposures are expected for any ESA-listed cetacean species during installation of the goal post piles. Results of the acoustic modeling indicate a maximum distance to the PTS SEL_{24h} threshold was 1,939 feet (591 meters) for LFC and 69 feet (21 meters) for MFC (Table 3-8). Though the PTS thresholds may be exceeded for all species considered in this BA, PTS is not likely to be realized given the nearshore location of this activity (Section 1.3.1.1, *Onshore Activities and Facilities*), and the mitigation included under the Proposed Action to eliminate the risk of PTS occurring. First, both the clearance and shutdown zones for NARW will extend to any distance from the goal post piles (Table 1-7), which fully covers the extent of the 1,939 feet (591 meters) PTS range for LFC for the NARW. All other LFC species and sperm whales will have a clearance and shutdown zone which extends out to 3,281 feet (1,000 meters) (Table 1-7), which fully covers the PTS ranges for all species. Additionally, vibratory pile driving for the cofferdams would only occur between May 1 and October 31 to avoid the NARW migration season. Therefore, potential for PTS exposures resulting from of the installation of the goal post piles are **discountable.** Therefore, the effects of noise exposure above PTS thresholds **may affect, not likely to adversely affect** ESA-listed marine mammals.

Effects of Exposure to Noise Above the Behavioral Thresholds

The results of the exposure modeling (Table 3-9) indicated no ESA-listed marine mammals would be exposed to noise above the behavioral threshold during installation of the goal post piles (Tetra Tech 2022b). This is largely due to the nearshore location of this activity (Figure 1-1) which equates to low densities of LFC and MFC (specifically sperm whales) occurring within the area ensonified above the behavioral threshold (Table 3-9). The frequency range and characteristics of noise produced during installation of the goal post piles is expected to be similar to that described for installation of the WTG and OSS foundations (Section 3.2.5.2.3.1, *WTG and OSS Foundations [C]*) as they will both be installed using impact pile driving methods, so similar types of behavioral effects would also be expected. Hearing group-specific analyses are presented in the following subsections.

Low-frequency Cetaceans (LFC)

The noise produced will have the greatest acoustic energy in the lower frequency bands (less than 1 kHz), which overlaps best with the hearing range of the LFC species present in the Project area. Behavioral effects that could occur during installation of the goal post piles would be similar to those described for noise associated with installation of the WTG and OSS foundations (Section 3.2.5.2.3.1, *WTG and OSS Foundations [C]*), primarily short-term avoidance or displacement from the pile-driving site. However, the spatial extent and severity of the behavioral disturbances would be less than what is expected for the WTG and OSS foundations. First, noise levels produced during installation of the goal post piles will be substantially lower than that produced during installation of the WTG and OSS foundations, so noise levels meeting or exceeding the SPL 160 dB re 1 µPa behavioral threshold would not extend as far from the source. This is supported by the difference in the behavioral threshold ranges between the WTG and OSS foundation installation (maximum of 8.6 kilometers [Table 3-4]) versus the behavioral range for the goal post pile installation (up to 1.5 kilometers [Table 3-8]). Secondly, the duration of this activity is less than that described for installation of the WTG and OSS foundations, as pile driving during installation of the goal post piles would only occur up to 3 hours a day for 54 days. Therefore, the likelihood of an ESA-listed LFC species being exposed to sound energy above the behavioral threshold is low, and no long-term avoidance of the area or auditory masking is expected.

Mid-frequency Cetaceans (MFC)

Similar to that described for noise associated with installation of the WTG and OSS foundations (Section 3.2.5.2.3.1, *WTG and OSS Foundations [C]*), noise during impact pile driving of the goal post piles would partially overlap with the hearing sensitivity for sperm whales, though it is not within their peak sensitivity range (Section 3.2.4, *Sperm Whale*). Like with LFC, the spatial extent of the above-threshold noise would be less than that for impact pile driving of the WTG and OSS foundations. This would reduce the likelihood of sperm whales being exposed to sound energy above the behavioral disturbance threshold. Additionally, the nearshore location of this activity would especially limit the likelihood of sperm whales being exposed to above-threshold noise, as these species prefer deeper waters (Section 3.2.4, *Sperm Whale*). Therefore, the likelihood of ESA-listed MFC species being exposed to sound energy above the behavioral threshold is low, and no long-term avoidance of the area or auditory masking is expected.

Goal Post Pile Installation – Behavioral Effect Summary

The Proposed Action includes a clearance and shutdown zone which extends to any distance from the goal post piles for NARW, and out to 3,281 feet (1,000 meters) for all other ESA-listed species (Table 1-7). Although this doesn't cover the full 4,757 feet (1,450 meters) behavioral threshold distance for fin whales, sei whales, and sperm whales, the nearshore location of his activity limits the likelihood of these species being exposed to noise levels above the behavioral threshold and no behavioral disturbance exposure were estimated for any species (Table 3-9). Additionally, impact pile driving for installation of the goal post piles would only occur up to 3 hours a day for 54 days further limiting the likelihood of exposure, and goal post installation would only occur between May 1 and October 31 to avoid the NARW migration season. As a result, the potential for noise exposure leading to behavioral disturbance of these ESA-listed species is **discountable.** Therefore, the effects of exposure to noise above behavioral thresholds resulting from installation of the goal post piles **may affect, not likely to adversely affect** ESA-listed marine mammals.

3.2.5.2.3.3 Cofferdam Installation (C)

Vibratory pile driving (non-impulsive source) will be used to install up to nine temporary cofferdams at the Offshore and Nearshore Trenchless Installation Punch-Out. The nine proposed locations are within the same general area; therefore, the center cofferdam was used as the representative location in the model (Dominion Energy 2022). The cofferdams will be constructed using 20-inch (0.51-meter) steel sheet piles surrounding a 20-by-50-foot (6.1-by-15-meter) area. The modeling assumed up to 1,800 kilonewton vibratory force for all sheet piles, and source levels and spectral levels were obtained by adjusting measurements from similar offshore construction activity. No noise mitigation will be applied during this activity (Dominion Energy 2022). Installation activities are anticipated to take approximately 9 to 12 months and would only occur between May and October to avoid peak NARW presence.

Table 3-10 summarizes the maximum distances to PTS and behavioral disturbance thresholds for the two hearing groups applicable to species included in this BA during cofferdam installation.

Table 3-10 Maximum distances (meters) to thresholds for vibratory pile driving during installation of the cofferdam to support trenchless installation of the offshore export cable with no noise mitigation

LFC		MFC	
PTS (SEL_{24h})	Behavior (SPL)	PTS (SEL_{24h})	Behavior (SPL)
108	3,097	0	3,097

Source: Tetra Tech 2022a
dB = decibel; LFC = low-frequency cetacean; MFC = mid-frequency cetacean; SEL_{24h} = sound exposure level over 24 hours in units of dB referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of dB referenced to 1 micropascal; PTS = permanent threshold shift.

The number of ESA-listed marine mammal species potentially exposed to noises above thresholds for vibratory pile driving during cofferdam installation were estimated using the same methods as those described for the goal post piles (Section 3.2.5.2.3.2, *Goal Post Piles [C]*) and are summarized in Table 3-11, with the average seasonal densities used to estimate the exposures. However, it is worth noting that while the propagation modeling included noise mitigation, noise mitigation systems are not as commonly applied during nearshore construction activities such as the cofferdam installations, and the exposure estimates assume that no noise mitigation is applied during construction (Tetra Tech 2022b).

Table 3-11 Total estimated number of ESA-listed marine mammals exposed noise above behavioral-level thresholds from vibratory pile driving during installation of the temporary cofferdams

Species	Average Seasonal Density (animals/100 km²) [a]	Behavioral Exposures [b]
Fin whale	0.041	1
North Atlantic right whale	0.024	0
Sei whale	0.015	0
Sperm whale	0.001	0

Source: Tetra Tech 2022b.
ESA = Endangered Species Act
[a] Densities estimated using data from Roberts et al. (2022).
[b] Estimated exposures under the Proposed Action are equivalent to estimated exposures under the likely scenario of 176 WTGs and 3 OSSs.
km[s] = square kilometers

Effects of Exposure to Noise Above the PTS Thresholds

Due to the small threshold ranges (Table 3-10) and relatively low densities of large whales likely to be present during installation of the cofferdams (Table 3-11), no PTS exposures are expected to occur. The range to the PTS threshold for non-impulsive sources was estimated to be 354 feet (108 meters) for LFC but would not be exceeded for MFC (Table 3-10). Though the PTS thresholds may be exceeded for LFC species considered in this BA, PTS is not likely to be realized given the nearshore location of this activity (Section 1.3.1.1, *Onshore Activities and Facilities*), and the mitigation included under the Proposed Action to eliminate the risk of PTS occurring. First, both the clearance and shutdown zones for NARW will extend to any distance from the goal post piles (Table 1-7), which fully covers the extent of the 354-foot (108-meter) PTS range for LFC for NARW. All other LFC species will have a clearance and shutdown zone, which extends out to 3,281 feet (1,000 meters) (Table 1-7) to cover the PTS ranges for all species. Additionally, vibratory pile driving for the cofferdams would only occur between May 1 and October 31 to avoid the NARW migration season. As a result, the potential for PTS exposures resulting from of the installation of a cofferdam are highly unlikely and, therefore, are **discountable.** Therefore, effects of noise exposure above PTS thresholds **may affect, not likely to adversely affect** any ESA-listed marine mammals.

Effects of Exposure to Noise Above Behavioral Thresholds

Exposures to noise above the behavioral threshold were only predicted to occur for a single fin whale; all other species had 0 exposures estimated (Table 3-11). This is largely due to the low densities of the animals predicted to occur around the cofferdam installation location (Table 3-11), which limit the number of animals potentially exposed. Vibratory pile driving during installation of the cofferdam would only occur up to 1 hour a day for 54 days. Though the range to the behavioral disturbance threshold may extend out to 3,097 meters, the nearshore location of this activity limits the likelihood of ESA-listed LFC or MFC species being exposed.

Low-frequency Cetaceans (LFC)

Behavioral effects that could occur during installation of the cofferdams would be similar to those described for noise associated with vibratory pile driving of the WTG and OSS foundations (Section 3.2.5.2.3.1, *WTG and OSS Foundations [C]*), primarily short-term avoidance or displacement from the pile-driving site. However, only one behavioral exposure was predicted for fin whales, and no exposures were estimated for any other LFC species (Table 3-11) The noise produced will have the greatest acoustic energy in the lower frequency bands (less than 1 kHz), which overlaps best with the hearing range of the LFC species present in the Project area. The primary difference between noise produced during installation of the cofferdams and installation of the WTG and OSS foundations are the location and the levels of noise produced. The cofferdams would be installed in a location close to shore (Figure 1-1) which limits the number of ESA-listed LFC present compared to the WTG and OSS foundations. This is further evidenced by the densities estimated for the two areas (Table 3-4 for the WTG and OSS foundations; Table 3-10 for the cofferdams). Also, noise during installation of the cofferdams would only meet or exceed the behavioral threshold out to 10,161 feet (3,097 meters; Table 3-10) versus the 20,282-foot (6,182-meter) range predicted for vibratory pile driving of the WTG and OSS (Table 3-4). Lastly, the duration of this activity is less than that described for installation of the WTG and OSS foundations, as pile driving during installation of the cofferdam would only occur up to 1 hour a day for 54 days. Therefore, the likelihood of an ESA-listed LFC species being exposed to sound energy above the behavioral threshold is low, and no long-term avoidance of the area or auditory masking is expected.

Mid-frequency Cetaceans (MFC)

Similar to that described for noise associated with installation of the WTG and OSS foundations (Section 3.2.5.2.3.1, *WTG and OSS Foundations [C]*), noise during vibratory pile driving of the cofferdams would partially overlap with the hearing sensitivity for sperm whales, though it is not within their peak sensitivity range (Section 3.2.4, *Sperm Whale*). Like with LFC, the spatial extent of the above-threshold noise would be less than that for vibratory pile driving of the WTG and OSS foundations. This would reduce the likelihood of sperm whales being exposed to sound energy above the behavioral disturbance threshold. Additionally, the nearshore location of this activity would especially limit the likelihood of sperm whales being exposed to above-threshold noise, as these species prefer deeper waters (Section 3.2.4, *Sperm Whale*). Therefore, the likelihood of ESA-listed MFC species being exposed to sound energy above the behavioral threshold is low, and no long-term avoidance of the area or auditory masking is expected.

Cofferdam Installation – Behavioral Effects Summary

The Proposed Action includes a clearance and shutdown zone which extends to any distance from the cofferdams for NARW, and out to 3,281 feet (1,000 meters) for all other ESA-listed species (Table 1-7). Although this doesn't cover the full 3,097-meter behavioral threshold distance for fin whales, sei whales, and sperm whales, it will eliminate exposures to the higher noise isopleths around the cofferdam. Further, the likelihood of exposure is extremely low given the nearshore location of this activity, limited duration of piling, and the seasonal restrictions imposed to avoid NARWs migrating through the area. Any exposures received would be at the limits of the threshold ranges in areas already heavily influenced by other sources of anthropogenic noise (i.e., ongoing vessel traffic noise). Therefore, there would be no measurable behavioral exposures expected, if they were to occur exposures would not rise to the level of adverse effect and would be considered **insignificant**. Thus, exposure to noise above behavioral thresholds during installation of the cofferdams **may affect, not likely to adversely affect** ESA-listed marine mammals.

3.2.5.2.3.4 HRG Surveys (C, O&M, D)

HRG survey activities may be required pre-, during-, and post-construction site characterization surveys in the Lease Area and export cable route corridor. The types of equipment that will be used during the proposed HRG surveys with operational frequencies less than 180 kHz include both impulsive and non-impulsive equipment such as parametric sub-bottom profilers; ultra-short baseline positioning equipment; compressed high-intensity radiated pulse (CHIRP) sonar; sparkers; and boomers (Tetra Tech 2022a). Of these equipment types, only the CHIRP sonar, sparkers, and boomers have the potential to propagate sound to appreciable distances whereby marine mammals may be exposed to sound levels above established thresholds (Baker and Howsen 2021). Ranges to acoustic thresholds provided in Table 3-12 were estimated using NMFS User Spreadsheets for PTS thresholds and interim guidance from NMFS (2019b) for behavioral thresholds (Tetra Tech 2022a).

Table 3-12 Maximum ranges (meters) to PTS and behavioral thresholds for high-resolution geophysical survey equipment

Equipment Type	Range to PTS Threshold		Range to Behavioral Threshold
	LFC	MFC	All Hearing Groups
CHIRP sonar	0	0	10.2
Sparker	0.1	0	100
Boomer	5.9	0.2	21.9

Source: Tetra Tech 2022a
CHIRP = compressed high-intensity radiated pulse; LFC = low-frequency cetacean; MFC = mid-frequency cetacean

To assess the potential for effects on marine mammals, the duration of the surveys needs to be considered. For this assessment, it was assumed the HRG equipment would cover up to 58 kilometers per day, and would take place intermittently between 2024 and 2028 following the schedule in Table 3-13. Exposures were estimated following the same methodology as described in Section 3.2.5.2.3.2, *Goal Post Piles (C)* for the goal post piles and are provided in Table 3-14 with the estimated densities used to calculate the exposures.

Table 3-13 Proposed high-resolution geophysical survey schedule for the Project

Survey Type	Number of Active Survey Days
Pre-lay Surveys – 2024	65
As-built Surveys and Pre-lay Surveys – 2025	249
As-built Surveys – 2026	58
Post-construction Surveys – 2027	368
Post-construction Surveys – 2028	368
Post-construction Surveys – 2029	0 [a]

Source: Tetra Tech 2022a,b.
[a] Given that the Letter of Authorization is not anticipated to be begin until March 2024, the 5-year period that it covers will extend into several months of 2029; however, no activities are planned during that time.

Table 3-14 Annual estimated number of ESA–listed marine mammals exposed to behavioral threshold noise during HRG surveys for the Proposed Action

Species	Average Seasonal Density [a] (animals/100 km^2)	Construction Year	Behavioral Exposures [b]
Fin whale	0.080	2024	0
		2025	1
		2026	0
		2027	2
		2028	2
		2029	0
Total			**5**

Species	Average Seasonal Density [a] (animals/100 km²)	Construction Year	Behavioral Exposures [b]
North Atlantic right whale	0.095	2024	0
		2025	1
		2026	0
		2027	2
		2028	2
		2029	0
Total			**5**
Sei Whale	0.038	2024	0
		2025	1
		2026	0
		2027	1
		2028	1
		2029	0
Total			**3**
Sperm whale	0.002	2024	0
		2025	0
		2026	0
		2027	0
		2028	0
		2029	0
Total			**0**

Source: Tetra Tech 2022b.
[a] Densities estimated using data from Roberts et al. (2022).
[b] Estimated exposures under the Proposed Action are equivalent to estimated exposures under the likely scenario of 176 WTGs and 3 OSSs.
km^2 = square kilometers

Effects of Exposure to Noise above the PTS Thresholds

No PTS exposures are expected to occur due to the small threshold ranges (Table 3-12) and relatively low densities of ESA-listed marine mammals likely to be present during HRG surveys (Table 3-13). The range to the PTS threshold for non-impulsive sources was estimated to be a maximum of 19 feet (5.9 meters) for LFC, and a maximum of 0.7 foot (0.2 meter) for MFC during operations of boomers (Table 3-12), which would not be realized given the mitigation measures included under the Proposed Action to eliminate the risk of PTS exposures. Both the clearance and shutdown ranges for all ESA-listed species would extend out to 500 meters (Table 1-8) and fully cover the largest PTS threshold range. Additionally, the maximum range is only applicable during operations of boomer equipment, which would not occur during the entire survey period, further limiting the risk of exposure to sound energy above the PTS threshold. Therefore, potential for PTS exposures during installation of the goal post piles are **discountable**. Therefore, the effects of noise exposure above PTS thresholds **may affect, not likely to adversely affect** any ESA-listed marine mammals.

Effects of Exposure to Noise Above Behavioral Thresholds

Though HRG surveys would occur intermittently between 2024 and 2029, the maximum range to behavioral thresholds was estimated to be 328 feet (100 meters) during operations of sparker equipment (Table 3-12). As discussed in the LOA application, Dominion Energy may use a range of equipment including multibeam echosounders, side scan sonar, parametric sub-bottom profilers, CHIRPs, sparkers, and boomers; however, the exact amount of time each of these equipment may be used during the proposed HRG surveys so the exposures in Table 3-15 assumed the equipment with the largest behavioral threshold range (i.e., the sparker) was used during all survey days (Table 3-13). Using this assumption, the modeling predicted five fin whales, five NARWs, and three sei whales would be exposed to noise above the behavioral threshold during the HRG surveys between 2024 and 2029 (Table 3-14). No behavioral disturbance exposures were estimated for sperm whales (Table 3-14).

Low-frequency Cetaceans (LFC)

Although the HRG sources assessed in this BA can be detected by marine mammals, given several key physical characteristics of the sound sources (e.g., source level, frequency range, duty cycle, beamwidth) most HRG sources are unlikely to result in behavioral disturbance of marine mammals, even without mitigation (Ruppel et al. 2022). The areas where HRG surveys will occur overlaps with a Biologically Important Area for migrating NARWs. Timing of migrations includes a norward migration during March and April and a southward migration during October and November between summer feeding and winter calving grounds. During this migration period adults may be accompanied by calves and periodically feed and rest along their migration route. Fin whales are present in the area year-round; however, fin as well as sei whales generally prefer the deeper waters of the continental slope and more often can be found in water greater than 295 feet (90 meters) deep (Hain et al. 1985; Waring et al. 2011; Hayes et al. 2022). There is limited information regarding the potential behavioral reactions of LFCs to HRG surveys. For some of the higher-amplitude sources such as some boomers and the highest-power sparkers, behavioral disturbance is possible within an immediate area around the vessel (up to 328 feet (100 meters) from the source; Table 3-12). The behavioral disturbance area (328 feet [100 meters] from the vessel) would not be expected impede the migration of NARWs to critical habitats located to the north and south of the survey area as animals would still be able to move outside of the behavioral disturbance zone easily or wait until the vessel passes. Additionally, a 1,640-foot (500-meter) clearance and shutdown zone included in the Proposed Action (Table 1-7) for the selected HRG surveys covers the entire behavioral zone for NARWs and part of the behavioral zones for fin and sei whales (Table 3-12), which would limit the potential for behavioral effects. Due to the range of frequencies emitted during the equipment assessed in this BA, masking of all hearing groups is considered possible. Masking of LFC communications is considered more likely due to the overlap of these surveys with lower-frequency signals produced by these species. However, as the effects of masking would be transient in nature (moving with the vessel) the potential for communications to be masked is reduced.

Mid-frequency Cetaceans (MFC)

The area over which HRG surveys would occur would not extend to the OCS where sperm whales are more commonly observed, as evidenced by the low densities and lack of behavioral exposures estimated (Table 3-14). Additionally, available studies suggest MFC have a low likelihood of responding to HRG survey noise. Kates Varghese et al. (2020) found no change in three of four beaked whale foraging behavior metrics (i.e., number of foraging clicks, foraging event duration, click rate) during two deep-water mapping surveys using a 12 kHz multibeam echosounder. There was an increase in the number of foraging events during one of the mapping surveys, but this trend continued after the survey ended, suggesting that the change was more likely in response to another factor, such as the prey field of the beaked whales, than to the mapping survey. During both multibeam mapping surveys, foraging continued in the survey area and the animals did not leave the area (Kates Varghese et al. 2020, 2021). Vires (2011) also found no change in Blainville's beaked whale click durations before, during, and after a scientific survey with a 38 kHz EK-60 echosounder, while Cholewiak et al. (2017) found a decrease in beaked whale echolocation click detections during use of an EK-60 and Quick et al. (2017) found that short-finned pilot whales did not change foraging behavior but did increase their heading variance during use of an EK-60. For some of the higher-amplitude sources such as some boomers and the highest-power sparkers, behavioral disturbance is possible, but unlikely given the mitigation included in the Proposed Action (Table 1-7). A 1,640-foot (500-meter) clearance and shutdown zone will be applied for all ESA-listed marine mammals during HRG surveys, which fully covers the maximum 328-foot (100-meter) behavioral threshold range predicted by the modeling (Table 3-12) and would reduce the likelihood to animals being exposed to sound energy above the behavioral threshold for extended periods of time. These sounds could result in acoustic masking in MFC but are unlikely to result in behavioral disturbance given their low source levels and intermittent use.

HRG Surveys – Behavioural Effect Summary

The Proposed Action includes a clearance and shutdown zone, which extends to 1,640 feet (500 meters) for all ESA-listed species (Table 1-7) and effectively covers the maximum range to behavioral thresholds that were modeled were estimated to be 100 meters during operations of sparker equipment (Table 3-12). These exposure estimates do not account for mitigation measures applied during the survey, the variability in survey operations, the presence and noise of the vessel, or the usage of specific equipment which will change the ranges to behavioral thresholds for ESA-listed species and are considered conservative. Exposures, if they were to occur, would be **insignificant** because are not expected to rise to the level of ESA take (as defined by the interim definition of harassment under the ESA) because any changes in biologically important activities, would be at the lower limits of the threshold ranges, temporary, and unlikely to produce any measurable behavioral changes. Therefore, effects of exposures above behavioral thresholds from Project HRG surveys **may affect, not likely to adversely affect** ESA-listed marine mammals.

3.2.5.2.3.5 Vessel Noise (C, O&M, D)

Up to 53 types of vessels may be used to support construction, O&M, and decommissioning of the Proposed Action (Table 1-6). These include larger barges and HLV which range in size from 400 to 711 feet (122 to 217 meters) in length, 105 to 161 feet (32 to 49 meters) in breadth, and drafts from 20 to 36 feet (6 to 11 meters); cable-laying vessels ranging in size from 87 to 401 feet (27 to 122 meters) in length, 34 to 110 feet (10 to 34 meters) in breadth, and drafts from 10 to 18 feet (3 to 5 meters); and smaller support vessels ranging from 65 to 112 feet (20 to 34 meters) in length, 34 to 35 feet (10 to 11 meters) in breadth, and drafts from 10 to 19 feet (3 to 6 meters) (Table 1-6). Project vessel traffic will be intermittently present throughout the lift of the Project from before construction through decommissioning with transit frequencies ranging from daily to only a few cycles for the whole Project depending on the role and port of origin.

Vessel sound is characterized as low frequency, typically below 1,000 Hz with peak frequencies between 10 and 50 Hz, non-impulsive rather than impulsive like impact pile driving, and continuous, meaning there are no substantial pauses in the sounds that vessels produce. The acoustic signature produced by a vessel varies based on the type of vessel (e.g., tanker, bulk carrier, tug, container ship) and vessel characteristics (e.g., engine specifications, propeller dimensions and number, length, draft, hull shape, gross tonnage, speed). Larger barges and commissioning vessels would produce lower frequency noise with a primary energy near 40 Hz and underwater source levels that can range from 177 to 200 dB re 1 µPa m (McKenna et al. 2012; Erbe et al. 2019). Smaller crew transfer vessels would typically produce higher frequency noise (1,000 to 5,000 Hz) at source levels between 150 and 180 dB re 1 µPa m

(Kipple and Gabriele 2003, 2004). Vessels using DP thrusters (such as platform or cable laying vessels) are known to generate substantial underwater noise with source levels ranging from 150 to 180 dB re 1 µPa m depending on operations and thruster use (BOEM 2013; McPherson et al. 2016). While vessel noise was not modeled for the Project, qualitative information about vessel noise, which may be produced during Project activities and how it may affect marine mammals was obtained from available literature. Parsons et al. (2021) reviewed literature for the source levels and spectral content of vessels less than 82 feet (25 meters) in length, a category often not addressed in vessel noise assessment measurements. Parsons et al. (2021) found reported source levels in these smaller vessels to be highly variable (up to 20 dB difference); however, an increase in speed was consistently shown to increase source levels while vessels at slower speeds were shown to emit low frequency acoustic energy (less than 100 Hz) that is often not characterized in broadband analyses of small vessel sources.

Effects of Exposure to Noise Above the PTS Thresholds

No PTS exposures are expected to occur to marine mammals as a result of vessel noise due to the non-impulsive nature of the sources and relatively low source levels produced (BOEM 2013; McPherson et al. 2016). Therefore, potential PTS exposures resulting from vessel noise are **discountable. Thus,** the effects of noise exposure above PTS thresholds **may affect, not likely to adversely affect** ESA-listed marine mammals.

Effects of Exposure to Noise Above Behavioral Thresholds

Based on the source levels presented in the literature for vessels similar to those that will be used for the Project (outlined previously), behavioral disturbance thresholds could be exceeded.

A comprehensive review of the literature (Richardson et al. 1995; Erbe et al. 2019) revealed that most of the reported adverse effects of vessel noise and presence are changes in behavior, though the specific behavioral changes vary widely across species. Physical behavioral responses include changes to dive patterns (Finley et al. 1990), disruption to resting behavior (Mikkelsen et al. 2019), increases in swim velocities (Finley et al. 1990; Sprogis et al. 2020; Williams et al. 2022), and changes in respiration patterns (Nowacek et al. 2006; Hastie 2006; Sprogis et al. 2020). These responses have, in certain cases, been correlated with numbers of vessels and their proximity, speed, and directional changes. Responses have been shown to vary by gender and by individual. Hearing group-specific analyses are presented in the following subsections.

Low-frequency Cetaceans (LFC)

A playback study of humpback whale mother-calf pairs exposed to varying levels of vessel noise revealed that the mother's respiration rates doubled and swim speeds increased by 37 percent in the high noise conditions (LF-weighted received SPL at 328 feet (100 meters) was 133 dB re 1 µPa) compared to control and low-noise conditions (104 dB re 1 µPa and 112 dB re 1 µPa, respectively) (Sprogis et al. 2020). Rolland et al. (2012) showed that fecal cortisol levels in NARWs decreased following the September 11, 2001 terrorist attacks, when vessel activity was significantly reduced. Interestingly, NARWs do not seem to avoid vessel noise nor vessel presence (Nowacek et al. 2004), yet they may incur physiological effects as demonstrated by Rolland et al. (2012). This lack of observable response, despite a physiological response, makes it challenging to assess the biological consequences of exposure. In addition, there is evidence that individuals of the same species may have differing responses if the animal has been previously exposed to the sound versus if it is completely novel interaction (Finley et al. 1990). Reactions may also be correlated with other contextual features, such as the number of vessels present, their proximity, speed, direction or pattern of transit, or vessel type (Erbe et al. 2019).

Some marine mammals may change their acoustic behaviors in response to vessel noise, either due to a sense of alarm or in an attempt to avoid masking. For example, fin whales (Castellote et al. 2012) have altered frequency characteristics of their calls in the presence of vessel noise. When vessels are present, humpbacks and belugas have been seen to completely stop vocal activity (Tsujii et al. 2018; Finley et al. 1990). Fin whales have been documented shortening their calls to avoid acoustic masking from vessel noise (Castellote et al. 2012).

Understanding the scope of acoustic masking is difficult to observe directly, but several studies have modeled the potential decrease in "communication space" when vessels are present (Clark et al. 2009; Erbe et al. 2016; Putland et al. 2017). For example, Putland et al. (2017) showed that during the closest point of approach (<10 kilometers) of a large commercial vessel, the potential communication space of Bryde's whale was reduced by 99 percent compared to ambient conditions. Large vessels generally emit underwater noises in the low frequency bands below 1 kHz (McKenna et al. 2012; Erbe et al. 2019) that have the potential to overlap with LFC communications. Smaller vessels typically produce higher-frequency sound concentrated in the 1,000 Hz to 5,000 Hz range (Erbe et al. 2019). Masking of LFC communications is considered possible across large and small vessel frequency spectrums. However, as the effects of masking would be transient in nature (moving with the vessel) the potential for communications to be masked is also considered temporary and transient.

Although there have been many documented behavioral changes in response to vessel noise (Erbe et al. 2019), it is necessary to consider what the biological consequences of those changes may be. One of the first attempts to understand the energetic cost of a change in vocal behavior found that metabolic rates in bottlenose dolphins increased by 20 to 50 percent in comparison to resting metabolic rates (Holt et al. 2015). Although this study was not tied directly to exposure to vessel noise, it provides insight about the potential energetic cost of this type of behavioral change documented in other works (i.e., increases in vocal effort such as louder, longer, or increased number of calls). In another study, the energetic cost of high-speed escape responses in dolphins was modeled, and the researchers found that the cost per swimming stroke was doubled during such a flight response (Williams et al. 2017). When this sort of behavioral response was also coupled with reduced glide time for beaked whales, the researchers estimated that metabolic rates would increase by 30.5 percent (Williams et al. 2017). Differences in response have been reported both within and among species groups (Finley et al. 1990; Tsujii et al. 2018). Despite demonstrable examples of biological consequences to individuals, there is still a lack of understanding about the strength of the relationship between many of these acute responses and the potential for long-term or population-level effects. The energetic consequences of any avoidance behavior or masking effects and potential 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.

Mid-frequency Cetaceans (MFC)

Changes to foraging behavior, which can have a direct effect on an animal's fitness, have been observed in porpoises (Wisniewska et al. 2018) and killer whales (Holt et al. 2021) in response to vessel noise. Other MFC species have been observed altering their acoustic behavior in response to vessel noise. When vessels are present, bottlenose dolphins have been observed increasing the number of whistles (Buckstaff 2006; Guerra et al. 2014), while sperm whales decrease the number of clicks (Azzara et al. 2013). Killer whales have been observed increasing their call amplitude (Holt et al. 2009) to avoid acoustic masking from vessel noise.

Masking of echolocation clicks used by sperm whales is not anticipated given the low-frequencies of noise produced by vessel (McKenna et al. 2012; Erbe et al. 2019); however, some masking of other communications used by this species is possible. Observed changes in acoustic vocalizations from Gordon (1992) demonstrate that, in response to whale watching vessel exposures, sperm whales produce brief or minor changes in vocal rates and signal characteristics. These effects would be transient in nature (moving with the vessel) the potential for communications to be masked for all is considered reduced.

Vessel Noise – Behavioral Effects Summary

ESA-listed marine mammals may be exposed to noise above the behavioral thresholds and may experience masking effects depending on the type and speed of the vessel. However, the likelihood of prolonged exposures that would affect biologically important behaviors such as foraging or reproduction is low with the proposed mitigation and monitoring measures. The Proposed Action includes mitigation for vessel strike avoidance (Table 1-7; see Section 3.2.5.6, *Vessel Traffic Effects on Marine Mammals [C, O&M, D]*) such as minimum separation distances, which would reduce the risk of an animal being close enough to receive sound energy above the behavioral threshold, and vessel speed restrictions, which would help reduce the level of noise produced by Project vessels (ZoBell et al. 2021). With these combined mitigation measures, exposures of ESA-listed LFC and MFC to vessel noise that results in behavioral disturbances is **insignificant**. Vessel noise as a result of the Proposed Action, therefore, **may affect, not likely to adversely affect** ESA-listed marine mammals in the Action Area.

3.2.5.2.3.6 Cable Laying or Trenching Noise (C)

As described in Section 1.3.1.2, *Offshore Activities and Facilities*, The most likely cable burial methods being considered as part of the Proposed Action include jet plow, jet trenching, hydroplow (simultaneous lay and burial), mechanical plowing (simultaneous lay and burial) Cables can be installed using a tool towed behind the installation vessel to simultaneously open the seabed and lay the cable, or by laying the cable and following with a tool to embed the cable. If the cables are not simultaneously laid and buried, they may remain on the seabed within the Project area for up to 2 weeks prior to burial. The net durations related to the Nearshore Trenchless Installation and Offshore Export Cable installation have been estimated as follows (COP Volume I, Section 3.4.1.4; Dominion Energy 2023):

- The Nearshore Trenchless Installation is assumed at a rate of 9 to 18 days per unit;
- Cable laying speed of the nearshore cables is assumed at a rate if 197 to 1,148 feet per hour (60 to 350 meters per hour), including the simultaneous burial;
- Cable laying speed of the offshore cables is assumed at a rate of 197 to 1,148 feet per hour (60 to 350 meters per hour); and
- Cable jointing takes 10 days per joint.

Cable faults are expected to occur over the life of the Project. Faults would be detected by the wind farm protection system and would require location testing using remote diagnostic testing to identify the exact location along the cable length. Where a fault is detected, the cable would be exposed and repaired or replaced. A new section of cable would be jointed aboard the cable-handling vessel. Upon completion of the repair, the cable would be lowered onto the seabed and assessed to determine whether it is on or as close as practicable to the original cable/trench location. Reburial by a jetting tool is expected. Post-burial survey would be completed to determine the success of burial.

During construction, vessels used for array cable installation would include cable laying vessels and burial vessels in addition to support vessels (Table 1-5). The action of laying the cables on the seafloor itself is unlikely to generate high levels of underwater noise. Most of the noise energy would originate from the vessels themselves including propellor cavitation noise and noise generated by onboard thruster/stabilization systems and machinery (e.g., generators), including noise emitted by the tugs when moving the anchors, as discussed in Section 3.2.5.2.3.2, *Vessel Noise (C, O&M, D)*.

There is limited information regarding underwater noise generated by cable-laying and burial activities in the literature. Johansson and Andersson (2012) recorded underwater noise levels generated during a comparable operation involving pipelaying and a fleet of nine vessels. Mean noise levels of 130.5 dB re 1 µPa were measured at 4,924 feet (1,500 meters) from the source. Reported noise levels generated during a jet trenching operation provided a source level estimate of 178 dB re 1 µPa measured at 3.3 feet (1 meter) from the source (Nedwell et al. 2003). This value was used as a proxy for modeling underwater noise fields for the Project jetting operation relative to existing acoustic thresholds for marine mammals in the Project area. To estimate the extent of behavioral disturbance from cable-laying operations, a practical spreading loss equation (15 log [range]) was applied with the estimated source level to estimate the range to the marine mammal behavioral disturbance thresholds (Section 3.2.5.2.2, *Auditory Criteria for Marine Mammals)*.

Expected acoustic frequencies emitted by these sound sources are more likely to overlap with the hearing range of LFC than with MFC; however, masking of communications from both hearing groups is considered possible.

Effects of Exposure to Noise Above the PTS Thresholds

Cable-laying noise sources associated with the Project were below the established PTS injury thresholds for all marine mammal hearing groups (Section 3.2.5.2.2, *Auditory Criteria for Marine Mammals)*. Therefore, the potential for ESA-listed marine mammals to be exposed to noise above PTS thresholds from cable laying is extremely unlikely to occur and is **discountable**. Therefore, the effects of noise exposure from Project cable laying operations leading to PTS **may affect, not likely to adversely affect** ESA-listed marine mammals.

Effects of Exposure to Noise Above the Behavioral Thresholds

Based on the source levels previously presented from the available literature for cable laying activities comparable to those that will be used for the Project, behavioral disturbance thresholds could be exceeded, and behavioral disturbance could occur if the animals do not avoid the activities. However, all of the ESA-listed cetaceans are highly mobile and expected to move away from any noise effects that may result in prolonged behavioral disturbance.

Low-frequency Cetaceans (LFC)

Though the Project Lease Area, where impact pile driving will occur, does not overlap with any critical habitat (Section 2.3, *Species and Critical Habitat Considered, but Discounted from Further Analysis*), it does overlap with a Biologically Important Area for migrating NARWs. Timing of migrations includes a northward migration during March to April and a southward migration during October and November between summer feeding and winter calving grounds. During this migration period, adults may be accompanied by calves and periodically feed and rest along their migration route (Hayes et al. 2022). Fin and sei whales generally prefer the deeper waters of the continental slope and more often can be found in water >295 feet (90 meters) deep (Hain et al. 1985; Waring et al. 2011; Hayes et al. 2022)..

Any behavioral effects would be expected to dissipate once the activity has ceased or the individual has left the area and would, therefore, be considered temporary. Behavioral disturbances from cable laying operations are not expected to impede the migration of NARWs to critical habitats located to the north and south of the Project area as animals would still be able to move outside of the behavioral disturbance zone. LFCs would be expected to resume pre-exposure activities once the activity stopped or the animal moved out of the disturbance zone. With the implementation of vessel separation distances outlined in Table 1-7, potential behavioral effects are further reduced.

Masking of LFC communications is considered possible; however, the effects of masking would be transient in nature, moving with the cable lay vessel, and would occur intermittently in several separate areas as discussed previously. The potential for communications to be masked from cable laying operations is, therefore, considered temporary and transient.

Mid-Frequency Cetaceans (MFC)

The area over which the cable laying operations would occur does not extend beyond the continental slope where sperm whales are more commonly observed. If sperm whales are exposed to underwater noise above behavioral thresholds, effects would likely be localized the area around the operations, would be temporary and transient. Sperm whales would be expected to resume pre-exposure activities once the activity stopped or the animal moved out of the disturbance zone. With the implementation of vessel separation distances outlined in Table 1-7, potential behavioral effects are further reduced. In addition, the vessel speed restrictions outlined for the Project (Table 1-7) could reduce the source levels emitted by certain vessels (ZoBell et al. 2021).

Masking of the higher frequency echolocation clicks used by sperm whales is not anticipated; however, some masking of other communications used by this species is possible. However, as discussed for LFC, these effects would be transient in nature (moving with the cable laying activity) and would not overlap with areas frequently used by this species or in areas where they hunt for preferred prey (e.g., squid in deep waters).

Cable Laying - Behavioral Impact Summary

Based on the mitigation measures presented and discussed (Tables 1-7 and 1-8) the potential for exposure of these ESA-listed cetaceans to noise produced by cable laying activities at levels leading to behavioral disruption would be reduced to the level of the individual animal and would not be expected to have population-level effects. As discussed above, NARWs, fin whales, sei whales, and sperm whales may be exposed to noise above the behavioral thresholds depending on the type of the vessel and equipment used for cable laying operations. However, given the interim definition for ESA harassment (Section 3.2.5.1, *Definition of Take, Harm, and Harass*), an animal's ability to avoid harmful noises, and the established mitigation and monitoring measures (including vessel separation distances) in Table 1-7 and 1-8, the potential for ESA-listed marine mammals to be exposed to underwater noise exceeding behavioral disruption thresholds from cable laying operations would be so minor that they cannot be meaningfully evaluated and is, therefore, considered **insignificant**. Therefore, the effects of noise exposure from Project cable laying and trenching operations leading to behavioral disturbance and masking **may affect, not likely to adversely affect** ESA-listed marine mammals**.**

3.2.5.2.3.7 WTG Operations (O&M)

Reported sound levels of operational wind turbines is generally low (Madsen et al. 2006; Tougaard et al. 2020; Stöber and Thomsen 2021) with a source SPL of about 151 dB re 1 µPa m and a frequency range of 60 to 300 Hz (Wahlberg and Westerberg 2005; Tougaard et al. 2020). At the Block Island Wind Farm, low-frequency noise generated by turbines reach ambient levels at 164 feet (50 meters) (Miller and Potty 2017). SPL measurements from operational WTGs in Europe indicate a range of 109 to 127 dB re 1 µPa at 46 and 66 feet (14 to 20 meters) from the WTGs (Tougaard et al. 2009). Thomsen et al. (2016) indicated SPL ranging from 122 to 137 dB re 1 µPa 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, 500 Hz, and 1,200 Hz from a jacket foundation turbine and from 133 to 135 dB re 1 µPa at 492 and 131 feet (150 and 40 meters), respectively, with peak frequencies at 50 and 140 Hz from a steel monopile foundation turbine. The measurements within 131 feet (40 meters) of the 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.

Tougaard et al. (2020) reviewed the literature sources previously cited, along with others to attempt some standardization in reporting and assessment. The resulting analyses showed that sound levels produced by individual WTG were low in all literature and comparable to or lower than sound levels within 0.6 mile of commercial ships. The complied data also showed an increase in noise levels with increasing WTG power and wind speed; however, Tougaard et al. (2020) noted that the noise produced from a WTG is stationary and persistent, which differs from the transitory nature of sound produced by vessel traffic, and the cumulative contribution of multiple WTG within a region must be critically assessed and planned. Stöber and Thomsen (2021) reviewed published literature and also identified an increase in underwater source levels (up to 177 dB re 1 µPa) with increasing power size with a nominal 10 MW WTG. They also estimate a sound decrease of roughly 10 dB from WTG using gear boxes (which is what has been used on the majority of WTG measured in Europe) compared to WTG using direct drive technology in which the gear box which connects the generator to the turbine blades is removed and instead the turbine rotor is connected directly to the generator (Osmanbasic 2020).

Effects of Exposure to Noise Above the PTS Thresholds

Based on the currently available sound field data for turbines smaller than 6.2 MW (Tougaard et al. 2020) and comparisons to acoustic impact thresholds (NMFS 2018), underwater sound from offshore wind turbine operations is not likely to cause PTS for any ESA-listed species assessed in this BA. Tougaard et al. (2020) summarized available monitoring data on wind farm operational noise, including both older-generation, geared turbine designs and quieter, modern, direct-drive systems like those proposed for this Project. They determined that operating WTG produce underwater noise on the order of 110 to 125 dB re 1 µPa SPL at a reference distance of 164 feet (50 meters), occasionally reaching as high as 128 dB re 1 µPa SPL, in the 10-Hz to 8-kilohertz range. This is consistent with the noise levels observed at the Block Island Wind Farm (Elliot et al. 2019) and the range of values observed at European wind farms. More recently, Stöber and Thomsen (2021) used monitoring data and modeling to estimate operational noise from larger (10-MW), current-generation, direct-drive WTGs and concluded that these designs could generate higher operational noise levels than those reported in earlier research. This suggests that operational noise effects on ESA-listed marine mammals could be more intense and extensive than those considered herein, however, due to the relatively low source levels referenced in the available data, injury-level effects are not considered likely and are **discountable**. Therefore, the effects of noise exposure above PTS thresholds resulting from WTG operations **may affect**, **not likely to adversely affect** ESA-listed marine mammals.

Effects of Exposure to Noise Above Behavioral Thresholds

Based on the available source level and modeling information previously presented, underwater noise from WTG operations could exceed behavioral thresholds and cause masking of communications. Estimated ranges to behavioral thresholds for marine mammals from gear box versus direct drive WTG extended to 3.9 miles (6.3 kilometers) versus 0.87 mile (1.4 kilometers), respectively. Given the relatively low sound levels that would be produced during WTG operations, only temporary changes in marine mammal behavior would be expected to occur at close distances from the Project turbines. Hearing group-specific analyses are presented in the following subsections.

Low-frequency Cetaceans (LFC)

Very few empirical studies have looked at the effect of operational wind turbine noise on wild marine mammals. Some have shown an increase in acoustic occurrences of marine mammals within a wind farm during the operational phase of wind farms (Russell et al. 2016; Scheidat et al. 2011), while another study showed a decrease in the abundance of harbor porpoises one year after operation began in comparison with the pre-construction period (Tougaard et al. 2005). However, no change in acoustic behavior was detected in the animals that were present (Tougaard et al. 2005). In these field monitoring studies, it is not always clear if the behavioral responses have anything to do with operational noise, or merely the presences of turbine structures. Regardless, these findings suggests that turbine operational noise did not have any severe adverse effect on the acoustic behavior of the animals.

Based on the modeling conducted by Tougaard et al. (2020), the noise from a single, 1 MW turbine dropped below ambient conditions within a few kilometers for an array of 81 turbines. For high ambient noise conditions, the distance at which the turbine could be heard above ambient noise was even less. It is important to note that just because a sound is audible, that does not mean that it would be disturbing or be at a sufficient level to mask important acoustic cues. There are many natural sources of underwater sound which vary over space and time and would affect an animal's ability to hear turbine operational noise over ambient conditions.

Masking of LFC communications is considered likely but as with behavioral disturbance, the extent of these effects is unknown. There is no published literature assessing long-term movement or acoustic exposure of LFC in or around offshore wind farms. Rather than sound levels produced by individual WTGs, cumulative noise from individual wind farms as well as combined regional wind farms are likely to produce more widespread sound fields, which, in the absence of other similar ambient noise (e.g., ships) could produce a pronounced change to the regional soundscape and could affect marine mammals (and other species) acoustic acuity (Tougaard et al. 2020).

Mid-frequency Cetaceans (MFC)

Similar to LFC, there are limited data regarding responses of MFC species to WTG operational noise. Some studies have indicated no change in the acoustic presence of marine mammals during wind farm operations (Russell et al. 2016; Scheidat et al. 2011), while some indicate temporary avoidance of the wind farm (Tougaard et al. 2005). For sperm whales specifically, the behavioral disturbance zone is not likely to extend beyond the OCS slope where this species is most likely to occur offshore Virginia (Section 3.2.4, *Sperm Whale*), limiting the likelihood of sperm whales being exposed to above-threshold noise for extended periods of time.

Masking of high-frequency echolocation clicks used by sperm whales is not anticipated; however, some masking of other communications used by this species is possible. These effects are not expected to overlap with areas frequently used by this species or in areas where they hunt for preferred prey (i.e., squid in deep waters). However, any behavioral or masking effects would be temporary and would not be expected to affect an individual's ability to successfully obtain food to maintain their health, make seasonal migrations, or participate in breeding or calving. Lucke et al. (2007) explored the potential for acoustic masking from operational noise by conducting hearing tests on trained harbor porpoises while they were exposed to sounds resembling operational wind turbines (<1 kHz). They saw masking effects at 128 dB re 1 μPa at frequencies of 700, 1,000, and 2,000 Hz, but found no masking at SPLs of 115 dB re 1 μPa. Based on propagation loss in a shallow water environment, the sound would attenuate to 115 dB re 1 μPa within 20 meters of the operating turbine (Lucke et al. 2007), suggesting the range for masking for high-frequency cetaceans is very small, and would likely be similarly small for sperm whales given the low overlap between the frequencies of WTG operational noise and the peak hearing sensitivity of sperm whales (Section 3.2.4, *Sperm Whale*).

<u>WTG Operations – Behavioral Effects Summary</u>

The potential for exposure of ESA-listed LFC and MFC to noise levels which meet or exceed the behavioral disturbance threshold during WTG operations would be reduced to the level of the individual animal and would not be expected to have population-level effects. NARWs, fin whales, sei whales, and sperm whales may be exposed to noise above the behavioral thresholds during WTG operations, particularly during high wind events when WTG noise levels are likely to be elevated (Tougaard et al. 2020). However, available studies suggest WTG turbine operational noise would not have any severe adverse effect on the behavior of the animals, and potential behavioral effects of ESA-listed cetaceans from WTG operations is considered **insignificant**. Therefore, the effects of exposures to noise above behavioral threshold levels from Project WTG operations **may affect, not likely to adversely affect** ESA-listed marine mammals.

3.2.5.2.3.8 Summary of Underwater Noise Effects

Noise generated from Project activities include impulsive (e.g., impact pile driving, some HRG surveys) and non-impulsive sources (e.g., vibratory pile diving, some HRG surveys, vessels, turbine operations). Of those activities, only impact pile driving could cause PTS effects on marine mammals. All noise sources have the potential to cause behavioral disturbance effects through behavioral modification, masking, and other non-lethal effects in certain species. The mitigation measures outlined in Tables 1-8 and 1-9 are expected to be effective in limiting the potential for PTS effects in most marine mammal species; however, the potential for some PTS, behavioral effects, and masking remain. Table 3-15 summarizes the number of ESA-listed marine mammals potentially exposed to underwater noises above PTS and behavioral thresholds for all underwater noise sources.

Table 3-15 Estimated number of ESA-listed marine mammals exposed to sound levels above PTS and behavioral thresholds

	Marine Mammal Species	PTS Exposures [a]	Behavioral Exposures [b]
WTG and OSS Foundation Installation (10 dB noise mitigation)			
LFC	NARW	0	18
	Fin whale	9	240 (205 [c])
	Sei whale	3	7
MFC	Sperm whale	0	9
Goal Post Pile Installation (0 dB noise mitigation)			
LFC	NARW	0	0
	Fin whale	0	0
	Sei whale	0	0
MFC	Sperm whale	0	0
Cofferdam Installation (0 dB noise mitigation)			
LFC	NARW	0	0
	Fin whale	0	1
	Sei whale	0	0
MFC	Sperm whale	0	0
HRG Surveys (5-Year Total) (0 dB noise mitigation)			
LFC	NARW	0	5
	Fin whale	0	5
	Sei whale	0	3
MFC	Sperm whale	0	0

dB = decibels; HRG = high-resolution geophysical; LFC = low-frequency cetacean; MFC = mid-frequency cetacean; NARW = North Atlantic right whale; OSS = offshore substation; WTG = wind turbine generator
Source: Tetra Tech 2022b [a] Estimated PTS exposures under the Proposed Action are equivalent to estimated PTS exposures under the likely scenario of 176 WTGs and 3 OSSs.

[b] Unless otherwise noted, estimated behavioral exposures under the Proposed Action are equivalent to estimated behavioral exposures under the likely scenario of 176 WTGs and 3 OSSs.
[c] Up to 205 behavioral exposures could occur under the likely scenario of 176 WTGs and 3 OSSs, as opposed to 240 under the Proposed Action.

3.2.5.2.3.9 Effects on Prey Organisms

Reduction of prey availability could affect marine mammals if rising sound levels alter prey abundance, behavior, distribution, or both (McCauley et al. 2000a,b; Popper and Hastings 2009; Slabbekoorn et al. 2010). Prey species may show responses to noise; however, there are limited data on hearing mechanisms and potential effects of noise on common prey species (i.e., crustaceans, cephalopods, fish) that would result loss of availability to marine mammals. These species have been increasingly researched as concern has grown related to noise effects on the food web. Invertebrates appear to be able to detect sounds and particle motion (André et al. 2016; Budelmann 1992; Solé et al. 2016, 2017) and are most sensitive to low-frequency sounds (Packard et al. 1990; Budelmann and Williamson 1994; Lovell et al. 2005a,b; Mooney et al. 2010).

Squid and other cephalopods are an extremely important food chain component for many higher order marine predators, including fin and sperm whales. Cephalopods (i.e., octopus, squid) and decapods (i.e., lobsters, shrimps, crabs) are capable of sensing low-frequency sound. Packard et al. (1990) showed that three species of cephalopod were sensitive to particle motion, not sound pressure, with the lowest particle acceleration thresholds reported as 0.002 to 0.003 m s^{-2} at 1 to 2 Hz. Solé et al. (2017) showed that SPL ranging from 139 to 142 dB re 1 µPa at one-third octave bands centered at 315 Hz and 400 Hz may be suitable threshold values for trauma onset in cephalopods. Cephalopods have exhibited behavioral responses to low frequency sounds under 1,000 Hz, including inking, locomotor responses, body pattern changes, and changes in respiratory rates (Kaifu et al. 2008; Hu et al. 2009). In squid, Mooney et al. (2010) measured acceleration thresholds of -26 dB re 1 m s^{-2} between 100 and 300 Hz and an SPL threshold of 110 dB re 1 µPa at 200 Hz. Lovell et al. (2005a) found a similar sensitivity for prawn (*Palaemon serratus*), SPL of 106 dB re 1 µPa at 100 Hz, noting that this was the lowest frequency at which they tested and that the prawns might be more sensitive at frequencies below this. Hearing thresholds at higher frequencies have been reported, such as 134 and 139 dB re 1 µPa at 1,000 Hz for the oval squid (*Sepioteuthis lessoniana*) and the common octopus (*Octopus vulgaris*), respectively (Hu et al. 2009). McCauley et al. (2000a) reported that of caged squid exposed to seismic airguns showed behavioral responses such as inking. Wilson et al. (2007) exposed two groups of squid (*Loligo pealeii*) in a tank to killer whale echolocation clicks at SPL from 199 to 226 dB re 1 µPa, which resulted in no apparent behavioral effects or any auditory debilitation. However, both the McCauley et al. (2000a) and Wilson et al. (2007) experiments used caged squid, so it is unclear how unconfined animals would react. André et al. (2011) exposed four cephalopod species (European squid [*Loligo vulgaris*], cuttlefish [*Sepia officinalis*], octopus, and southern shortfin squid [*Ilex coindetii*]) to 2 hours of continuous noise from 50 to 400 Hz at received SPL of 157 dB re 1 µPa ± 5 dB, and reported lesions occurring on the statocyst's sensory hair cells of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. Similar to André et al. (2011), Solé et al. (2013) conducted a low-frequency (50 to 400 Hz) controlled exposure experiment on two deep-diving squid species (southern shortfin squid and European squid), which resulted in lesions on the statocyst epithelia. Sóle et al. (2013) described their findings as "morphological and ultrastructural evidence of a massive acoustic trauma induced by low-frequency sound exposure." In experiments conducted by Samson et al. (2014), cuttlefish exhibited escape responses (i.e., inking, jetting) when exposed to sound frequencies between 80 and 300 Hz with SPL above 140 dB re 1 µPa and particle acceleration of 0.01 m s^{-2}; the cuttlefish habituated to repeated 200 Hz sounds. The intensity of the cuttlefish response with the amplitude and frequency of the sound stimulus suggest that cuttlefish possess loudness perception with a maximum sensitivity of approximately 150 Hz (Samson et al. 2014).

Several species of aquatic decapod crustaceans are also known to produce sounds. Popper et al. (2001) concluded that many are able to detect substratum vibrations at sensitivities sufficient to tell the proximity of mates, competitors, or predators. Popper et al. (2001) reviewed behavioral, physiological, anatomical, and ecological aspects of sound and vibration detection by decapod crustaceans and noted that many decapods also have an array of hair-like receptors within and upon the body surface that potentially respond to water- or substrate-borne displacements as well as proprioceptive organs that could serve secondarily to perceive vibrations. However, the acoustic sensory system of decapod crustaceans remains poorly studied (Popper et al. 2001). Lovell et al. (2005a, b, 2006) reported potential auditory-evoked responses from prawns (*Palaemon serratus*) showing auditory sensitivity of sounds from 100 to 3,000 Hz, and Filiciotto et al. (2016) reported behavioral responses to vessel noise within this frequency range.

Marine mammal prey species of fish are typically sensitive to the 100 to 500 Hz range, which is below most HRG survey sources, but does overlap with many of the Project activities described previously. Several studies have demonstrated that seismic airguns and impulsive sources might affect the behavior of at least some species of fish. For example, field studies by Engås et al. (1996) and Løkkeborg et al. (2012b) showed that the catch rate of haddock (*Melanogrammus aeglefinus*) and Atlantic cod (*Gadus morhua*) significantly declined over the 5 days immediately following seismic surveys, after which the catch rate returned to normal. Other studies found only minor responses by fish to noise created during or following seismic surveys, such as a small decline in lesser sand eel (*Ammodytes marinus*) abundance that quickly returned to pre-seismic levels (Hassel et al. 2004) or no permanent changes in the behavior of marine reef fishes (Wardle et al. 2001). However, both Hassel et al. (2004) and Wardle et al. (2001) noted that when fish sensed the airgun firing, they performed a startle response and sometimes fled. Squid (*Sepioteuthis australis*) are an extremely important food chain component for many higher order marine predators, including fin and sperm whales. McCauley et al. (2000a) recorded caged squid responding to airgun signals. Given the generally low sound levels produced by HRG sources in comparison to airgun sources, no short-term effects on potential prey items (fishes, cephalopods, crustaceans) are expected from the proposed survey activities.

Minimal data are available for zooplankton (the primary prey for NARW) responses to anthropogenic sound. A 2022 study (Guihen et al. 2022) found a noted avoidance of Antarctic krill species to the presence of an autonomous glider carrying a single beam echosounder. However, these disturbances had small ranges (approximately 131 feet [40 meters]) and did not show a large-scale movement in krill. It is expected that although reactionary behavior to acoustic disturbance by zooplankton is likely, the localized and temporary nature of the movement would not cause significant loss in the availability of the species to marine mammals.

The effects on ESA-listed cetaceans due to reduction in prey items from underwater noise generated by the Project would be so small that they could not be measured, detected, or evaluated and are, therefore, **insignificant**. Therefore, effects from underwater noise sources due to the Proposed Action **may affect, not likely to adversely affect** prey organisms of ESA-listed marine mammals.

