# Appendix J.    Overview of Acoustic Modeling Report

## J.1.    Introduction and Short Project Description

This appendix is focused on providing an overview of the methods, assumptions, and results of the technical acoustic modeling report prepared for the Project (COP Appendix Z; Dominion Energy 2022) and the accompanying exposure assessment included in the Letter of Authorization (LOA) application submitted to the National Marine Fisheries Service (NMFS) for incidental take authorization under the Marine Mammal Protection Act (MMPA) (Tetra Tech 2022a, 2022b). The Project would consist of up to 205 wind turbine generators (WTGs), up to three offshore substations (OSS), inter-array and export cables, and onshore components (interconnection cables, switching station[s] and substation). The Project would be on the OCS offshore Virginia in BOEM Lease Area OCS-A 0483. Primary noise-generating activities which have the potential to expose marine mammals to noise above recommended permanent threshold shift (PTS) and behavioral thresholds (NMFS 2018) include impact and vibratory pile driving during WTG and OSS foundation installation; impact pile driving during installation of goal post piles to support trenchless installation of the export cable offshore at the cable landing location; vibratory pile driving during cofferdam installation; and high-resolution geophysical (HRG) survey activities.

For the installation of the WTG and OSS foundations and installation of the cofferdam, underwater sound propagation modeling was completed using dBSea, a software developed by Marshall Day Acoustics for the prediction of underwater noise in a variety of environments. The three-dimensional model was built by importing bathymetry data and placing noise sources in the environment. Noise levels were calculated throughout the entire Offshore Project area and displayed in three dimensions (COP Appendix Z; Dominion Energy 2022). Noise associated with installation of the goal post piles and HRG surveys was modeled using guidance from NMFS which involved updates to their User Spreadsheet tool (NMFS 2018) to incorporate new adjustment factors in the spreadsheets which account for the accumulation of noise using the source characteristics (duty cycle and speed) following work by Silve et al. (2014) for PTS (i.e., Level A) thresholds; and a simple spreading loss calculation to estimate the distance to the behavioral (i.e., Level B) threshold (Tetra Tech 2022a).

Noise associated with vessel activity related to cable laying and WTG operation is also qualitatively discussed in COP Appendix Z (Dominion Energy 2022). However, these activities are not expected to result in harassment which could jeopardize the continued existence of any marine mammal populations due to the characteristics of these sound sources. Cable laying would be accomplished using a jet trencher or plow towed by a vessel equipped with dynamic positioning (DP) thrusters to maintain the vessel position. DP thruster sound source levels may vary, in part due to technologies employed and are not necessarily dependent on either vessel size, propulsion power, or the activity engaged. However, DP thruster noise is non-impulsive and continuous in nature reducing the risk of effect on marine mammal species. 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 WTGs produces underwater noise on the order of 110 to 125 dB re 1 µPa SPL at a reference distance of 50 m, occasionally reaching as high as 128 dB re 1 µPa SPL, in the 10-Hz to 8-kHz 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-Megawatt), 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 marine mammals could be more intense and extensive than those considered herein; however, due to the relatively low source levels of operational WTGs, injury-level impacts are not

considered likely. For these reasons, a detailed acoustic modeling analysis was not conducted for these sound sources and they will not be discussed further.

## J.2.    Acoustic Models and Assumptions

As mentioned above, the acoustic assessment for pile driving activities associated with installation of the WTG and OSS foundations and installation of the cofferdams relied on dBSea software developed by Marshall Day Acoustics for the prediction of underwater noise. Noise levels were calculated throughout the entire Offshore Project area and displayed in three dimensions. Levels were calculated in third octave bands. For the Project, two different solvers were used for the low and high-frequency ranges:

- dBSeaPE (Parabolic Equation Method): The dBSeaPE solver makes use of the parabolic equation method, a versatile and robust method of marching the sound field out in range from the sound source. This method is one of the most widely used in the underwater acoustics community and offers excellent performance in terms of speed and accuracy in a range of challenging scenarios.
- dBSeaRay (Ray Tracing Method): The dBSeaRay solver forms a solution by tracing rays from the source to the receiver. Many rays leave the source covering a range of angles, and the sound level at each point in the receiving field is calculated by coherently summing the components from each ray. This is currently the only computationally efficient method at high frequencies.

The underwater acoustic modeling analysis used a split solver, with dBSeaPE evaluating the 12.5 Hz to 200 Hz and dBSeaRay addressing 250 Hz to 20,000 Hz. Additional assumptions and information pertaining to pile driving sound source development and sound propagation modeling can be found in the acoustic modeling report (COP Appendix Z; Dominion Energy 2022).

For the installation of the goal post piles and HRG survey activities, distances to the PTS thresholds were calculated using the NMFS User Spreadsheet tool with adjustments to account for accumulation using the Safe Distance Methodology outlined by Silve et al. (2014) and source characteristics such as duty cycle and speed (e.g., pile strike rate for goal post installation, pulse rate for HRG survey equipment). Distances to the behavioral disturbance thresholds were calculated using the following formula:

$SPL(r) = SL - PL(r)$

Where SPL is the root-mean-square sound pressure level (in units of dB re 1 µPa) at a given range, r (in meters). SL is the estimated source level 1 meter from the source, and PL is the propagation loss calculated as:

$PL(r) = 20log_{10}(r) + a(f) \times r/1,000$

Where a is an attenuation factor at a given frequency, f (Tetra Tech 2022a).

### J.2.1    Physical Environment

The bathymetry information used in the modeling was obtained from the National Geophysical Data Center (NGDC) and the U.S. Coastal Relief Model (COP Appendix Z, citing NOAA and Information Service 2020; Dominion Energy 2022). The bathymetric data were sampled by creating a fan of radials at a given angular spacing. This grid was then used to determine depth points along each modeling radial transect. The underwater acoustic modeling was conducted over these radial planes in set increments depending on the acoustic wavelength and the sampled depth. These radial transects were used for modeling acoustic impacts during both the construction and operation of the Project, with each radial centered on the given Project sound source or activity (COP Appendix Z; Dominion Energy 2022) The water column properties change seasonally. Because the construction timeframe for WTGs and OSSs is

expected from May to October, the June sound speed profile was selected as is exhibited maximum case characteristics for long-range noise propagation effects (Dominion Energy 2022).

The sediment layers used in the modeling and the main geoacoustic properties are defined in Table J-1 and J-2 for the WTG and OSS installation scenarios and the cofferdam installation scenarios, respectively. The term "compressional" refers to the fact that particle motion of the sound wave is in the same direction as propagation. The term "compressional sound speed" refers to the speed of sound in the sediment along the direction of acoustic propagation. The term "compressional attenuation" refers to how much sound (in dB) is lost per wavelength ($\lambda$) of the signal. Finally, density is the physical density ($\rho$) of the sediment. Ranges are provided for the different geoacoustic properties because the values vary depending on the location specifically being modeled for a given scenario (COP Appendix Z; Dominion Energy 2022).

**Table J-1**      **Geoacoustic Properties of Sub-bottom Sediments as a Function of Depth for the WTG and OSS Modeling Scenarios**

| Seabed Layer (meters) | Material | Geoacoustic Properties |
|---|---|---|
| 0 to 12 | Sand | $C_p$ = 1650 m/s<br>$\alpha_s$ (dB/$\lambda$) = 0.8 dB/$\lambda$<br>$\rho$ = 1900 kg/m$^3$ |
| 12 to 15 | Clay | $C_p$ = 1500 m/s<br>$\alpha_s$ (dB/$\lambda$) = 0.2 dB/$\lambda$<br>$\rho$ = 1500 kg/m$^3$ |
| 15 to 22 | Dense Silty and | $C_p$ = 1650 m/s<br>$\alpha_s$ (dB/$\lambda$) = 1.1 dB/$\lambda$<br>$\rho$ = 1800 kg/m$^3$ |
| 22 to 31 | Stiff Sandy Clay | $C_p$ = 1560 m/s<br>$\alpha_s$ (dB/$\lambda$) = 0.2 dB/$\lambda$<br>$\rho$ = 1600 kg/m$^3$ |
| 31 to 37 | Clay | $C_p$ = 1500 m/s<br>$\alpha_s$ (dB/$\lambda$) = 0.2 dB/$\lambda$<br>$\rho$ = 1500 kg/m$^3$ |
| 37 to 42 | Silty Sand | $C_p$ = 1650 m/s<br>$\alpha_s$ (dB/$\lambda$) = 1.1 dB/$\lambda$<br>$\rho$ = 1800 kg/m$^3$ |
| 42 to 53 | Clay, Fine Sand | $C_p$ = 1598 m/s<br>$\alpha_s$ (dB/$\lambda$) = 0.5 dB/$\lambda$<br>$\rho$ = 1575 kg/m$^3$ |
| 53 to 87 | Sandy Silt | $C_p$ = 1605 m/s<br>$\alpha_s$ (dB/$\lambda$) = 1.0 dB/$\lambda$<br>$\rho$ = 1700 kg/m$^3$ |
| >87 | Dense Sand | $C_p$ = 1800 m/s<br>$\alpha_s$ (dB/$\lambda$) = 0.9 dB/$\lambda$<br>$\rho$ = 2000 kg/m$^3$ |

Source: COP Appendix Z, Table Z-5; Dominion Energy 2022.

**Table J-2    Geoacoustic Properties of Sub-bottom Sediments as a Function of Depth for the Cofferdam Installation Modeling Scenario**

| Seabed Layer (meters) | Material | Geoacoustic Properties |
|---|---|---|
| 0 to 2 | Silty Sand | Cp = 1650 m/s<br>αs (dB/λ) = 1.1 dB/λ<br>$\rho$ = 1800 kg/m$^3$ |
| 2 to 6 | Medium Dense Sand | Cp = 1725 m/s<br>αs (dB/λ) = 0.8 dB/λ<br>$\rho$ = 1950 kg/m$^3$ |
| 6 to 9 | Lean Clay | Cp = 1485 m/s<br>αs (dB/λ) = 0.1 dB/λ<br>$\rho$ = 1300 kg/m$^3$ |
| 9 to 15 | Silty Sand | Cp = 1650 m/s<br>αs (dB/λ) = 1.1 dB/λ<br>$\rho$ = 1800 kg/m$^3$ |
| 15 to 26 | Sandy Lean Clay | Cp = 1560 m/s<br>αs (dB/λ) = 0.2 dB/λ<br>$\rho$ = 1600 kg/m$^3$ |
| 26 to 32 | Medium Dense Sand | Cp = 1725 m/s<br>αs (dB/λ) = 0.8 dB/λ<br>$\rho$ = 1950 kg/m$^3$ |

Source: COP Appendix Z, Table Z-6; Dominion Energy 2022.

