South Fork Wind Farm Construction and Operations Plan

APPENDIX P1

Assessment of Impacts to Marine Mammals, Sea Turtles, and Sturgeon

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The impact-producing factors (IPFs) of underwater noise, vessel traffic, sediment suspension, seafloor disturbance, trash and debris, visible structures, lighting, and electromagnetic fields (EMF) were assessed for their potential to adversely impact marine mammals, sea turtles, and sturgeon that are reasonably expected to occur in or near the South Fork Wind Farm (SFWF) and associated South Fork Export Cable (SFEC) areas during construction and operation of the SFWF and SFEC. This Appendix is designed to provide supplemental information regarding affected marine mammal, sea turtle, and sturgeon species, and the IPFs that have the potential to reach ***minor*** to ***major*** impact determination, with an emphasis on underwater noise. Underwater noise is treated in more detail as the species under consideration in this Appendix are known to be more vulnerable to this IPF, and as most of these species are already considered vulnerable populations, more care was taken to address potential impacts.

A matrix was developed to identify the IPFs which are analyzed within the South Fork Wind, LLC (SFW) (formerly Deepwater Wind South Fork) federal Construction and Operations Plan (COP). The level of impact associated with each interaction was categorized as "potential impact for analysis" (i.e., a measurable impact to a resource is predicted) or "negligible or no impact expected" (i.e., no measurable impact to a resource is evident). Those categorized as negligible or no impact expected were excluded from this appendix, and information supporting these determinations can be found in the main COP.

As an overall IPF, underwater noise has the potential to cause ***minor*** to ***major*** impacts on marine mammals, sea turtles, and sturgeon; however, noise produced from impact pile driving, vibratory pile driving, vessels, and turbine operations may have differing impact potentials ranging from ***negligible*** to ***major***. Therefore, each of the noise sources were all assessed even if any of the individual sources produced negligible impacts only, they are still addressed in this Appendix due to their contribution to the overall underwater noise impact assessment.

Potential impacts to marine mammals were determined to be ***negligible*** to ***major*** for underwater noise IPFs, which comprises minor to moderate impacts for noise generated by wind turbine operations; ***negligible*** to ***minor*** impacts for vessel noise; ***minor*** to ***major*** impacts for noise generated from impact pile driving; and ***negligible*** to ***minor*** impacts for noise generated by vibratory pile driving. Non-acoustic impacts to marine mammals were assessed as ***negligible*** to ***moderate*** for vessel traffic and ***negligible*** from seafloor disturbance, sediment suspension, trash and debris, discharges and releases, visible structures, lighting, and EMF.

Potential sea turtle impacts were determined to be ***negligible*** to ***minor*** for underwater noise sources, which comprises ***negligible*** impacts for noise generated by wind turbine operations; ***negligible*** impacts for vessel noise; ***minor*** to ***moderate*** impacts for noise generated from impact pile driving; and ***negligible*** to ***minor*** impacts for noise generated by vibratory pile driving. Non-acoustic impacts to sea turtles were assessed as ***negligible*** to ***moderate*** for vessel traffic; beneficial for seafloor disturbance due to the increased structural habitat provided by the foundations and potential food sources resulting from colonization of the foundations; and negligible or no impacts for sediment suspension, trash and debris, discharges and releases, visible structures, lighting, and EMF.

Potential Atlantic sturgeon (*Acipenser oxyrhincus*) impacts were determined to be ***negligible*** to ***minor*** for underwater noise, which comprises ***negligible*** impacts for noise generated by wind turbine operations; ***negligible*** impacts for vessel noise; ***negligible*** to ***minor*** impacts for noise generated from impact pile driving; and ***negligible*** impacts for noise generated by vibratory pile driving. Non-acoustic impacts to sturgeon were assessed as ***negligible*** to ***minor*** for vessel traffic and ***negligible*** or no impact for seafloor disturbance, sediment suspension, trash and debris, discharges and releases, visible structures, lighting, and EMF.

Acoustic propagation and animal exposure modeling conducted by JASCO Applied Sciences, Inc. (JASCO) (COP Appendix J1, P2 [Denes et al., 2021a,b]) was used to assess modeled sound pressure levels (SPLs) from underwater noise resulting from impact pile driving the wind turbine generator foundations reached regulatory threshold criteria for potential onset of behavioral and/or physiological impacts to marine mammals, sea turtles, and sturgeon. The distances to the various regulatory thresholds were dependent on hammer type, pile type, propagation environment, and hearing sensitivities of the animal receiver. The potential for regulatory-level exposures for all species were highest for unattenuated impact piling operations; with potential physiological exposures for certain species. When sound attenuation mitigation was applied to the model, physiological exposures were eliminated for all but the high frequency cetacean group.

Similarly, behavioral exposures were highest for unattenuated sources. Exposure modeling demonstrated a relatively low potential for North Atlantic right whale (*Eubalaena glacialis*) behavioral exposures, even for unattenuated piling operations. Mitigation measures, including sound attenuation methods, are expected to eliminate injurious exposures during impact pile driving for marine mammals, sea turtles and sturgeon and minimize behavioral exposures for all species. No long term impacts are expected from impact piling operations.

SPLs were also modeled for vibratory pile driving associated with cofferdam installation or operation of dynamically positioned vessels during cable lay activities. No physiological acoustic thresholds are expected to be met for these activities. Modeled behavioral disturbance isopleths from these activities are large; however, no long term impacts are expected from the behavioral exposures because noise levels are not expected to affect critical behaviors or habitats, and the cable lay and cofferdam operations will have a relatively short duration.

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Acronyms

AMAPPS	Atlantic Marine Assessment Program for Protected Species
APE	American Pile driving Equipment
ASMFC	Atlantic States Marine Fisheries Commission
ASSRT	Atlantic Sturgeon Status Review Team
BBC	big bubble curtain
BOEM	Bureau of Ocean Energy Management
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
COP	Construction and Operations Plan
CPA	closest point of approach
CRESLI	Coastal Research and Education Society of Long Island
dB	decibel
dB re 1 µPa	decibel referenced to one micropascal
dB re 1 µPa m	decibel reference to one micropascal at one meter
dB re 1 μPa^2 Hz^{-1}	decibel referenced to one micropascal squared per hertz
dB re 1 μPa^2 m^2 s	decibel referenced to one micropascal squared meter squared second
dB re 1 μPa^2 s	decibel referenced to one micropascal squared second
DMA	Dynamic Management Area
DON	Department of the Navy
DP	dynamic positioning
DPS	distinct population segment
EA	Environmental Assessment
EEZ	exclusive economic zone
EMF	electromagnetic field
$ER_{95\%}$	95% exposure range
ESA	Endangered Species Act
ESL	sound exposure source level
EZ	exclusion zone
FHWG	Fisheries Hydroacoustic Working Group
HDD	horizontal directional drilling
HFC	high-frequency cetacean
HRG	high-resolution geophysical
Hz	hertz
IHA	Incidental Harassment Authorization
IPF	impact producing factor
IR	infrared
IUCN	International Union for Conservation of Nature
JASCO	JASCO Applied Sciences, Inc.
kHz	kilohertz
kW	kilowatt
LFC	low-frequency cetacean
MFC	mid-frequency cetacean
MHz	megahertz
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MW	megawatt
MZ	monitoring zone

Acronyms
(Continued)

NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMS	noise mitigation system
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NYSERDA	New York State Energy Research and Development Authority
OCS	outer continental shelf
O&M	operation and maintenance
OPA	Offshore Planning Area
PAM	passive acoustic monitoring
PBR	potential biological removal
PPW	phocid pinnipeds in water
PSMMP	Protected Species Mitigation and Monitoring Plan
PSO	protected species observer
PTS	permanent threshold shift
RI-MA	Rhode Island-Massachusetts
SAMP	Special Area Management Plan
SEL	sound exposure level
SEL_{cum}	cumulative sound exposure level
SFEC	South Fork Export Cable
SFW	South Fork Wind, LLC
SFWF	South Fork Wind Farm
SL	source level
SL_{pk}	zero to peak source level
SL_{rms}	root-mean-square source level
SMA	Seasonal Management Area
SPL	sound pressure level
SPL_{pk}	zero to peak sound pressure level
SPL_{rms}	root-mean-square sound pressure level
SPUE	sighting per unit effort
TTS	temporary threshold shift
USFWS	U.S. Fish and Wildlife Service
WDA	wind development area
WTG	wind turbine generator
WEA	wind energy area
ZOI	zone of influence

1.0 Introduction

The purpose of this Appendix is to provide supplemental information to assess potential impacts to marine protected species in or near the South Fork Wind Farm (SFWF) and associated South Fork Export Cable (SFEC) areas in support of South Fork Wind, LLC (SFW) (formerly Deepwater Wind South Fork) federal Construction and Operations Plan (COP). This Appendix is designed to provide supplemental information only for the impact producing factors (IPFs) that have the potential to reach ***minor*** to ***major*** impact determination, with a focused assessment of the underwater noise IPF, for marine mammals, sea turtles, and sturgeon. Underwater noise is treated in more detail than other IPFs within this Appendix because it has the greatest potential for producing impacts to the above listed species groups. Noise produced from impact pile driving, vibratory pile driving, vessels, and turbine operations were all assessed individually; however, even if any of these individual sources produced negligible impacts only, they are still addressed in this Appendix due to their contribution to the overall underwater noise impact assessment. Construction noise sources, with the exception of pile driving, were presumed to be equivalent to decommissioning sources, therefore decommissioning is not assessed separately in this Appendix.

The acoustic assessment in this Appendix is intended to provide the reader with a substantial overview of the regulatory frameworks addressing marine protected species and management of underwater noise impacts, as well as the expected underwater sound propagation resulting from the predicted construction and installation scenarios for the SFWF and SFEC. The modeling results presented in COP Appendices J1 and P2 (Denes et al., 2021a,b), in combination with this Appendix, are intended to provide the basis for future National Environmental Policy Act (NEPA) and Marine Mammal Protection Act (MMPA) consultation and documentation.

Resources (i.e., affected species) may be vulnerable to one or more IPFs. Therefore, a matrix was developed to identify the IPFs, and associated resources, for which impacts were analyzed (**Table 2-1**). In the impact analysis phase, the level of impact associated with each interaction was categorized as "potential impact for analysis" (i.e., a measurable impact to a resource is predicted) or "negligible or no impact expected" (i.e., no measurable impact to a resource is evident). IPFs which have negligible or no impact expected are not discussed further in this Appendix, and justification for these determinations can be found in the main SFWF COP document.

Table 2-1. Summary of impact producing factors that could result in minor, moderate, and major impacts to marine mammals, sea turtles or sturgeon during installation, operation, and decommissioning of the South Fork Wind Farm (SFWF) and associated export cables based on the assessment conducted within the SFWF Construction and Operation Plan.

Resource	Underwater Noise	Vessel Traffic	Sediment Suspension/Deposition	Seafloor Disturbance	EMF	Discharges and Releases	Trash and Debris	Visible Structures	Lighting
Marine Mammals	+	+	-	-	-	-	-	-	-
Sea Turtles	+	+	-	+/++	-	-	-	-	-
Sturgeon	+	+	-	-	-	-	-	-	-

Key: + indicates a potential minor, moderate, or major impact; - indicates negligible or no impact expected; ++ indicates a beneficial impact; EMF = electromagnetic field.

Broad significance criteria were developed for the three resources addressed in this Appendix (i.e., marine mammals, sea turtles, sturgeon). Criteria reflect consideration of the context and intensity of impact (40 Code of Federal Regulations [CFR] § 1508.27) based on four parameters: detectability (i.e., measurable or detectable impact); duration (i.e., short-term, long-term); spatial extent (i.e., localized, extensive); and severity (i.e., severe, less than severe). The significance criteria have been broadly defined as follows:

- **Negligible:** generally those impacts that, if perceptible, would not be measurable;
- **Minor:** impacts that, if adverse, would be perceptible but, in context, avoidable with proper mitigation; and, if impacts are measurable, the affected system would be expected to recover completely without mitigation once the impact is eliminated;
- **Moderate:** impacts are those that, if adverse, would be measurable but would not threaten the viability of the affected system and would be expected to absorb the change or impact if proper mitigation or remedial action is implemented; and
- **Major:** impacts are those that, if adverse, would be measurable but not within the capacity of the affected system to absorb the change, and without major mitigation, could be severe and long lasting.

Each IPF was evaluated on a resource-specific basis to determine the appropriate impact level. Resource attributes such as distribution/range, life history, and susceptibility to impact of individuals and populations were considered, among other factors. The evaluation process to determine the significance considered potential impacts by context (e.g., localized versus widespread) and intensity (e.g., severity), following NEPA regulations as guidance (40 CFR § 1508.27). Context was defined as the extent of the effect (geographic extent or extent within a species, ecosystem, or region), while intensity of an impact was defined as its magnitude and any special circumstances (e.g., endangered species or legal status). Moreover, the potential effect was evaluated in terms of duration or frequency (short-term, long-term, and intermittent), and any potentially beneficial impacts were also considered. The evaluation process also consisted of evaluating the likelihood (likely or not likely) of an effect to occur (i.e., whether it was plausible or just speculative). During the preparation of the analysis of impacts, each application of an impact level was accompanied by a statement or statements explaining how the impact level was reached. The determinations are based on the best available information. Data or information from referenced journals used to support each determination are cited, as applicable, and professional judgement by experienced impact analysts. Overall, the impact assessment is designed to address effects to local populations or stocks, rather than to individual animals. The definitions of each impact level were purposely broad to avoid exceptions to single impact ratings resulting from variability in project-related IPFs and resources that occur within the SFWF and SFEC areas. Potential impacts to species listed as endangered or threatened by the Endangered Species Act (ESA), and marine mammal stocks listed as strategic by the National Marine Fisheries Service (NMFS), were given greater "weight" than impacts to non-listed species and non-strategic marine mammal stocks.

2.1 UNDERWATER NOISE

Marine mammals, sea turtles, and sturgeon are susceptible to impacts from underwater noise. Various natural and anthropogenic activities contribute to noise in the ocean creating a complex acoustic environment. The acoustic environment is made up of concomitant noise which create regional background, or ambient, noise conditions through which discrete signals must be sent and gathered by animals adapted to living in acoustically-dominated habitats. Changes in the acoustic environment can therefore change an animal's ability to function within its given acoustic habitat. Noise generated by human activities may be introduced into the environment for a specific purpose, for example, navigational sonar and seismic exploration, or as an indirect by-product of activities such as shipping, pile driving, or other industrial activities. The sound propagation characteristics of these sound sources are determined by the local physical and environmental conditions which will influence the regional acoustic environment. Additionally, variations in local ambient noise levels as a function of frequency can change by as much as 10 to 20 decibels (dB) from day to day, based on variations in the noise sources (Richardson et al., 1995; Krause, 2016). Large and small-scale temporal fluctuations (e.g., daily, seasonal) in the acoustic environment and species vocalization patterns may influence or directly affect temporal patterns in animal communication systems and detections of other acoustic cues.

Marine animals can perceive underwater noise over a broad range of frequencies from about 10 hertz (Hz) to more than 200 kilohertz (kHz). Dolphins and porpoises use even higher frequency sound for echolocation and perceive these high-frequency sounds with great acuity. The primary acoustic habitat for a species will be focused within their specific vocal and hearing ranges. Therefore, resource partitioning may be viewed on a frequency-band basis as well as an energy basis. Ruppé et al. (2015) documented apparent resource partitioning in the acoustic communication behavior of a community of nocturnal marine fishes in which 17 distinctive sounds that differed in peak frequency and pulsing characteristics were recorded. The sounds produced by soniferous species during the day did not overlap with those produced by nocturnal species and were far less diverse, thus indicating that the acoustic resource use was maximized when visual resource use was less important (Ruppé et al., 2015; Hastings and Sirovic, 2015). Sound is important for species communication, individual recognition, predator avoidance, prey capture, orientation, navigation, mate selection, and mother-offspring bonding. Where there is an overlap between anthropogenic noise sources and the frequencies of sound used by marine life, there is the potential for noise to interfere with their biological functions.

For the purposes of impact assessment, noise produced by project activities are classified as impulsive or non-impulsive, generated from either stationary or moving sources over a specified period of time and/or duty cycle. Impulsive sound is characterized by a distinct energy pulse that has a rapid rise time and high zero to peak sound pressure level (SPL_{pk}). Most impulsive sounds are broadband and are generated by sources such as airguns, impact pile driving, explosions, commercial and recreational echosounders, and subbottom profilers. Non-impulsive sounds tend to be tonal and do not have the rapid rise times seen in impulsive sources; non-impulsive sources include vessels, drilling, and vibratory pile driving (Southall et al., 2007). Some non-impulsive sources can be broadband and like impulsive sounds may be generated from stationary or moving sources over a specified period of time and/or duty cycle.

Impact pile driving is expected to produce the most severe impacts during construction relative to other noise producing activities. Unmitigated impact pile driving noise could reach ***minor*** to ***major*** impact levels for some species through a combination of acoustic characteristics driving mainly by frequencies and sound pressure levels (SPLs). Impact pile driving noise may produce impacts ranging from temporary behavioral disruptions to physical injury that could result in delayed mortality. A temporary behavioral response by marine mammals, sea turtles, and sturgeon is the most likely impact from noise introduced during construction and operation of the SFWF and SFEC. There is a potential of more severe effects (e.g., temporary or permanent hearing loss) when animal exposure to a high source level (SL) occurs close to the source; however, the magnitude and probability of most effects generally decrease with increasing distance from the source. The potential for major impacts may be further reduced by implementing passive mitigation measures such as seasonal work windows and active mitigation measures such as noise attenuation.

2.1.1 Acoustic Environments Within the Rhode Island-Massachusetts Wind Energy Area

Acoustic environments can be represented by plotting the ratios of sound energy within selected frequency bandwidths for the habitat of interest. The acoustic habitat and changes within that habitat will be represented by shifts in dominant frequency and by the increases or decreases in energy within a selected bandwidth. Modeled soundscapes and sound maps, such as those provided in National Oceanic and Atmospheric Administration (NOAA)'s sound data mapping products (https://cetsound.noaa.gov/sound_data), are generated by incorporating environmental (e.g., bathymetric, oceanographic), biological, and anthropogenic source data then modeling the sound propagation over space and time. These models represent the basis for assessment of the acoustic environment and the baseline for potential impact analysis to species due to the introduction of acoustic sources, such as those expected during construction and operation, within that environment.

The ambient noise analysis for the Rhode Island-Massachusetts (RI-MA) region was provided by Kraus et al. (2016) through the deployment of autonomous acoustic recorders from 2011 through 2015, and with dedicated recorders deployed specifically within the RI-MA wind energy area (WEA) between 2013 and 2015. The acoustic data were analyzed for both biological signals and ambient noise. In the analyses, Kraus et al. (2016) built power spectral densities, which provide the relative frequency content for the received SPLs; and the cumulative distribution which provides the percentage of time that sound within a selected frequency band reached specific SPLs. The cumulative distribution allows analysis of acoustic habitat availability within a species' vocal range. Kraus et al. (2016) used a frequency band of 20 to 447 Hz to capture the acoustic habitat of low-frequency cetaceans (LFC). By correlating the ambient SPLs within this band with the average SPL of the LFC calls, some predictions can be made regarding acoustic habitat availability and potential masking.

Kraus et al. (2016) found that the power spectrum levels above 200 Hz did not differ greatly among the nine recording sites; however, sites that were closest to shipping lanes showed an increase in SPLs for spectral content below 100 Hz. Their site RI-3, centrally located within the SFWF, had one of the lowest overall ambient noise levels with an increase around the 20 Hz frequency band, which was attributed to persistent fin whale (*Balaenoptera physalus*) vocal pulses. For frequencies between 70.8 and 224 Hz, the RI-3 site recorded SPLs of 95 decibels referenced to one micropascal (dB re 1 µPa) or less for 40% of the recoding time, and SPLs of 104 dB re 1 µPa or greater for only 10% of the recording time.

2.1.2 SFWF and SFEC Acoustic Sources

Noise contributing to the acoustic environment of the RI-MA WEA are produced by either natural processes or human activities within the marine environment.

The dominant physical mechanism of naturally occurring noise in the ocean occurs at or near the ocean surface in the form of wind and wave activity. Sound levels associated with wind and waves are generally correlated with one another and are in the medium frequency band (300 kHz to 3 megahertz [MHz]). Ambient noise levels tend to increase with increasing wind speed and wave height (Urick, 1984; Richardson et al., 1995). In the high-frequency band (3 to 30 MHz), “thermal noise” caused by the random motion of water molecules is the primary sound source (Hildebrand, 2009). Ambient noise sources, especially noise from wave and tidal action, can cause coastal environments to have particularly high ambient noise levels.

Precipitation on the ocean surface also contributes noise to the ocean. In general, noise from rain or hail is an important component of total noise at frequencies >500 Hz during periods of precipitation. Rain can increase natural ambient noise levels by up to 35 dB across a broad band of frequencies from several hundred Hz to more than 20 kHz (Richardson et al., 1995; National Research Council [NRC], 2003). Heavy precipitation associated with large storms can generate noise at frequencies as low as 100 Hz and significantly affect ambient noise levels at a considerable distance from the storm’s center (NRC, 2003). Movement of sediment by currents across the ocean bottom can also be a significant source of ambient noise at frequencies from 1 to >200 kHz (NRC, 2003). Biological noise sources are sounds created by animals and can contribute significantly to ambient noise levels in certain areas of the ocean. Marine mammals are major contributors, but some Crustacea (e.g., snapping shrimp [*Alpheus heterochaelis*]) and soniferous fish can also be significant (Richardson et al., 1995; NRC, 2003).

Surveys conducted off the coast of Rhode Island and Massachusetts indicate delphinids are the most commonly detected species in this region. Species observed included common bottlenose dolphins (*Tursiops truncatus*), common dolphins (*Delphinus delphis*), Risso’s dolphins (*Grampus griseus*), Atlantic white-sided dolphins (*Lagenorhynchus acutus*), Atlantic spotted dolphins (*Stenella frontalis*), and long-finned pilot whales (*Globicephala melas melas*) (Bureau of Ocean Energy Management [BOEM], 2012; Kraus et al., 2016). These species were observed during all seasons, with the greatest sightings in summer and autumn. Harbor porpoises (*Phocoena phocoena*) were also observed in this region, primarily in winter and spring (Kraus et al., 2016).

Acoustic detections of large whale species indicated fin whales were the most commonly detected cetacean species in the region, but humpback (*Megaptera novaeangliae*), minke (*Balaenoptera acutorostata*), blue (*Balaenoptera musculus*), and North Atlantic right whale (*Eubalaena glacialis*) calls were also detected. Cetacean calls were primarily detected in the winter and spring, but fin and humpback whales were detected in all seasons, and minke whales showed a peak acoustic presence in May (Kraus et al., 2016). Visual surveys also indicated that sei whales (*Balaenoptera borealis*) are present in the spring and summer, and sperm whales (*Physeter macrocephalus*) in the summer and autumn (Kraus et al., 2016).

Fish vocalizations were also a substantial source of noise observed in this region. Series of buzzes, grunts, and thumps from unidentified fish species were heard primarily between December and February. The only identifiable fish call was detected between June and August, described as a jack-hammer sound and thought to be produced by striped cusk eels (*Ophidion marginatum*) (Martin et al., 2014).

Vessel noise is the primary man-made source contributing to ambient ocean noise, mainly in the low-frequency bands under 500 Hz (NRC, 2003; Hildebrand, 2009). A large portion of the noise from vessel traffic comes from engines and propeller cavitation, and those noises predominately occupy the low-frequency spectral bands (Richardson et al., 1995). In the open water, ship traffic can influence ambient background noise at distances of thousands of kilometers; however, the effects of ship traffic noise in shelf and coastal waters are variable due to sound reflection, refraction, and absorption by the bathymetric and geological characteristics of the area.

Underwater noise sources associated with the project as identified in the COP include impact and vibratory pile driving implemented during the construction phase; vessels and dynamic positioning (DP) vessels used during all phases including decommissioning; and turbine activity during the operational life of the wind farm facility. Overall, the potential for impacts of noise from these sources on marine species is variable and dependent on the equipment scenarios and circumstances of each exposure situation.

2.1.2.1 Vessel Noise

Vessel noise is characterized as low frequency, typically less than 1,000 Hz with peak frequencies between 10 and 50 Hz, non-impulsive rather than impulsive like impact pile driving, and continuous, versus intermittent such as geophysical surveying. The acoustic signature produced by a vessel varies based on the type of vessel (e.g., tanker, bulk carrier, tug, container ship) and vessel characteristics (e.g., engine specifications, propeller dimensions and number, length, draft, hull shape, gross tonnage, speed). Large shipping vessels and tankers produce lower frequency noise with a primary energy near 40 Hz and underwater SLs for these commercial vessels generally range from 177 to 188 decibels referenced to 1 micropascal at 1 meter (dB re 1 µPa m) (McKenna et al., 2012). Smaller vessels typically produce higher frequency sound (1,000 to 5,000 Hz) at SLs of 150 to 180 dB re 1 µPa m (Kipple and Gabriele, 2003; Kipple and Gabriele, 2004).

DP vessels are known to generate significant underwater noise with continuous SLs ranging from 150 to 180 dB re 1 µPa m (BOEM, 2013; McPherson et al., 2016) depending on operations and thruster use. Acoustic propagation modeling calculations for DP vessel operations were completed by JASCO Applied Sciences, Inc. (JASCO) for two representative locations for pile foundation construction within the SFWF based on a 107 m DP vessel equipped with six thrusters (Denes et al., 2021a). Unweighted root-mean-square sound pressure levels (SPL_{rms}) ranged from 166 dB re 1 µPa at 50 m from the vessel and 120 dB re 1 µPa over 14,000 m from the vessel (Denes et al., 2021a). Further information about this model is provided in **Section 4.2**.

