Appendix J. Overview of Acoustic Modeling Report

J.1. Introduction and Short Project Description

This appendix is focused on providing a brief background on underwater sound and a description of the sound sources applicable to this Project based on published literature, as well as an overview of the methods, assumptions, and results of the technical acoustic modeling report prepared for the Project (COP, Appendix Z; Dominion Energy 2023) 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, 2023). The Project would consist of up to 176 wind turbine generators (WTGs) with seven potential spares, 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, 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 2023). Noise associated with installation of the goal post piles, cofferdam installation, 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 all other Project activities such as vessel noise, cable laying and trenching, and WTG operations was not modeled, but it is qualitatively described in Section J.2 for reference.

J.2. Background on Underwater Sound

Ocean sounds originate from a variety of sources. Some come from non-biological sources such as wind and waves, while others come from the movements or vocalizations of marine life (Hildebrand 2009). In addition, humans introduce sound into the marine environment through activities like oil and gas exploration, construction, military sonars, and vessel traffic (Hildebrand 2009). The acoustic environment or “soundscape” of a given ecosystem comprises all such sounds—biological, non-biological, and anthropogenic (Pijanowski et al. 2011). Soundscapes are highly variable across space, time, and water depth, among other factors, due to the properties of sound transmission and the types of sound sources present in each area. A soundscape is sometimes called the “acoustic habitat,” as it is a vital attribute of a given area where an animal may live (i.e., habitat) (Hatch et al. 2016).

J.2.1 Physics of Underwater Sound

Sounds are created by the vibration of an object within its medium (Figure J-1). This movement generates kinetic energy (KE), which travels as a propagating wave away from the sound source. As this wave moves through the medium, the particles undergo tiny back-and-forth movements ("particle motion") along the axis of propagation, but the particles themselves do not travel with the wave. Instead, they oscillate in roughly the same location, transferring their energy to surrounding particles. The vibration is transferred to adjacent particles, which are pushed into areas of high pressure (compression) and low pressure (rarefaction). Acoustic pressure is a non-directional (scalar) quantity, whereas particle motion is an inherently directional quantity (a vector) taking place in the axis of sound transmission. The total energy of the sound wave includes the potential energy (PE) associated with the sound pressure as well as the KE from particle motion.