## J.2.2    Vibratory Driving Source Details

The WTG monopile and OSS jacket foundations were both modeled using a vertical array of eight point sources for the deep location and five point sources for the shallow location, distributing the sound emissions from pile driving throughout the water column. The vertical array was assigned third-octave band sound characteristics adjusted for site-specific parameters discussed above, including expected hammer energy and number of blows. Third octave band center frequencies from 12.5 Hz up to 20 kHz were used in the modeling. In addition, a constant 15 dB/decade roll-off was applied to the modeled spectra after the second spectral peak. A roll-off is a filter, which can be imposed on a signal at either the low- or high-frequency range in order to more closely match expected sound propagation characteristics of that signal indicated by modeling or measurement results. Applying the 15 dB/decade roll-off is a conservative measure, which was based on guidance from NOAA Fisheries regarding the representation of pile-driving sound source characteristics in the high-frequency range (COP Appendix Z; Dominion Energy 2022).

If required, the temporary offshore cofferdams will be constructed by installing steel sheet piles in a tight configuration around an area of approximately 20 by 50 feet (6.1 by 15 meters). For estimating source levels and frequency spectra, the vibratory pile driver was estimated assuming an 1,800 kN vibratory force. Modeling was accomplished using adjusted one-third-octave band vibratory pile-driving source levels from measurements of a similar offshore construction activity and adjusted to account for the estimated force necessary for driving Project cofferdam sheet piles. The assumed sound source level for vibratory pile driving corresponded to and SEL of 195 dB re 1 μPa$^2$m$^2$ s (COP Appendix Z; Dominion Energy 2022).

## J.3.   Noise Attenuation

A range of potential sound reduction was applied to the modeled sound fields associated with impact pile driving. Attenuation factors of 6 dB and 10 dB were applied to all impact pile-driving scenarios to evaluate potential mitigated underwater noise impacts (COP Appendix Z; Dominion Energy 2022).

The main energy associated with vibratory pile driving is radiated at lower frequencies compared to impact piling, and sound waves below a lower cut-off frequency do not propagate in shallow waters. As a result, high peak levels can be avoided and continuous sound levels can be kept low. Noise emissions from vibratory pile driving are on the order of 10 to 20 dB below mitigated impact pile driving at identical monopiles (COP Appendix Z, citing Koschinski and Lüdemann 2020; Dominion Energy 2022). To date, there is very limited information available regarding the use, effectiveness, and noise emissions produced using vibratory pile driving for installation of larger pile diameters consistent with those proposed for the Project; therefore, further investigation is required. Correspondingly, the lower frequencies radiated by vibratory pile driving may restrict the ability of a bubble curtain to allow for a further 6 to 10 dB reduction in noise level. For the purposes of the Project underwater acoustic assessment, a 6 and 10 dB reduction was still applied for consistency. From a feasibility standpoint, it is unlikely that another noise mitigation measure (e.g., isolation casing, cofferdam) along with a bubble curtain would be implemented in the field. As indicated previously, use of vibratory pile driving is considered a somewhat mitigative activity, and unmitigated vibratory pile driving modeling results shown in COP Appendix Z, Section Z.6.2 suggest that vibratory pile driving, when compared to impact pile driving results, will likely not dictate noise mitigation measures used for the Project (COP Appendix Z; Dominion Energy 2022).

## J.4.   Methodology

Underwater acoustic model simulations were conducted for primary noise-generating activities occurring during Project construction and operation. The following subsections summarize the modeling calculations approach, modeled scenarios, and model input values contained in COP Appendix Z (Dominion Energy 2021).

### J.4.1   Acoustic Modeling Scenarios

A summary of construction and operational scenarios included in the underwater acoustic modeling analysis is provided in Table J-3. Model scenarios included locations where potential underwater noise impacts of marine species were anticipated including impact and vibratory pile driving associated with WTG and OSS foundation installation; impact pile driving of the goal post piles; vibratory pile driving during cofferdam installation associated with nearshore trenchless installation activities; and HRG survey activity (COP Appendix Z; Dominion Energy 2022; Tetra Tech 2022a). The modeling scenarios for the WTG foundation installation occur at representative foundation locations; one at a shallow water depth of 69 feet (21 meters) (Universal Transverse Mercator [UTM] Coordinates: 459846 m, 4075324 m) within the Lease Area and another at a deep-water depth of 121 feet (37 meters) (UTM Coordinates: 48066 m, 4089018 m) within the Lease Area. These two locations were selected so that the effects of sound propagation at the range of water column depths occurring within the Lease Area could be observed. Sound fields for the OSS foundations were modeled at the location where the greatest sound propagation was expected out of the three proposed OSS locations. Installation of the goal post piles was modeled at one representative location, and the central cofferdam location was used as the representative location for this activity in the model (COP Appendix Z; Dominion Energy 2022). The source level for the vibratory hammer was developed using an empirical model similar to the model used for the impact hammer. Further details pertaining to the underwater sound propagation modeling analysis, pile driving sound

source development, vibratory hammer sound source development, and a model verification completed for the CVOW Pilot Project is provided in COP Appendix Z (COP Appendix Z; Dominion Energy 2022).

The model accommodates for differences in hammer energy, number of strikes, installation duration, sound source level, and pile progression as appropriate for the jacket pin piles and/or monopiles. This analysis also assumes a conservative duration for the use of the vibratory hammer. The pile diameters selected for the impact pile-driving modeling scenarios were based on maximum Project Design Envelope considerations provided by Dominion Energy. Scenarios 1 through 8 occur at representative WTG locations while Scenario 9 occurs at the cofferdam locations at the Nearshore Trenchless Installation Area. Several of the scenarios (1, 2, 3, 4, and 5) include monopile foundation impact pile driving using the maximum rated hammer energy of 4,000 kilojoules (kJ); however, that hammer energy assumption is considered conservative. The actual transferred energy to the pile during installation will be less than the maximum rated hammer energy, with losses in energy from sources such as heat and friction. Scenarios 6, 7, and 8 represent activities associated with pin pile installation and Scenarios 4, 5, 7, and 8 represent activities that involve a combination of impact and vibratory pile driving to achieve installation (COP Appendix Z; Dominion Energy 2021). Propagation modeling was conducted using the maximum projected blow energy as applicable for the various scenarios; however, a soft start and pile progression were also incorporated into the model for each pile (see COP Appendix Z, Table Z-6; Dominion Energy 2021).

**Table J-3          Underwater Acoustic Modeling Scenarios**

| Scenario | Activity Description | Maximum Hammer Energy (kilojoules) | Duration of Single Pile Installation (minutes) | Total Hammer Blows | Location (UTM Coordinates) | Sound Source Level[1] |
|---|---|---|---|---|---|---|
| 1: Standard Driving Installation | Monopile Foundation (includes 1 pile per day) Diameter: 9.5 m | Impact Pile Driving: 4,000[2] | 85 | 3,240 | Deep: 480,666 m, 4,089,018 m Shallow: 459,846 m, 4,075,324 m | Lpk: 249 dB re 1 µPa m SEL$_{1s}$: 226 dB re 1 µPa$^2$m$^2$ s SPL: 236 dB re 1 µPa m |
| | | Vibratory Pile Driving | 60 | N/A | | SEL$_{1s}$: 202 dB re 1 µPa$^2$m$^2$ s |
| 2: Hard-to-Drive Installation | Monopile Foundation (includes 1 pile per day) Diameter: 9.5 m | Impact Pile Driving: 4,000[2] | 99 | 3,720 | Deep: 480,666 m, 4,089,018 m Shallow: 459,846 m, 4,075,324 m | Lpk: 249 dB re 1 µPa m SEL$_{1s}$: 226 dB re 1 µPa$^2$m$^2$ s SPL: 236 dB re 1 µPa m |
| | | Vibratory Pile Driving | 30 | N/A | | SEL$_{1s}$: 202 dB re 1 µPa$^2$m$^2$ s |
| 3: One Standard and One Hard-to-Drive Installation | Monopile Foundation (includes 2 piles per day) Diameter: 9.5 m | Impact Pile Driving: 4,000[2] | 184 | 6,960 | Deep: 480,666 m, 4,089,018 m 471,303 m, 4,085,595 m Shallow: 459,846 m, 4,075,324 m 467,653 m, 4,080,459 m | Lpk: 249 dB re 1 µPa m SEL$_{1s}$: 226 dB re 1 µPa$^2$m$^2$ s SPL: 236 dB re 1 µPa m |

| Scenario | Activity Description | Maximum Hammer Energy (kilojoules) | Duration of Single Pile Installation (minutes) | Total Hammer Blows | Location (UTM Coordinates) | Sound Source Level[1] |
|---|---|---|---|---|---|---|
| | | Vibratory Pile Driving | 90 | N/A | | $SEL_{1s}$: 202 dB re 1 $\mu Pa^2 m^2$ s |
| 4: OSS Foundation | Pile Jacket Foundation (includes 2 piles per day) Diameter: 2.8 m | Impact Pile Driving: 3,000 | 410 | 15,120 | Deep: 480,666 m, 4,089,018 m Shallow: 459,846 m, 4,075,324 m | Lpk: 240 dB re 1 $\mu Pa$ m $SEL_{1s}$: 214 dB re 1 $\mu Pa^2 m^2$ s SPL: 224 dB re 1 $\mu Pa$ m |
| | | Vibratory Pile Driving | 120 | N/A | | $SEL_{1s}$: 194 dB re 1 $\mu Pa^2 m^2$ s |
| 5: Cofferdam Installation | Cofferdam, Vibratory Pile Driving | Vibratory Pile Driving | 60 | NA | 414,213 m, 4,074,917 m | $SEL_{1s}$: 195 dB re 1 $\mu Pa^2 m^2$ s |
| 6: Goal Post Pile Installation | Goal Post Piles (includes 2 piles per day) Diameter: 1.07 m | Impact Pile Driving | 130 | 260 | 414,396 m 4,074,917 m | Lpk: 210 dB re 1 $\mu Pa$ m $SEL_{1s}$: 183 dB re 1 $\mu Pa^2 m^2$ s |

Source: COP Appendix Z, Table Z-7; Dominion Energy 2022

m = meter; kJ = kilojoule $SEL_{1s}$ = sound exposure level over 1 second; Lpk= peak sound pressure; SPL = root-mean-square sound pressure level

[1] Source levels are based on the SERO Pile Driving Noise Data Spreadsheet - Humboldt Bay Bridges (CALTRANS 2015). N/A s included in the table for vibratory pile driving because this activity is not quantified in terms of hammer blows.

[2] 4,000 kJ corresponds to the maximum rated hammer energy; however, actual hammer energy transferred to the pile during installation will be less.