2.1.2.2 Impact Pile Driving

Impact pile driving produces high intensity sound pulses at levels capable of producing injury to marine species (Popper et al., 2014; Halvorsen et al., 2012; NMFS, 2018). Subsequent impacts from the produced noise are dependent upon the physical propagation environment, receiver species, and the implementation and effectiveness of mitigation measures. Pile driving noise produced from foundation installation is expected to fall predominately within low-frequency bandwidths (below 1,000 Hz); however, Bailey et al. (2010) measured broadband sound within 1 km of impact pile driving in Moray Firth off the coast of Ireland.

Noise produced during impact pile driving is a primary concern with respect to underwater noise impacts from SFWF construction. SFW will employ hydraulic (impact) hammers to install foundation piles. Due to the complexity of sound propagation generated from pile driving activities, which includes not only in-water transmission but also seabed transmission, modeled distances to acoustic thresholds often differ from measured distances and highlight the site-specific nature of sound propagation and impact radii during pile installation.

Environmental and seabed conditions, hammer type, and the size and type of pile will all affect the predicted ranges to impact criteria. Measurements may differ from predicted distances due to the many variables influencing sound propagation in the underwater environments. While models and measurements from one project are not fully applicable across other similar projects, they do provide general scales of information for predicting potential impacts during similar activities.

Modeled and *in situ* underwater noise measurements for jacket pile installation of the Block Island Wind Farm showed variability by distance and sample methods (Amaral et al., 2018). Similarly, Patricio et al. (2014) measured noise produced during piling for the Westernmost Rough Wind farm and compared modeled results to field measurements. Patricio et al. (2014) found modeled distances to injury criteria ranged from 15 to 300 m from the pile, and distances based on field measurements ranged from 200 to 1,500 m from the pile for cetaceans.

To help identify the potential for impacts to marine species, site specific acoustic propagation modeling was conducted for impact pile driving for the SFWF and SFEC as described in COP Appendix J1 (Denes et al., 2021a), and results of this model are summarized in **Section 4.2**.

2.1.2.3 Vibratory Pile Driving

Vibratory pile driving produces a non-impulsive sound with peak pressures lower than those generated by impact pile driving (Popper et al., 2014). Measurements from vibratory pile driving of sheet piles during construction activities for bridges and piers indicate that apparent SPL_{rms} produced by this activity can range from 130 to 170 dB re 1 µPa depending on the measured distance from the source and physical properties of the location (Buehler et al., 2015; Illingworth and Rodkin, Inc., 2017). Approximately 10 m from the source, the average SPL_{rms} was approximately 155 dB re 1 µPa, while measurements taken 200 m away were closer to 140 dB re 1 µPa (Illingworth and Rodkin, Inc., 2017). Sound exposure levels (SELs) 10 m away from the source were approximately 162 decibels referenced to 1 micropascal squared seconds (dB re 1 μPa^2 s) (Buehler et al., 2015). Acoustic modeling of vibratory pile driving for the SFEC (COP Appendix J1) is discussed further in **Section 4.2**.

2.1.2.4 Turbine Operation

Wind turbine generators (WTGs) primarily produce two types of noise: aerodynamic turbine blade noise and mechanical noise (Minerals Management Service [MMS], 2007). Mechanical noise may be transmitted underwater through the turbine towers and pilings causing underwater SPL_{rms} noise levels between 80 and 150 dB re 1 µPa, at frequencies within the hearing range of fish and mammals (Bergström et al., 2014). A recent study by Miller and Potty (2017) measured an SPL_{rms} of 100 dB re 1 µPa at 50 m from a set of five GE Haliade 150-6 megawatt (MW) turbines with a peak signal frequency 72 Hz. Other studies measured root-mean-square source levels (SL_{rms}) of operational noise from WTGs ranging from 125 to 130 dB re 1 µPa m across all octave bands (Tougaard et al., 2009; Lindeboom et al., 2011). Maximum SPLs occurred in a one-third octave band level of 25 Hz for a 450-kilowatt (kW) turbine during normal operations (Tougaard et al., 2009; Lindeboom et al., 2011).

In a compilation of case studies published by BOEM in 2017 (English et al., 2017), similar noise levels were identified:

- The one-third octave SPL_{rms} were measured between 90 to 115 dB re 1 μPa at 110 m from a 1.5-MW turbine in Sweden (Thomsen et al., 2006). The frequency range was 20 to 1,000 Hz with peak energy levels occurring at 50, 160, and 200 Hz.
- Pangerc et al. (2016) found the main signal associated with turbine operations had a mean-square power spectral density level that peaked at 126 decibels referenced to 1 micropascal squared per hertz (dB re 1 μPa^2 Hz^{-1}) at the 162 Hz one-third octave band, and a broadband SPL_{rms} of 128 dB re 1 μPa at wind speeds of 10 m s^{-1}.
- Collett and Mason (2014) found that noise from operating turbines dropped to ambient levels at approximately 100 m from the turbine.

While underwater noise from turbines has been measured within the hearing frequency of marine species, impacts, at the anticipated levels, would be limited to audibility, and perhaps some degree of behavioral response or auditory masking (MMS, 2007). Behavioral responses include changes in foraging, socialization, or movement, while auditory masking could impact foraging and predator avoidance. Due to the long expected duration of this source and the low likelihood of impacts to marine species, turbine noise was not included in the acoustic model presented in COP Appendix J1 (Denes et al., 2021a). However, potential impacts from this sound source using published literature are discussed in **Section 5.0**.

2.1.3 Potential Impacts From Underwater Noise

Underwater noise is the primary IPF expected from construction of the SFWF and SFEC. Acoustic impacts can be generalized for marine mammals, sea turtles, and sturgeon. The general impacts of hearing impairment, auditory masking, stress and behavioral responses, and reduction in prey availability are discussed in the sections below. While most available references pertain to marine mammal species, the general impact categories also apply to sea turtles and sturgeon.

2.1.3.1 Hearing Threshold Shifts

The minimum sound level an animal can hear at a specific frequency is called the hearing threshold. Sound levels above a hearing threshold are accommodated until a certain level of sound intensity or duration is reached, after which the ear's hearing sensitivity decreases (i.e., the hearing threshold increases) (Southall et al., 2007). This process is referred to as a threshold shift, meaning that only sounds louder than a certain level will be heard within a given frequency range following the shift. Threshold shifts can be temporary (TTS) or permanent (PTS) and are defined as follows (NMFS, 2018; Southall et al., 2007; Au and Hastings, 2008):

- TTS – also known as auditory fatigue, this is the milder form of hearing impairment that is non-permanent and reversible, results from exposure to high intensity sounds for short durations or lower intensity sounds for longer durations. Both conditions are species-specific, and lead to an elevation in the hearing threshold meaning it is more difficult for an animal to hear sounds. TTS can last for minutes, hours, or days; the magnitude of the TTS depends on the level (frequency and intensity), energy distribution, and duration of the noise exposure among other considerations.

- PTS – a permanent elevation in the hearing threshold and permanent loss of hearing, which is considered an auditory injury. PTS is attributed to exposure to very high SPL_{pk} and short intensity rise times, or very prolonged or repeated exposures to noise strong enough to elicit TTS. Permanent damage to the inner ear such as irreparable damage to sensory hair cells in the cochlea is associated with sound-induced PTS. Because few direct data are currently available regarding noise levels that might induce PTS in marine mammals, PTS onset thresholds are inferred from TTS marine mammal data (NMFS, 2018). For impulsive sources, NMFS acoustic guidance defines dual metric criteria, SPL_{pk} and cumulative sound exposure level (SEL_{cum}), for PTS onsets, as well as the incorporation of frequency weighting functions (M-weighting) to account for the differential hearing abilities in the different functional hearing groups (NMFS, 2018).

- Auditory impairment, either temporary or permanent, is a possibility when marine mammals are exposed to underwater noise. The minimum SPL_{pk} (or SEL_{cum}) necessary to cause PTS is higher than the level that induces TTS, although there are insufficient data to determine the precise difference. Data indicate that TTS onset in marine mammals is more closely correlated with the received SEL_{cum} than with the SPL_{rms} and that received sound energy over time, not just the single strongest pulse, should be considered a primary measure of potential impact (Southall et al., 2007; NMFS, 2018).

2.1.3.2 Barotrauma

Barotrauma can occur in marine mammals, sea turtles, and fish if exposed to rapid pressure changes that can theoretically be realized within close proximity to an impact pile driving source. However, barotrauma is typically only associated with explosives when considering impacts to marine mammals and sea turtles; therefore, it is only discussed within the context of fish impacts for this Appendix. Fish are the only species considered to potentially be within the proximity of pile driving to receive the pressure changes necessary to induce barotrauma. Barotrauma results from rapid and instantaneous changes in ambient pressure level in the water as well as within the fluids and tissue of the animal causing physical injury to soft tissue and organs.

Injury to fish from exposure to impulsive sound would likely be due to barotrauma (Carlson, 2012; Halvorsen et al., 2012a,b). Barotrauma is a tissue injury resulting from rapid changes in pressure. Barotrauma injuries in fish involve the swim bladder or dissolved gases in the blood and tissues. It can cause ruptured capillaries and internal hemorrhaging to the organs, fins, or eyes, hematoma, and a deflated or ruptured swim bladder. Depending on the affected tissues or organs, the resulting injuries may be mild (e.g., external fin hematoma; deflated, but not ruptured swim bladder), moderate (e.g., renal, intestinal, muscular hematoma), or lethal (e.g., pericardial or cerebral hemorrhage, gill embolism, ruptured swim bladder) (Brown et al., 2012; Rummer and Bennett, 2005; Gaspin, 1975; Yelverton et al., 1975; Christian, 1973; Goertner, 1978).

Some fishes, such as sturgeon and salmonids, have the ability to voluntarily rapidly release the gas from their swim bladder. The ability to vent swim bladder gas means that when the swim bladder is under pressure during an acoustic event, these fishes can decrease the volume of swim bladder gas, thereby partially protecting themselves from barotrauma injuries.

A controlled exposure laboratory study by Halvorsen et al. (2012a) exposed several fish species to an underwater SEL_{cum} ranging from 204 to 216 dB re 1 μPa^2 s. At an SEL_{cum} greater than 210 dB re 1 μPa^2 s, lake sturgeon (*Acipenser fulvescens*), whose swim bladder is not involved in hearing, experienced recoverable barotrauma injuries characterized by hematomas on the swim bladder, kidney, and intestine, and a partially deflated swim bladder, but showed no external or mortal injuries. Nile tilapia (*Oreochromis niloticus*), which have a swim bladder that is involved in hearing, are thus more vulnerable to barotrauma at a relatively lower SEL_{cum}; they exhibited recoverable injuries including gonadal and swim bladder hematoma at 207 to 210 dB re 1 μPa^2 s and lethal injuries such as a ruptured swim bladder and renal hemorrhage at 213 to 216 dB re 1 μPa^2 s. By contrast, no internal or external barotrauma injuries were observed at any of the SEL_{cum} for hogchoker (*Trinectes maculatus*), a flatfish that lacks a swim bladder. Although this study was conducted in a controlled laboratory setting, it replicated acoustic conditions in the field.

Barotrauma injuries may be more severe for fish exposed to fewer hammer blows at higher energy versus a greater number of hammer blows at lower energy, even when the SEL_{cum} are equivalent. In a study by Halvorsen et al. (2012b), juvenile Chinook salmon (*Oncorhynchus tshawytscha*) were exposed to an underwater SEL_{cum} ranging from 204 to 220 dB re 1 μPa^2 s and SPL_{pk} from 199 to 213 dB re 1 μPa. The fish exposed to SEL_{cum} of 213 to 220 dB re 1 μPa^2 s and SPL_{pk} of 210 to 213 dB re 1 μPa exhibited a greater number of barotrauma injuries, specifically those that were classified as moderate or having the potential to cause delayed mortality.

Overall, it is more likely that fish will experience sub-lethal impacts that increase the possibility for delayed mortality (Hawkins et al., 2014). Because the majority of construction sound sources produce low-frequency noise that is within the sensitive hearing range of most fish, the potential for fish to experience TTS, masking, and behavioral impacts are a higher likelihood than permanent injury or mortality.

2.1.3.3 Auditory Masking

In addition to affecting hearing, noise can partially or completely reduce an individual's ability to effectively communicate; detect important predator, prey, and conspecific signals; and detect important environmental features associated with spatial orientation (Clark et al., 2009). This is defined as auditory masking, where a reduction in the detectability of a sound signal of interest (e.g., communication calls, echolocation) occurs due to the presence of another sound, which is usually background noise in the environment, often for sounds with similar frequencies. Under normal circumstances, in the absence of high background noise levels, an animal would hear a sound signal if it is above its absolute hearing threshold. Auditory masking prevents part or all of a sound signal from being heard and decreases the distances that underwater sound can be detected by marine animals (i.e., reduction in communication space). These effects could cause a long-term decrease in a marine mammal's efficiency at foraging, navigating, or communicating (International Council for the Exploration of the Sea [ICES], 2005). For some types of marine mammals, specifically common bottlenose dolphins, beluga whales (*Delphinapterus leucas*), and killer whales (*Orcinus orca*), empirical evidence confirms that the degree of masking depends strongly on the relative directions at which noise arrives and the characteristics of the masking sound (Penner et al., 1986; Dubrovskiy, 1990; Bain et al., 1993; Bain and Dahlheim, 1994).

Ambient noise from natural and anthropogenic sources can result in masking for marine animals, effectively interfering with the ability of an animal to detect a sound signal that it otherwise would hear. Spectral, temporal, and spatial overlap between the masking sound and the sender/receiver determines the extent of interference; the greater the spectral and temporal overlap, the greater the potential for masking. Naturally occurring ambient noise is produced from various sources, including environmental noise from wind, waves, precipitation, and earthquakes; biological sounds produced by animals; and thermal noise resulting from molecular agitation (at frequencies above 30 kHz) (Richardson et al., 1995). Biological sounds are commonly produced by fish, for example, which create low-frequency sounds (50 to 2,000 Hz, most often from 100 to 500 Hz) that can be a significant component of local ambient sound levels (Zelick and Mann, 1999; Martin et al., 2014). Anthropogenic sources known to contribute to ambient sound levels can include boats and ships, sonar (military and commercial), geophysical surveys, acoustic deterrent devices, construction noise, and scientific research sensors. Ambient noise is highly variable in the shallower waters over continental shelves (Desharnais et al., 1999) where many anthropogenic activities occur, effectively creating a wide range of sound levels and frequencies at which anthropogenic noises can be detected. In coastal waters, noise from boats and ships, particularly commercial vessels, are the predominant source of anthropogenic noise (Parks et al., 2011).

Over the past 50 years, commercial shipping, the largest contributor of anthropogenic sound (McDonald et al., 2008), has increased the ambient sound levels in the deep ocean at low frequencies by 10 to 15 dB re 1 μPa (Hatch and Wright, 2007). This increase in low-frequency ambient noise coincides with a significant increase in the number and size of vessels making up the world's commercial shipping fleet (Hildebrand, 2009). Tournadre (2014) estimated from satellite altimetry data that, globally, ship traffic grew by approximately 60% from 1992 to 2002 at a nearly constant rate of approximately 6% per year; however, after 2002, the rate of increase in ship traffic rose steadily to more than 10% by 2011, except in 2008 and 2009 when ship traffic remained steady. The highest estimated rate of growth was in the Indian and western North Pacific Oceans, especially in the continental seas along China; the rate of growth in shipping in the Atlantic Ocean and Mediterranean Sea, however, decreased after 2008 (Tournadre, 2014).

2.1.3.4 Stress and Behavioral Responses

Stress and behavioral changes are the result of marine mammals responding to extreme or excessive disturbances in their environment, either of natural or anthropogenic origin. Stress responses are typically physiological changes in a marine mammal's blood chemistry while behavioral responses involve changes in a marine mammal's normal actions.

Stress is a change in the body's equilibrium in response to an extreme environmental or physiological disruption. Marine mammals respond to environmental stress by releasing biochemicals into their blood stream, and measuring changes in an animal's blood chemistry can indicate a stress response. Stress responses in marine mammals are immediate, acute, and characterized by the release of neurohormones such as norepinephrine, epinephrine, and dopamine (Office of Naval Research, 2009). The NRC (2003) examined acoustically induced stress in marine mammals and stated that a one-time exposure to noise was less likely to have population-level effects than noises animals are exposed repeatedly over extended periods of time. Various researchers have summarized the available evidence regarding stress induced events (e.g., Romano et al., 2004; Cowan and Curry, 2008; Mashburn and Atkinson, 2008; Eskesen et al., 2009).

Romano et al. (2004) examined the levels of three stress-related blood hormones (norepinephrine, epinephrine, and dopamine) in a beluga whale after exposure to varying SPL_{pk} signals produced by a seismic water gun between 198 and 226 dB re 1 μPa. Hormone levels were measured after a control, low-level sound, and a high-level sound exposure. No significant differences in the hormone blood concentrations were found between the control and low-level sound exposure, but elevated levels of all three hormones were measured in response to high-level sound exposure. Furthermore, a regression analysis demonstrated a linear trend for increased hormone level with sound level. Romano et al. (2004) noted that no quantitative approach to estimating changes in mortality or fecundity due to stress has been identified, but qualitative effects may include increased susceptibility to disease and early termination of pregnancy.

Following the terrorist attacks of September 11, 2001, shipping traffic dramatically decreased in the Bay of Fundy, Canada, resulting in a 6-dB decrease in the ambient underwater noise level, including a significant reduction below 150 Hz, which was associated with decreased baseline levels of stress-related hormone metabolites in North Atlantic right whales. This reduction in ambient noise levels associated with shipping was the first evidence that exposure to low-frequency noise from shipping may be associated with chronic stress in whales, particularly North Atlantic right whales (Rolland et al., 2012).

Anthropogenic noise in aquatic environments has also been demonstrated to elicit a stress response in fish. This response has been measured in terms of short-term (i.e., less than an hour) indicators such as a startle response, increased gill ventilation, increased heart rate and blood pressure, increased plasma cortisol and glucose levels, and increased oxygen intake, as well as long-term (i.e., days to months) indicators including reduced foraging, growth and reproductive fitness, diminished immune response, and increased vulnerability to predation (Smith et al., 2004; Sierra-Flores et al., 2015; Bruintjes et al., 2016a,b; Simpson et al., 2016). Temporary stressors such as pile driving and vessel noise may cause a short-term stress response in fish, but the potential for these activities to cause longer term growth and fitness consequences has not been demonstrated for fish in a field setting. In general, fish may acclimate to long-term exposure to acoustic stressors (Schreck, 2000). Goldfish (*Carassius auratus*) exposed to long-term, continuous sound sources, such as the hum or vibration of vessel traffic at SPL_{rms} of 160 to 170 dB re 1 μPa, exhibited a short-term stress response characterized by increased cortisol and glucose levels, but they did not exhibit a long-term physiological stress response (Smith et al., 2004).

Disturbances can also cause subtle to extreme changes in normal behavior, with some behavioral responses resulting in biologically significant consequences. Behavioral responses including startle, avoidance (i.e., changes in swim speed and direction), displacement, diving, and vocalization alterations have been observed in mysticetes, odontocetes, and pinnipeds. In some cases, these have occurred at ranges of tens to hundreds of kilometers from the sound source (Gordon et al., 2004; Tyack, 2008; Miller et al., 2014). However, behavioral observations are variable, some findings are contradictory, and the biological significance of the effects are not fully quantified (Gordon et al., 2004). Behavioral reactions of marine mammals to noise are difficult to predict because reactions depend on numerous factors including the species being evaluated; the animal's state of maturity, prior experience with or exposure to anthropogenic noises, current activity patterns, and reproductive state; time of day; and weather state (Wartzok et al., 2004). There is also the potential for differences among individuals of the same species (Castellote et al., 2014). If a marine mammal reacts to underwater noise by changing its behavior or moving to avoid the sound, the impacts of that change may not be important to the individual, the stock, or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area, impacts on individuals and the population could be significant.

Assessing the severity of marine mammal behavioral effects associated with anthropogenic noise exposure presents unique challenges due to the inherent complexity of behavioral responses and the contextual factors affecting them, both within and between individuals and species. Severity of responses can vary depending on characteristics of the sound source including whether it is moving or stationary, the number and spatial distribution of sound source(s), its similarity to predator sounds, and other relevant factors (Richardson et al., 1995; NRC, 2005; Southall et al., 2007; Bejder et al., 2009; Barber et al., 2010; Ellison et al., 2012).

Many examples have been reported of individuals of the same species exposed to the same noise reacting differently (Nowacek et al., 2004), as well as different species reacting differently to the same noises (Bain and Williams, 2006). Odontocetes appear to exhibit a greater variety of reactions to man-made underwater noise than mysticetes. Odontocete reactions can vary from approaching vessels (e.g., bow riding) to strong avoidance. Richardson et al. (1995) noted that most small and medium-sized odontocetes exposed to prolonged or repeated underwater noises are unlikely to be displaced unless the overall received SPL_{rms} is at least 140 dB re 1 μPa.

Limited data exist on sound levels that may induce stress or behavioral changes in sea turtles (Nelms et al., 2016), and no data exist on population impacts from acoustic disturbance in sea turtles. Lavender et al. (2011) collected behavior audiograms from sea turtles and found that loggerhead sea turtles (*Caretta caretta*) may be more sensitive to behavioral disturbance from underwater sound than electrophysiological studies suggest. Avoidance responses by sea turtles to seismic signals have been observed at received SPL_{rms} between 166 and 179 dB re 1 µPa (McCauley et al., 2000); however, these studies were done in a caged environment, so the extent of avoidance could not be fully monitored. During experiments using airguns to repel sea turtles from dredging operations, Moein et al. (1994) observed a habituation effect to seismic sounds; the animals stopped responding to the signal after three presentations, although it was not clear whether this was a result of behavioral habituation or physical effects from TTS or PTS. The potential effects of impulsive sound on sea turtles are likely to be varied and sometimes cryptic (Nelms et al., 2016). The frequency and duration of exposure are not discussed in the literature, however this topic is important when determining the level of risk to sea turtles.

2.1.3.5 Reduction of Prey Availability

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

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

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

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

2.2 VESSEL TRAFFIC

Vessel traffic poses a physical strike risk to marine species, particularly those that spend time at the surface such as marine mammals and sea turtles. A temporary increase in vessel traffic is expected around the SFWF and along routes between the SFWF and the ports used to support project construction, operation and maintenance (O&M), and decommissioning. Timing of vessel traffic will be clarified once final construction schedules are issued and approved. The number of vessel transits back and forth to the SFWF and how long they will remain on station varies according to foundation type and is greatly dependent on final design factors, weather, sea conditions, and other natural factors. The larger installation vessels, like the floating/jack-up crane barge and DP cable-laying vessel, will generally travel to and out of the construction area at the beginning and end of the SFWF construction and not on a regular basis. Tugs and barges transporting construction equipment and materials will make more frequent trips while smaller support vessels carrying supplies and crew may travel to and from the SFWF daily. However, construction crews responsible for assembling the WTGs will hotel onboard installation vessels at sea, limiting the number of crew vessel transits expected during SFWF installation. During SFWF O&M, vessel traffic will be limited to routine maintenance visits and non-routine maintenance, as needed. Limited crew and supply runs using smaller support vessels will be required.

Table 3.1-6 in the COP outlines the project vessels, vehicles, and associated activities planned for use during installation, operations, and decommissioning of the SFWF and SFEC.

2.3 SEAFLOOR DISTURBANCE

Seafloor disturbances will occur during the installation of the foundations for up to 15 WTGs, one offshore substation, the installation of the inter-array cables, submarine export cable, and horizontal directional drilling (HDD) as part of the sea-to-shore transition area. During O&M, disturbance will be associated with changes in seafloor, water column, and land because of the presence of infrastructure and anchored maintenance vessels. Over the life of the installation, the foundation and scour infrastructure will change the seafloor and associated habitat by creating a reefing effect that results in colonization by assemblages of both sessile and mobile animals. The introduction of additional structural habitat and food resources could have beneficial impacts on sea turtles. Some species of marine mammals may also opportunistically take advantage of increased fish and invertebrate aggregations around the pile foundations. There is very little information available about the long term activities of marine mammals and sea turtles around wind foundations. Much of the assessment information is derived from other ocean-based structures such as oil platforms.

3.0 Description of the Affected Resources

3.1 MARINE MAMMALS

There are 36 species of marine mammals in the Northwest Atlantic Outer Continental Shelf (OCS) region that are protected by the MMPA (**Table 4**) (BOEM, 2014). The marine mammal assemblage comprises cetaceans (whales, dolphins, and porpoises), pinnipeds (seals), and sirenians (manatee).

There are 31 cetaceans, including 25 members of the suborder Odontoceti (toothed whales, dolphins, and porpoises) and 6 of the suborder Mysticeti (baleen whales) within the region. Five whale species listed as Endangered under the ESA have ranges that include the Project Area:

- Fin whale (*Balaenoptera physalus*);
- Sei whale (*Balaenoptera borealis*);
- Blue whale (*Balaenoptera musculus*);
- North Atlantic right whale (*Eubalaena glacialis*); and
- Sperm whale (*Physeter macrocephalus*).