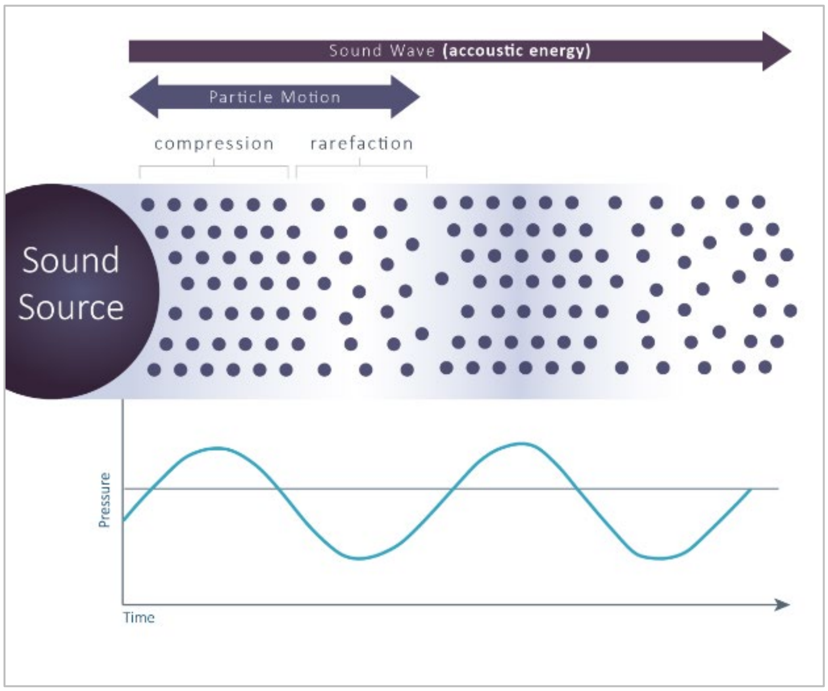

Figure J-1 Basic Mechanics of an Underwater Sound Wave

J.2.2 Particle Motion

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 impacts 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). Conversely, all fishes and invertebrates are capable of sensing the particle motion component of a sound. The inner ear of fishes is similar to that of all vertebrates. Each ear has three otolithic end organs, which contain a sensory epithelium lined with hair cells, as well as a dense structure called an otolith (Popper et al. 2021). As the back-and-forth particle motion moves the body of the fish (which has a density similar to seawater), the denser otoliths lag behind, creating a shearing force on the hair cells, which sends a signal to the brain via the auditory nerve (Fay and Popper 2000). Many invertebrates have structures called statocysts which, similar to fish ears, act like accelerometers: a dense statolith sits within a body of hair cells, and when the animal is moved by particle motion, it results in a shearing force on the hair cells (Budelmann 1992; Mooney et al. 2010). Some invertebrates also have sensory hairs on the exterior of their bodies, allowing them to sense changes in the particle motion field around them (Budelmann 1992), and the lateral line in fishes also plays a role in hearing (McCormick 2011). The research thus far shows that the primary hearing range of most particle-motion sensitive organisms is below 1 kHz (Popper et al. 2021).

In fish with primitive swim bladders that are not involved in hearing, like Atlantic sturgeon, particle motion is thought to play a key role in detection of underwater noise (Hawkins and Chapman 2020). However, measurements of sensitivity to particle motion and pressure were rarely performed simultaneously, leaving a data gap in the understanding of particle motion sensitivity in fish (Popper and Hawkins 2018). Currently, there are no regulatory thresholds for particle motion for any noise-producing activities from which the potential for impact may be assessed. Therefore, information available on particle motion detection in fish and invertebrate species is provided for reference, but the modeling described in Sections J.3 through J.9 below as well as the impact assessment in Section 3.13 of the FEIS focus on the pressure component of underwater noise.

J.2.3 Propagation of Sound Pressure in the Ocean

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. The sound level decreases with increasing distance from the acoustic source as the sound travels through the environment. The amount by which the sound levels decrease between the theoretical source level and a receiver is called propagation loss. Among other things, the amount of propagation loss that occurs depends on the source-receiver separation, the geometry of the environment the sound is propagating through, the frequency of the sound, the properties of the water column, and the properties of the seafloor and sea surface.

When sound waves travel through the ocean, they may encounter areas with different physical properties that will likely alter the propagation pathway of the sound, compared to a homogenous and boundaryless environment. For example, near the ocean's surface, water temperature is usually higher, resulting in relatively fast sound speeds. As temperature decreases with increasing depth, the sound speed decreases. Sounds bend toward areas with lower speeds (Urick 1983). Ocean sound speeds are often slowest at mid-latitude depths of about 1,000 meters, and, because of sound's preference for lower speeds, sound waves above and below this "deep sound channel" often bend toward it. Sounds originating in this layer can travel great distances. Sounds can also be trapped in the mixed layer near the ocean's surface (Urick 1983). Latitude, weather, and local circulation patterns influence the depth of the mixed layer, and the propagation of sounds near the surface is highly variable and difficult to predict.

At the boundaries near the sea surface and the sea floor, acoustic energy can be scattered, reflected, or attenuated depending on the properties at the surface (e.g., roughness, presence of wave activity, or bubbles) or seafloor (e.g., bathymetric features, substrate heterogeneity). For example, fine-grain sediments tend to absorb sounds well, while hard bottom substrates reflect much of the acoustic energy back into the water column. The presence of ice on the ocean's surface can also affect sound propagation. For example, the presence of solid ice may dampen sound levels by blocking surface winds. The presence of ice can also increase sound levels when pieces of ice break and/or scrape together (Urick 1983). The effect will also depend on the thickness and roughness of the ice, among many other factors related to the ambient conditions. As a sound wave moves from a source to a receiver (i.e., an animal), it may travel on multiple pathways that may be direct, reflected, refracted, or a combination of these mechanisms, creating a complex pattern of transmission across range and depth. The patterns may become even more complicated in shallow waters due to repeated interactions with the surface and the bottom, frequency-specific propagation, and more heterogenous seafloor properties. All these variables contribute to the difficulty in reliably predicting the sound field in a given marine environment at any particular time.

J.2.4 Sound Source Classification

In the current regulatory context, anthropogenic sound sources are divided into four types: impulsive, non-impulsive, continuous, and intermittent, based on their differing potential to affect marine species (NMFS 2018). Specifically, when it comes to potential damage to marine mammal hearing, sounds are classified as either impulsive or non-impulsive, and when considering the potential to affect behavior or acoustic masking, sounds are classified as either continuous or intermittent.