3.2.5.3 Habitat Disturbance Effects on Marine Mammals (C, O&M, D)

Habitat disturbance related to the Project would occur through all three phases of construction, O&M, and decommissioning. Individual stressors under habitat disturbance encompass displacement of marine mammal species, prey items, or both from physical disturbance of sediment; behavioral changes due to the presence of structures; changes in oceanographic and hydrological conditions due to presence of structures; conversion of soft-bottom habitat to hard-bottom habitat; and the changes in or concentration of prey species due to the reef effect.

3.2.5.3.1 Displacement from Physical Disturbance of Sediment (C, D)

In general, effects from disturbance and alteration of the seabed resulting from the Proposed Action would be limited to short-term, localized displacement of some ESA-listed marine mammal species in the Project area. Displacement would result from temporary turbidity or displacement of prey species due to disturbance of the seabed. Temporary disturbances of the seabed during construction could result from pre-lay grapnel runs for the inter-array and offshore export cables; Project vessel anchoring; installation of the WTG, OSS, and goal post foundations; installation of the inter-array and export cables; temporary cofferdams installed in the nearshore trenchless installation work area; and potential UXOs clearance and mitigation in the event that UXOs that are unable to be avoided through micrositing. Relocation of UXOs would involve non-detonation methods (Tetra Tech 2022a); therefore, potential disturbances from underwater explosions are not included under the Proposed Action. Based on the information provided in the COP, the total area of permanent and temporary seabed disturbance resulting from the project component footprints during construction is provided in Table 3-16.

Table 3-16 Estimated permanent and temporary seabed disturbance resulting from Project construction for the Proposed Action and likely scenario

Disturbance Type	Component	Proposed Action [a] (acres)	Proposed Action [a] (km^2)	Likely Scenario [b] (acres)	Likely Scenario [b] (km^2)
Permanent	WTG foundation with scour protection	191.9	0.78	103.8	0.42
	OSS piles	11.4	0.046	11.4	0.046
	Offshore export cable protection [c]	1.19	0.005	1.19	0.005
	Total Permanent	**204.5**	**0.83**	**116.4**	**0.47**
Temporary	Pre-lay grapnel run – inter-array cables	2,988.8	12.1	2,604.1	10.5
	Inter-array cables [d]	2,405.6	9.7	2,096.0	8.48
	Pre-lay grapnel run – offshore export cables	3,358.5	13.6	3,358.5	13.6
	Offshore export cables [d]	2,047.9	8.29	2,047.9	8.29
	UXO clearance and mitigation	1.58	0.01	1.58	0.01
	WTG work area	3,526.5	14.27	3,072.6	12.4
	Maximum construction footprint for OSS	3.16	0.013	3.16	0.013
	Maximum work area for nearshore trenchless installation	8.92	0.036	8.92	0.036
	Anchoring disturbance – nearshore and offshore construction activities	1,659.2	6.71	1,659.2	6.71
	Total Temporary[d]	**16,000.1**	**64.8**	**14,851.9**	**60.1**

Source: Dominion Energy 2022
OSS = offshore substation; WTG = wind turbine generator; UXO = unexploded ordinance.
[a] The Proposed Action = 202 WTGs and 3 OSSs
[b] The likely scenario = 176 WTGs and 3 OSSs is based on impacts per WTG and applied to 176 WTGs.
[c] No cable protection is expected for the inter-array cables.
[d] The total excludes the inter-array and offshore export cable acreage as they fall within the footprint of the pre-lay grapnel run disturbances indicated.

Based on information provided by Dominion (COP, Table 4.2-17; Dominion Energy 2022), an estimated 14,851.9 to 16,000.1 acres (60.1 to 64.8 km^2) would be temporarily disturbed during the Project construction (Table 3-16). Habitat disturbance effects to marine mammals during decommissioning would likely be similar to or less than those experienced during construction. Given that decommissioning techniques are expected to advance over the life of the Project, potential impacts would need to be evaluated at that time; however, effects on ESA-listed marine mammals are not expected to not be greater than those experienced during construction. Additionally, no sensitive resources, hard-bottom, or biogenic (sea grass beds, corals, shellfish reefs and beds, etc.) substrates were identified within the Lease Area and Offshore Export Cable Route corridor during COP-required benthic monitoring surveys (COP Appendix D; Dominion Energy 2022). Therefore, significant displacement of ESA-listed marine mammals or their prey items due to seabed disturbance is not expected during construction or decommissioning. Further, restoration of marine soft-sediment habitats occurs through a range of physical (e.g., currents, wave action) and biological (e.g., bioturbation, tube building) processes (Dernie et al. 2003). Disturbed areas not replaced with hardened structures or scour protection would, therefore, be resettled and the benthic community would be expected to return to normal conditions, typically within 1 year (Dernie et al. 2003; Department for Business, Enterprise and Regulatory Reform 2008).

Given the limited area affected and the lack of overlap with important benthic feeding habitats for ESA-listed marine mammals, and the temporary nature of the disturbance, effects from seabed disturbance during construction and decommissioning would be so small that they could not be measured, detected, or evaluated and are **insignificant.**

3.2.5.3.2 Effects of the Structure Presence on Marine Mammals (O&M)

The estimated permanent footprint of the Proposed Action is up to 204.5 acres (0.83 km^2; Table 3-16) and up to 116.4 acres (0.47 km^2; Table 3-16) for the likely scenario, both of which represent a very small portion of overall habitat available offshore of Virginia (Figure 1-1). The permanent Project footprint includes the WTG and OSS foundations and their associated scour protection, and the offshore export cable protection (Table 3-16). According to the NOAA Habitat Complexity Categories, all areas within the WTG and offshore substation work area are comprised of 100 percent softbottom habitat. Permanent new hard structure will cover up to The WTG and OSS foundations are vertical structures that constitute obstacles in the water column that could alter the normal behavior of marine mammals in the Project area during operations, whereas the cable protection would predominantly affect benthic prey species through the introduction of new hard-bottom habitat, as discussed in Section 3.2.5.3.4, *Effects of Changes in and Concentration of Prey Species due to the Reefing Effect of Structures (O&M, D)*. There are limited data on the potential effects directly associated with the presence of physical structures in the water column. Five turbines constituting Block Island Wind Farm and two pilot turbines for CVOW have not presented data with observable changes in marine mammal movement (NMFS 2021). Long (2017) compiled several years of observer data for marine mammal and bird interactions with tidal and wave energy testing facilities in Scotland. The study was unable to identify any changes in behavior or distribution associated with the presence of ocean energy structures once construction was complete, concluding that the available data were insufficient to determine the presence or absence of significant effects. Marine mammals, including baleen whales have been regularly sighted around offshore oil and gas platforms (Barkaszi and Kelly 2019; Delefosse et al. 2018; Todd et al.2020). Increased localize biomass, including Clupeids, have been documented for oil and gas installations operating at <28 feet (<100 meters) in the North Sea (Delefosse et al. 2018) which indicates a key prey item for fin and sei whales would not be negatively affected.

As provided in Table 1-1, WTGs are proposed to be laid out in an offset grid-like pattern with spacing of 0.75 to 0.93 nautical mile between turbines. The upper range of whale lengths are as follows: NARW (59 feet [18 meters]), fin whale (79 feet [24 meters]), sei whale (59 feet [18 meters]), and sperm whales

(59 feet [18 meters]). As noted in this BA, for reference, about 103, 59-feet long NARWs (large females) would fit end-to-end between two foundations spaced at 1 nautical mile. Based on a simple assessment of spacing, it does not appear that the WTGs would be a barrier to the movement of any ESA-listed marine mammal species through the area.

Insufficient empirical information is available to characterize precisely how the presence of WTG foundations in the water column would affect the behavior of whales, fish, and other organisms (Long 2017; Thompson et al. 2015). Operational noise from WTG structures is recognized as a potential stressor; however, it is difficult to separate out any behavioral reactions of marine mammal to the presence of WTGs during operations versus reactions to the underwater noise the structures may emit. Operational noise from WTGs is analyzed in Section 3.2.5.2.3.6, *WTG Operations (O&M)*; it is not discussed further in this section.

The spacing and size of the offshore wind structures are not expected to pose barriers to movement of ESA-listed marine mammals. Further, cetaceans are documented around similar offshore structures in other parts of the world. Based on the limited information available regarding whale activity, or changes in activity, resulting from the physical presence of offshore structures any effects would be considered **insignificant**.

3.2.5.3.3 Effects of Changes in Oceanographic and Hydrological Conditions due to Presence of Structures (O&M)

Offshore wind facilities have the potential to impact atmospheric and oceanographic processes through the presence of structures and the extraction of energy from the wind. There has been extensive research into characterizing and modeling atmospheric wakes created by wind turbines in order to design the layout of wind facilities and to understand hydrodynamic wake/turbulence related to predicting seabed scour. However, relatively few studies have analyzed hydrodynamic wakes coupled with the interaction of atmospheric wakes with the sea surface. Further, even fewer studies have analyzed wakes and their impact on regional scale oceanographic processes and potential secondary changes to primary production and ecosystems. Studies thus far in this topic have focused on ocean modeling rather than field measurement campaigns.

The general understanding of offshore wind related impacts on hydrodynamics is derived primarily from European based studies. A synthesis of European studies by van Berkel et al. (2020) summarized the potential effects of wind turbines on hydrodynamics, the wind field, and fisheries. Local to a wind facility, the range of potential impacts include increased turbulence downstream, remobilization of sediments, reduced flow inside wind farms, downstream changes in stratification, redistribution of water temperature, and changes in nutrient upwelling and primary productivity.

Human-made structures, especially tall vertical structures such as foundations, alter local water flow at a fine scale by potentially reducing wind-driven mixing of surface waters or increasing vertical mixing as water flows around the structure (Carpenter et al. 2016; Cazenave et al. 2016; Segtnan and Christakos 2015). When water flows around the structure, turbulence is introduced that influences local current speed and direction. Turbulent wakes have been observed and modeled at the kilometer scale (Cazenave et al. 2016; Vanhellemont and Ruddick 2014). While impacts on current speed and direction decrease rapidly around monopiles, there is a potential for hydrodynamic effects out to a kilometer from a monopile (Li et al. 2014). Direct observations of the influence of a monopile extended to at least 300 meters, however, was indistinguishable from natural variability in a subsequent year (Schultze et al. 2020). The range of observed changes in current speed and direction 300 to 1,000 meters from a monopile is likely related to local conditions, wind farm scale, and sensitivity of the analysis.

Several hydrodynamic processes have been identified to exhibit changes resulting from vertical structures:

1. Advection and Ekman transport are directly correlated with shear wind stress at the sea surface boundary. Vertical profiles from Christiansen et al. (2022) exhibit reduced mixing rates over the entire water column. As for the horizontal velocity, the deficits in mixing are more pronounced in deep waters than in well-mixed, shallow waters, which is likely favored by the influence of the bottom mixed layer in shallow depths. In both cases, the strongest deficits occur near the pycnocline depth.
2. Additional mixing downstream has been documented from Kármán vortices and turbulent wakes due to the pile structures of wind turbines (Carpenter et al. 2016; Grashorn and Stanev 2016; Schultze et al. 2020).
3. Up-dwelling and down-dwelling dipoles under contact of constant wind directions affecting average surface elevation of waters have been documented as the result of offshore wind farms (Broström 2008; Paskyabi and Fer 2012; Ludewig 2015). Mean surface variability is between 1 percent and 10 percent.
4. With sufficient salinity stratification, vertical flow of colder/saltier water to the surface occurs in lower sea surface level dipoles and warmer/less saline water travels to deeper waters in elevated sea surface heights (Ludewig 2015; Christiansen et al. 2022). This observation also suggested impacts on seasonal stratification, as documented in Christiansen et al. (2022). However, the magnitude of salinity and temperature changes with respect to vertical structures is small compared to the long-term and interannual variability of temperature and salinity.

The potential hydrodynamic effects previously identified from the presence of vertical structures in the water column affect nutrient cycling and could influence the distribution and abundance of fish and planktonic prey resources throughout O&M (van Berkel et al. 2020). Several studies have modeled and theorized potential impacts, but overall science is limited as to what environmental effects will accompany the hydrologic changes brought about by a large turbine installation at the proposed spacing in an environment such as the U.S. OCS. The anticipated hydrodynamic effects of structures are expected to be localized and not extend beyond a few hundred meters from the foundation (Miles et al. 2017; Schultze et al. 2020).

As discussed above, the presence of vertical structures in the water column could cause a variety of long-term hydrodynamic effects during O&M, which could impact prey species of ESA-listed whales. Increased mixing could impact seasonal stratification (Carpenter et al. 2016), which could affect prey presence or distribution. As aggregations of plankton are concentrated by physical and oceanographic features, increased mixing may disperse aggregations and may decrease efficient foraging opportunities. Potential effects of hydrodynamic changes in prey aggregations will primarily affect the NARW that feeds on plankton whose movement is largely controlled by water flow, as opposed to the sperm, fin and sei whale that feed predominately on fish and cephalopods. The analysis of benthic resources in the COP indicated the presence of the foundations is not likely to negatively affect regional abundances or dispersion of plankton species (COP, Section 4.2.4.3; Dominion Energy 2022). The offshore waters of Virginia are not primary feeding sites for NARWs and large aggregations of Calanas spp. copepods are not abundant in this area. Further, the degree of effect on planktonic prey species is expected to be limited to an area within a few hundred meters of individual turbines (Miles et al. 2017; Schultze et al. 2020). Therefore, the effects on ESA-listed species' prey availability resulting from changes in oceanographic and hydrological conditions due to presence of structures would be so small that they could not be meaningfully evaluated and are, therefore, insignificant.

3.2.5.3.4 Effects of Changes in and Concentration of Prey Species due to the Reefing Effect of Structures (O&M, D)

The reef effect is another habitat-related result of in-water structures, which may have long-term effects on marine mammal prey species during O&M and potentially after decommissioning. Russell et al. (2014) found clear evidence that seals were attracted to a European wind farm, apparently attracted by the abundant concentrations of prey created by the artificial reef effect. The artificial reef effect created by these structures forms biological hotspots that could support species range shifts and expansions and changes in biological community structure resulting from a changing climate (Raoux et al. 2017; Methratta and Dardick 2019; Degraer et al. 2020). There is no example of a large-scale offshore renewable energy project, or combination of projects, within the geographic analysis area for marine mammals to evaluate this potential. However, it is not expected that any reef effect from the Proposed Action would result in an increased abundance or aggregations of species preyed on by NARWs or sperm whales, but may increase prey abundance or aggregations of fish preyed upon by fin whales or sei whales. Fisheries studies conducted over 7 years at the Block Island Wind Farm showed a marked increase in black sea bass and Atlantic cod over the maturity of the foundation installation (Wilber et al. 2022). During the Block Island study, catches of schooling fishes such as herring, which would be more indicative of fin and sei whale prey effects, declined throughout the survey period; however these declines were also reflected regionally (outside of the wind farm) thus not attributable to foundation effects (Wilber et al. 2022). Further, fish that prey heavily upon herring (e.g., spiny dogfish), showed large peaks in abundance during some survey trawls indicating periodic, high prey availability (Wilber et al. 2022). Therefore, similar periodic peaks in prey for fin and sei whales could be expected, but not a consistent increase in fish prey species.

The NARW is primarily a pelagic filter feeder that does not rely directly on benthic habitats. Fin and sei whales commonly depredate on sand lance as well as schooling fish species on feeding grounds in the Gulf of Maine; primary feeding activity is the mid-Atlantic OCS is expected to be on pelagic schooling fishes such as Clupeids (i.e., herrings, menhaden) (Engelhaupt et al. 2019; Zoidis et al. 2021). Sperm whales are deep diving species feeding primarily on cephalopods in the water column and are, therefore, not expected to be affected by seabed disturbance associated with the Proposed Action.

The only forage fish species that is expected to be impacted by permanent habitat alterations (i.e., conversion from soft substrate to hard substrate) would be the sand lance. Permanent hard structure will cover up to 204.5 acres (0.83 km^2; Table 3-16) for the Proposed Action and up to 116.4 acres (0.47 km^2; Table 3-16) for the likely scenario, both of which represent a very small portion of overall habitat available offshore of Virginia (Figure 1-1). Sand lance was present in 6 percent of the towed video transects conducted for COP site assessment surveys and are, therefore, part of the prey base used by fin and sei whales. Sand lance are strongly associated with sandy substrate, and the Project may result in a loss of such soft bottom that theoretically could result in a localized reduction in the abundance of sand lance in the Project area. Even in a worst-case scenario assuming that the reduction in the abundance of sand lance in the Project area is directly proportional to the amount of soft substrate lost, it would be expected to be an unmeasurable reduction in the sand lance available as forage for fin and sei whales in the Project area since the baseline densities are not known.

Although the reef effect may aggregate fish species and potentially attract an increased number of opportunistic predators, they are not anticipated to have any measurable effect on ESA-listed marine mammals. Based on the available information, it is expected that there may be an increase in abundance of schooling fish that sei or fin whales may prey on but that this increase would likely be small and does not represent a measurable increase in prey abundance throughout the Project area. Therefore, the impact, if any, would be considered **insignificant** on ESA-listed marine mammals.

Any beneficial, yet not measurable, increase in aggregation of prey species of the fin and sei whale due to the reef effect would be removed following decommissioning.

3.2.5.3.5 Summary of Habitat Disturbance Effects

As described in Section 3.2.5.3.4, *Effects of Changes in and Concentration of Prey Species due to the Reefing Effect of Structures (O&M, D)*, any effects from habitat disturbance on marine mammals is expected to be **insignificant**. Therefore, the effects of habitat disturbance from Project structures in the Proposed Action **may affect, not likely to adversely affect** ESA-listed marine mammals**.**

3.2.5.4 Water Quality Effects on Marine Mammals (C, D)

The seabed within the Action Area comprises soft-bottom sediments characterized by fine sand punctuated by gravel and silt/sand mixes (Section 2.1.1.1, *Seabed Conditions*) so it is likely that increases in turbidity during construction and decommissioning may occur. Physical or lethal effects in increased turbidity during Project construction and decommissioning are unlikely to occur because marine mammals are air-breathing and highly mobile and, therefore, do not share the physiological sensitivities of susceptible organisms like fish and invertebrates. These effects on water quality for finer sediments are anticipated to be localized adjacent to the trench and temporary in nature.

The NMFS Atlantic Region has developed a policy statement on turbidity and TSS effects on ESA-listed species for the purpose of Section 7 consultation (Johnson 2018). The agency concluded that elevated TSS could result in effects on listed whale species under specific circumstances (e.g., high TSS levels over long periods during dredging operations), but insufficient information is available to make ESA effect determinations. In general, marine mammals are not subject to effects mechanisms that injure fish (e.g., gill clogging, smothering of eggs and larvae), so injury-level effects are unlikely. Behavioral effects, including avoidance or changes in behavior, increased stress, and temporary loss of foraging opportunity, could occur but only at excessive TSS levels (Johnson 2018). Todd et al. (2015) postulated that dredging and related turbidity effects could affect the prey base for marine mammals, but the significance of those effects would be highly dependent on site-specific factors. Small-scale changes from one-time, localized activities are not likely to have significant effects.

Data are not available regarding whales' avoidance of localized turbidity plumes; however, Todd et al. (2015) suggest that since marine mammals often live in turbid waters, significant effects from turbidity are not likely. If elevated turbidity caused any behavioral responses such as avoiding the turbidity zone or changes in foraging behavior, such behaviors would be temporary, and any negative effects would likewise be short-term and temporary. Cronin et al. (2017) suggest that NARWs may use vision to find copepod aggregations, particularly if they locate prey concentrations by looking upwards. However, Fasick et al. (2017) indicate that NARWs must rely on other sensory systems (e.g., vibrissae on the snout) to detect dense patches of prey in very dim light (at depths greater than 525 feet [160 meters] or at night). These studies indicate that whales, including NARWs, are likely able to forage in low-visibility conditions, and thus could continue to feed in the elevated turbidity. If turbidity from cable installation caused foraging whales to leave the area, there would be an energetic cost of swimming out of the turbid area. However, whales could resume foraging behavior once they were outside of the turbidity zone; any associated small-scale behavioral changes are expected to be temporary in nature and not likely to have significant biological effects.

Increased turbidity effects could affect the prey species of marine mammals, both in offshore and inshore environments. Studies of the effects of turbid water on fish suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute reaction is expected (Wilber and Clark 2001). However, as mentioned previously, sedimentation effects will be temporary and localized with regions returning to previous levels soon after the activity. In addition, there would be increased vessel anchoring during the construction of offshore components of the proposed Project. Anchoring would cause increased turbidity levels but it is expected to have discountable effects because the affected areas would be localized and would have short-term, minor effects on turbidity levels during construction. Any changes to marine mammals or their prey resulting from increases turbidity during Project construction and decommissioning would be so small they could not be meaningfully measured and, therefore, **insignificant**.

During construction of the proposed Project, Project vessels could generate exhaust and could be a source of potential accidental spills of petroleum-based toxics. Marine mammals that occur in the analysis area could be exposed to these contaminants. Inhalation of fumes from oil spills can result in mortality or sublethal effects on individual fitness, including adrenal effects, hematological effects, liver effects, lung disease, poor body condition, skin lesions, and several other health effects (Kellar et al. 2017; Mazet et al. 2001; Mohr et al. 2008; Smith et al. 2017; Sullivan et al. 2019; Takeshita et al. 2017). Additionally, accidental releases may result in impacts on marine mammals due to effects on prey species. However, the likely number of additional releases associated with future offshore wind development would fall within the range of accidental releases that already occur on an ongoing basis from non-offshore wind activities. Although these effects are acknowledged, the likelihood of adverse population-level impacts on marine mammals from accidental releases of debris or contaminants from future activities on the OCS is low.

Additionally, all Project vessels would comply with USCG requirements for the prevention and control of oil and fuel spills and would implement proposed best management practices (BMPs) for waste management and mitigation as well as marine debris awareness training for Project personnel, reducing the likelihood of an accidental release. Dominion Energy will have an Oil Spill Response Plan (COP, Appendix Q; Dominion Energy 2022) in place that would decrease potential effects in the unlikely event of a spill. Therefore, releases of contaminants from Project vessels at levels that could affect marine mammals are unlikely and, therefore, **discountable**.

Therefore, water quality effects resulting from activities under the Proposed Action **may affect, not likely to adversely affect** ESA-listed marine mammals potentially present within the Action Area.

3.2.5.5 Secondary Entanglement due to Increased and Altered Fishing Activity Caused by the Presence of Structures (O&M)

Offshore structures and the anticipated reef effect have the potential to lead to increased recreational fishing within the lease areas and result in an increased risk of interaction with fishing gear that may lead to entanglement, ingestion, injury, and death (Moore and van der Hoop 2012). The reef effect may result in drawing in recreational fishing effort from inshore areas, and overall interaction between marine mammals and fisheries could increase if marine mammals are also drawn to the Lease Areas due to increased prey abundance. Larger fishing vessels with small mesh bottom-trawl gear and mid-water trawl gear may be more likely to be displaced from the Lease Area compared to smaller fishing vessels with similar gear types that may be easier to maneuver. In addition, some potential exists for a shift in gear types from fixed to mobile, or from mobile to fixed gear, due to displacement from the Lease Area. The potential impact on marine mammals from these changes is uncertain. However, if a shift from mobile gear to fixed gear occurs due to inability of the fishermen to maneuver mobile gear, there would be a potential increase in the number of vertical lines, resulting in an increased risk of marine mammal interactions with fishing gear. Additionally, abandoned or lost fishing gear (commercial and recreational) may become entwined within foundation structures and pose a hazard to marine mammals.

Entanglement in fishing gear has been identified as one of the leading causes of mortality in NARWs and may be a limiting factor in the species' recovery (Knowlton et al. 2012). Over 80 percent of individual NARWs show evidence of at least one entanglement in fishing gear (Knowlton et al. 2012). Additionally, recent literature indicates that the proportion of NARW mortality attributed to fishing gear entanglement is likely higher than previously estimated from recovered carcasses (Pace 2021). Entanglement may also be responsible for high mortality rates in other large whale species, including fin whales (Henry et al.

2020; Read et al. 2006).

The following monitoring and mitigation measure (Table 1-8) will act to reduce potential impacts on marine mammals resulting from lost or discarded fishing gear that accumulates around WTG foundations:

- Dominion Energy must monitor indirect effects associated with charter and recreational fishing gear lost from expected increases in fishing around WTG foundations by surveying at least 10 of the WTGs located closest to shore in the Lease Area annually. Survey design and effort may be modified with review and concurrence by Department of Interior. Dominion Energy may conduct surveys by remotely operated vehicles, divers, or other means to determine the frequency and locations of marine debris. Dominion Energy must report the results of the surveys to BOEM and BSEE in an annual report for the preceding calendar year. Annual reports must include survey reports that include: the survey date; contact information of the operator; the location and pile identification number; photographic, video documentation, or both of the survey and debris encountered; any animals sighted; and the disposition of any located debris (i.e., removed or left in place). Annual reports must also include claim data attributable to the Project from Dominion Energy corporate gear loss compensation policy and procedures. Required data and reports may be archived, analyzed, published, and disseminated by BOEM.

The implementation of the BOEM-proposed monitoring surveys would provide data regarding the presence of gear on structures that will help assess the secondary entanglement risk. Through this monitoring, removal actions could be taken if entanglement risk appears high, thus, reducing likelihood of any marine mammals becoming entangled. Currently, published data do not exist on the amount or type of debris that accumulates on offshore wind foundations in the U.S. Atlantic; therefore, the scale of entanglement risk is not known. The monitoring and disposition requirement provides BOEM with the ability to require removal of entanglement hazards should they occur.

Secondary entanglement of ESA-listed whale species would be unlikely as contact with or presence in close proximity to the foundations are not expected. Unlike other marine mammals such as porpoise, dolphins, and seals, the ESA-listed whales are not expected to opportunistically forage on the foundations where contact with fishing gear caught on foundations would occur. The likelihood of ESA-listed whale entanglement occurring specifically with gear entrained on foundations is so low as to be **discountable**. Therefore, the effects of secondary entanglement due to altered fishing activity caused by the presence of structures **may affect, not likely to adversely affect** ESA-listed marine mammals**.**

3.2.5.6 Vessel Traffic Effects on Marine Mammals (C, O&M, D)

Project vessels working during all phases of the Proposed Action pose a potential collision risk to marine mammals. Additionally, the noise and disturbance generated by vessel presence may temporarily displace individual marine mammals from preferred habitats. HRG survey vessels would be limited to siting surveys and biological survey vessels with periodic activity on the wind farm and export cable routes. Vessel activity is anticipated to be highest during Project construction, followed by decommissioning. The number of vessels operating during O&M will be comparatively lower than during construction but will be long-term throughout the operational lifespan of the Project.

Vessel-animal collisions are a measurable source of mortality and injury for many marine mammal species (Laist et al. 2001; Vanderlaan and Taggart 2007; Martin et al. 2016; Hayes et al. 2022), indicating the importance of protective measures to minimize risks to vulnerable species. Vessel strikes are of particular concern for mysticetes due to their size, relatively slow maneuverability, proportion of time spent at the surface between dives, lack of clear and consistent avoidance behavior, and their relatively low detectability by vessels without focused observation efforts and (Garrison et al. 2022; Gende et al. 2011; Rockwood et al 2017; Martin et al 2016). Vessel strikes are relatively common for cetaceans

(Kraus et al. 2005) and are a known or suspected contributor to three active unusual mortality events in the Atlantic Ocean for cetaceans (humpback whale, minke whale, and NARW).

If a vessel strike does occur, the impact on marine mammals would range from minor injury to mortality of an individual, depending on the species and severity of the strike. Injuries are typically the result of one of two mechanisms: either blunt force trauma from impact with the vessel, or lacerations from contact with the propellers (Wiley et al. 2016). Depending on the severity of the strike and the injuries inflicted, the animal may or may not recover (Wiley et al. 2016). The size of the vessel and animal, speed of the vessel, and the orientation of the marine mammal with respect to vessel trajectory will all affect the severity of the injury (Vanderlaan and Taggart 2007; Martin et al. 2016).

The ability for vessel operators to detect a marine mammal within the path of the moving vessel can reduce vessel strike risk and is dependent on a variety of factors, including atmospheric/visibility conditions, observer training and experience, and vessel size and speed. Vessel speed is inversely correlated with detection rates, such that slower transit speeds, especially those below 9.7 knots (5.0 m/s), generally lead to a higher in-time detection rates for most vessel sizes provided adequate (3,281 feet [>1,000 meters]) reliable detection ranges (Baille and Zitterbart 2022).

Almost all sizes and classes of vessels have been involved in collisions with marine mammals around the world, including large container ships, ferries, cruise ships, military vessels, recreational vessels, commercial fishing boats, whale-watch vessels, research vessels and even jet skis (Dolman et al. 2006; Winkler et al. 2020).

Primary factors that affect the probability of a marine mammal-vessel strike include:

- Density, distribution, species, age, size, speed, health, and behavior of animal(s) (Vanderlaan and Taggart 2007; Martin et al. 2016);
- Number, speed, and size of vessel(s) (Vanderlaan and Taggart 2007; Martin et al. 2016);
- Vessel path (Vanderlaan and Taggart 2007; Martin et al. 2016);
- Operator’s ability to detect and avoid collisions (Martin et al. 2016; Williams et al. 2016); and
- Animal’s ability to detect an approaching vessel and propensity to avoid collisions (Gende et al. 2019; McKenna et al. 2015; Nowacek et al. 2004).

A marine mammal’s ability to detect and actively avoid a vessel collision is poorly understood. An individual’s aversion to an approaching vessel is likely dependent on the age and behavioral state of the animal and will differ among species (Gende et al. 2019; McKenna et al. 2015; Nowacek et al. 2004). Auditory recognition of a vessel by a marine mammal such that timely avoidance is triggered is likely highly variable and highly contextual. The following factors can impair the ability of a marine mammal to detect and locate the sound of an approaching vessel:

- Attenuation of low frequency vessel sound near the surface (i.e., Lloyd mirror effect);
- Decreased propeller sound at the bow as a vessel’s length increases (i.e., spreading loss);
- Impedance of forward-projecting propeller sound due to hull shape and relative placement of keel (above-keel propeller location resulting in acoustic shadowing); and
- Ambient (background) sound interfering with the sound of an approaching vessel (i.e., acoustic masking).

Vessel speed and size are two of the most important factors for determining the probability and severity of vessel strikes. The size and bulk of the large vessels inhibits the ability for crew to detect and react to marine mammals along the vessel’s transit route. In 93 percent of marine mammal collisions with large vessels reported in Laist et al. (2001), whales were either not seen beforehand, or were seen too late to be avoided. Laist et al. (2001) reported that the most lethal or severe injuries are caused by ships 262 feet (80 meters) or longer traveling at speeds greater than 13 knots (6.7 m/s). An analysis conducted by Conn and Silber (2013) built upon collision data collected by Vanderlaan and Taggart (2007) and Pace and Silber (2005) and included new observations of serious injury to marine mammals as a result of vessel strikes at lower speeds (e.g., 2 and 5.5 knots [1.0 and 2.8 m/s]). The relationship between lethality and strike speed was still evident; however, the speeds at which 50 percent probability of lethality occurred was approximately 9 knots (4.6 m/s). Smaller vessels have also been involved in marine mammal collisions. Minke, humpback, and fin whales have been killed or fatally wounded by whale-watching vessels around the world (Jensen and Silber 2003). Strikes have occurred when whale watching boats were actively watching whales as well as when they were transiting through an area, with the majority of reported incidences occurring during active whale watching activities (Laist et al. 2001 and Jensen and Silber 2004).

The construction vessels that would be used for Project construction are described in Table 1-6 of this BA as well as Section 3.4.1.5 and Table 3.4-5 in the COP (Dominion Energy 2022). Typical large construction vessels used in this type of construction have estimated lengths of up to 528 feet (160.9 meters) (COP, Section 3.4.1.5, Dominion Energy 2022). Based on information provided in the COP, construction activities (including offshore installation of WTGs, OSSs, array cables, interconnection cable, and export cable) would require up to 73 construction vessels (Table 1-5), transiting between the various ports and the Project area on a variety of schedules depending on the phase of construction. Average operating speeds for the main construction vessels are expected to be less than 12 knots. Support vessels; however, may travel at up to 24 knots during construction activities if not restricted by vessel speed rules. Vessel transits under the Proposed Action would average 46 trips per day through the duration of construction activities; daily estimated vessel trips would be dependent on the construction period and activity and range from a minimum of 3 trips per day to a maximum of 95 trips per day. Vessel transits under the likely scenario may be reduced overall by 15 percent, though daily estimated vessel trips would still likely range from a minimum of 3 trips per day to a maximum of 95 trips per day. As a result, this BA considers the maximum construction scenario (i.e., the Proposed Action) in the assessment of effects due to vessel traffic. While not directly comparable based on the limitations of AIS data, the average of 46 Project vessel trips per day would represent an approximately 79 percent increase over the current number of unique vessels operating in the Project area, though actual baseline vessel transits are likely considerably underrepresented in the data (see Section 2.1.3.2, *Vessel Traffic*, for a discussion of baseline data limitations). Decommissioning vessel activities are expected to be comparable or less than those anticipated for construction.

Detailed O&M vessel activity is not yet outlined in the COP; however, the main vessel transits will be conducted by CTVs and SOVs. There is some potential for development and use of Surface Effects Ships but no use of Surface Effects Ships for the Proposed Action has been indicated at this time and are therefore, not considered in this analysis. SOVs are large (>230 feet [70 meters] length), DP vessels that have multiple on-site work capabilities including station keeping for weeks at a time. Average operating speeds for the SOVs are expected to be similar to that for construction vessels, or less than 12 knots. CTVs are usually aluminum catamarans 65 to 98 feet (20 to 30 meters) in length with transit speeds of 15 to 25 knots with some having top speeds of 35 knots (ABS 2021). For vessel strike risk analysis in this BA, Dominion Energy has estimated that Project operations would involve approximately 75 annual round trips for each of the two crew transfer vessels and 26 annual round trips for the single service operations vessel. In total, and accounting for other vessel transits for routine surveys (25 annual round trips) and the SOV daughter craft (26 annual round trips), an estimated 253 annual roundtrips are expected, with the majority originating from the Norfolk, Virginia O&M facility (COP Appendix N; Dominion Energy 2022). This equates to a 1.2 percent increase over baseline vessel activity (see Section 2.1.3.2, *Vessel Traffic*, for a discussion of baseline data limitations). This 253 annual round trip estimate is based on current information provided by the Applicant. Additionally, there is not likely to be a reduction in vessel activity during O&M under the likely scenario as compared to the Proposed Action given the relatively small number of annual round trips.

ESA-listed marine mammal densities are relatively low for the Lease Area and export cable route (Tetra Tech 2022b):

- Fin whale density estimates have a high of 0.00069 animals per km^2 in the spring and a low of 0.00019 animals per km^2 in the fall. (Equates to <1 fin whale expected within the 456 km^2 Lease Area during any season);
- NARW whale density estimates have a high of 0.00015 animal per km^2 in spring and a low of 0.00004 animal per km^2 in summer. (Equates to <1 NARW expected whale within the 456 km^2 Lease Area during any season);
- Sei whale density estimates have a high of 0.00021 animals per km^2 in spring and a low of 0.00001 animals per km^2 in summer. (Equates to <1 Sei whale expected within the 456 km^2 Lease Area during any season); and
- Sperm whale density estimates have a high of 0.00003 animals per km^2 in spring and a low of 0.00000 animals per km^2 in summer. (Equates to <1 sperm whale expected within the 456 km^2 Lease Area during any season).

Dominion Energy has committed to a range of mitigation and monitoring measures and established a Vessel Strike Avoidance Plan to minimize the potential for vessel collisions and impacts to marine mammals (Table 1-7). A final Vessel Strike Avoidance Plan will be submitted to NMFS and BOEM at least 90 days prior to commencement of vessels used for any project construction activities. Under the Proposed Action, these vessel strike avoidance measures were included in the effects analysis and are detailed in Table 1-7 and 1-8. The measures include:

- Training and common operating picture awareness:
    - CVOW-C Monitoring and Coordination Center will establish and maintain a Common Operating Procedure detailing the monitoring, project communication and external reporting requirements associated with marine mammal and sea turtle detections
    - Minimum of daily monitoring of sighting communication tools such as Mysticetus, Whale Alert, WhaleMap, WhaleAlert during project construction, operation and maintenance activities
    - Regular monitoring of the USCG Very High Frequency Channel 16 to receive notifications of NARW speed restriction zones
    - Monitoring of any real-time acoustic networks
    - Process for reporting sightings to appropriate external parties and regulatory agencies
    - Vessel operators and crews shall receive protected species identification training. This training will cover sightings of marine mammals and other protected species known to occur or that have the potential to occur in the Project area. It will include training on making observations in both good weather conditions (i.e., clear visibility, low wind, low sea state) and bad weather conditions (i.e., fog, high winds, high sea states, in glare). Training will include not only identification skills but information and resources available regarding applicable federal laws and regulations for protected species. It will also cover any critical habitat requirements, migratory routes, expected seasonal variation patterns, behavior identification, etc. and will outline reporting procedures.
- Speed restrictions:
    - All vessels will comply with NMFS regulations and speed restrictions and state regulations as applicable for NARW.
    - All Project-related vessels will comply with 10 knot speed restrictions in any SMA, Dynamic

Management Area (DMA), or Slow Zone.

- All Project-related vessels will reduce vessel speed to 10 knots or less when mother/calf pairs, pods, or larger assemblages of whales are observed near an underway vessel.

As per BOEM-Proposed measures (Table 1-8), all vessels regardless of size operating from **November 1 through April 30** will operate at speeds of 10 knots or less when transiting from port to port within the Lease Area and export cable route, or within the boundaries of any DMA, slow zone, or SMA.

- Dedicated lookouts:
  - All vessels will employ a dedicated lookout during all operations
- Vessel separation
  - Vessels will maintain, to the extent practicable, separation distances of >1,640 feet (500 meters) from any sighted ESA-listed whale, including the NARW or unidentified large whale; >328 feet (100 meters) from sperm whales and non-ESA listed baleen whales; and >164 feet (50 meters) for dolphins, porpoises, seals, and sea turtles.
  - All attempts shall be made to remain parallel to the animal's course when a traveling marine mammal is sighted in proximity to the vessel in transit. All attempts shall be made to reduce any abrupt changes in vessel direction until the marine mammal has moved beyond its associated separation distance.
  - If an animal or group of animals is sighted in the vessel's path or in proximity to it, or if the animals are behaving in an unpredictable manner, all attempts shall be made to divert away from the animals or, if unable due to restricted movements, reduce speed and shift gears into neutral until the animal(s) has moved beyond the associated separation distance (except for voluntary bow riding dolphin species).

There is a moderate risk of interaction between marine mammals and Project vessel traffic during construction based on the density of marine mammals in the Action Area and the estimated vessel activity over the total construction period (see Section 1.3.1, *Construction and Installation*). The primary vessels used for Project O&M have overall shallower drafts than construction vessels, which reduces the three-dimensional ship strike risk zone for subsurface individuals, but operate at higher speeds, which is correlated with an increased ship strike risk to marine mammals. Based on the density of marine mammals in the Action Area and the estimated activity over the operational life of the Project, there is a low to moderate risk of vessel interaction with marine mammals in the Action Area during O&M. An estimated 78 round trips per year is expected throughout the duration of the Project's anticipated 33-year operational period which is a nominal increase in existing vessel traffic.

The contribution of the number of vessel trips under the proposed Project would be moderate during construction and relatively small during O&M compared to existing vessel activity (see Section 2.1.3.2, *Vessel Traffic*). The baseline encounter rate for vessels and animals to be within a strike risk with one another is already low. The common operating picture that raises project awareness to the presence of marine mammals, and NARWs in particular, combined with the mitigation measures (Table 1-7 and Table 1-8; COP approval conditions) would minimize encounters that have a high risk of resulting in collision or injury by reducing both the encounter potential (e.g., separation distances, seasonal restrictions, avoidance of aggregations) and severity potential (e.g., speed reduction, vessel positioning parallel to animals). However, ultimate reduction in strike/injury risk relies on the ability for a responsive action to be taken if there is an encounter with a marine mammal. The deployment of trained lookouts on all vessels along with operable and effective monitoring equipment, including equipment specialized for low-light conditions in order to effectively monitor at night, will serve to minimize the collision and injury risk of any encounters that may occur.

The risk of vessel strike cannot be fully eliminated due to the unpredictable nature of animal-vessel interactions, even with dedicated observers. However, vessel strike risk, and importantly, injury resulting from vessel strikes, can be significantly reduced to a negligible level by adhering to the guidelines and proposed mitigation measures outlined in the vessel strike avoidance measures in Table 1-7 and Table 1-8. Therefore, vessel strikes are not anticipated when monitoring and mitigation activities are effectively implemented, as outlined; and trained, dedicated lookouts are used on all vessels. With full implementation of mitigation measures, the potential for injury-causing vessel strikes to ESA-listed marine mammals is unlikely and **discountable**.

An additional potential effect of vessel traffic on marine mammals or their prey is spills from refueling or vessel-to-vessel/vessel-to-structure collisions. Effects on individual marine mammals, including decreased fitness, health effects, and mortality, may occur if individuals are present in the vicinity of a spill, but accidental releases are expected to be rare, and injury or mortality are not expected to occur. Project vessels would comply with USCG requirements for the prevention and control of oil and fuel spills and would implement proposed BMPs for waste management and mitigation as well as marine debris awareness training for Project personnel, reducing the likelihood of an accidental release. Dominion Energy will have an Oil Spill Response Plan (COP, Appendix Q; Dominion Energy 2022) in place that would decrease potential effects in the unlikely event of a spill. Therefore, vessel spills are not anticipated and distribution of spills into the surrounding environment where damage may occur to animals or habitat is not anticipated when monitoring and mitigation activities are effectively implemented, as outlined. Thus, vessel accidents and spills will have an **insignificant** effect on ESA-listed marine mammals.

The effects of vessel traffic during Project activities **may affect, not likely to adversely affect** ESA-listed marine mammals.

3.2.5.7 Fisheries Monitoring Survey Effects on Marine Mammals (C)

Fisheries monitoring surveys for the Project are proposed during the construction phase. To fulfill the COP requirements, fisheries monitoring would be conducted prior to starting construction activities. The details of each survey type are provided in Section 1.3.4, *Fisheries Monitoring Plans*. Many of the potential impacts to ESA-listed marine mammal species arising from fisheries monitoring surveys are related to entanglement risk, increased vessel traffic, and increased for potential for vessel strikes. Increased vessel traffic and potential for vessel strike stressors are discussed in Section 3.2.5.6, *Vessel Traffic Effects on Marine Mammals (C, O&M, D)*, and are not addressed further in this assessment. Effects of survey methods include habitat disturbance during pot setting, potential for entrapment, or entanglement in monitoring gear.

Impacts to ESA-listed marine mammals specific to each survey type and equipment are described in Section 3.2.5.7.1, *Welk Surveys* and 3.2.5.7.2, *Black Sea Bass Surveys*.

3.2.5.7.1 Welk Surveys

The Welk surveys have been designed while actively working with the VADEQ, VMR), VIMS, Rutgers University, and commercial fishers.

Welk pots and the associated lines and rigging, have the potential to cause adverse impacts on marine mammals resulting in entanglement in lines and floats. The design of the pot and line layout has been modified to reduce the number of vertical lines by deploying the strings of multiple pots along the seafloor connected by groundlines to reduce the potential of entanglement by marine mammals. In addition, the buoy lines will have whale releases (weak link/swivel) and colored markings (yellow and black markings) which is assumed to allow whales to break free from the ropes and avoid life-threatening entanglement (NOAA 2021a). The sampling protocols will be constructed consistent with specifications that align with the current industry practices (i.e., pot material, volume, bait type, soak time). The monitoring efforts will occur seasonally twice a month during times of traditionally high fishing activity (November to March) and once a month during times of traditionally low fishing activity (April to October).

Dominion Energy's proposed monitoring contractor, VIMS has submitted a fisheries permit application to NOAA Greater Atlantic Regional Fisheries Office (GARFO) and a request for a protected species risk assessment in October 2022 and received a letter of acknowledgement but to date has not received further feedback. However, a similar survey method is being proposed for black sea bass monitoring (Section 3.2.5.7.2, *Black Sea Bass Surveys*) and GARFO's Protected Resources Division (PRD) determined that the plan as designed does not include any activities that are likely to result in a take of a protected marine species. A similar determination is expected for the Welk monitoring plan. Therefore, the potential for entanglement of ESA-listed marine mammals based upon the limited number of associated buoy lines and the implementation of NOAA-required risk reduction measures the entanglement in gear would be extremely unlikely to occur and is **discountable**.

3.2.5.7.2 Black Sea Bass Surveys

Black sea bass pots and the associated lines and rigging, have the potential to cause adverse impacts on marine mammals resulting in entanglement in lines and floats. The typical design of the pot and line layout has been modified by instead of using a vertical line with buoy for gear marking the section of rope between the anchor and the first pot in the string will consist of an elongated section of sinking ground line and use yellow and black markings scheme on the top 12 feet of the rope to reduce the potential of entanglement by marine mammals. Pots will be constructed so as to be consistent with regional efforts with respect to design elements of the gear (i.e., trap material, volume, entrance funnels, escape vent configuration). It is anticipated to construct eight strings of six pots for deployment. The monitoring efforts will occur following current fishery practices with samples obtained every 12 to 14 days during times of traditionally high fishing effort (October to early January; late March to December). During times of lower traditional effort (winter months), the gear will be hauled.

Dominion Energy's proposed monitoring contractor, VIMS has submitted a fisheries permit application to NOAA GARFO and a request for a protected species risk assessment in August 2022 and received a letter of acknowledgement in September 2022 and received confirmation from GARFO's PRD that the plan as designed does not include any activities that are likely to result in a take of a protected marine species. Therefore, the potential for entanglement of ESA-listed marine mammals based upon the limited number of associated buoy lines and the implementation of NOAA-required risk reduction measures the entanglement in gear would be extremely unlikely to occur and is **discountable**.

3.2.5.7.3 Atlantic Surf Clam Surveys

The proposed dredging activities for the Atlantic survey clam surveys have the potential to cause adverse impacts on marine mammals resulting primarily in turbidity and vessel strike. The limited extent of the dredging activities for the Atlantic clam surveys minimize the risk for marine mammals in the Project area. ESA-listed marine mammals in the Project area are not expected to face a risk of entrainment, impingement, or capture in dredging equipment associated with the Proposed Action due to their relatively large body sizes. Additionally, as discussed in Section 3.2.5.4, effects of turbidity on marine mammals or their prey would be limited to small-scale behavioral changes are expected to be temporary in nature and not likely to have significant biological effects. Through the implementation of standard vessel strike avoidance mitigation measures that require minimum separation distances form all ESA-listed marine mammals (Section 1.3.5), the risk of vessel strikes can also be effectively mitigated. The likelihood of potential effects on ESA-listed marine mammals is further reduced by the short duration of these dredge surveys, as each dredge will sample the bottom for 5 minutes at a vessel speed of

1.5 knots, and the full survey is anticipated to occur over a maximum of 7 days in the late spring/early summer of 2023, and only medium-sized vessel will be used (Section 1.3.4.3).

Dominion Energy's proposed monitoring contractor, VIMS has submitted a fisheries permit application to NOAA GARFO and a request for a protected species risk assessment in August 2022 and received a letter of acknowledgement in September 2022 and received confirmation from GARFO's PRD that the plan as designed does not include any activities that are likely to result in a take of a protected marine species. Therefore, the potential risk of effect on ESA-listed marine mammals based upon the limited duration of dredging activities and the implementation of NOAA-required risk reduction measures vessel strikes would be extremely unlikely to occur and is **discountable.**

3.2.5.7.4 Summary of Fisheries Monitoring Survey Effects

As described in Section 3.2.5.7.1, *Welk Surveys*, Section 3.2.5.7.2, *Black Sea Bass Surveys*, and Section 3.2.5.7.3, *Atlantic Surf Clam Surveys,* any effects from monitoring surveys (e.g., entanglement, reductions in prey) on ESA-listed marine mammals are considered unlikely to occur. A number of monitoring and mitigation measures are designed to further minimize the risk of entanglement and monitor the potential effects of fisheries monitoring surveys (Table 1-8); these measures are summarized in Section 3.3.5.6.3, *Summary of Fisheries Monitoring Survey Effects,* for sea turtles and are likewise applicable to reducing impact on marine mammals. Effects from fisheries monitoring surveys on marine mammals are **discountable** or are expected to be so small that they cannot be meaningfully measured, evaluated, or detected and are, thus, **insignificant**. Therefore, the effects of monitoring surveys from the Project **may affect, not likely to adversely affect** ESA-listed marine mammals.

3.2.5.8 EMF Effects on Marine Mammals (O&M)

Normandeau Associates, Inc. (Normandeau 2011) reviewed available evidence on marine mammal sensitivity to human-created EMF in the scientific literature. Although the scientific evidence is generally limited, available studies suggest that baleen and toothed whales, including the ESA-listed species known or likely to occur in the Project area, are likely sensitive to magnetic fields based on the presence of magnetosensitive anatomical features and observed behavioral and physiological responses. Marine mammals are likely to orient to the earth's magnetic field for navigation, suggesting they may have the ability to detect induced magnetic fields from underwater electrical cables. Assuming a 50-mG sensitivity threshold (Normandeau 2011), marine mammals could theoretically be able to detect EMF effects from other, similar, inter-array and export cables, but only in close proximity to cable segments lying on the bed surface. Individual marine mammals would have to be within 3 feet (0.9 meter) or less of those cable segments to encounter EMF above the 50-mG detection threshold which is not likely to occur for durations of time that may affect an individual's ability to navigate or orient during migrations or other biologically necessary movements. Given the low field intensities involved and the limited extent of detectable effects relative to body size, swimming speed, dive durations, and overall movement patterns, EMF effects on marine mammals are likely to be **discountable**. Therefore, effects from potential increases in EMF due to Project cables operating under the Proposed Action **may affect, not likely to adversely affect** ESA-listed marine mammals in the Action Area.

3.3 Sea Turtles

Five species of sea turtles are known to occur in or near the Project area, all of which are protected under the ESA (16 USC 1531 et seq.): the leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle, Kemp's ridley sea turtle (*Lepidochelys kempii*), green sea turtle, and hawksbill sea turtle. The hawksbill sea turtle occurs in the Action Area but is rare in the immediate Project area and would only be encountered by vessels transiting in the Gulf of Mexico. Therefore, the hawksbill sea turtle is discounted from further analysis (see Section 2.3.8, *Hawksbill Sea Turtle – Endangered*). As discussed in Section 2.3.11, *Critical Habitat in the Gulf of Mexico*, the only critical habitat for sea turtles within the Action Area is the loggerhead Sargassum critical habitat in the Gulf of Mexico and southeast U.S.; and the loggerhead nearshore reproductive, breeding, and migratory critical habitat of south Florida. Both of these critical habitats would only encounter Project vessels transiting from ports in the Gulf of Mexico and any effects from the Proposed Action are discountable and not discussed further.

The combination of sightings, strandings, and bycatch data provide the best available information on sea turtle distribution in the Project area. This section includes species descriptions, status, and likelihood of occurrence in the Project area. Information about feeding habits and hearing ability that are relevant to this effects analysis is also included. Likelihood of occurrence is summarized from data for each of the four sea turtle species from the most current sightings surveys of Virginia waters (Palka et al. 2017, 2021; Engelhaupt et al. 2020, 2021), the NMFS Sea Turtle Stranding and Salvage Network (NMFS 2022c), and recent and historic population or density estimates from NMFS and the U.S. Navy, where available. Sea turtles are generally wide-ranging, slow to reach breeding maturity, and long-lived, making population estimates and impact analysis difficult because sea turtles will be affected by factors outside of the Project area (TEWG 2007, 2009; NMFS and USFWS 2013, 2015a,b).

Atlantic nesting sites for sea turtle species are concentrated in the southeast U.S. south of Virginia, although loggerhead, green, and Kemp's ridley sea turtles have been documented nesting in Virginia (USFWS 2005; Wright 2015; Parker 2020).

The suitability of Mid-Atlantic OCS sea turtle foraging habitats is shifting as a result of current trends in climate change. For example, pelagic foraging habitats for leatherback sea turtles in the North Atlantic are strongly associated with the 59°F (15°C) isotherm, which is shifting northward at a rate of approximately 124 miles (200 kilometers) per decade (McMahon and Hays 2006). Other sea turtle species are likely to shift their range in response to changing temperature conditions and changes in the distribution of preferred prey (Hawkes et al. 2009). Numerous fish and invertebrate species on the Mid-Atlantic OCS are currently undergoing or likely to undergo changes in abundance and distribution in response to climate change effects (Hare et al. 2016; Rogers et al. 2019). The implications of these range shifts are difficult to predict and will likely vary by species. Loggerhead sea turtles exhibit a high degree of dietary flexibility (Plotkin et al. 1993; Ruckdeschel and Shoop 1988; Seney and Musick 2007) and may more readily adapt to changes in ecosystem structure than dietary specialists like leatherbacks. Rare species like green sea turtles that are currently at the northern limit of their range could become more or less common in the Project area as summer temperature conditions become more or less favorable for submerged aquatic vegetation (SAV) forage sites.

Sea turtles will bask at the water surface on days with ample sun exposure when faced with cooling water temperatures (Sapsford and van der Riet 1979; Dodge et al. 2014; Freitas et al. 2018). Published data showed more surface basking behavior off Nova Scotia than in Massachusetts, inferring potentially more frequent or longer surface periods are associated with more northern or colder waters (Dodge et al. 2014). This suggests that while sea turtles may be more available for vessel strike in northern waters during cold conditions, this may not hold true for more temperate waters off Virginia. Lower water temperatures can result in cold stunning of turtles that causes them to become lethargic and float to the surface, which makes them more vulnerable to predators, vessel strikes, and strandings (NMFS 2022d,e,f,g).

Sea turtles in the Action Area are subject to a variety of ongoing human-caused effects, including collisions with vessels, entanglement with fishing gear, fisheries bycatch, dredging, anthropogenic noise, pollution, disturbance of marine and coastal environments, effects on benthic habitat, accidental fuel leaks or spills, waste discharge, and climate change. Sea turtle migrations can cover long distances, and these factors can have effects on individuals over broad geographical scales. Climate change has the potential to affect the distribution and abundance of prey due to changing water temperatures, ocean currents, and increased acidity. Illegal harvest of eggs and mature adults and incidental fisheries mortality remain significant threats, particularly outside the U.S.

3.3.1 Green Sea Turtle

Green sea turtles have a worldwide distribution and can be found in both tropical and subtropical waters (NMFS and USFWS 1991; NatureServe 2022). In the Western North Atlantic Ocean, they can be found from Massachusetts to Texas as well as in waters off Puerto Rico and the U.S. Virgin Islands (NMFS and USFWS 1991). Green sea turtles are divided into 11 DPSs with varying ESA statuses. Individuals found in Virginia are members of the North Atlantic DPS. Depending on the life stage, green sea turtles inhabit high-energy oceanic beaches, convergence zones in pelagic habitats, and benthic feeding grounds in shallow protected waters (NMFS and USFWS,1991). Green sea turtles are known to make long-distance migrations between their nesting and feeding grounds. Hatchlings occupy pelagic habitats and are omnivorous. Juvenile foraging habitats include coral reefs, emergent rocky bottoms, Sargassum spp. mats, lagoons, and bays (USFWS 2022a). Once mature, green sea turtles leave pelagic habitats and enter benthic foraging grounds, primarily feeding on seagrasses and algae (Bjorndal 1997), although they will occasionally feed on sponges and invertebrates (NMFS 2022d).

Major green sea turtle nesting beaches occur on Ascension Island, Aves Island, Costa Rica, and Suriname. In the U.S., green sea turtles nest in North Carolina, South Carolina, Georgia, Florida, the U.S. Virgin Islands, and Puerto Rico (USFWS 2022a). Nesting seasons vary by region. On average, individual females nest every 2 to 4 years, laying an average of 3.3 nests per season at approximately 13-day intervals. The average clutch size is approximately 136 eggs and incubation ranges from 45 to 75 days (USFWS 2022a).

Bartol and Ketten (2006) measured the auditory evoked potentials of two Atlantic green sea turtles and six sub adult Pacific green sea turtles. Sub-adults were found to respond to stimuli between 100 and 500 Hz, with a maximum sensitivity of 200 and 400 Hz. Juveniles responded to stimuli between 100 and 800 Hz, with a maximum sensitivity between 600 and 700 Hz. Piniak et al. (2016) found that the auditory evoked potentials of juvenile green sea turtles were between 50 and 1,600 Hz in water and 50 and 800 Hz in air, with ranges of maximum sensitivity between 50 and 400 Hz in water and 300 and 400 Hz in air.

3.3.1.1 Current Status

The North Atlantic DPS, which is likely to occur in the Project area, was listed as Threatened in 1978 (NMFS 2022d). The global population is listed as Endangered under the IUCN Red List (IUCN 2022). The species is also listed as Threatened by the VA DWR (2022). Worldwide, green sea turtle populations have declined due to past harvesting for eggs and meat (USFWS 2022a). Currently, major risks to green sea turtles include loss of nesting and foraging habitat, nest predation, marine pollution, vessel strikes, and anthropogenic activity such as offshore dredging or fishing (USFWS 2022a). There is no designated critical habitat for green sea turtles in the Project area.