Along with cetaceans, seals are also protected under the MMPA. There are four species of phocids (true seals) with ranges that include the Project Area, including harbor seals (*Phoca vitulina*), gray seals (*Halichoerus grypus*), harp seals (*Pagophilus groenlandicus*), and hooded seals (*Cystophora cristata*) (Hayes et al., 2020). Finally, one species of sirenian, the Florida manatee (*Trichechus manatus*) is an occasional visitor to the region during summer months (U.S. Fish and Wildlife Service [USFWS], 2019). The Florida manatee is listed as Threatened under the ESA and is protected under the MMPA along with the other marine mammals.

The expected occurrence of each species is based on information provided in the BOEM RI-MA Environmental Assessment (EA) (BOEM, 2013), the Incidental Harassment Authorization (IHA) issued to Deepwater Wind, LLC for marine construction activity off the coast of New York (82 *Federal Register* [*FR*] 32330), and the Northeast Large Pelagic Survey (Kraus et al., 2016), and/or species habitat models (Roberts et al., 2016, Roberts, 2018, 2020) available for the Project Area. Five categories for marine mammal occurrence within the Project Area are applied in this application, including:

- Common – Occurring consistently in moderate to large numbers;
- Regular – Occurring in low to moderate numbers on a regular basis or seasonally;
- Uncommon – Occurring in low numbers or on an irregular basis;
- Rare – Records for some years but limited; and
- Not expected – Range includes the Project Area but due to habitat preferences and distribution information species are not expected to occur in the Project Area although records may exist for adjacent waters.

The protection status, stock identification, occurrence, and abundance estimates of each marine mammal species with geographic ranges that include the Project Area are listed in **Table 3-1**.

Table 3-1. Marine mammals with geographic ranges that include the Project Area.

Common Name	Scientific Name	Stock	Federal ESA/MMPA Status	Relative Occurrence in the SFWF and SFEC	Best Estimate[1]
Order Cetacea					
Suborder Mysticeti (baleen whales)					
Minke whale	*Balaenoptera acutorostrata*	Canadian East Coast	Non-strategic	Common	21,968
Sei whale	*Balaenoptera borealis*	Nova Scotia	ESA Endangered/ Depleted and Strategic	Regular	6,292
Blue whale	*Balaenoptera musculus*	Western North Atlantic	ESA Endangered/ Depleted and Strategic	Rare	402
Fin whale	*Balaenoptera physalus*	Western North Atlantic	ESA Endangered/ Depleted and Strategic	Common	6,802
North Atlantic right whale	*Eubalaena glacialis*	Western North Atlantic	ESA Endangered/ Depleted and Strategic	Common	412
Humpback whale	*Megaptera novaeangliae*	Gulf of Maine	Non-strategic	Common	1,393
Suborder Odontoceti (toothed whales, dolphins, and porpoises)					
Sperm whale	*Physeter macrocephalus*	North Atlantic	ESA Endangered/ Depleted and Strategic	Common	4,349
Pygmy sperm whale	*Kogia breviceps*	Western North Atlantic	Non-strategic	Rare	7,750
Dwarf sperm whale	*Kogia sima*	Western North Atlantic	Non-strategic	Rare	7,750
Northern bottlenose whale	*Hyperoodon ampullatus*	Western North Atlantic	Non-strategic	Not Expected	unknown
Cuvier's beaked whale	*Ziphius cavirostris*	Western North Atlantic	Non-strategic	Rare	5,744
Mesoplodont beaked whales	*Mesoplodon spp.*	Western North Atlantic	Depleted	Rare	10,107
Killer whale	*Orcinus orca*	Western North Atlantic	Non-strategic	Rare	unknown
False killer whale	*Pseudorca crassidens*	Western North Atlantic	Strategic	Rare	1,791
Pygmy killer whale	*Feresa attenuata*	Western North Atlantic	Non-strategic	Not Expected	unknown
Short-finned pilot whale	*Globicephala macrorhynchus*	Western North Atlantic	Strategic	Rare	28,924
Long-finned pilot whale	*Globicephala melas*	Western North Atlantic	Strategic	Common	39,215
Melon-headed whale	*Peponocephala electra*	Western North Atlantic	Non-strategic	Not Expected	unknown
Risso's Dolphin	*Grampus griseus*	Western North Atlantic	Non-strategic	Common	35,493
Common dolphin	*Delphinus delphis*	Western North Atlantic	Non-strategic	Common	172,974
Fraser's dolphin	*Lagenodelphis hosei*	Western North Atlantic	Non-strategic	Rare	unknown
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	Western North Atlantic	Non-strategic	Common	93,233
White-beaked dolphin	*Lagenorhynchus albirostris*	Western North Atlantic	Non-strategic	Rare	536,016

Table 3-1. (Continued).

Common Name	Scientific Name	Stock	Federal ESA/MMPA Status	Relative Occurrence in the SFWF and SFEC	Best Estimate[1]
Pantropical spotted dolphin	*Stenella attenuata*	Western North Atlantic	Non-strategic	Rare	6,593
Clymene dolphin	*Stenella clymene*	Western North Atlantic	Non-strategic	Not Expected	4,237
Striped dolphin	*Stenella coeruleoalba*	Western North Atlantic	Non-strategic	Rare	67,036
Atlantic spotted dolphin	*Stenella frontalis*	Western North Atlantic	Non-strategic	Uncommon	39,921
Spinner dolphin	*Stenella longirostris*	Western North Atlantic	Non-strategic	Rare	4,102
Rough toothed dolphin	*Steno bredanensis*	Western North Atlantic	Non-strategic	Rare	136
Common bottlenose dolphin	*Tursiops truncatus*	Western North Atlantic, offshore	Non-strategic	Common	62,851
		Western North Atlantic, Northern migratory coastal	Depleted and Strategic	Rare	6,639
Harbor porpoise	*Phocoena phocoena*	Gulf of Maine/Bay of Fundy	Non-strategic	Common	95,543
Order Carnivora					
Suborder Pinnipedia					
Hooded seal	*Cystophora cristata*	Western North Atlantic	Non-strategic	Rare	unknown
Gray seal	*Halichoerus grypus*	Western North Atlantic	Non-strategic	Regular	27,131
Harp seal	*Pagophilus groenlandica*	Western North Atlantic	Non-strategic	Rare	unknown
Harbor seal	*Phoca vitulina*	Western North Atlantic	Non-strategic	Regular	75,834
Order Sirenia					
Florida manatee[2]	*Trichechus manatus latirostris*	-	ESA Threatened/ Depleted and Strategic	Rare	13,000[3]

ESA = Endangered Species Act; MMPA = Marine Mammal Protection Act.
[1]Best estimate from the most recently updated National Oceanic and Atmospheric Administration Stock Assessment Reports (National Marine Fisheries Service, 2020).
[2]Under management jurisdiction of United States Fish and Wildlife Service rather than National Marine Fisheries Service (USFWS, 2019).
[3]Current range-wide estimate from the USFWS (2019).

Definitions:

- Common – Occurring consistently in moderate to large numbers;
- Regular – Occurring in low to moderate numbers on a regular basis or seasonally;
- Uncommon – Occurring in low numbers or on an irregular basis;
- Rare – Records for some years but limited; and
- Not expected – Range includes the Project Area but due to habitat preferences and distribution information species are not expected to occur in the Project Area although records may exist for adjacent waters.

Of the 36 marine mammal species with geographic ranges that include the Project Area, 16 species can be reasonably expected to reside, traverse, or routinely visit the Project Area in densities that could result in acoustic exposures during the construction period, and therefore, be considered *affected species*. Species not expected or rare are not carried forward in this Appendix. The following affected species are those that have a common, uncommon, or regular relative occurrence in the Project Area, or have a very wide distribution with limited distribution or abundance details.

- Fin whale (*Balaenoptera physalus*);
- Minke whale (*Balaenoptera acutorostrata*);
- Sei whale (*Balaenoptera borealis*);
- Humpback whale (*Megaptera novaeangliae*);
- North Atlantic right whale (*Eubalaena glacialis*);
- Blue whale (*Balaenoptera musculus*);
- Sperm whale (*Physeter macrocephalus*);
- Long-finned pilot whale (*Globicephala melas*)
- Atlantic spotted dolphin (*Stenella frontalis*);
- Atlantic white-sided dolphin (*Lagenorhynchus acutus*);
- Common dolphin (*Delphinus delphis*);
- Risso's dolphin (*Grampus griseus*);
- Common bottlenose dolphin (*Tursiops truncatus*);
- Harbor porpoise (*Phocoena phocoena*);
- Grey seal (Halichoerus grypus); and
- Harbor seal (*Phoca vitulina*).

Species information was based on a review of NMFS stock assessment reports (SARs) (Hayes et al., 2017, 2018, 2019, 2020; NMFS, 2020; Waring et al., 2015), and regional survey records (e.g., Cetacean and Turtle Assessment Program [CETAP] 1982; Atlantic Marine Assessment Program for Protected Species [AMAPPS], 2010 to 2014; North Atlantic Right Whale Sighting Survey [NARWSS] (Khan et al., 2018), 2003 to 2013; BOEM RI-MA EA [BOEM, 2013]); and preliminary results (unpublished) of mitigation surveys conducted during 2017 and 2018.

Species will not be equally affected by the proposed activities due to individual exposure patterns, the context in which noise is received, and, most prominently, individual hearing sensitivities. To account for this sensitivity, marine mammal species are categorized into functional hearing groups that are designated to better predict and quantify impacts of noise (Southall et al., 2007; NMFS, 2018). These functional hearing groups are described below with associated reference frequencies. While all these species likely hear beyond these bounds, primary sensitivities fall within the listed frequencies (**Section 1.2.1.2**).

- Low-frequency cetaceans (LFC): 7 Hz and 25 kHz;
- Mid-frequency cetaceans (MFC): 150 Hz and 160 kHz;
- High-frequency cetaceans (HFC): 200 Hz and 180 kHz; and
- Phocid pinnipeds (true seals) in water (PPW): 75 Hz to 100 kHz.

The following information summarizes data on the status and trends, distribution and habitat preferences, behavior and life history, and auditory capabilities of marine mammals found in the Northwest Atlantic OCS region as available in published literature and reports, including NMFS marine mammal SARs (Waring et al., 2006, 2007, 2014, 2015, 2016; Hayes et al., 2017, 2018, 2019, 2020; NMFS, 2020).

3.1.1 Non-ESA Listed Species

The non-ESA listed species that are likely to occur within the SFWF area include the humpback whale, minke whale, Atlantic white-sided dolphin, common bottlenose dolphin, long-finned pilot whale, Risso's dolphin, common dolphin, harbor porpoise, gray seal, and harbor seal (Kraus et al., 2016; CSA Ocean Sciences, 2018; Hayes et al., 2020; NMFS, 2020). Not all species have the same likelihood of occurrence and some may be highly seasonal, but all have records or show positive habitat densities (Roberts et al., 2016; Roberts, 2018, 2020) in the region encompassing the SFWF and SFEC project areas. Some species in **Table 3-1** (i.e., white-beaked dolphin [*Lagenorhynchus albirostris*], harp seal and hooded seal), while potentially present in the region, are not expected to occur in or near the SFWF or SFEC project areas. Regional occurrence for these species were based on information from Kenney and Vigness-Raposa (2010) who analyzed existing data for the region around Rhode Island Sound, Block Island Sound, and the outer continental shelf out to the 50 m isobath. While these species were classified as common or regular for the region in this report, surveys conducted in the RI-MA WEA indicate they are unlikely to be encountered around the SFWF Project Area. The remaining species were classified as rare or hypothetical by Kenney and Vigness-Raposa (2010) and are also unlikely to be encountered in the SFWF project area (BOEM, 2013; Klaus et al., 2016). Only those species that are likely to occur in the SFWF area are included in the acoustic exposure assessment (**Section 5.4**) and have the potential to be affected by Project activities (**Section 5.0**).

3.1.1.1 Humpback Whale

<u>South Fork Wind Farm</u>

The humpback whale can be found worldwide in all major oceans from the equator to sub-polar latitudes. In the summer, humpbacks are found in higher latitudes feeding in the Gulf of Maine and Gulf of Alaska. During the winter months, humpbacks migrate to calving grounds in subtropical or tropical waters, such as the Dominican Republic in the Atlantic and Hawaiian Islands in the Pacific (NMFS, 2020). Humpback whales from the North Atlantic feeding areas mate and calve in the West Indies (NMFS, 2020).

NMFS revised the listing status for humpback whales under the ESA (81 *FR* 62259). Globally, there are 14 distinct population segments (DPS) recognized for humpback whales, four of which are listed as endangered. The Gulf of Maine stock (formerly known as the Western North Atlantic stock) is not considered strategic under the MMPA and does not coincide with any ESA-list DPS (NMFS, 2020). The global humpback whale population is listed as Least Concern on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List (IUCN, 2018). Recent estimates of the Gulf of Maine stock based on photo identification recapture data through October 2016 estimate a population abundance of 1,393 (NMFS, 2020). These data indicate that this stock is characterized by a positive population trend. The best available estimate of the average rate of increase for the West Indies breeding population (which includes the Gulf of Maine stock) is 3.1% per year.

Kraus et al. (2016) reported humpback whale sightings in the RI-MA WEA during all seasons, with peak abundance during the spring and summer. Their presence within the region varies between years (Kraus et al., 2016). Stocks of sand lance (*Ammodytes* spp.) appear to correlate with the years in which the most abundant whales are observed, suggesting that humpback whale distribution and occurrences could be largely be influenced by prey availability (Kenney and Vigness-Raposa, 2010). The greatest number of sightings of humpbacks in the RI-MA WEA occurred during April (33 sightings); their presence started in March and continuing through July. Seasonal abundance estimates of humpback whales range from 0 to 41, with higher estimates observed during the spring and summer (Kraus et al., 2016). Within the WEA, the species per unit effort (SPUE) ranged from 0.2 to 40 whales per 1,000 km in the spring and 100 to 200 whales per 1,000 km in the summer (BOEM, 2013; Kraus et al., 2016). Detections within the RI-MA WEA were primarily during the summer months (Kraus et al., 2016). Based on these data, humpback whales would occur in the SFWF area; however, most likely only during the summer.

<u>South Fork Export Cable</u>

In the 1980s, numerous sightings of humpbacks were reported between Long Island and Martha's Vineyard by Montauk and Galilee whale-watching boats. Montauk boats reported 2 sightings in 1986, and 63 sightings in 1987 (Kenney and Vigness-Raposa, 2010). Recently, multiple humpbacks were reported feeding off Long Island during July 2016 and near New York City during November to

December 2016 (Waring et al., 2016). Humpback strandings have also been reported along the southern shore of eastern Long Island in February 1992, November 1992, October 1993, August 1997, and April 2004.

Humpbacks do occur within the SFEC route area; however, their presence is relatively unpredictable and may be strongly influenced by prey availability (Kenney and Vigness-Raposa, 2010). During most years, their occurrence within the SFEC route area would be rare; however, they may become locally abundant in certain years.

3.1.1.2 Minke Whale

<u>South Fork Wind Farm</u>

Minke whales prefer the colder waters of the northern and southern latitudes but they can be found in every ocean in the world. They stay in relatively shallow, coastal, and inshore waters; therefore, they have the potential to be found within the SFWF area. The minke whale is the smallest of the North Atlantic baleen whales with adults ranging from approximately 6 to 10 m in length (Jefferson et al., 1993).

A prominent feature is the large, pointed median ridge on top of the rostrum. The body is dark gray to black with a pale belly, and frequently shows pale areas on the sides that may extend up onto the back. The flippers are smooth and taper to a point, and the middle third of each flipper has a conspicuous bright white band. The dorsal fin is tall, prominent, and falcate, and is located about two-thirds of the way back along the body (Kenney and Vigness-Raposa, 2010).

Minke whales are not listed under the ESA or classified as strategic under the MMPA and are classified as Least Concern on the IUCN Red List (IUCN, 2018; NMFS, 2020). The best available current global abundance estimate for the common minke whale, compiled by the IUCN Red List, is around 200,000 (Cooke et al., 2018). The most recent population estimate for the Canadian East Coast stock is 21,968 minke whales, which was derived from the 2016 shipboard and aerial surveys (NMFS, 2020). There are no current population trends or current and maximum net productivity rates for this species, as the abundance estimates are imprecise. An assumed maximum net productivity rate of 0.04 is used, based on theoretical modeling showing that cetacean populations are not expected to grow at a rate 4% or greater given the constraints of their reproductive lives (NMFS, 2020).

Over the course of BOEM’s study, 103 minke whales were sighted within the lease area. Spring observations included the most individuals (76 sightings) followed by summer (26 sightings), with and fall (1 sighting) (Kraus et al., 2016). The SPUE within the WEA ranged from 0.1 to 35 whales per 1,000 km in the spring and summer (BOEM, 2013; Kraus et al., 2016). Minke whales are likely to occur in the spring and summer within the SFWF Project area.

<u>South Fork Export Cable</u>

Minke whales were reported in the Rhode Island Special Area Management Plan (SAMP) study area during all four seasons (Kenney and Vigness-Raposa, 2010). A large proportion of these sightings were reported from whale-watching boats. A dense concentration was seen between Block Island and Montauk Point in the spring and summer (Kenney and Vigness-Raposa, 2010); making it likely that this species would occur within the SFEC route and within the vicinity of the SFEC south approach area.

3.1.1.3 Atlantic Spotted Dolphin

<u>South Fork Wind Farm</u>

Atlantic spotted dolphins are found in tropical and warm temperate waters. In the western North Atlantic, their distribution ranges from southern New England south through the Gulf of Mexico and the Caribbean to Venezuela (Waring et al., 2014). They generally occur in coastal or continental shelf waters from 20 to 250 m deep (NMFS, 2020). The Atlantic spotted dolphin occurs in two ecotypes which may be distinct sub-species. The larger heavily spotted form inhabits the continental shelf waters and is usually found inside or near 200 m isobath. The smaller form is less spotted and is found offshore and only occurs in the Atlantic. Both ecotypes can occur in southern New England; however, they are difficult to differentiate at sea (Waring et al., 2014).

Atlantic spotted dolphins are not listed under the ESA and are classified as Data Deficient on the IUCN Red List (Kenney and Vigness-Raposa, 2010). The best population estimate available for this species is 39,921 (Hayes et al., 2020). Data are insufficient to determine the population trend for this species, but they are not considered a strategic stock under the MMPA because estimates of human-cause mortality and injury do not exceed the calculated potential biological removal (PBR) (Hayes et al., 2020).

There are few reported occurrences of spotted dolphins in the Project Area. CETAP described spotted dolphins as the seventh most commonly sighted cetaceans in the study area, with 126 sightings over the course of 3-year study. The 1982 CETAP data observed 40 individuals south of Block Island (CETAP, 1982). NMFS shipboard surveys conducted during June-August between central Virginia and the Lower Bay of Fundy reported 542 to 860 individual sightings from two separate visual teams (Palka, et al., 2017). Atlantic spotted dolphins tend to be a more subtropical and offshore species, so while they may be encountered in the SFWF area, this would be an uncommon occurrence.

<u>South Fork Export Cable</u>

Atlantic spotted dolphins tend to be more of a subtropical and offshore species; therefore, they are not likely to occur in the SFEC route area.

3.1.1.4 Atlantic White-sided Dolphin

<u>South Fork Wind Farm</u>

Atlantic white-sided dolphins migrate between the temperate and polar waters of the North Atlantic Ocean, but usually maintain migration routes over the deeper-sloped continental shelves. This is the most abundant dolphin in the Gulf of Maine and the Gulf of St. Lawrence, but they are rarely seen off the coast of Nova Scotia (Kenney and Vigness-Raposa, 2010). The Atlantic white-sided dolphin gets its name from the distinctive white stripe on its side, which starts just below the dorsal fin and runs into a yellow/ochre blaze continuing onto the tailstock, which is easily seen when the animal is bow-riding or porpoising. It has a whitish lower jaw, throat, and belly to genital region, with a dark eye patch and face-flipper stripe (Jefferson et al., 1993; Cipriano, 2002).

Behaviorally, this species is highly social, but not as demonstrative as some other common dolphins. They typically form pods of around 30 to 150 individuals but have also been seen in very large pods of 500 to 2,000 individuals (Hayes et al., 2020). It is common to find these pods associated with the presence of other white-beaked dolphins, pilot whales, fin whales, and humpback whales.

Atlantic white-sided dolphins are not listed under the ESA or considered a strategic stock under the MMPA and are classified as Least Concern on the IUCN Red List (Hammond et al., 2008a; Hayes et al., 2020). A recent population estimate for Atlantic white-sided dolphins off the U.S. East Coast places this species at 93,233 individuals (Hayes et al., 2020).

Seasonal abundances off the northeast United States in spring through fall are 38,000 to 42,000 animals (CETAP, 1982; Kenney and Vigness-Raposa, 2010). Over the course of BOEM's study, 185 individual Atlantic white-sided dolphins were sighted within the RI-MA WEA; most were observed during summer (112 sightings) followed by fall (70 sightings) (Kraus et al., 2016). Atlantic white-sided dolphins are one of the most likely delphinids that would occur seasonally within the SFWF area.

South Fork Export Cable

Atlantic white-sided dolphin is one of the three odontocetes primarily inhabiting continental shelf waters, shoreward of the 100-m depth contour (CETAP, 1982; Waring et al., 2016). Most of the sightings (90%) were seen from a range of approximately 38 to 271 m. Sightings are concentrated in coastal waters near Cape May and in shallow waters within the Gulf of Maine (CETAP, 1982). The Gulf of Maine population is commonly seen from the Hudson Canyon to Georges Bank. Sightings south of Georges Bank and Hudson Canyon occur year-round; however, at lower densities (Waring et al., 2016). In the Rhode Island SAMP study area, Atlantic white-sided dolphins were common in continental shelf waters, with a slight tendency to occur in shallower waters in the spring (Kenney and Vigness-Raposa, 2010). Records indicate that there is an aggregation of sightings southeast of Montauk Point during the spring and summer. Strandings of white-sided dolphins within the SFEC area are relatively rare; from 2001 to 2005, there was an average of 1.2 strandings per year (Kenney and Vigness-Raposa, 2010). Atlantic white-sided dolphins occur in seasonably high numbers in nearshore areas during the spring and summer; therefore, they can potentially occur along the SFEC route and onshore approach areas.

3.1.1.5 Common Bottlenose Dolphin

South Fork Wind Farm

In the Western North Atlantic, there are two morphologically and genetically distinct common bottlenose dolphin morphotypes, which include the western North Atlantic Northern Migratory Coastal stock (described below in the SFEC section) and the western North Atlantic Offshore stock. The offshore stock is primarily distributed along the OCS and continental slope from Georges Bank to Florida (Hayes et al., 2017). Whereas, the coastal stock is distributed along the coast, south of Long Island, New York to Florida (Hayes et al., 2017). Common bottlenose dolphins that occur within the nearshore areas of the Project Area are likely to come from the offshore population, as the seasonal stranding records match the temporal patterns of the offshore stock than the northern migratory coastal stock (Kenney and Vigness-Raposa, 2010).

Common bottlenose dolphins are not listed under the ESA and are classified as Least Concern on the IUCN Red List (Hayes et al., 2018, 2020; IUCN, 2018). The offshore stock is not considered strategic as the estimated annual human-caused injury and mortality do not exceed PBR, and the best abundance estimate is 62,851 (Hayes et al., 2020). There are no current population trends available for this stock, as there are methodological difference with the existing abundance estimates for this species. As such, an assumed maximum net productivity rate of 4% is used (Hayes et al., 2020).

Common bottlenose dolphins occur in the RI-MA WEA in all seasons with the highest seasonal abundance estimates during the fall, summer, and spring. Kraus, et al. (2016) reports the offshore stock as only be sighted in the RI-MA WEA during the summer months. The SPUE ranges from 1 to 1,230 dolphins per 1,000 km. The greatest concentrations of common bottlenose dolphins were observed in the southernmost portion of the RI-MA WEA study area with an SPUE of 3,221 to 7,120 dolphins per 1,000 km in the fall (BOEM, 2013; Kraus et al., 2016).

South Fork Export Cable

The northern migratory coastal stock is distributed along the coast, south of Long Island, New York to Florida (Hayes et al., 2020). Unlike the offshore stock, the northern migratory coastal stock is considered strategic due to its status as depleted under the MMPA (Hayes et al., 2020). However, common bottlenose dolphins that occur within the nearshore areas of the Project Area are likely to come from the offshore population, as the seasonal stranding records match the temporal patterns of the offshore stock than the northern migratory coastal stock (Kenney and Vigness-Raposa, 2010).

3.1.1.6 Long-finned Pilot Whale

South Fork Wind Farm

There are two species of pilot whale in the Western North Atlantic, long-finned and short-finned (*Globicephala macrorhynchus*). Because it is difficult to differentiate the difference between these two species in the field, sightings are usually reported to a genus level only (Hayes et al., 2017; CETAP, 1982). However, short-finned pilot whales are a southern or tropical species and generally pilot whale sightings above approximately 42° N are most likely long-finned pilot whales (Hayes et al., 2017; CETAP, 1982). Pilot whales are distributed along the continental shelf waters off the northeastern U.S. coast in the winter and early spring. By late spring, pilot whales will migrate into more northern waters including Georges Bank and the Gulf of Maine and will remain there until fall.

The best available estimate of long-finned pilot whales in the Western North Atlantic is 39,215 (Hayes et al., 2020). A trend analysis has not been conducted for this stock; therefore, a maximum net productivity rate of 4% is assumed (Hayes et al., 2020). The estimated annual human-causes mortality and injury does not exceed the calculated PBR, so this stock is not classified as strategic (Hayes et al., 2020). Long-finned pilot whales are not listed under the ESA and are classified as Least Concern on the IUCN Red List (Hayes et al., 2020; IUCN, 2018).