Impulsive noises are characterized as having (Finneran 2016):

- Broadband frequency content
- Fast rise-times and rapid decay times
- Short durations (i.e., <1 s)
- High peak sound pressures

Whereas the characteristics of non-impulsive sound sources are less clear but may:

- Be variable in spectral composition, i.e., broadband, narrowband, or tonal
- Have longer rise-time/decay times, and total durations compared to an impulsive sound
- Be continuous (e.g., vessel engine radiated noise), or intermittent (e.g., echosounder pulses)

It is generally accepted that sources like explosions, airguns, sparkers, boomers, and impact pile-driving are impulsive and have a greater likelihood of causing hearing damage than non-impulsive sources. At close distances to impulsive sounds, physiological effects to an animal are likely, including temporary threshold shift (TTS) and permanent threshold shift (PTS). This binary, at-the-source classification of sound types, therefore, provides a conservative framework upon which to predict potential adverse hearing impacts on marine mammals.

For behavioral effects of anthropogenic sound on marine mammals, NMFS classifies sound sources as either intermittent or continuous (NMFS 2018). Continuous sounds, such as drilling or vibratory pile-driving, remain “on,” i.e., above ambient noise, for a given period of time, though this is not well-defined. An intermittent sound typically consists of bursts or pulses of sound on a regular on-off pattern, also called the duty-cycle. Examples of intermittent sounds are those from scientific echosounders, sub-bottom profilers, and even pile-driving. It is important to recognize that these delineations are not always practical in application, as a continuous yet moving sound source (such as a vessel passing over a fixed receiver) could be considered intermittent from the perspective of the receiver.

In reality, animals will encounter many signals in their environment that may contain many or all of these sound types, called complex sounds. Even for sounds that are impulsive at the source, as the signal propagates through the water, the degree of impulsiveness decreases (Martin et al. 2020). While there is evidence, at least in terrestrial mammals (Hamernik and Hsueh 1991), that complex sounds can be more damaging than continuous sounds, there is not currently a regulatory category for this type of sound. One current approach for assessing the impulsiveness of a sound that has gained attention is to compute the kurtosis of that signal. *Kurtosis* is a statistical measure that describes the prevalence of extreme values within a distribution of observations, in other words the “spikiness” of the data. Martin et al. (2020) showed that a sound with a kurtosis value of 3 or less has very few extreme values and is generally considered Gaussian (i.e., normally distributed) noise, whereas a kurtosis value greater than 40 represents a distribution of observations with many extreme values and is very spiky. This generally describes an impulsive noise. A distribution of sound level observations from a time series with a kurtosis value somewhere in between these two values would be considered a complex sound.

J.2.5 Sound Sources Related to the Project Not Included in the Modeling

J.2.5.1. Vessels

During construction, vessels may be used to transport crew and equipment. Large vessels will be used during the construction phase to conduct pile-driving, and may use dynamic positioning (DP) systems. DP systems are used on vessels to hold station over a specific seafloor location without the use of a physical anchor using input from gyrocompasses, motion sensors, GPS, active acoustic positioning systems, and wind sensors to determine relative movement and environmental forces at work. Most acoustic energy for vessels using DP systems is below 1,000 Hz, often below 50 Hz, with tones related to engine and propeller size and type. The sound can also vary directionally, and this directionality is much more pronounced at higher frequencies. Because this is a dynamic operation, the sound levels produced will vary based on the specific operation, DP system used (e.g., jet or propeller rotation, versus a rudder or steering mechanism), and factors such as the blade rate and cavitation, in some cases. Representative sound field measurements from the use of DP are difficult to obtain because the sound transmitted is often highly directional and context specific. The direction of sound propagation may change as different DP needs requiring different configurations are applied.

Many studies have found that the measured sound levels of DP alone are, counterintuitively, higher than those of DP combined with the intended activities such as drilling (Jiménez-Arranz et al. 2020; Kyhn et al. 2011; Nedwell and Edwards 2004) and coring (Warner and McCrodan 2011). Nedwell and Edwards (2004) reported that DP thrusters of the semi-submersible drill rig *Jack Bates* produced periodic noise (corresponding to the rate of the thruster blades) with most energy between 3 to 30 Hz. The received SPL measured at 100 meters from the vessel was 188 dB re 1 µPa. Warner and McCrodan (2011) found that most DP related sounds from the self-propelled drill ship, R/V *Fugro Synergy* were in the 110 to 140 Hz range, with an estimated source level of 169 dB re 1 µPa m. Sounds in this frequency range varied by 12 dB during DP, while the broadband levels, which also included diesel generators and other equipment sounds, varied by only 5 dB over the same time period. All the above sources report high variability in levels with time, due in part to the intermittent usage and relatively slow rotation rates of thrusters used in DP. It is also difficult to provide a realistic range of source levels from the data thus far because most reports do not identify the direction from which sound was measured relative to the vessel, and DP thrusters are highly directional systems.