3.3.1.2 Potential Habitat Surrounding and within the Project Area

In Virginia, green sea turtles occur from spring through fall and are least common during the winter; their presence peaks during summer months when juveniles reside in summer developmental foraging habitats (DoN 2007). Since 2010, with the exception of 2015, green sea turtles have typically averaged 11 strandings per year (Barco and Lockhart 2016; Swingle et al. 2016, 2017, 2018; Costidis et al. 2019). In 2015, a fall mortality event of unknown origin resulted in 69 green sea turtle strandings (Swingle et al. 2016). Strandings reflect higher occurrences of juveniles than of adults and typically begin occurring in July (Barco and Lockhart 2016; Swingle et al. 2016, 2017, 2018; Costidis et al. 2019). Data from the NMFS Sea Turtle Stranding and Salvage Network for Virginia between 2017 and 2022 show

148 strandings of green sea turtles, 53 of which were attributed to cold stunning; 7 attributed to incidental capture; and 88 attributed to traditional stranding causes; traditional stranding causes is defined as a situation where a dead, sick, or injured sea turtle is found washed ashore, floating, or underwater that is not attributable to an incidental capture, post hatchling, or cold-stunning (NMFS 2022c). Twenty-four of the strandings were found in Norfolk County, five in Portsmouth county, and 48 in Virginia Beach (NMFS 2022c), which overlap with the areas where the Project landing site and vessel ports will occur (Section 1.3, *Description of the Proposed Action*). The first green sea turtle nest in Virginia was documented in 2005 at the Back Bay National Wildlife Refuge (USFWS 2005) which is approximately 10 miles (16 kilometers) south of the proposed Cable Landing Location (Figure 1-4). In Virginia's waters, the relative occurrence of green sea turtles increases in spring on the OCS, peaks in summer, declines in fall, and is lowest during winter months according to biogeographic information data (Palka et al. 2021). Previous PSO surveys conducted within the Lease Area and export cable route corridor reported four sightings of green sea turtles in May, three in June and two in August of 2020 (COP Table 4.2-37; Dominion Energy 2022).

3.3.2 Leatherback Sea Turtle

The leatherback sea turtle is primarily a pelagic species and is distributed in temperate and tropical waters worldwide. The leatherback is the largest, deepest diving, most migratory, widest ranging, and most pelagic of the sea turtles (NMFS 2022e). Adult leatherback sea turtles forage in temperate and subpolar regions in all oceans. Satellite tagged adults reveal migratory patterns in the North Atlantic that can include a circumnavigation of the North Atlantic Ocean basin, following ocean currents that make up the North Atlantic gyre, and preferentially targeting warm-water mesoscale ocean features such as eddies and rings as favored foraging habitats (Hays et al. 2006). Soft-bodied animals such as jellyfish and salps are the major component of the leatherback diet; they are also known to feed on sea urchins, squid, crustaceans, tunicates, fish, blue-green algae, and floating seaweed (NMFS 2022e; USFWS 2022b).

Historically, the most important nesting ground for the leatherback was the Pacific coast of Mexico. However, because of exponential declines in leatherback nesting, French Guiana in the Western Atlantic now has the largest nesting population. Other important nesting sites for the leatherback include Papua New Guinea, Papua-Indonesia, and the Solomon Islands in the Western Pacific. In the U.S., nesting sites include the Florida east coast; Sandy Point, U.S. Virgin Islands; and Puerto Rico. U.S. nesting occurs from March through July. On average, individual females nest every 2 to 3 years, laying an average of 5 to 7 nests per season with an average clutch size of 70 to 80 eggs (USFWS 2022b).

Dow Piniak et al. (2012) found that hatchling leatherback sea turtles responded to auditory stimuli between 50 and 1,200 Hz in water and 50 and 1,600 Hz in air. The maximum sensitivity was between 100 and 400 Hz in water and 50 and 400 Hz in air.

3.3.2.1 Current Status

The leatherback sea turtle has been federally listed as Endangered under the ESA since 1970 and is considered Vulnerable by the IUCN Red List (IUCN 2022; NMFS 2022e). The species is also listed as Endangered by the VA DWR (2022). In 2017, NMFS received a petition to identify the Northwest Atlantic subpopulation as a DPS and list it as Threatened under the ESA. In response to this petition, NMFS initiated a status review for the leatherback sea turtle to include new data made available since the original listing (82 *FR* 57565). The status review was completed and NMFS concluded there was not sufficient evidence to designate any DPS for leatherback sea turtles. Threats to this population include fisheries bycatch, habitat loss, nest predation, and marine pollution (USFWS 2022b). While critical habitat for this species was designated in waters adjacent to Sandy Point Beach, U.S. Virgin Islands in 1979 (44 *FR* 17710), there is no designated critical habitat within the Project area.

3.3.2.2 Potential Habitat Surrounding and within the Project Area

In Virginia, leatherback presence peaks from May to July, although they occur in small numbers year-round (Barco and Lockhart 2016; Swingle et al. 2016, 2017, 2018; Costidis et al. 2019). They may occur in shelf waters or offshore waters just beyond the shelf break. Their annual strandings dropped to a record low of 0 in 2018, reversing a trend of increasing annual strandings since 2012 (Barco and Lockhart 2016; Swingle et al. 2016, 2017, 2018; Costidis et al. 2019). The relative occurrence of leatherback sea turtles remains consistent throughout the year on the OCS, with an increase in occurrence in waters just outside the Project area southeast of the Lease Area, based on biogeographic information data (Palka et al. 2021). Sightings data from the U.S. Navy's VACAPES Operating Area off Virginia Beach, Virginia showed three detections in 2019 and one detection in 2020 (Engelhaupt et al. 2020, 2021). Occurrence in the offshore export cable route corridor is relatively low compared to the Lease Area. Stranding data from NMFS reported 21 strandings of leatherback sea turtles between 2017 and 2022, 12 of which were reported as incidental capture and 9 attributed to traditional stranding causes (NMFS 2022c). Of those strandings that overlapped geographically with the Project area, only one stranding was reported in Norfolk, and 11 were reported in Virginia Beach county (NMFS 2022c). Previous PSO surveys conducted within the Lease Area and export cable route corridor reported 208 sightings of leatherback sea turtles during 8 months of surveys conducted between May and December of 2020, and 3 leatherback sea turtles between May and June of 202. No counts per unit of effort were provided in the COP (COP Table 4.2-37; Dominion Energy 2022).

3.3.3 Loggerhead Sea Turtle

Loggerhead sea turtles have a worldwide distribution and inhabit temperate and tropical waters, including estuaries and continental shelves of both hemispheres. Globally, loggerhead sea turtles are divided into nine DPSs with varying federal (ESA) statuses. Individuals found in Virginia are members of the Northwest Atlantic DPS.

Female loggerhead sea turtles in the western north Atlantic nest from late April through early September. Individual females might nest several times within one season and usually nest at intervals of every 2 to 3 years. For their first 7 to 12 years of life, loggerhead sea turtles inhabit pelagic waters near the North Atlantic Gyre and are called pelagic immatures. When loggerhead sea turtles reach 40 to 60 cm straight-line carapace length, they begin recruiting to coastal inshore and nearshore waters of the OCS through the U.S. Atlantic and Gulf of Mexico and are referred to as benthic immatures. Benthic immature loggerheads have been found in waters from Cape Cod, Massachusetts, to southern Texas. Most recent estimates indicate that the benthic immature stage ranges from ages 14 to 32 years; they reach sexual maturity at approximately 20 to 38 years of age. Loggerhead sea turtles are largely present year-round in waters south of North Carolina, but will forage during summer and fall as far north as the Northeastern U.S. and Canada and migrate south as water temperatures drop. Prey species for omnivorous juveniles include crab, mollusks, jellyfish, and vegetation at or near the surface. Coastal subadults and adults feed on benthic invertebrates, including mollusks and decapod crustaceans (TEWG 2009).

Based on Bartol et al. (1999), juvenile loggerhead sea turtles respond to auditory stimuli from tone bursts of 250 to 750 Hz. Martin et al. (2012) recorded the auditory evoked potentials of one adult loggerhead sea turtle, which responded to frequencies between 100 and 1,131 Hz, with greatest sensitivity between 200 and 400 Hz.

3.3.3.1 Current Status

The Northwest Atlantic Ocean DPS, which occurs in the Project area, was listed as Threatened in 2011 (NMFS 2022f). The global population is listed as Vulnerable by the IUCN Red List (IUCN 2022). The species is also listed as Threatened by the VA DWR (2022). Major threats to this population include loss of nesting and foraging habitat, nest predation, marine pollution, vessel strikes, disease, and fisheries bycatch (USFWS 2022c). In 2014, NMFS designated critical habitat for the Northwest Atlantic Ocean DPS in multiple locations along the U.S. East Coast and in the Gulf of Mexico. These areas include Sargassum. habitat in the Gulf of Mexico and Atlantic, and nearshore reproductive habitat, overwintering areas, breeding habitat, and migratory corridors located between North Carolina and Florida in the Atlantic Ocean (79 *FR* 39855). The designated critical habitat does not overlap with the immediate Project area. The closest critical habitat to the immediate Project area is migratory habitat located near the North Carolina-Virginia border.

3.3.3.2 Potential Habitat Surrounding and within the Project Area

Loggerheads are the most common sea turtle found in Virginia waters and pass through Virginia en route to summer foraging areas or overwintering grounds (Hawkes et al. 2007; Barco and Lockhart 2016; Swingle et al. 2016, 2017, 2018; Costidis et al. 2019). They begin appearing in mid-May when surface water temperatures approach 60°F (20°C) and nest regularly on Virginia's ocean-facing beaches, with an average of 5 to 15 nests observed annually (Barco and Swingle 2014). They have been recorded nesting in the Back Bay National Wildlife Refuge (approximately 10 miles [16 kilometers] south of the proposed cable landing location), Sandbridge Beach (approximately 8 miles [13 kilometers] south of the proposed cable landing location) and in Virginia Beach on the edge of the dunes leading to Camp Pendleton which is located at the beach just east of the proposed cable landing location (Figure 1-4) (USFWS 2001, Mansfield 2006; Parker 2020).

Juveniles use Virginia estuaries, bays, and sounds as developmental feeding habitat during summer months, and exhibit site fidelity, often returning to the same seasonal foraging areas in consecutive years (Barco and Swingle 2014). They typically leave Virginia waters when temperatures fall below 65°F (18°C), usually in October (Barco and Swingle 2014). Strandings have remained consistent in the past decade, with an average of between 125 and 165 annual strandings (Barco and Lockhart 2016; Swingle et al. 2016, 2017, 2018; Costidis et al. 2019). Data from the NMFS Sea Turtle Stranding and Salvage Network between 2017 and 2022 reported 845 strandings of loggerhead sea turtles over that 5-year period, 102 attributed to cold stunning, 62 attributed to incidental capture, five reported as post hatchling strandings, and the remaining 676 attributed to traditional stranding causes (NMFS 2022c). Strandings occurred in 15 different counties throughout Virginia, but of those that overlap with the Project area 98 were reported in Norfolk county, 5 in Portsmouth, and 292 in Virginia Beach county.

The relative occurrence of loggerhead sea turtles remains consistent throughout the year on the OCS, occurring along the entirety of the Lease Area and extending along the majority of the offshore export cable route corridor (Palka et al. 2021). Their presence shifts slightly inland during summer months. Sightings data from the U.S. Navy's VACAPES Operating Area off Virginia Beach, Virginia showed 15 detections in 2019 and six detections in 2020 (Engelhaupt et al. 2020, 2021). Previous PSO surveys conducted within the Lease Area and export cable route corridor reported 610 sightings of loggerhead sea turtles occurring in all months of surveying between April and December 2020, and 352 loggerhead sea turtles observed between April and August of 2021 (COP Table 4.2-37; Dominion Energy 2022).

3.3.4 Kemp's Ridley Sea Turtle

Kemp's ridley sea turtles occur off the coast of the Gulf of Mexico and along the U.S. Atlantic Coast (TEWG 2000). Juveniles inhabit the U.S. Atlantic Coast from Florida to the Canadian Maritime Provinces. In late fall, Atlantic juveniles/sub adults travel northward to forage in the coastal waters off Georgia through New England, then return southward for the winter (Stacy et al. 2013; New York State Department of Environmental Conservation 2022). Preferred habitats include sheltered areas along the coastline, such as estuaries, lagoons, and bays (NMFS 2022g). Kemp's ridley sea turtles are opportunistic foragers, feeding on decapod crustaceans, shellfish, and fish (NMFS 2022g). Sixty percent of Kemp's ridley nesting occurs on beaches near Rancho Nuevo, Tamaulipas, Mexico. The nesting season spans from April through July (NMFS and USFWS 2007). On average, individual females nest every 1 to 2 years, with an average of 1 to 3 clutches every season and an average clutch size of 110 eggs per nest (NMFS and USFWS 2007).

Data are limited on Kemp's ridley hearing capability; however, available studies show that this species can likely detect lower frequency noises below approximately 1 to 2 kHz (Bartol and Ketten 2006; Martin et al. 2012; Popper et al. 2014; Piniak et al. 2016).

3.3.4.1 Current Status

The Kemp's ridley sea turtle was listed as Endangered under the ESA throughout its range in 1970 and is currently listed as Critically Endangered under the IUCN Red List (NMFS, 2021e; IUCN 2022). The species is also listed as Endangered by the VA DWR (2022). The decline in global Kemp's ridley populations is the result of human activity, such as harvesting adults and eggs for food and as fisheries bycatch (USFWS 2022d). There is no designated critical habitat for this species in the Project area (NMFS 2021d).

3.3.4.2 Potential Habitat Surrounding and within the Project Area

In Virginia, Kemp's ridley sea turtles occur from spring through early fall and are the second most commonly observed turtle in the state (Barco and Lockhart 2016; Swingle et al. 2016, 2017, 2018; Costidis et al. 2019). Virginia coastal and estuarine waters offer important seasonal developmental habitat; individual juveniles exhibit site fidelity and have been known to return to the same seasonal foraging areas in consecutive years (Barco and Lockhart 2016). Strandings have increased in recent years, with an annual average of 80 to 90 strandings since 2015 and a recent peak of 101 strandings in 2018 (Swingle et al. 2016, 2017, 2018; Costidis et al. 2019). Records reflect higher occurrences of juveniles than adults and show strandings typically beginning in mid-May and peaking in June (Barco and Swingle 2014; Barco and Lockhart 2016). Stranding data from NMFS between 2017 and 2022 reported 483 stranding of Kemp's ridley sea turtles in Virginia, 19 attributed to cold stunning, 187 attributed to incidental capture, and the remaining 277 attributed to traditional stranding causes (NMFS 2022c). Of the strandings reported in counties which overlap with the Project area, 93 were reported in Norfolk, three in Portsmouth, and 204 in Virginia Beach (NMFS 2022c). Two nests have been recorded in Virginia Beach (which is just east of the proposed cable landing location [Figure 1-4]) in the past decade, marking the northernmost extent of their nesting territory (Wright 2015). In Virginia waters, the relative occurrence of Kemp's ridley sea turtles remains consistent throughout the year on the OCS, occurring within the eastern half of the Lease Area and covering much of the Project area, according to biogeographic information data (Palka et al. 2021). Previous PSO surveys reported one sighting of Kemp's ridley sea turtles in June and one in July of 2020 (COP Table 4.2-37; Dominion Energy 2022).

3.3.5 Effects Analysis for Sea Turtles

3.3.5.1 Underwater Noise

3.3.5.1.1 Effects on Sea Turtles

Underwater noise generated by impact pile driving during installation of WTG foundations, OSS foundations, and goal post piles; vibratory pile driving during installation of WTG foundation, OSS foundations, and cofferdams; HRG surveys; vessel activity; and WTG operation, would increase sound levels in the marine receiving environment and may result in potential adverse effects on sea turtles in the Project area including PTS and behavioral disturbances. Exposure modeling was conducted using a 205 WTG and 3 OSS scenario. Given the very small difference between the modeling scenario and the

Proposed Action (202 WTGs and 3 OSSs), PTS and behavioral exposures estimated for the Proposed Action are considered equivalent to the modeled scenario. Additionally, the likely scenario (176 WTGs and 3 OSSs) is represented by a 15 percent reduction from the Proposed Action, applied across all construction years with conservative rounding. Although piling may be completed in 2025 for the likely scenario, this BA still considers the effects of piling through 2026 for consistency with the LOA and to maintain construction flexibility. Section 3.3.5.1.2 *Auditory Criteria for Injury and Disturbance*, and Section 3.3.5.1.3 *Assessment of Effects*, provides a review of the available information on sea turtles hearing, the thresholds applied to this assessment and the results of the underwater noise modeling conducted in the COP (Appendix Z; Dominion Energy 2022) and effects assessment of applicable underwater noise sources for this BA.

3.3.5.1.2 Auditory Criteria for Injury and Disturbance

Sea turtle auditory perception is thought to occur in air and in water through bone conduction, which is the vibration of the skull and other bones in response to underwater sound pressure (Lenhardt 1982; Lenhardt and Harkins 1983). Detailed descriptions of sea turtle ear anatomy are found in Ridgway et al. (1969), Lenhardt et al. (1985) and Bartol and Musick (2003). Sea turtles do not have external ears, but the middle ear is well adapted as a peripheral component of a bone conduction system. The thick tympanum is disadvantageous as an aerial receptor but enhances low-frequency bone conduction hearing (Lenhardt et al. 1985; Bartol et al. 1999; Bartol and Musick 2003). A layer of subtympanal fat emerging from the middle ear is fused to the tympanum (Ketten et al. 2006; Bartol 2004, 2008). This arrangement enables sea turtles to hear low-frequency sounds while underwater and makes them relatively insensitive to sound above water. Vibrations can also be conducted through the bones of the carapace to reach the middle ear.

The limited data available on sea turtle hearing abilities is summarized in Table 3-17. The frequency range of best hearing sensitivity of sea turtles ranges from ~100 to 700 Hz, however there is some sensitivity to frequencies as low as 60 Hz, and possibly as low as 30 Hz (Ridgway et al. 1969). Thus, there is substantial overlap in the frequencies that sea turtles detect, and the dominant frequencies produced by pile driving activities. Given the high energy levels of pile driving, it is likely that sea turtles hear pile driving noise. However, there are no available measurements of the absolute hearing thresholds of any sea turtle to waterborne sounds to the exact sources being analyzed. Most available data on sea turtle behavioral responses to underwater noise involve seismic airgun surveys that are impulsive like impact pile driving, but differ in terms of spectral content, mobility, and duration. In addition, recent reports assessing the severity of behavioral reactions to underwater noise sources indicate that applying behavioral responses across broad sound categories (e.g., impact pile driving and seismic both considered impulsive sources) can lead to significant errors in predicting effects (Southall et al. 2021a). As a result, assessment of potential effects rely primarily on applicable sources and the results of the propagation and exposure modeling, rather than attempting to extrapolate from non-pile driving sources.

Table 3-17 Hearing capabilities of sea turtles

Sea Turtle Species	Hearing		Source
	Range (Hz)	Highest Sensitivity (Hz)	
Green (*Chelonia mydas*)	60–1,000	300–500	Ridgway et al. 1969
	100–800	600–700 (juveniles) 200–400 (subadults)	Bartol and Ketten 2006; Ketten and Bartol 2006
	50–1,600	50–400	Piniak et al. 2016
Loggerhead (*Caretta caretta*)	250–1,000	250	Bartol et al. 1999

Sea Turtle Species	Hearing		Source
	Range (Hz)	Highest Sensitivity (Hz)	
	50–1,100	100–400	Martin et al. 2012; Lavender et al. 2014
Kemp's Ridley (*Lepidochelys kempii*)	100–500	100–200	Bartol and Ketten 2006; Ketten and Bartol 2006
Leatherback (*Dermochelys coriacea*)	50–1,200 (underwater)	100–400	Dow Piniak et al. 2012

Table 3-18 outlines the acoustic thresholds for the onset of PTS, TTS, and behavioral disruptions for sea turtles for impulsive and non-impulsive noise sources. Also known as auditory fatigue, TTS is the milder form of hearing impairment that is non-permanent and reversible, and results from exposure to high intensity sounds for short durations or lower intensity sounds for longer durations. Both conditions are species-specific, and lead to an elevation in the hearing threshold, meaning it is more difficult for an animal to hear sounds. TTS can last for minutes, hours, or days; the magnitude of the TTS depends on the level (frequency and intensity), energy distribution, and duration of the noise exposure among other considerations.

TTS is typically applied when assessing regulatory impacts of specific activities (e.g., military operations, explosions). For marine mammals, data indicate that TTS onset in marine mammals is more closely correlated with the received SEL_{24h} than with the Lpk and that received sound energy over time, not just the single strongest pulse, should be considered a primary measure of potential impact (Southall et al. 2007; Finnern et al. 2017; NMFS 2018). For sea turtles, however, less is known about the onset of TTS, but some studies indicate threshold shifts up to 40 dB re 1 µPa may be experienced in freshwater turtle experiments; however, turtle hearing returned initial sensitivities following a recovery period of 20 minutes to several days (Woods Hole Oceanographic Institute 2022). It is reasonable to assume that the thresholds for TTS onset are lower than those for PTS onset, but higher than behavioral disturbance onset. Preliminary analyses from the Woods Hole Oceanographic Institute (2022) freshwater turtle study showed TTS onset occurring lower than the 200 dB re 1 μPa^2 s criteria currently used to predict TTS in sea turtles, which could be a function of species and other conditions. Until more studies improve the understanding of TTS in sea turtles, ranges to TTS thresholds and TTS exposures should be considered qualitative; and mitigation measures designed to reduce PTS exposures should also contribute to reducing the risk of the TTS exposures.

For behavioral thresholds, no distinction is made between impulsive and non-impulsive sources. Behavioral criteria for impact and vibratory pile driving were developed by the U.S. Navy in consultation with NMFS and was based on exposure to airgun noise presented in McCauley et al. (2000b) (Finneran et al. 2017). Impact pile driving produces repetitive, impulsive sounds like airgun shots. The received SPL at which sea turtles have been observed exhibiting behavioral responses to airgun exposures, 175 dB re 1 µPa, is also expected to be the received sound level at which sea turtles would exhibit behavioral responses when exposed to impact pile driving (impulsive) and vibratory pile driving (non-impulsive) activities (Finneran et al. 2017).

Table 3-18 Acoustic thresholds for onset of acoustic effects (PTS, TTS, or behavioral disturbance) for ESA-listed sea turtles

Impulsive Sources			Non-impulsive Sources		
PTS	TTS	Behavioral Disturbance	PTS	TTS	Behavioral Disturbance

Lpk	SEL24h[a]	Lpk	SEL24h[a]	SPL	SEL24h[a]	SEL24h[a]	SPL
232	204	226	189	175	220	200	175

Source: Finneran et al. (2017)
Lpk = peak sound pressure level in units of decibels referenced to 1 micropascal; PTS = permanent threshold shift; TTS = temporary; SEL_{24h} = sound exposure level over 24 hours in units of decibels referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of decibels referenced to 1 micropascal.
[a] SEL_{24h} thresholds including frequency weighting for sea turtles as described by Finneran et al. (2017).

As with marine mammals, the potential for underwater noise to result in adverse effects on a sea turtle depends on the received sound level, the frequency content of the sound relative to the hearing ability of the animal, the duration of the exposure, and the context of the exposure. Potential effects range from subtle changes in behavior at low received levels to strong disturbance effects or PTS at high received levels. Auditory masking may also occur when sound signals used by sea turtles (e.g., predator vocalizations and environmental cues) overlap in time and frequency with another sound source (e.g., pile driving). Popper et al. (2014) determined that continuous noise produced at frequencies and sound levels detectable by sea turtles can mask signal detection. As with behavioral effects, the consequences of masking to sea turtle fitness are unknown. The frequency range of best hearing sensitivity estimated for sea turtles is estimated at 100 to 700 Hz (Table 3-17). Masking is, therefore, more likely to occur with sound sources that have dominant low frequency spectrums such as vessel activities, vibratory pile driving, and WTG operations. These sound sources are also considered continuous, meaning they are present within the water column for longer durations and, therefore, have a higher chance of affecting sea turtle auditory perception.

3.3.5.1.3 Assessment of Effects

3.3.5.1.3.1 WTG and OSS Foundation Installation (C)

As discussed in Section 3.2.5.2.3.1, *WTF and OSS Foundations (C)*, WTG and OSS foundations will be installed under four piling scenarios using both vibratory (non-impulsive) and impact (impulsive) pile driving methods. Under the Proposed Action, installation of 176 foundations was identified as the most likely scenario with seven spare locations identified (COP Section 1.2; Dominion Energy 2023). However, should the seven spare locations be required, the modeling conducted for the Project included the assessment of all 183 foundation locations being used and requiring piling to meet the needs of the proposed Project. Table 3-19 summarizes the maximum threshold ranges to the sea turtle acoustic criteria metrics (Table 3-18) used in this BA analysis for the WTG and OSS foundation installations. The ranges reported are modeled for vibratory and impact pile-driving scenarios with 10 dB noise mitigation. The 10 dB noise mitigation is considered the minimum potential reduction expected to be achieved using the noise mitigation systems described in Section 1.3, *Description of the Proposed Action*.

Table 3-19 Maximum distances (meters) to sea turtle thresholds for impact pile driving during installation of the WTG and OSS foundations using vibratory and impact pile driving with 10 dB noise mitigation

Scenario	Installation Method	PTS (Lpk)	PTS (SEL_{24h})	TTS (Lpk)	TTS (SEL_{24h})	Behavior (SPL)
WTG Monopile 1 - Standard Installation	Impact	10	1,044	67	3,575	2,146
	Vibratory	NA	6	NA	179	82
WTG Monopile 2 - Hard-to-drive Installation	Impact	10	1,142	67	3,902	2,146
	Vibratory	NA	0	NA	132	82
WTG Monopile 3 -	Impact	10	1,410	67	4,812	2,146

Scenario	Installation Method	PTS (Lpk)	PTS (SEL_{24h})	TTS (Lpk)	TTS (SEL_{24h})	Behavior (SPL)
One Standard and One Hard-to-drive	Vibratory	NA	8	NA	200	82
OSS Foundation	Impact	0	653	0	2,303	742
	Vibratory	NA	0	NA	94	7

Source: Dominion Energy 2022
dB = decibel; Lpk = peak sound pressure level in units of dB re 1 micopascal; OSS = offshore substation; PTS = permanent threshold shift; SEL_{24h} = sound exposure level over 24 hours in units of dB referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of dB referenced to 1 micropascal; TTS = temporary threshold shift; WTG = wind turbine generator.

As stated previously (Section 3.2.5.2.3.1, *WTF and OSS Foundations [C]*), the modeled ranges only account for the source and environmental characteristics, which pertain to propagation of noise through the water column and do not incorporate animal movement and behavior, which allows an estimate of the number of individuals potential exposed during Project construction. To estimate the number of individuals expected to receive sound levels above established thresholds, Marine Acoustics, Inc. conducted exposure modeling, which combines animal movement modeling available for sea turtle species with the sound fields produced by each pile type and scenario (COP Appendix GG; Dominion Energy 2023).

The number of behavioral exposures and PTS exposures for sea turtles was estimated following the same methodology as described in Section 3.2.5.2.3.1, *WTF and OSS Foundations (C)*. TTS exposures were not modeled; however, TTS thresholds were estimated in Table 3-19. TTS thresholds are more often applied to sources such as underwater explosions where exposure to high sound energy would likely result in TTS before a notable behavioral response. Few at-sea density data are available for these sea turtles. To estimate the number of exposures, the modeling report used two sources of sea turtle densities available: U.S Department of the Navy (DoN) (2007) and Barco et al. (2018). The DoN (2007) density estimates were prepared for the Navy's U.S. Atlantic operating areas, which include the immediate Project area. More recent loggerhead sea turtle density estimates for the immediate Project area are available in Barco et al. (2018). These more recent loggerhead densities presented in Barco et al. (2018) are much higher than the older DoN (2007) estimates. Additionally, Barco et al. (2018) included a seasonal availability correction factor. Instead of selecting one of these loggerhead density estimates to apply to the exposure modeling output, both the DoN (2007) and Barco et al. (2018) density estimates for the loggerhead sea turtle were included. For this effects analysis, the exposures estimated with the Barco et al. (2018) densities were used because they represented the highest potential number of exposures. Although its acknowledged that these numbers are likely overestimates of the actual expected exposures, upward shifts in sea turtle densities within the Mid-Atlantic Bight (Patel et. Al. 2021) indicate that using higher densities projected forward for the Proposed Action represents the best available data and approach. Densities calculated for the Project Lease area with an 5.5-mile (8.9-kilometer) buffer surrounding it (Figure 3-1) for each season during which WTG and OSS foundations may occur are provided in Table 3-20. The numbers of individual turtles predicted to receive sound levels above PTS and behavioral exposure criteria with 10-dB attenuation during pile-driving of the WTG and OSS foundations for the Proposed Action are based on the densities in Table 3-20 and the ranges in Table 3-19. The estimated exposures are shown in Table 3-21. Although piling may be completed in 2025 for the likely scenario, this BA still considers the effects of piling through 2026 for consistency with the LOA. However, the total number of exposures throughout the entire construction period (i.e., 2024 through 2026 or 2024 through 2025) is expected to remain the same.

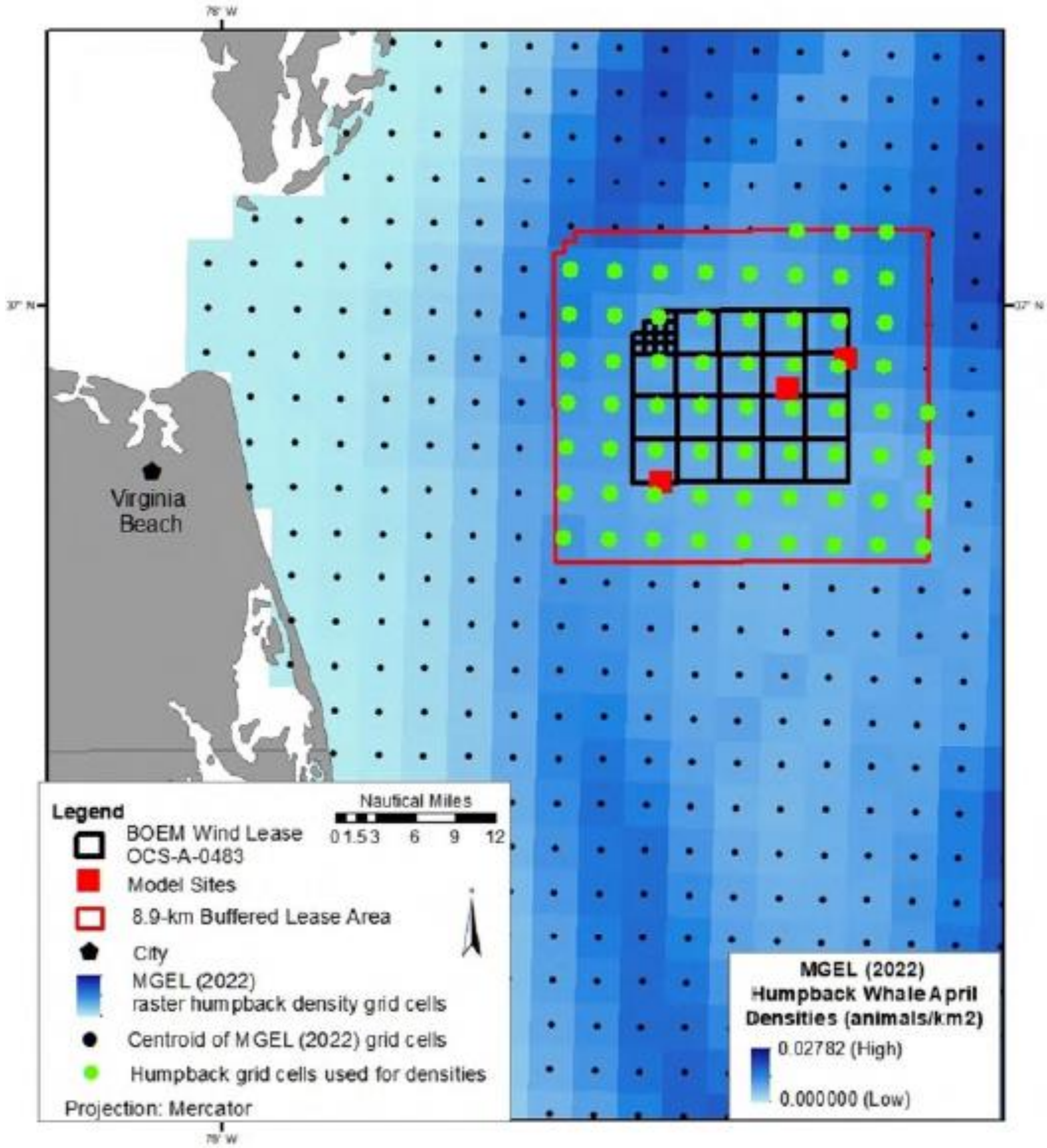


Figure 3-1 Map of the area around the CVOW-C Project area used to calculate seasonal sea turtle densities in the CVOW-C modeling report

Source: Figure 4, COP Appendix GG (Dominion Energy 2023)

Table 3-20 Estimated seasonal densities (animals/km^2) for sea turtle species occurring in the Project area

Species	Spring (May)	Summer (June through August)	Fall (September and October)
Green sea turtle [a]	0.04584	0.06558	0.04584
Kemp's ridley sea turtle	0.05472	0.05472	0.05472
Leatherback sea turtle	0.00301	0.00137	0.00301
Loggerhead sea turtle [b]	2.514	1.385	1.289

Source: Table 8, COP Appendix GG; Dominion Energy (2023).
[a] Population data were insufficient to determine an individual species density estimate for the green sea turtles in the Department of the Navy (2007) dataset. However, the available data for the green sea turtles were included in the hard-shelled guild density estimate. Thus, the hard-shelled turtle guild density estimate was used a surrogate density for the green sea turtles.
[b] Densities for loggerhead sea turtles use data from Barco et al. (2018) rather than the Department of the Navy (2007) dataset which was used for all other species in the table.

Table 3-21 Annual estimated number of ESA–listed sea turtles exposed to PTS or behavioral-level noise effects from impact pile-driving activities (with 10-dB noise mitigation)

Species	Construction Year	PTS Exposures	Behavioral Exposures
Green sea turtles	2024	24	114
	2025	22	101
Total		**46**	**215**
Kemp's ridley sea turtle	2024	24	112
	2025	20	91
Total		**44**	**203**
Leatherback sea turtle	2024	1	5
	2025	1	3
Total		**2**	**8**
Loggerhead sea turtle	2024	657	3,134
	2025	557	2,630
Total		**1,214**	**5,764**

Source: COP Appendix GG; Dominion Energy (2023).
dB = decibel; ESA = Endangered Species Act

Although green sea turtles may occur seasonally in the Project area, no at-sea density estimates are available for this less commonly occurring species. Green turtles were included in the "hardshelled guild" in the DoN (2007) density dataset; therefore, the seasonal density estimates from this guild as a whole were used as surrogate densities for the green sea turtle. The resulting higher-than-expected numbers of green sea turtle exposures compared to other more common species is likely the result of a combination of using this hardshelled guild for densities and the more inshore distribution of Kemp's ridley sea turtles which may not be fully captured in the DoN density layers. Acknowledging that the results from using the hardshelled guild will likely be overestimated, it represents the best available data for green sea turtles in this area. Further, the U.S. Navy set the precedent for using the hardshelled guild's density estimates to represent the green sea turtle (DoN 2018) and represents the only available data provided in the modeling report.

Effects of Exposure to Noise Above PTS Thresholds

Modeled sea turtle PTS threshold isopleths range from 2,142 to 4,625 feet (653 to 1,410 meters) for impact pile driving of foundations, and from 0 to 26 feet (0 to 8 meters) for vibratory piling of foundations (Table 3-19). The potential effects from vibratory piling of foundations are **discountable** for sea turtles due to the small size of the PTS ranges. PTS exposures resulting from impact pile driving were calculated for all sea turtle species, with the highest being calculated for loggerhead sea turtles at 1,214 individuals. This is using densities from Barco et al. (2018) with a correction factor that elevates loggerhead sea turtle densities for that area, and should, therefore, be considered a maximum potential value. Density estimates available for other species are from the DoN (2007). The number of PTS exposures for the other three species was estimated to range from 49 to 55 for green sea turtles, 36 to 41 for Kemp's ridley sea turtles, and 52 to 60 for leatherback sea turtles for the likely scenario and Proposed Action, respectively, over the construction period (Table 3-21).

The proposed clearance zone for sea turtles during impact pile driving is 3,281 feet (1,000 meters) with a shutdown range of 328 feet (100 meters). The effective range for reliable and consistent visual detection of sea turtles from vessels is often less than 1,640 feet (500 meters) in good visibility conditions (Barkaszi and Kelly 2019; Smultea Environmental Sciences 2020; Vandeperre et al. 2019). Therefore, even with observers using Big Eye binoculars on the raised construction vessel and up to two PSO vessels circling the pile location, the ability to effectively clear the entire PTS isopleth area for sea turtles is unlikely and thus there is a moderate risk of PTS exposure even with the dedicated observer teams. Additionally, because the clearance zone does not fully encompass the PTS range and the shutdown zone is significantly smaller than the PTS range, there is a high likelihood for sea turtles to experience PTS-level exposures during impact pile driving of foundations. Mitigation and monitoring measures (pre-clearance, ramp up, shutdowns) will reduce risk of PTS in sea turtles but will not eliminate the risk. Therefore, the effects of noise exposure above PTS thresholds during impact pile driving of foundations **may affect, likely to adversely affect** ESA-listed sea turtles.

Effects of Exposure to Noise Above the Behavioral Thresholds

Modeled sea turtle behavior threshold isopleths range from 22 to 269 feet (7 to 82 meters) for vibratory piling of foundations (Table 3-19). Therefore, potential effects from vibratory piling of foundations are **discountable** for sea turtles because the small size of the behavioral ranges make it very unlikely that a sea turtle will be within that range to be exposed to noise levels that exceed thresholds.

The modeled behavioral threshold isopleths, with 10 dB noise mitigation, for sea turtles resulting from impact pile driving range from 2,434 to 7,041 feet (742 to 2,146 meters); the modeled TTS threshold isopleths with 10 dB noise mitigation range from 7,555 to 15,787 feet (2,303 to 4,812 meters). The behavioral threshold ranges use the SPL metric which is based on the acoustic energy produced by a single hammer strike on the pile, while the TTS ranges are based on the SEL_{24h} metric which requires accumulation of acoustic energy for the full duration of the pile installation. Therefore, while it appears animals would reach TTS thresholds prior to reaching behavioral thresholds, the time consideration in the TTS metric renders these ranges not fully comparable to the SPL ranges since the approach used assumes any given animal would be stationary for the full pile installation period which is not representative of how an animal would be expected to behave in the wild. A shorter modeled time exposure, a single strike exposure for TTS, or modeled TTS exposure ranges which account for animal movement and behavior may provide more comparable results; however, these are not available in the modeling report and would not be expected to change the effects determinations. As discussed previously, TTS is a form of auditory fatigue that, unlike PTS, is non-permanent and reversible. As mentioned previously, very little is known about the onset of TTS in sea turtles and this metric is rarely used to assess potential impacts from impact pile driving beyond a few hammer strikes at the highest hammer energy. This metric is more often applied to sources such as underwater explosions where exposure to high sound energy could result in TTS when behavioral responses are unlikely to occur. Additionally, as discussed for behavioral responses, onset of TTS does not equate to an individual being removed from a population or facing any long-term restrictions on critical behaviors as TTS is recoverable.

Much of the knowledge of the behavioral reactions of sea turtles to underwater sounds has been derived from few studies, most of which have been conducted in a laboratory or caged setting. Potential behavioral effects may include altered submergence patterns, startle responses (e.g., diving, swimming away), short-term displacement of feeding or migrating activity, and a temporary stress response if present within the ensonified area (NSF and USGS 2011; Samuel et al. 2005). The accumulated stress and energetic costs of avoiding repeated exposures to pile-driving noise over a season or life stage could have long-term effects on survival and fitness (DoN 2018), though the consequences of potential behavioral changes to sea turtle fitness are unknown.

The frequency range of best hearing sensitivity estimated for sea turtles has been to be within the range of ~100 to 700 Hz and, therefore, acoustic effects on sea turtles would be most likely to occur from activities producing noise within that bandwidth. Lenhardt (1994) demonstrated that avoidance reactions of sea turtles in captivity were elicited when the animals were exposed to low frequency tones. Moein et al. (1995) also conducted experiments on caged loggerhead sea turtles and monitored the behavior of the animals when exposed to seismic activities with source levels ranging from 175 to 179 dB re 1 μPa m. Avoidance was also demonstrated by O'Hara and Wilcox (1990) who found that sea turtles in a canal would avoid the area where seismic work was being conducted, although the received levels were not measured. McCauley et al. (2000b) estimated an airgun array operating in 328 to 394 feet (100 to 120 meters) water depth could elicit behavioral changes in sea turtles out to 2 kilometers, whereas avoidance responses would occur out to approximately 1 kilometer. A monitoring assessment conducted by DeRuiter and Doukara (2012) estimated 51 percent of loggerhead sea turtles observed dove at or before the closest point of approach to the airgun array. Conversely, Weir (2007) reported no obvious avoidance by sea turtles at the sea surface as recorded by ship-based observers to seismic sounds, although the observers noted that fewer turtles were observed at the surface when the airgun array was active versus when it was inactive.

As outlined previously in Section 3.2.5.2.3.1, *WTG and OSS Foundations (C),* auditory masking occurs when acoustic cues used by sea turtles (e.g., physical sounds of prey activity, acoustic signature of key habitats such as hard-bottom structures, environmental cues) overlap in time and frequency with another sound source, such as seismic sound. Popper et al. (2014) concluded that continuous noise of any level that is detectable by sea turtles can mask signal detection. The consequences of potential masking and associated behavioral changes to sea turtle fitness are unknown. Masking is more likely to occur from sound sources with dominant frequencies in the low frequency spectrum such as vessel activities, vibratory pile driving and WTG operations. These activities also have high-duty cycles (i.e., are continuous) and, therefore, while the activity is occurring, have a higher chance of affecting sea turtles ability to detect biologically important acoustic cues compared to intermittent sources.

Modeling of 202 WTG foundations and 3 OSS foundations indicated up to 6,413 individual loggerheads; 281 individual leatherbacks; 260 individual green; and 194 individual Kemp's ridley sea turtles may be exposed to noise exceeding the behavioral thresholds levels over the 3 years of construction (Table 3-21). Under the likely scenario, the number of exposures to noise above behavioral thresholds during installation of the WTG and OSS foundations was up to 5,452 individual loggerheads; 240 individual leatherbacks; 222 individual green; and 166 individual Kemp's ridley sea turtles over the three years of construction (Table 3-21). Exposure probability is high given that the foundation piling will occur between May and October which falls into the migratory timelines as well as summer residency for some species. While the mitigation and monitoring measures are expected to decrease the severity of behavioral disturbances that do occur, predominantly by limiting the duration of the exposure through pre-clearance and shutdown procedures, the possibility for behavioral disturbances of relatively large numbers of individuals cannot be discounted. Therefore, the effects of noise exposures above behavioral thresholds resulting from impact pile driving during foundation installation **may affect, likely to adversely affect** ESA-listed sea turtles.

3.3.5.1.3.2 Goal Post Piles (C)

The ranges to the PTS and behavioral thresholds for sea turtles during installation of the goal post piles follows the same methodology described in Section 3.2.5.2.3.2, *Goal Post Piles (C)* and are provided in Table 3-22. Given the small threshold ranges and relatively short duration of this activity (up to 3 hours a day for 54 days), exposures of sea turtles to above threshold noise are unlikely.

Table 3-22 Maximum ranges (meters) to sea turtle PTS and behavioral thresholds during installation of up to two goal post piles per day using impact pile driving to support trenchless installation of the export cable with no noise mitigation

PTS (Lpk)	PTS (SEL_{24h})	Behavior (SPL)
0	0	156

Source: Dominion Energy 2022
Lpk = peak sound pressure level in units of dB referenced to 1 micropascal; SEL_{24h} = sound exposure level over 24 hours in units of dB referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of dB referenced to 1 micropascal

Effects of Exposure to Noise Above the PTS Thresholds

Results of the modeling show that PTS thresholds for sea turtles are not likely to be exceeded during goal post installation at any range. No animal movement or exposure modeling was conducted for this activity. The modeling assumed the source levels produced during impact pile driving of the goal post piles were 210 dB re 1 µPa m, expressed as Lpk, and 183 dB re 1 $\mu Pa^2 m^2$ s, expressed as SEL (COP Appendix Z; Dominion Energy 2022). These source levels are below both the Lpk and SEL_{24h} PTS thresholds in Table 3-18 indicating this activity would not meet or exceed the sound energy sufficient to result in PTS for sea turtles at any distance from the source. PTS in sea turtles resulting from installation of the goal post piles is considered extremely unlikely and **discountable.** Therefore, the effects of noise exposures above PTS thresholds resulting from goal post pile installation **may affect, not likely to adversely affect** ESA-listed sea turtles.

Effects of Exposure to Noise Above the Behavioral Thresholds

Modeling results show the behavioral threshold may be met or exceeded out to 512 feet (156 meters) (Table 3-22) during installation of the goal post piles. Because of the small ranges to the behavioral disturbance threshold, the mitigation and monitoring measures implemented (Table 1-7; which include a 3,281-foot [1,000-meter] pre-start clearance zone and a 328-foot [100-meter] shutdown zone), and the short, intermittent duration of this activity (up to 3 hours a day for 54 days), the potential for any sea turtles to experience behavioral disruptions leading to adverse effects is **discountable**. Therefore, effects of noise exposure above behavioral thresholds during installation of the goal post piles **may affect, not likely to adversely affect** ESA-listed sea turtles.

3.3.5.1.3.3 Cofferdam Installation (C)

The maximum results of the modeling for vibratory pile driving during installation of the temporary cofferdams described in Section 3.2.5.2.3.3, *Cofferdam Installation (C)* as they apply to sea turtles are provided in Table 3-23. Similar to the assessment of the goal post piles, the small threshold ranges; mitigation and monitoring measures; and relatively short duration of this activity (up to 1 hour a day for 54 days, including removal), acoustic exposures of sea turtles to above-threshold noise leading to PTS or behavioral disruption are unlikely.

Table 3-23 Maximum distances (meters) to sea turtle thresholds for vibratory pile driving during installation of the temporary cofferdams used to support offshore export cable installation with no noise mitigation

PTS (SEL_{24h})	Behavior (SPL)
0	0

Source: Dominion Energy 2022
PTS = permanent threshold shift; SEL_{24h} = sound exposure level over 24 hours in units of dB referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of dB referenced to 1 micropascal

Effects of Exposure to Noise Above the PTS Thresholds

Maximum ranges for all scenarios to PTS thresholds for sea turtles indicate that the PTS thresholds are not likely to be met or exceeded at any range (Table 3-23). No animal movement or exposure modeling was conducted for this activity; but no PTS or behavior-level exposures are expected. The modeling assumed a source level of 195 dB re 1 $\mu Pa^2 m^2$ s, expressed as SEL over 1 second, which is below the PTS threshold for non-impulsive sources in Table 3-18. Therefore, there is no risk (no effect) of exposure to noise above PTS thresholds based on modeling results. Exposures below PTS thresholds would be **discountable** because the time necessary to receive an enough exposure to elicit an effect would be an unrealistically long duration. Therefore, the effects of noise exposures above PTS thresholds resulting from cofferdam installation **may affect, not likely to adversely affect** ESA-listed sea turtles.

Effects of Exposure to Noise Above the Behavioral Thresholds

Modeling results show behavioral thresholds are also not likely to be met or exceeded at any range (Table 3-23). Unlike the PTS modeling information, source levels in root mean square sound pressure levels were not provided in the modeling report; therefore, no assumption can be made regarding whether the source level was below threshold or low enough such that the propagation range to the 175 dB re 1 µPa threshold resulted in an effective threshold range of 0 meters. The later scenario is assumed for analysis. Additionally, as this activity would only occur up to 1 hour a day over approximately 54 days, any potential behavioral disturbances resulting from vibratory pile driving during installation of the temporary cofferdams leading to behavioral disturbances are considered extremely unlikely to occur and are **discountable**. Therefore, the effects of noise exposures above behavioral thresholds resulting from installation of temporary cofferdams **may affect, not likely to adversely affect** ESA-listed sea turtles.

3.3.5.1.3.4 HRG Survey Activities (C, O&M, D)

Acoustic modeling for HRG surveys was not conducted for sea turtles. However, HRG survey activities as described in Section 3.2.5.2.3.4, *HRG Surveys (C, O&M, D)* indicate a maximum modeled range to the marine mammal LFC PTS thresholds of 0 feet (0 meters) for CHIRPs; 0.33 feet (0.1 meters) for sparkers; and 19.4 feet (5.9 meters) for boomers (Table 3-12). The ranges to the SPL 160 dB re 1 µPa behavioral threshold for marine mammals ranged from 35.8 feet (10.9 meters) for the CHIRPs to 328 feet (100 meters) for the sparker (Table 3-12). Therefore, these values allow inference that the PTS and behavioral threshold ranges for sea turtles would be smaller than those noted for marine mammals. This is because that even within their best hearing range, sea turtles have a lower sensitivity to underwater noise than marine mammals, with their lowest thresholds being almost 40 dB higher than those for MFCs and audiograms with no specialized auditory adaptations for higher-frequency hearing (Popper et al. 2014; Finneran et al. 2017). This position is further validated by the assessment conducted by Baker and Howsen (2021) which estimated the PTS thresholds for sea turtles would not be met or exceeded at any distance for any HRG source type, and the maximum behavioral disturbance threshold range would extend out to 295 feet (90 meters) for sparkers. However, this assessment assumed the maximum power and source settings were used for each type of equipment which is not applicable to the HRG surveys proposed by Dominion Energy (Tetra Tech 2022a) so it is expected that with the source and power settings included in the Proposed Action the maximum range to the sea turtle behavioral disturbance threshold would be even lower. HRG survey activities affecting sea turtles would follow the same indicative schedule provided in Table 3-13.

Effects of Exposure to Noise Above the PTS Thresholds

The Proposed Action includes shutdowns of HRG survey activities when sea turtles are sighted within 328 feet (100 meters) of the source (Table 1-7), which meets the maximum threshold ranges estimated for marine mammals and would, therefore, be expected to fully cover the area over which both the PTS and behavioral threshold ranges for sea turtles are met or exceeded. Additionally, based on the modeling conducted for marine mammals presented in Section 3.2.5.2.3.4, *HRG Surveys (C, O&M, D)*, and the assessment conducted by Baker and Howsen (2021), PTS thresholds for sea turtles would only be met or exceeded within a few meters (<5 meters) of the source. The potential for ESA-listed sea turtles to be exposed to HRG Survey noise above PTS thresholds is considered extremely unlikely to occur and is **discountable**. Therefore, the effects of noise exposures above PTS thresholds resulting from HRG surveys **may affect, not likely to adversely affect** ESA-listed sea turtles.

Effects of Exposure to Noise Above the Behavioural Thresholds

As discussed previously, modeling conducted for marine mammals in Section 3.2.5.2.3.4, *HRG Surveys (C, O&M, D)*, as well as the assessment conducted by Baker and Howsen (2021) indicate that the behavioral threshold for sea turtles would extend out <328 feet (<100 meters) from the source. The clearance zone and shutdown zone included in the Proposed Action (Table 1-7) would be expected to fully cover the area exceeding the behavioral disturbance threshold, reducing the likelihood of sea turtles experiencing changes in behavior that affect their long-term fitness. Additionally, the effects are transient and would dissipate as the vessel moves away from the turtle. The potential for behavioral exposure to ESA-listed turtles is considered extremely unlikely to occur and is **discountable**. Therefore, the effects of noise exposures above behavioral thresholds during HRG surveys **may affect, not likely to adversely affect** ESA-listed sea turtles.

3.3.5.1.3.5 Vessel Noise (C, O&M, D)

Up to 53 types of vessels may be used to support construction, O&M, and decommissioning of the Proposed Action (Table 1-5). These include larger barges and HLV, which range in size from 400 to 711 feet (122 to 217 meters) in length, 105 to 161 feet (32 to 49 meters) in breadth, and drafts from 20 to 36 feet (6 to 11 meters); cable-laying vessels ranging in size from 87 to 401 feet (27 to 122 meters) in length, 34 to 110 feet (10 to 34 meters) in breadth, and drafts from 10 to 18 feet (3 to 5 meters); and smaller support vessels ranging from 65 to 112 feet (20 to 34 meters) in length, 34 to 35 feet (10 to 11 meters) in breadth, and drafts from 10 to 19 feet (3 to 6 meters) (Table 1-5). Project vessel traffic will be intermittently present throughout the lift of the Project from before construction through decommissioning with transit frequencies ranging from daily to only a few cycles for the whole Project depending on the role and port of origin (Table 1-5).

The frequency and sound levels produced by vessels are determined by a variety of parameters including vessel shape, speed, size, prop structure and condition, power plant, onboard equipment such as generators, and operating environment. In general, larger vessels and faster operating speeds produce higher sound levels than smaller vessels or slower operating speeds. Large shipping vessels and tankers produce low frequency noise with a primary energy near 40 Hz with underwater source levels that can range from 177 to 200 dB re 1 µPa m (McKenna et al. 2012; Erbe et al. 2019) while smaller vessels typically produce higher frequency noise (1,000 to 5,000 Hz) at source levels between 150 and 180 dB re 1 µPa m (Kipple and Gabriele 2003, 2004). Vessels using DP thrusters are known to generate substantial underwater noise with SLs ranging from 150 to 180 dB re 1 µPa m depending on operations and thruster use (BOEM 2013; McPherson et al. 2016).

Effects of Exposure to Noise Above the PTS Thresholds

It is unlikely that received levels of underwater noise from vessel activities would exceed PTS thresholds for sea turtles, as the PTS threshold for non-impulsive sources is an SEL_{24h} of 200 dB re 1 μPa^2 s which comparable to the maximum source level reported for large shipping vessels (McKenna et al. 2012; Erbe et al. 2019). This means beyond 1 meter, the sound level produced by the loudest Project vessel would likely be below the sea turtle PTS threshold and the potential for ESA-listed sea turtles to be exposed to Project vessel noise above PTS thresholds is considered extremely unlikely to occur and is **discountable**. Therefore, the effects of noise exposure above PTS thresholds during Project vessel operations **may affect, not likely to adversely affect** ESA-listed sea turtles.

Effects of Exposure to Noise Above the Behavioral Thresholds

The most likely effects of vessel noise on sea turtles would include behavioral disturbances. There is very little information regarding the behavioral responses of sea turtles to underwater noise. A recent study suggests that sea turtles may exhibit TTS effects even before they show any behavioral response (Woods Hole Oceanographic Institution 2022). Hazel et al. (2007) demonstrated that sea turtles appear to respond behaviorally to vessels at approximately 33ft (10 meters) or closer. Based on the source levels outlined previously, the behavioral threshold for sea turtles is likely to be exceeded by Project vessels. Popper et al. (2014) suggest that in response to continuous shipping sounds, sea turtles have a high risk for behavioral disturbance in the closer to the source (e.g., tens of meters), moderate risk at hundreds of meters from the source, and low risk at thousands of meters from the source.

Behavioral effects are considered possible but would be temporary with effects dissipating once the vessel or individual has left the area. A greater volume of vessel traffic is anticipated for construction and decommissioning, which could result in a detectable increase in background noise levels in the Action Area; however this would be temporary and would cease once construction and decommissioning are completed. Operational vessels would constitute a longer-term source of noise throughout the 33-year operational live of the Project, but the overall volume of vessels and frequency of trips proposed is lower than construction and would not be expected to result in an appreciable increase in noise levels. The Proposed Action includes the implementation of minimum vessel separation distance of 164 feet (50 meters) for sea turtles which, though geared towards vessel strike avoidance, would help to reduce the level of noise a turtle is exposed to and reducing the likelihood of sea turtles receiving sound energy above the behavioral threshold. The additional BOEM proposed measures to reduce vessel strikes on sea turtles which includes slowing to 4 knots when sea turtle sighted within 328 feet (100 meters) of the forward path of the vessel and avoiding transiting through areas of visible jellyfish aggregations or floating sargassum will also reduce the potential for behavioral disturbance effects by reducing the sound level received by sea turtles in the Action Area during vessel activities. Though these mitigation measures won't eliminate the potential for sea turtles to be exposed to above-threshold noise, the potential effects if exposure were to occur would be brief (e.g., a sea turtle may approach the noisy area and divert away from it), and any effects on this brief exposure would be so small that they could not be measured, detected, or evaluated and are, therefore, **insignificant**. Therefore, the effects of noise exposures above behavioral disturbance thresholds during Project vessel operations **may affect, not likely to adversely affect** ESA-listed sea turtles in the Action Area.

3.3.5.1.3.6 Cable Laying or Trenching Noise (C)

As described previously in Section 3.2.5.2.3.6, *Cable Laying or Trenching Noise (C),* the most likely cable burial methods being considered as part of the Proposed Action include jet plow, jet trenching, hydroplow (simultaneous lay and burial), mechanical plowing (simultaneous lay and burial). The action of laying the cables on the seafloor itself is unlikely to generate high levels of underwater noise. Most of the noise energy would originate from the vessels themselves including propellor cavitation noise and noise generated by onboard thruster/stabilization systems and machinery (e.g., generators), including noise emitted by the tugs when moving the anchors as discussed in Section 3.3.5.1.3.5, *Vessel Noise (C, O&M, D)*.

There is limited information regarding underwater noise generated by cable-laying and burial activities in the literature. Johansson and Andersson (2012) recorded underwater noise levels generated during a comparable operation involving pipelaying and a fleet of nine vessels. Mean noise levels of 130.5 dB re 1 µPa were measured at 4,921 feet (1,500 meters) from the source. Reported noise levels generated during a jet trenching operation provided a source level estimate of 178 dB re 1 µPa m (Nedwell et al. 2003).

Effects of Exposure to Noise Above the PTS Thresholds

Cable-laying noise sources associated with the Proposed Action were below the established PTS injury thresholds for sea turtles as outlined in Section 3.3.5.1.2, *Auditory Criteria for Injury and Disturbance*. Therefore, the potential for ESA-listed sea turtles to be exposed to noise above PTS thresholds from cable laying is extremely unlikely to occur and is **discountable**. Therefore, the effects of noise exposure from Project cable laying operations leading to PTS **may affect, not likely to adversely affect** ESA-listed sea turtles.

Effects of Exposure to Noise Above the Behavioral Thresholds

Cable-laying operations could exceed the disturbance threshold for sea turtles (and SPL of 175 dB re 1 µPa). As outlined above, there is very little information regarding the behavioral responses of sea turtles to underwater noise. Behavioral responses to vessel noise include avoidance behavior but only at very close range (32 feet [10 meters]; Hazel et al. 2007). Popper et al. (2014) suggest that in response to continuous sounds, sea turtles have a high risk for behavioral disturbance in the near field (e.g., tens of meters), moderate risk in the intermediate field (hundreds of meters) and low risk in the far field (thousands of meters).