## J.4.2　　Threshold Range Calculations

To determine the ranges to the defined threshold isopleths, a maximum received level-over-depth approach was used. This approach uses the maximum received level that occurs within the water column at each sampling point. Both the $R_{max}$ and the $R_{95\%}$ ranges were calculated for each of the regulatory thresholds. The $R_{max}$ is the maximum range in the model at which the sound level was calculated. The $R_{95\%}$ is the maximum range at which a sound level was calculated excluding 5 percent of the $R_{max}$. The $R_{95\%}$ excludes major outliers or protruding areas associated with the underwater acoustic modeling environment. Regardless of shape of the calculated isopleths, the predicted range encompasses at least 95 percent of the area that would be exposed to sound at or above the specified level. All distances to injury thresholds presented in this Underwater Acoustic Assessment Report are presented in terms of the $R_{95\%}$ range (COP Appendix Z; Dominion Energy 2022).

## J.5.　Animal Movement Model Methodology

To estimate the number of animals expected to receive sound levels above established thresholds, Marine Acoustics, Inc. (MAI) conducted exposure modeling which combines animal movement modeling with the sound fields produced by each pile type and scenario using their Acoustic Integration Model© (AIM) (Tetra Tech 2022a). Different simulations were run in AIM 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 to the animat simulation densities for each species modeled (Tetra Tech 2022a).

## J.6.    Marine Species Present in the Project Area

### J.6.1        Marine Mammal Presence and Seasonality for the Project Duration

Several sources of data, reports, and studies were reviewed by Dominion Energy to identify which marine mammals are expected to be present in the study area and their seasonal occurrence including: the most recent stock assessment reports from NMFS (Hayes et al. 2022); and Protected Species Observer (PSO) sighting data (and some Passive Acoustic Monitoring [PAM] data), which were also collected during Project-related vessel-based survey activities conducted in 2018–2019 which are provided in the PSO report sightings report (Milne 2018 as cited in COP Section 4.2; Dominion Energy 2022). The most recent 2020-2021 PSO sighting data made available since the Milne (2018) report was published are summarized below in Table J-4. Marine mammals known to occur in the marine waters of coastal and offshore Virginia are listed in Table J-5.

**Table J-4       PSO Sighting Data Summary**

| PSO Sightings in 2020–2021 by Month | | | | | | | | | | | | | | | | | |
| Species | 2020 | | | | | | | | | 2021[1] | | | | | | | | |
| | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic spotted dolphin | 5 | 34 | 77 | 260 | 112 | 44 | 53 | | | | | | 20 | 36 | 68 | | | |
| Common bottlenose dolphin | 10 | 59 | 102 | 107 | 303 | 377 | 150 | 124 | 27 | 3 | 20 | 6 | 11 | 126 | 46 | 362 | 130 | |
| Common dolphin | | | 27 | 46 | 16 | | | | 224 | 840 | 366 | 620 | 945 | | | | | |
| False killer whale | | | | | | 4 | | | | | | | | | | | | |
| Fin whale | | | | 1 | | | | | | | 13 | | | | | | | |
| Humpback whale | | 1 | | | | | 7 | 1 | 23 | 10 | 25 | | | | | | | |
| Minke whale | | | | | | | | 1 | | | | | 1 | | | | | |
| North Atlantic right whale | | | | | | | | | 3 | | 3 | 1 | | | | | | |
| Pantropical spotted dolphin | | | 72 | | 7 | | | | | | | | | 10 | 10 | | | |
| Pilot whale spp. | | | | | 5 | | | | | | | | | | | 3 | | |
| Pygmy sperm whale | | | | | | | 1 | | | | | | | | | | | |
| Sperm whale | | | | 1 | | | | | | | | | | | | | | |
| Spinner dolphin | | | 1 | | | | | | | | | | | | | | | |

Source: COP, Section 4.2, Table 4.2-19; Dominion Energy 2022.

[1] Data for 2021 are preliminary and will undergo additional review before reports are finalized.

**Table J-5    Marine Mammals Known to Occur in the Marine Waters of Coastal and Offshore Virginia**

| Common Name | Scientific Name | Stock | Estimated Abundance | Known Offshore Project Area Distribution | Occurrence/Seasonality[1] | Federal Status | Virginia Status |
|---|---|---|---|---|---|---|---|
| **High-Frequency Cetaceans** | | | | | | | |
| Harbor Porpoise | *Phocoena* | Gulf of Maine/Bay of Fundy | 95,543 | Shallow, inshore and nearshore, estuarine and coastal waters | Common/Winter/Spring | MMPA—non- strategic | — |
| **Mid-Frequency Cetaceans** | | | | | | | |
| Atlantic Spotted Dolphin | *Stenella frontalis* | Western North Atlantic | 39,921 | Continental shelf and slope | Common/Year-round | MMPA—non- strategic | — |
| Atlantic White-Sided Dolphin | *Lagenorhynchus acutus* | Western North Atlantic | 93,233 | Continental shelf and slope | Uncommon/Fall/ Winter/Spring | MMPA—non- strategic | — |
| Common Bottlenose Dolphin | *Tursiops truncatus* | Western North Atlantic | 62,851 | Deeper, offshore waters | Common/Year-round | MMPA—non- strategic | — |
| | | Southern Migratory Coastal | 3,751 | Shallow, inshore, and nearshore, estuarine and coastal waters | Common/Year-round | MMPA—strategic | — |
| Clymene Dolphin | *Stenella clymene* | Western North Atlantic | unknown | Deeper, offshore waters | Extralimital/Summer | MMPA—non- strategic | — |
| Dwarf Sperm Whale | *Kogia sima* | Western North Atlantic | 7,750 | Continental shelf and deeper, offshore waters | Uncommon/Variable | MMPA—non- strategic | — |
| False Killer Whale | *Pseudorca crassidens* | Western North Atlantic | 1,791 | Continental shelf and deeper, offshore waters | Uncommon/Variable | MMPA—non- strategic | — |
| Fraser's Dolphin | *Lagenorhynchus hosei* | Western North Atlantic | unknown | Deeper, offshore waters | Uncommon/Variable | MMPA—non- strategic | — |
| Killer Whale | *Orcinus orca* | Western North Atlantic | unknown | Continental shelf and deeper, offshore waters | Uncommon/Year-round | MMPA—non- strategic | — |
| Long-finned Pilot Whale | *Globicephala melas* | Western North Atlantic | 39,493 | Continental shelf | Common/Year-round | MMPA—non- strategic | — |

| Common Name | Scientific Name | Stock | Estimated Abundance | Known Offshore Project Area Distribution | Occurrence/Seasonality[1] | Federal Status | Virginia Status |
|---|---|---|---|---|---|---|---|
| Short-finned pilot whale | *Globicephala macrorhynchus* | Western North Atlantic | 28,924 | Continental shelf | Uncommon/Year-round | MMPA—non- strategic | — |
| Pan-tropical Spotted Dolphin | *Stenella attenuata* | Western North Atlantic | 6,593 | Deeper, offshore waters | Uncommon /Summer | MMPA—non- strategic | — |
| Melon-headed whale | *Peponocephala electra* | Western North Atlantic | unknown | Continental shelf and deeper, offshore waters | Uncommon/Variable | MMPA—non- strategic | — |
| Pygmy Killer Whale | *Feresa attenuata* | Western North Atlantic | unknown | Deeper, offshore waters | Uncommon/Variable | MMPA—non- strategic | — |
| Pygmy Sperm Whale | *Kogia breviceps* | Western North Atlantic | 7,750 | Continental shelf and deeper, offshore waters | Uncommon/Year-round | MMPA—non- strategic | — |
| Risso's Dolphin | *Grampus griseus* | Western North Atlantic | 35,493 | Continental shelf | Common/Year-round | MMPA—non- strategic | — |
| Rough Toothed Dolphin | *Steno bredanensis* | Western North Atlantic | 136 | Continental shelf and deeper, offshore waters | Uncommon/Year-round | MMPA—non- strategic | — |
| Common Dolphin | *Delphinus delphis* | Western North Atlantic | 172,974 | Continental shelf and slope | Common/Year-round | MMPA—non- strategic | — |
| Sperm Whale | *Physeter macrocephalus* | North Atlantic | 4,349 | Deeper, offshore waters and slope | Uncommon/Year-round | MMPA—strategic; Endangered ESA | Endangered |
| Spinner Dolphin | *Stenellalongirostris orientalis* | Western North Atlantic | 4,102 | Deeper, offshore waters and slope | Uncommon/Year-round | MMPA—non- strategic | — |
| Striped Dolphin | *Stenella coeruleoalba* | Western North Atlantic | 67,036 | Deeper, offshore waters and slope | Uncommon/Year-round | MMPA—non- strategic | — |
| White Beaked Dolphin | *Lagenorhynchus albirostris* | Western North Atlantic | 536,016 | Continental shelf | Uncommon/Variable | MMPA—non- strategic | — |
| Blainville's Beaked Whale | *Mesoplodon densirostris* | Western North Atlantic | 10,107 | Deeper, offshore waters | Uncommon/Spring/Summer | MMPA—non- strategic | — |

| Common Name | Scientific Name | Stock | Estimated Abundance | Known Offshore Project Area Distribution | Occurrence/Seasonality[1] | Federal Status | Virginia Status |
|---|---|---|---|---|---|---|---|
| Cuvier's Beaked Whale | *Ziphius cavirostris* | Western North Atlantic | 5,744 | Deeper, offshore waters | Uncommon/Variable | MMPA—non- strategic | — |
| Gervais' Beaked Whale | *Mesoplodon europaeus* | Western North Atlantic | 10,107 | Deeper, offshore waters | Uncommon/Spring/Summer | MMPA—non- strategic | — |
| Sowerby's Beaked Whale | *Mesoplodon bidens* | Western North Atlantic | 10,107 | Deeper, offshore waters | Uncommon/Variable | MMPA—non- strategic | — |
| True's Beaked Whale | *Mesoplodon mirus* | Western North Atlantic | 10,107 | Deeper, offshore waters | Uncommon/Spring/Summer | MMPA—non- strategic | — |
| **Low-Frequency Cetaceans** | | | | | | | |
| Blue Whale | *Balaenoptera musculus* | Western North Atlantic | unknown | Continental shelf and deeper, offshore waters | Uncommon/Year-round | MMPA—strategic; Endangered ESA | Endangered |
| Fin Whale | *Balaenoptera physalus* | Western North Atlantic | 6,802 | Continental shelf and deeper, offshore waters | Common/Year-round | MMPA—strategic; Endangered ESA | Endangered |
| Humpback Whale (West Indies DPS) | *Megaptera novaeangliae* | Gulf of Maine | 1,396 | Continental shelf and coastal waters | Common/Fall/Winter/Spring | MMPA—non- strategic[2] | Endangered |
| Minke Whale | *Balaenoptera acutorostrata* | Canadian East Coast | 21,960 | Continental shelf | Common/Year-round | MMPA—non- strategic | — |
| Sei Whale | *Balaenoptera borealis* | Nova Scotia | 6,292 | Continental Shelf | Uncommon/Winter/Spring/ Summer | MMPA—strategic; Endangered ESA | Endangered |
| North Atlantic Right Whale | *Eubalaena glacialis* | Western Atlantic | 412 | Continental shelf and coastal waters | Common/Year-round | MMPA—strategic; Endangered ESA | Endangered |
| **Sirenians** | | | | | | | |
| West Indian Manatee | *Trichechus manatus* | Florida | unknown | Coastal, bays, estuaries, and inlets | Extralimital/Variable | MMPA—strategic; Threatened ESA | Endangered |
| **Phocid Pinnipeds in Water** | | | | | | | |
| Gray Seal | *Halichoerus grypus* | Western North Atlantic | 27,131 | Coastal, bays, estuaries, and inlets | Uncommon/Fall/Winter/ Spring | MMPA—non- strategic | — |
| Harbor Seal | *Phoca vitulina* | Western North Atlantic | 75,834 | Coastal, bays, estuaries, and inlets | Common/Fall/Winter/Spring | MMPA—non- strategic | — |

| Common Name | Scientific Name | Stock | Estimated Abundance | Known Offshore Project Area Distribution | Occurrence/Seasonality[1] | Federal Status | Virginia Status |
|---|---|---|---|---|---|---|---|
| Harp Seal | *Pagophilus groenlandicus* | Western North Atlantic | unknown | Coastal, bays, estuaries, and inlets | Uncommon/Winter/Spring | MMPA—non- strategic | — |
| Hooded Seal | *Cystophora cristata* | Western North Atlantic | unknown | Coastal, bays, estuaries, and inlets | Extralimital/Summer/Fall | MMPA—non- strategic | — |