The active acoustic positioning systems used in DP can be additional sources of high frequency sound. These systems usually consist of a transducer mounted through the vessel's hull and one or more transponders affixed to the seabed. Kongsberg High Precision Acoustic Positioning (HiPAP) systems produce pings in the 10 to 32 kHz frequency range. The hull-mounted transducers have source levels of 188 to 206 dB re 1 µPa m depending on adjustable power settings (Kongsberg Maritime AS 2013). The fixed transponders have maximum source levels of 186 to 206 dB re 1 µPa m depending on model and beam width settings from 15 to 90° (Jiminez-Arranz et al. 2020). These systems have high source levels, but beyond 2 kilometers they are generally quieter than other components of the sound from DP vessels for various reasons, including: their pulses are produced in narrowly directed beams, each individual pulse is very short, and their high frequency content leads to faster attenuation.

During operations, small vessels may be used to transport crew and supplies. Noise from vessels in transit is considered to be continuous, with a combination of broadband and tonal sounds (Richardson et al. 1995; Ross 1976). Transiting vessels generate continuous sound from their engines, propeller cavitation, onboard machinery, and hydrodynamics of water flows (Ross 1976). The actual radiated sound depends on several factors, including the type of machinery on the ship, the material conditions of the hull, how recently the hull has been cleaned, interactions with the sea surface, and shielding from the hull, which reduces sound levels in front of the ship.

In general, vessel noise increases with ship size, power, speed, propeller blade size, number of blades, and rotations per minute. Source levels for large container ships can range from 177 to 188 dB re 1 μPa m (McKenna et al. 2013) with most energy below 1 kHz. Smaller vessels typically produce higher-frequency sound concentrated in the 1 to 5 kHz range. Kipple and Gabriele (2003) measured underwater sound from vessels ranging from 14 to 65 feet long (25 to 420 horsepower), and back-calculated source levels were estimated to be 157 to 181 dB re 1 μPa m. Similar levels are reported by Jiménez-Arranz et al. (2020), who provide a review of measurements for support and crew vessels, tugs, rigid hull inflatable boats, icebreakers, cargo ships, oil tankers, and more.

During transit to and from shore bases, survey vessels typically travel at speeds that optimize efficiency, except in areas where transit speed is restricted. The vessel strike speed restrictions that are in place along the Atlantic OCS are expected to offer a secondary benefit of underwater noise reduction. For example, recordings from a speed reduction program in the Port of Vancouver (210 to 250 meter water depths) showed that reducing speeds to 11 knots reduced vessel source levels by 5.9 to 11.5 dB, depending on the vessel type (MacGillivray et al. 2019). Vessel noise is also expected to be lower during geological and geophysical surveys, as they typically travel around 5 knots when towing instruments.

J.2.5.2. Cable Laying and Trenching

The installation of cables can be done by towing a tool 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. Possible installation methods for these options include jetting, vertical injection, control flow excavation, trenching, and plowing. Burial depth of the cables is typically 1 to 2 meters. Cable installation vessels may use dynamic positioning to lay the cables (Section J.2.5.1). Nedwell et al. (2003) recorded underwater sound at 160 meters from trenching, in water depths of 7 to 11 meters, and the back-calculated the source level was estimated to be 178 dB re 1 μPa m. They describe trenching sound as generally broadband in nature, but variable over time, with some tonal machinery noise and transients associated with rock breakage. 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.

J.2.5.3. Wind Turbine Operations

Once windfarms are operational, low-level noise is generated by each wind turbine generator (WTG), but sound levels are much lower than during construction. This type of sound is considered to be continuous, omnidirectional radially from the pile, and non-impulsive. Most of the energy associated with operations is below 120 Hz. Sound levels from wind turbine operations are likely to increase somewhat with increasing generator size and power ratings, as well as with wind speeds. Recordings from Block Island Wind Farm indicated that there was a correlation between underwater sound levels and increasing wind speed, but this was not clearly influenced by turbine machinery; rather, it may have been explained by the natural effects that wind and sea state have on underwater sound levels (Elliott et al. 2019; Urick 1983).