CETAP surveys reported pilot whales as the third most commonly sighted small whale in their study area with 12,438 individuals (CETAP, 1982). An abundance estimate of 11,865 was generated based on aerial and shipboard surveys conducted during the summer of 2011 (Palka et al., 2017). The survey area covered the coastline from north of New Jersey through the U.S. and Canadian Gulf of Maine. Pilot whales have been observed in the Rhode Island SAMP study area in all four seasons, with peak occurrences in the spring (Kenny and Vigness-Raposa, 2010). There were 43 records of long-finned pilot whales, 1 confirmed sighting of a short-finned pilot whale, and 226 records of non-specific pilot whales. Nine sightings during the summer and three sightings in the spring were reported from whale-watching data for pilot whales (Kenney and Vigness-Raposa, 2010).

Within the RI-MA WEA, no sightings of pilot whales were observed during the summer, fall, or winter; however, the SPUE in the spring ranged from 0.1 to 1,710 per 1,000 km (BOEM, 2013; Kraus et al., 2016). Pilot whales are relatively abundant in the area; therefore, they may potentially occur in the SFWF area. However, the likelihood of occurrences would only be in the spring.

South Fork Export Cable

Long-finned pilot whales prefer deep pelagic temperate to subpolar oceanic waters; therefore, they are not likely to occur along the SFEC route area.

3.1.1.7 Risso's Dolphin

South Fork Wind Farm

Risso's dolphins are not listed under the ESA and are classified as a species of Least Concern on the IUCN Red List (Hayes et al., 2020; IUCN, 2018). The best abundance estimate in the Western North Atlantic is 35,493 (Hayes et al., 2020). A trend analysis was not conducted on this species, because there is insufficient data to generate this information, but the annual human-cause mortality and injury does not exceed PBR for this species, so they are not considered strategic under the MMPA (Hayes et al., 2020).

Risso's dolphins were observed in the Rhode Island SAMP study area year-round, with the most abundant seen during the summer (Kenney and Vigness-Raposa, 2010). The sighting data primarily observes this species along the shelf break, with only few species seen in waters shallower than 100 m. Only one sighting in the Rhode Island SAMP study area was observed in the spring (Kenney and Vigness-Raposa, 2010). Kraus et al. (2016) only observed two Risso's dolphins in the RI-MA WEA during the spring season. Risso's dolphins do occur in the area; however, because of the infrequent sightings in shallower waters and more concentrated distribution along the continental shelf, the likelihood of encountering Risso's dolphins in the SFWF area is relatively low.

South Fork Export Cable

Risso's dolphins are unlikely to occur along the SFEC route area, due to their primary occurrence on the continental shelf edge.

3.1.1.8 Common Dolphin

South Fork Wind Farm

The common dolphin has a wide distribution and can be found in both tropical and temperate areas of the Pacific and Atlantic Oceans, in both nearshore and deep offshore waters (Perrin, 2002). Two species of common dolphin were previously recognized: the long-beaked common dolphin (*Delphinus capensis*) and the short-beaked common dolphin (*Delphinus delphis)*; however, Cunha et al. (2015) summarized the relevant data and analyses, along with additional molecular data and analysis, and recommended that the long-beaked common dolphin not be further used for the Atlantic. This taxonomic convention is used by the Society or Marine Mammalogy. This highly social and energetic species usually travels in large pods consisting of 50 to thousands of individuals (Hammond, 2008b). The common dolphin can frequently be seen performing acrobatics and interacting with large vessels and other marine mammals. This dolphin has a very distinct color pattern that takes the form of an hourglass on its side (Waring et al., 2015). Most individuals have a prominent white patch on the dorsal fin.

The common dolphin is not listed under the ESA and is classified as Least Concern on the IUCN Red List (Kenney and Vigness-Raposa, 2010). Like the harbor porpoise, the common dolphin faces major anthropogenic effects because of its nearshore habitat and highly social nature, but it is not considered a strategic stock under the MMPA because the average annual human-cause mortality and serious injury doesn't exceed the PBR for this stock (NMFS, 2020).

Historically, this species was hunted in large numbers for food and oil. Currently, they continue to suffer incidental mortality from vessel collisions and eastern North American fishing activities within the Atlantic, most prominently yellowfin tuna (*Thunnus albacares*) nets, driftnets, and bottom-set gillnets (Hayes et al., 2020; Kraus et al., 2016). In the western North Atlantic, sink gill nets and bottom trawls take an average of 105 short-beaked common dolphins each year (Waring et al., 2006). The current best abundance estimate for the western North Atlantic stock is 172,974 (NMFS, 2020). A trend analysis was not conducted for this stock because of the imprecise abundance estimate (NMFS, 2020).

Kraus et al. (2016) observed 3,896 individual short-beaked common dolphins within the RI-MA WEA. Summer surveys observed the most individuals (1964 sightings) followed by fall (725 sightings), winter (132), then spring (75 sightings) (Kraus et al., 2016). This was the highest number of individual sightings of all the small cetaceans; therefore, it is anticipated to be one of the most frequent delphinids to occur seasonally within the SFWF area.

<u>*South Fork Export Cable*</u>

Since the short-beaked dolphin has a wide distribution and can be found in both tropical and temperate areas of the Pacific and Atlantic Oceans, in both nearshore and deep offshore waters (Perrin, 2002), they can potentially occur along the SFEC route and onshore approach areas.

3.1.1.9 Harbor Porpoise

<u>*South Fork Wind Farm*</u>

The harbor porpoise is mainly a temperate, inshore species which prefers to inhabit shallow, coastal waters of the North Atlantic, North Pacific, and Black Sea. The preferred habitat of the harbor porpoise increases the likelihood of encountering them within the SFWF area (BOEM, 2012; Hayes et al., 2020). This species is among the smallest of the toothed whales, growing to a maximum length of around 2 m. A distinguishing physical characteristic is the dark stripe that extends from the flipper to the eye. The rest of its body has common porpoise features; a dark gray back, light gray sides, and small, rounded flippers (Jefferson et al., 1993).

This species faces major anthropogenic effects because of its nearshore habitat. Historically, the Greenland populations were hunted in large numbers for food and oil. Currently, they continue to suffer incidental mortality from Northwestern Atlantic fishing activities, such as cod and salmon nets, and bottom-set gillnets. It is estimated that human-related activities kill 365 harbor porpoises in U.S. and Canadian waters each year. This species is not listed under the ESA and is listed as Least Concern on the IUCN Red List, but is considered strategic under the MMPA because anthropogenic mortality exceeds PBR (Hayes et al., 2020; IUNC, 2018). The best available current abundance estimate for Gulf of Maine/Bay of Fundy harbor porpoises is 95,543 (Hayes et al., 2020). A population trend analysis is not available because data are insufficient for this species (Hayes et al., 2020).

Over the course of BOEM's study, 121 individual harbor porpoises were observed within the RI-MA WEA. Fall observations included the most individuals (49 sightings) followed by winter (35 sightings), spring (36 sightings), and summer (1 sighting) (Kraus et al., 2016). Vertical camera detections of all small cetaceans showed that the most commonly detected species over time was the harbor porpoise (Kraus et al., 2016). Harbor porpoises are highly likely to occur in the fall, winter, and spring within the SFWF area.

<u>*South Fork Export Cable*</u>

Harbor porpoises mostly occur in shallow continental shelf and coastal waters. In the spring, they tend to congregate in the southwestern Gulf of Maine around Nantucket Shoals, western Georges Bank, and the southern New England shelf. In the fall and spring, harbor porpoises are widely distributed from New Jersey to Maine, from the coastline to deep waters (more than 1,800 m) (Hayes et al., 2020). In the winter, intermediate densities can be found from New Jersey to North Carolina, with lower densities from New York to New Brunswick, Canada (Kenney and Vigness-Raposa, 2010).

Strandings are reported all along the southern shore of Long Island and along both sides of Long Island Sound. There are occasional sightings in the bays, estuaries, and rivers. These strandings occur seasonally and are highest in the winter and spring. Harbor porpoises are also common in eastern Long Island Sound, Gardiner's Bay, and Peconic Bay during the winter, which is within the vicinity of the SFEC route and onshore approach areas (Kenney and Vigness-Raposa, 2010). Therefore, harbor porpoises are likely to occur within the SFEC route area.

3.1.1.10 Gray Seal

South Fork Wind Farm

Gray seals inhabit temperate to sub-Arctic waters of the North Atlantic, in both nearshore and deeper continental shelf waters (Hall, 2002). Three different geographic populations occur; northwestern Atlantic, northeastern Atlantic, and Baltic populations (Kenney and Vigness-Raposa, 2010). Gray seals are among the larger phocids found in the northwest Atlantic. Adult males can reach 2.4 m long and weigh nearly 295 kg. Peak breeding and pupping times are January to late March, and breeding occurs in the open water (Baker et al., 1995).

The gray seal was commercially and recreationally hunted until 1972. From 2006 to 2010, the average rate of mortality by non-hunting related anthropogenic causes was approximately 853 per year, primarily because of entanglement in commercial gillnets, debris, scientific collection, and vessel collisions. This species is non listed under the ESA, is listed as Least Concern on the IUCN Red List, and considered non-strategic under the MMPA because anthropogenic mortality does not exceed PBR (Hayes et al., 2020; IUCN, 2018). Estimates of the entire North Atlantic gray seal population is not available, only estimated portions of the stock are available, although recent genetic evidence suggests that all Western North Atlantic gray seals may actually comprise a single stock (Hayes et al., 2020). The best available current abundance estimate for gray seals of the Canadian gray seal stock is 424,300 and the current U.S. population estimate is 27,131 (Hayes et al., 2020). The population of gray seals is likely increasing in the U.S. Atlantic exclusive economic zone (EEZ); however, net productivity rates for this stock are unknown. An assumed rate of 12% is used, based on theoretical modeling on pinniped populations (Hayes et al., 2020).

Overall, individuals within the SFWF area are relatively low; occasionally young pups have been found stranded off eastern Long Island beaches. The AMAPPS surveys identified 11 individuals during their winter aerial surveys (Palka et al., 2017). Two breeding and pupping grounds are in Nantucket Sound at Monomoy and Muskeget Island. Gray seals live there year-round and exhibit minimal migration patterns; however, recent tagging studies have observed increased movement between U.S. and Canada. The overall time spent in U.S. waters remains uncertain, but the updated U.S. population estimates make it possible that these seals will be seen around the SFWF area (Hayes et al., 2020).

South Fork Export Cable

Historically, gray seals were relatively absent from Rhode Island and nearby waters. However, with the recent recovery of the Massachusetts and Canadian populations, their occurrence has increased in southern New England and the mid-Atlantic (Hayes et al., 2020). Records of gray seal strandings are primarily observed in the spring and are distributed broadly along ocean-facing beaches in Long Island and Rhode Island. In New York, gray seals are typically seen alongside harbor seal haul-outs. Two frequent sighting locations include Great Gull Island and Fisher's Island (Kenney and Vigness-Raposa, 2010). Even though sightings are not as frequent as harbor seals, gray seals do occur in Long Island; therefore, these seals may be present in the proposed northern and southern SFEC route and landfall areas.

3.1.1.11 Harbor Seal

South Fork Wind Farm

Harbor seals, also known as common seals, are one of the most widely distributed seal species in the northern hemisphere. They can be found inhabiting coastal and inshore waters from temperate to polar latitudes. Genetic variability from different geographic populations have led to five subspecies being recognized. Harbor seals occur in the western Atlantic from the mid-Atlantic United States to the Canadian Arctic and east to Greenland and Iceland (Rice, 1998). The harbor seal is one of the smaller pinnipeds, with adult males ranging from 1.5 to 1.8 m long and weighing 68 to 150 kg (Kenney and Vigness-Raposa, 2010). Peak breeding and pupping times range from February to early September, and breeding occurs in the open water (Temte, 1994).

Until 1972, harbor seals were commercially and recreationally hunted. Currently, only Alaska natives can hunt harbor seals for sustenance and the creation of authentic handicrafts. From 2003 to 2007, the average rate of mortality by non-hunting-related anthropogenic causes was approximately 467 per year (Hayes et al., 2020). This species is not listed under the ESA, is listed as Least Concern on the IUCN Red List, and is considered non-strategic under the MMPA because anthropogenic mortality does not exceed PBR (Hayes et al., 2020). The best available current abundance estimate for harbor seals in the western North Atlantic is 75,834, with global population estimates reaching 610,000 to 640,000 (Hayes et al., 2020; Lowry, 2016; Bjørge et al., 2010). There is no population trend analysis for this species, because of insufficient data. An assumed net productivity rate of 12% is used, which is based on theoretical modeling for pinniped populations (Hayes et al., 2020).

Seals are regularly observed in coastal areas; however, there are few records of harbor seals from shipboard and aerial surveys. Harbor seals are difficult to detect, as the only sighting cue available would be seeing the seal's head above the water. CETAP excluded seals from their data collection efforts specifically for this reason. Most records that are available are of strandings and haul-out counts. Harbor seals inhabit southern New England waters year-round, although the population steadily increases in April and then abruptly declines in May. Survey data collected from NMFS and the Provincetown Center for Coastal Research reported 151 harbor seal sightings, a large concentration of which were observed near the coast from eastern Long Island to Buzzards Bay and Vineyard Sound. There were occurrences of harbor seal offshore; however, the level of abundance was lower than what was observed near haul-out sites (Kenney and Vigness-Raposa, 2010).

Harbor seals can be found along the coast near the Rhode Island SAMP study area and RI-MA WEA, as well as in surrounding waters. Several haul-out sites are located on Block Island, which are close to the western end of the RI-MA WEA (BOEM, 2013). Therefore, harbor seals could be potentially encountered in the SFWF area.

South Fork Export Cable

Harbor seals are the most abundant seals found in New York State. Important haul-outs in Long Island include Fishers Island, Great Gull Island, Montauk Point, Gardiners Island, and Sag Harbor (Kenney and Vigness-Raposa, 2010). The Coastal Research and Education Society of Long Island (CRESLI) estimates there to be about 30 known Long Island haul-out sites, which are scattered around the eastern end of Long Island and along both sides of the Atlantic and Long Island Sound shores (CRESLI, 2019; Kenney and Vigness-Raposa, 2010). Harbor seals utilize Eastern Point and Montauk Point of Long Island as terrestrial habitat, and the nearshore portion of the SFEC as foraging and potential breeding grounds. These seals can likely be found in the nearshore areas around the proposed northern and southern SFEC landfall locations. In 2012, NOAA conducted an abundance study by using aerial photographic surveys and radio tracking of harbor seals along the coast of Maine (Hayes et al., 2017). The study identified an estimated

75,834 harbor seals (Waring et al., 2015, 2016). The most localized estimates of populations residing within the Long Island Sound harbors come from CRESLI, having observed nearly 16,000 harbor seals over 302 seal observation trips from 2007 through 2017 around Cupsogue Beach, during which CRESLI found the highest monthly concentrations of seals from December through April.

Harbor seals are highly likely to be one of the most frequent and densely occurring marine mammals that would occur annually within the SFEC route area.

3.1.2 ESA-Listed Species

Five species of large whale marine mammals are known to occur in the Western North Atlantic, all of which are listed under the ESA. These species include the blue whale, fin whale, North Atlantic right whale, sei whale, and sperm whale. However, these species are highly migratory and do not spend extended periods of time in a localized area. The blue whale is a more pelagic and their presence within the SFWF area is considered unlikely; however, due to their endangered status and because they have been detected in the SFWF area during acoustic surveys (Kraus et al., 2016), they were included in the acoustic exposure assessment (**Section 5.4**) and have the potential to be affected by Project activities (**Section 5.0**).

3.1.2.1 Fin Whale

South Fork Wind Farm

Fin whales have a wide distribution and can be found in the Atlantic, Pacific, and Southern Hemisphere (NMFS, 2020). The population is divided by ocean basins; however, these boundaries are arbitrary as these are based off historical whaling patterns rather than biological evidence (NMFS, 2020). In the Northeastern United States, fin whales are the most commonly sighted species and account for 47% of the large whale sightings in the area (CETAP, 1982). They have been observed in all four seasons, and their distribution ranges from the continental shelf waters from the Mid-Atlantic coast to Nova Scotia (Kenney and Vigness-Raposa, 2010).

Fin whales are classified as Endangered under the ESA and IUCN Red List (Kenney and Vigness-Raposa, 2010). The best abundance estimate available for the western North Atlantic stock is 6,802 with a minimum population estimate of 5,573 (NMFS, 2020). A population trend analysis does not exist for this species because of insufficient data; however, based on photographic identification, the gross annual reproduction rate is 8% with a mean calving interval of 2.7 years (Agler et al., 1993; NMFS, 2020).

Two well-known feeding grounds for fin whales are present within the vicinity of the SFWF area. These include the Great South Channel and Jeffrey's Ledge and in waters directly east of Montauk, Long Island, New York (NMFS, 2020; Kenney and Vigness-Raposa, 2010). The highest occurrences are identified south of Montauk Point to south of Nantucket (Kenney and Vigness-Raposa, 2010). Within the RI-MA WEA, fin whale sightings were the highest during the spring and summer. SPUE ranged from 0.3 to 350 whales per 1,000 km in the summer, 0.3 to 135 whales per 1,000 km in the winter, 0.3 to 50 whales per 1,000 km in the spring, and 0.3 to 135 whales per 1,000 km in the fall (BOEM, 2012). Because of these high occurrences within the inner shelf areas and offshore near the continental shelf break, it is likely that fin whales will be present within the SFWF area.

South Fork Export Cable

A dense aggregation of fin whale sightings occurs south of Montauk Point to south of Nantucket. This area is also a well-known feeding area for fin whales. Because of their regular occurrence in this area, a large number of whale-watching boats also frequent this area (Kenney and Vigness-Raposa, 2010). Their feeding grounds are located directly within the SFEC and within the vicinity of the southern approach. It is highly likely that fin whales will be encountered in the SFEC route area.

3.1.2.2 North Atlantic Right Whale

South Fork Wind Farm

The North Atlantic right whale is listed as Endangered under the ESA and IUCN Red List (Kenney and Vigness-Raposa, 2010). North Atlantic right whales are considered to be the most critically endangered large whales in the world (NMFS, 2020). The best estimate for the western North Atlantic population size 412 individuals with a minimum population estimate of 408 (NMFS, 2020). Human-caused mortality and serious injury was reported to be a minimum of 8.15 right whales per year from 2014 to 2018. The average annual human-related mortality/injury rate exceeds that of the calculated PBR, classifying this population as a strategic stock. During 1980 to 1992, the number of calves born annually ranged from 5 to 17. Highly variable data exists in regard to the productivity of this stock. Over time, there have been periodic swings of per capita birth rates. Net productivity rates do not exist as the western North Atlantic stock lacks any definitive population trend (NMFS, 2020).

Krause et al. (2016) only observed North Atlantic right whales in the RI-MA WEA during the winter and spring. However, the North Atlantic right whale has the potential to occur within the waters off Rhode Island and Massachusetts any time of the year. Typically, right whale sightings begin in December and continue through April. A total of 77 individuals were sighted in the RI-MA WEA from October 2011 to June 2015. The greatest numbers are seen in March. The Muskeget Channel and south of Nantucket were also identified as right whale hotspots during the spring. These areas are located within the RI-MA WEA (Kraus et al., 2016).

Seasonal management areas (SMAs) also exist within the vicinity of the SFWF, including Great South Channel SMA (April 1 – July 31), Cape Cod Bay SMA (January 1 – May 15), Off Race Point SMA (March 1 – April 30), and Block Island SMA (November 1 – April 30) (NMFS, 2019a); therefore, right whales are likely to occur within the SFWF area.

South Fork Export Cable

North Atlantic right whales are known to occur within the waters of Rhode Island and Massachusetts year-round. The Gulf of Maine has also been designated as a critical habitat area, and therefore, they potentially migrate through the SFEC route area. Kraus et al. (2016) reported a seasonal cluster of right whales south of Martha's Vineyard and east of Nantucket during the winter. This area is also designated as the Block Island SMA from November 1 through April 20, in which the SFEC route would directly intersect. Therefore, it is likely right whales would occur within the SFEC route area.

Kraus (2018) provided recent survey right whale survey information for crew training prior to the 2017 South Fork site characterization surveys. Right whale sighting results from 2011 to 2015 are presented in **Figure 3-1**. Kraus (2018) also presented the sighting locations from 2017 that reported skim (surface) feeding activity by right whales (**Figure 3-2**). Skim feeding is an important activity identified in impact assessments because first, it demonstrates a critical behavior (feeding) which could be disrupted by introduced noise; and second, it represents a vulnerable time for right whales to be exposed to ship strikes because they are active at or near the surface.

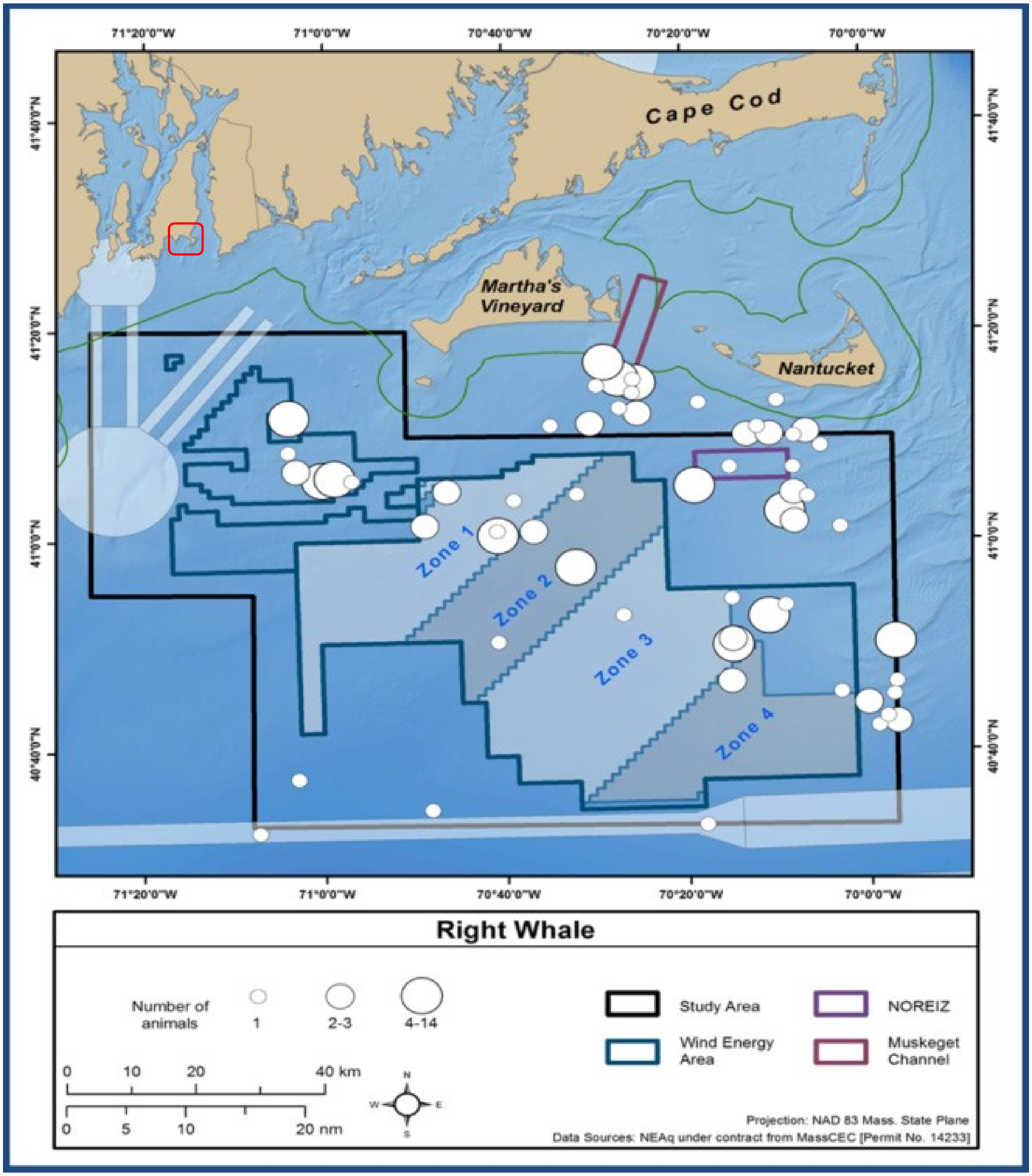

Figure 3-1. Right whale sighting data from 2011 to 2015. Figure and data from Kraus (2018).