Behavioral effects are considered possible but would be temporary with effects dissipating once the activity has ceased or individual has left the area. Should an exposure occur, the potential effects would be brief (e.g., a sea turtle may approach the noisy area and divert away from it), and any effects to this brief exposure would be so small that they could not be measured, detected, or evaluated and are therefore **insignificant**. Therefore, the effects of noise exposure from Project cable-laying operations leading to behavioral disturbance **may affect, not likely to adversely affect** ESA-listed sea turtles.

3.3.5.1.3.7 WTG Operations (O&M)

Reported sound levels of operational wind turbines is generally low (Madsen et al. 2006; Tougaard et al. 2020; Stöber and Thomsen 2021) with a source SPL of about 151 dB re 1 µPa m and a frequency range of 60 to 300 Hz (Wahlberg and Westerberg 2005; Tougaard et al. 2020). At the Block Island Wind Farm, low-frequency noise generated by turbines reach ambient levels at 164 feet (50 meters) (Miller and Potty 2017). SPL from operational WTGs in Europe indicate a range of 109 to 127 dB re 1 µPa at 46 and 66 feet (14 and 20 meters) from measurements the WTGs (Tougaard et al. 2009). Thomsen et al. (2006) indicated SPL ranging from 122 to 137 dB re 1 µPa 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, 500 Hz, and 1,200 Hz from a jacket foundation turbine and from 133 to 135 dB re 1 µPa at 492 and 131 feet (150 and 40 meters), respectively, with peak frequencies at 50 and 140 Hz from a steel monopile foundation turbine. The measurements within 131 feet (40 meters) of the 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.

Tougaard et al. (2020) reviewed the literature sources previously cited, along with others to attempt some standardization in reporting and assessment. The resulting analyses showed that sound levels produced by individual WTG were low in all literature and comparable to or lower than sound levels within 0.6 mile of commercial ships. The complied data also showed an increase in noise levels with increasing WTG power and wind speed; however, Tougaard et al. (2020) noted that the noise produced from a WTG is stationary and persistent, which differs from the transitory nature of sound produced by vessel traffic, and the cumulative contribution of multiple WTG within a region must be critically assessed and planned. Stöber and Thomsen (2021) reviewed published literature and also identified an increase in underwater source levels (up to 177 dB re 1 µPa) with increasing power size with a nominal 10 MW WTG. They also estimate a sound decrease of roughly 10 dB from WTG using gear boxes compared to WTG using direct drive technology.

Sea turtle hearing (frequencies less than 1,200 Hz) is within the frequency range for operational WTG (less than 500 Hz; Popper et al. 2014; Thomsen et al. 2006; Tougaard et al. 2009). Thus, it is possible that WTG noise is perceptible to sea turtles and may influence sea turtle behavior. Potential responses to WTG noise generated during normal operations may include avoidance of the noise source, disorientation, and disturbance of normal behaviors such as feeding (MMS 2007). In the discussion on reef effects from foundation structures (Section 3.3.5.2.4, *Effects of Changes in and Concentration of Prey Species due to the Reefing Effect of Structures [C, O&M, D]*) sea turtles may be attracted to prey concentrations at foundation structures. This attraction may override avoidance of low level noise sources, in these cases, the acclimation of sea turtles to WTG noise may introduce low-level, long-term effects of noise exposures or masking.

<u>Effects of Exposure to Noise Above the PTS Thresholds</u>

Based on the source levels presented in Section 3.3.5.1.3.6, *WTG Operations (O&M)*, it is unlikely that received levels of underwater noise from WTG operations would exceed the SEL_{24h} 200 dB re 1 µPa^2 s PTS thresholds for sea turtles for non-impulsive sources. As a result, the potential for ESA-listed sea turtles to be exposed to noise above PTS thresholds is considered extremely unlikely to occur and is **discountable**. Therefore, effects of noise exposure above PTS thresholds during Project WTG operations **may affect, not likely to adversely affect** ESA-listed sea turtles.

<u>Effects of Exposure to Noise Above the Behavioral Thresholds</u>

Behavioral responses to noise, particularly long-term increases in ambient noise levels due to ocean development activities are not well studied. Similar to increases in vessel noise, WTG operations have the potential to increase sound levels within the hearing range of sea turtles throughout the habitat used in the Project area. While avoidance of WTG structures due to increased noise levels is possible, there is no evidence of abandonment of habitats due to an increase in sound levels. Many species of sea turtles occupy coastal and heavily industrialized areas such as ports and harbors which have high ambient noise levels. However, the lack of a behavioral reaction may not fully capture potential effects of smaller noise increases that are expected during WTG operations. Samuel et al. (2005) recorded seasonal increases in vessel noise within coastal sea turtle habitat in the Peconic Bay Estuary, New York and noted that such increases highlight that the spatial overlap between increased sound levels and sea turtles poses a potential acoustic exposure risk even though the "activity" is already part of the acoustic environment within which the sea turtles congregate. While the WTG sound level contributions may be small, the long-term change in acoustic habitat has the potential to cause some behavioral changes. Sea turtles are known to be attracted to offshore energy structures (Lohoefener et al. 1990; Valverde and Holzwart, 2017; Viada et al. 2008); and sea turtles will likely be attracted to the WTG and OSS foundations due to beneficial foraging and sheltering opportunities (Barnette 2017; NRC 1996). Oil and gas platforms used by sea turtles are expected to produce higher sound pressure levels than WTG operations. Further, satellite telemetered sea turtles in the Gulf of Mexico, showed that platforms were part of home range core areas; and home range sizes for turtles captures at platforms were comparable to the home range sizes for telemetered turtles captured at Flower Garden Banks National Marine Sanctuary (Valverde and Holzwart 2017). In a comprehensive noise control study conducted by Spence et al. (2007), underwater noise sources were ranked based on the approximate overall source level for the source type, the affected or detectable range from the source, and duration or prominence of sounds. All types of oil and gas platforms ranked in the lowest significance category which is indicative of a low likelihood of acoustic impacts (e.g., seismic surveys were ranked as highest significance). Because WTG operations are expected to produce even lower sound levels, the acoustic impact to sea turtles is expected to be low even for turtles that frequent the foundations or remain at the foundations for long periods. Therefore, the potential effects of operational WTG noise could not be measurable or meaningfully evaluated and would be **insignificant.** Therefore, effects of noise exposures above behavioral thresholds during WTG operations **may affect, not likely to adversely affect** ESA-listed sea turtles.

3.3.5.1.3.8 Effects to Prey Organisms

Sea turtles assessed in this BA feed on a variety of prey items including invertebrates like crabs, jellyfish, and mollusks, and fish (Carr and Caldwell 1956; Byles 1988; Ruckdeschel and Shoop 1988; Burke et al. 1993; Plotkin et al. 1993; Schmid 1998; Heithaus et al. 2002; NMFS and USFWS 2008; NMFS 2011; Eckert et al. 2012; Seminoff et al. 2015; NMFS and USFWS 2020). A discussion of sea turtle life history traits is provided in Sections 3.3.1, *Green Sea Turtle* through 3.3.4, *Kemp's Ridley Sea Turtle*.

Green sea turtles primarily feed on seagrasses and algae (Bjorndal 1997); leatherbacks primarily feed on soft-bodied animals such as jellyfish and salps (NMFS 2022e; USFWS 2022b); juvenile loggerheads feed on crabs, mollusks, jellyfish, and vegetation at or near the surface while subadults and adults are known to feed on benthic invertebrates such as mollusks and decapod crustaceans (TEWG 2009); and Kemp's ridley sea turtles are opportunistic foragers, feeding on decapod crustaceans, shellfish, and fish (NMFS 2022g).

As discussed in Section 3.2.5.2.3.8 *Effects to Prey Organisms*, invertebrate sound sensitivity is restricted primarily to particle motion (André et al. 2016; Budelmann 1992; Solé et al. 2016, 2017), and effects are expected to dissipate rapidly such that any effects are highly localized from the noise source (Edmonds et al. 2016). This indicates that the invertebrate forage base for turtles is unlikely to be measurably affected by underwater noise resulting from any of the Project activities. However, Solé et al. (2021) also show that seagrasses may be sensitive to anthropogenic noise. In their study, they exposed *Posidoniaceae oceanica* to noise sweeping through 50 to 400 Hz frequencies at received SPL of 157 dB re 1 µPa within a few meters (16 feet [<5 meters]) from the source to the grasses. *Posidoniaceae oceanica* is a slow-growing seagrass, endemic to the Mediterranean Sea which, though is not the same species as the common eelgrass (*Zostera marina*) found offshore Virginia (VIMS 2022b), they both come from same order (*Alismatales*) and have similar physiological traits (Biodiversity of the Central Coast 2022). Results show deformed structure of starch grains in the plants studies after 48 hours of noise exposure, and damage to starch grains present after 96 to 120 hours of exposures (Solé et al. 2021). Damage to the starch grains in seagrasses could affect successful growth, and though the sound source used in the study are not the same as many of the noise-producing activities included under the Proposed Action, this shows seagrasses may be affected by low-frequency noise. However, as discussed in Section 3.3.5.2, *Habitat Disturbance Effects on Sea Turtles (C, O&M, D)*, there are not seagrass beds in the Lease Area or offshore export cable route corridor (COP Appendix D; Dominion Energy 2022) so the likelihood of this food resource being exposed to Project-related noise is low.

Marine fish, particularly those with swim bladders, are also sensitive to underwater sound pressure, and are typically sensitive to the 100 to 500 Hz range which overlaps with many of the Project activities described previously. Several studies have demonstrated that seismic airguns and other impulsive sources might affect the behavior of at least some species of fish; however, while these studies lend some information regarding behavior, it should be noted that the high energy, impulsive nature of seismic surveys are most comparable to but do not fully equate to the source levels and spectra produced by impact pile driving of foundations. Other activities (e.g., vibratory piling, goal post piling) do not lend themselves to comparisons with seismic surveys. Field studies by Engås et al. (1996) and Løkkeborg et al. (2012) showed that the catch rate of haddock and Atlantic cod significantly declined over 5 days immediately following seismic surveys, after which the catch rate returned to normal. Other studies found only minor responses by fish to noise created during or following seismic surveys, such as a small decline in lesser sand eel abundance that quickly returned to pre-seismic levels (Hassel et al. 2004) or no permanent changes in the behavior of marine reef fishes (Wardle et al. 2001). However, both Hassel et al. (2004) and Wardle et al. (2001) noted that when fish sensed the airgun firing, they performed a startle response and sometimes fled.

Based on available data, only temporary behavioral responses to noise-producing Project activities would be expected to occur to prey species resulting from underwater noise produced in the Proposed Action. No long-term or population-level effects are expected for any prey species during Project construction, O&M, or decommissioning, and, therefore, no long-term reduction in prey availability is expected for sea turtles. The potential for WTG construction/operations/decommissioning noise to reduce prey items for sea turtles is extremely unlikely and is **discountable**. Therefore, effects from noise exposures due to activities conducted in the Proposed Action **may affect, not likely to adversely affect** prey organisms for ESA-listed sea turtles.

3.3.5.2 Habitat Disturbance Effects on Sea Turtles (C, O&M, D)

Effects from habitat disturbance to sea turtles are expected to be similar to the effects described for this stressor in marine mammals (Section 3.2.5.33, *Habitat Disturbance Effects on Marine Mammals [C, O&M, D]*). Habitat disturbance related to the Project would occur through all three phases of construction, O&M, and decommissioning. Potential effects to ESA-listed sea turtles and their prey from habitat disturbance are analyzed in the following subsections and range from short- to long-term impacts. Individual stressors under habitat disturbance encompass displacement from physical disturbance of sediment; changes in oceanographic and hydrological conditions due to presence of structures; conversion of soft-bottom to hard-bottom habitat; and concentration of prey species due to the reef effect. These are discussed separately and organized by Project phase in the following paragraphs.

3.3.5.2.1 Displacement from Physical Disturbance of Sediment (C, D)

Construction of the Proposed Action would result in temporary disturbances of the seabed within the Project area as provided in Table 3-16. As discussed previously in Section 3.2.5.3.1, *Displacement from Physical Disturbance of Sediment (C, D)*, there were no sensitive resources, hard-bottom, or biogenic (sea grass beds, corals, shellfish reefs and beds, etc.) substrates identified within the Project area (COP, Appendix D; Dominion Energy 2022). Therefore, significant displacement of ESA-listed sea turtles or their prey items due to seabed disturbance is not expected to occur during construction or decommissioning. Additionally, the natural restoration of marine soft-sediment habitats occurs through a range of physical (e.g., currents, wave action) and biological (e.g., bioturbation, tube building) processes (Dernie et al. 2003). Disturbed areas not replaced with hardened structures or scour protection would resettle and the benthic community would be expected to return to normal, typically within one year (Dernie et al. 2003; Department for Business, Enterprise and Regulatory Reform 2008).

Given the limited area affected and the lack of overlap with important benthic feeding habitats for ESA-listed sea turtles, and the temporary nature of the disturbance, effects from seabed disturbance during construction and decommissioning would be so small that they could not be measured, detected, or evaluated and are, therefore, **insignificant**.

3.3.5.2.2 Effects of the Structure Presence on Sea Turtles (O&M)

The estimated permanent footprint of the Proposed Action throughout O&M is provided in Table 3-16. The WTG and OSS foundations are vertical structures that constitute obstacles in the water column that could alter the normal behavior of sea turtles in the Project area during operations, whereas the cable protection would predominantly affect benthic prey species, as discussion in Section 3.3.5.2.4, *Effects of Changes in and Concentration of Prey Species due to the Reefing Effect of Structures (O&M, D)*. The Proposed Action of 202 WTGs with monopile foundations, installed with a spacing of 0.75 to 0.93 nautical mile (1.39 to 1.72 kilometers) in an offset grid pattern (east–west by northwest by southeast gridded layout), are considered, as well as a likely scenario of 176 WTGs using the same installed spacing and grid pattern, are evaluated. In total, approximately 116.4 to 204.5 acres (0.47 to 0.83 km^2) of new hard structure will be installed within the wind farm, including foundation and cable scour protection. ESA-listed sea turtles present in the immediate Project area would not be obstructed from transiting through the wind farm and the structures would not be a barrier to the movement of any listed sea turtle species through the area.

Sea turtles are known to be attracted to offshore energy structures (Lohoefener et al. 1990; Valverde and Holzwart 2017; Viada et al. 2008); and studies have shown that sea turtles incorporate oil and gas platforms in core areas within their home ranges (Valverde and Holzwart 2017). The presence of the Project structures would create an artificial habitat that could provide multiple benefits for sea turtles, including foraging habitats, shelter from predation and strong currents, and methods of removing biological build-up from their carapace (Barnette 2017; NRC 1996). Sea turtles have been observed within the vicinity of offshore structures, such as oil platforms, foraging and resting under the platforms (Klima et al. 1988). High concentrations of sea turtles have been reported around these oil platforms (NRC 1996) and during a surface survey at a platform off the coast of Galveston, Texas, approximately 170 sightings were reported (Gitschlag 1990). Multiple species like green, hawksbill, and loggerhead sea turtles have also been observed using anthropogenic structures and submerged rocks to remove biological buildup and clean their flippers and carapace (Barnette 2017). In the Gulf of Mexico, both loggerhead and leatherback sea turtles were often observed resting at oil and gas platforms, making it possible that these species may behave similarly at wind farm structures (Gitschlag and Herczeg 1994; NRC 1996).

The spacing and size of the offshore wind structures are not expected to pose barriers to movement of ESA-listed sea turtles. Further, sea turtles are well-documented around similar offshore structures in the

Gulf of Mexico, California, and other parts of the world. Based upon the ability to move among structures and documented use of offshore structures, the effects from the physical presence of offshore structures, if any, would be considered **insignificant.**

3.3.5.2.3 Effects of Changes in Oceanographic and Hydrological Conditions due to Presence of Structures (O&M)

Hydrodynamic processes resulting from the presence of structures is described in Section 3.2.5.3.3, *Effects of Changes in Oceanographic and Hydrological Conditions due to Presence of Structures (O&M*). The potential hydrodynamic effects identified from the presence of vertical structures in the water column influence nutrient cycling and could influence the distribution and abundance of fish and planktonic prey resources throughout O&M (van Berkel et al. 2020); however, these hydrodynamic effects are not expected to extend beyond a few hundred meters from the foundation (Miles et al. 2017; Schultze et al. 2020).

Hydrodynamic changes in prey aggregations would primarily affect the leatherback sea turtle that feeds on planktonic prey that have limited independent movement beyond the ocean currents (Section 3.3.2, *Leatherback Sea Turtle*), as opposed to green sea turtles, loggerhead sea turtles, and Kemp's ridley sea turtles that consume prey (or forage on SAV) that are sessile or can actively swim against ocean currents. The analysis of benthic resources in the COP indicated the presence of the foundations is not likely to negatively affect regional abundances or dispersion of plankton species (COP. Section 4.2.4.3, Dominion Energy 2022). In the Mid-Atlantic, jellies preyed upon by leatherback sea turtles are seasonally abundant from mid-summer to late fall, feeding on zooplankton (Sexton 2012), and their abundance and distribution are likely influenced by a number of factors rather than just currents (Sexton 2012; Gibbons and Richardson 2008). The effects on ESA-listed sea turtle prey availability resulting from changes in oceanographic and hydrological conditions due to presence of structures, if there were effects, would be so small that they could not be meaningfully evaluated and are, therefore, insignificant.

3.3.5.2.4 Effects of Changes in and Concentration of Prey Species due to the Reefing Effect of Structures (O&M, D)

Another long-term O&M effect created by the presence of the wind farm structures is the reef effect. Foundations and cable armoring form are the biological hotspots that support species range shifts and expansions and changes in biological community structure resulting from a changing climate (Raoux et al. 2017; Methratta and Dardick 2019; Degraer et al. 2020). Around the base of the monopiles, colonizing organisms on the surface of the pile would likely enhance food availability and food web complexity through an accumulation of organic matter (Degraer et al. 2020; Mavraki et al. 2020). The accumulation could lead to an increased importance of the detritus-based food web but is unlikely to result in significant broad scale changes to the local trophic structure (Raoux et al. 2017).

Leatherback sea turtles primarily feed on pelagic soft-bodied animals such as jellyfish and salps, which are unlikely to be substantially affected by benthic habitat alteration (Section 3.3.2, *Leatherback Sea Turtle*); therefore, effects from physical disruption of sediments from the proposed action would be **discountable** for leatherback sea turtles. Adult green sea turtles primarily forage on seagrass and marine algae, but occasionally will consume marine invertebrates (Section 3.3.1, *Green Sea Turtle*). The results of the Benthic Resource Characterization Report (COP, Appendix D; Dominion Energy 2022) indicate that no seagrass beds are expected to occur in the Lease Area or Offshore Export Cable Route corridor, and preliminary benthic surveys showed no seagrass beds within the Project area. Additionally, as described in Section 1.3.1.1, *Onshore Activities and Facilities*, Dominion Energy proposes to use trenchless installation methods to install the Offshore Export Cable under the beach and dune to the Cable Landing Location which will avoid direct impacts on aquatic vegetation, if present, in the Export Cable Route corridor. Given the low likelihood of seagrasses or other SAV in the Project area, any effects to green sea turtles and their forage sources are expected to be **discountable**.

Loggerhead and Kemp's ridley sea turtles are the only species whose diet consists predominantly of benthic species such as mollusks, crustaceans, and shellfish (Sections 3.3.3, *Loggerhead Sea Turtle* and 3.3.4, *Kemp's Ridley Sea Turtle* respectively) Therefore, physical displacement of benthic prey items from offshore export and inter-array cable installation has greater potential to impact the loggerhead and Kemp's ridley sea turtles. However, available information suggests that the predominant prey base for Kemp's ridley and loggerhead sea turtles may increase in the Project area due to the reef effect of the WTGs and associated scour protection resulting in an increase in crustaceans and other forage species (Sections 3.3.3, *Loggerhead Sea Turtle* and 3.3.4, *Kemp's Ridley Sea Turtle*). This effect would be **beneficial** to those species. Loggerhead sea turtles are likely to benefit more than Kemp's ridley due to the nature of their distribution with Kemp's ridleys being primarily near shore and loggerheads being primarily offshore. Although both may benefit, the effect would be greatest for the loggerhead sea turtle. Sea turtles with increased habitat and foraging opportunities could potentially remain in the area longer than they typically would and become susceptible to cold stunning or death, although there is no quantitative evidence of this.

3.3.5.2.5 Summary of Habitat Disturbance Effects

As discussed above, all effects of habitat disturbance types resulting from WTG structures are either **discountable**, **insignificant**, or **beneficial**. Therefore, effects resulting from habitat disturbance due to activities conducted in the Proposed Action are **likely to affect, not likely to adversely affect** ESA-listed sea turtles.

3.3.5.3 Water Quality Effects on Sea Turtles (C & D)

The seabed within the Action Area is comprised of soft-bottom sediments characterized by fine sand punctuated by gravel and silt/sand mixes (Section 2.1.1.1, *Seabed Conditions*) so it is likely that increases in turbidity during construction and decommissioning may occur. Physical or lethal effects in increased turbidity during Project construction and decommissioning are unlikely to occur because sea turtles are air-breathing and land-brooding, and, therefore, do not share the physiological sensitivities of susceptible organisms like fish and invertebrates. Elevated suspended sediments may cause individuals to alter normal movements and behaviors. However, these changes are expected to be limited in extent, short term in duration, and likely too small to be detected (NOAA 2021b). Moreover, many sea turtle species routinely forage in nearshore and estuarine environments with periodically high natural turbidity levels. Therefore, short-term exposure to elevated suspended sediment levels is unlikely to measurably inhibit foraging (Michel et al. 2013). However, elevated levels of turbidity may negatively affect sea turtle prey items, including benthic mollusks, crustaceans, sponges, and sea pens by clogging respiratory apparatuses. The more mobile prey items like crabs may also be negatively affected by turbidity by clogging their gills, but likely to a lesser extent due to their ability to leave the turbid area (BOEM 2021). Any effects from increased turbidity levels from construction activities on turtles, their habitat or their prey would be isolated and temporary and are so small that they could not be measured and are, therefore, **insignificant**.

Water quality contaminants could also be accidentally released as a result of increased vessel activity associated with the Proposed Action. Exposure to aquatic contaminants could result in lethal or sublethal effects including depressed immune system function; poor body condition; and reduced growth rates, fecundity, and reproductive success (Gall and Thompson 2015; Hoarau et al. 2014; Nelms et al. 2016; Schuyler et al. 2014). Additionally, accidental releases may indirectly affect sea turtles through effects on prey species. However, all Project vessels would comply with USCG regulations and BOEM regulations that would avoid and minimize accidental release of aquatic contaminants. The Project also has its own Oil Spill Response Plan to implement in the case of accidental releases (COP, Appendix Q; Dominion

Energy 2022). Therefore, potential accidental releases at volumes that could affect sea turtles are unlikely and, therefore, **discountable**.

Therefore, effects from changes in water quality due to activities conducted under the Proposed **may affect, not likely to adversely affect** ESA-listed turtles.

3.3.5.4 Secondary Entanglement due to Increased and Altered Fishing Activity Caused by the Presence of Structures (O&M)

Another long-term impact of the presence of structures during O&M is the potential to concentrate recreational fishing around foundations, potentially increasing the risk of sea turtle entanglement in both lines and nets and increasing the risk of injury and mortality due to ingestion, infection, starvation, or drowning (Nelms et al. 2016; Gall and Thompson 2015; Shigenaka et al. 2010; Barnette 2017). These structures could also result in commercial fishing vessel displacement or gear shift. The potential impact on sea turtles from these changes is uncertain. However, if a shift from mobile gear to fixed gear occurs due to inability of fishermen to maneuver mobile gear, there could be an increase in the number of vertical lines in the water column, potentially resulting in an increased risk of sea turtle interactions with fishing gear. Greater fishing efforts around the wind farm area would increase the amount of fishing gear in the water, particularly monofilament line, which has been identified as a major hazard for all sea turtle species. As discussed in Section 3.2.5.5, *Secondary Entanglement due to Increased and Altered Fishing Activity Caused by the Presence of Structures (O&M)*, this is expected to be low in intensity and persist until decommissioning is complete and structures are removed. Additionally, abandoned or lost fishing gear (commercial and recreational) may become entwined within foundation structures and pose a hazard to sea turtles. The following monitoring and mitigation measure (Table 1-8) will act to reduce potential impacts on sea turtles resulting from lost or discarded fishing gear that accumulates around WTG foundations:

- Dominion Energy must monitor indirect effects associated with charter and recreational fishing gear lost from expected increases in fishing around WTG foundations by surveying at least 10 of the WTGs located closest to shore in the Lease Area annually. Survey design and effort may be modified with review and concurrence by Department of Interior. Dominion Energy may conduct surveys by remotely operated vehicles, divers, or other means to determine the frequency and locations of marine debris. Dominion Energy must report the results of the surveys to BOEM and BSEE in an annual report for the preceding calendar year. Annual reports must include survey reports that include: the survey date; contact information of the operator; the location and pile identification number; photographic, video documentation, or both of the survey and debris encountered; any animals sighted; and the disposition of any located debris (i.e., removed or left in place). Annual reports must also include claim data attributable to the Project from Dominion Energy corporate gear loss compensation policy and procedures. Required data and reports may be archived, analyzed, published, and disseminated by BOEM.

The implementation of the BOEM-proposed monitoring surveys would provide data regarding the presence of gear on structures that will help assess the secondary entanglement risk. Through this monitoring, removal actions could be taken if entanglement risk appears high thus reducing likelihood of any sea turtles becoming entangled. Currently, published data do not exist on the amount or type of debris that accumulates on offshore wind foundations in the U.S. Atlantic; therefore, the scale of entanglement risk is not known.

The monitoring and disposition requirement provides BOEM with the ability to require removal of entanglement hazards should they occur. Secondary entanglement would pose a risk to the loggerhead sea turtles who have the greatest propensity for foraging or occupying the foundation structure. Although leatherback sea turtles would not be expected to feed off the foundations, their pelagic nature and high degree of fisheries interactions indicate that they would be at risk of secondary entanglement. It is uncertain how much Kemp's ridleys will use offshore structures; however, it is likely that their more coastal distribution will result in a low likelihood of entanglement such that the effects are **discountable**. Similarly, green sea turtles that have a low occurrence in the Project area and primarily forage on SAV, thus posing a low likelihood of entanglement resulting in a **discountable** effect.

Given the foraging strategies and expected presence of sea turtle species in Project area, effects of secondary entanglement in fishing gear within the proposed wind farm foundations **may affect, likely to adversely affect** loggerhead and leatherback sea turtles, but **may affect**, **not likely to adversely affect** green and Kemp's ridley sea turtles.

3.3.5.5 Vessel Traffic Effects on Sea Turtles (C, O&M, D)

Project vessels operating during all phases of the Proposed Action pose a potential collision risk to sea turtles. HRG survey vessels would be limited to site investigation survey and biological survey vessels with periodic activity on the wind farm and export cable routes. Vessel activity is anticipated to be highest during Project construction, followed by decommissioning. The number of vessels operating during O&M will be comparatively lower than during construction, but will be long-term throughout the operational lifespan of the Project.

Vessel-animal collisions are a measurable and increasing source of mortality and injury for sea turtles; the percentage of stranded loggerhead sea turtles with injuries that were apparently caused by vessel strikes increased from approximately 10 percent in the 1980s to over 20 percent in 2004, although some stranded turtles may have been struck post-mortem (NMFS and USFWS 2008). Sea turtles are expected to be most vulnerable to vessel strikes in coastal foraging areas and may not be able to avoid collisions when vessel speeds exceed 2 knots (Hazel et al. 2007). The Recovery Plan for loggerhead sea turtles (NMFS and USFWS 2008) notes that, from 1997 to 2005, 14.9 percent of all stranded loggerheads in the U.S. Atlantic and Gulf of Mexico were documented as having some type of propeller or collision injuries although it is not known what proportion of these injuries occurred before or after the turtle died. Therefore, increased vessel traffic associated with the Proposed Action may increase the potential for impacts from vessel strikes.

Vessels traveling at higher speeds pose a higher risk to sea turtles. Relative to marine mammals, as discussed in Section 3.2.5.6, *Vessel Traffic Effects on Marine Mammals (C, O&M, D)*, sea turtles require more stringent speed reductions before lethal injury probabilities are reduced. To reduce the risk of lethal injury to loggerhead sea turtles from vessel strikes by 50 percent, Sapp (2010) found that small vessels (10 to 30 feet [3 to 6 meters] in length) had to slow down to approximately 7.5 knots (3.9 m/s); the probability of lethal injury decreased by 60 percent for vessels idling at 4 knots (2.1 m/s). The most informative study of the relationship between ship speed and collision risk was conducted on green sea turtles (Hazel et al. 2007). Green sea turtles often failed to flee approaching vessels. Hazel et al. (2007) concluded that green sea turtles rarely fled when encountering fast vessels (>10 knots [5.1 m/s]), infrequently fled when encountering vessels at moderate speeds of around 6 knots (3.1 m/s), and frequently fled when encountering vessels at slow speeds of approximately 2 knots (1 m/s). Based on the observed responses of green sea turtles to approaching boats, Hazel et al. (2007) further concluded that sea turtles rely primarily on vision rather than hearing to avoid vessels; although both may play a role in eliciting responses, sea turtles may habituate to vessel sound and be more likely to respond to the sight of a vessel rather than the sound of a vessel. The potential for collisions between vessels and sea turtles thus increases at night and during inclement weather. Based on these findings, vessel speed restrictions may be inconsequential to reducing strike risk at anything but the slowest speeds (< 2 knots [1 m/s]) due to the relatively low rate of flee responses of sea turtles.

Vessel traffic for the Project would occur during, construction, O&M, and decommissioning phases.

Increased vessel traffic associated with the Project may increase the potential for lethal or sublethal effects from vessel strikes traveling between the Action Area and the ports (Section 1.3, *Description of the Proposed Action*). Overall, while some increase in vessel traffic associated with the Proposed Action would occur, the incremental increase would be relatively small compared to current vessel traffic in the area (see Section 2.1.3.2, *Vessel Traffic*, for baseline vessel data). Construction vessels that would be used for Project construction are described in Table 1-6 of this BA as well as Section 3.4.1.5 and Table 3.4-5 in the COP (Dominion Energy 2022). Typical large construction vessels used in this type of construction have estimated lengths of up to 528 feet (160.9 meters) (COP, Section 3.4.1.5, Dominion Energy 2022). Based on information provided in the COP, construction activities (including offshore installation of WTGs, OSSs, array cables, interconnection cable, and export cable) would require up to 73 construction vessels (Table 1-6), transiting between the various ports and the Action Area on a variety of schedules depending on the phase of construction. Vessel transits would average 46 trips per day through the duration of construction activities. Daily estimated vessel trips would be dependent on the construction period and activity and range from a minimum of 3 trips per day to a maximum of 95 trips per day. Vessel transits under the likely scenario may be reduced overall by 15 percent, though daily estimated vessel trips would still likely range from a minimum of 3 trips per day to a maximum of 95 trips per day. As a result, this BA considers the maximum construction scenario (i.e., the Proposed Action) in the assessment of effects due to vessel traffic. While not directly comparable based on the limitations of AIS data, the average of 46 Project vessel trips per day would represent an approximately 79 percent increase over the current number of unique vessels operating in the Project area, though actual baseline vessel transits are likely considerably underrepresented in the data (see Section 2.1.3.2, *Vessel Traffic*, for a discussion of baseline data limitations). Decommissioning vessel activities are expected to be comparable or less than those anticipated for construction.

Detailed O&M vessel activity is not yet outlined in the COP; however, primary vessel transits will be conducted by CTVs and SOVs. SOVs are large (>230 feet [70 meters] length), DP vessels with expected transit speeds averaging 12 knots or less that have multiple on-site work capabilities including station keeping for weeks at a time. CTVs are usually smaller vessels (65 to 98 feet [20 to 30 meters] in length) with transit speeds of 15 to 25 knots with some having top speeds of 35 knots (ABS 2021). Smaller vessels typically have a shallow draft, which would reduce the likelihood of a subsurface collision with sea turtles; however, animals resting or breathing on the surface would still be affected. In addition, the high rate of speed of these vessels allows less reaction time from the sea turtles and for the vessel operator conducting a maneuver to avoid the sea turtle. For vessel strike risk analysis in this BA, Dominion Energy has estimated that Project operations would involve approximately 75 annual round trips for each of the two crew transfer vessels and 26 annual round trips for the single service operations vessel. In total, and accounting for other vessel transits for routine surveys (25 annual round trips) and the SOV daughter craft (26 annual round trips), an estimated 253 annual roundtrips are expected, with the majority originating from the Norfolk, Virginia O&M facility, which equates to a 1.2 percent increase over baseline vessel activity (see Section 2.1.3.2, *Vessel Traffic*, for a discussion of baseline data limitations). This 253 annual trip estimate is based on current information provided by the Applicant. Additionally, there is not likely to be a reduction in vessel activity during O&M under the likely scenario as compared to the Proposed Action given the small number of annual round trips.

ESA-listed sea turtle densities (Table 3-18) range from low for green, Kemp's ridley, and leatherback sea turtles to moderately high for loggerhead sea turtles for the Lease Area and export cable route from spring through fall (Tetra Tech 2022a):

- Leatherback sea turtle density estimates have a high of 0.00509 animals per km^2 in spring and fall and a low of 0.00427 animal per km^2 in summer (equates to up to 2.3 leatherback sea turtles expected within the 456 km^2 Lease Area during spring and fall).

- Kemp's ridley sea turtle density estimates are 0.04687 animal per km^2 in spring through fall (equates to up to 21 Kemp's ridley sea turtles expected within the 456 km^2 Lease Area during spring through fall);
- Green sea turtle density estimates have a high of 0.07241 animal per km^2 in summer and a low of 0.04561 animals per km^2 in spring (equates to up to 33 green sea turtles expected within the 456 km^2 Lease Area during summer); and
- Loggerhead sea turtle density estimates have a high of 2.514 animals per km^2 in spring and a low of 1.289 animals per km^2 in fall (equates to up to 1,146 loggerhead sea turtles expected within the 456 km^2 Lease Area during spring).

There are limited measures that have been proven to be effective at reducing collisions between sea turtles and vessels (Schoeman et al. 2020). Also, the relatively small size of turtles and the significant time spent below the surface makes their observation by vessel operators extremely difficult, therefore, reducing the effectiveness of PSOs to mitigate vessel strike risk on sea turtles. Nevertheless, the use of trained lookouts and other measures presented in Tables 1-8 and 1-9 would serve to reduce potential collisions. Under the Proposed Action, these vessel strike avoidance measures were included in the effects analysis and are detailed in Table 1-7 and Table 1-8. The measures include:

1. Training and common operating picture awareness:
    a. CVOW-C Monitoring and Coordination Center will establish and maintain a Common Operating Procedure detailing the monitoring, project communication, and external reporting requirements associated with marine mammal and sea turtle detections
    b. Platform for communicating sighting information to all Project vessels
    c. Process for reporting sightings to appropriate external parties and regulatory agencies
    d. Vessel operators and crews shall receive protected species identification training. This training will cover sightings of marine mammals and other protected species known to occur or that have the potential to occur in the Project area. It will include training on making observations in both good weather conditions (i.e., clear visibility, low wind, low sea state) and bad weather conditions (i.e., fog, high winds, high sea states, in glare). Training will include not only identification skills but information and resources available regarding applicable federal laws and regulations for protected species. It will also cover any critical habitat requirements, migratory routes, expected seasonal variation patterns, behavior identification, etc. and will outline reporting procedures.
2. Trained lookouts and reporting:
    e. For all vessels operating north of the Virginia/North Carolina border, between June 1 and November 30, Dominion Energy would have a trained lookout posted on all vessel transits during all phases of the project to observe for sea turtles. The trained lookout would communicate any sightings, in real time, to the captain so that the following requirements can be implemented.
    f. For all vessels operating south of the Virginia/North Carolina border, year-round, Dominion Energy would have a trained lookout posted on all vessel transits during all phases of the project to observe for sea turtles. The trained lookout would communicate any sightings, in real time, to the captain so that the following requirements can be implemented. This requirement is in place year-round for any vessels transiting south of Virginia, as sea turtles are present year-round in those waters.
    g. The trained lookout would monitor https://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.
    h. The trained lookout would maintain a vigilant watch and monitor a Vessel Strike Avoidance Zone (1,640 feet [500 meters]) at all times to maintain minimum separation distances from ESA-listed

species. Alternative monitoring technology (e.g., night vision, thermal cameras, etc.) would be available to ensure effective watch at night and in any other low visibility conditions. If the trained lookout is a vessel crew member, this would be their designated role and primary responsibility while the vessel is transiting. Any designated crew lookouts would receive training on protected species identification, vessel strike minimization procedures, how and when to communicate with the vessel captain, and reporting requirements.

i. If a sea turtle is sighted within 328 feet (100 meters) or less of the operating vessel's forward path, the vessel operator would slow down to 4 knots (unless unsafe 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 328 feet (100 meters) at which time the vessel may resume normal operations. If a sea turtle is sighted within 164 feet (50 meters) of the forward path of the operating vessel, the vessel operator would shift to neutral when safe to do so and then proceed away from the turtle at a speed of 4 knots. The vessel may resume normal operations once it has passed the turtle.

j. Vessel captains/operators would 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 would slow to 4 knots while transiting through such areas.

k. All vessel crew members would be briefed in the identification of sea turtles and in regulations and best practices for avoiding vessel collisions. Reference materials would 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) would 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.

l. The only exception is when the safety of the vessel or crew necessitates deviation from these requirements on an emergency basis. If any such incidents occur, they would be reported to NMFS within 24 hours.

m. If a vessel is carrying a PSO or trained lookout for the purposes of maintaining watch for NARWs, an additional lookout is not required and this PSO or trained lookout would maintain watch for whales and sea turtles.

n. Vessel transits to and from the Action Area, that require PSOs will maintain a speed commensurate with weather conditions and effectively detecting sea turtles prior to reaching the 328 feet (100 meters) avoidance measure.

3. Vessel separation:

o. Vessels will maintain, to the extent practicable, separation distances of >164 feet (50 meters) for sea turtles

In addition to the previously stated mitigation, all Project vessels would comply with NMFS regulations and speed restrictions as applicable for NARW, including the 10 knot speed restrictions in any SMA, DMA, or Slow Zone and other seasonal and visibility restrictions (see Section 3.2.5.6, *Vessel Traffic Effects on Marine Mammals [C, O&M, D]*). Although the 10-knot (5.1 m/s) speed restrictions in certain areas would reduce potential impacts, sea turtle collisions may still occur at slow speeds and individuals would still be vulnerable when vessels travel over 2 knots. Additionally, effective detection of sea turtles in low visibility conditions (nighttime, fog, inclement weather) is likely low, thereby increasing the vulnerability of sea turtles to vessel strike risk during these periods, even with all other mitigative measures implemented.

There is a moderate risk of interaction between sea turtles and Project vessel traffic during construction based on the density of sea turtles in the Action Area (Table 3-18) and the estimated vessel activity over the total construction period (Section 1.3.1, *Construction and Installation*). An estimated 78 round trips per year is expected throughout the duration of the Project's anticipated 33-year operational period. Based on the density of sea turtles in the Project area (Table 3-18) and the estimated activity over the operational life of the Project, there is a moderate risk of vessel interaction with sea turtles in the Action Area during O&M. The operational conditions combined with planned mitigation measures would reduce collision risk during all Project phases. Vessel strikes would be minimized by monitoring and mitigation activities such as crew training requirements, vessel speed reduction, and separation distances, as required (Section 1.3.5, *Proposed Mitigation, Monitoring, and Reporting Measures*). Although vessel strike risks to sea turtles are expected to be reduced, some unavoidable effects on sea turtles may occur due to the difficulty in detecting sea turtles, especially during periods of low visibility (i.e., nighttime, fog, inclement weather) or those that just below the surface but within the vessel's draft.

The contribution of the number of vessel trips under the proposed Project is considered moderate during construction and relatively small during O&M compared to existing vessel activity (see Section 2.1.3.2, *Vessel Traffic*, for baseline vessel data). Mitigation measures (e.g., minimum vessel separation distances, vessel speed restrictions) would reduce the overall encounter potential. The deployment of trained observers on all vessels along with operable and effective monitoring equipment (measure numbers 3 and 4 in Table 1-7 and measure number 10(d) in Table 1-8) will additionally serve to minimize the collision risk with sea turtles. As a result of these measures, the probability of a vessel strike between Project vessels and sea turtles throughout all Project phases would be reduced, but not eliminated.

Based on this analysis, Project vessel traffic leading to collisions with sea turtles cannot be discounted given the expected density and distribution of sea turtles in the Action Area, the incremental increase in vessel traffic, and the difficulty in detecting sea turtles during transits. The seasonal patterns of sea turtles in the region will result in a reduction in risk during periods of time when individuals are less likely to be present, such as during winter months. The species and age classes most likely to be affected are adults, sub-adults, and juveniles of leatherback, Kemp's ridley, loggerhead, and green sea turtles.

An additional potential effect of vessel traffic on sea turtles or their prey is spills from refueling or vessel-to-vessel/vessel-to-structure collisions. Effects on individual sea turtles, including decreased fitness, health effects, and mortality, may occur if individuals are present in the vicinity of a spill, but accidental releases are expected to be rare, and injury or mortality are not expected to occur. Project vessels would comply with USCG requirements for the prevention and control of oil and fuel spills and would implement proposed BMPs for waste management and mitigation as well as marine debris awareness training for Project personnel, reducing the likelihood of an accidental release. Dominion Energy will have an Oil Spill Response Plan (COP, Appendix Q; Dominion Energy 2022) in place that would decrease potential effects in the unlikely event of a spill. Therefore, vessel spills are not anticipated and distribution of spills into the surrounding environment where damage may occur to animals or habitat is not anticipated when monitoring and mitigation activities are effectively implemented, as outlined. Thus, vessel accidents and spills will have an **insignificant** effect on ESA-listed sea turtles. Therefore, the effects of spills resulting from vessel traffic **may affect, not likely to adversely affect** ESA-listed sea turtles. However, the risk of an adverse effect on sea turtles resulting from vessel strikes due to vessel traffic during activities conducted under the Proposed Action **may affect, likely to adversely affect** ESA-listed sea turtles.

3.3.5.6 Fisheries Monitoring Surveys Effects on Sea Turtles (C)

As mentioned in Section 3.2.5.7, *Fisheries Monitoring Survey Effects on Marine Mammals (C)*, fisheries monitoring surveys for the Project are proposed prior to construction. The details of each survey type can be found in Section 1.3.4, *Fisheries Monitoring Plans*. Potential impacts to ESA-listed sea turtles arising from fisheries monitoring surveys prior to construction assessed elsewhere in this document are related to entanglement risk, increased vessel traffic, and increased for potential for vessel strikes. Increased vessel traffic and potential for vessel strike stressors are discussed in Section 3.3.5.5, *Vessel Traffic Effects on*

Sea Turtles (C, O&M, D). Additional effects of survey methods include; habitat disturbance during pot setting, and potential for entrapment or entanglement in monitoring gear.

Impacts to ESA-listed sea turtles specific to each survey type and equipment are described in Section 3.3.5.6.1, *Welk Surveys*, and Section 3.3.5.6.2, *Black Sea Bass Surveys*.

3.3.5.6.1 Welk Surveys

The welk surveys have been designed while actively working with VADEQ, VMRC, VIMS, Rutgers University, and commercial fishers.

Welk pots and the associated lines and rigging, have the potential to cause adverse impacts on sea turtles resulting in entanglement in lines and floats. Of all the Atlantic sea turtles, the leatherback seems to be the most vulnerable to entanglement in trap/pot fishing gear, possibly due to its physical characteristics, diving and foraging behaviors; distributional overlap with the gear; and the potential attraction to prey items that collect on buoys and buoy lines at or near the surface (NMFS 2016b). Individuals entangled in pot gear generally have a reduced ability to forage, dive, surface, breathe, or perform other behaviors essential for survival (Balazs 1985). In addition to mortality, gear entanglement can restrict blood flow to extremities and result in tissue necrosis and death from infection. Individuals that survive may lose limbs or limb function, decreasing their ability to avoid predators and vessel strikes (NMFS 2016b). There is a risk of sea turtle entanglement, particularly for leatherbacks in trap or pot gear.

Welks, which are sea turtle prey items are the focus of these surveys and in addition, other prey items such as crabs and fish may also be removed from the marine environment as bycatch in trap gear. Some sea turtle species or know to feed on these some of these species that may be caught as bycatch in the trap/pot gear. However, all bycatch is expected to be returned to the water alive, dead, or injured to the extent that the organisms will shortly die. Injured or deceased bycatch would still be available as prey for sea turtles, particularly loggerhead sea turtles, which are known to eat a variety of live prey as well as scavenge dead organisms. Given this information, any effects on sea turtles from collection of potential sea turtle prey in the trap gear will be so small that they cannot be meaningfully measured, detected, or evaluated and, therefore, effects are **insignificant**.

The design of the pot and line layout has been modified to reduce the number of vertical lines by deploying the strings of multiple pots along the seafloor connected by groundlines to reduce the potential of entanglement by sea turtles. The sampling protocols will be constructed to be consistent with specifications that align with the current industry practices (i.e., pot material, volume, bait type, soak time). The monitoring efforts will occur seasonally twice a month during times of traditionally high fishing activity (November to March) and once a month during times of traditionally low fishing activity (April to October). In addition, Dominion Energy's proposed monitoring contractor, VIMS has submitted a fisheries permit application to NOAA GARFO and a request for a protected species risk assessment in October 2022 and received a letter of acknowledgement but to date has not received further feedback. However, a similar survey method is being proposed for black sea bass monitoring (Section 3.3.5.6.2, *Black Sea Bass Surveys*) and GARFO's PRD determined that the plan as designed does not include any activities that are likely to result in a take of a protected marine species. A similar determination is expected for the welk monitoring plan. Therefore, the potential for entanglement of ESA-listed sea turtle based upon the limited number of associated buoy lines the entanglement in gear would be extremely unlikely to occur and is **discountable**.

3.3.5.6.2 Black Sea Bass Surveys

Black sea bass pots and the associated lines and rigging, have the potential to cause adverse impacts on sea turtles resulting in entanglement in lines and floats. Of all the Atlantic sea turtles, the leatherback seems to be the most vulnerable to entanglement in trap/pot fishing gear, possibly due to its physical characteristics, diving and foraging behaviors; distributional overlap with the gear; and the potential attraction to prey items that collect on buoys and buoy lines at or near the surface (NMFS 2016b). Individuals entangled in pot gear generally have a reduced ability to forage, dive, surface, breathe, or perform other behaviors essential for survival (Balazs 1985). In addition to mortality, gear entanglement can restrict blood flow to extremities and result in tissue necrosis and death from infection. Individuals that survive may lose limbs or limb function, decreasing their ability to avoid predators and vessel strikes (NMFS 2016b). There is a risk of sea turtle entanglement, particularly for leatherbacks in trap or pot gear.

Sea turtle prey items such as crabs and fish may also be removed from the marine environment as bycatch in trap gear. Some sea turtle species or know to feed on these some of these species that may be caught as bycatch in the trap/pot gear. However, all bycatch is expected to be returned to the water alive, dead, or injured to the extent that the organisms will shortly die. Injured or deceased bycatch would still be available as prey for sea turtles, particularly loggerhead sea turtles, which are known to eat a variety of live prey as well as scavenge dead organisms. Given this information, any effects on sea turtles from collection of potential sea turtle prey in the trap gear will be so small that they cannot be meaningfully measured, detected, or evaluated and, therefore, effects are **insignificant**.

The design of the pot and line layout has been modified to reduce the number of vertical lines by deploying the strings of multiple pots along the seafloor connected by groundlines to reduce the potential of entanglement by sea turtles. The sampling protocols will be constructed to be consistent with specifications that align with the current industry practices (i.e., pot material, volume, bait type, soak time). The monitoring efforts will occur seasonally twice a month during times of traditionally high fishing activity (November to March) and once a month during times of traditionally low fishing activity (April to October). In addition, Dominion Energy’s proposed monitoring contractor, VIMS has submitted a fisheries permit application to NOAA GARFO and a request for a protected species risk assessment in August 2022 and received a letter of acknowledgement in September 2022 and received confirmation from GARFO’s PRD that the plan as designed does not include any activities that are likely to result in a take of a protected marine species. Therefore, the potential for entanglement of ESA-listed sea turtle based upon the limited number of associated buoy lines the entanglement in gear would be extremely unlikely to occur and is **discountable**.

3.3.5.6.3 Atlantic Surf Clam Surveys

The proposed dredging activities for the Atlantic survey clam surveys have the potential to cause adverse impacts on sea turtles resulting primarily in turbidity, entrainment, and vessel strike. Sea turtles are vulnerable to impingement or entrainment in dredges, which can result in injury or mortality (USACE 2020). However, the risk of interactions between dredges and individual sea turtles is expected to be lower in the open ocean areas where dredging may occur for the proposed Project’s Atlantic surf clam surveys compared to nearshore navigational channels (Michel et al. 2013; USACE 2020). This may be due to the lower density of sea turtles in these areas, as well as differences in behavior and other risk factors. Additionally, as discussed in Section 3.3.5.4, effects of turbidity on turtles, their habitat or their prey would be isolated and temporary. Through the implementation of standard vessel strike avoidance mitigation measures that require minimum separation distances form all ESA-listed sea turtles (Section 1.3.5), the risk of vessel strikes can also be effectively mitigated. The likelihood of potential effects on ESA-listed turtles is further reduced by the short duration of these dredge surveys, as each dredge will sample the bottom for 5 minutes at a vessel speed of 1.5 knots, and the full survey is anticipated to occur over a maximum of 7 days in the late spring/early summer of 2023, and only medium-sized vessel will be used (Section 1.3.4.3).

Dominion Energy’s proposed monitoring contractor, VIMS has submitted a fisheries permit application to NOAA GARFO and a request for a protected species risk assessment in August 2022 and received a letter of acknowledgement in September 2022 and received confirmation from GARFO's PRD that the plan as designed does not include any activities that are likely to result in a take of a protected marine species. Therefore, the potential risk of effect on ESA-listed sea turtles based upon the limited duration of dredging activities and the implementation of NOAA-required risk reduction measures vessel strikes would be extremely unlikely to occur and is **discountable.**

3.3.5.6.4 Summary of Fisheries Monitoring Survey Effects

As described in Section 3.3.5.6.1, *Welk Surveys*, and Section 3.3.5.6.2, *Black Sea Bass Surveys*, 3.3.5.6.3, *Atlantic Surf Clam Surveys,* any effects from monitoring surveys (e.g., entanglement, reductions in prey) on sea turtles are considered unlikely to occur. A number of monitoring and mitigation measures are designed to further minimize the risk of entanglement and monitor the potential effects of fisheries monitoring surveys (Table 1-8), including the following:

1. All sampling gear would be hauled at least once every 30 days, and all gear would be removed from the water and stored on land between survey seasons to minimize risk of entanglement.
2. To facilitate identification of gear on any entangled animals, all trap/pot gear used in the surveys would be uniquely marked to distinguish it from other commercial or recreational gear. Using black and yellow striped duct tape, place a 3-foot-long mark within 2 fathoms of a buoy. In addition, using black and white paint or duct tape, place three additional marks on the top, middle and bottom of the line. These gear marking colors are proposed as they are not gear markings used in other fisheries and are, therefore, distinct. Any changes in marking would not be made without notification and approval from NMFS.
3. If any survey gear is lost, all reasonable efforts that do not compromise human safety would be undertaken to recover the gear. All lost gear would be reported to NMFS within 24 hours of the documented time of missing or lost gear. This report would include information on any markings on the gear and any efforts undertaken or planned to recover the gear.
4. Dominion Energy would ensure that vessel operators, employees, and contractors engaged in offshore activities pursuant to the approved COP complete marine trash and debris awareness training annually. The training consists of two parts: (1) viewing a marine trash and debris training video or slide show; and (2) receiving an explanation from management personnel that emphasizes their commitment to the requirements. The marine trash and debris training videos, training slide packs, and other marine debris related educational material may be obtained at https://www.bsee.gov/debris or by contacting BSEE. The training videos, slides, and related material may be downloaded directly from the website. Operators engaged in marine survey activities would continue to develop and use a marine trash and debris awareness training and certification process that reasonably assures that their employees and contractors are in fact trained.
5. At least one of the survey staff onboard the trawl surveys and ventless trap surveys would have completed Northeast Fisheries Observer Program observer training (within the last 5 years) or other training in protected species identification and safe handling (inclusive of taking genetic samples from Atlantic sturgeon). Reference materials for identification, disentanglement, safe handling, and genetic sampling procedures would be available on board each survey vessel. BOEM would ensure that Dominion Energy prepares a training plan that addresses how this requirement would be met and that the plan is submitted to NMFS in advance of any trawl or trap surveys. This requirement is in place for any trips where gear is set or hauled.
6. Vessels deploying fixed gear (e.g., pots/traps) would have adequate disentanglement equipment (i.e., knife and boathook) onboard. Any disentanglement would occur consistent with the Northeast Atlantic Coast STDN Disentanglement Guidelines.
7. Any sea turtles or ESA-fish caught, retrieved, or both in any fisheries survey gear would first be identified to species or species group. Each ESA-listed species caught, retrieved, or both would then

be properly documented using appropriate equipment and data collection forms. Biological data, samples, and tagging would occur. Live, uninjured animals should be returned to the water as quickly as possible after completing the required handling and documentation.

8. Any sea turtles or ESA-fish caught and retrieved in gear used in fisheries surveys would be handled and resuscitated (if unresponsive) according to established protocols and whenever at-sea conditions are safe for those handling and resuscitating the animal(s) to do so.
9. GARFO PRD would be notified as soon as possible of all observed takes of sea turtles and ESA-fish occurring as a result of any fisheries survey.

Given the limited duration and spatial extent of all fisheries monitoring survey efforts and the implementation of the monitoring and mitigation measures, the effects from monitoring surveys (e.g., entanglement, reductions in prey) on sea turtles are considered extremely unlikely to occur and **discountable** or are expected to be so small that they cannot be meaningfully measured, evaluated, or detected and are, therefore, **insignificant**. Therefore, the effects of fisheries monitoring surveys from the Project **may affect, not likely to adversely affect** ESA-listed sea turtles.

3.3.5.7 Electromagnetic Field Effects on Sea Turtles (O&M)

Similar to the review conducted by the same author on marine mammals, Normandeau (2011) conducted a review of sea turtle sensitivity to human-made EMF in the scientific literature. The available evidence indicates that sea turtles are magnetosensitive and orient to the earth's magnetic field for navigation, but they are unlikely to detect magnetic fields below 50 mG. Normandeau (2011) summarized theoretical concerns in the literature that human-created EMF could disrupt adult migration to and juvenile migration from nesting beaches. However, the only reported nesting beach within the Project area is for loggerhead sea turtles in Virginia Beach (Section 3.3.3.2, *Potential Habitat Surrounding and within the Immediate Project Area*). Although the Proposed Action would produce magnetic field effects above the 50-mG threshold at selected locations where transmission cables lie on the bed surface, the affected areas would be localized around unburied cable segments and limited to within 3 feet (1 meter) of the cable surface. Given the lack of sensitive life stages present, the limited field strength involved, and limited potential for highly mobile species like sea turtles to encounter field levels above detectable thresholds, the effects of Proposed Action–related EMF exposure on ESA-listed sea turtles would be **discountable**. Therefore, effects of exposure to EMF due to the Proposed Action **may affect, not likely to adversely affect** ESA-listed sea turtles.

3.4 Marine Fish

The only ESA-listed fish species considered for analysis in this BA are the Atlantic sturgeon and the giant manta ray (*Mobula birostris*). Applicable life history and distributional information from previous surveys and available literature are provided in the following subsections.

3.4.1 Atlantic Sturgeon

The Atlantic sturgeon is a large (up to 13 feet [4 meters] long and can reach up to 600 pounds), long-lived, anadromous fish. They primarily feed on benthic invertebrates but will adjust their diet to exploit other types of prey resources when available, and have been documented feeding on species such as anchovies (*Engraulidae*), silversides (*Atherinidae*), herrings (*Clupeidae*), and sand lances (*Ammodytidae*) (NMFS 2022h; Kritzer et al. 2016). Johnson et al. (1997) found that polychaetes composed approximately 86 percent of the diet of adult Atlantic sturgeon captured in the New York Bight. Isopods, amphipods, clams, and fish larvae composed the remainder of the diet, with the latter accounting for up to 3.6 percent of diet in some years. In contrast, Guilbard et al. (2007) observed that small fish accounted for up to 38 percent of subadult Atlantic sturgeon diet in the St. Lawrence River estuarine transition zone during summer, but less than 1 percent in fall. The remainder of the species' diet consisted primarily of amphipods, oligochaetes, chironomids, and nematodes, with the relative importance of each varying by season.

Five DPSs (or geographic portions of a species' or subspecies' population) of the Atlantic sturgeon are listed under the ESA (four DPSs as federally Endangered, the Gulf of Maine DPS as Threatened) (77 *FR* 5880, 77 *FR* 5914). Though these DPSs represent distinct geographic populations along the U.S. Atlantic Coast, individuals from all DPSs migrate across the coast and are not easily distinguished visually from one another. Therefore, any Atlantic sturgeon encountered in the Project area is considered endangered for the purpose of this analysis. No critical habitat for the Atlantic sturgeon has been designated in the Project area (82 *FR* 39160). Atlantic sturgeon are a benthic fish that are found from Canada to Florida in estuarine habitats and rivers as well as in coastal and shelf marine environments. Atlantic sturgeon are anadromous, meaning they are born in freshwater, migrate to sea, and then back to freshwater to spawn. There are 22 rivers along the U.S. East Coast that currently host spawning Atlantic Sturgeon (NMFS 2022h). Spawning in rivers from Delaware to Canada occurs from spring to early summer; some rivers may support a second fall spawning population, though supporting data is limited (NMFS 2022h). Juveniles typically remain in their natal river for two to three years before migrating into coastal and ocean waters (NMFS 2022h). Subadults move out to estuarine and coastal waters in the fall; and adults inhabit fully marine environments and migrate through deep water when not spawning (Atlantic Sturgeon Status Review Team [ASSRT] 2007). While most individual are most common near their natal river, extensive migrations within the marine environment have been documented for both adults and subadults, with some individuals traveling thousands of kilometers from their natal rivers (Kazyak et al. 2021). Five genetically DPS make up the U.S. East Coast population; the Project area falls within the New York Bight DPS. However, given the species' proclivity to migrate, with extensive movements up and down the U.S. East Coast and into Canadian waters, Atlantic sturgeon encountered within the Project area may originate from any of the five DPSs (Kazyak et al. 2021).