A recent compilation (Tougaard et al. 2020) of operational noise from several wind farms, with turbines up to 6.15 MW in size, showed that operational noise generally attenuates rapidly with distance from the turbines, falling to near ambient sound levels within ~1 kilometer from the source; the combined noise levels from multiple turbines are lower or comparable to those generated by a small cargo ship. Tougaard et al. (2020) developed a formula predicting a 13.6 dB increase for every 10-fold increase in WTG power rating. This means that operational noise could be expected to increase by 13.6 dB when increasing in size from a 0.5 MW turbine to a 5 MW one, or from 1 MW to 10 MW. The least squares fit of that dataset would predict that the SPL measured 100 meters from a hypothetical 15 MW turbine in operation in 10 m/s (19 kt or 22 mph) wind would be 125 dB re 1 μPa. However, all of the 46 data points in that dataset, with the exception of the two from the Block Island Wind Farm, were from WTGs operated with gear boxes of various designs rather than the newer use of direct drive technology, which is expected to lower underwater noise levels significantly. Stöber and Thomsen (2021) make predictions for source levels of 10 MW turbines based on a linear extrapolation of maximum received levels from WTGs with ratings up to 6.15 MW. The linear fit is likely inappropriate, and the resulting predictions may be exaggerated. Tougaard et al. (2020) point out that received level differences among different pile types could be confounded by differences in water depth and turbine size. In any case, additional data is needed to fully understand the effects of size, foundation type properties (e.g., structural rigidity and strength), and drive type on the amount of sound produced during turbine operation.

J.2.6 Underwater Sound and Marine Life

J.2.6.1. Marine Mammals

Marine mammals rely heavily on acoustic cues for extracting information from their environment. Sound travels faster and farther in water (~1500 m/s) than it does in air (~350 m/s), making this a reliable mode of information transfer across large distances and in dark environments where visual cues are limited. Acoustic communication is used in a variety of contexts, such as attracting mates, communicating to young, or conveying other relevant information (Bradbury and Vehrencamp 2011). Marine mammals can also glean information about their environment by listening to acoustic cues, like ambient sounds from a reef, the sound of an approaching storm, or a call from a nearby predator. Finally, toothed whales produce and listen to echolocation clicks to locate food and to navigate (Madsen and Surlykke 2013).

Like terrestrial mammals, the auditory anatomy of marine mammals generally includes the inner, middle, and outer ear (Ketten 1994). Not all marine mammals have an outer ear, but if it is present, it funnels sound into the auditory pathway. The middle ear acts as a transformer, filtering and amplifying the sound. The inner ear is where auditory reception takes place. The key structure in the inner ear responsible for auditory perception is the cochlea, a spiral-shaped structure containing the basilar membrane, which is lined with auditory hair cells. Specific areas of the basilar membrane vibrate in response to the frequency content of the acoustic stimulus, causing hair cells mapped to specific frequencies to be differentially stimulated and send signals to the brain (Ketten 1994). While the cochlea and basiliar membrane are well conserved structures across all mammalian taxa, there are some key differences in the auditory anatomy of terrestrial vs. marine mammals that require explanation. Marine mammals have the unique need to hear in aqueous environments. Amphibious marine mammals (including seals, sea otters, and sea lions) have evolved to hear both in air and under water, and all except phocid pinnipeds have external ear appendages. Cetaceans do not have external ears, do not have air-filled external canals, and the bony portions of the ear are much denser than those of terrestrial mammals (Ketten 1994).

All marine mammals have binaural hearing and can extract directional information from sound. But the pathway that sound takes into the inner ear is not well understood for all cetaceans and may not be the same for all species. For example, in baleen whales, bone conduction through the lower jaw may play a role in hearing (Cranford and Krysl 2015), while odontocetes have a fat-filled portion of the lower jaw which is thought to funnel sound towards the ear (Mooney et al. 2012). Hearing tests have been conducted on several species of odontocetes, but there has yet to be a hearing test on a baleen whale, so most of our understanding comes from examining the ears of deceased whales (Erbe et al. 2016; Houser et al. 2017).

Many marine mammal species produce sounds through vibrations in their larynx (Frankel 2002). In baleen whales, for example, air in the lungs and laryngeal sac expands and contracts, producing vibrations and sounds within the larynx (Frankel 2002). Baleen whales produce low frequency sounds that can be used to communicate with other animals over great distances (Clark and Gagnon 2002). Differences in sound production among marine mammals varies, in part, with their use of the marine acoustic environment. Toothed whales hunt for their prey using relatively high-frequency (tens of kHz) echolocation signals. To produce these signals, they have a specialized structure called the “melon” in the top of their head that is used for sound production. When air passes through the phonic lips, a vibration is produced, and the melon helps transmit the vibration from the phonic lips to the environment as a directed beam of sound (Frankel 2002). It is generally believed that if an animal produces and uses a sound at a certain frequency, its hearing sensitivity will at least overlap those particular frequencies. An animal’s hearing range is likely much broader than this, as they rely heavily on acoustic information, beyond the signals they produce themselves, to understand their environment.