Source: COP, Section 4.2, Table 4.2-20; Dominion Energy 2022.
Notes:
Marine Mammal Protection Act (MMPA)
[1] Occurrence defined as:
    Common: occurrences are regularly documented, and the study area is generally considered within the typical range of the species. Uncommon: occurrences are occasionally documented, and the study area is generally considered within the typical range of the species.
    Extralimital: few occurrences have been documented and the study area is generally considered outside the typical range of the species; any occurrences would likely be of incidental individuals.
[2] Note that the humpback whale (*Megaptera novaeangliae*) was previously federally listed as endangered; however, based on the revised listing completed by NOAA Fisheries in 2016, the Distinct Population Segment (DPS) of humpback whales that occurs along the East Coast of the U.S., the West Indies DPS, is no longer considered endangered or threatened. The Commonwealth of Virginia has retained the endangered state listing status for the humpback whale.
Status denoted as (--) indicates no regulatory status for that species under Federal or Virginia authority.

### J.6.2    Marine Mammal Densities

The marine mammal species potentially occurring in the Project modeling areas were determined by Tetra Tech (2022b) based on habitat-based marine mammal density models developed by Roberts et al. (2022). Density estimates are a necessary part of the analysis process to determine acoustic exposure for each potentially occurring marine mammal in an area. Density estimates for each marine mammal species or species group by season were derived from the best available scientific information (Table J-6). As per Dominion Energy's commitment to seasonal restrictions from November through April, no WTG or OSS foundation installation activities are planned for winter, so modeling was conducted for the remaining three seasons, with spring including the months of March through May, summer ranging from the months of June to August, and fall extending from September through November. Construction activities, however, are not planned to occur for the entirety of spring through fall. Monopile and OSS construction is planned for only part of spring (May) and part of fall (September through October) annually. Using the Roberts et al. (2022) density data (which are delineated by grid cell), the densities for all of the grid cells within the modeling area were averaged for each month to provide a monthly average density. The three seasonal densities were calculated as the average of the months within each of the three seasons when construction is expected to occur.

Some marine mammal species were modeled as representative groups rather than individual species. For instance, members of the same genus that inhabit the same type of habitat and have similar dive and swim behaviors, such as the two pilot whale species, were modeled as an inclusive generic group (pilot whales) rather than by their individual species (long- and short-finned pilot whales). The two potentially occurring species of phocid seals, the harbor and gray seals, were also modeled as a representative group (seals). A summer density for the seals is given as 0.00001 animals/km$^2$ which is not the density derived from Roberts et al. (2022). A higher density estimate, 0.0004 animals /km$^2$, was derived for the summer season for this species group from Roberts et al. (2022). However, the Roberts et al. (2022) derived density estimate is unrealistic given that neither seal species is expected to occur in the waters of the Project area during summer (Hayes et al. 2022). For harbor seals, Hayes et al. (2022) estimates the occurrence in mid-Atlantic waters to range only from September through May, not during summer. The summer distribution of both species is well documented in more northern waters. To reconcile the known distribution of these species with the need for a density estimate, the conservative density estimate of 0.00001 animals/km$^2$ was used to represent the summer density of both seal species.

Two bottlenose dolphin stocks are present within the Project area, but density values are only available in the Roberts et al. density data for the species. Hayes et al. (2022) defines the boundary between the Western North Atlantic, Southern Coastal Migratory stock and the Western North Atlantic, offshore stock of bottlenose dolphins as the 20 m isobath north of Cape Hatteras, North Carolina. The 20 m isobath was used with the Roberts et al. (2022) to differentiate the two stocks and derive densities for the bottlenose dolphins in the Project area less than 20 m for the Southern Coastal Migratory stock and more than 20 m for the offshore stock.

The modeled marine mammal animats were set to populate each of the model areas with representative nominal densities. In some cases, the modeled animat density was higher than the real-world density estimate. This "over population" ensures that the result of the animat model simulation is not unduly influenced by the chance placement of a few simulated marine mammals and provides statistical robustness without overestimating risk. To obtain final exposure estimates, the modeled results are normalized by the ratio of the modeled animat density to the real-world (Roberts et al. 2022) marine mammal seasonal density estimates. Density estimates for all species considered common in Table J-5, or have confirmed sightings within the Lease Area based on PSO data in Table J-4 are provided in Table J-6.

**Table J-6     Mean Seasonal Density Estimates (animals/km²) for the Potentially Occurring Marine Mammal Species in the Project Area**

| Marine Mammal Species or Model Group | Spring (May) | Summer (June to August) | Fall (September to October) |
|---|---|---|---|
| Atlantic spotted dolphin | 0.00507 | 0.05873 | 0.03822 |
| Common bottlenose dolphin Western North Atlantic Southern Coastal Migratory Stock[1] | 0.13098 | 0.13509 | 0.13852 |
| Common bottlenose dolphin Western North Atlantic Offshore Stock[1] | 0.07352 | 0.07415 | 0.06439 |
| Common dolphin | 0.05355 | 0.00559 | 0.00103 |
| Minke whale | 0.00519 | 0.00028 | 0.00011 |
| Fin whale[2] | 0.00069 | 0.00036 | 0.00019 |
| Harbor porpoise | 0.00315 | 0.00000 | 0.00000 |
| Humpback whale | 0.00136 | 0.00023 | 0.00040 |
| North Atlantic right whale[2] | 0.00015 | 0.00004 | 0.00005 |
| Pantropical spotted dolphin[3] | 0.00008 | 0.00008 | 0.00008 |
| Pilot whale *spp.* (long- and short-finned pilot whales)[4] | 0.00098 | 0.00098 | 0.00098 |
| Risso's dolphin | 0.00084 | 0.00042 | 0.00021 |
| Seals[5] | 0.01828 | 0.00001 | 0.00047 |
| Sei whale[2] | 0.00021 | 0.00001 | 0.00004 |
| Sperm whale[2] | 0.00003 | 0.00000 | 0.00000 |

Source: Table 24, Tetra Tech 2022b.

[1] Common bottlenose dolphin density values from Duke University (Roberts et al. 2016b, 2017, 2018, 2020) are reported as "bottlenose" and not identified to stock. Given the foundation installation sound would be confined to beyond the 20 m isobath, where the offshore stock is anticipated to predominate, estimated Level B take for cofferdam installation was accrued to the offshore stock.

[2] Indicates species listed under the Endangered Species Act.

[3] Pantropical spotted dolphins are included due to challenges with PSO identification of Atlantic spotted versus pantropical
spotted dolphins.

[4] Pilot whale density values from Duke University (Roberts et al. 2016a, 2016b, 2017, 2018, 2020) are reported as "Kogia *spp.*" and are not species-specific.

[5] Seal density values from Duke University (Roberts et al. 2016a, 2016b, 2017, 2018, 2020) are reported as "seals" and not
species-specific; therefore, 50% were attributed to harbor seals and 50% to gray seals.

## J.6.3     Sea Turtle Presence and Seasonality for the Project Duration

Five species of sea turtles have historically been reported to occur in mid-Atlantic waters off the coast of Virginia, all of which are listed as threatened or endangered under the Endangered Species Act (ESA). These species include the federally endangered Atlantic hawksbill (*Eretmochelys imbricata*), federally threatened green (*Chelonia mydas*), federally Endangered Kemp's ridley (*Lepidochelys kempii*), federally endangered leatherback (*Dermochelys coriacea*), and federally threatened loggerhead (*Caretta caretta*) (COP Section 4.2; Dominion Energy 2021). Table J-7 provides a summary of key information for these species and their known distribution within the study area.

**Table J-7    Sea Turtles Known to Occur in the Marine Waters of Coastal and Offshore Virginia**

| Common Name | Scientific Name | Estimated Abundance | Known Offshore Project Area Distribution | Occurrence[1] Seasonality | Federal Status | State of Virginia Status |
|---|---|---|---|---|---|---|
| Leatherback Sea Turtle | *Dermochelys coriacea* | 34,000–94,000 | Offshore, continental shelf and deeper | Uncommon/Year-round | Endangered | Endangered |
| Atlantic Hawksbill Sea Turtle | *Eretmochelys imbricata* | 19,000[2] | N/A | Extralimital/Year-round | Endangered | Endangered |
| Green Sea Turtle (North Atlantic Distinct Population Segment) | *Chelonia mydas* | 215,000[2] | Coastal, bays, estuaries, and inlets | Uncommon/Year-round | Threatened | Threatened |
| Kemp's Ridley Sea Turtle | *Lepidochelys kempii* | 248,300 | Coastal, bays, estuaries, and inlets | Common/Year-round | Endangered | Endangered |
| Loggerhead Sea Turtle (Northwest Atlantic Distinct Population Segment) | *Caretta* | 588,000 | Throughout: offshore, continental shelf and deeper; coastal, bays, estuaries, and inlets | Common/Year-round | Threatened | Threatened |

Source: COP, Section 4.2, Table 4.2-28.
Notes:
[1] Occurrence defined as:
Common: Occurrences are regularly documented, and the study area is generally considered within the typical range of the species. Uncommon: Occurrences are occasionally documented, and the study area is generally considered within the typical range of the species.
Extralimital: Few occurrences have been documented, and the study area is generally considered outside the typical range of the species; any occurrences would likely be of incidental individuals.
[2] Abundance estimates based on current nesting female and sex ratio estimates.