There is no available information on the hearing capabilities of Atlantic sturgeon specifically, although the hearing of other species of sturgeon have been studied. Meyer et al. (2010) and Lovell et al. (2005b) studied the auditory system morphology and hearing ability of lake sturgeon (*Acipenser fulvescens*), a closely related species. The Acipenseridae (sturgeon family) have a well-developed inner ear that is independent of the swim bladder and it, therefore, appears as though sturgeon rely directly on their ears for hearing. The results of these studies indicate a generalized hearing range from 50 Hz to approximately 700 Hz, with greatest sensitivity between 100 and 300 Hz. Popper (2005) summarized studies measuring the physiological responses of the ear of European sturgeon (*Acipenser sturio*). The results of these studies suggest sturgeon are likely capable of detecting sounds from below 100 Hz to about 1 kHz. While sturgeon do have a swim bladder, it is not involved in hearing (Popper et al. 2014).

3.4.1.1 Current Status

NMFS listed the New York Bight DPS as Endangered in 2012 (77 *FR* 5879) and the critical habitat designation was finalized in 2017 (82 *FR* 39160). The IUCN lists the Atlantic sturgeon as Near Threatened (St. Pierre and Parauks 2006) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora lists the species under Appendix II, which lists species that are not necessarily now threatened with extinction but may become so unless trade is closely controlled. The species is also listed as Endangered by the VA DWR (2022). The most recent status review for the Atlantic sturgeon was conducted in 2007. In this review, commercial bycatch was assessed, which showed that the majority (61 percent of tagged sturgeon recaptures came from ocean waters within 4.8 kilometers of shore, with the lowest ocean bycatch occurring in the summer months (July to September) (ASSRT 2007). The Atlantic Sturgeon benchmark (Atlantic States Marine Fisheries

Commission 2017) indicates that all DPS stocks are depleted but recovering. It is estimated that biomass and abundance are currently higher than that in 1998 (last year of available survey data) for the New York Bight DPS (75 percent average probability), which primarily spawn in the Delaware and Hudson Rivers. The estimated abundance of age-0 to age-1 Atlantic sturgeon in the Delaware River in 2014 was 3,656 individuals (Hale et al. 2016), which is similar to the age-1 estimate of 4,314 for the Hudson River in 1995 (Peterson et al. 2000). Similar estimates from the 2007 status review suggest that the Hudson River population consists of approximately 4,600 wild juveniles with a spawning stock of 870 adults. Current threats to Atlantic sturgeon within critical habitat include dams and turbines, dredging, water quality, and climate change. Critical habitat for the Atlantic sturgeon encompasses approximately 773 kilometers of 31 tidally affected rivers from Florida to Maine, including the Delaware River bordering Delaware, New Jersey, and Pennsylvania. No designated critical habitat for Atlantic sturgeon exists within the Project area.

Recently, Kahn et al. (2019) used a closed population mark-recapture model to estimate the population of Atlantic sturgeon from 2013 to 2018 in the York River, Virginia based on data collected from an acoustic tags deployed during sturgeon surveys within the York River. Population estimates (95% confidence interval) ranged from 73 to 222 individuals across their study. Since Atlantic sturgeon do not spawn every year, the trend in these estimates do not suggest a recovering or declining population, but a variability in the number of adults that return to spawn each year. Adult sex ratios from these data are estimated to approximately 0.51 (95% confidence intervals of 0.43-0.58) (Kahn et al. 2021).

Both spawning and non-spawning fish are known to utilize Chesapeake Bay with females and males arriving as early as late February (7.7 degrees C) and early March (6.4 degrees C) and departing as late as the end of January (6.4 degrees C). Timing of peak occupation ranges from April to August and again from mid-October to early December. Females tend to remain in bay longer than males before spawning but leave faster than males after spawning (Kahn pers com to G. Fulling [BOEM] - courtesy copy of draft Fishery Bulletin publication).

3.4.1.2 Potential Habitat Surrounding and within the Project Area

In the Mid-Atlantic, mature females generally spawn every 1 to 5 years by migrating upriver from April to May and depositing more than 400,000 eggs on gravel or other hard substrates (USACE 2015). In non-spawning years, adults remain in marine waters year-round (Smith and Clugston 1997). Larvae develop into juveniles as they migrate downstream; juveniles remain in brackish waters until they grow to 30 to 35 inches (75 to 90 centimeters) and move into nearshore coastal waters (Stein et al. 2004; Erickson et al. 2011). The nearest Atlantic sturgeon spawning areas to the Project area the James and York Rivers, which provide important habitat for the Chesapeake Bay DPS (VIMS 2022c). Adult Atlantic sturgeon utilize Chesapeake Bay for most of the year, with highest occurrences during the summer months. As the waters begin to warm, adults can begin moving back into Chesapeake Bay as early as February for females and March for males. Spawning in these rivers can occur in the spring (April to May) and during the fall (September to October). Based on these broad migratory movement patterns, Atlantic sturgeon are most likely to utilize the offshore waters, including in the vicinity of the Lease Area, during the winter months.

Given the presence of spawning adults in the James and York Rivers, the Atlantic sturgeon is known to be present in the Project area, potentially year-round in non-spawning years. In spawning years, some adults may be present in the Project area, but most spawning adults would have migrated to their spawning rivers and would not be expected to be present near any Project activities.

3.4.2 Giant Manta Ray

As the largest ray species, the giant manta ray occurs globally in tropical, sub-tropical, and temperate waters in both offshore and coastal regions (NMFS 2022i). They are slow growing, highly migratory animals with sparsely distributed and fragmented populations throughout the world. Regional population sizes are small, estimated to be between 100 to 1,500 individuals (Marshall et al. 2020; NMFS 2022i). They occur off the East Coast U.S. most commonly in waters ranging from 66°F to 72°F (19°C to 22°C) from Florida to the Carolinas, though they can also occur off the Mid-Atlantic and Northeast (Farmer et al. 2022). Giant manta rays undergo seasonal migrations, which are thought to coincide with the movement of zooplankton, ocean current circulation and tidal patterns, seasonal upwelling, sea surface temperature, and possibly mating behavior (NMFS 2022i). The giant manta ray is a seasonal visitor to coastlines, oceanic island groups, and offshore pinnacles and seamounts that feature high levels of primary and secondary productivity. They primarily feed on planktonic organisms including euphausiids and copepods (NMFS 2022i). Giant manta rays utilize a wide variety of depths during feeding, including aggregations in waters less than 33 feet (10 meters) deep and dives 656 to 1,476 feet (200 to 450 meters), which are likely driven by vertical shifts in their prey location (NMFS 2022i).

A compilation of giant manta ray detections from Farmer et al. (2022) showed regular sightings within the Mid-Atlantic during standardized surveys. Records north of Cape Hatteras were concentrated during the summer months (mainly June through September) and showed use of OCS, slope, and nearshore waters; most abundant sightings for the region occurred on the shelf and in proximity to the slope edge (Farmer et al. 2022). Giant manta rays were reported in bays and estuaries in the southern U.S. and Gulf of Mexico (Farmer et al. 2022). The detection information was used to model potential distribution, which showed preference for sea surface temperatures from 63°F to 90°F (17°C to 32°C) with a strong affinity for thermal fronts (Farmer et al. 2022). As expected from the sighting records, the model predicted highest probability of occurrence north of Cape Hatteras during warmer months when sea temperatures are highest (May to October). Forward predictions by the model show a northward shift for this species distribution through 2024 (Farmer et al. 2022).

Giant manta rays belong to the subclass Elasmobranchii that, like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Popper and Schilt 2008). Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2003, 2012; Casper and Mann 2009; Casper 2006; Ladich and Fay 2013; Myrberg Jr. 2001).

The hearing range for the giant manta ray specifically is not known and there are no known studies that have tested their hearing sensitivity. Known hearing sensitivity of several elasmobranchs species is discussed in Mickle and Higgs (2022), which range from 10 Hz (lemon sharks) to 1500 Hz (bull sharks). A benthic skate (*Leucoraja erinacea*) has a hearing sensitivity range of 100 to 800 Hz (Casper et al. 2003) and may represent the mid-range of hearing sensitivities for the pelagic giant manta ray.

3.4.2.1 Current Status

The giant manta ray is listed as Threatened under the ESA and Endangered on the IUCN Red List (Marshall et al. 2020; NMFS 2022i). Commercial fishing is the primary threat to the giant manta ray (NMFS 2022i) as it is targeted and caught as bycatch in several global fisheries throughout its range. No designated critical habitat exists for the giant manta ray in the Project area.

3.4.2.2 Potential Habitat Surrounding and within the Project Area

The species is known to occur off the coast of Virginia may occasionally transit through the Project area (Farmer et al. 2022). There are substantial records of giant manta rays from systematic surveys (Farmer et al. 2022) as well as ancillary reports made by fishermen and recreational boaters in the Mid-Atlantic region (e.g., Eichmann, 2016). The highest likelihood for giant manta ray occurrence within the Project area is during May through October (Farmer et al. 2022) in shelf habitats. Although the giant manta ray is often observed in shallow coastal waters and estuaries in warmer climates, their preference is for deeper waters and thermal fronts north of Cape Hatteras (Farmer et al. 2022). However, giant mantas have been reported close to shore in systematic surveys along the U.S. East Coast and may, therefore, be found occasionally in the export cable route corridor.

3.4.3 Effects Analysis for Marine Fish

3.4.3.1 Underwater Noise Effects on Marine Fish

3.4.3.1.1 Acoustic Criteria

For fish, NMFS has adopted recoverable injury criteria relative to impulsive sources using dual criteria developed by the Fisheries Hydroacoustic Working Group (FHWG 2008). These dual criteria were created to ensure that fish were neither exposed to high levels of accumulated energy for repeated impulsive sounds nor single strikes. The FHWG (2008) criteria include a maximum accumulated SEL and a maximum Lpk for a single pile-driving strike (Popper et al. 2014). Currently, FHWG (2008) recommends a 150 dB re 1 µPa criterion for behavioral response of all fish and does not distinguish between impulsive and non-impulsive noise. Threshold criteria are also available from Popper et al. (2014) which have not been adopted by NMFS, but they distinguish between different types of fish based on their hearing sensitivity. The modeling report associated with the COP also presents ranges to the Popper et al. (2014) thresholds. For these reasons, the Popper et al. (2014) thresholds are provided here for reference in the discussion. Table 3-24 outlines the acoustic thresholds for the onset of PTS, significant behavioral disruptions for marine fish, or both, for both impulsive and non-impulsive noise sources.

Swim bladders in some fish play a role in sound detection and perception; therefore, a fish's susceptibility to injury from noise exposure depends, in part, on the presence and function of a swim bladder. Thus, in development of fish noise exposure guidelines presented in Table 3-24, fish are categorized based on the presence or absence and role of the swim bladder in hearing as follows:

- Fish with no swim bladder or other gas chamber. This group includes elasmobranchs (sharks and rays, e.g., giant manta ray), jawless fishes, flatfish, and gobies that are expected to be only capable of detecting particle motion (Casper et al. 2012). These species are least susceptible to barotrauma i.e., tissue injury that results from rapid pressure changes (e.g., forced change in depth, explosions, and intense sound) (Popper et al. 2014).
- Fish with swim bladders or other gas volumes not involved in hearing. This group includes some pelagic species such as Atlantic salmon and tuna, as well as Atlantic sturgeon. These fishes are susceptible to barotrauma and are only capable of detecting particle motion.
- Fish with swim bladder or other gas volumes involved in hearing. This group includes Atlantic cod, herring, shad, otophysans, mormyrids, and squirrelfish. They detect both sound pressure and particle motion and are susceptible to barotrauma. There are no ESA-listed marine fish species included in this BA that fall into this category so it will not be discussed further.
- Fish eggs and larvae (Popper et al. 2014).

Table 3-24 Acoustic thresholds for onset of acoustic effects (injury or behavioral disturbance) for ESA-listed fish

Fish Category	Impulsive Sources			Non-impulsive Sources	
	Recoverable Injury		Behavioral Disturbance	Recoverable Injury	Behavioral Disturbance
	Lpk	SEL_{24h}	SPL	SPL	SPL
Fish <2 g	206	183	150	-	150
Fish >2 g	206	187	150	-	150
Fish without swim bladder (includes giant manta ray)	213	216	150	-	150
Fish with swim bladder not involved in hearing (includes Atlantic sturgeon)	207	203	150	-	150
Eggs and Larvae	207	210	150	-	150

Source: Fisheries Hydroacoustic Working Group (2008); Popper et al. (2014)
- = threshold not available; Lpk = peak sound pressure level in units of decibels referenced to 1 micropascal; PTS = permanent threshold shift SEL_{24h} = sound exposure level over 24 hours in units of decibels referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of decibels referenced to 1 micropascal.

The current classification considers effects on fish mainly through sound pressure without taking into consideration the effect of particle motion. Popper et al. (2014) and Popper and Hawkins (2018) suggest that extreme levels of particle motion induced by various impulsive sources may also have the potential to affect fish tissues and that proper attention needs to be paid to particle motion as a stimulus when evaluating the effects of sound on aquatic life. However, lack of evidence for any source due to extreme difficulty of measuring particle motion and determining fish's sensitivity to particle motion renders establishing of any guidelines or thresholds for particle motion exposure currently impossible (Popper et al. 2014; Popper and Hawkins 2018). Mitigation to reduce adverse effects from underwater noise on ESA-listed marine fish, such as soft-start procedures, have been proposed for the Project (Tables 1-8 and 1-9).

3.4.3.1.2 Assessment of Effects

3.4.3.1.2.1 WTG and OSS Foundation Installation (C)

A detailed description of underwater noise modeling conducted for the installation of WTG and OSS under the Proposed Action is described in Section 3.2.5.2.3.1 *WTG and OSS Foundations (C)*. This section summarizes the results of the acoustic modeling for the installation of the WTG and OSS foundations as it relates to the potential for effects on the Atlantic sturgeon and giant manta ray. Results for the acoustic ranges to the thresholds for fish provided in Table 3-21 resulting from impact pile driving of the WTG and OSS foundations under the various modeling scenarios are provided in Table 3-25, and threshold ranges for vibratory pile driving of the WTG and OSS foundations are provided in Table 3-26.

Table 3-25 Maximum modeled distances (meters) to recoverable injury and behavioral thresholds resulting from impact pile driving during installation of the WTG and OSS foundations with 10 dB noise mitigation

Fish Group	WTG Monopile 1 - Standard			WTG Monopile 2 – Hard-to-drive			WTG Monopile 3 – One Standard and One Hard-to-drive			OSS Foundation		
	Injury (Lpk)	Injury (SEL_{24h})	Behavior (SPL)	Injury (Lpk)	Injury (SEL_{24h})	Behavior (SPL)	Injury (Lpk)	Injury (SEL_{24h})	Behavior (SPL)	Injury (Lpk)	Injury (SEL_{24h})	Behavior (SPL)
Fish <2 g	445	6,131	15,010	445	6,824	15,010	445	8,291	15,010	94	4,000	5,530
Fish ≥2 g	445	4,501	15,010	445	5,085	15,010	445	5,880	15,010	94	2,959	5,530
Fish with no swim bladder	242	352	15,010	242	389	15,010	242	477	15,010	0	213	5,530
Fish with swim bladder not involved in hearing	402	748	15,010	402	829	15,010	402	1,042	15,010	74	488	5,530
Eggs and Larvae	402	748	NA	402	829	NA	402	1,042	NA	74	488	NA

Source: Dominion Energy 2022
dB = decibel; Lpk = peak sound pressure level in units of dB referenced to 1 micropascal; OSS = offshore substation; SEL_{24h} = sound exposure level over 24 hours in units of dB referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of dB referenced to 1 micropascal; WTG = wind turbine generator.

Table 3-26 Maximum modeled distances (meters) to physiological injury and behavioral thresholds resulting from vibratory pile driving during installation of the WTG and OSS foundations with 10 dB noise mitigation

Fish Group	WTG Monopile 1 - Standard		WTG Monopile 2 – Hard-to-drive		WTG Monopile 3 – One Standard and One Hard-to-drive		OSS Foundation	
	Injury (SEL_{24h})	Behavior (SPL)	Injury (SEL_{24h})	Behavior (SPL)	Injury (SEL_{24h})	Behavior (SPL)	Injury (SEL_{24h})	Behavior (SPL)
Fish <2 g	1,216	903	886	903	1,442	903	569	393
Fish ≥2 g	796	903	601	903	961	903	427	393

Source: Dominion Energy 2022
dB = decibel; Lpk = peak sound pressure level in units of dB referenced to 1 micropascal; OSS = offshore substation; SEL_{24h} = sound exposure level over 24 hours in units of dB referenced to 1 micropascal squared second; SPL = root-mean-square sound pressure level in units of dB referenced to 1 micropascal; WTG = wind turbine generator.

There are minimal direct mitigation measures that are effective for ESA-listed fish species during pile driving. The primary mitigation measures are the sound mitigation devices that reduce the propagated sound levels and soft-start procedures. The use of soft-start procedures for pile driving has been a standard mitigation and engineering measure at the start of most underwater piling events; however, the effectiveness of soft-start procedures for moving fish away from a sound source is largely assumed with minimal empirical data. Acoustic deterrents have been used to manage fish populations (e.g., keep fish from water intake structures; guide fish toward fish passes); however most of these activity are highly specific to the genera or family of fish species of interest (Putland and Mensigner 2019). In underwater blasting studies, the use of “scare charges” to move fish from zones of mortality were only nominally effective and often temporary (Keevin and Hempen 1997). It is assumed that the activity and disturbance at the site, combined with the soft start procedures, will result in some movement by fish out of the highest impact zones and; therefore, effects determinations consider the soft-start as effective for minimizing physiological injury to ESA-listed fish species.

Effects of Exposure to Noise Above the Physiological Injury Thresholds

Results indicate that impact pile driving during WTG monopile installation would exceed physiological injury thresholds for ESA-listed fish up to 19,291 feet (5,880 meters) from the source when applying the FHWG (2008) cumulative threshold metrics for fish ≥2 g; 3,419 feet (1,042 meters) from the source when applying the Popper et al. (2014) threshold metrics for fish with swim bladder not involved in hearing (applicable for Atlantic sturgeon); and 1,565 feet (477 meters) when applying the Popper et al. (2014) threshold metrics for fish with no swim bladder (applicable to giant manta rays). Modeled ranges for OSS foundation installation for the same three fish metric categories were 9,708 feet (2,959 meters), 1,601 feet (488 meters), and 699 feet (213 meters), respectively (Table 3-25).

As discussed in Section 3.4.2, *Giant Manta Ray*, data are limited regarding the hearing capabilities of elasmobranchs (i.e., sharks, skates, and rays, including the giant manta ray), but available information indicate that they are more sensitive to lower frequencies (<1,000 Hz), and their primary mode of sound detection is through particle motion rather than sound pressure since they do not have swim bladders (Casper et al. 2012; Popper and Hawkins 2018; Mickle et al. 2020; Mickle and Higgs 2022). Popper et al. (2014) and Popper and Hawkins (2018) suggest that particle motion induced by various impulsive sources could have the potential to affect fish tissues; therefore, particle motion as a stimulus should be included when evaluating the effects of sound on aquatic life. However, particle motion measurement standards and resulting effects analyses are evolving but still very limited thus there are currently no broadly accepted guidelines or thresholds for particle motion exposure. (Popper et al. 2014; Popper and Hawkins 2018). Particle motion is expected to be dominant only within short ranges (i.e., within 33 feet

[10 meters]) around the source (Mickle and Higgs 2022; Harding and Cousins 2022), outside of which sound pressure effects would dominate. Soft-start procedures included in the Proposed Action would also facilitate a gradual increase of equipment energy to allow marine life to leave the area prior to the start of operations at full energy that could result in injury, further reducing the risk of physiological injury. Given the relatively short range to the acoustic physiological injury thresholds for elasmobranchs (1,565 feet [477 meters] to the SEL_{24h} threshold) and the fact that levels of particle motion outside this range would not be sufficient to result in auditory injury, the potential effects of exposure to noise above physiological injury thresholds on giant manta ray would be **insignificant**.

Atlantic sturgeon are able to detect sound pressure as well as particle motion, but have a relatively primitive swim bladder, which is not directly connected to the inner ear. In addition, they are able to voluntarily release gas from their swim bladder (Logan-Chesney et al. 2018) to accommodate rapid changes in pressure in their environment. The risk of non-auditory injury due to exposure to impulsive signals from impact pile driving is lower for Atlantic sturgeon relative to fish species that cannot release swim bladder gas. However, because the range to the physiological injury threshold is relatively large (3,419 feet [1,042 meters]) and there are limited mitigation and monitoring methods that would approach any level of effectiveness for this species, there is still risk of auditory injury occurring to individuals within the population.

For injury to occur, however, sturgeon would need to remain within the distances (3,419 feet [1,042 meters] to the SEL_{24h} threshold [from the source when applying the Popper et al. (2014) threshold metrics for fish with swim bladder not involved in hearing]) duration of the activity. With the implementation of soft-starts, the potential for serious injury is minimized. Soft-start would facilitate a gradual increase of hammer blow energy to allow fish to leave the area prior to the start of operations at full energy that could result in injury. Soft-starts could be effective in deterring Atlantic sturgeon from impact pile driving activities prior to exposure resulting in a serious injury. The potential for serious injury is also minimized by using a noise mitigation system during all impact pile-driving operations. Based on this analysis, the potential for Atlantic sturgeon to be exposed to cumulative noise that could result in physiological injury is considered extremely unlikely occur and is, therefore, **discountable**.

Therefore, the effects of noise exposures above PTS thresholds during pile driving of foundations **may affect, not likely to adversely affect** ESA-listed fish species.

Effects of Exposure to Noise Above the Behavioral Thresholds

Acoustic stressors such as impact and vibratory pile driving may cause a short-term stress response in fish, but the potential for these activities to cause longer term growth and fitness consequences has not been demonstrated in a field setting. In general, fish may acclimate to long-term or repeated exposures to acoustic stressors (Schreck 2000). Goldfish (*Carassius auratus*) exposed to continuous noise sources, such as the hum or vibration of vessel traffic at SPL of 160 to 170 dB re 1 μPa, exhibited a short-term stress response characterized by increased cortisol and glucose levels, but they did not exhibit a long-term stress response following continued or repeated exposures (Smith et al. 2004). In addition, Neo et al. (2014) indicated that the temporal nature of the noise may influence the rate of recovery following behavioral disturbance. Both intermittent (e.g., pile driving) and continuous (e.g., vessel traffic, drilling) noises elicited behavioral changes in fish, but the time it took to return to normal baseline behavior was longer in response to intermittent noises compared to continuous noises (Neo et al. 2014).

Modeled behavioral threshold (provided by FHWG [2008]) ranges reached up to 49,245 feet (15,010 meters) from WTG foundation installation and up to 18,143 feet (5,530 meters) from OSS foundation installation during impact pile driving (Table 3-25). Behavioral threshold ranges during vibratory pile driving were for the WTG and OSS foundations were 2,963 and 1,289 feet (903 and 393 meters), respectively (Table 3-25).

There are no available studies assessing the responses of giant manta ray to impulsive or continuous sound sources. Available studies indicate that stingrays exhibited behavioral responses in the form of increased swimming activity to tonal sounds at low frequencies (less than 1,000 Hz) and at SPLs of 140 to160 dB re 1 µPa (Mickle et al. 2020). As discussed previously, the primary method of hearing for elasmobranchs such as giant manta ray is through particle motion (Mickle and Higgs 2021), which is not expected to propagate more than a few meters at levels that would have biologically relevant effects. Given their pelagic nature, giant manta ray are likely to transit the ensonified area during construction rather than remain for long periods of time. Feeding bouts may take place in areas of plankton concentrations; however, these events would not be predictable or expected at the piling location. There is no critical habitat or biologically important habitat designated for the giant manta within the Project area. Therefore, effects from exposure to noise above behavioral thresholds are expected to be **insignificant** for the giant manta ray.

Atlantic sturgeon may be present in small numbers year-round in the Project area. However, as discussed in Section 2.3.10, *Critical Habitat for All Listed Distinct Population Segments of Atlantic Sturgeon*, no marine habitats were identified as critical habitat and no critical habitat is present within the Project area. During spawning season, the likelihood of their presence in the Project area is even lower. Elevated noise levels could cause Atlantic sturgeon to temporarily vacate the area ensonified above behavioral thresholds (Krebs et al. 2016), resulting in a temporary disruption of feeding, mating, and other essential activities. No long-term avoidance of the Project area or effects on spawning behavior are expected to occur. Atlantic sturgeon have a primitive swim bladder which allows them to detect sound pressure in addition to particle motion (Popper et al. 2014; Popper and Hawkins 2018), but their swim bladder is not involved in their hearing, making them less sensitive to underwater sound pressure levels than fish with swim bladders involved in hearing. Several studies have been conducted on the behavioral response of fish to impulsive noise sources. Those that have been published show varying results, ranging from avoidance (moving out of the affected area or into deeper water; Dalen and Knutsen 1987; Slotte et al. 2004) to minor changes in behavior (Wardle et al. 2001; Hassel et al. 2004) or no reaction at all (Peña et al. 2013).

As stated above, the potential for Atlantic sturgeon to be present in the Project Area is considered possible but would occur intermittently, and no preferred foraging areas or aggregation areas have been identified in the Project Area. Therefore, Atlantic sturgeon could be exposed to noises above behavioral threshold and may avoid the area; however, avoidance of preferred foraging areas and accessing of spawning or overwintering areas would not occur, and only cessation of opportunistic foraging areas during migration period is expected. Soft-start procedures included in the Proposed Action would also facilitate a gradual increase of equipment energy to allow marine life to leave the area prior to the start of operations at full energy that could result in injury, further reducing the risk of physiological injury. Should an exposure occur, it would be temporary with effects dissipating once the activity had ceased or the individual had left the area. Potential effects would be brief (e.g., Atlantic sturgeon may approach the noisy area and divert away from it), and any effects from this brief exposure would be so small that they could not be measured, detected, or evaluated and would, therefore, be **insignificant**.

Therefore, the effects of noise exposures above behavioral thresholds during pile driving of foundations **may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.1.2.2 Goal Post Piles (C)

The ranges to the behavioral thresholds for fish during installation of the goal post piles follows the same methodology described in Section 3.2.5.2.3.2 *Goal Post Piles (C)* and are provided in Table 3-27.

Table 3-27 Maximum modeled ranges (meters) to fish behavioral thresholds during installation of up to two goal post piles per day using impact pile driving to support trenchless installation of the export cable with no noise mitigation

Fish <2 g	Fish >2 g
1,450	1,450

Source: Dominion Energy 2022

Effects of Exposure to Noise Above the Physiological Injury Thresholds

Results of the modeling indicate the acoustic injury is not expected for any ESA-fish species (Appendix Z; Dominion Energy 2022). The modeling assumed the source levels produced during impact pile driving of the goal post piles were 210 dB re 1 µPa m, expressed as Lpk, and 183 dB re 1 $\mu Pa^2 m^2$ s, expressed as SEL (COP Appendix Z; Dominion Energy 2022). Though the Lpk source level is below the threshold for some fish categories (Table 3-27), this threshold would not be exceeded more than a few meters (<16 feet [<5 meters]) limiting the risk of exposure to above-threshold noise. Additionally, the giant manta ray is more common further offshore and is not likely to be present nearshore where the goal post piles would be installed (Section 3.4.2, *Giant Manta Ray*). The lowest SEL_{24h} physiological injury threshold applicable for the two species considered in this BA (Atlantic sturgeon and giant manta ray) is 187 dB re 1 μPa^2 s which is higher than the estimated source level for this source used in the modeling, so this threshold would also not be expected to be met or exceeded beyond a couple meters from the source. Because there is no expectation of exposure to noise above physiological injury thresholds during goal post pile installation, the potential for adverse effects to occur is **discountable.** Therefore, the effects of noise exposure above PTS thresholds during goal post pile installation **may affect, not likely to adversely affect** ESA-listed fish species.

Effects of Exposure to Noise Above the Behavioral Thresholds

Behavioral thresholds for goal post installation may be exceeded out to 4,757 feet (1,450 meters) for all fish species present in the Project area (Table 3-27). Potential behavioral disturbances to ESA-listed fish would be comparable to those described for impact pile driving of the WTG and OSS foundations (Section 3.4.3.1.2.1, *WTG and OSS Foundation Installation [C]*) but with a lesser spatial extent given the lower source levels expected during installation of the goal post piles. The nearshore location of the goal post pile installation (Section 1.3.1.1, *Onshore Activities and Facilities*) would limit the risk of exposure of giant manta rays as they are more likely to occur offshore (Section 3.4.2, *Giant Manta Ray*). The primary method of sound detection in elasmobranchs like the giant manta ray is through particle motion. Particle motion components (i.e., acceleration, velocity, displacement) would not reach levels expected to substantially alter behavior out to 4,757 feet (1,450 meters). Due to their preference for offshore waters and the limited range of particle motion influence expected around the piles, the potential for behavioral effects on giant manta rays would be **insignificant**.

Atlantic sturgeon are more likely to be present in nearshore waters around the installation location which is located just off the Virginia coast approximately 7 miles (11 kilometers) south of the mouth of the Chesapeake Bay (Figure 1-1), primarily when traveling between the spawning habitats in the James and York rivers to marine waters where adults are expected to occur (Section 3.4.1, *Atlantic Sturgeon*). Given the relatively larger (4,757 feet [1,450 meters]) behavioral threshold range, the fact that Atlantic sturgeon are more sensitive to sound pressure than giant manta rays, and limited effective mitigation techniques for marine fish, the potential for behavioral effects cannot be discounted. However, noise from goal post pile installation is unlikely to result in behavioral effects could impact critical biological activities such as reproduction or foraging, and the effects would be **insignificant**.

Therefore, effects of exposures to noise above behavioral thresholds during goal post pile installation **may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.1.2.3 Cofferdam Installation (C)

Underwater noise modeling of vibratory pile driving construction scenarios is described in Section 3.2.5.2.3.3 *Cofferdam Installation (C)* and is summarized in Table 3-28.

Table 3-28 Maximum modeled distances (meters) to fish thresholds for vibratory pile driving during installation of the cofferdams used to support trenchless installation of the export cable with no mitigation

Fish <2 g		Fish ≥2 g	
Injury (SEL_{24h})	Behavior (SPL)	Injury (SEL_{24h})	Behavior (SPL)
317	248	206	248

Source: Dominion Energy 2022
SEL_{24h} = sound exposure level over 24 hours in units of dB referenced to 1 micropascal squared second;
SPL = root-mean-square sound pressure level in units of dB referenced to 1 micropascal.

Effects of Exposure to Noise Above the Physiological Injury Thresholds

Modeled ranges to physiological injury thresholds for vibratory pile driving of the cofferdams were 676 feet (206 meters for fish ≥2 g, which is applicable for Atlantic sturgeon and giant manta rays (Table 3-28). Given this small distance over which potential effects could occur and the nearshore location, the likelihood of any fish being exposed to sufficient sound energy to result in injury is considered unlikely and, therefore, **discountable** for all ESA-listed fish in the Action Area. Therefore, the effects of exposure to noise above physiological injury thresholds during cofferdam installation **may affect, not likely to adversely affect** ESA-listed fish species.

Effects of Exposure to Noise Above the Behavioral Thresholds

Non-impulsive sources, such as vibratory pile driving, have the potential to result in behavioral responses in marine fish such as startle responses, avoidance, and changes in swim speed, direction, or both (Popper and Hawkins 2018 Mickle et al. 2020); however, limited responses are expected to result from the non-impulsive noise associated with cofferdam installation activities. Both the Atlantic sturgeon and giant manta ray have limited sensitivity to sound pressures, particularly at low levels. Additionally, the cofferdams would be installed closer to shore, which further limits the risk of exposure of the giant manta ray who prefer deeper waters (Section 3.4.2, *Giant Manta Ray*). Atlantic sturgeon and giant manta ray are both able to detect low frequency noise less than 1,000 Hz, which overlaps with the source characteristics of vibratory pile driving; however, the modeled range to the behavioral thresholds for vibratory pile driving of the cofferdams was 813 feet (248 meters) for fish ≥2 g (Table 3-28), which applies to both species. The small range over which behavioral disturbances may occur limits the likelihood of effects for ESA-listed fish species around the cofferdam installation location and potential effects would not be measurable and, therefore, **insignificant**. Therefore, effects from noise exposures above behavioral thresholds during cofferdam installation **may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.1.2.4 HRG Survey Activities (C, O&M, D)

As discussed in previously, HRG surveys will be conducted prior to construction and during operations to identify any seabed obstructions or potential cable burial or scour protection issues. HRG survey activities as described in Section 3.2.5.2.3.4, *HRG Surveys (C, O&M, D)* indicate a maximum modeled range to the marine mammal LFC PTS thresholds of 0 feet (0 meters) for CHIRPs; 0.33 foot (0.1 meter) for sparkers; and 19.4 feet (5.9 meters) for boomers (Table 3-12). The ranges to the SPL 160 dB re 1 µPa behavioral threshold for marine mammals ranged from 35.8 feet (10.9 meters) for the CHIRPs to 328 feet (100 meters) for the sparker (Table 3-13). Although acoustic modeling was not conducted specifically for fish for HRG surveys, it can be inferred that the injury and behavioral threshold ranges would be substantially smaller than those noted for marine mammals. This is because, as discussed previously, fish are more sensitive to particle motion that sound pressure, and though Atlantic sturgeon have a swim bladder, which enables detection of underwater sound pressure, it is not directly connected to their hearing so they are less sensitive to underwater sound than marine mammals (Popper et al. 2014).

In an assessment of HRG survey noise conducted by Baker and Howsen (2021), the PTS thresholds for fish were estimated to extend to 30 feet (9 meters) for sparker equipment, and the maximum behavioral disturbance threshold range would extend out to 6,549 feet (1,996 meters) for sparkers. However, this assessment assumed the maximum power and source settings were used for each type of equipment which is not applicable to the HRG surveys proposed by Dominion Energy (Tetra Tech 2022a) so it is expected that with the source and power settings included in the Proposed Action the maximum range to the fish thresholds would be even lower. Additionally, the ranges for boomers, one of the other types of equipment assessed under the Proposed Action, was estimated to be 10.5 feet (3.2 meters) for the physiological injury threshold and 2,323 feet (708 meters) for the behavioral threshold; and ranges for the CHIRPs were estimated to be 0 feet (0 meters) for the physiological injury thresholds as they would not be met or exceeded by this source type and 105 feet (32 meters) for the behavioral threshold (Baker and Howsen 2021). HRG survey activities affecting fish would follow the same indicative schedule provided in Table 3-13.

Effects of Exposure to Noise Above the Physiological Injury Thresholds

The sparker and boomer HRG equipment included in this BA produce noise in low frequencies below 1 kHz, which overlap with the hearing sensitivity for most fish (Section 3.4.1, *Atlantic Sturgeon*, and Section 3.4.2, *Giant Manta Ray*) and may, therefore, be detectable by Atlantic sturgeon and giant manta ray. CHIRP systems produce frequencies starting around 2 kHz depending on the source so while the noise may be detectable by fish, it is outside their main sensitivity range and would not be likely to affect them. Based on the previous assessment conducted by Baker and Howsen (2021), sparker equipment used during these surveys has the potential to produce noise that would exceed physiological injury thresholds for fish up to 30 feet (9 meters), which is a small enough range from the source that the likelihood of any individual experiencing sufficient sound energy to result in injury is low. Additionally, HRG sources would be moving throughout the survey activities, so individuals present near the vessel would only be exposed for a short duration before the survey vessel moves away. Soft-start procedures included in the Proposed Action would also facilitate a gradual increase of equipment energy to allow marine life to leave the area prior to the start of operations at full energy that could result in injury, further reducing the risk of injury. Given the small ranges, transient nature of the survey equipment, and soft-start procedures, the potential for physiological injury in Atlantic sturgeon and giant manta ray resulting from HRG surveys are **discountable**. Therefore, effects of noise exposures above physiological injury thresholds during HRG **surveys may affect, not likely to adversely affect** ESA-listed fish species.

Effects of Exposure to Noise Above the Behavioral Thresholds

Behavioral thresholds for fish up may extend up to approximately 1.2 miles (2 kilometers) based on previous assessments (Baker and Howsen 2021). However, the behavioral threshold does not account for exposure duration; given the transient nature of these sources, individuals near the source would only be exposed to above-threshold noise for a short duration before the survey vessel moves away, so no long-term effects would be expected. Should an exposure occur, the potential effects would be brief, and no long-term avoidance of the Project area or effects on reproduction are expected. Effects of this brief exposure could result temporary disruptions to foraging behavior; however, any impacts associated with this avoidance would be so small that they could not be measured, detected, or evaluated and are, therefore, **insignificant**. Therefore, the effects exposure to noise above behavioral thresholds during HRG surveys **may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.1.2.5 Vessel Noise (C, O&M, D)

Up to 53 types of vessels may be used to support construction, O&M, and decommissioning of the Proposed Action (Table 1-5). These include larger barges and HLV which range in size from 400 to 711 feet (122 to 217 meters) in length, 105 to 161 feet (32 to 49 meters) in breadth, and drafts from 20 to 36 feet (6 to 11 meters); cable-laying vessels ranging in size from 87 to 401 feet (27 to 122 meters) in length, 34 to 110 feet (10 to 34 meters) in breadth, and drafts from 10 to 18 feet (3 to 5 meters); and smaller support vessels ranging from 65 to 112 feet (20 to 34 meters) in length, 34 to 35 feet (10 to 11 meters) in breadth, and drafts from 10 to 19 feet (3 to 6 meters) (Table 1-5). Project vessel traffic will be intermittently present throughout the life of the Project from before construction through decommissioning with varying transit frequencies associated with each phase (Table 1-5).

Large shipping vessels and tankers produce lower frequency noise with a primary energy near 40 Hz and underwater source levels that can range from 177 to 200 dB re 1 µPa m (McKenna et al. 2012; Erbe et al. 2019) while smaller vessels typically produce higher frequency noise (1,000 to 5,000 Hz) at source levels between 150 and 180 dB re 1 µPa m (Kipple and Gabriele 2003, 2004). Vessels using DP thrusters for station keeping are known to generate substantial underwater noise with SLs ranging from 150 to 180 dB re 1 µPa m depending on operations and thruster use (BOEM 2013; McPherson et al. 2016).

<u>Effects of Exposure to Noise Above the Physiological Injury Thresholds</u>

Research indicates that the effects of vessel noise, including DP vessel noise, will not cause mortality or injuries in adult fish (Hawkins et al. 2014) given the low source levels and non-impulsive nature of this source. The potential for exposures above physiological injury thresholds to occur is extremely unlikely and are **discountable**. Therefore, the effects of exposure to noise above physiological injury thresholds as a result of vessel activity **may affect, not likely to adversely affect** ESA-listed fish species.

<u>Effects of Exposure to Noise Above the Behavioral Thresholds</u>

Continuous sounds produced by marine vessels have been reported to change fish behavior causing fish to change speed, direction, depth, induce avoidance, or alter schooling behavior (Engås et al. 1995, 1998; Sarà et al. 2007; De Robertis and Handegard 2013; Mitson and Knudsen 2003). DP vessel source levels have been shown to cause several different behavioral responses, auditory masking, and changes in blood chemistry. The most common behavioral responses are avoidance, alteration of swimming speed and direction, and alteration of schooling behavior (Becker et al. 2013; Handegard and Tjøstheim 2005; Sarà et al. 2007; Vabø et al. 2002). Laboratory and field studies have demonstrated several other behaviors that are influenced by DP vessel noise. For example, several studies noted changes in foraging behavior (Bracciali et al. 2012; Purser and Radford 2011; Voellmy et al. 2014a, b), vocalization patterns (Picciulin et al. 2008, 2012), and overall frequency of movement (Buscaino et al. 2010). These studies also demonstrated that behavioral changes were generally temporary. Auditory masking in fish exposed to vessel noise has been demonstrated in a few studies. Auditory thresholds have been shown to increase by as much as 40 dB when fish are exposed to vessel noise playbacks (Codarin et al. 2009; Vasconcelos et al. 2007; Wysocki and Ladich 2005). The degree of auditory masking generally depends on the hearing sensitivity of the fish, the frequency, and the noise levels tested (Wysocki and Ladich 2005).

Evidence suggests fish will return to normal baseline behavior faster following exposure to continuous sources such as vessel noise versus intermittent noise such as pile driving (Neo et al. 2014). Therefore, while vessel noise would be present within the Action Area throughout the life of the Proposed Action, behavioral disturbances would only be expected within and few meters of the vessel and would dissipate once the vessel has moved away. In addition, though Atlantic sturgeon have swim bladders, which are not involved in hearing, and are likely to be more sensitive to vessel noise than giant manta ray, who do not have a swim bladder (Popper et al. 2014), both species are thought to be more sensitive to particle motion that sound pressure (Popper and Hawkins 2018; Mickle and Higgs 2021). Given the nature of non-impulsive sources such as vessels noise, particle motion levels sufficient to result in behavioral disturbances would not occur more than a few meters from the source, and any effects to this brief exposure would be so small that they could not be measured, detected, or meaningfully evaluated and are, therefore, **insignificant**. Therefore, the effects from exposure to noise levels above behavioral thresholds resulting from vessel operations **may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.1.2.6 Cable Laying or Trenching Noise (C)

As described previously in Section 3.2.5.2.3.6, *Cable Laying or Trenching Noise (C)*, the most likely cable burial methods being considered as part of the Proposed Action include jet plow, jet trenching, hydroplow (simultaneous lay and burial), mechanical plowing (simultaneous lay and burial). The action of laying the cables on the seafloor itself is unlikely to generate high levels of underwater noise. Most of the noise energy would originate from the vessels themselves including propellor cavitation noise and noise generated by onboard thruster/stabilization systems and machinery (e.g., generators), including noise emitted by the tugs when moving the anchors as discussed in Section 3.4.3.1.2.5, *Vessel Noise (C, O&M, D)*..

There is limited information regarding underwater noise generated by cable-laying and burial activities in the literature. Johansson and Andersson (2012) recorded underwater noise levels generated during a comparable operation involving pipelaying and a fleet of nine vessels. Mean noise levels of 130.5 dB re 1 µPa were measured at 4,921 feet (1,500 meters) from the source. Reported noise levels generated during a jet trenching operation provided a source level estimate of 178 dB re 1 µPa m measured at 3.3 feet (1 meter) from the source (Nedwell et al. 2003).

Effects of Exposure to Noise Above the Physiological Injury Thresholds

It is unlikely that received levels of underwater noise from cable-laying operations would exceed physiological injury thresholds for Atlantic sturgeon or giant manta ray since the animals would move away from any noise that could result in injury. Thus, the potential for ESA-listed fish to be exposed to noise above physiological injury thresholds is considered extremely unlikely to occur and is **discountable**. Therefore, the effects of noise exposure from Project cable-laying operations leading to physiological injury **may affect, not likely to adversely affect** ESA-listed fish.

Effects of Exposure to Noise Above the Behavioral Thresholds

Behavioral effects are considered possible but would be temporary with effects dissipating once the activity or individual has left the area. Should an exposure occur, the potential effects would be brief (e.g., an individual may approach the noisy area and divert away from it), and any effects to this brief exposure would be so small that they could not be measured, detected, or evaluated and are therefore **insignificant**. Therefore, the effects of noise exposure from Project vessel operations leading to behavioral disturbance **may affect, not likely to adversely affect** ESA-listed fish.

3.4.3.1.2.7 WTG Operations (O&M)

Noise produced by WTGs is within the hearing range of most marine fish. Depending on the noise intensity, such noises could disturb or displace fish within the surrounding area or cause auditory masking (MMS, 2007). However, with generally low noise levels expected from WTG operations, fish would be affected only at close ranges (within 100 meters) (Thomsen et al. 2006, 2020). Thomsen et al. (2006) reviewed the observations of fish behaviors in proximity to an operational WTG and found varying results, from no perceived changes in swimming behavior of European eels (*Anguilla anguilla*) and both increased and decreased catch rates of cod within 100 meters of the operational WTGs.

The analyses conducted by Tougaard et al. (2020) showed that sound levels produced by individual WTG were low in all literature and were comparable to or lower than sound levels within 1 kilometer of commercial ships. The complied data also showed an increase in noise levels with increasing WTG power and wind speed. However, Tougaard et al. (2020) noted that the noise produced from a WTG is stationary and persistent, which differs from the transitory nature of sound produced by vessel traffic, and the cumulative contribution of multiple WTG within a region must be critically assessed and planned. Stöber and Thomsen (2021) reviewed published literature and also identified an increase in underwater sound level with increasing power size with a nominal 10 MW WTG. However, they also reported a sound decrease of roughly 10 dB re 1 µPa from WTG using gear boxes to WTG using direct drive technology. In addition, Atlantic sturgeon are an anadromous species that primarily utilize rivers, bays, estuaries, coastal, and shallow OCS waters, and giant manta ray are only seasonally expected to transit the Lease Area; their occurrence in the Project area is expected to be seasonal and in very low numbers.

Effects of Exposure to Noise Above the Physiological Injury Thresholds

Noise produced by WTG operations is within the hearing range of both Atlantic sturgeon and giant manta rays; however, this is a non-impulsive sound source, which produces relatively low noise levels (compared to construction noise) so noise produced at levels sufficient to elicit injury in either species would only occur within of few meters of the WTG foundations. Therefore, the potential for injury resulting from WTG noise is extremely low and would be **discountable** for Atlantic sturgeon and giant manta rays. Therefore, the effects of exposure to noise above physiological injury thresholds resulting from WTG operations and **may affect, not likely to adversely affect** ESA-listed fish species.

Effects of Exposure to Noise Above the Behavioral Thresholds

Depending on the intensity, noises produced by WTG operations could disturb or displace fish within the surrounding area or cause auditory masking (MMS 2007). However, with generally low noise levels, fish would be affected only at close ranges (within 100 meters) to the operating WTG (Thomsen et al. 2006, 2020). As described previously, Atlantic sturgeon would be more likely to be present around the wind farm in non-spawning years as spawning adults typically travel upriver to reproduce (Section 3.4.1, *Atlantic Sturgeon*), and giant manta ray are regularly found offshore Virginia and would likely be present around the wind farm between May and October (Section 3.4.2, *Giant Manta Ray*), so there is potential for both species to be found around the WTG foundations during O&M. While there may be some behavioral modifications, these would be localized and would not be likely to affect activities such as foraging or reproduction. Effects of the behavioral disturbances resulting from WTG noise would be minor enough that they cannot be meaningfully evaluated and are **insignificant**. Therefore, the effects of exposure to noise above physiological injury thresholds during WTG operations **may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.1.3 Effects to Prey Organisms

Effects of noise during construction, operations, and decommissioning the Proposed Action (as described previously in Section 3.2.4.2, *Potential Habitat Surrounding and within the Immediate Project Area*, Section 3.3.5.1, *Underwater Noise*, and Section 3.4.3.1, *Underwater Noise Effects on Marine Fish*) on prey organisms for the Atlantic sturgeon and giant manta ray has the potential to result in behavioral disturbances for certain species. Atlantic sturgeon are benthic foragers, typically feeding on invertebrates and bottom-dwelling fish, such as sand lance (NMFS 2022h), while giant manta ray are pelagic foragers who primarily feed on planktonic organisms but have also been observed eating small and moderately sized fish (NMFS 2022i).

Invertebrates appear to be able to detect both sound pressure and particle motion (André et al. 2016; Budelmann 1992; Solé et al. 2016, 2017) and are most sensitive to low frequency noises (Budelmann and Williamson 1994; Lovell et al. 2005a, b; Mooney et al. 2010; Packard et al. 1990). Reduction of prey fish availability could affect marine mammals and sea turtles if rising sound levels affect fish populations and alter prey abundance, behavior, and distribution (McCauley et al. 2000a,b; Popper and Hastings 2009; Slabbekoorn et al. 2010).

Cephalopods (i.e., octopus, squid) and decapods (i.e., lobsters, shrimps, crabs) are capable of sensing both particle motion and sound pressure at lower frequencies. Packard et al. (1990) showed that three species of cephalopod (common cuttlefish, common octopus, and European squid) were sensitive to particle motion rather than sound pressure, with the highest sensitivity to particle motion reported at 1 to 2 Hz. In longfin squid, Mooney et al. (2010) also observed responses to particle motion at lower frequencies between 100 and 300 Hz and also observed responses to sound pressure at 200 Hz. These data indicate that some prey species may be responding to both the particle motion and pressure component of low frequency noises, but thresholds for physiological or behavioral responses to particle motion in invertebrates are not currently available.

Potential onset thresholds for both physiological and behavioral respones to the pressure component of underwater noise are available in published literature. Solé et al. (2017) showed that SPL ranging from 139 to 142 dB re 1 μPa at one-third octave bands centered at 315 Hz and 400 Hz may be suitable threshold values for trauma onset from sound pressure in cephalopods. Hearing thresholds for sound pressure at higher frequencies have been reported, such as 134 and 139 dB re 1 μPa at 1,000 Hz for the oval squid and the common octopus, respectively (Hu et al. 2009). Cephalopods have also exhibited behavioral responses to low frequency noises (below 1,000 Hz) including inking, locomotor responses, body pattern changes, and changes in respiratory rates (Hu et al. 2009; Kaifu et al. 2008). McCauley et al. (2000a) reported that caged squid exposed to seismic airguns showed behavioral responses such as inking. Wilson et al. (2007) exposed two groups of longfin squid in a tank to killer whale echolocation clicks at SPL from 199 to 226 dB re 1 μPa, which resulted in no apparent behavioral effects or any acoustic debilitation. However, both the McCauley et al. (2000a) and Wilson et al. (2007) experiments used caged squid, so it is unclear how unconfined animals would react. André et al. (2011) exposed four cephalopod species (European squid, common cuttlefish, common octopus, and southern shortfin squid) to 2 hours of continuous noise from 50 to 400 Hz at received SPL of 157 dB re 1 μPa and reported lesions occurring on the sensory hair cells of the statocyst that increased in severity with time, suggesting that cephalopods are particularly sensitive to low frequency noise. Similarly, Solé et al. (2013) conducted a low frequency (50 to 400 Hz) controlled exposure experiment on two deep-diving squid species (southern shortfin squid and European squid), which resulted in lesions on the statocyst epithelia. Solé et al. (2013) described their findings as "morphological and ultrastructural evidence of a massive acoustic trauma induced by low-frequency sound exposure." In experiments conducted by Samson et al. (2014), common cuttlefish exhibited escape responses (i.e., inking, jetting) when exposed to frequencies between 80 and 300 Hz with SPL above 140 dB re 1 μPa, and they habituated to repeated 200 Hz noises. The intensity of the cuttlefish response with the amplitude and frequency of the noise stimulus suggest that cuttlefish possess loudness perception with a maximum sensitivity of approximately 150 Hz (Samson et al. 2014). Jones et al. (2020) exposed longfin inshore squid (*Doryteuthis pealeii*) to playbacks of impact pile driving recorded at the Block Island Wind Farm ranging from approximately 190 to 194 dB re 1 µPa, which were meant to match sound levels recorded 500 meters from the piles. Most of the squid tested showed alarm behavior (e.g., inking, jetting, body pattern change), but the proportion of the trial in which squid exhibited these behaviors decreased substantially following the first 30 impulses of the playback, indicating the squid may become habituated to the noise (Jones et al. 2020).

Several species of aquatic decapod crustaceans are also known to produce sounds. Popper et al. (2001) reviewed behavioral, physiological, anatomical, and ecological aspects of noise and vibration detection by decapod crustaceans and noted that many decapods also have an array of hair-like receptors within and upon the body surface that potentially respond to water- or substrate-borne displacements as well as proprioceptive organs that could serve secondarily to perceive vibrations. They concluded that many are able to detect substratum vibrations at sensitivities sufficient to tell the proximity of mates, competitors, or predators (Popper et al. 2001). However, the acoustic sensory system of decapod crustaceans remains poorly studied (Popper et al. 2001). Lovell et al. (2005a,b, 2006) reported potential auditory-evoked responses from prawns that showed auditory sensitivity of noises from 100 to 3,000 Hz. Filiciotto et al. (2016) also reported behavioral responses to vessel noise within this frequency range. Lovell et al. (2005b) found that the greatest sensitivity for prawns was an SPL of 106 dB re 1 µPa at 100 Hz, noting that this was the lowest frequency at which they tested and that prawns might be more sensitive at frequencies below this.

Marine fish are typically sensitive to the 100 to 500 Hz range, and several studies have demonstrated that seismic airguns and impulsive sources might affect the behavior of at least some species of fish. For example, field studies by Engås et al. (1996) and Løkkeborg et al. (2012a) showed that the catch rate of haddock and Atlantic cod significantly declined over 5 days immediately following seismic surveys, after which the catch rate returned to normal. Other studies found only minor responses by fish to noise created during or following seismic surveys, such as a small decline in lesser sand eel abundance that quickly returned to pre-seismic levels (Hassel et al. 2004) or no permanent changes in the behavior of marine reef fishes (Wardle et al. 2001). However, both Hassel et al. (2004) and Wardle et al. (2001) noted that when fish sensed the airgun firing, they performed a startle response and sometimes fled.

While noise produced by Project activities is likely to affect prey species for Atlantic sturgeon and giant manta ray, effects on these species is unlikely to result in an effect on their survival and fitness based on the ability of the species to adjust their diet to exploit other types of prey resources when available and the availability of foraging opportunities outside the immediate Project area. The effects on Atlantic sturgeon and giant manta ray due to reduction in prey items resulting only from underwater noise generated by the Project are likely to be undiscernible from prey changes due to overall wind farm construction and operations and, therefore, would be so small that they could not be measured, detected, or evaluated and are, therefore, **insignificant**. Therefore, effects from underwater noise sources due to activities conducted under the Proposed Action **may affect, not likely to adversely affect** prey organisms for ESA-listed fish species.

3.4.3.2 Habitat Disturbance Effects on Marine Fish (C, O&M, D)

Similar to the effects described for this stressor in marine mammals Section 3.2.5.3, *Habitat Disturbance Effects on Marine Mammals (C, O&M, D)* and sea turtles Section 3.3.5.2, *Habitat Disturbance Effects on Sea Turtles (C, O&M, D)*, habitat disturbance related to the Project would occur throughout all three phases of construction, O&M, and decommissioning. Potential effects to ESA-listed fish species and their prey from habitat disturbance range from short- to long-term impacts. Individual stressors under habitat disturbance encompass displacement from physical disturbance of sediment; changes in oceanographic and hydrological conditions due to presence of structures; conversion of soft- to hard-bottom habitat; and concentration of prey species due to the reef effect. These are discussed separately and organized by Project phase in the following subsections.

3.4.3.2.1 Displacement from Physical Disturbance of Sediment (C, D)

As discussed in Section 3.2.5.3.1, *Displacement from Physical Disturbance of Sediment (C, D)*, displacement would result from temporary turbidity or removal of prey species due to disturbance of the seabed. Construction of the Proposed Action would result in temporary disturbance of the seabed within the Project area resulting in short-term displacement of ESA-listed fish and their prey species present during construction or decommissioning. Based on information provided in Table 3-16, an estimated 14,851.9 to 16,000.1 acres (60.1 to 64.8 km^2) would be temporarily disturbed during Project construction. However, as discussed previously in Section 3.2.5.3.1, *Displacement from Physical Disturbance of Sediment (C, D)*, there were no sensitive resources, hard-bottom, or biogenic (sea grass beds, corals, shellfish reefs and beds, etc.) substrates identified within the Project area (COP, Appendix D; Dominion Energy 2022).

After Project construction activities are completed, the areas of temporary disturbance should return to the baseline state. The restoration of marine soft-sediment habitats occurs through a range of physical (e.g., currents, wave action) and biological (e.g., bioturbation, tube building) processes (Dernie et al. 2003). Disturbed areas not replaced with hardened structures or scour protection would resettle and the benthic community would be expected to return to normal typically within 1 year (Dernie et al. 2003). Atlantic sturgeon are known to eat a variety of benthic organisms and are believed to be opportunistic feeders with stomach contents ranging from mollusks, worms, amphipods, isopods, shrimp, and small benthic fish (e.g., sand lance; Smith 1985; Johnson et al. 1997; Dadswell 2006; Novak et al. 2017). Generally, the disturbance of benthic habitat would be short-term and localized, with an abundance of similar foraging habitat and prey available in adjacent areas for Atlantic sturgeon. Atlantic sturgeon are unlikely to be affected by the effects of short term, localized, seabed disturbance. Therefore, the effects of displacement of Atlantic sturgeon and their prey from physical disturbance of sediment are expected to be minimal. The giant manta ray feeds on planktonic organisms and is, therefore, unlikely to be feeding along the seafloor. Therefore, the effects of habitat disturbance on giant manta ray is not expected.

Habitat disturbance effects to fish during decommissioning would likely be similar to or less than those experienced during construction. Given that decommissioning techniques are expected to advance over the life of the Project, potential impacts would need to be evaluated at that time; however, effects on ESA-listed fish species are not expected to be greater than those experienced during construction.

The impacts on the Atlantic sturgeon or the giant manta ray from sediment disturbance cannot be meaningfully measured, evaluated, or detected and are, therefore, **insignificant**.