J.2.6.2. Sea Turtles

While the general importance of sound to sea turtles is not well understood, there is a growing body of knowledge suggesting that sea turtles use sound in a multitude of ways. Sea turtles may use sound for navigation, locating prey or preferred habitat, predator avoidance, and environmental awareness (Piniak et al. 2016). They occupy different ecological niches throughout their life cycle, each characterized by unique acoustic conditions. There are few studies reporting sound production in sea turtles, despite their ability to hear sounds in both air and water. Cook and Forrest (2005) found that nesting leatherback sea turtles produce sound when breathing in air, but this work suggested the sound was a byproduct of labored breathing rather than a communication signal. Sea turtle embryos and hatchlings have been reported to make airborne sounds, thought to be produced for synchronizing hatching and nest emergence (Ferrara et al. 2014a, 2014b, 2019; McKenna 2016; Monteiro et al. 2019). Charrier et al. (2022) noted the production of 10 different underwater sounds in juvenile green sea turtles including those within and above the frequency range of hearing reported for this species. A more comprehensive understanding of sound production and hearing is needed in sea turtles, but the growing available information thus far suggests sound may be important to these animals.

In general, sea turtle auditory perception is thought to occur through a combination of both bone and water conduction rather than air conduction (Lenhardt et al. 1983, 1985). The outermost part of the sea turtle ear, or tympanum, is covered by a thick layer of skin covering a fatty layer that conducts sound in water to the middle and inner ear. This is a distinguishing feature from terrestrial and semi-aquatic turtles. This thick outer layer makes it difficult for turtles to hear well in air, but it facilitates the transfer of sound from the aqueous environment into the ear (Ketten et al. 1999). The middle ear has two components that are encased by bone, the columella and extracolumella, which provide the pathway for sound from the tympanum on the surface of the turtle head to the inner ear consisting of the cochlea and basilar membrane. This arrangement enables sea turtles to hear low-frequency sounds while underwater. The middle ear is also connected to the throat by the Eustachian tube. Because there is air in the middle ear, it is generally believed that sea turtles detect sound pressure rather than particle motion. Vibrations can also be conducted through the bones of the carapace to reach the middle ear. Based on studies of semi-aquatic turtles, Christensen-Dalsgaard et al. (2012) speculated that the sea turtle ear may not be specialized for bone conduction, but rather that sound-induced pulsations may drive the tympanic disc if the middle ear cavity is air-filled.

Hearing in sea turtles has been measured through electrophysiological and/or behavioral studies both in air and water on a limited number of life stages for each of the five species. In general, sea turtles hear best in water between 100 and 750 Hz, do not hear well above 1 kHz, and are generally less sensitive to sound than marine mammals (Reese et al. 2023; Papale et al. 2020). While there are still substantial data gaps on hearing sensitivity across species and throughout ontogeny, there is data on Loggerhead hearing capabilities at the post-hatchling (Lavender et al. 2012, 2014b), juvenile (Bartol et al. 1999a; Lavender et al. 2012, 2014b), and adult stages (Martin et al. 2012). Available data on sea turtle hearing capabilities is summaries in Table J-1.

Table J-1 Hearing Capabilities of Sea Turtles

Sea Turtle Species		Hearing[1]		Sources
		Range of audibility (Hz)	Range of highest sensitivity (Hz)	
Green (Chelonia mydas)	Juvenile	50–1,600	200–400	Bartol and Ketten 2006; Dow Piniak et al. 2012c; Piniak et al. 2016; Ridgway et al. 1969a
Hawksbill (Eretmochelys imbricata)	Hatchling	50–1,600	400	Piniak 2012
Kemp's ridley (Lepidochelys kempii)	Juvenile	100–500[2]	100–500[2]	Bartol and Ketten 2006
Leatherback (Dermochelys coriacea)	Hatchling	50–1,200	300	Dow Piniak et al. 2012b; Piniak 2012
Loggerhead (Caretta caretta)	Post-Hatchling[3]	50–1,100	200	Bartol et al. 1999a; Lavender et al. 2014b; Lenhardt 2002; Martin et al. 2012
	Juvenile	50–1,100	50–800	
	Adult	35–1,131	100–400	

[1] Data adapted from Papale et al. 2020 and Reese et al. 2023 based on highest and lowest frequency of underwater audibility that was reported for each species including both auditory evoked potential and behavioral studies.
[2] Only in-air measurements are available for Kemp's ridley sea turtles.
[3] Post-hatchling refers to the size classification given to hatchlings when they reach a straight maximum length of 5 centimeters.

J.3. 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 630 Hz and dBSeaRay addressing 800 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 2023).

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:

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

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

J.3.1 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 2023). 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 2023). 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 2023).

The sediment layers used in the modeling and the main geoacoustic properties are defined in Table J-2 and Table J-3for 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 (λ) of the signal. Finally, density is the physical density (ρ) 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 2023).