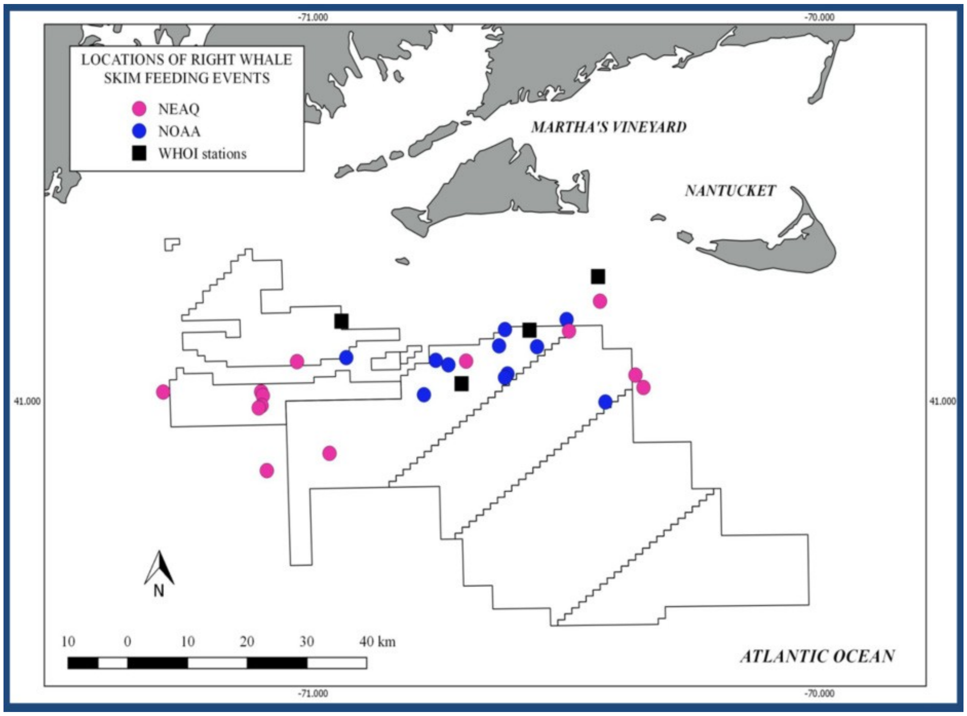

Figure 3-2. The 2017 North Atlantic right whale sightings that reported skim (surface) feeding activity. Figure from Kraus (2018).

3.1.2.3 Sei Whale

<u>*South Fork Wind Farm*</u>

Sei whales occur in all the world's oceans and migrate between feeding grounds in temperate and sub-polar regions to winter grounds in lower latitudes (Kenney and Vigness-Raposa, 2010). In the western North Atlantic, most of the population is concentrated in northerly waters along the Scotian Shelf. Sei whales are observed in the spring and summer, utilizing the northern portions of the U.S. Atlantic EEZ as feeding grounds, including the Gulf of Maine and Georges Bank. The highest concentration is observed during the spring along the eastern margin of Georges Bank and in the Northeast Channel area along the southwestern edge of Georges Bank. In general, sei whales are associated with the deeper waters along the continental shelf edge at the 2,000-m depth contour (Hayes et al., 2017).

Sei whales are classified as Endangered under the ESA and Endangered under the IUCN Red List (Kenney and Vigness-Raposa, 2010). Prior to 1999, sei whales in the western North Atlantic were considered a single stock, but following the suggestion of the Scientific Committee of the International Whaling Commission (IWC), two separate stocks were identified for this species; a Nova Scotia stock and a Labrador Sea stock. Only the Nova Scotia stock can be found in U.S. waters, and the estimated abundance for this population is 6,292. Population trends are available because of insufficient data (Hayes et al., 2020).

CETAP surveys observed sei whales along the continental shelf edge only during the spring (237 ± 327) and summer (101 ± 293) (CETAP, 1982). This agrees with the Kraus et al. (2016) study, where sei whales were also only observed in the RI-MA WEA during the spring (8 individuals) and summer (13 individuals). No sightings were reported during the fall and winter (Kraus et al., 2016). A small cluster of five individuals was reported south of Montauk Point and Block Island in July 1981, August 1982, and May 2003 (Kenney and Vigness-Raposa, 2010). Therefore, sei whales may occur in the SFWF area, but their presence would be seasonal, primarily in the spring and summer.

South Fork Export Cable

Since sei whales are associated with the deeper waters along the continental shelf edge at the 2,000-m depth contour (Hayes et al., 2020), they are unlikely to occur along the SFEC route area.

3.1.2.4 Blue Whale

South Fork Wind Farm

The blue whale is the largest cetacean, although its size range overlaps with that of fin and sei whales. The species is currently divided into five subspecies (Committee on Taxonomy, 2018) and only the northern hemisphere subspecies (*B. m. musculus*) is known to occur within the region. Most adults of this subspecies are 23 to 27 m (75 to 90 ft) in length (Jefferson et al., 2008). In the Western North Atlantic Ocean, the blue whale's range extends from the Arctic to Cape Cod, Massachusetts, although it is frequently sighted off eastern Canada (e.g., Newfoundland) (Waring et al., 2012). Using U.S. Navy asset hydrophone arrays, Clark and Gagnon (2004) identified blue whales as far south as Bermuda (but rarely farther south). Yochem and Leatherwood (1985) suggest an occurrence of this species south to Florida and the Gulf of Mexico. In general, the blue whale's range and seasonal distribution is governed by the availability of prey (Hayes et al., 2020).

The blue whale is listed as an Endangered species, species-wide and range-wide, under both the ESA and IUCN Red List (Hayes et al., 2020; IUCN, 2018). Blue whales in the Western North Atlantic were exploited heavily. A full assessment of present status has not been carried out, though available evidence suggests they are increasing in numbers at least in the area of the central North Atlantic though they remain rare in the northeastern Atlantic where they were once common. There are insufficient data to determine the current abundance of the Western North Atlantic stock, however photo-identification surveys of this species in the St. Lawrence estuary between 1979 and 2009 indicate the minimum abundance estimate for this stock is 402 whales. This stock is listed as strategic and depleted under the MMPA because the species is listed as endangered under the ESA (Hayes et al., 2020). There is no designated critical habitat for this species within the proposed survey area.

The blue whale is considered by NMFS as an occasional visitor in U.S. Atlantic EEZ waters, which may represent the current southern limit of its feeding range (Waring et al., 2012). Surveys conducted in the RI-MA WEA detected blue whale vocalizations in winter (Kraus et al., 2016), but given the large estimated detection range for these calls and the limited number of detections, it is unlikely this species will be encountered within the SFWF area.

South Fork Export Cable

Blue whales are associated primarily with the deeper waters along the continental shelf edge at the 2,000-m depth contour (Waring et al., 2012), they are unlikely to occur along the SFEC route area.

3.1.2.5 Sperm Whale

South Fork Wind Farm

Sperm whales can be found throughout the world's oceans. They can be found near the edge of the ice pack in both hemispheres and also common along the equator. The Western North Atlantic stock is distributed mainly along the continental shelf-edge, over the continental slope, and mid-ocean regions, where they prefer water depths of 600 m or more and are uncommon in waters less than 300 m deep (Hayes et al., 2020).

Historically, thousands of sperm whales were killed during the early 18th Century. A moratorium on sperm whale hunting was adopted in 1986. Presently, no hunting is allowed for any purposes in the North Atlantic. Occasionally, sperm whales will become entangled in fishing gear or struck by ships off the east coast of the United States. However, this rate of mortality is not believed to have biologically significant impacts. The North Atlantic stock is a strategic stock due to its listing as Endangered under the ESA and is classified as Vulnerable on the IUCN Red List (Kenney and Vigness-Raposa, 2010; Waring et al., 2015).

The best and most recent abundance estimate is 4,349. No population trend analysis is available for this stock. The U.S. fishery-related mortality and serious injury rate is less than 10% of the calculated PBR; therefore, the impact is considered insignificant (Hayes et al., 2020).

Sperm whales were the fifth most commonly sighted large whale in the CETAP study area and were observed in all four seasons. The study sighted 341 individuals, which accounted for only 8% of the total large whale sightings during their survey period (CETAP, 1982). Kraus et al. (2016) reported sightings of sperm whales in the RI-MA WEA during the summer and fall months, with five individuals in August 2012, one in September 2012, and three in June 2015 (Kraus et al., 2016). There has also been occasional stranding is Massachusetts and Long Island (Kenney and Vigness-Raposa, 2010). Although accounts of sperm whales in the area are low, their occurrence within the SFWF area and surrounding waters is possible.

South Fork Export Cable

CETAP reported that the distribution of sperm whales primarily centers at about the 1,000 m depth contour. However, their distribution also extends shoreward, inshore of the 100-m contour (CETAP, 1982). Sightings have also been reported in waters as shallow at 60 m. Southern New England is one of the few locations in the world in which sperm whales frequent inshore areas (Kenney and Vigness-Raposa, 2010). Many reported sightings take place in a narrow band just south of Block Island, Martha's Vineyard, and Nantucket from May through November, in which the SFEC route area would intersect. This high seasonal occurrence of sperm whales is believed to be related to the presence of spawning squid (CETAP, 1982).

3.2 SEA TURTLES

Four species of sea turtles could potentially be present in the Project Area; green sea turtle (*Chelonia mydas*), Kemp's Ridley sea turtle (*Lepidochelys kempii*), loggerhead sea turtle, and leatherback sea turtle (*Dermochelys coriacea*). Regional Kemp's ridley and leatherback sea turtle stocks are listed as Endangered under the ESA, while the green and loggerhead sea turtle stocks are listed as Threatened. Sea turtle life history stages are similar in all species and include eggs, hatchling, juvenile, and adult stages. In general, sea turtles nest in tropical, subtropical, and warm-temperate beaches (Davenport, 1997). In the U.S., common nesting colonies are located in the Gulf of Mexico and Southwest Atlantic Ocean; however, specific nesting distributions by species are described in the following sections. Females will mate in nearshore waters and then lay their eggs on the beach. Hatchling sea turtles move offshore in a swimming frenzy immediately after hatching (Davenport, 1997). At the surface-pelagic juvenile stage, sea turtles move to convergence zones or to *Sargassum* mats and undergo passive oceanic migrations (Witherington et al., 2012). Juvenile sea turtles actively recruit to nearshore nursery habitats and move into adult foraging habitats when approaching sexual maturity. At maturity, sea turtles return to their natal beaches to breed (Davenport, 1997).

3.2.1 Green Sea Turtle

South Fork Wind Farm

Green sea turtles have a worldwide distribution and can be found in both tropical and subtropical waters (NatureServe, 2018; NMFS and USFWS, 1991). In the Western North Atlantic Ocean, they can be found from Massachusetts to Texas, as well as in waters off Puerto Rico and the U.S. Virgin Islands (NMFS and USFWS, 1991). There are 11 listed DPSs for green sea turtles, all of which are listed as Threatened or Endangered under the ESA. The Western North Atlantic DPS which is likely to occur in the SFWF area was listed as Threatened in 1978 (NMFS, 2019b).

Major green sea turtle nesting colonies occur on Ascension Island, Aves Island, Costa Rica, and Surinam. In the United States, green sea turtles nest in North Carolina, South Carolina, Georgia, Florida, the U.S. Virgin Islands, and Puerto Rico (USFWS, 2017a). Nesting seasons vary by region. On average, individual females nest every 2 to 4 years, laying an average of 3.3 nests per season at approximately 13-day intervals. The average clutch size is approximately 136 eggs and incubation ranges from 45 to 75 days (USFWS, 2017a)

Depending on the life stage, green sea turtles inhabit high-energy oceanic beaches, convergence zones in pelagic habitats, and benthic feeding grounds in shallow protected waters (NMFS and USFWS, 1991). Green sea turtles are known to make long-distance migrations between their nesting and feeding grounds. Hatchlings occupy pelagic habitats and are omnivorous. Juvenile foraging habitats include coral reefs, emergent rocky bottoms, *Sargassum* mats, lagoons, and bays (USFWS, 2017a). Once adult, green sea turtles leave pelagic habitats and enter benthic foraging grounds, primarily feeding on seagrasses and algae (Bjorndal, 1997).

Critical habitat, which identifies specific areas that have physical or biological features essential to species conservation and/or might require special management considerations, was designated by NOAA fisheries for the green sea turtles in 1998. Critical habitat for green sea turtles includes the coastal waters of Culebra Island, Puerto Rico, and its outlying Keys (USFWS, 2017a).

There are few records of green sea turtle sightings in the SFWF area. Only one confirmed green sea turtle sighting was reported in March 2005 south of Long Island between the 40- and 50-m isobaths (Kenney and Vigness-Raposa, 2010). NOAA Northeast Fisheries Science Center conducted a combination of aerial and shipboard surveys (AMAPPS) along the northeast coast from 2010 through 2015 (Palka et al., 2017). Survey waters spanned from Cape May, New Jersey, to the mouth of the Gulf of St. Lawrence, Canada. Out of five surveys that were conducted, green sea turtles were spotted only during 2010 and 2011. Six individuals were sighted south of Long Island, New York, and within the Nantucket Shoals during summer aerial surveys (17 August through 26 September 2010). Five green sea turtles were also sighted off the southern coast of Long Island during the summer aerial surveys (7 August through 26 August 2011) (Palka et al., 2017).

In preparation of the offshore wind energy development, New York State Energy Research and Development Authority (NYSERDA) conducted digital aerial surveys to gather baseline data on birds, marine mammals, turtles, and fish in the New York Offshore Planning Area (OPA). Surveys were conducted in the summer of 2016 (26 July 2016 through 9 August 2016); fall 2016 (December through February 2016); and winter 2017 (surveys began on 6 March 2017). During the summer and fall 2016 surveys, no green sea turtles were encountered in the New York OPA (Normandeau and APEM, 2019).

Due to the infrequent occurrence of green sea turtles within southern New England waters, it is unlikely that green sea turtles would occur within the SFWF area and will therefore not be included in the animal exposure assessment (**Section 5.4**).

South Fork Export Cable

Green sea turtles are known to occur in Northeast Atlantic waters; however, the reported records of strandings are far less than the ones reported for species such as the Kemp's ridley sea turtle. From 1979 to 1986, only two stranded green sea turtles were recovered during cold stunning events (Meylan and Sadove, 1986), and one was detected in the New York OPA in the summer 2016 NYSERDA surveys (Normandeau and APEM, 2019). During the winter of 1985 through 1987, five cold-stunned green sea turtles were collected along the shores of Long Island, New York. Although green sea turtles have been documented in New York waters, because of the infrequency of records and the wide distribution of these reports, it is not likely that green sea turtles would be encountered in the SFEC route area.

3.2.2 Kemp's Ridley Sea Turtle

South Fork Wind Farm

The Kemp's ridley sea turtle was listed as Endangered throughout its range in 1970 (NMFS, 2019c). They occur off the coast of the Gulf of Mexico and along the Atlantic coast of the United States (Turtle Expert Working Group [TEWG], 2000). Juveniles inhabit the Atlantic Coast from Florida to the Canadian Maritime Provinces. In late autumn, Atlantic juveniles/sub adults travel northward to forage in the coastal waters of Georgia through New England, then return southward for the winter (New York State Department of Environmental Conservation [NYSDEC], 2019; Stacy et al., 2013). Preferred habitats include sheltered areas along the coastline including estuaries, lagoons, and bays (NMFS, 2019c).

Sixty percent of Kemp's ridley sea turtle nesting occurs on beaches near Rancho Nuevo, Tamaulipas, Mexico. The nesting season spans from April through July (NMFS and USFWS, 2007). On average, individual females nest every 1 to 2 years, with an average of 1 to 3 clutches every season and an average clutch size of 110 eggs per nest (NMFS and USFWS, 2007).

The diets of the Kemp's ridley sea turtles is regionally specific. Turtles foraging in the waters of the Gulf of Mexico typically prey on sea pens, calico crabs, purse crabs, and spider crabs. Whereas in the Chesapeake Bay, the diet of juvenile turtles mainly consists of horseshoe crabs and rock crabs (Burke et al., 1993).

There are little visual sighting data for Kemp's ridley sea turtles in the RI-MA WEA. This could be because Kemp's ridley sea turtles are small and would be difficult to detect during aerial surveys. These surveys also do not consider coastal habitats such as bays and estuaries; therefore, Kemp's ridley sea turtles travelling through these areas would not be detected (BOEM, 2013). AMAPPS surveys documented five Kemp's ridley sea turtles during aerial surveys conducted from August 17 through September 26, 2010, in waters from Cape May, New Jersey, to the Gulf of St. Lawrence, Canada. No confirmed sightings were reported from 2011 through 2014 (Palka et al., 2017). Kraus et al. (2016) detected Kemp's ridley sea turtles in the RI-MA WEA using vertical camera photographs. However, only four photographic detections were confirmed 2012 (Kraus et al., 2016). NYSERDA reported no sightings of Kemp's ridley sea turtles in the New York OPA during their summer and winter 2016 aerial surveys (Normandeau and APEM, 2019).

Many juveniles have been documented migrating from nesting beaches in the Gulf of Mexico to coastal feeding areas as far north as Long Island Sound, New York (Morreale et al., 1992). Cold-stunned Kemp's ridley sea turtles are often found stranded on beaches of Massachusetts and New York from November through December (Stacy et al., 2013).

Because of the infrequent occurrence of Kemp's ridley sea turtles in the southern New England waters and the RI-MA WEA, it is not likely they would be encountered in the SFWF area.

South Fork Export Cable

The Kemp's ridley sea turtle is the most abundant turtle observed off the coast of Long Island, New York, and are likely to be encountered in the SFEC route area. The Long Island Sound has not been formally identified as critical habitat. However, research has inferred that this area could potentially provide critical coastal developmental habitat for immature Kemp's ridley sea turtles during the early turtle life stages (2 to 5 years) (NYSDEC, 2019; Morreale et al., 1992). The main characteristics of developmental habitats are coastal areas sheltered from high winds and waves such as embayments, estuaries, and nearshore temperate waters shallower than 50 m (NMFS, 2019c).

Beginning in July, Kemp's ridley sea turtles begin inhabiting the Long Island Sound area. To date, all Kemp's ridley sea turtles encountered in Long Island Sound have been juveniles. Between July and early October, juveniles occupy estuarine waters of the Long Island Sound and Peconic Bay and the southern bays. During this time, growth rates increase by approximately 25% per month, indicating that these waters provide an abundant food source for these turtles. In October, the turtles will begin to migrate out of the estuaries and back into pelagic environments. Kemp's ridley sea turtles that do not migrate out by late November are likely to become cold-stunned. There are many records of cold stunned Kemp's ridley sea turtles washing ashore on Long Island (Burke et al., 1993).

From 1986 to 1997, there was a total of 212 Kemp's ridley sea turtle strandings reported in the Northeast U.S. Most were juveniles, ranging in size from approximately 22 to 37 cm (Morreale, 1992). Approximately 130 cold-stunned sea turtles were collected over a 3-year period along the shores of Long Island and the eastern bays of Long Island. Out of the 130 turtles collected, 77% were Kemp's ridley sea turtles (Morreale et al., 1992). During the summer 2016 NYSERDA Digital Aerial Baseline Surveys, 18 Kemp's ridley sea turtles were detected in the New York OPA. Only one Kemp's ridley sea turtle was detected in the fall 2016 surveys (Normandeau and APEM, 2019).

3.2.3 Leatherback Sea Turtle

South Fork Wind Farm

The leatherback sea turtle has been federally listed as Endangered since 1970. It is primarily a pelagic species and is distributed in temperate and tropical waters worldwide. The leatherback sea turtle is the largest, deepest diving, most migratory, widest ranging, and most pelagic of the sea turtles (NMFS, 2019d).

Historically, the most important nesting ground for the leatherback sea turtle was the Pacific coast of Mexico. However, because of exponential declines in leatherback nesting, French Guiana in the Western North Atlantic now has the largest nesting population. Other important nesting sites for the leatherback include Papua New Guinea, Papua-Indonesia, and the Solomon Islands in the western Pacific. In the U.S., nesting sites include the Florida east coast; Sandy Point, U.S. Virgin Islands; and Puerto Rico. U.S. nesting occurs from March through July. On average, individual females nest every 2 to 3 years, laying an average of 5 to 7 nests per season with an average clutch size of 70 to 80 eggs. Critical habitat has been designated for the leatherback sea turtle in the U.S. Virgin Islands at Sandy Point Beach, St. Croix, and the water adjacent to Sandy Point Beach (USFWS, 2017b).

Adult leatherback sea turtles forage in temperate and subpolar regions in all oceans. Jellyfish are the major component of the leatherback diet; they are also known to feed on sea urchins, squid, crustaceans, tunicates, fish, blue-green algae, and floating seaweed (USFWS, 2017b, NMFS, 2019d).

Leatherback sea turtles were the most frequently sighted turtle species in the RI-MA WEA, primarily between May and November (Kraus et al., 2016). Leatherback sea turtles were rarely detected in the spring and not detected at all during the winter. A strong peak in leatherback sea turtle sightings was seen during August, with 71 reported sightings from Kraus et al. (2016). In the autumn, there is a high concentration of sightings south of Nantucket (Kraus et al., 2016). The SPUE within the RI-MA WEA ranged from 20 to 105 turtles per 1,000 km in the fall and 20 to 35 turtles per 1,000 km in the summer and winter (BOEM, 2013). NYSERDA reported one leatherback sea turtle in the New York OPA during fall 2016 aerial surveys. None were detected in summer 2016 surveys (Normandeau and APEM, 2019). The AMAPPS surveys reported four leatherback sea turtle sightings during the summer 2011 shipboard abundance surveys (Palka et al., 2017). Because of the documented occurrence and use of southern New England waters and within the vicinity of the RI-MA WEA, it is likely that leatherback sea turtles could occur in the SFWF area during the summer and fall months. However, it is unlikely that large concentrations of these animals would be found in the SFWF area because observations show that their distribution is widespread, and the only concentrated occurrence was documented south of Nantucket.

South Fork Export Cable

Leatherback sea turtle strandings on U.S. shores are mostly of adult or near-adult size turtle (NMFS and USFWS, 1992). In relation to species occurrences, leatherback sea turtle sightings generally are fewer in number when compared to loggerhead and Kemp's ridley sea turtles. Leatherback sea turtle distribution is similar to that of loggerhead sea turtles with occurrences from Cape Hatteras to Long Island, but leatherback sea turtles are more frequently observed in the Gulf of Maine, southwest of Nova Scotia, Canada. Boaters fishing within 16 km of the south shore of Long Island frequently report leatherback sea turtle sightings (NMFS and USFWS, 1992). CETAP reported a small cluster with a high-mean relative density near the shore of central to eastern Long Island. In the NYSERDA Digital Aerial Baseline summer 2016 surveys, nine leatherback sea turtles were detected in the New York OPA. During the fall 2016, 28 leatherback sea turtles were detected in the New York OPA (Normandeau and APEM, 2019). Leatherback sea turtle occurrence within the SFEC route area is therefore expected to be common.

3.2.4 Loggerhead Sea Turtle

South Fork Wind Farm

There are nine listed DPSs for loggerhead sea turtles; the Northwest Atlantic Ocean DPS which is likely to occur in the Project Area was listed as Threatened in 2011 (NMFS, 2019e). Loggerhead sea turtles have a worldwide distribution and inhabit temperate and tropical waters, including estuaries and continental shelves of both hemispheres. Five populations of loggerhead sea turtle exist worldwide in the Atlantic Ocean, Pacific Ocean, Indian Ocean, Caribbean Sea, and Mediterranean Sea. In the Western North Atlantic Ocean, the five major nesting aggregations are: (1) a northern nesting aggregation from North Carolina to northeast Florida, approximately 20° N latitude; (2) a south Florida nesting aggregation from 29° N latitude on the east coast to Sarasota on the west coast; (3) a Florida Panhandle nesting aggregation at Eglin Air Force Base and the beaches near Panama City, Florida; (4) a Yucatán nesting aggregation on the eastern Yucatán Peninsula, Mexico; and (5) a Dry Tortugas nesting aggregation on the islands of the Dry Tortugas, near Key West, Florida (TEWG, 2000).

Female loggerhead sea turtles mate from late April through early September. Individual females might nest several times within one season, but usually nest at intervals of every 2 to 3 years. For their first 7 to 12 years, loggerhead sea turtles inhabit the pelagic waters near the North Atlantic Gyre and are called pelagic immatures. When loggerhead sea turtles reach 40 to 60 cm straight-line carapace length, they begin recruiting to coastal inshore and nearshore waters of the continental shelf through the U.S. Atlantic and Gulf of Mexico and are referred to as benthic immatures. Benthic immature loggerhead sea turtles have been found in waters from Cape Cod, Massachusetts, to southern Texas. Loggerhead sea turtles forage off the Northeastern United States and migrate south in the fall as temperatures drop. Most recent estimates indicate that the benthic immature stage ranges from ages 14 to 32 years and the loggerhead sea turtle matures around ages 20 to 38 years. Prey species for omnivorous juveniles include crab, mollusks, jellyfish, and vegetation at or near the surface. Coastal sub adults and adults feed on benthic invertebrates, including mollusks and decapod crustaceans (TEWG, 2000).

Loggerhead sea turtles are frequently seen in waters off the coast of Rhode Island, Massachusetts, and Long Island, New York. AMAPPS surveys reported loggerhead sea turtles as the most commonly sighted sea turtles on the shelf waters from New Jersey to Nova Scotia, Canada. During the December 2014 to March 2015 aerial abundance surveys, 280 individuals were recorded (Palka et al., 2017). Kraus et al. (2016) reported that loggerhead sea turtle occurrence in the RI-MA WEA was highest during August and September. Across all four survey years, there were 27 sightings in August and 45 sightings in September within the RI-MA WEA. The SPUE for loggerhead sea turtles in the RI-MA WEA ranged from 1 to 85 turtles per 1,000 km (Kraus et al., 2016; BOEM, 2013). The NYSERDA Digital Aerial Baseline Surveys detected few loggerhead sea turtles; however, it confirmed four sightings in the New York OPA during the summer 2016 surveys. None were detected during the fall 2016 surveys (Normandeau and APEM, 2019).

Because of their documented occurrence, it is likely that loggerhead sea turtles could occur within the SFWF area during the summer and fall. However, it is unlikely there would be a high concentration of turtles within the SFWF area, because most of these observations were reported as single sightings widely distributed throughout the RI-MA WEA (Kraus et al., 2016; Palka et al., 2017).