3.4.3.2.2 Changes in Oceanographic and Hydrological Conditions due to Presence of Structures (O&M)

The greatest concern for ESA-listed fish and changes in oceanographic and hydrologic conditions resulting from structures in the open ocean would be potential impacts to prey sources. Atlantic sturgeon consume prey not as closely affected by physical oceanographic features, such as the sand lance, mollusks, polychaete worms, amphipods, isopods, and shrimp, as other species discussed in this BA. Potential impacts on larval dispersion and survival of Atlantic sturgeon prey species could be affected by hydrologic conditions on a very localized level. As described in Section 3.2.5.3.3, *Effects of Changes in Oceanographic and Hydrological Conditions due to Presence of Structures (O&M)*, the potential hydrodynamic effects identified from the presence of vertical structures in the water column affect nutrient cycling and could influence the distribution and abundance of fish and planktonic prey resources throughout O&M (van Berkel et al. 2020). Given the colonization seen on the Block Island Wind Farm foundations (HDR 2020), recruitment of mollusk and decapod larvae do not appear to be negatively affected by hydrologic conditions at the WTG; therefore, recruitment of larval prey species for Atlantic sturgeon would likely not be affected.

The presence of the offshore structures may potentially affect nutrient cycling, which may in turn influence planktonic distributions, either positively or negatively, although the full effects of the structures on plankton are not fully known (see Section 3.2.5.3.3, *Effects of Changes in Oceanographic and Hydrological Conditions due to Presence of Structures [O&M]*). The densities of planktonic organisms are typically spatially and temporally patchy and highly dependent on many factors, all of which could be influenced by the presence of structures. Giant manta ray feeding, therefore, could be affected by the presence of WTG and OSS foundations. However, the giant manta ray is pelagic and exhibits high plasticity in their use water depth and habitat (NMFS 2022i) and would be expected to adapt to prey variability that would not likely be any more variable than natural conditions without these structures.

Analysis of benthic resources in the COP indicated the presence of the foundations is not likely to negatively affect regional abundances or dispersion of plankton species (COP, Section 4.2.4.3, Dominion Energy 2022). Further, the anticipated hydrodynamic effects of structures are expected to be localized and not extend beyond a few hundred meters from the foundation (Miles et al. 2017; Schultze et al. 2020). Any effects resulting from oceanographic and hydrographic conditions produced by the foundations and structures would be small and unlikely to be meaningfully evaluated and, therefore, are considered **insignificant** for both the Atlantic sturgeon and giant manta ray.

3.4.3.2.3 Effects of Changes in and Concentration of Prey Species due to the Reefing Effect of Structures (O&M)

Long-term habitat alterations from soft-bottom to hard-bottom conversion during O&M of the Project would occur through placement of monopiles and jacketed piles, scour protection, and cable protection. The presence of the WTGs, OSSs, and scour protection would convert 116.4 to 204.5 acres (0.47 to 0.83 km^2; Table 3-16) of current soft-bottom to new hard-bottom habitat, which could lead to potential changes in foraging habitat for Atlantic sturgeon (Table 3-16). The addition of the hard-bottom habitat is expected to result in a shift in the area immediately surrounding each monopile to a structure-oriented system, including an increase in fouling organisms. Over time (weeks to months), the areas with scour protection are likely to be colonized by sessile or mobile organisms (e.g., sponges, hydroids, and crustaceans). This results in a modification of the benthic community in these areas from primarily infaunal organisms (e.g., amphipods, polychaetes, and bivalves). The addition of new hard-bottom substrate in a predominantly soft-bottom environment will enhance local biodiversity; enhanced biodiversity associated with hard-bottom habitat is well documented (Pohle and Thomas 2001). Hard bottom habitat 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 sturgeon compared to the surrounding soft-bottom habitat. The only forage fish anticipated to be affected 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 Project area. Although these effects would be long term, the small area of converted habitat is not likely to affect the Atlantic sturgeon. Given this small, localized reduction in sand lance and that sand lance is only one of many species the Atlantic sturgeon may feed on in the Project area, any effects to these species are expected to be so small that they cannot be meaningfully measured, evaluated, or detected and are, therefore, **insignificant**.

The giant manta ray is a pelagic, migratory species often occurring at upwellings and is mainly a filter feeder. As a result, they will not be directly impacted by the reefing effect surrounding the offshore structure foundations; effects on the giant manta ray as a result of the reefing effect are, therefore, considered **insignificant.**

3.4.3.2.4 Summary of Habitat Disturbance Effects

As described in Section 3.4.3.2, *Habitat Disturbance Effects on Marine Fish (C, O&M, D)*, any effects from habitat disturbance on Atlantic sturgeon and giant manta rays are considered so small that they could not be measured, detected, or evaluated and are **insignificant**. Therefore, the effects of habitat disturbance from activities conducted under the Proposed Action **may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.3 Secondary Entanglement due to Increased and Altered Fishing Activity Caused by the Presence of Structures (O&M)

As discussed in other resource sections above, the presence of structures during O&M has the potential to concentrate recreational fishing around foundations and alter the existing distribution and gear type of existing commercial fisheries.

3.4.3.3.1 Redistribution of Commercial Fisheries

The primary trap/pot fisheries that utilize vertical lines in Project area are the blue crab, black sea bass, scup, and whelk fisheries. In the limited bycatch data for these fisheries, only finfish and invertebrates captured were in the pots/traps rather than vertical line entanglements. There were no sturgeon captures reported in a comprehensive blue crab pot fisheries study in Georgia (Page et al. 2013) or in pot fisheries in a U.S. fisheries assessment (Savoca et al. 2020). Additionally, fish pots were not identified as a threat to sturgeon in a bycatch review conducted by Zollett (2009). There is no evidence that vertical lines pose a substantial entanglement risk to sturgeon. Vertical lines pose a significant entanglement threat to NARWs, as discussed in Section 3.2.5.5 (*Secondary Entanglement due to Increased and Altered Fishing Activity Caused by the Presence of Structures [O&M]*), and this threat would be roughly comparable to the threat posed to manta rays. However, data regarding manta ray entanglement in vertical line gear is lacking and occurrence is expected to be much lower than entanglement with gill net fisheries. If a shift from mobile gear to fixed gear occurs due to the inability of the fishermen to maneuver mobile gear, there would be a potential increase in the number of vertical lines, resulting in an increased risk of manta ray interactions with trap/pot fishing gear. However, the likelihood of significant changes in already low entanglement rates due to a shift in fishing activities to fixed gear is very low.

Commercial fisheries that use gillnet and trawl gear have the greatest risk of sturgeon bycatch (Stein et al. 2004; ASSRT 2007; Dunton et al. 2015; ASMFC 2017), with the highest levels of bycatch in the mid-Atlantic occurring in dogfish and monkfish fisheries. Tie-down gillnets with long soak time produced the greatest sturgeon mortality (ASSRT 2007). Observer data showed concentrations of bycatch east and southeast of Chincoteague, VA and south of the mouth of Chesapeake Bay. Recommendations by the Atlantic Sturgeon Bycatch Working Group in 2021 that include modifications of tie-down length, reduced soak times, and seasonal set restrictions are likely to reduce bycatch. In the U.S. Southeast gill net fisheries, giant manta rays were most commonly taken in drift and strike nets from the shark and mackerel fisheries (Kroetz et al. 2020). Drift nets set in water depths between 10 and 39 feet (12 meters) with soak times of more than 8 hours were responsible for the most manta ray bycatch incidents (Kroetz et al. 2020). Like the sturgeon recommendations, reduction in the use of gill nets combined with reduction in soak times and increased net monitoring are expected to reduce bycatch. Fisheries recommendations regarding both pot fisheries (e.g., weak links) and gill net fisheries would likely reduce the risk of sturgeon and manta ray bycatch around the Project area in a comprehensive manner. The fishing gear and methods pose a greater risk to ESA-listed fish species than shifts in response to offshore wind. Therefore, the effects of redistribution of commercial fisheries to ESA-listed fish species would be **discountable**.

3.4.3.3.2 Increased Recreational Fishing

Increased recreational fishing poses a vessel strike risk (discussed in Section 3.4.3.5, *Vessel Traffic Effects on Marine Fish [C, O&M, D]*) and entanglement risk for ESA-listed fish species. Abandoned or lost recreational and commercial fishing gear may become entangled with foundations, resulting in an increased the risk of entanglement for the Atlantic sturgeon. Currently, published data do not exist on the amount or type of debris that accumulates on offshore wind foundations in the U.S. Atlantic and, therefore, the scale of entanglement risk is not known. Abandoned lines in the water column pose the greatest risk to the manta ray while lines that have consolidated at the bottom pose the greatest risk to sturgeon. Although there are unpublished, ancillary reports of sturgeon and manta ray entanglement in fishing line, recreational by-catch is not noted as a significant threat to these species. In the U.S. Gulf of Mexico where oil platforms and manta rays significantly overlap, recreational fishing near the platforms is a common activity. To date, no published reports exist regarding assessment and enumeration of fishing gear, or the associated entanglement risk for manta rays or sturgeon. Given that this long history of oil platforms and fishing exist, it is likely that the incidents of secondary entanglement are low. Additionally, the following monitoring and mitigation measure (Table 1-8) will act to reduce potential impacts on marine fish resulting from lost or discarded fishing gear that accumulates around WTG foundations:

- Dominion Energy must monitor indirect effects associated with charter and recreational fishing gear lost from expected increases in fishing around WTG foundations by surveying at least 10 of the WTGs located closest to shore in the Lease Area annually. Survey design and effort may be modified with review and concurrence by DOI. Dominion Energy may conduct surveys by remotely operated vehicles, divers, or other means to determine the frequency and locations of marine debris. Dominion Energy must report the results of the surveys to BOEM and BSEE in an annual report for the preceding calendar year. Annual reports must include survey reports that include: the survey date; contact information of the operator; the location and pile identification number; photographic and/or video documentation of the survey and debris encountered; any animals sighted; and the disposition of any located debris (i.e., removed or left in place). Annual reports must also include claim data attributable to the Project from Dominion Energy corporate gear loss compensation policy and procedures. Required data and reports may be archived, analyzed, published, and disseminated by BOEM.

The monitoring and disposition requirement provides BOEM with the ability to require removal of entanglement hazards should they occur. Secondary entanglement would pose a low risk to Atlantic sturgeon and giant manta ray due to their relatively low occurrences in the Project area and expected minimal direct use of or foraging at the foundations. The consequences of any entanglement are high in that it often results in a mortality; however, the expectation for secondary entanglement by Atlantic sturgeon or giant manta is extremely low such that it is **discountable**. Therefore, secondary entanglement due to increased and altered fishing activity caused by the presence of structures **may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.4 Water Quality Effects on Marine Fish (C & D)

Construction is likely to result in elevated levels of turbidity in the immediate proximity of seafloor-disturbing activities like pile driving, placement of scour protection, vessel anchoring, and burial of the inter-array and offshore export cables. There would be temporary increases in sediment suspension and deposition during activities that entail the disturbance of the seabed. Mitigation measures to minimize and reduce the potential for adverse effects from water quality changes on ESA-listed marine fish resulting from construction and decommissioning are included in the Proposed Action (Tables 1-8 and 1-9).

As described in Section 2.1, *Physical Environment*, the Lease Area is characterized by find sand, silt, and clay, and the resulting sediment plume that results from temporary and intermittent bottom disturbing activities is expected to settle out of the water column within a few hours. The installation of inter-array cables and offshore export cables would include site preparation activities (e.g., boulder removal) and cable installation via jet plow, jet trenching, chain cutting, trench former, hydroplow (simultaneous lay and burial), mechanical plowing (simultaneous lay and burial), pre-trenching (both simultaneous and separate lay and burial), mechanical trenching (simultaneous lay and burial), other technologies available at the time of installation, or both, which can cause temporary increases in turbidity and sediment resuspension. Other projects using similar installation methods (e.g., jet plowing, pile driving) have been characterized as having minor effects on water quality due to the short-term and localized nature of the disturbance (Latham et al. 2017). Sediment dispersion modeling was conducted for the COP (Dominion Energy 2022) to evaluate suspended sediment concentrations and deposition rates associated with Project construction activities. The modeling indicated that sediments resuspended during trenching would settle quickly to the seabed within the trench, potential plumes would be limited to right above the seabed and not within the water column, and concentrations greater than 10 mg/L would be short in duration (up to 4 hours) and limited to within approximately 2,625 feet (800 meters) of the center of the trench during flood conditions, and within 1,148 feet (350 meters) during ebb conditions. These effects on water quality for finer sediments are anticipated to be localized adjacent to the trench and temporary in nature.

Many proposed vessels for the Project would be equipped with DP systems, but some anchoring would be required to support specific construction activities. Increased vessel anchoring along with cable-laying and other construction activities during the installation and decommissioning phases would cause increased turbidity levels, which would be staggered, localized, and short term as well.

Studies of the effects of turbid water on fish suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute reaction is expected (Wilber and Clarke 2001). Directed studies of sturgeon TSS tolerance are currently lacking, but sturgeons, as a whole, are adapted to living in naturally turbid environments like large rivers and estuaries (Johnson 2018). Adult and subadult sturgeon that would be expected to occur in the Project area are tolerant of elevated suspended sediment levels, and as such, Johnson (2018) recommends that sturgeon should not be exposed to TSS levels of 1,000 mg/L above ambient levels for longer than 14 days at a time to avoid behavioral and physiological effects. Tolerance of juvenile Atlantic sturgeon to suspended sediments has been evaluated in a laboratory setting and exposed individuals to TSS concentrations of 100, 250, and 500 mg/L for a 3-day period (Wilkens et al. 2015). Of the fish exposed, 96 percent survived the test and the authors suggested that the absence of any significant effects on survival or swimming performance indicates that the impacts of sediment plumes in natural settings are minimal where fish can move or escape.

Atlantic sturgeon are opportunistic benthivores that feed primarily on mollusks, polychaete worms, amphipods, isopods, shrimps and small bottom-dwelling fishes; therefore, suspended sediment and turbidity could result in some temporary avoidance of turbid areas or feeding challenges. The giant manta ray is migratory and demonstrates high plasticity in terms of water depth. They are mainly filter feeders who would not be expected to be impacted by short term, localized turbidity. Any effects from elevated level of turbidity from the project on Atlantic sturgeon or their prey are considered so small that they could not be measured.

Studies of the effects of turbid water on fish suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute reaction is expected (Wilber and Clark 2001). Directed studies of sturgeon TSS tolerance are currently lacking, but sturgeons, as a whole, are adapted to living in naturally turbid environments like large rivers and estuaries (Johnson 2018). Adult and subadult sturgeon that would be expected to occur in the Project area are tolerant of elevated suspended sediment levels.

In addition, mitigation measures to minimize and reduce the potential for adverse effects from water quality changes on ESA-listed fish resulting from the Project are included in the Proposed Action (Table 1-7) or have been proposed by BOEM (Table 1-8). Fish would likely depart or avoid unfavorable water quality conditions they may encounter. Atlantic sturgeon abundance is low where hypoxic conditions occur, which can be up to 35 percent of Chesapeake Bay during summer months (ASSRT 2007), though this will not impact offshore waters. The ability for the giant manta ray to inhabit varying water depths, including offshore waters, will allow it to seek favorable water quality conditions.

Suspended sediment and turbidity could result in some temporary avoidance of turbid areas, but these short-term responses are expected to result in minor, non-measurable effects. Therefore, the risk of water quality effects on the Atlantic sturgeon and the giant manta ray is assumed to be extremely low, and effects, if any, would be **insignificant**.

Vessels associated with the Proposed Action may potentially generate operational waste, including bilge and ballast water, and sanitary and domestic wastes which could affect the water quality in the Project area. All vessels associated with the Proposed Action or would comply with USCG requirements for the prevention and control of oil and fuel spills. Proper vessel regulations and operating procedures would minimize effects on ESA-listed fish resulting from the release of fuel, hazardous materials, or waste (BOEM 2012). Additionally, training and awareness of BMPs proposed for waste management and mitigation of marine debris would be required of Project personnel, reducing the likelihood of occurrence to a very low risk. Likewise, utilizing BMPs for ballast or bilge water releases specifically from vessels transiting from foreign ports would reduce the likelihood of accidental release. These releases, if any, would occur infrequently at discrete locations and vary widely in space and time; as such, potential effects from accidental releases of waste material on ESA-listed fish are **discountable**.

Water quality effects on ESA-listed fish in the Project area resulting from increased turbidity levels and potential releases of aquatic contaminants during Project construction and decommissioning activities, therefore, **may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.5 Vessel Traffic Effects on Marine Fish (C, O&M, D)

While Atlantic sturgeon are known to be struck and killed by vessels in rivers and estuaries, there are no reports of vessel strikes in the marine environment, likely due to the space between bottom-oriented sturgeon and the propellers and hull of vessels (BOEM 2019b). Further, the dispersed nature of vessel traffic and individual sturgeon reduces the potential for co-occurrence of individual sturgeon and individual vessels. Propeller boats and barges can pose a risk to fish that swim near the water surface and are a potential source of mortality for Atlantic sturgeon as a result of direct collisions with the hull or propeller (Brown and Murphy 2010). Atlantic sturgeon strikes are most likely to occur in areas with abundant boat traffic such as large ports or areas with relatively narrow waterways (ASSRT 2007). The majority of vessel-related Atlantic sturgeon mortality is likely caused by large transoceanic vessels in river channels (Brown and Murphy 2010; Balazik et al. 2012). Large vessels have been implicated because of their deep draft (up to 40 to 45 feet [12.2 to 13.7 meters]) relative to smaller vessels (less than 15 feet [4.5 meters]), which increases the probability of vessel collision with demersal fishes like Atlantic sturgeon, even in deep water (Brown and Murphy 2010). Although smaller vessels and those with relatively shallow drafts provide more clearance from the river bottom to reduce the probability of vessel strikes, they can operate at a higher speed, which is expected to limit sturgeons' ability to avoid being struck. As previously discussed, Atlantic sturgeon are a demersal species and most likely to occur at or near the bottom of the water column in the marine environment. Notably, proposed Project-related vessel traffic would only operate in established navigation channels or open water areas of sufficient depth to make the potential for vessel strike extremely unlikely to occur.

Although data is limited, there is some evidence of vessel strikes on giant manta rays. Researchers in Florida reported five giant manta rays which showed propeller scars (NOAA 2021c), indicating vessel strikes. Since the giant manta ray is often observed in nearshore waters, faster moving recreational vessels may pose a higher risk than larger transoceanic vessels. In offshore areas, the risk of a vessel strike is likely to be minimal due to overall lower densities of sturgeon and their presence in benthic habitats instead of at the surface. The giant manta ray may occur at the surface and have been documented moving quickly, even leaping out of the water. It appears that they may be agile enough to avoid most vessel collisions; however, there is little evidence supporting this theory (NOAA 2021c).

As described in Section 2.1.3.2, *Vessel Traffic*, the contribution of the number of vessel trips under the proposed Project would be moderate during construction and relatively small during O&M compared to existing vessel activity (Section 2.1.3.2, *Vessel Traffic*). The baseline encounter rate for vessels and animals to be within a strike risk with one another is already low. Additionally, vessel strike avoidance measures for marine mammals and sea turtles (Table 1-7 and Table 1-8) may also benefit Atlantic sturgeon and giant manta ray. Therefore, the risk of vessel strikes on the Atlantic sturgeon and giant manta ray is assumed to be extremely low, and effects, if any, would be **insignificant**. The potential for vessel strikes, therefore, **may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.6 Monitoring Survey Effects on Marine Fish [C]

As mentioned in Section 3.2.5.7, *Fisheries Monitoring Survey Effects on Marine Mammals (C)*, fisheries monitoring surveys are for the Project are proposed prior to construction. The details of each survey type can be found in Section 1.3.4, *Fisheries Monitoring Plans*. Many of the potential impacts to ESA-listed marine fish arising from fisheries monitoring surveys are related to increased vessel traffic and increased for potential for vessel strikes. Increased vessel traffic and potential for vessel strike stressors are discussed in Section 3.4.3.5, *Vessel Traffic Effects on Marine Fish (C, O&M, D)*. Effects of survey methods include habitat disturbance during pot setting, and potential for entrapment or entanglement in monitoring gear. Impacts on ESA-listed marine fish specific to each survey type and equipment are described in Section 3.4.3.6.1, *Welk Survey,* and Section 3.4.3.6.2, *Black Sea Bass Surveys*.

3.4.3.6.1 Welk Survey

The welk surveys have been designed while actively working with VADEQ, VMRC, VIMS, Rutgers University, and commercial fishers. Welk pots are stationary pots that are baited and pose a potential risk to Atlantic sturgeon. However, fish traps and pots were not recorded as potential sources for capture of Atlantic sturgeon in the Northeast Fisheries Observer Program data (Dunton et al. 2015) and it is unlikely that giant manta rays would become entangled in the lines or pots. Atlantic sturgeon prey items such as mollusks and fish and giant manta ray prey items such as small fish may be removed from the marine environment as bycatch in trap gear. However, any bycatch prey items will be returned to the site. Therefore, the welk surveys will not affect the availability of prey for Atlantic sturgeon or giant manta ray in the Project area. Given this information, any effects on Atlantic sturgeon or giant manta ray from collection of potential prey in the trap gear will be so small that they cannot be meaningfully measured, detected, or evaluated and, therefore, effects are **insignificant**.

3.4.3.6.2 Black Sea Bass Surveys

Black sea bass pots are stationary pots that are baited and pose a potential risk to Atlantic sturgeon. However, fish traps and pots were not recorded as potential sources for capture of Atlantic sturgeon in the Northeast Fisheries Observer Program data (Dunton et al. 2015) and it is unlikely that giant manta rays would become entangled in the lines or pots. Atlantic sturgeon prey items such as mollusks and fish and giant manta ray prey items such as small fish may be removed from the marine environment as bycatch in trap gear. However, any bycatch prey items will be returned to the site. Therefore, the black sea bass surveys will not affect the availability of prey for Atlantic sturgeon or giant manta ray in the Project area. Given this information, any effects on Atlantic sturgeon or giant manta ray from collection of potential prey in the trap gear will be so small that they cannot be meaningfully measured, detected, or evaluated and, therefore, effects are **insignificant**.

3.4.3.6.3 Atlantic Surf Clam Surveys

The proposed dredging activities for the Atlantic survey clam surveys have the potential to cause adverse impacts on ESA-listed fish resulting primarily in turbidity and entrainment. Only Atlantic sturgeon are likely to be vulnerable to impingement or entrainment in dredges, which can result in injury or mortality (Reine et al. 2014; USACE 2020). However, data regarding Atlantic sturgeon capture in dredging equipment is predominantly for the Southeastern U.S. and is associated with navigational dredging projects (Reine et al. 2014; USACE 2020). Given their pelagic nature, giant manta rays are unlikely to face risk of entrainment in dredges. Additionally, as discussed in Section 3.4.3.4, effects of turbidity on fishes could result in some temporary avoidance of turbid areas, but these short-term responses are expected to result in minor, non-measurable effects. The likelihood of potential effects on ESA-listed fishes is further reduced by the short duration of these dredge surveys, as each dredge will sample the bottom for 5 minutes at a vessel speed of 1.5 knots, and the full survey is anticipated to occur over a maximum of 7 days in the late spring/early summer of 2023, and only medium-sized vessel will be used (Section 1.3.4.3).

Dominion Energy's proposed monitoring contractor, VIMS has submitted a fisheries permit application to NOAA GARFO and a request for a protected species risk assessment in August 2022 and received a letter of acknowledgement in September 2022 and received confirmation from GARFO's PRD that the plan as designed does not include any activities that are likely to result in a take of a protected marine species. Therefore, the potential risk of effect on ESA-listed fishes based upon the limited duration of dredging activities and the implementation of NOAA-required risk reduction measures vessel strikes would be extremely unlikely to occur and is **discountable.**

3.4.3.6.4 Summary of Fisheries Monitoring Survey Effects

As described in Sections 3.4.3.6.1 *Welk Survey*, 3.4.3.6.2 *Black Sea Bass Surveys*, and 3.4.3.6.3 *Atlantic Surf Clam Surveys*, any effects from monitoring surveys (e.g., entanglement, reductions in prey) on ESA-listed marine fish are considered unlikely to occur. A number of monitoring and mitigation measures are designed to further minimize the risk of entanglement and monitor the potential effects of fisheries monitoring surveys (Table 1-8); these measures are summarized in Section 3.3.5.6.3, *Summary of Fisheries Monitoring Survey Effects*, for sea turtles and are likewise applicable to marine fish. Monitoring survey effects due to the Proposed Action are, therefore, considered **insignificant** or **discountable. Therefore, impacts from monitoring surveys may affect, not likely to adversely affect** ESA-listed fish species.

3.4.3.7 Electromagnetic Field Effects on Marine Fish (O&M)

Marine fish are electrosensitive but appear to have relatively low sensitivity to magnetic fields based on studies of other sturgeon species. Bevelhimer et al. (2013) studied behavioral responses of lake sturgeon, a species closely related to marine fish, to artificial EMF fields and identified a detection threshold between 10,000 and 20,000 mG, well above the levels likely to result from the proposed Project (i.e., 9.1 to 76.6 mG). This indicates that marine fish are likely insensitive to magnetic field effects resulting from the proposed Project. However, fish may be sensitive to the induced electrical field generated by the cable.

Marine fish have specialized electrosensory organs capable of detecting electrical fields on the order of 0.5 mV/m (Gill et al. 2012; Normandeau 2011). Exponent Engineering (2018) calculated that the maximum induced electrical field strength in fish from the Project inter-array cable and the offshore export cable would be 0.43 mV/m or less, slightly below the detection threshold for the species. However, this analysis only considered the field associated with buried cable segments. Based on magnetic field strength, the induced electrical field in Atlantic sturgeon and giant manta rays in proximity to exposed cable segments is likely to exceed the 0.5-mV/m threshold. This suggests that fish would likely be able to detect the induced electrical fields in immediate proximity to exposed cable segments. Sturgeon species have been reported to respond to low frequency alternating current electric signals. For example, migrating Danube sturgeon (*Acipenser gueldenstaedtii*) have been reported to slow down when crossing beneath overhead high voltage cables and speed up once past them (Gill et al. 2012). This is not a useful comparison, however, because overhead power cables are unshielded and generate relatively powerful induced electrical fields compared to shielded subsea cables. Insufficient information is available to associate exposure with induced electrical fields generated by subsea cables with behavioral or physiological effects (Gill et al. 2012). However, it is important to note that natural electrical field effects generated by wave and current actions are on the order of 10 to 100 mV/m, many times stronger than the induced field generated by buried cable segments. Individual sturgeon may avoid EMF by moving away or vertically in the water column, but no impact to their migratory movements is expected. In addition, although giant manta rays may be more sensitive to underwater EMF than Atlantic sturgeon, they are a pelagic species and would spend less time on the seafloor versus Atlantic sturgeon, which would limit their exposure to EMF from Project cables. Given the range of baseline variability and limited area of detectable effects relative to available habitat on the OCS, the effects of fish's exposure to proposed Project-related EMF are, therefore, likely to be **insignificant** for both Atlantic sturgeon and giant manta ray. Therefore, EMF effects due to the Proposed Action **may affect, not likely to adversely affect** ESA-listed fish.

4. Conclusions and Effects Determinations

Table 4-1 summarizes the effects determinations for the listed marine mammals, sea turtles, and fish considered in this BA. Effects determinations incorporated the monitoring and mitigation measures outlined in Tables 1-8 and 1-9. The following three effects determinations were made in this BA.

1. A **may affect, not likely to adversely affect** determination was made when the Project stressors were determined to have **no effect**, **insignificant** effects or were **discountable**.
   a. **No effect:** No effect was assigned if it is determined the proposed Project would have no effects, positive or negative, on species or designated critical habitat. Generally, this means that the species or critical habitat would not be exposed to the proposed Project and its environmental consequences.
2. **Insignificant:** Effects relate to the size or severity of the effect and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effects conclusion when plausible effects are going to happen but will not rise to the level of constituting an adverse effect.
3. **Discountable:** Effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did affect a listed species), but it is extremely unlikely to occur (NMFS and USFWS 1998).[5]
4. In addition, if the Project had the potential to result in beneficial effects on listed species (for example, the aggregation of prey due to structures), but was also likely to cause some adverse effects, then a determination of **may affect, likely to adversely affect** was made.
5. A **may affect, likely to adversely affect** determination was made when a Project stressor could not be fully mitigated and was expected to result in an adverse effect on an ESA-listed species that could result in an ESA-level take.

Table 4-1 Effects determination summary for NMFS ESA–listed species known or likely to occur in the Project area

Stressor		Project Development Phase	Potential Effect	ESA-Listed Marine Mammals	ESA-Listed Sea Turtles	ESA-Listed Fish
Underwater Noise	WTG and OSS Foundation Installation Impact and	C	PTS	LAA for fin and sei whales NLAA for NARW and sperm whales	LAA	NLAA

[5] When the terms “discountable” or “discountable effects” appear in this document, they refer to potential effects that are found to support a “not likely to adversely affect” conclusion because they are extremely unlikely to occur. The use of these terms should not be interpreted as having any meaning inconsistent with the ESA regulatory definition of “effects of the action.”

Stressor		Project Development Phase	Potential Effect	ESA-Listed Marine Mammals	ESA-Listed Sea Turtles	ESA-Listed Fish
Underwater Noise	Vibratory Pile Driving		BD	NLAA for sperm and sei whale LAA for fin whales and NARW	LAA	NLAA
	Goal Post Pile Installation	C	PTS	NLAA	NLAA	NLAA
			BD	NLAA	NLAA	NLAA
	Cofferdam Installation	C	PTS	NLAA	NLAA	NLAA
			BD	NLAA	NLAA	NLAA
	HRG Surveys	C, O&M	PTS	NLAA	NLAA	NLAA
			BD	NLAA	NLAA	NLAA
	Vessel Noise	C, O&M, D	PTS and BD	NLAA	NLAA	NLAA
	Cable laying and Trenching Noise	C	PTS and BD	NLAA	NLAA	NLAA
	WTG Noise	O&M	PTS and BD	NLAA	NLAA	NLAA
Habitat Disturbance	Displacement from Physical Disturbance	C, O&M, D	Altered migration/ displacement	NLAA	NLAA	NLAA
	Effects of Changes in Oceanographic and Hydrological Conditions	O&M	Altered migration/ Displacement / Foraging/Prey availability	NLAA	NLAA	NLAA
	Changes in Prey Availability	O&M	Foraging/Prey availability	NLAA	NLAA	NLAA
Secondary Entanglement from Increased Recreational Fishing Due to Reef Effect		O&M	Secondary entanglement	NLAA	LAA for Loggerhead and Leatherback sea turtles NLAA for Kemp's and Green sea turtles	NLAA

Stressor		Project Development Phase	Potential Effect	ESA-Listed Marine Mammals	ESA-Listed Sea Turtles	ESA-Listed Fish
Water Quality	Turbidity	C, D	Foraging/Prey availability	NLAA	NLAA	NLAA
	Oil Spills/Chemical Release	C, O&M, D	Contaminant exposure	NLAA	NLAA	NLAA
Vessel Traffic		C, O&M, D	Injury/mortality	NLAA	LAA	NLAA
EMF		O&M	Effects on orientation/ migration or navigation	NLAA	NLAA	NLAA
Fishery Monitoring Plan		O&M	Secondary entanglement	NLAA	NLAA	NLAA
Overall Effects Determination		C, O&M, D	PTS/BD	LAA	LAA	LAA

BD = behavioral disturbance; C = construction; D = decommissioning; EMF = electromagnetic field; ESA = Endangered Species Act; LAA = likely to adversely affect; NARW = North Atlantic right whale; NMFS = National Marine Fisheries Service; NLAA = not likely to adversely affect; O&M = operations and maintenance; OSS = offshore substation; PTS = permanent threshold shift; WTG = wind turbine generator.

5. References

Agler, B.A., R.L. Schooley, S.E. Frohock, S.K. Katona, and I.E. Seipt. 1993. Reproduction of Photographically Identified Fin Whales, *Balaenoptera physalus*, from the Gulf of Maine. *Journal of Mammalogy* 74(3):577-587.

American Bureau of Shipping (ABS). 2021. *Requirements for Building and Classing Wind Farm Support Vessels*. May 2021. American Bureau of Shipping Incorporated by Act of Legislature of the State of New York 1862. 26 pp. Available at: https://ww2.eagle.org/content/dam/eagle/rules-and-guides/current/offshore/200_wind_farm_support_vesssels_2021/gd-wind-farm-support-vessels-may21.pdf. Accessed December 28, 2022.

Anatec Limited. 2022. *Coastal Virginia Offshore Wind Commercial OCS-A 0483. Navigational Safety Risk Assessment*. Prepared for Tetra Tech, Inc. and Dominion Energy, Inc., May 5, 2022. Document No. A4488-TT-NSRA-1. 258 pp.

André, M., M. Solé, M. Lenoir, M. Durfort, C. Quero, A. Mas, A. Lombarte, M. van der Schaar, M. López-Bejar, M. Morell, S. Zaugg, and L. Houégnigan. 2011. Low-frequency Sounds Induce Acoustic Trauma in Cephalopods. *Frontiers in Ecology and the Environment* 9(9):489-493.

André, M., K. Kaifu, M. Solé, M. van der Schaar, T. Akamatsu, A. Balastegui, A.M. Sánchez, and J.V. Castell. 2016. Contribution to the Understanding of Particle Motion Perception in Marine Invertebrates. In: A.N. Popper, A. Hawkins (Eds.), *The Effects of Noise on Aquatic Life II*. Springer New York, New York, NY. pp. 47-55.

Archer, F.I., R.L. Brownell Jr., B.L. Hancock-Hanser, P.A. Morin, K.M. Robertson, K.K. Sherman, J. Calambokidis, R.J. Urbán, P.E. Rosel, S.A. Mizroch, and S. Panigada. 2019. Revision of Fin Whale *Balaenoptera physalus* (Linnaeus, 1758) Subspecies Using Genetics. *Journal of Mammalogy* 100(5):1653-1670.

Atlantic States Marine Fisheries Commission (ASMFC). 2017. *Atlantic Sturgeon Benchmark Stock Assessment and Peer Review Report*. Raleigh, North Carolina: Prepared by the ASMFC Atlantic Sturgeon Stock Assessment Peer Review Panel. Pursuant to NOAA Award No. NA15NMF4740069. 456 pp.

Atlantic Sturgeon Status Review Team (ASSRT). 2007. *Status Review of Atlantic sturgeon* (*Acipenser oxyrinchus oxyrinchus*). Report to the U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Northeast Regional Office. 174 pp.

Azzara, A.J., W.M. von Zharen, and J.J. Newcomb. 2013. Mixed-methods Analytical Approach for Determining Potential Impacts of Vessel Noise on Sperm Whale Click Behavior. *The Journal of the Acoustical Society of America* 134:4566.

Bailey, H., A. Rice, J.E. Wingfield, K.B. Hodge, B.J. Estabrook, D. Hawthorne, A. Garrod, A.D. Fandel, L. Fouda, E. McDonald, E. Grzyb, W. Fletcher, and A.L. Hoover. 2018. *Determining Habitat Use by Marine Mammals and Ambient Noise Levels Using Passive Acoustic Monitoring Offshore of Maryland*. U.S. Department of the Interior, Bureau of Ocean Energy Management, Sterling, VA. OCS Study BOEM 2019-018. 232 pp.

Baille, L.M., and D.P. Zitterbart. 2022. Effectiveness of Surface-based Detection Methods for Vessel Strike Mitigation of North Atlantic Right Whales. *Endangered Species Research* 49:57-69.

Bain, M.B. 1997. Atlantic and Shortnose Sturgeons of the Hudson River: Common and Divergent Life History Attributes. *Environmental Biology of Fishes* 48:347–358.

Baines, M.E., and M. Reichelt. 2014. Upwellings, Canyons and Habitat for Balaenopterid Whales off Mauritania, Northwest Africa. *Journal of Cetacean Research and Management* 14:57-67.

Baker, K., and U. Howsen. 2021. *Data Collection and Site Survey Activities for Renewable Energy on the Atlantic Outer Continental Shelf. Biological Assessment*. U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. October 2018, Revised February 2021. 152 pp.

Balazik, M.T., K.J. Reine, A.J. Spells, C.A. Fredrickson, M.L. Fine, G.C. Garman, and S.P. McIninch. 2012. The Potential for Vessel Interactions with Adult Atlantic sturgeon in the James River, Virginia. *North American Journal of Fisheries Management* 32(6):1062–1069.

Balazs, G. H. 1985. Impact of Ocean Debris on Marine Turtles: Entanglement and Ingestion. In: *Proceedings of the Workshop on the Fate and Impact of Marine Debris*, November 27–29, 1984, Honolulu, Hawaii, Eds. R.S. Shomura, and O. Yoshida. NOAA Technical Memorandum NMFS-SWFSC-54. pp. 387-429.

Barco, S., and G. Lockhart. 2016. *Sea Turtle Tagging and Tracking in Chesapeake Bay and Coastal Waters of Virginia: 2015 Annual Progress Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470-10-3011, Task Order 50, issued to HDR Inc., Virginia Beach, VA. February 24, 2016. Available at: https://www.navymarinespeciesmonitoring.us/files/9914/7689/9615/Barco_et_al._2016_-_Turtle_tagging_2015.pdf. Accessed June 20, 2022.

Barco, S., and W. Swingle. 2014. *Sea Turtle Species in the Coastal Waters of Virginia: Analysis of stranding and survey data*. Prepared for the Virginia Department of Mines, Minerals and Energy. VAQF Scientific Report 2014-07b, Virginia Beach, VA. Available at: https://static1.squarespace.com/static/5b3cf461d274cb109aa488d8/t/5b8b4157562fa736b2ed7273/1535852888427/VAQF_Scientific_Report_2014-07b_Sea+Turtles.pdf. Accessed June 20, 2022.

Barco, S.G., M.L. Burt, R.A.D. Jr., W.M. Swingle, and A.S. Williard. 2018. Loggerhead Turtle *Caretta caretta* Density and Abundance in Chesapeake Bay and the Temperate Ocean Waters of the Southern Portion of the Mid-Atlantic Bight. *Endangered Species Research* 37:269-287.

Bardonnet, A., and J.-L. Baglinière. 2000. Freshwater Habitat of Atlantic salmon (*Salmo salar*). *Canadian Journal of Fisheries and Aquatic Sciences* 57(2):497-506.

Barkaszi, M.J., and C.J. Kelly. 2019. *Seismic Survey Mitigation Measures and Protected Species Observer Reports: Synthesis Report.* U.S. Department of the Interior, Bureau Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. Contract No.: M17PD00004. OCS Study BOEM 2019-012. 220 pp.

Barnette, M.C. 2017. *Potential Impacts of Artificial Reef Development on Sea Turtle Conservation in Florida.* NOAA Technical Memorandum NMFS-SER-5. 36 pp.

Bartol, S.M. 2004. Sea Turtle Hearing and Sensitivity to Acoustic Impact. Appendix H In: *Geophysical and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf*. OCS EIS/EA MMS 2004-054. US Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Bartol, S.M. 2008. A Review of Auditory Function of Sea Turtles. *Bioacoustics* 17(1-3):57-59.

Bartol, S.M., and I.K. Bartol. 2012. *Hearing Capabilities of Loggerhead Sea Turtles (Caretta caretta) throughout Ontogeny: An Integrative Approach involving Behavioral and Electrophysiological Techniques: Final Project Report.* E&P & Marine Life Programme. Prepared by Virginia Wesleyan College and Old Dominion University. JIP Grant No. 22 07-14. 37 pp. Available at: http://www.seaturtle.org/library/BartolSM_2011d_JIPTechReport.pdf Accessed January 24, 2023.

Bartol, S.M., and D.R. Ketten. 2006. Turtle and tuna hearing. pp. 98-103 In: Y. Swimmer and R. Brill (Eds.), *Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries*. NOAA Technical Memorandum NMFS-PIFSC-7.

Bartol, S.M., and J.A. Musick. 2003. Sensory Biology of SeaTturtles. pp. 79-102 In: P.L. Lutz, J.A. Musick and J. Wyneken (Eds.), *The Biology of Sea Turtles, Volume 2*. CRC Press, Boca Raton, FL. 455 pp.

Bartol, S.M., J.A. Musick, and M.L. Lenhardt. 1999. Auditory Evoked Potentials of the Loggerhead Sea Turtle (*Caretta caretta*). *Copeia* 1999(3):836-840.

Baum, E. 1997. *Maine Atlantic Salmon: A National Treasure*. Atlantic Salmon Unlimited, Hermon, ME. 224 pp.

Baumgartner, M.F., S.M. Van Parijs, F.W. Wenzel, C.J. Tremblay, H.C. Esch, and A.M. Warde. 2008. Low Frequency Vocalizations Attributed to Sei Whales (*Balaenoptera borealis*). *Journal of the Acoustical Society of America* 124(2):1339-1349.

Becker, A., A.K. Whitfield, P.D. Cowley, J. Järnegren, and T.F. Næsje. 2013. Does Boat Traffic Cause Displacement of Fish in Estuaries? *Marine Pollution Bulletin* 75(1):168-173.

Bellmann, M.A., J. Brinkmann, A. May, T. Wendt, S. Gerlach, and P. Remmers. 2020. *Underwater Noise during percusive Pile-driving: Influencing Factors on Pile-driving Noise and Technical Possibilities to Comply with Noise Mitigation Values.* Supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU)), FKZ UM16 881500. Commissioned and managed by the Federal Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie (BSH)). Order No. 10036866. Edited by the itap GmbH. 137 pp. ERa-Report (itap.de) Accessed January 24, 2023.

Bérubé, M., A. Aguilar, D. Dendanto, F. Larsen, G. Notarbartolo di Sciara, R. Sears, J. Sigurjónsson, J. Urban-Rich, and P.J. Palsbøll. 1998. Population Genetic Structure of North Atlantic, Mediterranean Sea and Sea of Cortez Fin Whales, *Balaenoptera physalus* (Linnaeus 1758): Analysis of Mitochondrial and Nuclear Loci. *Molecular Ecology* 7(5):85-599.

Bettridge, S., C.S. Baker, J. Barlow, P.J. Clapham, M. Ford, D. Gouveia, D.K. Mattila, R.M. Pace, III, P.E. Rosel, G.K. Silber, and P.R. Wade. 2015. *Status review of the humpback whale (Megaptera novaeangliae) under the Endangered Species Act*. NOAA Technical Memorandum NMFS. NOAA-TM-NMFS-SWFSC-540. March 2015. 263 pp.

Bevelhimer, M.S., G.F. Cada, A.M. Fortner, P.E. Schweizer, and K. Riemer. 2013. Behavioral responses of representative freshwater fish species to electromagnetic fields. *Transactions of the American Fisheries Society* 142(3):802–813.

Biodiversity of the Central Coast. 2022. Eelgrass, common eelgrass, *Zostera marina*. Available at: https://www.centralcoastbiodiversity.org/eelgrass-bull-zostera-marina.html. Accessed December 28, 2022.

Bjorndal, K.A. 1997. Foraging ecology and nutrition of sea turtles. In P. L. Lutz & J. A. Musick (Eds.), *The Biology of Sea Turtles.* pp. 213-246. Boca Raton, Florida: CRC Press.

Blackwell, S.B., C.S. Nations, T.L. McDonald, C.R. Greene, A.M. Thode, M. Guerra, and A.M. Macrander. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. *Marine Mammal Science* 29(4):E342-E365.

Bonfil, R., S. Clarke, and H. Nakano. 2008. Chapter 11: The Biology and Ecology of the Oceanic Whitetip Shark, *Carcharhinus longimanus*. In: M.D. Camhi, E.K. Pikitch, B.E. A (Eds.), *Sharks of the Open Ocean: Biology, Fisheries and Conservation*. Online: Blackwell Publishing Ltd. Pp. 128-139.

Bracciali, C., D. Campobello, C. Giacoma, and G. Sarà. 2012. Effects of Nautical Traffic and Noise on Foraging Patterns of Mediterranean Damselfish (*Chromis chromis*). *PLoS ONE* 7(7):e40582.

Brakes, P., and S.R.X. Dall. 2016. Marine mammal behavior: A review of conservation implications. *Frontiers in Marine Science* 3:00087. Doi:10.3389/fmars.2016.00087.

Branstetter, B.K., V.F. Bowman, D.S. Houser, M. Tormey, P. Banks, J. Finneran, and K. Jenkins. 2018. Effects of vibratory pile driver noise on echolocation and vigilance in bottlenose dolphins (*Tursiops truncatus*). *The Journal of the Acoustical Society of America* 143(1):429.

Broström, G. 2008. On the influence of large wind farms on the upper ocean circulation. *Journal of Marine Systems* 74:585–591.

Brown, M.W., D. Fenton, K. Smedbol, C. Merriman, K. Robichaud-Leblanc, and J.D. Conway. 2009. *Recovery Strategy for the North Atlantic Right Whale* (Eubalaena glacialis) *in Atlantic Canadian Waters [Final]*. Fisheries and Oceans Canada. Species at Risk Act Recovery Strategy Series. 66 pp.

Brown, J.J. and G.W. Murphy. 2010. Atlantic Sturgeon Vessel-Strike Mortalities in the Delaware Estuary. *Fisheries* 35:72-83.

Buckstaff, K.C. 2006. Effects of watercraft noise on the acoustic behavior of bottlenose dolphins, *Tursiops truncatus* in Sarasota Bay, Florida. *Marine Mammal Science* 20(4):709-725.

Budelmann, B.U. 1992. Hearing in Nonarthropod Invertebrates. In: D.B. Webster, A.N. Popper, R.R. Fay (Eds.), *The Evolutionary Biology of Hearing*. New York, NY: Springer New York. pp. 141-155.

Budelmann, B.U., and R. Williamson. 1994. Directional sensitivity of hair cell afferents in the Octopus statocyst. *The Journal of Experimental Biology* 187(1):245.

Bureau of Ocean Energy Management (BOEM). 2012. *Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New Jersey, Delaware, Maryland, and Virginia: Final Environmental Assessment*. U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS EIS/EA BOEM 2012-003. Available at: https://www.boem.gov/sites/default/files/uploadedFiles/BOEM/Renewable_Energy_Program/Smart_from_the_Start/Mid-Atlantic_Final_EA_012012.pdf. Access June 20, 2022.

Bureau of Ocean Energy Management (BOEM). 2013. *Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore Rhode Island and Massachusetts. Revised Environmental Assessment.* U.S. Department of the Interior, BOEM Office of Renewable Energy Programs. OCS EIS/EA BOEM 2013-1131. 417 p. Available at: https://www.boem.gov/sites/default/files/uploadedFiles/BOEM/Renewable_Energy_Program/State_Activities/BOEM%20RI_MA_Revised%20EA_22May2013.pdf Accessed January 26, 2023.

Bureau of Ocean Energy Management (BOEM). 2019a. *Guidelines for Providing Information on Fisheries for Renewable Energy Development on the Atlantic Outer Continental Shelf Pursuant to 30 CFR Part 585*. June 2019. Available at: https://www.boem.gov/sites/default/files/renewable-energy-program/Regulatory-Information/BOEM-Fishery-Guidelines.pdf. Accessed December 28, 2022.

Bureau of Ocean Energy Management (BOEM). 2019b. *National Environmental Policy Act Documentation for Impact-Producing Factors in the Offshore Wind Cumulative Impacts Scenario on the North Atlantic Outer Continental Shelf*. OCS Study BOEM 2019-036. May 2019. 201 pp. Available at: https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Renewable-Energy/IPFs-in-the-Offshore-Wind-Cumulative-Impacts-Scenario-on-the-N-OCS.pdf. Accessed June 20, 2022.

Bureau of Ocean Energy Management (BOEM). 2015. *Guidelines for Providing Geological and Geophysical, Hazards, and Archaeological Information Pursuant to 30 CFR Part 585*. Available at: https://www.boem.gov/sites/default/files/documents/about-boem/GG-Guidelines.pdf. Accessed January 30, 2023.

Bureau of Ocean Energy Management (BOEM). 2021. *South Fork Wind Farm and South Fork Export Cable Project Final Environmental Impact Statement*. U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS EIS/EA BOEM 2020-057. 1317 pp. Available at: https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/SFWF%20FEIS.pdf. Accessed January 26, 2023.

Burge, C.A., Mark Eakin, C., Friedman, C.S., Froelich, B., Hershberger, P.K., Hofmann, E.E., Petes, L.E., Prager, K.C., Weil, E., Willis, B.L. and Ford, S.E. 2014. Climate change influences on marine infectious diseases: implications for management and society. *Annual Review of Marine Science* 6:249-277.

Burke, V.J., E.A. Standora, and S.J. Morreale. 1993. Diet of juvenile Kemp's ridley and loggerhead sea turtles from Long Island, New York. *Copeia* 1993(4):1176-1180.

Buscaino, G., F. Filiciotto, G. Buffa, A. Bellante, V.D. Stefano, A. Assenza, F. Fazio, G. Caola, and S. Mazzola. 2010. Impact of an acoustic stimulus on the motility and blood parameters of European sea bass (*Dicentrarchus labrax* L.) and gilthead sea bream (*Sparus aurata* L.). *Marine Environmental Research* 69(3):136-142.

Byles, R.A. 1988. *The Behavior and Ecology of Sea Turtles in Virginia*. Unpublished Ph.D. dissertation, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA. 112 pp. Available at: Behavior and ecology of sea turtles from Chesapeake Bay, Virginia (wm.edu). Accessed January 27, 2023.

Carlson, J.K., and S. Gulak. 2012. Habitat use and movement patterns of oceanic whitetip, bigeye thresher and dusky sharks based on archival satellite tags. *Collective Volumes of Scientific Papers, ICCAT* 68(5):1922-1932.

Carpenter, J. R., L. Merchelbach, U. Callies, S. Clark, L. Gaslikova, and B. Baschek. 2016. Potential impacts of offshore wind farms on North Sea stratification. *PLoS ONE* 11(8):e0160830.

Carr, A., and D. Caldwell. 1956. The ecology and migrations of Sea Turtles, I. Results of field work in Florida, 1955. *American Museum Novitates* 1793:1–23.

Casper, B.M., P.S. Lobel, and H.Y. Yan. 2003. The hearing sensitivity of the little skate, *Raja erinacea*: a comparison of two methods. *Environmental Biology of Fishes* 68: 371-379.

Casper, B.M., M.B. Halvorsen, and A.N. Popper. 2012. Are sharks even bothered by a noisy environment? In: *The Effects of Noise on Aquatic Life*. Springer, New York, NY. pp. 93-97.

Castelao, R., S. Glenn, and O. Schofield. 2010. Temperature, salinity, and density variability in the central Middle Atlantic Bight. *Journal of Geophysical Research* 115:C10005.

Castellote, M., C.W. Clark, and M.O. Lammers. 2012. Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. *Biological Conservation* 147(1):115-122.

Cerchio S., S. Strindberg, T. Collins, C. Bennett, and H. Rosenbaum. 2014. Seismic surveys negatively affect humpback whale singing activity off northern Angola. *PLoS ONE* 9(3):e86464.

Cetacean and Turtle Assessment Program (CETAP). 1982. *A Characterization of Marine Mammals and Turtles in the Mid- and North-Atlantic Areas of the U.S. Outer Continental Shelf*. Kingston, Rhode Island: University of Rhode Island, Sponsored by the U.S. Department of the Interior, Bureau of Land Management. Contract #AA552-CT8-48. 576 pp.

Charif, R.A. and C.W. Clark. 2009. *Acoustic monitoring of large whales in deep waters north and west of the British Isles: 1996-2005, Preliminary Report*. Technical Report 08-07, Cornell University Lab of Ornithology Bioacoustics Research Program, Ithaca, New York, 40 pp.

Cholewiak, D., A.I. DeAngelis, D. Palka, P.J. Corkeron, and S.M. Van Parijs. 2017. Beaked whales demonstrate a marked acoustic response to the use of shipboard echosounders. *Royal Society Open Science* 4(12):170940.

Christiansen, N., U. Daewel, B. Djath, and C. Schrum. 2022. Emergence of Large-Scale Hydrodynamic Structures Due to Atmospheric Offshore Wind Farm Wakes. *Frontiers in Marine Science* 9:818501.

Clapham, P.J., and I.E. Seipt. 1991. Resightings of independent fin whales, *Balaenoptera physalus*, on maternal summer ranges. *Journal of Mammalogy* 72(4):88-790.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A.S. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. *Marine Ecology Progress Series* 395:201-222.

Codarin, A., L.E. Wysocki, F. Ladich, and M. Picciulin. 2009. Effects of ambient and boat noise on hearing and communication in three fish species living in a marine protected area (Miramare, Italy). *Marine Pollution Bulletin* 58(12):1880-1887.

Cole, T. V. N., D. L. Hartley, and R. L. Merrick. 2005. *Mortality and serious injury determinations for large whale stocks along the United States eastern seaboard, 1999–2003*. National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, Massachusetts.

Conn, P., and G. Silber. 2013. Vessel speed restrictions reduce risk of collision-related mortality for North Atlantic right whales. *Ecosphere* 4(4):1-16.

Cooke, J.G. 2018a. *Megaptera novaeangliae*. *The IUCN Red List of Threatened Species* 2018: e.T13006A50362794. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T13006A50362794.en. Accessed December 28, 2022.

Cooke, J.G. 2018b. *Balaenoptera physalus*. The IUCN Red List of Threatened Species 2018: e.T2478A50349982. Available at: https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T2478A50349982.en. Accessed June 20, 2022.

Cooke, J.G. 2018c. *Balaenoptera borealis*. The IUCN Red List of Threatened Species 2018: e.T2475A130482064. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T2475A130482064.en. Accessed December 28, 2022.

Cooke, J.G. 2020. *Eubalaena glacialis* (errata version published in 2020). The IUCN Red List of Threatened Species 2020: e.T41712A178589687. Available at: https://dx.doi.org/10.2305/IUCN.UK.2020-2.RLTS.T41712A178589687.en. Accessed June 20, 2022

Costidis, A.M., K.M. Phillips, S.G. Barco, and R. Boettcher. 2017. *Introduction to the Virginia Marine Mammal Conservation Plan*. Virginia Aquarium & Marine Science Center, Department of Game and Inland Fisheries. VAQF Scientific Report #2017-02.

Costidis, A., W. Swingle, S. Barco, E. Bates, S. Mallette, S. Rose, and A. Epple. 2019. *Virginia Sea Turtle and Marine Mammal Stranding Network 2018 Grant Report*. Final Report to the Virginia Coastal Zone Management Program, NOAA CZM Grant NA17NOS4190152, Task 49. VAQF Scientific Report 2019-01, Virginia Beach, VA. Available at: https://www.deq.virginia.gov/home/showpublisheddocument/10700/637673836090600000 Accessed January 26, 2023.

Cotter, M.P. 2019. *Aerial Surveys for Protected Marine Species in the Norfolk Canyon Region: 2018–2019 – Final Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470-15-D8006 Task Order 18F4019, issued to HDR, Inc., Virginia Beach, Virginia. November 2019. Available at: https://www.navymarinespeciesmonitoring.us/files/7215/7800/0588/Cotter_2019_-_Norfolk_Canyon_Aerial_Surveys_2018-19.pdf. Accessed June 20, 2022.

Cranford, T.W., and P. Krysl. 2015. Fin Whale Sound Reception Mechanisms: Skull Vibration Enables Low-Frequency Hearing. *PLoS ONE* 10(1):e0116222.

Cronin T.W., J.I. Fasick, L.E. Schweikert, S. Johnsen, L.J. Kezmoh, M.F. Baumgartner. 2017. Coping with Copepods: Do Right Whales (*Eubalaena glacialis*) Forage Visually in Dark Waters? *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences* 372(1717):20160067.

CSA Ocean Sciences Inc. and Exponent. 2019. *Evaluation of Potential EMF Effects on Fish Species of Commercial or Recreational Fishing Importance in Southern New England*. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2019-049. 59 pp. Available at: https://espis.boem.gov/final%20reports/BOEM_2019-049.pdf. Accessed January 26, 2023.

Dadswell, M.J. 2006. A review of the status of Atlantic sturgeon in Canada, with comparisons to populations in the United States and Europe. *Fisheries* 31(5):218–229.

Danie, D.S., J. Trial, and J.G. Stanley. 1984. *Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic), Atlantic Salmon*. Vol. 82. No. 11. National Coastal Ecosystems Team, Division of Biological Services, Research and Development, Fish and Wildlife Service, US Department of the Interior, 1984.

Davis, G.E., M.F. Baumgartner, J.M. Bonnell, J. Bell, C. Berchok, J. Bort Thornton, S. Brault, G Buchanan, R.A. Charif, D. Cholewiak, C.W. Clark, P. Corkeron, J. Delarue, K. Dudzinski, L. Hatch, J. Hildebrand, L. Hodge, H. Klinck, S. Kraus, B. Martin, D.K. Mellinger, H. Moors-Murphy, S. Nieukirk, D.P. Nowacek, S. Parks, A.J. Read, A.N. Rice, D. Risch, A. Širović, M. Soldevilla, K. Stafford, J.E. Stanistreet, E. Summers, S. Todd, A. Warde, and S.M. Van Parijs. 2017. Long-term passive acoustic recordings track the changing distribution of North Atlantic right whales (*Eubalaena glacialis*) from 2004 to 2014. *Scientific Reports* 7(13460):1–12.

Davis, G.E., M.F. Baumgartner, P.J. Corkeron, J. Bell, C. Berchok, J.M. Bonnell, J. Bort Thornton, S. Brault, G.A. Buchanan, D.M. Cholewiak, and C.W. Clark. 2020. Exploring movement patterns and changing distributions of baleen whales in the western North Atlantic using a decade of passive acoustic data. *Global Change Biology* 26(9):4812–4840.

De Robertis, A. and N.O. Handegard. 2013. Fish avoidance of research vessels and the efficacy of noise-reduced vessels: a review. *ICES Journal of Marine Science* 70:34–45.

Degraer, S., D.A. Carey, J.W.P. Coolen, Z.L. Hutchison, F. Kerckhof, B. Rumes, and J. Vanaverbeke. 2020. Offshore wind farm artificial reefs affect ecosystem structure and functioning. *Oceanography* 33(4):48-57.