### J.6.4     Sea Turtle Densities

Two sources of sea turtle densities represent the best available at-sea density data for sea turtles in the Project area: U.S. Department of the Navy (DON 2007) and Barco et al. (2018) (Tetra Tech 2022). The DON (2007) density estimates were prepared for the Navy's U.S. Atlantic operating areas, which include the CVOW-C Project area. More recent loggerhead turtle density estimates for the Project area are available in Barco et al. (2018); however, these densities are much higher than the older DON (2007) estimates for the loggerhead turtle. 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 turtle have been included.

Though green sea turtles may occur seasonally in the Project area, no at-sea density estimates are available for this species. Rather, the only available data for green sea turtles are those grouped into the "hardshelled guild" in the DON (2007) dataset, so the seasonal estimates from this guild were used as surrogate densities for green sea turtles (Tetra Tech 2022). Densities for all sea turtle species likely to occur in the Project area are provided in Table J-8.

**Table J-8      Mean Seasonal Density Estimates (animals km$^{-2}$) for Sea Turtles Potentially Occurring in the Project Area**

| Common Name | Scientific Name | Spring (May) | Summer (June – August) | Fall (September and October) |
|---|---|---|---|---|
| Leatherback Sea Turtle | *Dermochelys coriacea* | 0.00509 | 0.00427 | 0.00509 |
| Green Sea Turtle [1] | *Chelonia mydas* | 0.04561 | 0.07241 | 0.04867 |
| Kemp's Ridley Sea Turtle | *Lepidochelys kempii* | 0.04687 | 0.04687 | 0.04687 |
| Loggerhead Sea Turtle (DON 2007) | *Caretta caretta* | 0.13534 | 0.13062 | 0.13475 |
| Loggerhead Sea Turtle (Barco et al. 2018) | *Caretta caretta* | 2.514 | 1.385 | 1.289 |

Source: Appendix D, Table 8; Tetra Tech 2022.
Notes:
[1] Population data were insufficient to determine an individual species density estimate for green sea turtles from the DON (2007) dataset; therefore the hardshelled guild densities were used as a surrogate for green sea turtles in the Project area.

### J.6.5     Seasonal Restrictions

Portions of the study area fall within the Mid-Atlantic U.S. North Atlantic Right Whale Seasonal Management Area (SMA). Restrictions associated with these dynamic management areas are in effect between November 1 and April 30 annually. Vessels transiting these areas must comply with NMFS regulations and speed restrictions as applicable for North Atlantic right whales.

## J.7.   Acoustic Impact Criteria

NMFS (2018) defined acoustic threshold criteria at which PTS and temporary threshold shift (TTS) are predicted to occur for each hearing group for impulsive and non-impulsive signals (Table J-9     ), which are presented in terms of dual metrics; SEL$_{24h}$ and Lpk. The Level B (behavioral) harassment thresholds are also provided in Table J-9.

**Table J-9          Acoustic Threshold Criteria for Marine Mammals**

| Hearing Group | Sound Source Type | | | | | |
|---|---|---|---|---|---|---|
| | **Impulsive** | | | **Non-Impulsive** | | |
| | **PTS-Onset** | **TTS-Onset** | **Behavior** | **PTS-Onset** | **TTS-Onset** | **Behavior** |
| Low-frequency cetaceans | Lpk: 219 dB re 1 µPa  SEL$_{24h}$: 183 dB re 1 µPa$^2$ s | Lpk: 213 dB re 1 µPa  SEL$_{24h}$: 168 dB re 1 µPa$^2$ s | SPL:160 dB re 1 µPa | SEL$_{24h}$: 199 dB re 1 µPa$^2$ s | SEL$_{24h}$: 179 dB re 1 µPa$^2$ s | SPL: 120 dB re 1 µPa (continuous)  SPL: 160 dB re 1 µPa (intermittent) |
| Mid-frequency cetaceans | Lpk: 230 dB re 1 µPa  SEL$_{24h}$:185 dB re 1 µPa$^2$ s | Lpk: 224 dB re 1 µPa  SEL$_{24h}$: 170 dB re 1 µPa$^2$ s | | SEL$_{24h}$: 198 dB re 1 µPa$^2$ s | SEL$_{24h}$: 178 dB re 1 µPa$^2$ s | |
| High-frequency cetaceans | Lpk: 202 dB re 1 µPa  SEL$_{24h}$:155 dB re 1 µPa$^2$ s | Lpk: 196 dB re 1 µPa  SEL$_{24h}$: 140 dB re 1 µPa$^2$ s | | SEL$_{24h}$: 173 dB re 1 µPa$^2$ s | SEL$_{24h}$: 153 dB re 1 µPa$^2$ s | |
| Phocid pinnipeds underwater | Lpk: 218 dB re 1 µPa  SEL$_{24h}$:185 dB re 1 µPa$^2$ s | Lpk: 212 dB re 1 µPa  SEL$_{24h}$: 170 dB re 1 µPa$^2$ s | | SEL$_{24h}$: 201 dB re 1 µPa$^2$ s | SEL$_{24h}$: 181 dB re 1 µPa$^2$ s | |

Sources: NMFS 2018.
µPa = micropascal; dB = decibel; PTS = permanent threshold shift; re = referenced to; SEL$_{24h}$ = sound exposure level over 24 hours; Lpk = peak sound pressure level; SPL = root-mean-square sound pressure level; TTS = temporary threshold shift.

NOAA Fisheries anticipates behavioral response for sea turtles from impulsive sources such as impact pile driving to occur at SPL 175 dB re 1 µPa, which has elicited avoidance behavior of sea turtles (Blackstock et al. 2018). There is limited information available on the effects of noise on sea turtles, and the hearing capabilities of sea turtles are still poorly understood. In addition, the U.S. Navy introduced a weighting filter appropriate for sea turtle impact evaluation in their 2017 document titled "Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)" (Finneran et al. 2017). That weighting has been applied to both impulsive and non-impulsive criteria for PTS and TTS (Table J-10).

Fish noise injury thresholds have been established by the Fisheries Hydroacoustic Working Group, which was assembled by NOAA Fisheries with thresholds subsequently adopted by NOAA Fisheries. The NOAA Fisheries Greater Atlantic Regional Fisheries Office (GARFO) has applied these standards for assessing the potential effects of ESA-listed fish species and sea turtles exposed to elevated levels of underwater sound produced during pile driving, which were just recently updated (GARFO 2019) (COP Appendix Z; Dominion Energy 2022). These noise thresholds are based on sound levels that have the potential to produce injury or illicit a behavioral response from fishes (Table J-10).

A Working Group organized under the American National Standards Institute-Accredited Standards Committee S3, Subcommittee 1, Animal Bioacoustics, also developed sound exposure guidelines for fish and sea turtles (Table J-11        ; Popper et al. 2014) (COP Appendix Z; Dominion Energy 2022). They identified three types of fishes depending on how they might be affected by underwater sound. The categories include fishes with no swim bladder or other gas chamber (e.g., flounders, dab, and other flatfishes); fishes with swim bladders in which hearing does not involve the swim bladder or other gas volume (e.g., salmonids); and fishes with a swim bladder that is involved in hearing (e.g., channel catfish) (COP Appendix Z; Dominion Energy 2022).

**Table J-10      Acoustic Threshold Criteria for Fishes and Sea Turtles**

| Hearing Group | Impulsive Signals | | Non-Impulsive Signals | | Behavior (Impulsive and Non-Impulsive) |
| --- | --- | --- | --- | --- | --- |
| | PTS-Onset/Injury[1] | TTS-Onset | PTS-Onset/Injury[1] | TTS-Onset | |
| Fishes | Lpk: 206 dB re 1 µPa SEL$_{24h}$: 187 dB re 1 µPa$^2$ s | -- | -- | -- | SPL: 150 dB re 1 µPa |
| Sea turtles | Lpk: 232 dB re 1 µPa SEL$_{24h}$: 204 dB re 1 µPa$^2$ s | Lpk: 226 dB re 1 µPa SEL$_{24h}$: 189 dB re 1 µPa$^2$ s | SEL$_{24h}$: 200 dB re 1 µPa$^2$ s | SEL$_{24h}$: 220 dB re 1 µPa$^2$ s | SPL: 175 dB re 1 µPa |

Sources: Stadler and Woodbury (2009); GARFO 2019; Blackstock et al. 2018; Finneran et al. 2017.
-- = not applicable for fishes; µPa = micropascal; dB = decibel; PTS = permanent threshold shift; re = referenced to; SEL$_{24h}$ = sound exposure level over 24 hours; Lpk = peak sound pressure level; SPL = root-mean-square sound pressure level; TTS = temporary threshold shift.
[1] PTS-onset thresholds are applicable for sea turtles based on work from Finneran et al. (2017), where GARFO (2019) only provides thresholds for acoustic injury in fish.

**Table J-11      Acoustic Threshold Levels for Fishes**

| Hearing Group | Impulsive Sounds | | | Non-Impulsive Sounds | | |
| --- | --- | --- | --- | --- | --- | --- |
| | Mortality and Potential Mortal Injury | Recoverable Injury | TTS | TTS | Recoverable Injury | TTS |
| Fishes without swim bladders | Lpk: >213 dB re 1 µPa SEL$_{24h}$: >219 dB re 1 µPa$^2$ s | Lpk: >213 dB re 1 µPa SEL$_{24h}$: >216 dB re 1 µPa$^2$ s | SEL$_{24h}$: >186 dB re 1 µPa$^2$ s | -- | -- | |
| Fishes with swim bladder not involved in hearing | Lpk: 207 dB re 1 µPa SEL$_{24h}$: 210 dB re 1 µPa$^2$ s | Lpk: 207 dB re 1 µPa SEL$_{24h}$: 203 dB re 1 µPa$^2$ s | SEL$_{24h}$: >186 dB re 1 µPa$^2$ s | -- | -- | |
| Fishes with swim bladder involved in hearing | Lpk: 207 dB re 1 µPa SEL$_{24h}$: 207 dB re 1 µPa$^2$ s | Lpk: 207 dB re 1 µPa SEL$_{24h}$: 203 dB re 1 µPa$^2$ s | SEL$_{24h}$: 186 dB re 1 µPa$^2$ s | SPL: 170 dB re 1 µPa | SPL: 158 dB re 1 µPa | |
| Eggs and larvae | Lpk: 207 dB re 1 µPa SEL$_{24h}$: 210 dB re 1 µPa$^2$ s | (N) Moderate (I) Low (F) Low | (N) Moderate (I) Low (F) Low | -- | -- | |

Sources: Popper et al. 2014.
µPa = micropascal; dB = decibel; SEL$_{24h}$ = sound exposure level over 24 hours; Lpk = peak sound pressure level; SPL = root-mean-square sound pressure level; TTS = temporary threshold shift., N = near (10s of meters), I = intermediate (100s of meters), and F = far (1000s of meters); -- = not applicable.