Table J-2 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	Cp = 1650 m/s αs (dB/λ) = 0.8 dB/λ ρ = 1900 kg/m^3
12 to 15	Clay	Cp = 1500 m/s αs (dB/λ) = 0.2 dB/λ ρ = 1500 kg/m^3
15 to 22	Dense Silty and	Cp = 1650 m/s αs (dB/λ) = 1.1 dB/λ ρ = 1800 kg/m^3
22 to 31	Stiff Sandy Clay	Cp = 1560 m/s αs (dB/λ) = 0.2 dB/λ ρ = 1600 kg/m^3
31 to 37	Clay	Cp = 1500 m/s αs (dB/λ) = 0.2 dB/λ ρ = 1500 kg/m^3
37 to 42	Silty Sand	Cp = 1650 m/s αs (dB/λ) = 1.1 dB/λ ρ = 1800 kg/m^3
42 to 53	Clay, Fine Sand	Cp = 1598 m/s αs (dB/λ) = 0.5 dB/λ ρ = 1575 kg/m^3
53 to 87	Sandy Silt	Cp = 1605 m/s αs (dB/λ) = 1.0 dB/λ ρ = 1700 kg/m^3
>87	Dense Sand	Cp = 1800 m/s αs (dB/λ) = 0.9 dB/λ ρ = 2000 kg/m^3

Source: COP, Appendix Z, Table Z-5; Dominion Energy 2023.

Table J-3 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 αs (dB/λ) = 1.1 dB/λ ρ = 1800 kg/m^3
2 to 6	Medium Dense Sand	Cp = 1725 m/s αs (dB/λ) = 0.8 dB/λ ρ = 1950 kg/m^3
6 to 9	Lean Clay	Cp = 1485 m/s αs (dB/λ) = 0.1 dB/λ

Seabed Layer (meters)	Material	Geoacoustic Properties
		ρ = 1300 kg/m³
9 to 15	Silty Sand	Cp = 1650 m/s αs (dB/λ) = 1.1 dB/λ ρ = 1800 kg/m³
15 to 26	Sandy Lean Clay	Cp = 1560 m/s αs (dB/λ) = 0.2 dB/λ ρ = 1600 kg/m³
26 to 32	Medium Dense Sand	Cp = 1725 m/s αs (dB/λ) = 0.8 dB/λ ρ = 1950 kg/m³

Source: COP, Appendix Z, Table Z-6; Dominion Energy 2023.

J.3.2 Vibratory Driving Source Details

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 2023).

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 $\mu Pa^2 m^2$ s (COP, Appendix Z; Dominion Energy 2023).

J.4. 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 2023).

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 2023). 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 2023).

J.5. 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 2023).

J.5.1 Acoustic Modeling Scenarios

A summary of construction and operational scenarios included in the underwater acoustic modeling analysis is provided in Table J-4. 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 2023; 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 2023). 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 (Dominion Energy 2023).

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 2023). 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 2023).

Table J-4 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
		Vibratory Pile Driving	90	N/A		SEL$_{1s}$: 202 dB re 1 μPa^{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 μPa m SEL$_{1s}$: 214 dB re 1 μPa^{2}m^2 s SPL: 224 dB re 1 μPa m
		Vibratory Pile Driving	120	N/A		SEL$_{1s}$: 194 dB re 1 μPa^{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 μPa^{2}m^2 s
6: Goal Post Pile Installation	Goal Post Piles (includes 2 piles per day) Diameter: 1.07	Impact Pile Driving	130	260	414,396 m 4,074,917 m	Lpk: 210 dB re 1 μPa m SEL$_{1s}$: 183 dB re 1 μPa^{2}m^2 s

Scenario	Activity Description	Maximum Hammer Energy (kilojoules)	Duration of Single Pile Installation (minutes)	Total Hammer Blows	Location (UTM Coordinates)	Sound Source Level[1]
	m					

Source: COP, Appendix Z, Table Z-7; Dominion Energy 2023.
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.5.2 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 calculation 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 modeled environment at which the sound level was calculated to occur. The $R_{95\%}$ excludes major outliers or protruding areas associated with the underwater acoustic modeling environment and is determined by calculating the radius based on 95 percent of the area of the threshold isopleths. This is conducted by generating a circle approximating the extent of the sound contour isopleths and then calculating the associated radius using the following equation: the $R_{95\%}$ Radius (m) = $\sqrt{(\text{Area}*0.95)/\pi}$. The intent of this approach is to determine the predicted range encompassing at least 95 percent of the threshold isopleth area that would be exposed to noise from the source at or above the specified threshold level. All distances to injury thresholds reported in the Underwater Acoustic Assessment Report (COP, Appendix Z; Dominion Energy 2023) are presented in terms of the $R_{95\%}$ range. Based on the site- specific conditions and review of the resultant acoustic model output, even though this methodology for evaluating threshold ranges may differ from other acoustic models and may result in some slight irregularities in data trends (i.e., inconsistences in predictions in the near-field relative to pile driving activities), this methodology is representative of expected Project-related underwater acoustic impacts (COP, Appendix Z; Dominion Energy 2023).