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Loggerhead sea turtles are commonly seen off the coast of New York. The NYSERDA Digital Aerial Baseline surveys detected 395 loggerhead sea turtles in the New York OPA in the summer 2016 surveys and 6 in the fall 2016 surveys (Normandeau and APEM, 2019). The CETAP conducted extensive aerial surveys from 1978 through 1982 along the coast from Cape Hatteras, North Carolina to Long Island, New York. Many loggerhead sea turtles were sighted along the continental shelf waters between Cape Hatteras, North Carolina, and Long Island, New York. A high density of loggerhead sea turtles was seen near the shore of central Long Island. Loggerhead sea turtles show a northern limit at approximately 41° N latitude (CETAP, 1982), and few sightings were reported past that northern limit (Shoop and Kenney, 1992). Loggerhead sea turtles are most commonly seen in this region beginning in June, they then begin to decrease until October (Shoop and Kenney, 1992). The turtles that fall behind may succumb to cold-stunning, which usually occurs during the fall when water temperatures begin to fall. In 1985, 56 cold-stunned turtles were stranded in eastern Long Island (Kenney and Vigness-Raposa, 2010). Loggerhead sea turtle occurrence within the SFEC route area is therefore expected to be common.

3.3 STURGEON

There are two sturgeon species that potentially occur within the Project Area, the Atlantic sturgeon (*Acipenser oxyrhychus*) and shortnose sturgeon (*Acipenser brevirostrum*).

3.3.1 Atlantic Sturgeon

South Fork Wind Farm

The Atlantic sturgeon is listed as Endangered under the ESA and is the sturgeon species most likely to occur in the SFWF area. The Atlantic sturgeon is a large (up to 4 m long), long-lived, anadromous fish that feeds on benthic invertebrates (NMFS, 2019f).

Atlantic sturgeon are found from Canada to Florida in estuarine habitats and rivers as well as in coastal and shelf marine environments. Subadults move out to estuarine and coastal waters in the fall; and adults inhabit fully marine environments and migrate through deep water when not spawning (Atlantic Sturgeon Status Review Team [ASSRT], 2007). The most recent status review for the Atlantic sturgeon was conducted in 2007. In this review, commercial bycatch was assessed and showed that the majority (61%) of tagged sturgeon recaptures came from ocean waters within 4.8 km of shore, with the lowest ocean bycatch occurring in the summer months (July to September) (ASSRT, 2007). Atlantic sturgeon occurring the in the SFWF area are part of the New York Bight DPS. The Atlantic Sturgeon stock assessment (Atlantic States Marine Fisheries Commission [ASMFC], 2017) indicate that all DPS stocks are depleted but recovering. It is estimated that biomass and abundance are currently higher than that in 1998 (last year of available survey data) for the New York Bight DPS (75% average probability). The estimated abundance of age 0-1 Atlantic sturgeon in the Delaware River in 2014 was 3,656 individuals (Hale et al., 2016), which is similar to the age-1 estimate of 4,314 for the Hudson River in 1995 (Petersen et al., 2000). Similar estimates from the 2007 status review suggest that the Hudson River population consists of approximately 4,600 wild juveniles with a spawning stock of 870 adults. There is critical habitat designated for the New York Bight DPS within the Connecticut, Housatonic, Hudson, and Delaware Rivers, but no offshore critical habitat designation.

NMFS listed the New York Bight DPS of Atlantic sturgeon as Endangered under the ESA in 2012 (77 *FR* 5879) with critical habitat designation finalized in 2017 (82 *FR* 3916). The IUCN lists the Atlantic sturgeon as Near Threatened and the Convention on International Trade in Endangered Species of Wild Fauna and Flora lists the species under *Appendix II*, which lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. Current threats to Atlantic sturgeon within critical habitat include dams and turbines, dredging, water quality, and climate change.

South Fork Export Cable

Historically, this population of Atlantic sturgeon spawned in several rivers between Massachusetts and the Chesapeake Bay; currently, however, the New York Bight DPS is known to consistently spawn only within the Hudson and Delaware rivers between April and May (ASSRT, 2007), and may be encountered within the SFEC route area.

3.3.2 Shortnose Sturgeon

South Fork Wind Farm

Like the Atlantic sturgeon, the shortnose sturgeon is listed as Endangered under the ESA and much of the distribution information is the same for the two species which co-occur in habitats along the Atlantic coast. Individuals occurring in the SFWF area are from the Northeast spawning population which encompasses the Connecticut, Hudson, and Delaware Rivers. Morphologically, the shortnose sturgeon is smaller overall with a less pronounced snout than other sturgeon species. In a 2010 Biological Assessment (Shortnose Sturgeon Status Review Team, 2010), shortnose sturgeon were described as spending less time in open ocean habitats and spawning farther upriver than Atlantic sturgeon. The Northeast shortnose sturgeon population uses freshwater habitats more than any of the other shortnose sturgeon populations (Kynard et al., 2016). They are considered more of an amphidromous species (defined as a species that spawns and remains in freshwater for most of its lifecycle but spends some time in saline water) rather than fully anadromous. Marine migrations do occur, and individuals have been recorded traveling 140 km in 6 days when moving between rivers (Kynard et al., 2016). Because of the shortnose sturgeon proclivity to freshwater and estuarine habitats, the potential for shortnose sturgeon to be present in the SFWF area is considered extremely unlikely.

South Fork Export Cable

The Northeast shortnose sturgeon population uses freshwater habitat more than any of the other shortnose sturgeon populations (Kynard et al., 2016). They are considered more of an amphidromous species (defined as a species that spawns and remains in freshwater for most of its lifecycle but spends some time in saline water) rather than fully anadromous. However, because of the shortnose sturgeon proclivity to freshwater and estuarine habitats, the potential for shortnose sturgeon to be present in the SFEC route area is considered extremely unlikely.

4.0 Acoustic Assessment for SFWF and SFEC Construction

The COP Appendix J1 (Denes et al., 2021a) provides a thorough compilation of the sound propagation distances of multiple SFWF impact pile driving scenarios, vibratory pile driving during installation of the SFEC cofferdam, and DP vessel noise to impact thresholds that are either regulated under the MMPA or have substantial science-based criteria and have been applied in regulatory or impact assessment under the MMPA or ESA. All thresholds are based on an animal being exposed to either a maximum instantaneous sound (SPL_{pk}) or exposure to a noise over a specified time period (SEL_{cum}).

This acoustic assessment summarizes the modeling of only two construction scenarios in order to provide a straightforward overview of the primary risk factors to both listed and non-listed species, and methods undertaken to reduce these risks.

4.1 THRESHOLD CRITERIA

Acoustic thresholds are received sound levels that meet current scientific criteria as sufficient for eliciting the onset of a physiological effect (e.g., injury, mortality) or behavioral response in a given marine species. Threshold criteria are used to determine impact levels and the potential for acoustic exposures at levels that may constitute a regulatory action. Regulatory thresholds are defined for marine mammals, sea turtles, and fish; although the thresholds for each faunal group are defined for different sources and may have a slightly different regulatory context and application. Impulsive source criteria are typically presented as three thresholds, one for SPL_{pk} and one for SEL_{cum}, reflecting the different potential exposure characteristics of the source which may cause physiological impacts; and one for SPL_{rms}, which is used in behavioral impact assessments. Non-impulsive source criteria are typically presented as SEL_{cum} or SPL_{rms} as they do not have the characteristic peak in energy that impulsive sources do. Throughout this assessment, modeling results are presented for one physiological threshold criterion and one behavioral threshold criterion for each faunal group for both impulsive and non-impulsive sound sources. An explanation of the selected threshold criteria follows.

For marine mammals, acoustic thresholds are used within the context of harassment under the MMPA. The MMPA defines harassment in two levels; Level A (physiological) and Level B (behavioral). The marine mammal threshold criteria used in this assessment comprises the NMFS (2018) technical guidance criteria for Level A exposure (physiological) and the Level B exposure (behavior) thresholds for marine mammals previously published by NMFS (2019g). Marine mammal physiological thresholds are frequency weighted to account for differences in species' hearing sensitivities. Regulatory marine mammal behavioral thresholds are unweighted; however, it is common practice to apply frequency weighting to these behavior thresholds. The unweighted behavioral thresholds were used in this assessment because they have a regulatory foundation. While it is acknowledged the weighted threshold may be a more appropriate impact metric, the current review status for behavioral acoustic criteria and lack of regulatory basis for weighted values at this time warrant the use of the unweighted metric for this analysis.

There are three accepted references for defining acoustics thresholds in sea turtles and fish: Popper et al. (2014), the Fisheries Hydroacoustic Working Group (FHWG) criteria (FWHG, 2008) , and a recent analysis of acoustic impacts to marine mammals and sea turtles published by the U.S. Navy (Finneran et al., 2017) based on exposure studies by McCauley et al. (2000). These sources present criteria for physiological effects that are categorized as injury; however, Popper et al. (2014) concedes that injury includes a very wide spectrum of physiological effects, and even those sources that have the potential for mortal injury will likely vary by context and biological conditions. The physiological thresholds indicate received sound levels at amplitudes expected to cause physiological changes in the animal.

For fish, the Popper et al. (2014) SPL_{pk} physiological threshold value (207 dB re 1 µPa) is nearly identical to the SPL_{pk} physiological threshold value (206 dB re 1 µPa) developed by the FHWG (2008). However, the SEL_{cum} physiological thresholds for fish reported by the two references differs by 27 dB, demonstrating the continued uncertainty in the understanding of acoustic criteria in fish. The fish of primary concern in this assessment is the Atlantic sturgeon. Atlantic sturgeon have a relatively primitive swim bladder with no known connection between the swim bladder and inner ear. Atlantic sturgeon are not expected to be found close enough to the impact pile driving activities to sustain mortal injuries; therefore, this acoustic assessment presents the FHWG (2008) thresholds for fish >2 g for impulsive sources. For non-impulsive sources, the threshold used in this assessment is for fish with swim bladders that are involved with hearing because this is the only threshold available from Popper et al. (2014) for that source type. Popper et al. (2014) also does not provide thresholds for behavior criteria, instead using TTS as the onset threshold for a behavioral reaction. In order to better summarize potential injury verses behavioral impacts, the TTS criteria are not considered here but are presented in the full acoustic modeling report (Denes et al., 2021a). This assessment used the FHWG (2008) behavior criteria for sturgeon/salmon. The FHWG (2008) behavioral threshold of SPL_{rms} 150 dB re 1 µPa is admittedly not tested for biologically significant behavioral reactions in fish, and that behavioral responses in fish may range from a heightened awareness of the sound to changes in movement or feeding activity (Popper and Hastings, 2009); therefore, it should be considered a highly conservative estimate for the onset of behavioral responses in sturgeon.

For sea turtles, Finneran et al. (2017) provides thresholds for physiological impacts only for impulsive sounds, which were used in this assessment. Popper et al. (2014) provides subjective criteria for recoverable injury and TTS (e.g., near, intermediate, far) rather than discrete values. The subjective nature of these criteria are not applicable to the modeling and would be highly dependent on context of the activity. For non-impulsive sounds, the only available physiological threshold criteria is from FHWG (2008). Two options are available for behavior criteria in sea turtles, FHWG (2008) and Finneran et al. (2017). Both references base the onset of disturbed behavior on caged sea turtle studies conducted by McCauley et al. (2000) during an active seismic survey, with the difference being the assessment of the sea turtles at various received levels. Finneran et al. (2017) noted that due to the potential caging influence, the SPL_{rms} threshold of 175 dB re 1 µPa was likely a more appropriate threshold to use for onset of behavioral disturbance in sea turtles in open water; and this threshold was used for sea turtles in this assessment. The sources for all the threshold criteria values for all species groups are summarized in **Table 4-1**.

Table 4-1. Reference sources for the threshold criteria values used in this assessment.

Faunal Group	Physiological Threshold Criteria	Behavioral Threshold Criteria
Marine Mammals	NMFS (2018)	NMFS (2019g)
Sea Turtles	Finneran et al. (2017), FHWG (2008)	Finneran et al. (2017)
Atlantic sturgeon	Popper et al. (2014), FHWG (2008)	FHWG (2008)

FHWG = Fisheries Hydroacoustic Working Group; NMFS = National Marine Fisheries Service.

4.1.1 Impulsive Sources

For assessing potential impacts to species from impact pile driving, physiological exposure thresholds can be met if the animal is exposed to either the SPL_{pk} or SEL_{cum} criteria. Species weighting functions are applied to physiological threshold distances in marine mammals. These weighting functions provide a measure of species-specific sensitivities to the frequency component contained in the propagated sound. In all modeled results for non-attenuated operational scenarios, the maximum SPL_{pk} thresholds for marine mammals typically occur close to the source (<100 m for marine mammals), while SEL_{cum} thresholds produced larger isopleth distances. In addition to the larger isopleth distances, given the nature of construction activities where there is significant disturbance around the installation site, there is a higher potential for animals to be exposed to physiological-level SEL_{cum} thresholds than SPL_{pk} thresholds. Therefore, given the greater potential for physiological-level exposures, $SEL_{cum,}$ was selected to review potential impacts in this Appendix for all faunal groups, with the one exception being HFCs (e.g., harbor porpoises) where the maximum SPL_{pk} ranges extended up to 1,500 m for unattenuated impact pile driving; therefore both SPL_{pk} and SEL_{cum} threshold distances are presented for the HFC group.

Impulsive sources have only a single SPL_{rms} value for behavioral criteria for each faunal group (marine mammals, sea turtles, fish). The faunal group and associated criteria for physiological impacts and behavioral disturbance are provided in **Table 4-2**.

Table 4-2. Acoustic threshold criteria for impulsive sources used in acoustic assessment for South Fork Wind Farm Project activities.

Faunal Group	Physiological Thresholds[1]		Behavioral Threshold	
	Acoustic Metric	Threshold Value	Acoustic Metric	Threshold Value
Low-frequency Cetaceans	$SEL_{cum, 24hr}$	183 dB re 1 µPa² s	SPL_{rms}	160 dB re 1 µPa
Mid-frequency Cetaceans	$SEL_{cum, 24hr}$	185 dB re 1 µPa² s	SPL_{rms}	160 dB re 1 µPa
High-frequency Cetaceans	$SEL_{cum, 24hr}$	155 dB re 1 µPa² s	SPL_{rms}	160 dB re 1 µPa
	SPL_{pk}	202 dB re 1 µPa		
Phocid Pinnipeds in water	$SEL_{cum, 24hr}$	185 dB re 1 µPa² s	SPL_{rms}	160 dB re 1 µPa
Sea Turtles	$SEL_{cum, 24hr}$	204 dB re 1 µPa² s	SPL_{rms}	175 dB re 1 µPa
	SPL_{pk}	232 dB re 1 µPa		
Atlantic sturgeon	$SEL_{cum, 24hr}$	187 dB re 1 µPa² s	SPL_{rms}	150 dB re 1 µPa
	SPL_{pk}	206 dB re 1 µPa		

dB re 1 µPa = decibel referenced to 1 micropascal; dB re 1 µPa² s = decibel referenced to 1 micropascal squared second; $SEL_{cum, 24hr}$ = cumulative sound exposure level over a 24-h exposure period; SPL_{pk} = zero to peak sound pressure level; SPL_{rms} = root-mean-square sound pressure level.
[1]Physiological thresholds are defined here as onset of permanent threshold shift (PTS) in marine mammals; onset of potential mortal injury in sea turtles and Atlantic sturgeon.

4.1.2 Non-impulsive Sources

The criteria for non-impulsive sources is somewhat simplified due to it being a singular rather than dual criteria for marine mammals. Non-impulsive sources are only applicable for the DP vessel thrusters and the vibratory pile driving used for the installation of the SFEC cofferdam. In addition to the difference in source types, the timing, duration, and the location of the vibratory pile driving will be different than impact pile driving. Due to these factors, the non-impulsive sources are assessed separately in the operational scenario evaluations.

The thresholds criteria values for non-impulsive sources are different from those for impulsive sources. Non-impulsive thresholds values are provided in **Table 4-3**.

Table 4-3. Acoustic threshold criteria for non-impulsive sources used in the acoustic assessment for South Fork Wind Farm Project activities.

Faunal Group	Physiological Thresholds[1]		Behavioral Threshold	
	Acoustic Metric	Threshold Value	Acoustic Metric	Threshold Value
Low-frequency Cetaceans	$SEL_{cum,\ 24hr}$	199 dB re 1 µPa² s	SPL_{rms}	120 dB re 1 µPa
Mid-frequency Cetaceans	$SEL_{cum,\ 24hr}$	198 dB re 1 µPa² s	SPL_{rms}	120 dB re 1 µPa
High-frequency Cetaceans	$SEL_{cum,\ 24hr}$	173 dB re 1 µPa² s	SPL_{rms}	120 dB re 1 µPa
Phocid Pinnipeds in water	$SEL_{cum,\ 24hr}$	201 dB re 1 µPa² s	SPL_{rms}	120 dB re 1 µPa
Sea Turtles	$SEL_{cum,\ 24hr}$	180 dB re 1 µPa	SPL_{rms}	175 dB re 1 µPa
Atlantic sturgeon[2]	$SPL_{rms\ 48hr}$	170 dB re 1 µPa	SPL_{rms}	150 dB re 1 µPa

dB re 1 µPa = decibel referenced to 1 micropascal; dB re 1 µPa² s = decibel referenced to 1 micropascal squared second; $SEL_{cum,\ 24\ hr}$ = cumulative sound exposure level over a 24-h exposure period; SPL_{pk} = zero to peak sound pressure level; SPL_{rms} = root-mean-square sound pressure level.

[1]Physiological thresholds are defined here as onset of permanent threshold shift (PTS) in marine mammals; onset of potential mortal injury in sea turtles; and onset of recoverable injury in Atlantic sturgeon.

[2]Recoverable injury threshold reported for fish with swim bladders involved in hearing. Popper et al., (2014) does not provide thresholds for fish with swim bladder not involved with hearing. Threshold assumes that the Atlantic sturgeon is exposed to the SPL_{rms} value for 48 continuous hours.

4.2 ACOUSTIC MODELING

Modeled sound fields were used to determine potential impacts to marine species based on the corresponding threshold criteria; the methodology is fully described in the COP Appendix J1 (Denes et al., 2021a). To summarize, sound propagation through the water was modeled to produce three-dimensional isopleths of sound levels. The isopleth that encompasses 95% of any specific $SPL_{pk,}$ SEL_{cum}, or SPL_{rms} was used to define the horizontal distance from the source at which acoustic thresholds for a marine species may be met. An animal located within that isopleth for a defined period of time is said to be exposed to the corresponding threshold. These isopleth distances are used in the regulatory context of impact assessment and, in the case of marine mammals, are used to estimate takes as defined by the MMPA. Specified acoustic impact threshold isopleth distances may also serve as zones of influence (ZOIs) for a given project and can help assess whether standard mitigation methods (e.g., visual observation) adequately reduce the risk of acoustic impacts to a given marine species. Being exposed to a specific threshold or occupying the waters within a subsequent isopleth does not alone constitute an impact for a particular species. Estimated or predicted exposures that simultaneously consider the source, activity, propagation environment, weighting factors, mitigation factors, and autecological characteristics of at-risk species provide an appropriate means to assess potential noise impacts from an activity. Variability in each of these factors will in turn vary the potential impact risk to each species.

4.2.1 Modeling Parameters

The modeling report (Denes et al., 2021a) provides detailed results regarding sound propagation distances that occur with changes in all key operational variables: hammer type, pile type, pile schedule (hammer energy/number of strikes), season, geographic location, and implementation of sound attenuation measures. Some of these variables will have a greater influence on the computation of isopleths than other variables. More importantly, certain combinations of variables will affect the computation of isopleths more than others. The merging of modeled isopleth ranges that consider the sound source types and likely combinations of conditions (activity scenarios) with the threshold criteria previously described provide the parameters to assess expected ranges to the specified threshold distances for individual faunal groups to serve as the basis for acoustic impact assessment.

Several assumptions were applied to the presented data in order to streamline the viewing of the model results for use in an assessment framework (Denes et al., 2021a). The environmental propagation conditions used in the modeled scenarios consider seasonal and geographic location variability. Generally, modeled isopleth distances were larger during the fall/winter versus spring/summer. The actual isopleth distances created during construction are likely further influenced by *in situ* environmental conditions during construction. Therefore, isopleths for each season and each modeling location are combined and not presented separately in this assessment.

Finally, the energy output and number of blows at different impact pile driving schedules (e.g., start up, full driving, end set) will produce different isopleths for each energy level. This impact pile driving schedule is already accounted for in the calculation of SEL_{cum} thresholds. In order to better summarize the details of the model into an assessment of the installation activities, the SPL_{pk} and SPL_{rms} distances produced by individual impact pile driving schedules in each scenario were averaged, assuming that the average level across the entire impact pile driving schedule is a sufficient representation of potential impacts produced over the course of a full pile installation (i.e., start to completion of driving a pile foundation). The model also included four hammer energies to best characterize the potential isopleth distances resulting from this project, which were combined in this report to better summarize the modeling results.

A total of 16 monopile foundations are scheduled for installation. Eleven-meter diameter steel monopiles were used for the modeling assessment as they represent the maximum pile size that would be considered for construction of the SFWF. The impact pile driving parameters used in this analysis to estimate the range to prescribed physiological and behavior thresholds were based on engineering and project design assumptions. While not expected, some of the assumptions and design criteria may change slightly up to the point of SFWF construction. Modeling used the most accurate and current parameters expected for the Project, and where there is uncertainty, a conservative approach was used.

For impact pile driving, a standard pile schedule and a difficult pile schedule were modeled to determine threshold distances (Denes et al., 2021a). A single pile is expected to take roughly 120 min to install; however, there is the possibility that the Project will encounter conditions where a pile is difficult to install and will require additional strikes. A pile may be difficult to drive because of denser than anticipated substrate or the presence of an unavoidable boulder but no more than one difficult-to-drive pile is expected out of the total sixteen piles. Both piling schedules assume that only one pile will be installed within any single 24-h period; however, the standard pile schedule assumes that 4,500 strikes are required to complete installation while the difficult pile schedule assumes 8,000 strikes to complete installation. Modeling accounted for the inclusion of a soft start at the beginning of each pile. The soft start sequence, standard pile schedule, and difficult pile schedule are provided in **Table 4-4**, **Table 4-5**, and **Table 4-6** respectively. The standard schedule is the most likely scenario expected to occur during Project construction.

Table 4-4. Generic soft-start sequence reflecting the corresponding hammer energy, strike count, and duration of the strike sequence that will be implemented at the beginning of each pile installation.

% of Maximum Hammer Blow Energy	Soft Start
	10–20%
Monopile blow energy	600–800 kJ
Strike Rate	4–6 strikes/min
Duration	Minimum of 20 minutes or greater until pile verticality/self-stability is secured

kJ = kilojoule; min = minutes.

Table 4-5. Standard pile schedule reflecting the corresponding hammer energy, strike count, and penetration depth of the strike sequence that will be implemented after the soft start (Denes et al., 2021a).

Energy Level (kJ)	Strike Count	Penetration Depth (m)
~1,000	~500	6
~1,500	~1,000	17.5
~2,500	~1,500	17.5
~ 4,000	~1,500	4

kJ = kilojoule; m = meters; min = minutes.

Table 4-6. Difficult pile schedule reflecting the corresponding hammer energy, strike count, and penetration depth of the strike sequence that will be implemented after the soft start (Denes et al., 2021a).

Energy Level (kJ)	Strike Count	Penetration Depth (m)
~1,000	~800	6
~1,500	~1,200	17.5
~2,500	~3,000	17.5
~4,000	~3,000	4

kJ = kilojoule; m = meters; min = minutes.

For vibratory pile driving, modeling assumed a Z-type sheet pile 19.5 m long, 3/8 inch thickness, installed 9 m into the sediment in 9 m of water. Vibratory pile driving activities are expected to be completed in 12 to 18 h over no more than 1.5 days using an American Pile driving Equipment (APE) Model 200T Hammer.

A DP vessel, similar to the *Ndurance*, a 99-m cable lay vessel with 30-m beam and a 4.8-m draft, will be utilized during SFEC and SFWF inter-array cable lay activities. The *Ndurance* has four (two fore, two aft) azimuth thrusters and one bow thruster, with a combined rated power of 5,050 kW (6,772 BHP). The threshold radii were modeled using recordings from a proxy 107-m DP support vessel with a breadth of 19 m, a loaded draft of 6.6 m, and an operating source power of 2,983 kW (4,000 BHP) (MacGillivray 2006), which is described in COP Appendix J1 (Denes et al., 2021a).

4.2.2 Acoustic Modeling Results

For impact pile driving the linear ranges to regulatory acoustic thresholds (NMFS, 2018, 2019g) were modeled for four hammer energies to best characterize the distances to SEL_{cum} thresholds throughout the pile schedule and for the complete pile schedule. The SEL_{cum} standard schedule distances result from pile installation requiring roughly 4,500 strikes, while the SEL_{cum} difficult schedule distances result from installation of a difficult pile requiring roughly 8,000 strikes. Summaries of the acoustic ranges to physiological and behavioral acoustic thresholds for all species groups that are likely to occur in the SFWF and SFEC areas resulting from propagation modeling of impact and vibratory pile driving and DP vessels are provided in **Tables 4-7** through **4-11**. The acoustic ranges are calculated using only sound propagation through the environment and a receiver (i.e., animal) which is assumed to be stationary to predict the maximum distance at which that receiver could receive enough acoustic energy over a 24-h period to exceed the threshold criteria.