## J.8.   Results

### J.8.1      WTG and OSS Foundation Installation

The complete dBSea acoustic modeling results to assess distances to the various acoustic threshold levels identified above in Sections J.4.2 and J.7 are provided in COP Appendix Z (Dominion Energy 2022). The modeling scenarios analyzed are described in Table J-3 and include monopile impact pile-driving activities for pile diameters of 31.2 feet (9.5 meters) using hammer energy of 4,000 kilojoules, and pin pile impact pile driving for 9.2-foot (2.8-meter) pile diameter. Modeling scenarios also include a combination of vibratory and impact pile-driving activities to achieve installation as described for Scenarios 1, 2, 3, and 4 (Table J-3). All those activities may occur at the two representative WTG

locations within the Lease Area, where one location is in the deepest region (121 feet [37 meters]) of the Lease Area while the other location is in the shallowest region (69 feet [21 meters]) of the Lease Area; and the one representative for the OSS where the greatest sound propagation ranges will occur.

The results for impact and vibratory pile driving for the representative WTG location at the deepest water depth and the representative OSS foundation location are shown in Table J-12, Table J-13, and Table J-14 for marine mammals, sea turtles, and fish, respectively. Results are presented without mitigation and with two different levels of mitigation: a 6-dB reduction and a 10-dB reduction. Noise mitigation requirements and methods have not been finalized at this stage of Project design; therefore, these two levels of reduction were applied to potentially mimic the use of noise mitigation options such as bubble curtains (COP Appendix Z; Dominion Energy 2022). The results in Table J-12 indicate that the unmitigated distances to the Lpk thresholds for marine mammals are generally below 1,640 feet (500 meters) except for results for the high-frequency cetaceans group. Thresholds to the $SEL_{24h}$ PTS onset thresholds were larger for all marine mammal hearing groups (Table J-12). Similar results were seen for sea turtles (Table J-13) and fish (Table J-14), with ranges to applicable thresholds varying depending on the threshold value, installation method, and pile type. Expectedly, the largest ranges to thresholds are the ones for the marine mammal and fish behavioral response thresholds, which are and SPL of 160 and 120 dB re 1 µPa for marine mammals in response to impulsive and non-impulsive, continuous sound sources, respectively; and an SPL of 150 dB re 1 µPa for fish in response to all sound source types (Section J-7). Refer to COP Appendix Z, Figures Z-8 through Figure Z-31 for sound maps of unweighted and unmitigated underwater received sound pressure levels for deep and shallow modeling scenarios (Dominion Energy 2022).

**Table J-12      Marine Mammal Permanent Threshold Shift Onset and Behavioral Criteria Threshold Distances (meters) During Impact and Vibratory Pile Driving for Installation of the Wind Turbine Generator and Offshore Substation Foundation Scenarios**

| Scenario | Noise Attenuation (dB) | Distance to PTS Threshold (Lpk) | | | | Distance to PTS Threshold (SEL$_{24hr}$) | | | | Distance to Behavioral Threshold (SPL) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | LFC | MFC | HFC | PPW | LFC | MFC | HFC | PPW | All Hearing Groups |
| Standard WTG Driving Installation – Impact Pile Driving | 0 | 344 | 116 | 1,621 | 371 | 11,325 | 598 | 5,686 | 3,405 | 15,010 |
| | 6 | 182 | 67 | 927 | 213 | 6,020 | 320 | 2,946 | 1,852 | 8,700 |
| | 10 | 132 | 29 | 663 | 141 | 4,396 | 170 | 2,139 | 1,267 | 6,182 |
| Standard WTG Driving Installation – Vibratory Pile Driving | 0 | -- | -- | -- | -- | 414 | 0 | 367 | 104 | 21,404 |
| | 6 | -- | -- | -- | -- | 199 | 0 | 193 | 52 | 12,267 |
| | 10 | -- | -- | -- | -- | 141 | 0 | 85 | 0 | 10,114 |
| Hard-to-Drive WTG Installation – Impact Pile Driving | 0 | 344 | 116 | 1,621 | 371 | 12,423 | 664 | 6,273 | 3,809 | 15,010 |
| | 6 | 182 | 67 | 927 | 213 | 6,738 | 354 | 3,230 | 1,987 | 8,700 |
| | 10 | 132 | 29 | 663 | 141 | 4,980 | 187 | 2,304 | 1,358 | 6,182 |
| Hard-to-Drive WTG Installation – Vibratory Pile Driving | 0 | -- | -- | -- | -- | 356 | 0 | 507 | 133 | 21,404 |
| | 6 | -- | -- | -- | -- | 150 | 0 | 258 | 72 | 12,267 |
| | 10 | -- | -- | -- | -- | 113 | 0 | 120 | 31 | 10,114 |
| One Standard and One Hard-to-Drive WTG Installation – Impact Pile Driving | 0 | 344 | 116 | 1,621 | 441 | 14,363 | 840 | 7,647 | 4,651 | 15,010 |
| | 6 | 182 | 67 | 927 | 228 | 7,997 | 443 | 3,933 | 2,570 | 8,700 |
| | 10 | 132 | 29 | 663 | 158 | 5,663 | 226 | 2,884 | 1,756 | 6,182 |
| One Standard and One Hard-to-Drive WTG Installation – Vibratory Pile Driving | 0 | -- | -- | -- | -- | 534 | 0 | 507 | 133 | 21,404 |
| | 6 | -- | -- | -- | -- | 256 | 0 | 258 | 72 | 12,267 |
| | 10 | -- | -- | -- | -- | 158 | 0 | 120 | 31 | 10,114 |
| OSS Piled Jacket – Impact Pile Driving | 0 | 35 | 0 | 508 | 55 | 6,807 | 258 | 3,485 | 3,188 | 5,530 |
| | 6 | 0 | 0 | 284 | 0 | 3,697 | 121 | 1,938 | 1,746 | 3,291 |
| | 10 | 0 | 0 | 197 | 0 | 2,680 | 48 | 1,435 | 1,283 | 2,172 |
| OSS Piled Jacket – Vibratory Pile Driving | 0 | -- | -- | -- | -- | 218 | 0 | 190 | 63 | 8,921 |
| | 6 | -- | -- | -- | -- | 130 | 0 | 112 | 35 | 5,272 |
| | 10 | -- | -- | -- | -- | 75 | 0 | 68 | 0 | 3,601 |

Source: COP, Appendix Z; Dominion Energy 2022.

**Table J-13    Sea Turtle Permanent Threshold Shift Onset and Behavioral Criteria Threshold Distances (meters) During Impact and Vibratory Pile Driving for Installation of the Wind Turbine Generator and Offshore Substation Foundation Scenarios**

| Scenario | Noise Attenuation (dB) | Distance to PTS Threshold (Lpk) | Distance to PTS Threshold (SEL$_{24hr}$) | Distance to Behavioral Threshold (SPL) |
|---|---|---|---|---|
| Standard Driving Installation – Impact Pile Driving | 0 | 104 | 2,628 | 5,162 |
| | 6 | 48 | 1,408 | 2,829 |
| | 10 | 10 | 1,044 | 2,146 |
| Standard Driving Installation – Vibratory Pile Driving | 0 | N/A | 65 | 189 |
| | 6 | | 18 | 119 |
| | 10 | | 6 | 82 |
| Hard-to-Drive Installation – Impact Pile Driving | 0 | 104 | 2,918 | 5,162 |
| | 6 | 48 | 1,533 | 2,829 |
| | 10 | 10 | 1,142 | 2,146 |
| Hard-to-Drive Installation – Vibratory Pile Driving | 0 | N/A | 40 | 189 |
| | 6 | | 0 | 119 |
| | 10 | | 0 | 82 |
| One Standard and One Hard-to-Drive Installation – Impact Pile Driving | 0 | 104 | 3,685 | 5,162 |
| | 6 | 48 | 2,053 | 2,829 |
| | 10 | 10 | 1,410 | 2,146 |
| One Standard and One Hard-to-Drive Installation – Vibratory Pile Driving | 0 | N/A | 78 | 189 |
| | 6 | | 24 | 119 |
| | 10 | | 8 | 82 |
| OSS Piled Jacket – Impact Pile Driving | 0 | 0 | 1,695 | 2,041 |
| | 6 | 0 | 914 | 1,134 |
| | 10 | 0 | 653 | 742 |
| OSS Piled Jacket – Vibratory Pile Driving | 0 | N/A | 14 | 85 |
| | 6 | | 0 | 38 |
| | 10 | | 0 | 7 |

Source: COP, Appendix Z; Dominion Energy 2022.

OSS = offshore substation; PTS = permanent threshold shift; SEL$_{24h}$ = sound exposure level over 24 hours (dB re 1 µPa$^2$ s); Lpk = peak sound pressure level (dB re 1 µPa); SPL = root-mean=square sound pressure level (dB re 1 µPa); WTG = wind turbine generator.

**Table J-14    Fish Acoustic Injury and Behavioral Threshold Distances (meters) During Impact and Vibratory Pile Driving for Installation of the Wind Turbine Generator and Offshore Substation Foundation Scenarios**