Delarue, J., S.K. Todd, S.M. Van Parijs, and L. Di Iorio. 2009. Geographic variation in Northwest Atlantic fin whale (*Balaenoptera physalus*) song: Implications for stock structure assessment. *The Journal of the Acoustical Society of America* 125(3):1774-1782.

Delefosse, M., M.L. Rahbek, L. Roesen, and K.T. Clausen. 2018. Marine mammal sightings around oil and gas installations in the central North Sea. *Journal of the Marine Biological Association of the United Kingdom* 98(5):993-1001.

Department for Business, Enterprise and Regulatory Reform. 2008. *Review of Cabling Techniques and Environmental Effects Applicable to the Offshore Wind Industry*. Technical report. January 2008. Available at: Review of Cabling Techniques and Environmental Effects Applicable to the Offshore Wind Farm Industry (pnnl.gov) Accessed January 26, 2023.

Department of the Navy (DoN). 2007. *Navy OPAREA density estimates (NODES) for the Northeast, Southeast, and Gulf of Mexico OPAREAs*. Norfolk, Virginia: Naval Facilities Engineering Command, Atlantic Contract N62470-02-D-9997, Task Order 0046. Prepared by Geo-Marine, Inc., Hampton, Virginia. 163 pp.

Department of the Navy (DoN). 2017. Sperm whales tagged off Virginia Beach. Available at: https://www.navymarinespeciesmonitoring.us/blog/sperm-whales-tagged-virginia-beach/. Accessed June 20, 2022.

Department of the Navy (DoN). 2018. Hawaii-Southern California Training and Testing EIS/OEIS. Available at: https://www.hstteis.com/Documents/2018-Hawaii-Southern-California-Training-and-Testing-Final-EIS-OEIS/Final-EIS-OEIS. Accessed January 26, 2023.

Department of the Navy (DoN). 2022. Marine Species Monitoring. Available at: https://www.navymarinespeciesmonitoring.us/. Accessed December 28, 2022.

Dernie, K. M., M. J. Kaiser, and R. M. Warwick. 2003. Recovery rates of benthic communities following physical disturbance. *Journal of Animal Ecology* 72:1043-1056. https://doi.org/10.1046/j.1365-2656.2003.00775.x.

DeRuiter, S., and K.L. Doukara. 2012. Loggerhead turtles dive in response to airgun sound exposure. *Endangered Species Research* 16:55-63.

Di Iorio, L., and C.W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. *Biology Letters* 6(1):51-54.

Dodge, K.L., B. Galuardi, T.J. Miller, and M.E. Lutcavage. 2014. Leatherback turtle movements, dive behavior, and habitat characteristics in ecoregions of the Northwest Atlantic Ocean. *PLoS ONE* 9(3):e91726.

Dolman, S., V. Williams-Grey, R. Asmutis-Silvia, and S. Issac. 2006. *Vessel Collisions and Cetaceans: What Happens Wphen They Don't Miss the Boat*. Whale and Dolphin Conservation Society Science Report. 25 pp.

Dominion Energy. 2022. *Construction and Operations Plan, Coastal Virginia Offshore Wind Commercial Project.* Prepared by Tetra Tech, Inc. Submitted to Bureau of Ocean Energy Management. May 2022. Revised July 2022.

Dow Piniak, W.E., S.A. Eckert, C.A. Harms, and E.M. Stringer. 2012. *Underwater Hearing Sensitivity of the Leatherback Sea Turtle (*Dermochelys coriacea*): Assessing the Potential Effect of Anthropogenic Noise*. Herndon, Virginia: U.S. Department of the Interior, Bureau of Ocean Energy Management, Headquarters. OCS Study BOEM 2012-01156. 25 pp. Available at: https://www.cbd.int/doc/meetings/mar/mcbem-2014-01/other/mcbem-2014-01-submission-boem-05-en.pdf. Accessed January 26, 2023.

Dunlop, R.A., M.J. Noad, R.D. McCauley, L. Scott-Hayward, E. Kniest, R. Slade, D. Paton, and D.H. Cato. 2017. Determining the behavioural dose-response relationship of marine mammals to air gun noise and source proximity. *Journal of Experimental Biology* 220(16):2878-2886.

Dunlop, R.A., Noad, M.J., McCauley, R.D., Kniest, E., Slade, R., Paton, D. and Cato, D.H., 2016. Response of humpback whales (Megaptera novaeangliae) to ramp-up of a small experimental air gun array. Marine pollution bulletin, 103(1-2), pp.72-83.

Dunton, K.J., A. Jordaan, D.O. Conover, K.A. McKown, L.A. Bonacci, and M.G. Frisk. 2015. Marine distribution and habitat use of Atlantic sturgeon in New York lead to fisheries interactions and bycatch. *Marine and Coastal Fisheries* 7(1):18-32.

Eckert, K.L., B.P. Wallace, J.G. Frazier, S.A. Eckert, and P.C.H. Pritchard. 2012. *Synopsis of the Biological Data on the Leatherback Sea Turtle* (*Dermochelys coriacea*). Biological Technical Publication BTP-R4015-2012. Washington, DC.: U.S. Department of the Interior, U.S. Fish and Wildlife Service.

Edmonds, N.J., C.J. Firmin, D. Goldsmith, R.C. Faulkner, and D.T. Wood. 2016. A review of crustacean sensitivity to high amplitude underwater noise: Data needs for effective risk assessment in relation to UK commercial species. *Marine Pollution Bulletin* 108(1):5–11.

Edwards, E.F., C. Hall, T.J. Moore, C. Sheredy, and J.V. Redfern. 2015. Global distribution of fin whales *Balaenoptera physalus* in the post-whaling era (1980–2012). *Mammal Review* 45(4):197-214.

Eichmann, M. 2016. Giant Manta Ray rescued off Delaware Coast. Available at: https://whyy.org/articles/giant-manta-ray-rescued-off-delaware-coast/. Accessed June 20, 2022.

Elliot, J., A. A. Khan, L. Ying-Tsong, T. Mason, J. H. Miller, A. E. Newhall, G. R. Potty, and K J. Vigness-Raposa. 2019. *Field Observations during Wind Turbine Operations at the Block Island Wind Farm, Rhode Island*. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2019-028. Available at: https://espis.boem.gov/final%20reports/BOEM_2019-028.pdf. Accessed June 20, 2022.

Engås, A., O.A. Misund, A.V. Soldal, B. Horvei, and A. Solstad. 1995. Reactions of penned herring and cod to playback of original, frequency-filtered and time-smoothed vessel sound. *Fisheries Research* 22:243–254

Engås, A., S. Løkkeborg, E. Ona, and A.V. Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefi nus*). *Canadian Journal of Fisheries and Aquatic Sciences* 53:2238–2249.

Engås, A., E.K. Haugland, and J.T. Øvredal. 1998. Reactions of cod (*Gadus morhua L.)* in the pre-vessel zone to an approaching trawler under different light conditions. *Hydrobiologia* 371/372:199–206

Engelhaupt, A., J.M. Aschettino, D. Engelhaupt, A. DiMatteo, M. Richlen, and M. Cotter. 2019. *VACAPES Outer Continental Shelf Cetacean Study, Virginia Beach, Virginia: 2018 Annual Progress Report*. Prepared by HDR for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470-15-8006, Task Order 18F4082, issued to HDR Inc., Virginia Beach, Virginia. July 2019. 76 pp.

Engelhaupt, A., J.M. Aschettino, D. Engelhaupt, M. Richlen, and M. Cotter. 2020. *VACAPES Outer Continental Shelf Cetacean Study, Virginia Beach, Virginia: 2019 Annual Progress Report*. Prepared by HDR for Naval Facilities Engineering Systems Command Atlantic. Under Contract No. N62470-15-D-8006, Task Order 18F4082. April 2020. 60 pp.

Engelhaupt, A., J.M. Aschettino, D. Engelhaupt, M. Richlen, and M. Cotter. 2021. *VACAPES Outer Continental Shelf Cetacean Study, Virginia Beach, Virginia: 2020 Annual Progress Report*. Prepared by HDR for Naval Facilities Engineering Systems Command Atlantic. Under Contract No. N62470-15-D-8006, Task Order 19F4068. May 2021. 56 pp.

Environmental Protection Agency (EPA). 2012. *National Coastal Condition Report IV*. EPA842-R-10-003. United States Environmental Protection Agency, Washington, DC. 368 pp. Available at: https://www.epa.gov/sites/production/files/2016-01/documents/ncca_2010_technical_report_20160127.pdf. Accessed June 20, 2022.

Environmental Protection Agency (EPA). 2022. Climate Change Indicators: Oceans. Available at: https://www.epa.gov/climate-indicators/oceans. Accessed January 30, 2023.

Erbe, C. 2013. International Regulation of Underwater Noise. *Acoustics Australia* 41(1):12–19.

Erbe, C., C. Reichmuth, K. Cunningham, K. Lucke, and R. Dooling. 2016. Communication masking in marine mammals: A review and research strategy. *Marine Pollution Bulletin* 103:15-38.

Erbe, C., R. Dunlop, K.C.S. Jenner, M.N.M. Jenner, R.D. McCauley, I. Parnum, M. Parsons, T. Rogers, and C. Salgado-Kent. 2017. Review of Underwater and In-Air Sounds Emitted by Australian and Antarctic Marine Mammals. *Acoustics Australia* 45(2):179-241.

Erbe, C., S.A. Marley, R.P. Schoeman, J.N. Smith, L.E. Trigg, C.B. Embling. 2019. The Effects of Ship Noise on Marine Mammals – A Review. *Frontiers in Marine Science* 6(606):1-21.

Erickson, D. L., A. Kahnle, M. J. Millard, E. A. Mora, M. Bryja, A. Higgs, J. Mohler, M. DuFour, G. Kenney, J. Sweka, and E. K. Pikitch. 2011. Use of pop-up satellite archival tags to identify oceanic-migratory patterns for adult Atlantic Sturgeon, *Acipenser oxyrinchus oxyrinchus* Mitchell, 1815. *Journal of Applied Ichthyology* 27:356-365.

Exponent Engineering. 2018. *Deepwater Wind South Fork Wind Farm Onshore Electric and Magnetic Field Assessment.* Appendix K2 in the South Fork Wind Farm Construction and Operations Plan. Prepared for Deepwater Wind, LLC. 58 pp. Available at: Onshore Electric and Magnetic Field Assessment (boem.gov) Accessed January 27, 2023.

Farmer, N.A., L.P. Garrison, C. Horn, M. Miller, T. Gowan, R.D. Kenney, M. Vukovich, J.R. Willmott, J. Pate, D.H. Webb, T.J. Mullican, J.D. Stewart, K. Bassos-Hull, C. Jones, D. Adams, N.A. Pelletier, J. Waldron, and S. Kajiura. 2022. The Distribution of Manta Rays in the Western North Atlantic Ocean off the Eastern United States. *Scientific Reports* 12:6544.

Farr, E.R., M.R. Johnson, M.W. Nelson, J.A. Hare, W.E. Morrison, M.D. Lettrich, B. Vogt, C. Meaney, U.A. Howson, P.J. Auster, F.A. Borsuk, D.C. Brady, M.J. Cashman, P. Colarusso, J.H. Grabowski, J.P. Hawkes, R. Mercaldo-Allen, D.B. Packer, and D.K. Stevenson. 2021. An Assessment of Marine, Estuarine, and Riverine Habitat Vulnerability to Climate Change in the Northeast U.S. *PLoS ONE* 16(12):e0260654.

Fasick, J.I., M.F. Baumgartner, T.W. Cronin, B. Nickle, L.J. Kezmoh. 2017. Visual Predation During Springtime Foraging of The North Atlantic Right Whale (*Eubalaena Glacialis*). *Marine Mammal Science* 33(4):991–1013.

Fernandes, S.J., G.B. Zydlewski, J.D. Zydlewski, G.S. Wippelhauser, and M.T. Kinnison. 2010. Seasonal distribution and movements of shortnose sturgeon and Atlantic sturgeon in the Penobscot River Estuary, Maine. *Transactions of the American Fisheries Society* 139:1436–1449.

Filiciotto, F., M. Vazzana, M. Celi, V. Maccarrone, M. Ceraulo, G. Buffa, V. Arizza, G. de Vincenzi, R. Grammauta, S. Mazzola, and G. Buscaino. 2016. Underwater noise from boats: Measurement of its influence on the behaviour and biochemistry of the common prawn (*Palaemon serratus*, Pennant 1777). *Journal of Experimental Marine Biology and Ecology* 478:24-33.

Finley, K.J., G.W. Miller, R.A. Davis, and C.R. Greene. 1990. *Reactions of Belugas, Delphinapterus leucas, and Narwhals, Monodon monoceros, to Ice-Breaking Ships in the Canadian high Arctic. In: Advances in research on the Beluga Whale, Delphinapterus leucas*. Smith, T.G., D.J. St. Aubin, and J.R. Geraci (Eds.). *Canadian Bulletin of Fisheries and Aquatic Sciences* 224. 206 pp. Available at: Canadian Bulletin of Fisheries and Aquatic Sciences 224 (dfo-mpo.gc.ca) Accessed January 26, 2023.

Finneran, J.J. 2016. Auditory weighting functions and TTS/PTS exposure functions for marine mammals exposed to underwater noise. In: National Marine Fisheries Service, *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts*. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum. NMFS-OPR-55. Appendix A. pp. 38-110.

Finneran, J., E. Henderson, D. Houser, K. Jenkins, S. Kotecki, and J. Mulsow. 2017. *Criteria and Thresholds for US Navy Acoustic and Explosive Effects Analysis (Phase III)*. Technical report by Space and Naval Warfare Systems Center Pacific (SSC Pacific). 183 pp.

Finneran, J.J. and AK Jenkins. 2012. *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis.* San Diego, California: Space and Naval Warfare Systems Center Pacific. Technical Report. 65 pp.

Firestone, J., S.B. Lyons, C. Wang, and J.J. Corbett. 2008. Statistical modeling of North Atlantic right whale migration along the mid-Atlantic region of the eastern seaboard of the United States. *Biological Conservation* 141:221−232.

Fisheries Hydroacoustic Working Group (FHWG). 2008. *Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities*. Memorandum to Applicable Agency Staff. June 12, 2008. 4 pp.

Freitas, C., R. Caldeira, and T. Dellinger. 2019. Surface Behavior of Pelagic Juvenile Loggerhead Sea Turtles in the Eastern North Atlantic. *Journal of Experimental Marine Biology and Ecology* 510:73– 80.

Gall, S.C., and R.C. Thompson. 2015. The impact of debris on marine life. *Marine Pollution Bulletin* 92(1-2):170-179.

Garrison, L.P., J. Adams, E.M. Patterson, and C.P. Good. 2022. Assessing the risk of vessel strike mortality in North Atlantic right whales along the US East Coast. NOAA Technical Memorandum NOAA NMFS-SEFSC-757: 42 pp.

Gende, S.M., A.N. Hendrix, K.R. Harris, B. Eichenlaub, J. Nielsen, and S. Pyare. 2011. A Bayesian approach for understanding the role of ship speed in whale–ship encounters. *Ecological Applications* 21(6):2232-2240.

Gende, S.M., L. Vose, J. Baken, C.M. Gabriele, R. Preston, and A.N. Hendrix. 2019. Active whale avoidance by large ships: components and constraints of a complementary approach to reducing ship strike risk. *Frontiers in Marine Science* 6:592.

Gibbons, M.J., and A.J. Richardson. 2008. Patterns of jellyfish abundance in the North Atlantic. In: Pitt, K.A. and J.E. Purcell (Eds.), *Jellyfish Blooms: Causes, Consequences, and Recent Advances*. Springer, Dordrecht. pp. 51-65.

Gill A.B., M. Bartlett, and F. Thomsen. 2012. Potential interactions between diadromous fishes of U.K. conservation importance and the electromagnetic fields and subsea noise from marine renewable energy developments. *Journal of Fish Biology* 81(2):664-695.

Gill, A.B., I. Gloyne-Phillips, K.J. Neal, and J.A. Kimber. 2005. *The Potential Effects of Electromagnetic Fields Generated by Sub-Sea Power Cables Associated with Offshore Wind Farm Developments on Electrically and Magnetically Sensitive Marine Organisms – A Review*. No. COWRIE-EM FIELD 2-06-2004. Final report prepared by Cranfield University and the Centre for Marine and Coastal Studies Ltd. For Collaborative Offshore Wind Energy Research into the Environment.

Gitschlag, G.R. 1990. Sea turtle monitoring at offshore oil and gas platforms. In: *Proceedings of the 10th Annual Workshop on Sea Turtle Biology and Conservation.* pp. 223-246.

Gitschlag, G.R., and B.A. Herczeg. 1994. Sea Turtle Observations at Explosive Removals of Energy Structures. *Marine Fisheries Review* 56(2):1-8.

Goldbogen, J.A., A.S. Friedlaender, J. Calambokidis, M.F. McKenna, M. Simon, and D.P. Nowacek, 2013. Integrative Approaches to the Study of Baleen Whale Diving Behavior, Feeding Performance, and Foraging Ecology, *BioScience* 63(2):90-100.

Gordon, J., R. Leaper, F. Hartley, and O. Chappell. 1992. Effects of whale-watching vessels on the surface and underwater acoustic behaviour of sperm whales off Kaikoura, New Zealand. *Science and research series* 52:1-64.

Graham, I.M., E. Pirotta, N.D. Merchant, A. Farcas, T.R. Barton, B. Cheney, G.D. Hastie, and P.M. Thompson. 2017. Responses of bottlenose dolphins and harbor porpoises to impact and vibration piling noise during harbor construction. *Ecosphere* 8(5):e01793.

Graham, I.M., Gillespie, D., Gkikopoulou, K.C., Hastie, G.D. and Thompson, P.M., 2023. Directional hydrophone clusters reveal evasive responses of small cetaceans to disturbance during construction at offshore windfarms. Biology Letters, 19(1), p.20220101.

Grashorn, S., and E.V. Stanev. 2016. Kármán vortex and turbulent wake generation by wind park piles. *Ocean Dynamics* 66:1543–1557.

Greater Atlantic Regional Fisheries Office (GARFO). 2022. The Greater Atlantic Region ESA Section 7 Mapper. Available at: https://www.fisheries.noaa.gov/resource/map/greater-atlantic-region-esa-section-7-mapper. Accessed January 26, 2023.

Greene, C.H., and A.J. Pershing. 2000. The response of *Calanus finmarchicus* populations to climate variability in the Northwest Atlantic: basin-scale forcing associated with the North Atlantic Oscillation. *ICES Journal of Marine Science* 57:1536-1544.

Griffin, R.B. 1999. Sperm whale distributions and community ecology associated with a warm-core ring off Georges Bank. *Marine Mammal Science* 15(1):33-51.

Guerra, M., S.M. Dawson, T.E. Brough, and W.J. Rayment. 2014. Effects of boats on the surface and acoustic behaviour of an endangered population of bottlenose dolphins. *Endangered Species Research* 24:221-236.

Guihen, D., J.A. Brearley, and S. Fielding. 2022. Antarctic krill likely avoid underwater gliders. *Deep Sea Research Part I: Oceanographic Research Papers* 179:103680.

Hain, J.H., M.J. Ratnaswamy, R.D. Kenney, and H.E. Winn. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. *Reports of the International Whaling Commission* 42:653-669.

Hain, J. H. W., M. A. M. Hyman, R. D. Kenney, and H. E. Winn. 1985. The role of cetaceans in the shelf-edge region of the northeastern United States. *Marine Fisheries Review* 47:13–17.

Hale, E.A., I.A. Park, M.T. Fisher, R.A. Wong, M.J. Stangl, and J.H. Clark. 2016. Abundance estimate for and habitat use by early juvenile Atlantic sturgeon within the Delaware River Estuary. *Transactions of the American Fisheries Society* 145(6):1193-1201.

Handegard, N.O., and D. Tjøstheim. 2005. When fish meet a trawling vessel: examining the behaviour of gadoids using a free-floating buoy and acoustic split-beam tracking. *Canadian Journal of Fisheries and Aquatic Sciences* 62(10):2409-2422.

Harding, S., and N. Cousins. 2022. *Review of the Impacts of Anthropogenic Underwater Noise on Marine Biodiversity and Approaches to Manage and Mitigate Them*. Secretariat of the Convention on Biological Diversity, Montreal. Technical Series No. 99. 145 pp.

Hare, J.A., W.E. Morrison, M.W. Nelson, M.M. Stachura, E.J. Teeters, R.B. Griffis, M.A. Alexander, J.D. Scott, L. Alade, R.J. Bell, A.S. Chute, K.L. Curti, T.H. Curtis, D. Kircheis, J.F. Kocik, S.M. Lucey, C.T. McCandless, L.M. Milke, D.E. Richardson, E. Robillard, H.J. Walsh, M. Conor McManus, K.E. Marancik, and C.A. Griswold. 2016. A vulnerability assessment of fish and invertebrates to climate change on the northeast U.S. continental shelf. *PloS ONE* 11(2):e0146756. Doi:10.1371/journal.pone.0146756.

Harris, C.M., L. Thomas, E.A. Falcone, J. Hildebrand, D. Houser, P.H. Kvadsheim, F.P.A. Lam, P.J. Miller, D.J. Moretti, A.J. Read, and H. Slabbekoorn. 2018. Marine mammals and sonar: Dose-response studies, the risk-disturbance hypothesis and the role of exposure context. *Journal of Applied Ecology* 55(1):396-404.

Hassel, A., T. Knutsen, J. Dalen, K. Skaar, S. Løkkeborg, O.A. Misund, Ø. Østensen, M. Fonn, and E.K. Haugland. 2004. Influence of seismic shooting on the lesser sand eel (*Ammodytes marinus*). *Journal of Marine Science* 61:1165–1173.

Hastie, G.D., B. Wilson, L.H. Tufft, and P.M. Thompson. 2006. Bottlenose dolphins increase breathing synchrony in response to boat traffic. *Marine Mammal Science* 19(1):74-084.

Hatakeyama, Y., K. Ishii, T. Akamatsu, H. Soeda, T. Shimamura, and T. Kojima. 1994. A review of studies on attempts to reduce the entanglement of the Dall's porpoise, *Phocoenoides dalli*, in the Japanese salmon gillnet fishery. *Report of the International Whaling Commission* (Special Issue). 15:549-563.

Hatch L.T., C.W. Clark, S.M. Van Parijs, A.S. Frankel, and D.W. Ponirakis. 2012. Quantifying loss of acoustic communication space for right whales in and around a U.S. National Marine Sanctuary. *Conservation Biology* 26:983−994.

Hawkes, L., A. Broderick, M. Coyne, M. Godfrey, and B. Godley. 2007. Only some like it hot—Quantifying the environmental niche of the loggerhead sea turtle. *Diversity and Distributions* 13:447–457

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2009. Climate change and marine turtles. *Endangered Species Research* 7:137–154.

Hawkins, A.D., L. Roberts, S. Cheesman. 2014. Responses of free-living coastal pelagic fish to impulsive sounds. *The Journal of the Acoustical Society of America* 135(5):3101-3116.

Hayes, S.A. 2022. Letter of Memorandum to the Bureau of Ocean Energy Management regarding North Atlantic right whale effects from Offshore Wind Development in New England. Prepared by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center for Brian R. Hooker, Lead Biologist, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. May 13, 2022. 4 pp.

Hayes, S.A., E. Josephson, K. Maze-Foley, and P.E. Rosel (Eds.). 2020. *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2019*. NOAA Technical Memorandum NMFS NE-264. U.S. Department of Commerce, National Marine Fisheries Service. July 2020. 479 pp.

Hayes, S.A., E. Josephson, K. Maze-Foley, P.E. Rosel, and J.E. Wallace (Eds.). 2022. *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessment Reports 2021*. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. May 2022. 386 pp.

Hays, G.C., V.J. Hobson, J.D. Metcalfe, D. Righton, and D.W. Sims. 2006. Flexible foraging movements of leatherback turtles across the North Atlantic Ocean. *Ecology* 87(10):2647-2656.

Hays, G.C., A. Christensen, S. Fossette, G. Schofield, J. Talbot, and P. Mariani. 2014. Route optimization and solving Zermelo’s navigation problem during long distance migration in cross flows. *Ecology Letters* 17:137-143.

Hare, J.A., W.E. Morrison, M.W. Nelson, M. Stachura, E.J. Teeters, R.B. Griffis, M.A. Alexander, J.D. Scott, L. Alade, R.J. Bell, A.S. Chute, K.L. Curti, T.H. Curtis, D. Kircheis, J.F. Kocik, S.M. Lucey, C.T. McCandless, L.M. Milke, D.E. Richardson, E. Robillard, H.J. Walsh, M.C. McManus, K.E. Marancik, and C.A. Griswold. 2016. A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast US Continental Shelf. *PLoS ONE* 11(2):e0146756.

Hazel, J., I.R. Lawler, H. Marsh, and S. Robson. 2007. Vessel speed increases collision risk for the green turtle Chelonia mydas. *Endangered Species Research* 3(2):105-113.

HDR. 2020. *Benthic and Epifaunal Monitoring During Wind Turbine Installation and Operation at the Block Island Wind Farm, Rhode Island – Project Report.* Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2020-044. Volume 1: 263 pp; Volume 2:380 pp.

Heithaus, M.R., J.J. McLash, A. Frid, L.W. Dill, and G.J. Marshall. 2002. Novel insights into green sea turtle behavior using animal-borne video cameras. *Journal of the Marine Biological Association of the UK* 82(6):1049–1050.

Henderson, D., B. Hu, and E. Bielefeld. 2008. Patterns and mechanisms of noise-induced cochlear pathology. In: Schacht, J., A. N. Popper, and R. R. Fay (Eds.). *Auditory Trauma, Protection, and Repair*. Springer, New York. pp. 195-217.

Henry, A.G., M. Garron, D. Morin, A. Reid, W. Ledwell, and T.V.N. Cole. 2020. *Serious Injury and Mortality Determinations for Baleen Whale Stocks along the Gulf of Mexico, United States East Coast, and Atlantic Canadian Provinces, 2013-2017*. Woods Hole, MA: U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document 20-06.

Hoarau, L., L. Ainley, C. Jean, and S. Ciccione. 2014. Ingestion and defecation of marine debris by loggerhead sea turtles, *Caretta caretta*, from by-catches in the South-West Indian Ocean. *Marine Pollution Bulletin* 84(1-2):90-96.

Hodge, K.B., C.A. Muirhead, J.L. Morano, C.W. Clark, and A.N. Rice. 2015. North Atlantic right whale occurrence near wind energy areas along the Mid-Atlantic US coast: implications for management. *Endangered Species Research* 28(3):225-234.

Holt, M.M., D.P. Noren, V. Veirs, C.K. Emmons, and S. Veirs. 2009. Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. *Journal of the Acoustical Society of America* 125:EL27-EL32.

Holt, M.M., D.P. Noren, R.C. Dunkin, and T.M. Williams. 2015. Vocal performance affects metabolic rate in dolphins: implications for animals communicating in noisy environments. *Journal of Experimental Biology* 218(Pt 11):1647-1654.

Holt, M.M., J.B. Tennessen, M.B. Hanson, C.K. Emmons, D.A. Giles, J.T. Hogan, and M.J. Ford. 2021. Vessels and their sounds reduce prey capture effort by endangered killer whales (*Orcinus orca*). *Marine Environmental Research* 170:105429.

Hu, M.Y., H.Y. Yan, W.-S. Chung, J.-C. Shiao, and P.-P. Hwang. 2009. Acoustically evoked potentials in two cephalopods inferred using the auditory brainstem response (ABR) approach. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* 153(3):278-283.

International Union for Conservation of Nature (IUCN). 2022. The IUCN Red List of Threatened Species. Version 2021-3. Available at: https://www.iucnredlist.org/. Accessed June 20, 2022.

Jaquet, N., and H. Whitehead. 1996. Scale-dependent correlation of sperm whale distribution with environmental features and productivity in the South Pacific. *Marine Ecology Progress Series* 135:1-9.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. *FAO species identification guide. Marine Mammals of the World*. Rome, FAO. 1993.320. 328 pp.

Jensen, A.S., and G.K. Silber. 2003. *Large Whale Ship Strike Database*. U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, National Marine Fisheries Service. NOAA Technical Memorandum NMFS-OPR-25. 37 pp.

Johansson, T. J. and M. Andersson. 2012. FOI Ambient Underwater Noise Levels at Norra Midsjöbanken during Construction of the Nord Stream Pipeline. FOI Report

Johnson, S.R. 2002. *Marine mammal mitigation and monitoring program for the 2001 Odoptu 3-D seismic survey, Sakhalin Island, Russia: Executive summary*. Report by LGL Limited, Sidney, BC, Canada, for Exxon Neftegas Limited, Yuzhno-Sakhalinsk, Russia. 49 pp.

Johnson, A. 2018. *The Effects of Turbidity and Suspended Sediments on ESA-Listed Species from Projects Occurring in the Greater Atlantic Region.* NOAA Fisheries Greater Atlantic Regional Fisheries Office. Greater Atlantic Region Policy Series 18-02. 107 pp.

Johnson, J.H., D.S. Dropkin, B.E. Warkentine, J.W. Rachlin, and W.D. Andrews. 1997. Food habits of Atlantic sturgeon off the central New Jersey coast. *Transactions of the American Fisheries Society* 126:166–170.

Jones, I.T., J.A. Stanley, T.A. Mooney. 2020. Impulsive pile driving noise elicits alarm responses in squid (*Doryteuthis pealeii*). *Marine Pollution Bulletin* 150:1-14.

Kahn, J. E., C. Hager, J. C. Watterson, N. Mathies, and K. Hartman. 2019. Comparing abundance estimates from closed population mark recapture models of endangered adult Atlantic Sturgeon. Endangered Species Research 39:63–76.

Kahn J.E., J.C. Watterson, C.H. Hager, N. Mathies, and K.J. Hartman. 2021. Calculating adult sex ratios from observed breeding sex ratios for wide ranging, intermittently breeding species. Ecosphere 12:e03504.

Kaifu, K., T. Akamatsu, and S. Segawa. 2008. Underwater sound detection by cephalopod statocyst. *Fisheries Science* 74(4):781-786.

Kates Varghese, H., J. Miksis-Olds, N. DiMarzio, K. Lowell, E. Linder, L. Mayer, and D. Moretti. 2020. The effect of two 12 kHz multibeam mapping surveys on the foraging behavior of Cuvier's beaked whales off of southern California. *The Journal of the Acoustical Society of America* 147: 3849.

Kates Varghese, H., K. Lowell, J. Miksis-Olds, N. DiMarzio, D. Moretti, and L. Mayer. 2021. Spatial analysis of beaked whale foraging during two 12 kHz multibeam echosounder surveys. *Frontiers in Marine Science* 2021:1139.

Kazyak, D.C., S.L. White, B.A. Lubinski, R. Johnson, and M. Eackles. 2021. Stock composition of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) encountered in marine and estuarine environments on the US Atlantic Coast. *Conservation Genetics* 22(5):767-781.

Kellar, N.M., T.R. Speakman, C.R. Smith, S.M. Lane, B.C. Balmer, M.L. Trego, K.N. Catelani, M.N. Robbins, C.D. Allen, and R.S. Wells. 2017. Low reproductive success rates of common bottlenose dolphins *Tursiops truncatus* in the northern Gulf of Mexico following the *Deepwater Horizon* disaster (2010-2015). *Endangered Species Research* 33:143-158.

Kenney, R.D., G.P. Scott, T.J. Thompson, and H.E. Winn. 1997. Estimates of prey consumption and trophic impacts of cetaceans in the USA northeast continental shelf ecosystem. *Journal of Northwest Atlantic Fishery Science* 22:155-171.

Kenney, R.D., and K.J Vigness-Raposa. 2010. *Marine Mammals and Sea Turtles of Narragansett Bay, Block Island Sound, Rhode Island Sound, and Nearby Waters: An Analysis of Existing Data for the Rhode Island Ocean Special Area Management Plan*. University of Rhode Island. Ocean Special Area Management Plan Technical Report #10. 337 pp.

Ketten, D.R., I. Fischer, S. Cramer, S.M. Bartol, and J. O'Malley. 2006. Water, fats, and acoustic impedance: soft tissue adaptations for underwater hearing in turtles, seabirds and marine mammals. In: N.J. Pilcher (Ed.), *Proceedings of the 23rd Symposium on Sea Turtle Biology and Conservation.* NOAA Technical Memorandum NMFS-SEFSC-536. p. 162.

Ketten, D. R. 1998. *Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and its Implications for Underwater Acoustic Impacts*. NOAA Technical Memorandum NMFS: NOAA-TM-NMFS-SWFSC-256.

Ketten, D.R., S. Cramer, J. Arruda, D.C. Mountain, A. Zosuls. 2014. Inner ear frequency maps: First stage audiogram models for mysticetes. In: *The 5th International Meeting of Effects of Sound in the Ocean on Marine Mammals*. 7-12 September 2014, Amsterdam.

Kieffer, M.C., and B. Kynard. 1993. Annual movements of shortnose and Atlantic sturgeon in the Merrimack River, Massachusetts. *Transactions of the American Fisheries Society* 122:1088-1133.

King, L. 2011. Sei whale found stranded in Virginia Beach. Available at: https://www.pilotonline.com/news/article_2a66b71b-ff9c-506d-a621-9291983a3c7c.html. Accessed December 28, 2022.

Kipple, B., and C. Gabriele. 2003. *Glacier Bay watercraft noise.* Bremerton, Washington: Prepared for Glacier Bay National Park and Preserve, Naval Surface Warfare Center. Technical Report NSWCCDE-71-TR-2003/522. 54 pp.

Kipple, B., and C. Gabriele. 2004. *Glacier Bay watercraft noise – noise characterization for tour, charter, private, and government vessels*. Bremerton, Washington: Prepared for Glacier Bay National Park and Preserve, Naval Surface Warfare Center. Technical Report NSWCCDE-71-TR2004/545. 55 pp.

Klima, E.F., G.R. Gitschlag, and M.L. Renaud. 1988. Impacts of the Explosive Removal of Offshore Petroleum Platforms on Sea Turtles and Dolphins *Marine Fisheries Review* 50(3):33-42.

Knight, M., and M. Jasek. 2014. Elizabeth River whale likely died from blunt force trauma, plastic in its stomach. Available at: https://www.wtkr.com/2014/08/21/40-foot-whale-swimming-in-the-elizabeth-river-has-died. Accessed December 28, 2022.

Knowlton, A.R., J. Beaudin Ring, and B. Russell. 2002. *Right whale sightings and survey effort in the mid-Atlantic region: Migratory corridor, time frame, and proximity to port entrances*. Report for the NMFS ship strike working group. July 2002. Available at: https://www.researchgate.net/publication/237485805_RIGHT_WHALE_SIGHTINGS_AND_SURVEY_EFFORT_IN_THE_MID_ATLANTIC_REGION_MIGRATORY_CORRIDOR_TIME_FRAME_AND_PROXIMITY_TO_PORT_ENTRANCES_A_report_submitted_to_the_NMFS_ship_strike_working_group. Accessed June 20, 2022.

Knowlton, A.R., P.K. Hamilton, M.K. Marx, H.P. Pettis, and S.D. Kraus. 2012. Monitoring North Atlantic Right Whale *Eubalaena galcialis* Entanglement Rates: a 30-Year Retrospective. *Marine Ecology Progress Series* 466:293–302.

Kohler, N.E., J.G. Casey, and P.A. Turner. 1998. NMFS cooperative shark tagging program, 1962-93: an atlas of shark tag and recapture data. *Marine Fisheries Review* 60(2):1-1.

Kraus, S.D., M.W. Brown, H. Caswell, C.W. Clark, M. Fujiwara, P.H. Hamilton, R.D. Kenney, A.R. Knowlton, S. Landry, C.A. Mayo, W.A. McLellan, M.J. Moore, D.P. Nowacek, D.A. Pabst, A.J. Read, and R.M. Rolland. 2005. North Atlantic Right Whales in Crisis. *Science* 309:561–562.

Kraus, S.D., S. Leiter, K. Stone, B. Wikgren, C. Mayo, P. Hughes, R.D. Kenney, C.W. Clark, A.N. Rice, B. Estabrook and J. Tielens. 2016. Recent Scientific Publications Cast Doubt on North Atlantic Right Whale Future. *Frontiers in Marine Science* 3:00137.

Krebs, J., F. Jacobs, and A.N. Popper. 2016. Avoidance of Pile-Driving Noise by Hudson River Sturgeon During Construction of the New NY Bridge at Tappan Zee. In: A.N. Popper, A. Hawkins (Eds.), *The Effects of Noise on Aquatic Life II*. New York, NY: Springer New York. pp. 555-563.

Kritzer, J.P., M. Delucia, E. Greene, C. Shumway, M.F. Topolski, J. Thomas-Blate, L. A. Chiarella, K. B. Davy, and K. Smith. 2016. The importance of benthic habitats for coastal fisheries. *BioScience* 66(4):274-284.

Kroetz, A.M., A.N. Mathers, and J.K. Carlson. 2020. Evaluating protected species bycatch in the U.S. southeast gillnet fishery. *Fisheries Research* 228:105573.

Kynard, B., S. Bolden, M. Kieffer, M. Collins, H. Brundage, E.J. Hilton, M. Litvak, M.T. Kinnison, T. King, and D. Peterson. 2016. Life history and status of Shortnose Sturgeon (*Acipenser brevirostrum* LeSueur, 1818). *Journal of Applied Ichthyology* 32(S1):208-248.

LaBrecque, E, C. Curtice, J. Harrison, S.M. Van Parijs, and P.N. Halpin. 2015. Biologically important areas for cetaceans within U.S. waters—East coast region. *Aquatic Mammals* 41(1):17–29.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between ships and whales. *Marine Mammal Science* 17(1):35–75.

Latham, P., W. Fiore, M. Bauman, and J. Weaver. 2017. *Effects Matrix for Evaluating Potential Impacts of Offshore Wind Energy Development on U.S. Atlantic Coastal Habitats*. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2017-014. Available at: Effects-Matrix-Evaluating-Potential-Impacts-of-Offshore-Wind-Energy-Development-on-US-Atlantic-Coastal-Habitats.pdf (boem.gov) Accessed January 27, 2023.

Lavender, A.L., S.M. Bartol, and I.K. Bartol. 2014. Ontogenetic investigation of underwater hearing capabilities in loggerhead sea turtles (*Caretta caretta*) using a dual testing approach. *Journal of Experimental Biology* 217:2580–2589.

Le Prell, C.G. 2012. Noise-induced hearing loss: from animal models to human trials. In: Popper. A.N. and A. Hawkins (Eds.). *The Effects of Noise on Aquatic Life*. Springer, New York, NY. pp. 191-195.

Lenhardt, M.L. 1982. Bone conduction hearing in turtles. *Journal of Auditory Research* 22(3):153-160.

Lenhardt, M.L. 1994. Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). In: Bjorndal, K.A., AB Bolten, DA Johnson, and PJ Eliazar (Eds.). *Proceeding of the 14th Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFSSEFSC-351. pp. 238-241.

Lenhardt, M.L., and S.W. Harkins. 1983. Turtle shell as an auditory receptor. *Journal of Auditory Research* 23(4):251-260.

Lenhardt, M.L., R.C. Klinger, and J.A. Musick. 1985. Marine turtle middle-ear anatomy. *Journal of Auditory Research* 25(1):66-72.

Lesage, V., C. Barrette, M.C.S. Kingsley, and B. Sjare. 1999. The Effect of Vessel Noise on the Vocal Behavior of Belugas in the St. Lawrence River Estuary, Canada. *Marine Mammal Science* 15(1):65-84.

Lesage, V., K. Gavrilchuk, R.D. Andrews, and R. Sears. 2017. Foraging areas, migratory movements and winter destinations of blue whales from the western North Atlantic. *Endangered Species Research* 34:27-43.

Lesage, V., J.-F. Gosselin, J.W. Lawson, I. McQuinn, H. Moors-Murphy, S. Pourde, R. Sears, and Y. Simard. 2018. *Habits Important to Blue Whales (Balaenoptera musculus) in the western North Atlantic.* DFO Canada Science Advisory Secretariat Research Document 2016/080. iv + 50 p.

Logan-Chesney, L.M., M.J. Dadswell, R.H. Karsten, I. Wirgin, and M.J.W. Stokesbury. 2018. Atlantic sturgeon *Acipenser oxyrinchus* surfacing behaviour. *Journal of Fish Biology* 92(4):929-943.

Lohoefener, R., W. Hoggard, K. Mullin, C. Roden, and C. Rogers. 1990. *Association of sea turtles with petroleum platforms in the north-central Gulf of Mexico.* National Marine Fisheries Service, Pascagoula, MS (USA). OCS Study MMS 90-0025. 90 pp. Available at: Association of Sea Turtles with Petroleum Platforms in the North-Central Gulf of Mexico (unt.edu) Accessed January 27, 2023.

Lohrasbipeydeh, H., T. Dakin, T.A. Gulliver, and A. Zielinski. 2012. Characterization of sperm whale vocalization energy based on echolocation signals. Conference Proceedings: *OCEANS 2013* MTS/IEEE – An Ocean in Common. San Diego, California.

Løkkeborg, S., E. Ona, A. Vold, and A. Salthaug. 2012. Sounds from seismic airguns: gear- and species- specific effects on catch rates and fish distribution. *Canadian Journal of Fisheries and Aquatic Sciences* 69:1278–1291.

Long, C. 2017. *Analysis of the Possible Displacement of Bird and Marine Mammal Species Related to the Installation and Operation of Marine Energy Conversion Systems*. Scottish Natural Heritage Commissioned Report No. 947. 319 pp. Available at: https://tethys.pnnl.gov/sites/default/files/publications/Long-2017-SNH-947.pdf. Accessed January 27, 2023.

Love, M., A. Baldera, C. Young, and C. Robbins. 2013. *The GoM Ecosystem: A Coastal and Marine Atlas.* New Orleans, LA: Ocean Conservancy, Gulf Restoration Center. 232 pp. Available at: gulf-atlas.pdf (oceanconservancy.org) Accessed January 27, 2023.

Lovell, J.M., M.M. Findlay, R.M. Moate, and H.Y. Yan. 2005a. The hearing abilities of the prawn *Palaemon serratus*. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* 140(1):89-100.

Lovell, J.M., M.M. Findlay, R.M. Moate, J.R. Nedwell, and M.A. Pegg. 2005b. The inner ear morphology and hearing abilities of the Paddlefish (*Polyodon spathula*) and the Lake Sturgeon (*Acipenser fulvescens*). *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology* 142(3):286-296.

Lovell, J.M., R.M. Moate, L. Christiansen, and M.M. Findlay. 2006. The relationship between body size and evoked potentials from the statocysts of the prawn *Palaemon serratus*. *Journal of Experimental Biology* 209(13):2480.

Lucke, K., P.A. Lepper, B. Hoeve, E. Everaarts, N. van Elk, and U. Siebert. 2007. Perception of low-frequency acoustic signals by a harbour porpoise (*Phocoena phocoena*) in the presence of simulated offshore wind turbine noise. *Aquatic Mammals* 33(1):55-68.

Ludewig, E. 2015. *On the Effect of Offshore Wind Farms on the Atmosphere and Ocean Dynamics*. Cham: Springer International Publishing. 162 pp. Available at: 978-3-319-08641-5.pdf (springer.com) Accessed January 27, 2023.

Lund, P.F. 1985. Hawksbill turtle (*Eretmochelys imbricata*) nesting on the east coast of Florida. *Journal of Herpetology* 19(1):164-166.

Madsen, P.T., M. Wahlberg, J. Tougaard, K. Lucke, and P. Tyack. 2006. Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Marine Ecology Progress Series* 309:279-295.

Malme, C.I., B. Würsig, J.E. Bird, and P. Tyack. 1986. *Behavioural Responses of Gray Whales to Industrial Noise: Feeding Observations and Predictive Modelling. Final Report.* Outer Continental Shelf Environmental Assessment Program. Research Unit 675. August 1986.

Mansfield, K. 2006. *Sources of mortality, movements and behavior of sea turtles in Virginia*. Ph.D dissertation, Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, Virginia. Available at: "Sources of mortality, movements and behavior of sea turtles in Virgini" by Katherine Lamont. Mansfield (wm.edu) Accessed January 27, 2023.

Marn, N., M. Jusup, T. Legović, S.A.L.M Kooijman, and T. Klanjšček. 2017. Environmental effects on growth, reproductive, and life history traits of loggerhead sea turtles. *Ecological Modelling* 360:163-178.

Martin, K.J., S.C. Alessi, J.C. Gaspard, A.D. Tucker, G.B. Bauer, and D.A. Mann. 2012. Underwater hearing in the loggerhead turtle (*Caretta caretta*): A comparison of behavioral and auditory evoked potential audiograms. *Journal of Experimental Biology* 215(17):3001–3009.

Martin, J., Q. Sabatier, T.A. Gowan, C. Giraud, E. Gurarie, C.S. Calleson, J.G. Ortega-Ortiz, C.J. Deutsch, A. Rycyk, and S.M. Koslovsky. 2016. A quantitative framework for investigating risk of deadly collisions between marine wildlife and boats. *Methods in Ecology and Evolution* 7(1):42-50.

Marshall, A., R. Barreto, J. Carlson, D. Fernando, S. Fordham, M.P. Francis, D. Derrick, K. Herman, R.W. Jabado, K.M. Liu, C.L. Rigby, and E. Romanov. 2020. *Mobula birostris*. *The IUCN Red List of Threatened Species* 2020:e.T198921A68632946.

*Mavraki, N., S. Degraer, J. Vanave*rbeke, and U. Braeckman. 2020. Organic matter assimilation by hard substrate fauna in an offshore wind farm area: a pulse-chase study. *ICES Journal of Marine Science* 77:2681-2693.

Maybaum, M.L. 1993. Responses of humpback whales to sonar sounds. *Journal of the Acoustical Society of America* 94(3):1848.

Mayo, C., B. Letcher, S. Scott. 2001. Zooplankton filtering efficiency of the baleen of a North Atlantic right whale, *Eubalaena glacialis*. *Journal of Cetacean Research and Management* 3:245-250.

Mazet, J.A.K., I.A. Gardner, D.A. Jessup, and L.J. Lowenstine. 2001. Effects of petroleum on mink applied as a model for reproductive success in sea otters. *Journal of Wildlife Diseases* 37(4):686-692.

McCauley, R.D., M.N. Jenner, C. Jenner, K.A. McCabe, and J. Murdoch. 1998. The response of humpback whales (*Megaptera novaengliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. *APPEA Journal* 38(1):692-707.

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M.-N., Penrose, J. D., et al. 2000a. Marine seismic surveys: A study of environmental implications. *Australian Petroleum Production and Exploration Association Journal* 40:692-708.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000b. *Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid*. Curtin University of Technology, Centre for Marine Science and Technology, Bentley, Australia.

McKenna, M.F., D. Ross, S.M. Wiggins, J.A. Hildebrand. 2012. Underwater radiated noise from modern commercial ships. *The Journal of the Acoustical Society of America* 131(1):92-103.

McKenna, M.F., J. Calambokidis, E.M. Oleson, D.W. Laist, and J.A. Goldbogen. 2015. Simultaneous tracking of blue whales and large ships demonstrates limited behavioral responses for avoiding collision. *Endangered Species Research* 27(3):219-232.

McMahon, C.R., and G.C. Hays. 2006. Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. *Global Change Biology* 12:1330–1338.

McPherson, C.R., M. Wood, and R. Racca. 2016. *Potential Impacts of Underwater Noise from Operation of the Barossa FPSO Facility on Marine Fauna, ConocoPhillips Barossa Project*. Prepared by JASCO Applied Sciences for Jacobs. Technical Report 01117, Version 1.0. 50 pp.

Meister, A.L. 1984. The marine migrations of tagged Atlantic salmon (*Salmo salar L.*) of USA origin. *ICES Document CM*, *1000*. 27 pp.

Methratta, E. T., and W. R. Dardick. 2019. Meta-Analysis of Finfish Abundance at Offshore Wind Farms. *Reviews in Fisheries Science & Aquaculture* 27(2):242–260.

Meyer-Gutbrod, E.L., C.H. Greene, P.J. Sullivan, and A.J. Pershing. 2015. Climate-associated changes in prey availability drive reproductive dynamics of the North Atlantic right whale population. *Marine Ecology Progress Series* 535:243-258.

Meyer-Gutbrod, E.L., Greene, C.H., Davies, K.T. and Johns, D.G., 2021. Ocean regime shift is driving collapse of the North Atlantic right whale population. *Oceanography*, *34*(3), pp.22-31.

Meylan, A., and A. Redlow. 2006. *Eretmochelys imbricata*, Hawksbill Turtle. Chelonian Research Foundation, 2006.

Michel, J., A.C. Bejarano, C.H. Peterson, and C. Voss 2013. *Review of Biological and Biophysical Impacts from Dredging and Handling of Offshore Sand*. OCS Study BOEM 2013-0119. Herndon, Virginia: U.S. Department of the Interior, Bureau of Ocean Energy Management. 258 p.

Mickle, M.F., and D.M. Higgs. 2022. Towards a new understanding of elasmobranch hearing. *Marine Biology* 169:12.

Mickle, M.F., R.H. Pieniazek, and D.M. Higgs. 2020. Field assessment of behavioural responses of southern stingrays (*Hypanus americanus*) to acoustic stimuli. *Royal Society Open Science* 7(1):191544.

Mikkelsen, L., M. Johnson, D.M. Wisniewska, A. van Neer, U. Siebert, P.T. Madsen, and J. Teilmann. 2019. Long-term sound and movement recording tags to study natural behavior and reaction to ship noise of seals. *Ecology and Evolution* 9(5):2588-2601.

Miles, J., T. Martin, and L. Goddard. 2017. Current and wave effects around windfarm monopile foundations. *Coastal Engineering* 121:167–78.

Miller, J.H., and G.R. Potty. 2017. Measurements of underwater sound radiated from an offshore wind turbine. *The Journal of the Acoustical Society of America* 142(4):2699.

Minerals Management Service (MMS). 2007. *Final Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf*. U.S. Department of the Interior. OCS EIS/EA MMS 2007-046. 1780 pp. Available at: Final Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf | Tethys (pnnl.gov) Accessed January 27, 2023.

Mitson, R.B. and H.P. Knudsen. 2003. Causes and effects of underwater noise on fish abundance estimation. *Aquatic Living Resources* 16:255–263.

Moein, S.E., J.A. Musick, J.A. Keinath, D.E. Barnard, M. Lenhardt, and R. George. 1995. Evaluation of seismic sources for repelling sea turtles from hopper dredges. In: Hales, L.Z. (Ed.), *Sea Turtle Research Program: Summary Report*. Virginia, U.S.: Virginia Institute of Marine Sciences Report for U.S. Army Corps of Engineers and U.S. Naval Submarine Base, Kings Bay, GA. Technical Report CERC-95. pp. 90-93.

Mohr, F.C., B. Lasely, and S. Bursian. 2008. Chronic Oral Exposure to Bunker C Fuel Oil Causes Adrenal Insufficiency in Ranch Mink. *Archives of Environmental Contamination and Toxicology* 54:337–347.

Mooney, T.A., R.T. Hanlon, J. Christensen-Dalsgaard, P.T. Madsen, D.R. Ketten, and P.E. Nachtigall. 2010. Sound detection by the longfin squid (*Loligo pealeii*) studied with auditory evoked potentials: sensitivity to low-frequency particle motion and not pressure. *The Journal of Experimental Biology* 213(21):3748.

Moore, M.J., and J.M. van der Hoop. 2012. The Painful Side of Trap and Fixed Net Fisheries: Chronic Entanglement of Large Whales. *Journal of Marine Biology* 2012:230653.

Moretti, D., L. Thomas, T. Marques, J. Harwood, A. Dilley, B. Neales, J. Shaffer, E. McCarthy, L. New, S. Jarvis, and R. Morrissey. 2014. A risk function for behavioral disruption of Blainville's beaked whales (*Mesoplodon densirostris*) from mid-frequency active sonar. *PloS ONE* 9(1):e85064.

National Aeronautics and Space Administration (NASA). 2023. The Effects of Climate Change. Available at: https://climate.nasa.gov/effects/. Accessed January 30, 2023.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 1993. Recovery Plan for U.S. Population of the Atlantic Green Turtle (*Chelonia mydas*). Washington, D.C.: National Marine Fisheries Service. November 1993.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 1991. Recovery Plan for the Hawksbill Turtle *Eretmochelys imbricata* in the U.S. Caribbean, Atlantic and Gulf of Mexico. Prepared by the Leatherback and Hawksbill Turtle Recovery Team for Southeast Region USFWS and NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 1998. *Endangered Species Consultation Handbook. Procedures for conducting consultation and conference activities under Section 7 of the Endangered Species Act*. March 1998. 315 p. Available at: https://www.fws.gov/sites/default/files/documents/endangered-species-consultation-handbook.pdf. Accessed December 28, 2022.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2007. *Kemp's Ridley Sea Turtle (Lepidochelys kempii) 5-Year Review: Summary and Evaluation.* U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources and U.S. Department of the Interior, U.S. Fish and Wildlife Service, Southwest Region. 50 pp.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2008. *Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (Caretta caretta), Second Revision*. Silver Spring, Maryland: National Marine Fisheries Service. Available at: https://repository.library.noaa.gov/view/noaa/3720. Accessed September 1, 2022

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2013. *Leatherback Sea Turtle (Dermochelys coriacea) 5-Year Review: Summary and Evaluation*. Silver Spring, Maryland, and Jacksonville, Florida. November.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2015a. *Kemp's Ridley Sea Turtle (Lepidochelys kempii) 5-Year Review: Summary and Evaluation.* Silver Spring, Maryland, and Albuquerque, New Mexico. July.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2015b. *Green Turtle (Chelonia mydas) Status Review under the U.S. Endangered Species Act.* Report of the Green Turtle Status Review Team.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2020. *Endangered Species Act status review of the leatherback turtle (Dermochelys coriacea) 2020*. U.S. National Marine Fisheries Service and U.S. Fish and Wildlife Service. August 2020. 396 pp.

National Marine Fisheries Service (NMFS). 2010. *Recovery Plan for the Sperm Whale (Physeter macrocephalus).* Silver Spring, Maryland: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

National Marine Fisheries Service (NMFS). 2011. *Programmatic Informal Consultation – mid-Atlantic WEAs*. Gloucester, MA: National Marine Fisheries Service, Northeast Region. September 20, 2011. 48 p. Available at: https://www.boem.gov/sites/default/files/documents/renewable-energy/MidAtlanticRegional_NMFS_Concurrence.pdf. Accessed June 20, 2022.

National Marine Fisheries Service (NMFS). 2015. *National Marine Fisheries Service Endangered Species Act Section 7 Consultation, Biological Opinion.* Virginia Offshore Wind Technology Advancement Project. Greater Atlantic Regional Fisheries Office. July 9, 2015. Consultation ID NER-2015-12128. 248 pp.

National Marine Fisheries Service (NMFS). 2016a. *Interim guidance on the Endangered Species Act term "harass", National Marine Fisheries Service Procedural Instruction 02-110-19*. National Marine Fisheries Service, Office of Protected Resources. Available at: https://media.fisheries.noaa.gov/dam-migration/02-110-19.pdf. Accessed January 27, 2023.

National Marine Fisheries Service (NMFS). 2016b. *Endangered Species Act Section 7 Consultation on the Continued Prosecution of Fisheries and Ecosystem Research Conducted and Funded by the Northeast Fisheries Science Center and the Issuance of a Letter of Authorization under the Marine Mammal Protection Act for the Incidental Take of Marine Mammals Pursuant to those Research Activities PCTS ID: NER-2015-12532*.

National Marine Fisheries Service (NMFS). 2018. 2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. NOAA Technical Memorandum NMFS-OPR-59. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 167 pp. Available at: 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0) (noaa.gov) Accessed January 27, 2023.

National Marine Fisheries Service (NMFS). 2019a. *Fin whale (Balaenoptera physalus) 5-year review: summary and evaluation*. NMFS Office of Protected Resources, Silver Spring, MD. February 2019. 23 pp.

National Marine Fisheries Service (NMFS). 2019b. *Interim recommendation for Sound Source Level and Propagation Analysis for High Resolution Geophysical Sources, 24 October 2019*.

National Marine Fisheries Service (NMFS). 2021a. Oceanic Whitetip Shark (*Carcharhinus longimanus*) Species Page. Available at: https://www.fisheries.noaa.gov//species/oceanic-whitetip-shark. Accessed June 20, 2022.

National Marine Fisheries Service (NMFS). 2021b. *Endangered Species Act Section 7 Consultation Biological Opinion for the Construction, Operation, Maintenance, and Decommissioning of the South Fork Offshore Energy Project (Lease OCS-A 0517) GARFO-2021-00353 – [Corrected].* Conducted by National Marine Fisheries Service Greater Atlantic Regional Fisheries Office. 523 pp.

National Marine Fisheries Service (NMFS). 2021c. Loggerhead turtle (*Caretta caretta*) Species Page. Available: https://www.fisheries.noaa.gov//species/loggerhead-turtle. Accessed June 20, 2022.

National Marine Fisheries Service (NMFS). 2021d. Kemp's ridley turtle (*Lepidochelys kempii*) Species Page. Available: https://www.fisheries.noaa.gov//species/kemps-ridley-turtle. Accessed June 20, 2022.

National Marine Fisheries Service (NMFS). 2021e. Giant Manta Ray (*Manta birostris*) Species Page. https://www.fisheries.noaa.gov//species/giant-manta-ray. Accessed June 20, 2022.

National Marine Fisheries Service (NMFS). 2022a. Rice's whale (*Balaenoptera ricei*) Species Overview. Available at: https://www.fisheries.noaa.gov/species/rices-whale. Accessed December 28, 2022.

National Marine Fisheries Service (NMFS). 2023b. 2017 – 2022 North Atlantic Right Whale Unusual Mortality Event. Available at: https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2023-north-atlantic-right-whale-unusual-mortality-event. Accessed January 24, 2023.

National Marine Fisheries Service (NMFS). 2022c. ESA Section 7 Consultation Tools for Marine Mammals on the West Coast. Available: https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/esa-section-7-consultation-tools-marine-mammals-west. Accessed June 20, 2022.