4.2.2.1 Impulsive Noise

Impulsive noise will result from impact pile driving in the SFWF during installation of the 16 monopile foundations. Each monopile foundation will consist of a single steel pile, approximately 11 m in diameter with a 10.3 cm wall thickness. Piling schedules and parameters are available in **Section 4.2.1**.

Impact pile driving activities produce noise over a broad range of frequencies; however, the intensity of noise in individual frequency bands throughout the full source spectrum is not uniform. Frequency weighting functions, as determined in NMFS (2018), consider the heterogeneity of the source spectrum with the differences in marine mammal hearing between the various hearing groups to produce a more reasonable interpretation of the sound levels at which various groups are anticipated to meet regulatory thresholds. However, as previously mentioned, regulatory acoustic guidance only recognizes frequency weighting for physiological thresholds.

Additionally, noise attenuation was applied to the propagation model based on planned use of a big bubble curtain (BBC) or similar device to reduce noise propagation during impact pile driving. While some of the noise produced by impact pile driving activities is transmitted into the seabed and radiated into the water column that way, a reduction of the noise transmitted directly into the water column can be successfully achieved with the implementation of noise attenuation or abatement methods. It is useful to keep in mind that a reduction of 10 dB means reducing the sound energy level by 90% thus providing a significant reduction in the propagated sound levels and resulting impact isopleths. The acoustic model applied 6, 10, and 12 dB broadband noise attenuation through the use of a BBC, to gauge the effects of the mitigation on the ranges to thresholds relative to the unattenuated ranges.

Acoustic Ranges

Modeled acoustic ranges are presented for the standard and difficult pile schedules with 0, 6, 10, and 12 dB sound attenuation. For each summary table, the mean acoustic range produced by the modeled impact pile driving scenarios are presented. Fine-scale environmental as well as operational variability cannot be captured in the summarization; therefore, results and values in these tables are based solely on the assumptions described in the COP Appendix J1 (Denes et al., 2021a).

Results for the mean acoustic ranges (in m) to physiological threshold criteria are presented in **Tables 4-7** (SPL_{pk}) and **4-8** (SEL_{cum}), and the mean acoustic ranges to behavioral threshold values are presented in **Table 4-9**.

Table 4-7. Mean acoustic ranges to zero to peak sound pressure level (SPL_{pk}) acoustic threshold criteria for marine mammals (NMFS, 2018), sea turtles (Finneran et al., 2017), and Atlantic sturgeon (FHWG, 2008) due to impact pile driving of an 11-m monopile with 0, 6, 10, and 12 dB broadband noise attenuation applied (Denes et al., 2021a).

Faunal Group	Threshold SPL_{pk} (dB re 1 µPa)	Mean acoustic range (m) to threshold			
		0 dB attenuation	*6 dB attenuation*	*10 dB attenuation*	*12 dB attenuation*
Low-frequency cetaceans	219	87	22	8	7
Mid-frequency cetaceans	230	8	2	2	1
High-frequency cetaceans	202	1,545	541	301	183
Phocid pinnipeds in water	218	101	26	10	8
Sea Turtles	232	2	2	1	1
Atlantic sturgeon	206	461	170	84	64

dB re 1 µPa = decibel referenced to 1 micropascal; SPL_{pk} = peak sound pressure level.

Table 4-8. Mean acoustic ranges to cumulative sound exposure level (SEL_{cum}) acoustic thresholds for marine mammals (NMFS, 2018), sea turtles (Finneran et al., 2017), and sturgeon (FHWG, 2008) due to impact pile driving of an 11-m pile for a standard schedule (~4,500 strikes) and a difficult to drive pile schedule (~8,000 strikes) with 0, 6, 10, and 12 dB broadband noise attenuation applied (Denes et al., 2021a).

Faunal Group	Threshold SEL_{cum} (dB re 1 µPa^2 s)	Mean acoustic range (m) to threshold							
		0 dB attenuation		*6 dB attenuation*		*10 dB attenuation*		*12 dB attenuation*	
		Standard	Difficult	Standard	Difficult	Standard	Difficult	Standard	Difficult
Low-frequency cetaceans	183	16,416	21,941	8,888	11,702	6,085	7,846	5,015	6,520
Mid-frequency cetaceans	185	107	183	43	59	27	32	27	26
High-frequency cetaceans	155	9,290	13,374	4,012	6,064	2,174	3,314	2,006	2,315
Phocid pinnipeds	185	3,224	4,523	1,375	2,084	673	1,080	437	769
Sea Turtles	204	3,288	4,348	1,627	2,210	882	1,363	585	971
Sturgeon	187	17,853	23,243	10,293	13,290	7,264	9,230	6,109	7,724

dB re 1 µPa^2 s = decibel referenced to 1 micropascal squared second; SEL_{cum} = sound exposure level accumulated over 24 hours.

Table 4-9. Mean acoustic range to unweighted root-mean-square sound pressure level (SPL_{rms}) acoustic threshold for marine mammals (NMFS, 2019g), sea turtles (Finneran et al., 2017), and Atlantic sturgeon (Fisheries Hydroacoustic Working Group, 2008) due to impact pile driving of an 11-m pile with 0, 6, 10, and 12 dB broadband noise attenuation applied (Denes et al., 2021a).

Faunal Group	Threshold SPL_{rms} (dB re 1 µPa)	Mean acoustic range (m) to threshold			
		0 dB attenuation	*6 dB attenuation*	*10 dB attenuation*	*12 dB attenuation*
Marine Mammals	160	11,382	6,884	4,684	4,164
Sea Turtles	175	2,704	1,752	1,147	861
Atlantic sturgeon	150	21,675	12,495	8,861	7,375

dB re 1 µPa = decibel referenced to 1 micropascal; SPL_{rms} = root-mean-square sound pressure level.

Unattenuated SPLs generated during impact pile driving will exceed the biological thresholds associated with behavioral disturbance in marine mammals, sea turtles, and Atlantic sturgeon; and could exceed thresholds for the potential onset of physiological effects in LFCs, HFCs, PPWs, sea turtles, and Atlantic sturgeon beyond 500 m if the duration of exposure approached 24 h. Acoustic ranges to physiological thresholds for MFCs are 183 m or less and would not reach the exposure criteria onset for either distance or duration. The average unattenuated acoustic ranges to behavioral disturbance thresholds are relatively large for all faunal groups (~3 to 21 km).

Ranges to LFC, MFC, PPW physiological thresholds for the SPL_{pk} metric are less than approximately 101 m with no sound attenuation applied (Denes et al., 2021a). Although the mean acoustic range to SEL_{cum} physiological thresholds with 12 dB attenuation may range from 27 m for MFC to 7,724 m for Atlantic sturgeon, the actual potential for physiological exposures to occur is expected to be very low for marine mammals, sea turtles, and Atlantic sturgeon due to low species densities in the Project Area, short time periods of potential exposure (~3 h of impact pile driving during a 24-period), and general animal movements such as aversion to noise produced during construction activities.

For all species, noise attenuation reduces the risk of impacts in two ways. First, by reducing the distance to a specific threshold level, particularly the physiological thresholds, we increase the ability to monitor and mitigate an area of impact. Second, by reducing the radial distance to the threshold, the overall area (i.e., available habitat) contained within the threshold isopleths is substantially reduced and less likely to include a marine species. At 10 dB broadband attenuation, most threshold isopleths are negligible and within applicable mitigation distances using standard mitigation approaches.

Exposure Ranges

Modeled acoustic ranges to threshold levels may overestimate the actual distances at which animals receive exposures meeting the threshold criteria. As previously stated, modeled acoustic ranges to thresholds assume that receivers (i.e., animals) are stationary. Therefore, such ranges are not realistic, particularly for accumulating metrics like SEL_{cum}. Applying animal movement and behavior (Denes et al., 2021b) within the propagated noise fields provides the *exposure range*, which results in a more realistic indication of the distances at which acoustic thresholds are met. For modeled animals that have received enough acoustic energy to exceed a given threshold, the exposure range for each animal is defined as the closest point of approach (CPA) to the source made by that animal while it moved throughout the modeled sound field. The resulting exposure range for each species is the 95th percentile of the CPA distances for all animals that exceeded threshold levels for that species (termed the 95% exposure range [$ER_{95\%}$]). Notably, the $ER_{95\%}$ are species-specific rather than categorized only by hearing group which affords more biological content to be considered when assessing impact ranges. The $ER_{95\%}$ for SEL_{cum} are provided in **Table 4-10** and are smaller than the acoustic ranges calculated using propagation modeling alone (**Table 4-8**). $ER_{95\%}$ were not calculated for Atlantic sturgeon because animal movement modeling information is not currently available for this species

Table 4-10. Mean 95% exposure ranges ($ER_{95\%}$) to cumulative sound exposure level (SEL_{cum}) acoustic thresholds for marine mammals (NMFS, 2018) and sea turtles (Finneran et al., 2017) due to impact pile driving of an 11-m pile for a standard schedule (~4,500 strikes) and a difficult to drive pile schedule (~8,000 strikes) with 0, 6, 10, and 12 dB broad-band noise attenuation applied (Denes et al., 2021b).

Species†	$ER_{95\%}$ to SEL_{cum} threshold (m)							
	0 dB Attenuation		*6 dB Attenuation*		*10 dB Attenuation*		*12 dB Attenuation*	
	Standard	Difficult	Standard	Difficult	Standard	Difficult	Standard	Difficult
Low-frequency Cetaceans								
Fin whale*	5,386	6,741	2,655	2,982	1,451	1,769	959	1,381
Minke whale	5,196	6,033	2,845	2,882	1,488	1,571	887	964
Sei whale*	5,287	6,488	2,648	3,144	1,346	1,756	1,023	1,518
Humpback whale	9,333	11,287	5,195	5,947	3,034	3,642	2,450	2,693
North Atlantic right whale*	4,931	5,857	2,514	3,295	1,481	1,621	918	1,070
Blue whale*[1]	5,386	6,741	2,655	2,982	1,451	1,769	959	1,381
Mid-frequency Cetaceans								
Sperm whale*	0	0	0	0	0	0	0	0
Atlantic spotted dolphin	0	0	0	0	0	0	0	0
Atlantic white-sided dolphin	20	6	20	6	0	0	0	0
Common dolphin	0	0	0	0	0	0	0	0
Risso's dolphin	24	13	24	0	0	0	0	0
Bottlenose dolphin	13	13	0	0	0	0	0	0
Long-finned pilot whale	0	0	0	0	0	0	0	0
High-frequency Cetaceans								
Harbor porpoise	2,845	3,934	683	996	79	365	26	39
Phocid Pinnipeds in water								
Gray seal	1,559	1,986	276	552	46	117	0	21
Harbor seal	1,421	2,284	362	513	22	85	22	0
Sea turtles								
Kemps ridley turtle*	1,290	1,758	428	745	17	12	17	12
Leatherback turtle*	1,417	2,045	522	472	0	51	0	10
Loggerhead turtle*	1,560	2,003	393	337	15	179	15	10

SEL_{cum} = sound exposure level accumulated over 24 hours; dB = decibel.
*denotes ESA-listed species.
†Atlantic sturgeon are not included in $ER_{95\%}$ analysis because animal movement models do not currently exist for this species.
[1]Due to the low expected densities of blue whales in the Project Area, an $ER_{95\%}$ was not calculated; however, for the purposes of this assessment the $ER_{95\%}$ calculated for the fin whales was used as a proxy.

4.2.2.2 Non-Impulsive Noise

Two project activities will produce non-impulsive sounds: operation of the DP vessels during cable-laying activities and vibratory pile driving operations during cofferdam construction.

Vibratory Pile Driving

The use of a cofferdam is being considered for the nearshore SFEC connection and will require vibratory pile driving of sheet piles. This installation differs from impact pile driving used during SFWF construction in several ways. The location is close to shore, the duration of the installation is estimated to be short (roughly 12 to 18 h), and the source type is non-impulsive rather than impulsive.

Given these differences, both the propagation characteristics of vibratory pile driving noise and the threshold criteria for faunal groups are different than for impact pile driving. **Table 4-11** summarizes the acoustic ranges for marine mammals, sea turtles, and Atlantic sturgeon from vibratory pile driving at the expected cofferdam installation location.

Table 4-11 Maximum acoustic ranges to regulatory acoustic thresholds during 18 h of vibratory pile driving during South Fork Export Cable cofferdam installation for all faunal groups (Denes et al., 2021a).

Faunal Group and Criteria Metric	Acoustic ranges (m) to physiological thresholds	Distances (m) to behavioral thresholds
LFC ($SEL_{cum,24hr}$)	1,470	36,766
MFC ($SEL_{cum,24hr}$)	0	
HFC ($SEL_{cum,24hr}$)	63	
PPW ($SEL_{cum,24hr}$)	103	
Sea Turtle (SPL_{rms})	31	53
Atlantic sturgeon (SPL_{rms})[1]	63	779

HFC = high-frequency cetacean; MFC = mid-frequency cetacean; LFC = low-frequency cetacean; PPW = phocid pinniped in water; $SEL_{cum,24hr}$ = sound exposure level accumulated over a 24-h period in units of decibels referenced to 1 micropascal squared second; SPL_{rms} = root-mean-square sound pressure level in units of decibels referenced to 1 micropascal.
[1]Atlantic sturgeon injury threshold isopleths derived from Popper et al. (2014) for recoverable injury measured in SPL_{rms} with 48 h of continuous exposure for fish with a swim bladder involved with hearing. Atlantic sturgeon behavior SPL_{rms} threshold derived from the Fisheries Hydroacoustic Working Group (2008).

Dynamic Positioning Vessels

The modeled acoustic ranges to physiological and behavioral thresholds for marine mammals, sea turtles, and Atlantic sturgeon during the operation of DP vessels are provided in **Table 4-12**. Modeled ranges presented are averaged across seasons.

Table 4-12. Maximum acoustic ranges to regulatory thresholds during operation of thrusters on a dynamically positioned vessel along the potential South Fork Export Cable route (Denes et al., 2021a).

Faunal Group	Distances (m) to physiological thresholds	Distances (m) to behavioral thresholds
LFC ($SEL_{cum,24hr}$)	112	14,734
MFC ($SEL_{cum,24hr}$)	35	
HFC (SPL_{pk})	103	
PPW ($SEL_{cum,24hr}$)	50	
Sea Turtle (SPL_{rms})	0	0
Atlantic sturgeon (SPL_{rms})[1]	0	135

HFC = high-frequency cetaceans; MFC = mid-frequency cetacean; LFC = low-frequency cetaceans; PPW = phocid pinnipeds in water; $SEL_{cum,24hr}$ = sound exposure level accumulated over a 24-h period in units of decibels referenced to 1 micropascal squared second; SPL_{pk} = zero to peak sound pressure level in units of decibels referenced to 1 micropascal (dB re 1 µPa); SPL_{rms} = root-mean-square sound pressure level in units of dB re 1 µPa.
[1]Atlantic sturgeon injury threshold isopleths derived from Popper et al. (2014) for recoverable injury measured in SPL_{rms} with 48 h of continuous exposure for fish with a swim bladder involved with hearing. Atlantic sturgeon behavior SPL_{rms} threshold derived from the Fisheries Hydroacoustic Working Group (2008).

5.1 MARINE MAMMALS

As shown in **Table 2-1**, IPFs that potentially reach minor to major for marine mammals include underwater noise and vessel traffic (i.e., physical disturbance to and risk of collisions).

5.1.1 Underwater Noise

The range of potential effects from noise includes auditory injury/hearing threshold shift; masking; and stress and disturbance, including behavioral responses (Richardson et al., 1995; NRC, 2003, 2005; Nowacek et al., 2004; Southall et al., 2007). The severity of potential impacts increases when the exposure occurs close to a sound source and when duration of the exposure is longer. Pile driving (both impact and vibratory) and DP vessel usage were identified as the activities that would likely have the greatest potential for auditory impact on marine mammals. These sound sources would be operating during the construction phase of the SFWF and SFEC. Dependent on the level of noise generated from construction activities, elevated underwater noise levels can cause PTS or behavioral modifications to marine mammals.

5.1.1.1 Vessel Noise

Impacts to marine mammals from Project-related vessel and equipment noise are expected but would not be extensive or severe and would include temporary disruption of communication or echolocation from auditory masking; behavior disruptions of individual or localized groups of marine mammals; and limited, localized, and short term displacement of individuals of any species, including strategic stocks, from localized areas around the vessels. Aguilar-Soto et al. (2006) reported that the noise from a passing vessel masked ultrasonic vocalizations of a Cuvier's beaked whale (*Ziphius cavirostris*) and reduced the maximum communication range by 82% when exposed to a 15-dB increase in ambient noise levels at the vocalization frequencies; the effective detection distance of the Cuvier's beaked whale's echolocation clicks was reduced by 58%. Hatch et al. (2012) estimated that calling North Atlantic right whales might have lost 63 to 67% of their communication "space" due to shipping noise. Low-frequency noise (20 to 200 Hz) from large ships overlaps the frequency range of acoustic vocalizations of some mysticetes, and increased levels of underwater noise has been documented in areas with high shipping traffic, causing responses in some mysticetes that have included habitat displacement; changes in behavior; and alterations in the intensity, frequency, and intervals of their calls (Rolland et al., 2012).

Marine mammals are able to compensate, to a limited extent, for auditory masking through a variety of mechanisms, including increasing SLs (Lombard effect) or durations of their vocalizations or by changing spectral and temporal properties of their vocalizations (Parks et al., 2010; Hotchkin and Parks, 2013). North Atlantic right whales produced calls with a higher average fundamental frequency and lowered their call rate in high-noise conditions (Parks et al., 2007). In the presence of ship noise, beluga whales produced whistles of a higher frequency and longer duration (Lesage et al., 1999). Di Iorio and Clark (2009) found that blue whales increased their rate of social calling in the presence of subbottom exploration sparkers, which presumably represented a compensatory behavior to elevated ambient noise levels from surveys. Several marine mammal species are known to increase the SLs of their calls in the presence of elevated noise levels (Dahlheim, 1987; Lesage et al., 1999; Terhune, 1999). Holt et al. (2008) studied the effects of anthropogenic noise exposure on endangered southern resident killer whales in Puget Sound, reporting that these whales increased the SPL_{rms} of their calls by 1 dB for every 1 dB increase in background SPL_{rms} (1 to 40 kHz). Castellote et al. (2012) reported that male fin whales from two different subpopulations not only modified their song characteristics during increased ambient noise conditions, but also left the area for an extended period during seismic airgun activity, not returning for 14 days. Castellote et al. (2012) hypothesized that the fin whales modified their acoustic communications to compensate for the increased background noise and that the animals had a lower tolerance for seismic airgun noise than for shipping noise, perhaps having become desensitized to the ambient shipping noise.

Modeled acoustic ranges for DP vessel noise for SFWF and SFEC construction (Denes et al., 2021a) showed that the maximum modeled acoustic ranges to physiological thresholds for all marine mammals was less than 112 m from the vessel source (**Table 4-12**). The $ER_{95\%}$, which accounts for animal movement and behavior, would be less than this range and therefore no marine mammals are likely to exceed physiological threshold values. The average modeled acoustic range to behavioral thresholds extended beyond 14 km; however, this distance does not represent the onset of biologically significant behavioral changes. The anticipated additional vessel noise associated with DP operations during the project is temporary and is not expected to be a significant contribution to cumulative vessel noise in the region. With the added presumption that individual or groups of marine mammals in the area are familiar with vessel-related noises, particularly within trafficked areas around the SFWF and nearby shipping lanes, the effects of project-related vessel on marine mammals is expected to be ***negligible*** to ***minor***. Behavioral impacts to marine mammals from Project-related vessel noise are expected but are not extensive, severe, or biologically significant. Impacts could include temporary disruption of communication or echolocation from auditory masking; behavior disruptions of individual or localized groups of marine mammals; or limited, localized, and short-term displacement of individuals of any species from the immediate area around the vessels.

5.1.1.2 Impact Pile Driving

Potential impacts from impact pile driving noise include sound levels that can elicit direct injury to or behavioral responses in marine mammals, and in has the potential to cause displacement from critical habitat (Bailey et al., 2010; Brandt et al., 2011) and alteration of acoustic habitat availability and masking (Madsen et al., 2006). Within 10 m of the source, impact pile driving can generate zero to peak source levels (SL_{pk}) ranging from 233 to 245 dB re 1 µPa m and sound exposure source levels (ESLs) ranging from 218 to 249 decibels referenced to 1 micropascal squared meter squared second (dB re 1 $\mu Pa^2\ m^2\ s$) with predominant frequency content below 1,000 Hz (Amaral et al., 2018). During the 2015 Block Island impact pile driving operations, distances to measured behavioral SPL_{rms} threshold isopleths (160 dB re 1 µPa, unweighted) ranged from 2.7 to 4.6 km from the pile source (Amaral et al., 2018). Physiological threshold isopleths during the 2015 Block Island impact pile driving measurements used pre-2016 NOAA acoustic guidance criteria (SPL_{rms} of 180 dB re 1 µPa, unweighted). Recently, BOEM (2018) detailed best management practices designed to minimize pile driving impacts on marine mammals which will be applied during the SFWF installation activities. Application of the best management practices will minimize impact radii by reducing sound propagation; and maximize detection opportunities for species so that protective mitigation measures can be applied.

Acoustic modeling results are fully described in the COP Appendices J1 and P2 (Denes et al., 2021a,b) and are summarized here for assessment. Modeled acoustic ranges show unattenuated sound levels generated during impact pile driving will exceed the biological threshold associated with behavioral disturbance in marine mammals; and could exceed thresholds for the potential onset of physiological effects on LFCs, HFCs, and PPWs beyond 500 m if the duration of exposure approached 24 h. However, as described in **Section 4.2**, noise attenuation devices will be employed and the 24-h assumption is based on a stationary animal which is not a reasonable for the species under consideration. More realistically, mean $ER_{95\%}$ with 10 dB attenuation for LFCs ranged from 1,346 to 3,034 m for the standard pile schedule, and from 1,571 to 3,642 m for the difficult pile schedule while all other marine mammal $ER_{95\%}$ were under 1 m with 10 dB attenuation applied (**Table 4-10**).

The risk of physiological exposures is low due to animal movement and required accumulation periods (Denes et al., 2021b), the short duration of impact pile driving within a 24-h period (~3 h), and mitigation measures applied during pile driving (**Section 6.0**). There is a greater likelihood of behavioral threshold exposures because the metric for such exposures is based on an instantaneous received SPL_{rms}, unlike the physiological threshold metric (SEL_{cum}) which requires that an animal must accumulate an exposure to that sound level over an extended period of time to be considered at risk of physiological onset. The 4,684 m behavioral threshold distance applies to all marine mammals and the ability to mitigate for instantaneous exposures over that distance is challenging. Therefore, due to the likelihood of behavioral exposures to all hearing groups and the potential for physiological exposures in some LFCs and HFCs, impact pile driving has the potential for ***minor*** to ***major*** impacts on marine mammals.

5.1.1.3 Vibratory Pile Driving

Based on previous assessments of vibratory pile driving, sound levels may reach physiological threshold criteria for marine mammals at relatively small distances. *In situ* measurements conducted by the California Department of Transportation show SEL_{cum} less than the NMFS physiological criteria measured 10 m from the source (Buehler et al., 2015), and modeled SEL_{cum} distances ranged from 0 m to approximately 1 km depending on the duration of the activity (Buehler et al., 2015; Denes et al., 2021a).

While physiological thresholds consider exposure time, behavioral metrics do not consider the duration of the animal's exposure to a sound level. Therefore, the traditional assessment for behavioral exposures is dependent solely on the presence or absence of a species within the ensonified area. Animals are less likely to respond to sound levels distant from a source, even when those levels elicit responses at closer ranges; both proximity and received levels are important factors in aversion responses (Dunlop et al., 2017). Therefore, adverse behavioral responses to noise produced during cofferdam installation are not expected even if the noise is audible to the species at threshold levels.

Modeled vibratory pile driving activities for the SFEC (COP Appendix J1 [Denes et al., 2021a]) resulted in acoustic ranges to physiological thresholds for LFCs ranging from a minimum of 737 m for 6 h of piling to a maximum of 1,470 m for 18 h of piling (Denes et al., 2021a). Maximum acoustic ranges to physiological thresholds for other marine mammal hearing groups are all under 103 m. Physiological exposures are not expected due to low population densities of LFC species in the Project Area, animal movement and required accumulation periods (Denes et al., 2021b), the short duration of vibratory pile driving (~18 h), and proposed mitigation measures (**Section 6.0**). Vibratory pile driving during cofferdam installation for the SFEC has the potential to elicit behavioral responses in marine mammals. Modeled behavioral threshold acoustic ranges extend beyond 36 km from the source (**Table 4-11**). However, exposure to a SPL_{rms} at a specified threshold level does not equate to a behavioral response or a biological consequence. The low densities of most species nearshore and the transitory nature of marine mammals within the small period of vibratory pile driving significantly reduces the risk of behavioral exposures. Due to the large resulting acoustic ranges, vibratory pile driving still presents a risk of behavioral exposure, but not physiological exposure; therefore, impacts to marine mammals are expected to be ***negligible*** to ***minor.***

5.1.1.4 Turbine Operations

MMS (2007) summarized the potential impacts to marine mammals from wind turbine noise during routine operations. Wind turbine generators primarily produce two types of noise: aerodynamic turbine blade noise and mechanical noise. The mechanical noise type can be transmitted underwater via the turbine towers and foundations. Underwater noise from turbines have been measured within the hearing frequency of marine mammals, but at the anticipated levels, the impacts would be limited to audibility and perhaps some degree of responsiveness, such as avoidance (MMS, 2007). However, there is substantial uncertainty pertaining to the effect and magnitude of impacts caused by offshore wind farms due to a lack of empirical evidence (Bergström et al., 2014; Vellejo et al., 2017). It is presumed that the effects on marine mammals during the operation phase will be smaller than during the construction phase (Scheidat et al., 2011). Underwater noise levels produced by offshore wind turbines could cause behavioral changes (e.g., changes in foraging, socialization, movement) and cause auditory masking, which in turn could affect foraging and predator avoidance. However, in one case study, Tougaard et al. (2009) stated that it was unlikely that auditory masking was likely due to the low noise levels produced by operational WTGs. Noise produced during O&M will persist for longer periods of time and impact more species compared to noise produced during construction (MMS, 2007). Underwater noise generated by WTGs is concentrated below 500 Hz (Tougaard et al., 2009); and therefore, poses the greatest risk to LFCs. Tougaard et al. (2009) showed that SPL_{rms} produced by WTGs ranged from 100 to 120 dB re 1 μPa at roughly 100 m from the source, although the turbine size was not identified. Noise measurements taken 50 m from a 3.6 MW WTG reported peak power spectral density levels of 126 dB re 1 $\mu Pa^2\ Hz^{-1}$ with frequency centered at 162 Hz that varied by wind speed.