| Scenario | Noise Attenuation (dB) | Fish with no Swim Bladder | | Fish with Swim Bladder Not Involved in Hearing | | Fish with Swim Bladder Involved in Hearing | | Eggs and Larvae | | Fish <2 g | | Fish ≥2 g | | Behavioral (SPL) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lpk | SEL$_{24hr}$ | Lpk | SEL$_{24hr}$ | Lpk | SEL$_{24hr}$ | Lpk | SEL$_{24hr}$ | Lpk | SEL$_{24hr}$ | Lpk | SEL$_{24hr}$ | All Fish |
| Standard Driving Installation – Impact Pile Driving | 0 | 605 | 810 | 1,007 | 1,729 | 1,007 | 2,348 | 1,007 | 1,729 | 1,105 | 14,940 | 1,105 | 11,907 | 36,030 |
| | 6 | 344 | 489 | 605 | 1,021 | 605 | 1,301 | 605 | 1,021 | 663 | 8,653 | 663 | 6,131 | 20,512 |
| | 10 | 242 | 352 | 402 | 748 | 402 | 955 | 402 | 748 | 445 | 6,131 | 445 | 4,501 | 15,010 |
| Standard Driving Installation – Vibratory Pile Driving | 0 | - | - | - | - | - | - | - | - | - | 3,188 | - | 2,199 | 2,528 |
| | 6 | - | - | - | - | - | - | - | - | - | 1,831 | - | 1,216 | 1,359 |
| | 10 | - | - | - | - | - | - | - | - | - | 1,216 | - | 796 | 903 |
| Hard-to-Drive Installation – Impact Pile Driving | 0 | 605 | 906 | 1,007 | 1,986 | 1,007 | 2,683 | 1,007 | 1,968 | 1,105 | 16,655 | 1,105 | 12,722 | 36,030 |
| | 6 | 344 | 540 | 605 | 1,120 | 605 | 1,466 | 605 | 1,120 | 663 | 9,302 | 663 | 6,824 | 20,512 |
| | 10 | 242 | 389 | 402 | 829 | 402 | 1,041 | 402 | 829 | 445 | 6,824 | 445 | 5,085 | 15,010 |
| Hard-to-Drive Installation – Vibratory Pile Driving | 0 | - | - | - | - | - | - | - | - | - | 2,476 | - | 1,641 | 2,528 |
| | 6 | - | - | - | - | - | - | - | - | - | 1,338 | - | 886 | 1,359 |
| | 10 | - | - | - | - | - | - | - | - | - | 886 | - | 601 | 903 |
| One Standard and One Hard-to-Drive Installation – Impact Pile Driving | 0 | 605 | 1,121 | 1,007 | 2,439 | 1,007 | 3,315 | 1,007 | 2,439 | 1,105 | 20,786 | 1,105 | 14,787 | 36,030 |
| | 6 | 344 | 672 | 605 | 1,386 | 605 | 1,860 | 605 | 1,386 | 663 | 11,508 | 663 | 8,291 | 20,512 |
| | 10 | 242 | 477 | 402 | 1,042 | 402 | 1,266 | 402 | 1,042 | 445 | 8,291 | 445 | 5,880 | 15,010 |
| One Standard and One Hard-to-Drive Installation – Vibratory Pile Driving | 0 | - | - | - | - | - | - | - | - | - | 3,822 | - | 2,666 | 2,528 |
| | 6 | - | - | - | - | - | - | - | - | - | 2,191 | - | 1,442 | 1,359 |
| | 10 | - | 536- | - | - | - | - | - | - | - | 1,442 | - | 961 | 903 |
| OSS Piled Jacket – Impact Pile Driving | 0 | 172 | 536 | 311 | 1,231 | 311 | 1,599 | 311 | 1,231 | 344 | 10,069 | 344 | 7,306 | 13,641 |
| | 6 | 35 | 310 | 172 | 696 | 172 | 907 | 172 | 696 | 197 | 5,959 | 197 | 4,000 | 8,243 |
| | 10 | 0 | 213 | 74 | 488 | 74 | 633 | 74 | 488 | 94 | 4,000 | 94 | 2,959 | 5,530 |
| OSS Piled Jacket – Vibratory Pile Driving | 0 | - | - | - | - | - | - | - | - | - | 1,664 | - | 1,088 | 991 |
| | 6 | - | - | - | - | - | - | - | - | - | 887 | - | 569 | 540 |
| | 10 | - | - | - | - | - | - | - | - | - | 569 | - | 427 | 393 |

Source: COP, Appendix Z; Dominion Energy 2022.

OSS = offshore substation; PTS = permanent threshold shift; SEL$_{24h}$ = sound exposure level over 24 hours (dB re 1 µPa$^2$ s); Lpk = peak sound pressure level (dB re 1 µPa); SPL = root-mean=square sound pressure level (dB re 1 µPa); WTG = wind turbine generator.

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## J.8.2      Goal Post Pile Installation

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 (COP Appendix Z; 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. Similar to the WTG and OSS installation modeling, noise mitigation is also included assuming 0-, 6-, and 10-dB noise attenuation. Results of the modeling of the goal post pile installation are provided in Table J-15, Table J-16, and Table J-17 for marine mammals, sea turtles, and fish, respectively.

**Table J-15      Marine Mammal Permanent Threshold Shift Onset and Behavioral Criteria Threshold Distances (meters) During Impact Pile Driving for Installation of the Goal Posts to Support Trenchless Installation of the Export Cable**

| Scenario | Noise Attenuation (dB) | Distance to PTS Threshold (Lpk) | | | | Distance to PTS Threshold (SEL$_{24hr}$) | | | | Distance to Behavioral Threshold (SPL) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | LFC | MFC | HFC | PPW | LFC | MFC | HFC | PPW | All Hearing Groups |
| Goal Post Pile Installation – Impact Pile Driving | 0 | 2 | 0 | 31 | 3 | 591 | 21 | 704 | 316 | 1,450 |
| | 6 | 0 | 0 | 12 | 1 | 235 | 8 | 280 | 126 | 580 |
| | 10 | 0 | 0 | 7 | 0 | 127 | 4.5 | 152 | 68 | 314 |

Source: COP, Appendix Z Dominion Energy 2022.
HFC = high-frequency cetacean; LFC = low-frequency cetacean; MFC = mid-frequency cetacean; PPW = phocid pinniped in water; PTS = permanent threshold shift; SEL$_{24h}$ = sound exposure level over 24 hours (dB re 1 µPa$^2$ s); Lpk = peak sound pressure level (dB re 1 µPa); SPL = root-mean=square sound pressure level (dB re 1 µPa).

**Table J-16      Sea Turtle Permanent Threshold Shift Onset and Behavioral Criteria Threshold Distances (meters) During Impact Pile Driving for Installation of the Goal Posts to Support Trenchless Installation of the Export Cable**

| Scenario | Noise Attenuation (dB) | Distance to PTS Threshold (Lpk) | Distance to PTS Threshold (SEL$_{24hr}$) | Distance to Behavioral Threshold (SPL) |
|---|---|---|---|---|
| Goal Post Pile Installation – Impact Pile Driving | 0 | 0 | 0 | 0 |
| | 6 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 |

Source: COP, Appendix Z Dominion Energy 2022.
PTS = permanent threshold shift; SEL$_{24h}$ = sound exposure level over 24 hours (dB re 1 µPa$^2$ s); Lpk = peak sound pressure level (dB re 1 µPa); SPL = root-mean=square sound pressure level (dB re 1 µPa).

**Table J-17    Fish Acoustic Injury and Behavioral Criteria Threshold Distances (meters) During Impact Pile Driving for Installation of the Goal Posts to Support Trenchless Installation of the Export Cable**

| Scenario | Noise Attenuation (dB) | Fish with No Swim Bladder | | Fish with Swim Bladder Not Involved in Hearing | | Fish with Swim Bladder Involved in Hearing | | Eggs and Larvae | | Fish <2 g | | Fish ≥2 g | | Behavioral (SPL) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lpk | SEL24hr | Lpk | SEL24hr | Lpk | SEL24hr | Lpk | SEL24hr | Lpk | SEL24hr | Lpk | SEL24hr | All Fish |
| Goal Post Pile Installation – Impact Pile Driving | 0 | - | - | - | - | - | - | - | - | - | - | - | - | 6,750 |
| | 6 | - | - | - | - | - | - | - | - | - | - | - | - | 2,700 |
| | 10 | - | - | - | - | - | - | - | - | - | - | - | - | 1,450 |

Source: COP, Appendix Z Dominion Energy 2022.

PTS = permanent threshold shift; SEL24h = sound exposure level over 24 hours (dB re 1 $\mu Pa^2$ s); Lpk = peak sound pressure level (dB re 1 $\mu Pa$); SPL = root-mean=square sound pressure level (dB re 1 $\mu Pa$).

## J.8.3    Cofferdam Installation

Vibratory pile driving 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 (COP Appendix Z; 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. The modeling assumed up to 60 minutes to install each pile, and included 0-, 6-, and 10-dB noise attenuation (Dominion Energy 2022). Installation activities are anticipated to take approximately 9 to 12 months in 2024, but all installation activities would occur between May and October to avoid peak NARW presence.

Table J-18, Table J-19, and Table J-20 summarize the maximum distances to acoustic thresholds for marine mammals, sea turtles, and fish, respectively.

**Table J-18    Marine Mammal Permanent Threshold Shift Onset and Behavioral Criteria Threshold Distances (meters) During Vibratory Pile Driving for Installation of Cofferdams to Support Trenchless Installation of the Export Cable**

| Scenario | Noise Attenuation (dB) | Distance to PTS Threshold (Lpk) | | | | Distance to PTS Threshold (SEL$_{24hr}$) | | | | Distance to Behavioral Threshold (SPL) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | LFC | MFC | HFC | PPW | LFC | MFC | HFC | PPW | All Hearing Groups |
| Cofferdam Installation – Vibratory Pile Driving | 0 | -- | -- | -- | -- | 108 | 0 | 0 | 0 | 3,097 |
| | 6 | -- | -- | -- | -- | 16 | 0 | 0 | 0 | 2,228 |
| | 10 | -- | -- | -- | -- | 0 | 0 | 0 | 0 | 1,814 |

Source: COP, Appendix Z Dominion Energy 2022.
HFC = high-frequency cetacean; LFC = low-frequency cetacean; MFC = mid-frequency cetacean; PPW = phocid pinniped in water; PTS = permanent threshold shift; SEL$_{24h}$ = sound exposure level over 24 hours (dB re 1 µPa$^2$ s); Lpk = peak sound pressure level (dB re 1 µPa); SPL = root-mean=square sound pressure level (dB re 1 µPa).

**Table J-19    Sea Turtle Permanent Threshold Shift Onset and Behavioral Criteria Threshold Distances (meters) During Vibratory Pile Driving for Installation of Cofferdams to Support Trenchless Installation of the Export Cable**

| Scenario | Noise Attenuation (dB) | Distance to PTS Threshold (Lpk) | Distance to PTS Threshold (SEL$_{24hr}$) | Distance to Behavioral Threshold (SPL) |
|---|---|---|---|---|
| Cofferdam Installation – Vibratory Pile Driving | 0 | N/A | 0 | 0 |
| | 6 | | 0 | 0 |
| | 10 | | 0 | 0 |

Source: COP, Appendix Z Dominion Energy 2022.
PTS = permanent threshold shift; SEL$_{24h}$ = sound exposure level over 24 hours (dB re 1 µPa$^2$ s); Lpk = peak sound pressure level (dB re 1 µPa); SPL = root-mean=square sound pressure level (dB re 1 µPa).

**Table J-20    Fish Acoustic Injury and Behavioral Criteria Threshold Distances (meters) During Vibratory Pile Driving for Installation of Cofferdams to Support Trenchless Installation of the Export Cable**

| Scenario | Noise Attenuation (dB) | Fish with No Swim Bladder | | Fish with Swim Bladder Not Involved in Hearing | | Fish with Swim Bladder Involved in Hearing | | Eggs and Larvae | | Fish <2 g | | Fish ≥2 g | | Behavioral (SPL) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lpk | SEL$_{24hr}$ | Lpk | SEL$_{24hr}$ | Lpk | SEL$_{24hr}$ | Lpk | SEL$_{24hr}$ | Lpk | SEL$_{24hr}$ | Lpk | SEL$_{24hr}$ | All Fish |
| Cofferdam Installation – Vibratory Pile Driving | 0 | - | - | - | - | - | - | - | - | - | 567 | - | 506 | 470 |
| | 6 | - | - | - | - | - | - | - | - | - | 389 | - | 317 | 349 |
| | 10 | - | - | - | - | - | - | - | - | - | 317 | - | 206 | 248 |

Source: COP, Appendix Z Dominion Energy 2022.