National Marine Fisheries Service (NMFS). 2022d. Sea Turtle Stranding and Salvage Network. Available at: https://www.fisheries.noaa.gov/national/marine-life-distress/sea-turtle-stranding-and-salvage-network#:~:text=The%20Network%20is%20a%20cooperative,to%20inform%20conservation%20management%20and. Accessed December 28, 2022.

National Marine Fisheries Service (NMFS). 2022e. Green turtle (*Chelonia mydas*) Species Page. https://www.fisheries.noaa.gov//species/green-turtle. Accessed June 20, 2022.

National Marine Fisheries Service (NMFS). 2022f. Leatherback turtle (*Dermochelys coriacea*) Species Page. https://www.fisheries.noaa.gov//species/leatherback-turtle. Accessed June 20, 2022.

National Marine Fisheries Service (NMFS). 2022g. Atlantic Sturgeon (*Acipenser oxyrhynchus*) Species Page. https://www.fisheries.noaa.gov/species/atlantic-sturgeon. Accessed June 20, 2022.

National Marine Fisheries Service (NMFS). 2023a. Oceanic Whitetip Shark (*Carcharhinus longimanus*) Species Page. https://www.fisheries.noaa.gov/species/oceanic-whitetip-shark. Accessed March 1, 2023.

National Marine Fisheries Service (NMFS). 2023b. *Draft U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessment Reports 2022*. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. June 2022. 147 pp.

National Marine Fisheries Service (NMFS). 2023c. 2017–2023 North Atlantic Right Whale Unusual Mortality Event. https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2023-north-atlantic-right-whale-unusual-mortality-event. Accessed May 1, 2023.

National Oceanic and Atmospheric Administration (NOAA). 2021a. *Final Environmental Impact Statement, Regulatory Impact Review, and Initial Regulatory Flexibility Analysis for Amending the Atlantic Large Whale Take Reduction Plan: Risk Reduction Rule*. Vol. 1. Available: https://www.greateratlantic.fisheries.noaa.gov/public/nema/apsd/2021FEIS_Volume%20I.pdf. Accessed December 28, 2022.

National Oceanic and Atmospheric Administration (NOAA). 2021b. *Section 7 Effect Analysis: Turbidity in the Greater Atlantic Region*. NOAA Greater Atlantic Regional Fisheries Office. Available at: https://www.fisheries.noaa.gov/new-england-mid-atlantic/consultations/section-7-effect-analysis-turbidity-greater-atlantic-region. Accessed December 9, 2022.

National Oceanic and Atmospheric Administration (NOAA). 2021c. *Section 7 Consultation for the Data Collection and Site Survey Activities for Renewable Energy on the Atlantic Outer Continental Shelf BOEM Biological Assessment and supplemental Project Design Criteria*. Conducted by the National Marine Fisheries Service, June 2021. 67 pp. Available at: https://www.boem.gov/sites/default/files/documents/renewable-energy/OSW-surveys-NLAA-programmatic.pdf. Accessed December 28, 2022.

National Oceanic and Atmospheric Administration (NOAA). 2022a. Compute Earth's Magnetic Field Values. National Centers for Environmental Information. Available at: https://www.ngdc.noaa.gov/geomag/magfield.shtml. Accessed June 20, 2022.

National Oceanic and Atmospheric Administration (NOAA). 2022b. Biologically Important Areas. Available at: https://cetsound.noaa.gov/important. Accessed June 20, 2022.

National Research Council (NRC). 1996. *An Assessment of Techniques for Removing Offshore Structures*. Washington, DC: National Academy Press.

National Science Foundation (NSF) and U.S. Geological Survey (USGS). 2011. *Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research*. Available at: nsf-usgs-final-eis-oeis_3june2011.pdf Accessed January 27, 2023.

NatureServe. 2022. *Chelonia mydas* – (Linnaeus, 1785): Green Sea Turtle. NatureServe Explorer. http://explorer.natureserve.org/servlet/NatureServe?searchName=chelonia+mydas. Accessed June 20, 2022.

Nealon, C. 2012. Beached sei whale a big attraction in Norfolk's Ocean View. Available at: https://www.dailypress.com/news/dp-beached-sei-whale-a-big-attraction-in-norfolks-ocean-view-20120221-story.html. Accessed December 28, 2022.

Nedelec, S.L., J. Campbell, A.N. Radford, S.D. Simpson, and N.D. Merchant. 2016. Particle motion: the missing link in underwater acoustic ecology. *Methods in Ecology and Evolution* 7(7):836-842.

Nedwell, J., J. Langworthy, and D. Howell. 2003. Assessment of Sub-Sea Acoustic Noise and Vibration from Offshore Wind Turbines and its Impact on Marine Wildlife. The Crown Estates Office Report 544 R 0424. 72p. Available: www.subacoustech/information/downloads/reports/ 544R0424.pdf.

Nedwell, J.R., A.W. Turnpenny, J. Lovell, S.J. Parvin, R. Workman, and J.A.L. Spinks. 2007. *A validation of the dBht as a measure of the behavioural and auditory effects of underwater noise*. Report No. 534R1231 prepared by Subacoustech Ltd. for the UK Department of Business, Enterprise and Regulatory Reform under Project No. RDCZ/011/0004. Available at: A Validation of the dBht as a Measure of the Behavioural and Auditory Effects of Underwater Noise (pnnl.gov) Accessed January 27, 2023.

Nedwell, J.R., and A.W. Turnpenny. 1998. The use of a generic frequency weighting scale in estimating environmental effect. *Workshop on Seismic and Marine Mammals*. 23–25th June 1998, London, U.K.

Nelms, S.E., E.M. Duncan, A.C. Broderick, T.S. Galloway, M.H. Godfrey, M. Hamann, P.K. Lindeque, and B.J. Godley. 2016. Plastic and marine turtles: a review and call for research. *ICES Journal of Marine Science: Journal du Conseil* 73(2):165-181.

Nelson, M., M. Garron, R. L. Merrick, R. M. Pace III, and T. Cole. 2007. *Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian Maritimes, 2001 - 2005*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, Massachusetts.

Neo, Y.Y., J. Seitz, R.A. Kastelein, H.V. Winter, C. ten Cate, and H. Slabbekoorn. 2014. Temporal structure of sound affects behavioral recovery from noise impact in European seabass. *Biological Conservation* 178:65-73.

Normandeau Associates, Inc. (Normandeau). 2011. *Effects of EMFs From Undersea Power Cables on Elasmobranchs and Other Marine Species*. OCS Study Report No. BOEMRE 2011-09. Final report prepared for the U.S. Department of the Interior, Bureau of Ocean Energy Management, Pacific OCS Region.

Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC). 2020. *2019 Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Waters of the Western North Atlantic Ocean - AMAPPS II.* Prepared by NMFS-NEFSC, Woods Hole, Massachusetts and NMFS-SEFSC, Miami, Florida.

Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC). 2021. *2020 Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Waters of the Western North Atlantic Ocean - AMAPPS III.* Prepared by NMFS-NEFSC, Woods Hole, Massachusetts and NMFS-SEFSC, Miami, Florida.

Novak, A.J., A.E. Carlson, C.R. Wheeler, G.S. Wippelhauser, and J.A. Sulikowski. 2017. Critical foraging habitat of Atlantic sturgeon based on feeding habits, prey distribution, and movement patterns in the Saco River estuary, Maine. *Transactions of the American Fisheries Society* 146(2): 308–317.

Nowacek, D.P., M.P. Johnson, and P.L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proceedings of the Royal Society B: Biological Sciences* 271(1536):227-231.

Nowacek, S.M., R.S. Wells, and A.R. Solow. 2006. Short-term effects of boat traffic on bottlenose dolphins, *Tursiops Truncatus,* in Sarasota Bay, Florida. *Marine Mammal Science* 17(4):673-688.

O'Brien, O., D.E. Pendleton, L.C. Ganley, K.R. McKenna, R.D. Kenney, E. Quintana-Rizzo, C.A. Mayo, S.D. Kraus, and J.V. Redfern. 2022. Repatriation of a historical North Atlantic right whale habitat during an era of rapid climate change. *Scientific Reports* 12(1):1-10.

Ocean Biodiversity Information System (OBIS). 2022. OBIS Spatial Ecological Analysis of Megavertebrate Populations (SEAMAP). Available at: https://seamap.env.duke.edu/. Accessed January 27, 2023.

O'Hara, J., and J.R. Wilcox. 1990. Responses of loggerhead sea turtles, *Caretta caretta*, to low frequency sound. *Copeia* 199:564–567.

Olsen, E., W. P. Budgell, E. Head, L. Kleivane, L. Nottestad, R. Prieto, M. A. Silva, H. Skov, G. A. Víkingsson, G. Waring, and N. Oien. 2009. First satellite-tracked long-distance movement of a sei whale (*Balaenoptera borealis*) in the North Atlantic. *Aquatic Mammals* 35(3):313–318.

Osmanbasic, E. 2020. *The Future of Wind Turbines: Comparing Direct Drive and Gearbox. Development effort focuses on two types of wind turbines, is there a dominant choice?* Available at: https://www.engineering.com/story/the-future-of-wind-turbines-comparing-direct-drive-and-gearbox. Accessed December 28, 2022.

OSPAR Commission. 2009. *Overview of the impacts of anthropogenic underwater sound in the marine environment.* London, UK: OSPAR Commission.

Pace, R.M. 2021. *Revisions and Further Evaluations of the Right Whale Abundance Model: Improvements for Hypothesis Testing*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA. NOAA Technical Memorandum NMFS-NE-269. 54 pp.

Pace, R., and G. Silber. 2005. Simple analyses of ship and large whale collisions: Does speed kill? In: Abstract. Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego.

Packard, A., H.E. Karlsen, and O. Sand. 1990. Low frequency hearing in cephalopods. *Journal of Comparative Physiology A* 166(4):501-505.

Page, J.W., Curran, M.C. and Geer, P.J., 2013. Characterization of the bycatch in the commercial blue crab pot fishery in Georgia, November 2003–December 2006. Marine and Coastal Fisheries, 5(1), pp.236-245.

Palka, D. L., S. Chavez-Rosales, E. Josephson, D. Cholewiak, H. L. Haas, L. Garrison, M. Jones, D. Sigourney, G. Waring (retired), M. Jech, E. Broughton, M. Soldevilla, G. Davis, A. DeAngelis, C. R. Sasso, M. V. Winton, R. J. Smolowitz, G. Fay, E. LaBrecque, J. B. Leiness, K. Dettloff, M. Warden, K. Murray, and C. Orphanides. 2017. *Atlantic Marine Assessment Program for Protected Species: 2010–2014*. OCS Study BOEM 2017-071. 217 pp. Washington, D.C.: U.S. Department of the Interior, Bureau of Ocean Energy Management, Atlantic OCS Region. 230 p. Available at: https://espis.boem.gov/final%20reports/5638.pdf. Accessed June 20, 2022.

Palka, D. 2020. *Cetacean abundance in the US Northwestern Atlantic Ocean Summer 2016*. U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document 20-05. 60 pp. Available at: https://repository.library.noaa.gov/view/noaa/27117/noaa_27117_DS1.pdf? Accessed January 27, 2023.

Palka, D., L. Aichinger Dias, E. Broughton, S. Chavez-Rosales, D. Cholewiak, G. Davis, A. DeAngelis, L. Garrison, H. Haas, J. Hatch, M. Jech, E. Josephson, L. Mueller-Brennan, C. Orphanides, N. Pegg, C. Sasso, D. Sigourney, M. Soldevilla, and H. Walsh. 2021. *Atlantic Marine Assessment Program for Protected Species: FY15 – FY19*. US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2021-051. 330 pp. Marine Mammal Model Viewer Available at: BOEM_2021-051.pdf Accessed January 27, 2023.

Parker, S. 2020. *Loggerhead sea turtles are nesting in Virginia Beach*. Available at: https://www.pilotonline.com/life/wildlife-nature/vp-nw-sea-turtle-nest-0709-20200709-apv3xoqlbnd6ppvtd5h27hu53q-story.html. Accessed June 20, 2022.

Parks, S.E., M.W. Brown, L.A. Conger, P.K. Hamilton, A.R. Knowlton, S.D. Kraus, C.K. Slay, and P.L. Tyack. 2007a. Occurrence, Composition, and Potential Functions of North Atlantic Right Whale (*Eubalaena glacialis*) Surface Active Groups. *Marine Mammal Science* 23(4):868-887.

Parks, S.E., C.W. Clark, and P.L. Tyack. 2007b. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. *The Journal of the Acoustical Society of America* 122(6):3725-3731.

Parks, S.E., D.A. Cusano, S.M. Van Parijs, and D.P. Nowacek. 2019. Acoustic crypsis in communication by North Atlantic right whale mother-calf pairs on the calving grounds. *Biology Letters* 15:20190485.

Parsons, M.J., C. Erbe, M.G. Meekan, and S.K. Parsons. 2021. A Review and Meta-Analysis of Underwater Noise Radiated by Small (<25 m Length) Vessels. *Journal of Marine Science and Engineering* 9(8):827.

Paskyabi, M.B., and I. Fer. 2012. Upper ocean response to large wind farm effect in the presence of surface gravity waves. *Energy Procedia* 24:245-254.

Patel, S.H., M.V. Winton, J.M. Hatch, H.L. Haas, V.S. Saba, G. Fay, and R.J. Smolowitz. 2021. Projected shifts in loggerhead sea turtle thermal habitat in the Northwest Atlantic Ocean due to climate change. *Scientific Reports* 11(1):1-12.

Patrício, A.R., M.R. Varela, C. Barbosa, A.C. Broderick, P. Catry, L.A. Hawkes, A. Regalla, and B.J. Godley. 2019. Climate change resilience of a globally important sea turtle nesting population. *Global Change Biology* 25(2):522-535.

Pendleton, D.E., P.J. Sullivan, M.W. Brown, T.V.N. Cole, C.P. Good, C.A. Mayo, B.C. Monger, S. Phillips, N.R. Record, and A.J. Pershing. 2012. Weekly predictions of North Atlantic right whale *Eubalaena glacialis* habitat reveal influence of prey abundance and seasonality of habitat preferences. *Endangered Species Research* 18(2):147-161.

Perry, S.L., D.P. DeMaster, and G.K. Silber. 1999. The Sperm whale. *Marine Fisheries Review* 61:59-74.

Peterson, D.L., M.B. Bain, and N. Haley. 2000. Evidence of declining recruitment of Atlantic sturgeon in the Hudson River. *North American Journal of Fisheries Management* 20(1):231-238.

Pettis, H.M., R.M. Pace, and P.K. Hamilton. 2022. *North Atlantic Right Whale Consortium 2021 annual report card.* Report to the North Atlantic Right Whale Consortium, Boston MA. 25 pp. Available at: JOURNAL ARTICLE (narwc.org) Accessed January 27, 2023.

Picciulin, M., C. Franzosini, M. Spoto, and A. Codarin. 2008. Characterization of the noise produced by Class 1 powerboat race in Piran Bay (Slovenia) and potential impact on the marine fauna. *Annales: Series Historia Naturalis* 18(2):201-210.

Picciulin, M., L. Sebastianutto, A. Codarin, G. Calcagno, and E.A. Ferrero. 2012. Brown meagre vocalization rate increases during repetitive boat noise exposures: A possible case of vocal compensation. *The Journal of the Acoustical Society of America* 132(5):3118-3124.

Pike, D.G., G.A. Víkingsson, T. Gunnlaugsson, and N. Øien. 2009. A note on the distribution and abundance of blue whales (*Balaenoptera musculus*) in the Central and Northeast North Atlantic. *NAMMCO Scientific Publications* 7:19-29.

Piniak, W.E.D., D.A. Mann, C.A. Harms, T.T. Jones, and S.A. Eckert. 2016. Hearing in the juvenile green sea turtle (*Chelonia mydas*): a comparison of underwater and aerial hearing using auditory evoked potentials. *PLoS ONE* 11:e0159711.

Plotkin, P.T., M.K. Wicksten, and A.F. Amos. 1993. Feeding ecology of the loggerhead sea turtle, *Caretta caretta*, in the northwestern Gulf of Mexico. *Marine Biology* 115(1):1–15.

Pohle, G.W., and M.L.H. Thomas. 2001. *Marine biodiversity Monitoring. Monitoring protocol for marine benthos: Intertidal and subtidal macrofauna*. Report by the Marine biodiversity Monitoring Committee (Atlantic Marine Ecological Science Cooperative, Huntsman Marine Science Centre) to the Ecological Monitoring and Assessment network of Environment Canada. Available at: http://www.biomareweb.org/downloads/mbm.pdf. Accessed November 15, 2022.

Popper, A.N., M. Salmon, and K.W. Horch. 2001. Acoustic detection and communication by decapod crustaceans. *Journal of Comparative Physiology A* 187(2):83-89.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, et al. 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI Accredited Standards Committee S3/SC1 and registered with ANSI. ASA S3/SC1.4 TR-2014.* SpringerBriefs in Oceanography. ASA Press and Springer. Available at: https://doi.org/10.1007/978-3-319-06659-2. Accessed January 27, 2022

Popper, A.N., and M.C. Hastings. 2009. The effects of anthropogenic sources of sound on fishes. *Journal of Fish Biology* 75(3):455-489.

Popper, A.N., and A.D. Hawkins. 2018. The importance of particle motion to fishes and invertebrates. *The Journal of the Acoustical Society of America* 143:470.

Prieto, R., M. A. Silva, G. T. Waring, and J. M. A. Gonçalves. 2014. Sei whale movements and behaviour in the North Atlantic inferred from satellite telemetry. *Endangered Species Research* 26:103–113.

Purser, J., and A.N. Radford. 2011. Acoustic Noise Induces Attention Shifts and Reduces Foraging Performance in Three-Spined Sticklebacks (*Gasterosteus aculeatus*). *PLoS ONE* 6(2):e17478.

Putland, Rosalyn & Mensinger, Allen. 2019. Acoustic deterrents to manage fish populations. Reviews in Fish Biology and Fisheries. 29. 10.1007/s11160-019-09583-x.

Putland, R.L., N.D. Merchant, A. Farcas, and C.A. Radford. 2018. Vessel noise cuts down communication space for vocalizing fish and marine mammals. *Global Change Biology* 24(4):1708-1721.

Quick, N., L. Scott-Hayward, D. Sadykova, D. Nowacek, and A. Read. 2017. Effects of a scientific echo sounder on the behavior of short-finned pilot whales (*Globicephala macrorhynchus*). *Canadian Journal of Fisheries and Aquatic Sciences* 74(5):716-726.

Quintana-Rizzo, E., Leiter, S., Cole, T.V.N., Hagbloom, M.N., Knowlton, A.R., Nagelkirk, P., Brien, O.O., Khan, C.B., Henry, A.G., Duley, P.A. and Crowe, L.M., 2021. Residency, demographics, and movement patterns of North Atlantic right whales Eubalaena glacialis in an offshore wind energy development area in southern New England, USA. *Endangered Species Research*, *45*, pp.251-268

Raoux, A., S. Tecchio, J.-P. Pezy, G. Lassalle, S. Degraer, D. Wilhelmsson, M. Cachera, B. Ernande, C. Le Guen, and M. Haraldsson. 2017. Benthic and fish aggregation inside an offshore wind farm: which effects on the trophic web functioning? *Ecological Indicators* 72:33-46.

Read, A.J., P. Drinker, S. Northridge. 2006. Bycatch of marine mammals in U.S. and global fisheries. *Conservation Biology* 20(1):163–169.

Reeves, R.R., P.C. Clapham, and S.E. Whitmore. 2002. Humpback whale (*Megaptera novaeangliae*) occurrence near the Cape Verde Islands based on American 19th century whaling records. *Journal of Cetacean Research and Management* 4(3):235-253.

Reichmuth, C., J.M. Sills, J. Muslow, and A. Ghoul. 2019. Long-term evidence of noise-induced permanent threshold shift in a harbor seal (*Phoca vitulina*). *The Journal of the Acoustical Society of America* 146(4):2552-2561.

Reine, K., D. Clarke, M. Balzaik, S. O'Haire, C. Dickerson, C. Frederickson, G. Garman, C. Hager, A. Spells, and C. Turner. 2014. *Dredging Operations Technical Support Program. Assessing Impacts of Navigational Dredging on Atlantic Sturgeon (Acipenser oxyrinchus).* U.S. Army Engineer Research and Development Center. ERDC/EL TR-14-12. 42 p.

Reygondeau G, and G. Beaugrand. 2011. Future climate-driven shifts in distribution of *Calanus finmarchicus*. *Global Change Biology* 17:756–766.

Rheuban, J.E., M.T. Kavanaugh, and S.C. Doney. 2017. Implications of Future Northwest Atlantic Bottom Temperatures on the American Lobster (*Homarus americanus*) Fishery. *Journal of Geophysical Research: Oceans* 122:9387–9398.

Richardson, W.J., B. Wursig, and C.R. Greene. 1986. Reactions of bowhead whales, Balaena mysticetus, to seismic exploration in the Canadian Beaufort Sea. *The Journal of the Acoustical Society of America* 79(4):1117-1128.

Richardson, W. J., C. R. Greene, Jr., C. I. Malme, and D. H. Thomson. 1995. *Marine Mammals and Noise*. San Diego, CA: Academy Press. Available at: https://www.elsevier.com/books/marine-mammals-and-noise/richardson/978-0-08-057303-8. Accessed December 10, 2022.

Richardson, W.J., G.W. Miller, and C.R. Green. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. *The Journal of the Acoustical Society of America* 106(4):2281-2281

Ridgway, S.H., E.G. Wever, J.G. McCormick, J. Palin, and J.H. Anderson. 1969. Hearing in the giant sea turtle, Chelonia mydas. *Proceedings of the National Academy of Science U.S*. 64(2):884-890.

Ridgway, S.H., and D.A. Carder. 2001. Assessing hearing and sound production in cetaceans not available for behavioral audiograms: Experiences with sperm, pygmy sperm, and gray whales. *Aquatic Mammals* 27(3):267-276.

Roberts, J.J., T. Yack, and P.N. Halpin. 2022. Habitat-based Marine Mammal Density Models for the U.S. Atlantic: Latest Versions (last updated 20 June 2022), provided by Duke University Marine Geospatial Ecology Laboratory, v.12. Available at: https://seamap.env.duke.edu/models/Duke/EC/. Accessed September 12, 2022.

Rockwood, R.C., J. Calambokidis, and J. Jahncke. 2017. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the US West Coast suggests population impacts and insufficient protection. *PLoS One* 12(8):e0183052.

Rogers, L.A., R. Griffin, T. Young, E. Fuller, K. St. Martin, and M.L. Pinsky. 2019. Shifting habitats expose fishing communities to risk under climate change. *Nature Climate Change* 9:512–516.

Rolland, R.M., S.E. Parks, K.E. Hunt, M. Castellote, P.J. Corkeron, D.P. Nowacek, S.K. Wasser, and S.D. Kraus. 2012. Evidence that ship noise increases stress in right whales. *Proceedings of Royal Society B* 279(1737):2363-2368.

ROSA. 2021 ("a living document" or *in progress*). Offshore Wind Project Monitoring Framework and Guidelines. 55 pp. Available at: Microsoft Word - 56960180d21fc58b94111ded8d16457c (pnnl.gov) Accessed January 27, 2023.

Ruckdeschel, C.A., and C.R. Shoop. 1988. Gut Contents of Loggerheads: Findings, Problems and New Questions. *In Proceedings of the Eighth Annual Workshop on Sea Turtle Biology and Conservation.* NOAA Technical Memorandum NMFS-SEFC-214. pp. 97-98.

Ruppel, C.D., T.C. Weber, E.R. Staaterman, S.J. Labak, and P.E. Hart. 2022. Categorizing Active Marine Acoustic Sources Based on Their Potential to Affect Marine Animals. *Journal of Marine Science and Engineering* 10(9):1-46.

Russell, D.J.F., S. Brasseur, D. Thompson, G.D. Hastie, V.M. Janik, G. Aarts, B.T. McClintock, J. Matthiopoulos, S.E.W. Moss, and B. McConnell. 2014. Marine mammals trace anthropogenic structures at sea. *Current Biology* 24(14):R638-R639.

Russell, D.J.F., G.D. Hastie, D. Thompson, V.M. Janik, P.S. Hammond, L.A.S. Scott-Hayward, J. Matthiopoulos, E.L. Jones, and B.J. McConnell. 2016. Avoidance of wind farms by harbour seals is limited to pile driving activities. *Journal of Applied Ecology* 53:11.

Salisbury, D. P., C. Clark, and A. Rice. 2016. Right whale occurrence in the coastal waters of Virginia, U.S.A.: Endangered species presence in a rapidly developing energy market. *Marine Mammal Science* 32:508-519.

Salisbury, D.P., B.J. Estabrook, H. Klinck, A.N. Rice. 2018. *Understanding marine mammal presence in the Virginia Offshore Wind Energy Area*. Sterling (Virginia): U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2019-007. 103 p. Available at: https://espis.boem.gov/final%20reports/BOEM_2019-007.pdf. Accessed June 20, 2022.

Samson, J.E., T.A. Mooney, S.W.S. Gussekloo, and R.T. Hanlon. 2014. Graded behavioral responses and habituation to sound in the common cuttlefish *Sepia officinalis*. *The Journal of Experimental Biology* 217(24):4347.

Samuel, Y., S.J. Morreale, C.W. Clark, C.H. Greene, and M.E. Richmond. 2005. Underwater, low-frequency noise in a coastal sea turtle habitat. *The Journal of the Acoustical Society of America* 117(3):1465-1472.

Sapp, A. 2010. *Influence of small vessel operation and propulsion system on loggerhead sea turtle injury*. M.S. Thesis, Georgia Institute of Technology. May 2010. Available at: https://smartech.gatech.edu/bitstream/handle/1853/33845/sapp_adam_l_201005_mast.pdf. Accessed December 28, 2022.

Sapsford, C.W., and M. van der Riet. 1979. Uptake of Solar Radiation by the Sea Turtle, Caretta caretta, During Voluntary Surface Basking. *Comparative Biochemistry and Physiology Part A: Physiology* 63(4):471–474.

Sarà, G., J.M. Dean, D. D'Amato, G. Buscaino, A. Oliveri, S. Genovese, S. Ferro, G. Buffa, M.L. Martire, and S. Mazzola. 2007. Effect of boat noise on the behaviour of bluefin tuna *Thunnus thynnus* in the Mediterranean Sea. *Marine Ecology Progress Series* 331:243–253.

Saunders J.C., S.P. Dear, and M.E. Schneider. 1985. The anatomical consequences of acoustic injury: A review and tutorial. *Journal of the Acoustical Society of America* 78:833–860.

Scheidat, M., J. Tougaard, S. Brasseur, J. Carstensen, P.T. van Polanen, J. Teilmann, and P. Reijnders. 2011. Harbour Porpoise (*Phocoena phocoena*) and Wind Farms: A Case Study in the Dutch North Sea. *Environmental Research Letters* 6:1-10.

Scheifele P.M., S. Andrew, R.A. Cooper, M. Darre, F.E. Musiek, and L. Max. 2004. Indication of a Lombard vocal response in the St. Lawrence River beluga. *Journal of the Acoustical Society of America* 17:1486-1492.

Schleimer, A., C. Ramp, J. Delarue, A. Carpentier, M. Berube, P.J. Palsboll, R. Sears, and P.S. Hammond. 2019. Decline in abundance and apparent survival rates of fin whales (*Balaenoptera physalus*) in the northern Gulf of St. Lawrence. *Ecology and Evolution* 9(7):4231-4244.

Schmid, J.R. 1998. Marine turtle populations on the west-central coast of Florida: Results of tagging studies at the Cedar Keys, Florida, 1986–1995. *Fishery Bulletin* 96:589-602.

Schoeman, R.P., C. Patterson-Abrolat, and S. Plön. 2020. A global review of vessel collisions with marine animals. *Frontiers in Marine Science* 7:00292.

Schreck, C.B. 2000. Accumulation and long-term effects of stress in fish. In: Moberg, G.P., J.A. Mench (Eds.), *The Biology of Animal Stress - Basic Principles and Implications for Animal Welfare*. New York, New York: CABI Publishing. pp. 147-158.

Schultze, L., L. Merckelbach, J. Horstmann, S. Raasch, and J. Carpenter. 2020. Increased mixing and turbulence in the wake of offshore wind farm foundations. *Journal of Geophysical Research: Oceans* 125(8):e2019JC015858.

Schuyler, Q.A., C. Wilcox, K.A. Townsend, K.R. Wedemeyer-Strombel, G. Balazs, E. van Sebille, and B.D. Hardesty. 2016. Risk analysis reveals global hotspots for marine debris ingestion by sea turtles. *Global Change Biology* 22(2):567-576.

Seminoff, J.A., C.D. Allen, G.H. Balaz, P.H. Dutton, T. Eguchi, H.L. Haas, S.A. Hargrove, M.P. Jensen, D.L. Klemm, A.M. Lauritsen, S.L. MacPherson, P. Opay, E.E. Possardt, L.L. Pultz, E.E. Seney, K.S. Van Houtan, and R.S. Waples. 2015. *Status Review of the Green Turtle (Chelonia mydas) Under the U.S. Endangered Species Act*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries. NOAA Technical Memorandum, NOAA-NMFS-SWFSC-539. 571 p.

Seney, E.E., and J.A. Musick. 2007. Historical diet analysis of loggerhead sea turtles (*Caretta caretta*) in Virginia. *Copeia* 2007(2):478–489.

Sergeant, D.E. 1977. Stocks of fin whales *Balaenoptera physalus* L. in the North Atlantic Ocean. *Report of the International Whaling Commission* 27:460B473.

Sexton, M.A. 2012. Factors influencing appearance, disappearance, and variability of abundance of the sea nettle *Chrysaora quinquecirrha* in Chesapeake Bay. University of Maryland, College Park.

Slabbekoorn, H., N. Bouton, I. van Opzeeland, A. Coers, C. ten Cate, A.N. Popper. 2010. A noisy spring: the impact of globally rising underwater sound levels on fish. *Trends in Ecology & Evolution* 25(7):419-427.

Slater, M., A. Shultz, and R. Jones. 2010. Estimated ambient electromagnetic field strength in Oregon's coastal environment. Prepared by Science Applications International Corp. for Oregon Wave Energy Trust. September 10, 2010. 26 pp.

Smith, T.I.J. 1985. The fishery, biology, and management of Atlantic sturgeon, *Acipenser oxyrhynchus*, in North America. *Environmental Biology of Fishes* 14:61–72.

Smith, T., and J. Clugston. 1997. Status and management of Atlantic sturgeon, *Acipenser oxyrinchus*, in North America. *Environmental Biology of Fishes* 48(1):335-346.

Smith, T.D., and R.R. Reeves. 2003. Estimating American 19th century catches of humpback whaleas in the West Indies and Cape Verde Islands. *Caribbean Journal of Science* 39(3):286-297.

Smith, M.E., A.S. Kane, and A.N. Popper. 2004. Noise-induced stress response and hearing loss in goldfish (*Carassius auratus*). *Journal of Experimental Biology* 207:427-435.

Smith, C.R., T.K. Rowles, L.B. Hart, F.I. Townsend, R.S. Wells, E.S. Zolman, B.C. Balmer, B. Quigley, M. Ivnacic, W. McKercher, M.C. Tumlin, K.D. Mullin, J.D. Adams, Q. Wu, W. McFee, T.K. Collier, and L.H. Schwacke. 2017. Slow Recovery of Barataria Bay Dolphin Health Following the Deepwater Horizon Oil Spill (2013–2014), with Evidence of Persistent Lung Disease and Impaired Stress Response. *Endangered Species Research* 33:127–142.

Smultea Environmental Sciences. 2020. Protected species observer technical report for the Orsted New England IHA, BOEM Lease Areas OCS-A 0486, OCS-A 0487, and OCS-A 0500. 25 December 2020. 107 pp.

Solé, M., M. Lenoir, M. Durfort, M. López-Bejar, A. Lombarte, and M. André. 2013. Ultrastructural Damage of *Loligo vulgaris* and *Illex coindetii* statocysts after Low Frequency Sound Exposure. *PLoS ONE* 8(10):e78825.

Solé, M., M. Lenoir, J.M. Fortuño, M. Durfort, M. van der Schaar, and M. André. 2016. Evidence of Cnidarians sensitivity to sound after exposure to low frequency underwater sources. *Scientific Reports* 6:37979.

Solé, M., P. Sigray, M. Lenoir, M. van der Schaar, E. Lalander, and M. André. 2017. Offshore exposure experiments on cuttlefish indicate received sound pressure and particle motion levels associated with acoustic trauma. *Scientific Reports* 7:45899.

Solé, M., M. Lenoir, M. Durfort, J.-M. Fortuño, M. Van der Schaar, S. De Vreese, and M. André. 2021. Seagrass Posidonia is impaired by human-generated noise. *Communications Biology* 4(1):1-11.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals* 33(4):411–521.

Southall, B.L., J.J. Finneran, C. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek, P.L. Tyack. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. *Aquatic Mammals* 45(2):125-232.

Southall, B.L., D.P. Nowacek, A. E. Bowles, V. Senigaglia, L. Bejder, and P.L. Tyack. 2021a. Marine mammal noise exposure criteria: Assessing the severity of marine mammal behavioral responses to human noise. *Aquatic Mammals* 47(5):421-464.

Southall, B., Ellison, W., Clark, C., Tollit, D. and Amaral, J. 2021b. *Marine mammal risk assessment for Gulf of Mexico G&G activities.* Southall Environmental Associates. OCS Study BOEM 2021-022. 87 pp. Available at: [Marine Mammal Risk Assessment for Gulf of Mexico G&G Activities (boem.gov)]() Accessed January 27, 2023.

Spence, J., R. Fischer, M. Bahtiarian, L. Boroditsky, N. Jones, and R. Dempsey. 2007. *Review of existing and future potential treatments for reducing underwater sound from oil and gas industry activities*. NCE Report 07-001. 193 pp.

Sprogis, K.R., S. Videsen, and P.T. Madsen. 2020. Vessel noise levels drive behavioral response of humpback whales with implications for whale-watching. *Ecology* 9:e56760.

Stacy, N.I., C.J. Innis, J.A. Hernandez. 2013. Development and evaluation of three mortality prediction indices for cold-stunned Kemp's ridley sea turtles (*Lepidochelys kempii). Conservation Physiology* 1(2013):1-9.

Stanistreet, J.E., D.P. Nowacek, J.T. Bell, D.M. Cholewiak, J.A. Hildebrand, L.E. Hodge, S.M. Van Parijs, and A.J. Read. 2018. Spatial and seasonal patterns in acoustic detections of sperm whales *Physeter macrocephalus* along the continental slope in the western North Atlantic Ocean. *Endangered Species Research* 35:1-13.

Stein, A.B., K.D. Friedland, and M. Sutherland. 2004. Atlantic sturgeon marine bycatch and mortality on the continental shelf of the northeast United States. *North American Journal of Fisheries Management* 24(1):171–183.

Stewart, J.D., E.M. Hoyos-Padilla, K.R. Kumli, and R.D. Rubin. 2016. Deep-water feeding and behavioral plasticity in *Manta birostris* revealed by archival tags and submersible observations. *Zoology* 119:406-413.

Stöber, U. and F. Thomsen. 2021. How could operational underwater sound from future offshore wind turbines impact marine life? *Journal of the Acoustical Society of America* 149(3):1791–1795.

St. Pierre, R., and F.M. Parauka. 2006. *Acipenser oxyrinchus* (errata version published in 2016). *The IUCN Red List of Threatened Species* 2006:e.T245A107249015.

Sullivan, L., T. Brosnan, T.K. Rowles, L. Schwacke, C. Simeone, and T.K. Collier. 2019. Guidelines for Assessing Exposure and Impacts of pOil Spills on Marine Mammals. NOAA Technical Memorandum NMFS OPR-62. 82 pp.

Sutcliffe, M.H., and P.F. Brodie. 1977. Whale distributions in Nova Scotia waters. *Technical Report – Fisheries and Marine Service of Canada* 722:1-89.

Swingle, W., S. Barco, E. Bates, G. Lockhart, K. Phillips, K. Rodrique, S. Rose, and K. Williams. 2016. *Virginia Sea Turtle and Marine Mammal Stranding Network 2015 Grant Report*. Final Report to the Virginia Coastal Zone Management Program, NOAA CZM Grant #NA14NOS4190141, Task 49. VAQF Scientific Report 2016-01. Virginia Beach, VA.

Swingle, W., S. Barco, A. Costidis, E. Bates, S. Mallette, K. Phillips, S. Rose and K. Williams. 2017. *Virginia Sea Turtle and Marine Mammal Stranding Network 2016 Grant Report*. Final Report to the Virginia Coastal Zone Management Program, NOAA CZM Grant #NA15NOS4190164, Task 49. VAQF Scientific Report 2017-01. Virginia Beach, VA.

Swingle, W., S. Barco, A. Costidis, E. Bates, S. Mallette, S. Rose, and A. Epple. 2018. *Virginia Sea Turtle and Marine Mammal Stranding Network 2017 Grant Report*. Final Report to the Virginia Coastal Zone Management Program, NOAA CZM Grant NA16NOS4190171, Task 49. VAQF Scientific Report 2018-01, Virginia Beach, VA.

Takeshita, R., L. Sullivan, C. Smith, T. Collier, A. Hall, T. Brosnan, T. Rowles, and L. Schwacke. 2017. The *Deepwater Horizon* Oil Spill Marine Mammal Injury Assessment. *Endangered Species Research* 33:96–106.

Taormina, B., J. Bald, A. Want, G. Thouzeau, M. Lejart, N. Desroy, and A. Carlier. 2018. A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions. *Renewable and Sustainable Energy Reviews* 96:380-391.

Taylor, B.L., R. Baird, J. Barlow, S.M. Dawson, J. Ford, J.G. Mead, G. Notarbartolo di Sciara, P. Wade, R.L. Pitman. 2019. *Physeter macrocephalus* (amended version of 2008 assessment). *The IUCN Red List of Threatened Species* 2019:e.T41755A160983555.

Tetra Tech, Inc. (Tetra Tech). 2022a. *Dominion Energy Coastal Virginia Offshore Wind Commercial Project, Request for Rulemaking and Letter of Authorization (LOA) for Taking of Marine Mammals Incidental to Construction Activities on the Outer Continental Shelf (OCS) within Lease OCS-A 0483 and the Associated Offshore Export Cable Route Corridor.* Prepared for Dominion Energy, Submitted to NOAA National Marine Fisheries Service February 2022, Revised March, May, June, and July 2022. 311 pp.

Tetra Tech, Inc. (Tetra Tech). 2022b. *Dominion Energy Coastal Virginia Offshore Wind Commercial Project Request for Rulemaking and Letter of Authorization (LOA) for Taking of Marine Mammals Incidental to Construction Activities on the Outer Continental Shelf (OCS) within Lease OCS-A 0483 and the Associated Offshore Export Cable Route Corridor*: Roberts and Halpin (2022) Revision Addendum. Prepared for Dominion Energy, Submitted to NOAA National Marine Fisheries Service September 2022, revised December 2022. 31 pp.

Thompson, D., A.J. Hall, B.J. McConnell, S.P. Northridge, and C. Sparling. 2015. *Current State of Knowledge of the Effects of Offshore Renewable Energy Generation Devices on Marine Mammals and Research Requirements. Marine Mammal Scientific Support Research Programme MMSS/001/11.* St. Andrews: Sea Mammal Research Unit, Scottish Oceans Institute, University of St. Andrews.

Thomsen, F., K. Lüdemann, R. Kafemann, and W. Piper. 2006. *Effects of offshore wind farm noise on marine mammals and fish*. biola, Hamburg, Germany on behalf of COWRIE Ltd. 62 pp.

Thomsen, F., C. Erbe, A. Hawkins, P. Lepper, A.N. Popper, A. Scholik-Schlomer, and J. Sisneros. 2020. Introduction to the special issue on the effects of sound on aquatic life. *The Journal of the Acoustical Society of America* 148(2):934-938.

Todd, V.G.L., I.B. Todd, J.C. Gardiner, E.C.N. Morin, N.A. MacPherson, and F. Thomsen. 2015. A review of impacts of marine dredging activities on marine mammals. *ICES Journal of Marine Science* 72(2):328–340.

Todd, V.L., L. Lazar, L.D. Williamson, I.T. Peters, A.L. Hoover, S.E. Cox, I.B. Todd, P.I. Macreadie, and D.L. McLean. 2020. Underwater visual records of marin megafauna around offshore anthropogenic structures. *Frontiers in Marine Science* 7:00230.

Tolotti, M.T., P. Bach, F. Hazin, P. Travassos, and L. Dagorn. 2015. Vulnerability of the oceanic whitetip shark to pelagic longline fisheries. *PLoS ONE* 10(10):e0141396.

Tougaard, J., Carstensen, J., Teilmann, J., and Bech, N. I. 2005. *Effects of the Nysted Offshore Wind Farm on harbour porpoises- annual status report for the T-POD monitoring program*. Technical Report to Energi E2 A/S.

Tougaard, J., O.D. Henriksen, and L.A. Miller. 2009. Underwater noise from three types of offshore wind turbines: Estimation of impact zones for harbor porpoises and harbor seals. *The Journal of the Acoustical Society of America* 125(6):8.

Tougaard, J., L. Hermannsen, and P.T. Madsen. 2020. How loud is the underwater noise from operating offshore wind turbines? *Journal of the Acoustical Society of America* 148(5):2885–2893.

Tremblay, C.J., S.M. Van Parijs, and D. Cholewiak. 2019. 50 to 30-Hz triplet and singlet down sweep vocalizations produced by sei whales (*Balaenoptera borealis*) in the western North Atlantic Ocean. *The Journal of the Acoustical Society of America* 145(6):3351-3358.

Tsujii, K., T. Akamatsu, R. Okamoto, K. Mori, Y. Mitani, and N. Umeda. 2018. Change in singing behavior of humpback whales caused by shipping noise. *PloS ONE* 13(10):e0204112.

Turtle Expert Working Group (TEWG). 2000. *Assessment Update for the Kemp's Ridley and Loggerhead Sea Turtle Populations in the Western North Atlantic*. Miami, FL: U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum. NMFS-SEFSC-444. 115 pp.

Turtle Expert Working Group (TEWG). 2007. *An Assessment of the Leatherback Turtles Population in the Atlantic Ocean*. NOAA Technical Memorandum NMFS-SEFSC-555. A Report of the Turtle Expert Working Group. U.S. Department of Commerce. April 2007.

Turtle Expert Working Group (TEWG). 2009. *An Assessment of the Loggerhead Turtle Population in the Western North Atlantic Ocean*. NOAA Technical Memorandum NMFS-SEFSC-575. U.S. Department of Commerce.

U.S. Army Corps of Engineers (USACE). 2015. *Environmental Assessment for the Town of Kitty Hawk Shore Protection Project*. Draft January 2015. Report SAW-2014-02204-EA prepared by Coastal Planning & Engineering of North Carolina, Inc.: Wilmington, NC. Available at: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjY45nu4cPqAhXZoHIEHS8EBUEQFjAAegQIBRAB&url=https%3A%2F%2Fwww.saw.usace.army.mil%2FPortals%2F59%2Fdocs%2Fregulatory%2Fpublicnotices%2F2015%2FSAW-2014-02204-EA.pdf%3Fver%3D2015-04-08-115006-730&usg=AOvVaw3DJ6Yo4wiWkqGjHzMp-wGG. Accessed June 20, 2022.

U.S. Army Corps of Engineers (USACE). 2020. *South Atlantic Regional Biological Opinion for Dredging and Material Placement Activities in the Southeast United States. (2020 SARBO)*. Accessed: March 17, 2023. Retrieved from: https://media.fisheries.noaa.gov/dam-migration/sarbo_acoustic_revision_6-2020-opinion_final.pdf.

U.S. Coast Guard (USCG). 2020. *Shipping Safety Fairways Along the Atlantic Coast*. Washington, D.C.: USCG. Docket No. USCG-2019-0279. 7 pp.

U.S. Coast Guard (USCG). 2021. *Port Access Route Study: Approaches to the Chesapeake Bay, Virginia*. Washington, DC.: USCG. Docket No. USCG-2019-0862. 2 pp.

U.S. Fish and Wildlife Service (USFWS). 2001. *Nesting loggerhead sea turtle activity report 2000 and 1980–2000 nesting summary*. Prepared for U.S. Army Corps of Engineers, Department of the Army, Norfolk, Virginia by S. Williams and J. Gallegos, Back Bay National Wildlife Refuge.

U.S. Fish and Wildlife Service (USFWS). 2005. Refuge Update. *Newsletter of the National Wildlife Refuge System* 2(6):1-24.

U.S. Fish and Wildlife Service (USFWS). 2022a. Environmental Conservation Online System. Green sea turtle (*Chelonia mydas*). https://ecos.fws.gov/ecp/species/6199#:~:text=General%20Information,on%20the%20shell%20and%20limbs.. Accessed June 20, 2022.

U.S. Fish and Wildlife Service (USFWS). 2022b. Environmental Conservation Online System. Leatherback sea turtle (*Dermochelys coriacea*). https://ecos.fws.gov/ecp/species/1493. Accessed June 20, 2022.

U.S. Fish and Wildlife Service (USFWS). 2022c. Environmental Conservation Online System. Loggerhead Sea Turtle (*Caretta caretta*). https://ecos.fws.gov/ecp/species/1110. Accessed June 20, 2022.

U.S. Fish and Wildlife Service (USFWS). 2022d. Environmental Conservation Online System. Kemp's ridley sea turtle (*Lepidochelys kempii*). https://ecos.fws.gov/ecp/species/5523#:~:text=The%20Kemp%27s%20ridley%20turtle%20is,five%20pairs%20of%20costal%20scutes.. Accessed June 20, 2022.

Vabø, R., K. Olsen, and I. Huse. 2002. The effect of vessel avoidance of wintering Norwegian spring spawning herring. *Fisheries Research* 58(1):59-77.

Valverde, R.A. and K.R. Holzwart. 2017. Sea turtles of the Gulf of Mexico. In: *Habitats and biota of the Gulf of Mexico: before the Deepwater Horizon oil spill*. Springer, New York, NY. pp. 1189-1351.

van Berkel, J., H. Burchard, A. Christensen, L.O. Mortensen, O.S. Petersen, and F. Thomsen. 2020. The effects of offshore wind farms on hydrodynamics and implications for fishes. *Oceanography* 33(4): 108-117.

Vandeperre, F., H. Parra, C.K. Pham, M. Machete, M. Santos, K.A. Bjorndal, and A.B. Bolten. 2019. Relative abundance of oceanic juvenile loggerhead sea turtles in relation to nest production at source rookeries: implications for recruitment dynamics. *Scientific reports* 9(1):1-12.

Vanderlaan, A.S.M., and C.T. Taggart. 2007. Vessel collisions with whales: The Probability of Lethal Injury Based on Vessel Speed. *Marine Mammal Science* 23(1):144–156.

Van Parijs, S.M., K. Baker, J. Carduner, J. Daly, G.E. Davis, C. Esch, S. Guan, A. Scholik-Schlomer, N.B. Sisson, and E. Staaterman. 2021. NOAA and BOEM Minimum Recommendations for Use of Passive Acoustic Listening Systems in Offshore Wind Energy Development Monitoring and Mitigation Programs. *Frontiers in Marine Science* 8:760840.

Varela, M.R., A.R. Patrício, K. Anderson, A.C. Broderick, L. DeBell, L.A. Hawkes, D. Tilley, R.T. Snape, M.J. Westoby, and B.J. Godley. 2019. Assessing climate change associated sea-level rise impacts on sea turtle nesting beaches using drones, photogrammetry and a novel GPS system. *Global Change Biology* 25(2):753-762.

Vasconcelos, R.O., M.C.P. Amorim, and F. Ladich. 2007. Effects of ship noise on the detectability of communication signals in the Lusitanian toadfish. *Journal of Experimental Biology* 210: 2104-2112.

Vaudo, J., B.M. Wetherbee, G. Harvey, and M. Shivji. 2022. Region-specific movements of oceanic whitetip sharks in the western North Atlantic Ocean revealed by long-term satellite tracking. In: 2022 *Graduate Science Research Symposium*, February 24-25, 2022. Oral Presentation.

Viada, S.T., R.M. Hammer, R. Racca, D. Hannay, M.J. Thompson, B.J. Balcom, and N.W. Phillips. 2008. Review of potential impacts to sea turtles from underwater explosive removal of offshore structures. *Environmental Impact Assessment Review* 28(4):267-285.

Virginia Department of Wildlife Resources (VA DWR). 2022. Special Status Faunal Species in Virginia. Available at: https://dwr.virginia.gov/wp-content/uploads/media/virginia-threatened-endangered-species.pdf. Accessed June 20, 2022.

Virginia Institute of Marine Science (VIMS). 2022a. Virginia's Sea Turtles. Available at: https://www.vims.edu/research/units/legacy/sea_turtle/va_sea_turtles/index.php. Accessed June 20, 2022.

Virginia Institute of Marine Science (VIMS). 2022b. Seagrass. Available at: https://www.vims.edu/research/units/labgroups/ceel/research/seagrass_ceel/index.php. Accessed December 28, 2022.

Virginia Institute of Marine Science (VIMS). 2022c. Atlantic Sturgeon: Atlantic Sturgeon Spawning Habitat on the James River, Virginia. Available at: https://www.vims.edu/ccrm/research/ecology/fauna/sturgeon/index.php. Accessed June 20, 2022.

Vires, G. 2011. Echosounder effects on beaked whales in the Tongue of the Ocean, Bahamas. Masters project proposal for the Master of Environmental Management degree, Duke University. 37 pp. ViresG_MP_2011.pdf (duke.edu) Accessed January 24, 2023.

Visser, F., K.L. Hartman, G.J. Pierce, V.D. Valavanis, and J. Huisman. 2011. Timing of migratory baleen whales at the Azores in relation to the North Atlantic spring bloom. *Marine Ecology Progress Series* 440:267–279.

Voellmy, I.K., J. Purser, D. Flynn, P. Kennedy, S.D. Simpson, and A.N. Radford. 2014a. Acoustic noise reduces foraging success in two sympatric fish species via different mechanisms. *Animal Behaviour* 89:191-198.

Voellmy, I.K., J. Purser, S.D. Simpson, and A.N. Radford. 2014b. Increased Noise Levels Have Different Impacts on the Anti-Predator Behaviour of Two Sympatric Fish Species. *PLoS ONE* 9(7):e102946.

Wahlberg, M., and H. Westerberg. 2005. Hearing in fish and their reactions to sounds from offshore wind farms. *Marine Ecology Progress Series* 288:295-309.

Wardle, C.S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, A.M. Ziolkowski, G. Hampson, and D. Mackie. 2001. Effects of seismic airguns on marine fish. *Continental Shelf Research* 21: 1005–1027.

Waring, G.T., C.P. Fairfield, C.M. Ruhsam, and M. Sano. 1993. Sperm whales associated with Gulf Stream features off the north-eastern USA shelf. *Fisheries Oceanography* 2(2):101-105.

Waring, G. T., R. M. Pace, J. M. Quintal, C. P. Fairfield, K. Maze-Foley, eds. 2004. *US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2003*. National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA. NOAA Technical Memorandum NMFS-NE-182. 287 pp.

Waring, G.T., E. Josephson, K. Maze-Foley, P.E. Rosel, and (Eds.). 2011. U.*S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2011*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, MA. NOAA Technical Memorandum NMFS-NE-221. 332 pp.

Waring, G.T., S.A. Wood, and E. Josephson. 2012. *Literature search and data synthesis for marine mammals and sea turtles in the U.S. Atlantic from Maine to the Florida Keys*. New Orleans, LA: U.S. Department of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region. OCS Study BOEM 2012-109. 456 pp.

Watkins, W.A., P. Tyack, K.E. Moore, and J.E. Bird. 1987. The 20-Hz signals of finback whales (*Balaenoptera physalus*). *The Journal of the Acoustical Society of America* 82(6):1901-1912.

Watkins, W.A., M.A. Daher, K.M. Fristrup, T.J. Howald, and G. Notarbartolo Di Sciara. 1993. Sperm whales tagged with transponders and tracked underwater by sonar. *Marine Mammal Science* 9(1):55–67.

Webster, K., and R. Porter. 2020. Legal Limits on Recreational Fishing Near Offshore Wind Facilities. Sea Grant Law Fellow Publications. 98 pp.

Weir, C.R. 2007. Observations of marine sea turtles in relation to seismic airgun sound off Angola. *Marine Turtle Newsletter* 116:17–20.

Wenzel, F.W., F. Broms, P. López-Suárez, K. Lopes, N. Veiga, K. Yeoman, M.S.D. Rodrigues, J. Allen, T.W. Fernald, P.T. Stevick, L. Jones, B. Jann, L. Bouveret, C. Ryan, S. Berrow, and P. Corkeron. 2020. Humpback Whales (*Megaptera novaeangliae*) in the Cape Verde Islands: Migratory Patterns, Resightings, and Abundance. *Aquatic Mammals* 46(1):21-31.

Whitehead, H., 2003. *Sperm Whales: Social Evolution in The Ocean*. University of Chicago Press.

Wilber, D.H., and D.G. Clarke. 2001. Biological effects of suspended sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. *North American Journal of Fisheries Management* 21:855–875.

Wilber, D.H., L. Brown, M. Griffin, G.R. DeCelles, D.A. Carey, and M. Pol. 2022. Demersal fish and invertebrate catches relative to construction and operation of North America’s first offshore wind farm. *ICES Journal of Marine Science* 79(4):1274-1288.

Wiley, D.N., C.A. Mayo, E.M. Maloney, and M.J. Moore. 2016. Vessel strike mitigation lessons from direct observations involving two collisions between noncommercial vessels and North Atlantic right whales (*Eubalaena glacialis*). *Marine Mammal Science* 32(4):1501-1509.

Wilkens, J.L., A. W. Katzenmeyer, N.M. Hahn, and J.J. Hoover. 2015. Laboratory Test of Suspended Sediment Effects on Short-Term Survival and Swimming Performance of Juvenile Atlantic Sturgeon (*Acipenser Oxyrinchus Oxyrinchus*, Mitchill, 1815). *Journal of Applied Ichthyology* 31: 984-990.

Williams, S.H., S.M. Gende, P.M. Lukacs, and K. Webb. 2016. Factors affecting whale detection from large ships in Alaska with implications for whale avoidance. *Endangered Species Research* 30:209-223.

Williams, T.M., T.L. Kendall, B.P. Richter, C.R. Ribeiro-French, J.S. John, K.L. Odell, B.A. Losch, D.A. Feuerback, and M.A. Stamper. 2017. Swimming and diving energetics in dolphins: a stroke-by-stroke analysis for predicting the cost of flight responses in wild odontocetes. *Journal of Experimental Biology* 15(220):1135-1145.

Williams, T.M., S.B. Blackwell, O. Tervo, E. Garde, M.H.S. Sinding, B. Richter, and M.P. Heide-Jørgensen. 2022. Physiological responses of narwhals to anthropogenic noise: A case study with seismic airguns and vessel traffic in the Arctic. *Functional Ecology* 36(9):2251-2266.

Wilson, M., R.T. Hanlon, P.L. Tyack, and P.T. Madsen. 2007. Intense ultrasonic clicks from echolocating toothed whales do not elicit anti–predator responses or debilitate the squid *Loligo pealeii*. *Biology Letters* 3(3):225-227.

Winkler, C., S. Panigada, S. Murphy, and F. Ritter. 2020. *Global Numbers of Ship Strikes: An Assessment of Collisions between Vessels and Cetaceans Using Available Data in the IWC Ship Strike Database*. IWC/68B/SC. Available at: file:///C:/Users/khar/Downloads/RS17562_SC_68B_HIM_09_rev1.pdf. Accessed January 30, 2023.

Wisniewska, D.M., M. Johnson, J. Teilmann, U. Siebert, A. Galatius, R. Dietz, and P.T. Madsen. 2018. High rates of vessel noise disrupt foraging in wild harbour porpoises (Phocoena phocoena). *Proceedings of the Royal Society B: Biological Sciences* 285(1872):20172314.

Wood, J., B.L. Southall, and D.J. Tollit. 2012. *PG&E offshore 3-D Seismic Survey Project EIR – Marine Mammal Technical Draft Report*. SMRU Ltd. SMRUL-NA0611ERM. 124 pp.

Woods Hole Oceanographic Institution. 2022. Effects of noise on marine life: Study finds that turtles are among animals vulnerable to hearing loss. ScienceDaily. March 2. Available at: www.sciencedaily.com/releases/2022/03/220302190004.htm. Accessed December 28, 2022.

Wright, M. 2015. First Kemp's ridley sea turtle nests at Dam Neck Annex. *Currents* pp. 66–70.

Würsig, B., T.A. Jefferson, and D.J. Schmidly. 2000. *The Marine Mammals of the Gulf of Mexico*. Texas A&M College Station: University Press. 232 pp.

Wysocki, L.E., and F. Ladich. 2005. Hearing in fishes under noise conditions. *Journal of the Association for Research in Otolaryngology* 6(1):28-36.

Yost, W.A. 2000. *Fundamentals of Hearing: An Introduction*. New York: Academic Press.

Young, C.N., and J.K. Carlson. 2020. The biology and conservation status of the oceanic whitetip shark (*Carcharhinus longimanus*) and future directions for recovery. *Reviews in Fish Biology and Fisheries* 30(2):293-312.

ZoBell, V.M., K.E. Frasier, J.A. Morten, S.P. Hastings, L.E. Peavey Reeves, S.M. Wiggins, and J.A. Hildebrand. 2021. Underwater noise mitigation in the Santa Barbara Channel through incentive-based vessel speed reduction. *Scientific Reports* 11(1):18391.

Zoidis, A.M., K.S. Lomac-MacNair, D.S. Ireland, M.E. Rickard, K.A. McKown, and M.D. Schlesinger. 2021. Distribution and density of six large whale species in the New York Bight from monthly aerial surveys 2017 to 2020. *Continental Shelf Research* 230:104572.

Zollett, E.A., 2009. Bycatch of protected species and other species of concern in US east coast commercial fisheries. *Endangered Species Research* 9(1):49-59.