J.6. 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.7. Marine Species Present in the Project Area

J.7.1 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 2023). The most recent 2020-2021 PSO sighting data made available since the Milne (2018) report was published are summarized below in Table J-5. Marine mammals known to occur in the marine waters of coastal and offshore Virginia are listed in Table J-6T.

Table J-5 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 2023.
[1] Data for 2021 are preliminary and will undergo additional review before reports are finalized.

Table J-6 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 2023.
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.7.2 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-7). 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-7, or have confirmed sightings within the Lease Area based on PSO data in Table J-5 are provided in Table J-7.

Table J-7 Mean Seasonal Density Estimates (animals/km^2) 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.7.3 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 2023). Table J-8 provides a summary of key information for these species and their known distribution within the study area.

Table J-8 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.7.4 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 2022a). 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 2022a). Densities for all sea turtle species likely to occur in the Project area are provided in Table J-9.

Table J-9 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 2022a.
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.7.5 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.8. 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-10), which are presented in terms of dual metrics; SEL_{24h} and Lpk. The Level B (behavioral) harassment thresholds are also provided in Table J-11.

Table J-10 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-11).

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 2023). 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-12; Popper et al. 2014) (COP, Appendix Z; Dominion Energy 2023). 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 2023).

Table J-11 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-12 Acoustic Threshold Levels for Fishes

Hearing Group	Impulsive Sounds		Non-Impulsive Sounds		
	Mortality and Potential Mortal Injury	Recoverable Injury	TTS	Recoverabl e 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.9. Results

J.9.1 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.5.2 and J.8 are provided in COP, Appendix Z (Dominion Energy 2023). The modeling scenarios analyzed are described in Table J-4 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-4). 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-13, Table J-14, and Table J-15 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 2023). The results in Table J-13 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-13). 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 2023).

Table J-13 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 2023.

Table J-14 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 2023.
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-15 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 2023.
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.9.2 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 2023). 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-16, Table J-17, and Table J-18 for marine mammals, sea turtles, and fish, respectively.

Table J-16 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 2023.
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-17 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 2023.
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-18 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	SEL_{24hr}	Lpk	SEL_{24hr}	Lpk	SEL_{24hr}	Lpk	SEL_{24hr}	Lpk	SEL_{24hr}	Lpk	SEL_{24hr}	All Fish
Goal Post Pile Installation – Impact Pile Driving	0	-	-	-	-	-	-	-	-	-	-	-	-	6,750
	6	-	-	-	-	-	-	-	-	-	-	-	-	2,700
	10	-	-	-	-	-	-	-	-	-	-	-	-	1,450

Source: COP, Appendix Z Dominion Energy 2023.
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.9.3 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 2023). 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 2023). 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-19, Table J-20, and Table J-21 summarize the maximum distances to acoustic thresholds for marine mammals, sea turtles, and fish, respectively.

Table J-19 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 2023.
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-20 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 2023.
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-21 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 2023.
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.9.4 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 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 J-22 for marine mammals were estimated using NMFS User Spreadsheets for PTS thresholds and interim guidance from NMFS (2019) for behavioral thresholds (Tetra Tech 2022a). 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-22 were obtained from the Programmatic Biological Assessment conducted by BOEM (Baker and Howsen 2021).

Table J-22 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 2023; 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.9.5 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 2022a). The construction schedule used to estimate the number of exposures throughout the entire construction period is provided in Table J-23.

Table J-23 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	
	June	25	6	19	6	
	July	26	7	19	6	
	August	2 WTG, 12 OSS	1	1	1	65
	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	
	June	24	8	16	6	
	July	26	8	18	6	
	August	20	6	14	6	249
	September	5	2	3	0	
	October	3	1	2	0	
2025 Total		95	31	64	19	
2026	May	3	0	3	0	
	June	5	0	4	0	
	July	5	0	4	0	
	August	4	0	3	0	58
	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 2022a.
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.9.5.1. 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-24.

Table J-24 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

Marine Mammal Species		PTS	Behavioral
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.9.5.2. 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-25.

Table J-25 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 2022b.
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.

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