PTS = permanent threshold shift; SEL$_{24h}$ = sound exposure level over 24 hours (dB re 1 µPa$^2$ s); Lpk = peak sound pressure level (dB re 1 µPa); SPL = root-mean=square sound pressure level (dB re 1 µPa).

## J.8.4 HRG Surveys

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 2022). 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 J-21 for marine mammals were estimated using NMFS User Spreadsheets for PTS thresholds and interim guidance from NMFS (2019) for behavioral thresholds (Tetra Tech 2022). Only ranges to the SEL$_{24h}$ PTS threshold for marine mammals are shown as these represent the maximum distances. Ranges to the acoustic thresholds for sea turtles and fish in Table J-21 were obtained from the Programmatic Biological Assessment conducted by BOEM (Baker and Howsen 2021).

**Table J-21    Permanent Threshold Shift Onset and Behavioral Criteria Threshold Distances (meters) for Marine Mammals, Sea Turtles, and Fish During High-Resolution Geophysical Surveys**

| Equipment Type | Distance to PTS Threshold (SEL$_{24hr}$) | | | | | | Distance to Behavioral Threshold (SPL) | | |
|---|---|---|---|---|---|---|---|---|---|
| | LFC | MFC | HFC | PPW | Sea Turtles | Fish ≥2 g | All Marine Mammals | Sea Turtles | All Fish |
| CHIRP Sonar | 0 | 0 | 0.4 | 0 | NA | NA | 10.2 | 2 | 708 |
| Sparker | 0.1 | 0 | 1.5 | 0.1 | 0 | 9 | 100 | 90 | 1,996 |
| Boomer | 5.9 | 0.2 | 54.2 | 3.5 | 0 | 3.2 | 21.9 | 40 | 32 |

Source: COP, Appendix Z Dominion Energy 2022; Baker and Howsen 2021.
HFC = high-frequency cetacean; LFC = low-frequency cetacean; MFC = mid-frequency cetacean; NA = not applicable due to sound source being outside the hearing range of the group; PPW = phocid pinniped in water; PTS = permanent threshold shift; SEL$_{24h}$ = sound exposure level over 24 hours (dB re 1 µPa$^2$ s); SPL = root-mean=square sound pressure level (dB re 1 µPa).

## J.8.5 Animal Exposure Estimates

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 Action 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 using the animal movement modeling methodology described in Section J.5. No behavioral or animal movement information is available for fish species, so exposures could not be calculated for that group.

To estimate the number of marine mammals and sea turtles likely to be exposed above the acoustic thresholds discussed in Section J.7, a conservative construction schedule included all possible WTG monopile and OSS jacket foundation installation scenarios, and all possible HRG survey days was assumed (Tetra Tech 2022). The construction schedule used to estimate the number of exposures throughout the entire construction period is provided in Table J-22.

**Table J-22    Proposed Pile Driving and High-Resolution Geophysical Survey Schedule Used to Estimate the Number of Marine Mammals and Sea Turtles Potentially Exposed to Above-Threshold Noise during Project Activities**

| Year | Month | Total Number of Foundations Installed | Number Standard WTG Installations | Number Hard-to-Drive WTG Installations | Number of Days with Two WTG Installed | Number of Active HRG Survey Days |
|---|---|---|---|---|---|---|
| 2024 | May | 18 | 5 | 13 | 1 | 65 |
| | June | 25 | 6 | 19 | 6 | |
| | July | 26 | 7 | 19 | 6 | |
| | August | 2 WTG, 12 OSS | 1 | 1 | 1 | |
| | September | 13 | 3 | 10 | 0 | |
| | October | 11 | 1 | 10 | 0 | |
| **2024 Total** | | 95 WTG, 12 OSS | 23 | 72 | 14 | |
| 2025 | May | 17 | 6 | 11 | 1 | 249 |
| | June | 24 | 8 | 16 | 6 | |
| | July | 26 | 8 | 18 | 6 | |
| | August | 20 | 6 | 14 | 6 | |
| | September | 5 | 2 | 3 | 0 | |
| | October | 3 | 1 | 2 | 0 | |
| **2025 Total** | | 95 | 31 | 64 | 19 | |
| 2026 | May | 3 | 0 | 3 | 0 | 58 |
| | June | 5 | 0 | 4 | 0 | |
| | July | 5 | 0 | 4 | 0 | |
| | August | 4 | 0 | 3 | 0 | |
| | September | 1 | 0 | 1 | 0 | |
| | October | 0 | 0 | 0 | 0 | |
| **2026 Total** | | 15 | 0 | 15 | 0 | |
| **2027 Total** | | NA | NA | NA | NA | 368 |
| **2027 Total** | | NA | NA | NA | NA | 368 |

Source: Tetra Tech 2022.
HRG = high-resolution geophysical; NA = not applicable for this activity as construction is assumed to be completed by 2026, whereas HRG surveys will continue after construction to ensure Project components are not in need of maintenance; OSS = offshore substation; WTG = wind turbine generator.

### J.8.5.1.    Marine Mammals

The total number of marine mammals exposed to above-threshold noise from all noise-producing activities under the Proposed Action is provided in Table J-23.

**Table J-23   Total Number of Marine Mammal Exposed to Sound Levels Above PTS and Behavioral Thresholds from all Project Activities**

| Marine Mammal Species | | PTS | Behavioral |
|---|---|---|---|
| **WTG and OSS Foundation Installation (10 dB attenuation)** | | | |
| LFC | NARW | 3 | 6 |
| | Fin whale | 9 | 45 |
| | Minke whale | 18 | 113 |
| | Humpback whale | 9 | 36 |
| | Sei whale | 3 | 7 |
| MFC | Sperm whale | 0 | 3 |
| | Atlantic spotted dolphin | 0 | 4,473 |
| | Common bottlenose dolphin (southern migratory coastal and western North Atlantic offshore stocks) | 0 | 8,809 |
| | Common dolphin | 0 | 1,293 |
| | Pantropical spotted dolphin | 0 | 9 |
| | Long- and Short-finned pilot whale | 0 | 124 |
| | Risso's dolphin | 0 | 54 |
| HFC | Harbor porpoise | 3 | 49 |
| PPW | Gray seal | 2.5 | 128.5 |
| | Harbor seal | 2.5 | 128.5 |
| **Goal Post Pile Installation** | | | |
| LFC | NARW | 0 | 0 |
| | Fin whale | 0 | 0 |
| | Minke whale | 0 | 2 |
| | Humpback whale | 0 | 0 |
| | Sei whale | 0 | 0 |
| MFC | Sperm whale | 0 | 0 |
| | Atlantic spotted dolphin | 0 | 6 |
| | Common bottlenose dolphin (southern migratory coastal and western North Atlantic offshore stocks) | 0 | 46 |
| | Common dolphin | 0 | 6 |
| | Pantropical spotted dolphin | 0 | 0 |
| | Long- and Short-finned pilot whale | 0 | 0 |
| | Risso's dolphin | 0 | 1 |
| HFC | Harbor porpoise | 0 | 0 |
| PPW | Gray seal | 0 | 1 |
| | Harbor seal | 0 | 1 |

| Marine Mammal Species | | PTS | Behavioral |
|---|---|---|---|
| **Cofferdam Installation** | | | |
| LFC | NARW | 0 | 1 |
| | Fin whale | 0 | 1 |
| | Minke whale | 0 | 2 |
| | Humpback whale | 0 | 1 |
| | Sei whale | 0 | 0 |
| MFC | Sperm whale | 0 | 0 |
| | Atlantic spotted dolphin | 0 | 37 |
| | Common bottlenose dolphin (southern migratory coastal and western North Atlantic offshore stocks) | 0 | 267 |
| | Common dolphin | 0 | 28 |
| | Pantropical spotted dolphin | 0 | 0 |
| | Long- and Short-finned pilot whale | 0 | 1 |
| | Risso's dolphin | 0 | 0 |
| HFC | Harbor porpoise | 0 | 7 |
| PPW | Gray seal | 0 | 14 |
| | Harbor seal | 0 | 14 |
| **HRG Surveys (5-Year Total)** | | | |
| LFC | NARW | 0 | 5 |
| | Fin whale | 0 | 5 |
| | Minke whale | 0 | 13 |
| | Humpback whale | 0 | 8 |
| | Sei whale | 0 | 3 |
| MFC | Sperm whale | 0 | 0 |
| | Atlantic spotted dolphin | 0 | 22,160 |
| | Common bottlenose dolphin (southern migratory coastal and western North Atlantic offshore stocks) | 0 | 1,858 |
| | Common dolphin | 0 | 22,160 |
| | Pantropical spotted dolphin | 0 | 100 |
| | Long- and Short-finned pilot whale | 0 | 125 |
| | Risso's dolphin | 0 | 125 |
| HFC | Harbor porpoise | 0 | 90 |
| PPW | Gray seal | 0 | 87 |
| | Harbor seal | 0 | 87 |

Source: Tetra Tech 2022b.
dB = decibels; HRG = high-resolution geophysical; LFC = low-frequency cetacean; MFC = mid-frequency cetacean; NARW = North Atlantic right whale; OSS = offshore substation; PTS = permanent threshold shift; WTG = wind turbine generator.

### J.8.5.2. Sea Turtles

The total number of marine mammals exposed to above-threshold noise from all noise-producing activities under the Proposed Action is provided in Table J-24.

**Table J-24    Annual Estimated Number of Sea Turtles Exposed to Sound Levels Above PTS and Behavioral Thresholds from Installation of the Wind Turbine Generator and Offshore Substation Foundation Scenarios**

| Species | Construction Year | PTS Exposures | Behavioral Exposures |
|---|---|---|---|
| Green sea turtles | 2024 | 26 | 123 |
| | 2025 | 25 | 118 |
| | 2026 | 4 | 19 |
| **Total** | | **55** | **260** |
| Kemp's ridley sea turtle | 2024 | 20 | 96 |
| | 2025 | 18 | 84 |
| | 2026 | 3 | 14 |
| **Total** | | **41** | **194** |
| Leatherback sea turtle | 2024 | 57 | 270 |
| | 2025 | 2 | 9 |
| | 2026 | 1 | 2 |
| **Total** | | **60** | **281** |
| Loggerhead sea turtle (Barco et al. 2018)[1] | 2024 | 657 | 3,134 |
| | 2025 | 597 | 2,829 |
| | 2026 | 91 | 450 |
| **Total** | | **1,345** | **6,413** |

Source: Tetra Tech 2022.
dB = decibels; PTS = permanent threshold shift.
[1] Exposures for the loggerhead sea turtles comprise the estimates scaled using densities from Barco et al. (2018) rather than the DON (2007) as these represent the maximum potential for exposure to above-threshold noise from the Proposed Action.

## J.9.    References

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