Studies conducted on the harbor seal indicate that abundance may be reduced during the construction phase, but that population sizes during the O&M phase can return to pre-construction levels (Vellejo et al., 2017). Additionally, Scheidat et al. (2011) indicated that that population sizes can be higher within wind farms compared to reference areas. Reasons for this may be an increased food supply (Vellejo et al., 2017) or habituation to the noise produced from turbines (Teilmann and Carstensen, 2012). Tougaard et al. (2009) found that the noise produced by the operational WTGs they sampled would only be audible to harbor porpoises at distances of 63 m or less (English et al., 2017).

Due to the long term nature of operations, some long-term avoidance behaviors in marine mammals and potentially abandonment of feeding or mating grounds if feeding, mating areas, or migratory routes that intersect with a wind farm could result in ***minor*** to ***moderate*** impacts.

5.1.2 Vessel Traffic

Marine mammals may be vulnerable to collisions (vessel strikes) with moving vessels (Laist et al., 2001; Douglas et al., 2008; Pace, 2011). Vessel strikes happen when either a marine mammal or vessel fails to detect one another in time to avoid the collision. Variables that contribute to the likelihood of a collision include vessel speed, vessel size and type, and visibility. Marine mammal strikes have been reported at vessel speeds of 2 to 51 knots, and lethal or severe injuries most likely to occur at speeds of 14 knots or more (MMS, 2007). Most reports of vessel strikes involve large whales, but collisions with smaller species have also been reported (van Waerebeek et al., 2007). Laist et al. (2001) provided records of the vessel types associated with collisions with marine mammals; most severe and lethal marine mammal injuries involved large ships (80 m or more in length). Vessel speed was found to be a significant factor as well, with 89% of the records involving vessels moving at 14 knots or more (MMS, 2007).

All large marine mammals are potentially at risk of a vessel strike. Large whale species that are most frequently involved in vessel collisions include the fin whale, North Atlantic right whale, humpback whale, minke whale, sperm whale, sei whale, gray whale (*Eschrichtius robustus*), and blue whale (Dolman et al., 2006). Smaller cetaceans and pinnipeds are also at risk of ship strikes; however, these species tend to be more agile, power swimmers and are more capable of avoiding collisions with oncoming vessels (MMS, 2007).

For some species, like the North Atlantic right whale, vessel strikes pose a significant risk mainly due to behavioral characteristics and habitat preferences. Vessel strikes are consistently one of the most common causes of North Atlantic right whale mortality annually (NMFS, 2020), prompting NMFS to declare an Unusual Mortality Event for this species in 2017 (NMFS, 2021a). Since then, 46 whales have been discovered dead or seriously injured due to human interactions such as vessel strikes or entanglements

(NMFS, 2021a). Slow-moving and deep diving species that rest while on the surface or species that traverse or occupy shipping lanes are at highest risk.

Annual large whale mortality records include a vessel strike assessment. A high number of mortalities prompted NMFS to declare UMEs for both Atlantic coast humpback whales and minke whales in January 2016 and 2017, respectively (NMFS, 2021b,c). During that time period, a total of 145 humpback whales and 103 minke whales were found dead between Maine and North Carolina. Of the carcasses that were examined, 50% of the humpback whales and several of the minke whales showed evidence of pre-mortem vessel strikes or other indications of human interactions (NMFS, 2021b,c). Between 2014 through 2018, there was 0.8 annual vessel strikes of fin whales and 0.8 annual vessel strikes of sei whales (NMFS, 2020).

Most fast-moving cetacean species, including several delphinids such as the common bottlenose and common dolphin, actively approach vessels to swim within the pressure wave produced by the vessel's bow and are at lower risk of possible vessel strike (Laist et al., 2001; Jensen and Silber, 2004; Glass et al., 2009; van der Hoop et al., 2015).

Construction vessel traffic will result in a relatively short-term increase in the volume and movement of vessels in the Project Area. Larger work vessels will generally transit to the work location and remain in the area until installation is complete. These large vessels will move slowly over a short distance between work locations. Transport vessels will travel between several ports and the construction area. Dependent on the time of year, the Project-related increase in vessel traffic would be negligible when compared to other vessel operations within the area. For this analysis, it is expected that the proposed additional volume of vessel traffic associated with construction and subsequent decommissioning would not constitute a significant increase to existing vessel traffic within the region. Based on the expected volume of vessel traffic, the additional vessel activity within the RI-MA WEA from Project activities will contribute a nominal increase in vessel traffic within an already relatively heavy trafficked area due to the proximity of shipping lanes. To mitigate marine mammal vessel strikes, BOEM and NOAA require vessel strike avoidance measures that are based on NMFS's Vessel Strike Avoidance Measures and Reporting for Mariners. Adherence to these provisions would further reduce the risk of associated vessel strikes or disturbance to marine mammals that might result from the proposed SFWF construction activities or subsequent decommissioning activities.

The adherence to all NOAA and lease-stipulated speed restrictions and watch requirements on Project-related vessels will result in SFWF and SFEC vessels posing only a ***negligible*** strike risk to marine mammals. However, because of low population estimates for threatened and or endangered whale species that may occur in the area, any vessel collision of a Threatened or Endangered species could be detrimental to the population and would therefore result in a ***moderate*** impact for Threatened and Endangered species should a strike occur.

5.2 SEA TURTLES

Sea turtles are primarily present in the SFWF and SFEC areas during summer and fall months and can occur near shore and well offshore. As shown in **Table 2-1**, IPFs for sea turtles include underwater noise, vessel traffic (i.e., physical disturbance and risk of collisions), and seafloor disturbance through the introduction offshore structures.

5.2.1 Underwater Noise

Few studies have examined the role of acoustic cues in relation to sea turtle ecology (Mrosovsky, 1972; Cook and Forrest, 2005; Samuel et al., 2005). Sea turtles may use sound for navigation, locating prey, avoiding predators, and environmental awareness (Dow Piniak et al., 2012). The few vocalizations described for sea turtles are restricted to the grunts and gular (throat) pumps of nesting females, which are low-frequency sounds and are relatively loud when compared to ambient noise, leading to speculation that nesting females may use these sounds to communicate within species (Mrosovsky, 1972; Cook and Forrest, 2005). Very little is known about the extent to which sea turtles use their auditory environment ("soundscape") for navigation, assessment of their environment, or identification of predators and prey. The ambient acoustic environment for sea turtles changes with each life stage habitat shift. For example, the inshore ambient biotic environment where juvenile and adult sea turtles generally reside is dominated by low-frequency noise and has higher ambient noise levels than the open ocean environment where hatchlings reside (Hawkins and Myrberg, 1983). Moreover, in highly trafficked inshore areas, nearly constant low-frequency noises from shipping, recreational boating, and seismic surveys increase the potential for acoustic impact (Hildebrand, 2005, 2009) and may prevent an animal from hearing biologically important sounds (Fay, 2009).

Popper et al. (2014) made a distinction between "mortal injury" and "recoverable injury," with the latter defined as an injury that is not likely to result in mortality such as sensory hair cell damage, minor internal or external hematoma, etc. The definition of "recoverable injury" in this context implicitly includes PTS due to permanent inner-ear hair cell damage because the term "recoverable injury" is defined as any injury that is not a mortal injury. Therefore, PTS could be considered a threshold for injury, as it has been used for marine mammals (NMFS, 2018), and therefore the PTS thresholds from Finneran et al. (2017) were used in this assessment.

Due to the lack of data on sea turtle hearing and auditory impacts, no quantitative TTS criteria for sea turtles have been developed. Some previous environmental analyses have applied cetacean TTS criteria to sea turtles (U.S. Department. of the Navy, 2001; BOEM, 2014a). Finneran and Jenkins (2012) developed TTS criteria for sea turtles based on criteria for low-frequency cetaceans, with the inclusion of an auditory weighting function for sea turtles. However, Popper et al. (2014) concluded that sea turtle hearing is better represented by data from fishes than from marine mammals because the functioning of the inner ear of sea turtles (basilar papilla) is dissimilar to that of mammals (cochlea). Popper et al. (2014) used data from fishes exposed to pile driving to develop criteria for death or mortal injury of sea turtles exposed to airguns.

The potential for masking impacts on sea turtles is difficult to evaluate because the role of sound in their ecology is not known. Sea turtles can hear low-frequency sounds. It has been hypothesized that the natural noise of the surf zone may help nesting sea turtles find their nesting site (Nunny et al., 2011) and that grunts made by nesting sea turtles may be for terrestrial communication (Cook and Forrest, 2005). Ferrara et al. (2014) identified four types of sounds in leatherback sea turtle nests during incubation and hypothesized that sounds are used to coordinate group behavior in hatchlings. Recent studies of a freshwater turtle species identified 11 types of sounds that are used to synchronize behavior among hatchlings and coordinate the movements of hatchlings and adult females (Ferrara et al., 2013).

5.2.1.1 Vessel Noise

Underwater noise generated by cable-laying DP vessels could disturb sea turtles or contribute to auditory masking during the project period. The intensity of this noise is largely related to vessel size and speed as well as thruster operations on DP vessels. The most likely effects of DP vessel noise on sea turtles would include behavioral changes and auditory masking. DP vessel noise is transitory, and the SLs are too low to cause death or injuries such as auditory threshold shifts. Based on existing studies on the role of hearing in sea turtle ecology, it is unclear whether masking resulting from vessel noise would impact sea turtles. Behavioral responses to vessels have been observed but are difficult to attribute exclusively to noise rather than to visual or other cues. Studies of sea turtles are inconclusive as to whether they may habituate to a continuous sound source. Additionally, modeled acoustic ranges for DP vessel operations for this Project were 0 m for both physiological and behavioral thresholds for sea turtles (**Table 4-12**). Nevertheless, it is conservative to assume that noise associated with construction and support vessels may elicit behavioral changes in individual sea turtles near the vessels. It is assumed that these behavioral changes, if they were to occur, would be limited to evasive maneuvers such as diving, changes in swimming direction, or changes in swimming speed to distance themselves from vessels. Therefore, it is expected that impacts to sea turtles from DP vessel noise would be ***negligible***.

5.2.1.2 Impact Pile Driving

Available data (Ridgway et al., 1969; Bartol and Ketten, 2006; Dow Piniak et al., 2012, Bartol et al., 1999; Lavender et al., 2014; Martin et al., 2012) indicate that adult sea turtles in water can hear frequencies ranging from 50 Hz to 1,200 Hz and juveniles can hear frequencies up to 1,600 Hz, a range that overlaps with the main energy output from impact pile driving. Reported hearing ranges and thresholds differ somewhat among species and life stages, but the data are too limited to be definitive because of the small numbers of individuals tested. Death or injury can occur from exposure to high levels of impulsive sound (Popper et al., 2014). Sea turtle deaths and injuries have been documented in proximity to underwater explosions (Klima et al., 1988; Gitschlag and Hertzeg, 1994; Viada et al., 2008), but those impacts were attributed primarily to barotrauma resulting from exposure to the high energy of the shock wave generated by the explosions. Based on an extensive review of current scientific literature and studies, no sea turtle deaths or injuries are documented to have been caused by impact pile driving activities. Because of their rigid external anatomy, it is possible that sea turtles may be protected to some degree from the impacts of lower energy impulsive sounds (Ketten et al., 2005; Popper et al., 2014).

Avoidance of impulsive sound by sea turtles has also been inferred from field observations of sea turtle behavior during seismic surveys (Holst et al., 2007; Weir, 2007; DeRuiter and Doukara, 2012). Based on the best available data (McCauley et al., 2000; FHWG, 2008; Popper et al., 2104; Finneran et al., 2017), it is assumed that sea turtle behavioral responses to impulsive sound may begin to occur at a received SPL_{rms} of 166 to 175 dB re 1 µPa.

Modeled impact pile driving at the SFWF for 11-m standard monopiles with 10 dB attenuation (Denes et al., 2021a) resulted in mean acoustic ranges to SEL_{cum} acoustic thresholds of 882 m for the standard pile schedule and 1,363 m for the difficult pile schedule (**Table 4-8**). Sea turtles are not expected to linger within this distance for durations that would elicit a physiological impact; this is reflected in the modeled $ER_{95\%}$ for sea turtles which resulted in a mean range between 0 and 17 m for all species for the standard pile schedule, and between 12 and 179 m for the difficult pile schedule with 10 dB attenuation (**Table 4-10**). The maximum acoustic range to the SPL_{pk} threshold with 10 dB attenuation, which represents the greatest potential for instantaneous injury to sea turtles, was 1 m (**Table 4-7**) and would be reached only at the highest hammer energy near the end of pile schedule (Denes et al., 2021a). Due to the placement of noise attenuation devices and general construction activities combined with much smaller impact isopleths for the majority of the impact pile driving schedule, sea turtles are not expected to encroach any of the SPL_{pk} isopleths and, therefore, no physiological exposures are expected for sea turtles from impact pile driving.

The mean modeled acoustic range to the sea turtle behavioral threshold was 1,147 m with 10 dB attenuation applied (**Table 4-9**). There is a likelihood of behavioral threshold exposure and general activity in the area that could result in sea turtles temporarily vacating the SFWF construction area. Exposures to behavioral thresholds are expected to be temporary and would not result in biologically significant disturbances. Therefore, it is expected that impacts of impact pile driving activities on sea turtles will be ***minor*** to ***moderate***.

5.2.1.3 Vibratory Pile Driving

Vibratory pile driving associated with SFEC construction, while within the estimated hearing range of sea turtles, is expected to produce lower noise levels relative to impact pile driving. Propagation modeling of vibratory pile driving at SFEC (Denes et al., 2021a) indicates that acoustic ranges to both physiological and behavioral thresholds are relatively small: 31 m to physiological thresholds and 53 m to behavioral thresholds (**Table 4-11**). At these ranges, no injury or mortality is expected, and behavioral exposures are unlikely. If behavioral exposures occur, behavioral responses are expected to be temporary, short-term, and would not affect the reproduction, survival, or recovery of Threatened or Endangered species. Vibratory pile driving is anticipated to have ***negligible*** impacts on sea turtle species and may have no affect depending on the season in which this activity would take place. Winter and spring have very low densities of sea turtles in the Project Area and would have a lower potential for any exposure risk.

5.2.1.4 Turbine Operations

Sea turtle hearing is within the frequency range (<1,200 Hz) for operational WTGs (Popper et al., 2014; Thomsen et al., 2006). Thus, it is possible that WTG noise may influence sea turtle behavior. Potential responses to WTG noise generated during normal operations may be expected to be behavioral and include avoidance of the noise source, disorientation, and disturbance of normal behaviors such as feeding (MMS, 2007). Noise generated during normal operations might affect many individuals and for a much longer time period (MMS, 2007). Under routine conditions, there could be continuous SPL_{rms} noise of 90 to 115 dB re 1 µPa, which is higher than the ambient levels measured within the RI-MA WEA. This noise generation could potentially result in the long-term avoidance of the SFWF area and surrounding vicinity; however, sea turtles are known to occur in areas of higher ambient noise, and therefore, it is difficult to predict long term behavioral impacts from turbine operations. Based on this, the impact to sea turtles from turbine noise is expected to be ***negligible***.

5.2.2 Vessel Traffic

Sea turtles may be able to actively maneuver within the water column to avoid collisions with approaching slow-moving (<5 knots) Project vessels; however, support vessels may travel at much faster speeds and sea turtles may not be able to avoid them. Based on knowledge of their sensory biology (Bartol and Musick, 2003; Levenson et al., 2004; Bartol and Ketten, 2006a; Moein-Bartol and Ketten, 2006), sea turtles may detect objects such as vessels, prey, and predators in the water column by means of auditory and visual cues. However, research examining the ability of sea turtles to avoid collisions with vessels shows that they may rely more on visual than auditory cues (Hazel et al., 2007). Sea turtle collisions with commercial vessels are not well-documented; however, many rescued or stranded sea turtles show evidence of vessel strikes (Singel et al., 2007). From 1997 to 2005, 14.9% of all stranded loggerhead turtles in the U.S. Atlantic and Gulf of Mexico were documented as having sustained some type of propeller or vessel strike injury. This study did not indicate what proportion of these injuries was post- or ante-mortem (NMFS and USFWS, 2008). It is likely that collisions with small or submerged sea turtles or during nighttime or periods of poor visibility may go undetected and undocumented. Sea turtles are negatively buoyant and remains will sink in deep water, making them very unlikely to be recovered or drift to shore.

The potential for collisions between vessels and sea turtles increases at night and during inclement weather. Sea turtles spend at least 20 to 30% of their time at the surface for respiration, basking, feeding, orientation, and mating (Lutcavage et al., 1997), during which time they are most susceptible to vessel strikes. Project vessels could strike and injure or kill sea turtles. Project vessel traffic during the construction of the SFWF and SFEC would slightly increase the volume of vessel traffic within the region; however, it represents a very small contribution in overall vessel traffic in the region. Construction vessels will generally transit to the work location and remain in the area until installation is complete. These large vessels will move slowly and over short distance between work locations. Transport vessels will travel between several ports and the SFWF over the course of the construction period. These vessels will range in size from smaller crew transport boats to tug and barge vessels.

Sea turtles may be able to actively maneuver within the water column to avoid collisions with approaching slow-moving vessels. Research examining the ability of sea turtles to avoid collisions with vessels shows they may rely more on visual than auditory cues (Hazel et al., 2007). Collisions between these vessels and sea turtles, particularly at night and during inclement weather, would be unlikely but possible. While mortality from vessel strikes frequently is documented in sea turtle stranding data, the issue is most prevalent in shallow inshore and near-coastal waters with high densities of high-speed vessel traffic (Singel et al., 2007). Considering the previous discussion, and the implementation of mitigation measures potential impacts to sea turtles from vessel traffic would be ***negligible***; however, in the unlikely event that a sea turtle is struck, and injury or mortality occurs, impacts would be ***moderate*** due to the Threatened and Endangered status of sea turtle populations likely to occur in the Project Area.

5.2.3 Seafloor Disturbance

The "reef effect" caused by the introduction of a new hard bottom habitat in this area is expected to attract numerous species of algae, shellfish, finfish, and sea turtles to this site (Wilhelmsson et al., 2006; Reubens et al., 2013). For sea turtles, artificial reefs have been shown to provide a number of ecological functions such as foraging and sheltering habitat and structures to remove biological build-up from their carapace (NRC 1996; Barnette 2017). In the Gulf of Mexico, both loggerhead and leatherback turtles were often observed resting at oil and gas platforms, making it likely that these species will behave similarly at the proposed windfarm (NRC 1996; Gitschlag and Herczeg, 1994). The increased abundance of benthic species such as mussels and crabs, as well as the pelagic fish species attracted to this site would provide ample foraging opportunities for sea turtles transiting this site. Particularly in areas with minimal hard bottom habitat or structural relief, these artificial reefs may supply important inter-nesting habitats for sea turtles (Barnette 2017). Multiple species like green, hawksbill (*Eretmochelys imbricata*), and loggerhead sea turtles have been observed using anthropogenic structures and submerged rocks to clean their flippers and carapace as well (Barnette 2017). With the proposed foundations and scour protection, it is likely this will be result in a ***beneficial*** impact to sea turtles due to increased structural habitat and foraging opportunities.

However, the habitat conversion is also expected to attract commercial and recreational fishing to the area, which could pose an indirect threat to sea turtles through entanglement or ingestion of fishing gear. Greater fishing effort around this site would increase the amount of equipment in the water, particularly monofilament line, which has been identified as a major hazard for all sea turtle species. Examination of sea turtle strandings from 1980 to 2007 identified fishing gear as the most common form of pollution harming sea turtles, and the number of individuals entangled in fishing line increased throughout that period (Barnette, 2017). Commercial fisheries may also take advantage of increased aggregations of fish within the SFWF, increasing the potential for sea turtle interactions. Given the potential for increased fishing activity around the SFWF the potential impacts to sea turtles from habitat alteration are expected to be ***minor***.

During construction of the SFEC, disturbances of the seafloor may limit the prey available for sea turtles in the area. Some of their diet consists of benthic species such as crabs and shellfish, but it is unlikely that cable laying activities will have major impacts of sea turtle foraging success. The COP indicates that the cable will be buried beneath the sediment, so no long-term habitat conversion is anticipated around the export cable. Impacts to sea turtles would only be during construction and are expected to be ***negligible***.

5.3 ATLANTIC STURGEON

Potential impacts on Atlantic sturgeon would not be materially different from impacts on other fish species and species with designated essential fish habitat described in the main COP. No spawning habitat will be affected as Atlantic surgeon spawn in hard-bottom, freshwater habitats. Seasonal migratory patterns present the potential for Atlantic sturgeon to be present in the SFWF area; however, it is not expected to be a regular visitor or occupant in large numbers. As shown in **Table 2-1**, IPFs for Atlantic sturgeon include underwater noise, electromagnetic fields (EMF), vessel traffic (i.e., physical disturbance to and risk of collisions), seafloor disturbance, and sediment suspension/deposition. Only the underwater noise and vessel traffic IPFs are expected to produce impacts that could reach minor or greater severity.

5.3.1 Underwater Noise

The fish inner ear has three semicircular canals and three otolith organs. The otolith organ contains a dense structure called the otolith (ear stone), which lies near the auditory sensory macula (layer of sensory hair cells). The otolith organs act as an accelerometer and enables particle motion detection.

Some fishes also have a swim bladder that, when near enough (or connected) to the inner ear, provides acoustic input to the inner ear. This supplemental acoustic input increases the acoustic sensitivity threshold and broadens the range of frequencies that a fish detects. These species of fish detect both pressure and particle motion. Little is known about particle motion effects on fishes, and unlike sound pressure waves, no criteria to assess effects associated with particle motion have been established. It is expected that particle motion associated with pile driving will have similar effects as pressure waves with fish exhibiting behavioral responses such as temporarily vacating the impact area. Excess particle motion may also mask communication and could cause permanent or temporary damage to sensory structures.

Atlantic sturgeon have a primitive swim bladder that is not connected to the inner ear. Anatomical and physiological variation makes it difficult to generalize about the impacts of noise on individual species (Thomsen et al., 2006). There are few studies specific to Atlantic sturgeon hearing, however, Popper (2005) estimated sound detection in Atlantic sturgeon range from <100 Hz up to 1,000 Hz; and indicated that Atlantic sturgeon may be able to localize sound sources (i.e., determine the direction from which it comes). Atlantic sturgeon produce vocalizations during spawning indicating some level of acoustic dependence for critical biological functions.

A workshop report (Normandeau Associates, Inc., 2012) contains a summary of research on fish hearing and physiology and presents audiograms for fish that have been measured under appropriate acoustic conditions. However, measurements of sensitivity to particle motion and pressure were rarely performed simultaneously, leaving a data gap in our understanding of particle motion sensitivity in fish (Popper and Hawkins, 2018).

There are only limited data on mortality in response to anthropogenic noises and it is not clear whether death or injury only occurs in close proximity to a sound source (Hawkins et al., 2014). Overall, it is more likely that fish will experience sub lethal impacts that increase the possibility for delayed mortality (Hawkins et al., 2014). Because the majority of construction sound sources produce low-frequency noise that is within the sensitive hearing range of most fish, the potential for fish to experience TTS, masking, and behavioral impacts are a higher likelihood.

Behavioral responses (e.g., fleeing, avoidance) to active acoustic sound sources are the most likely direct effect for the majority of fish resources exposed to noise during SFWF and SFEC construction. Fewtrell and McCauley (2012) found that fish exhibited alarm responses to airgun noise exceeding SEL of 147 to 151 dB re 1 μPa^2 s. The potential for masking or behavioral response may exist at a distance of many kilometers from a sound source, depending on the ambient background noise level and the frequency and amplitude characteristics of the propagated sound.

5.3.1.1 Vessel Noise

Research indicates that the direct effects of vessel noise will not cause mortality or barotraumatic injuries in adult fish (Hawkins et al., 2014). Vessel noise SLs have been shown to cause several different behavioral responses, including TTS, auditory masking, and changes in blood chemistry. The most common behavioral responses are avoidance, alteration of swimming speed and direction, and alteration of schooling behavior (Vabø et al., 2002; Handegard and Tjøstheim, 2005; Sarà et al., 2007; Becker et al., 2013).

Laboratory and field studies have demonstrated several other behaviors that are influenced by vessel noise. For example, several studies have noted changes in the time spent burrowing or using a refuge, time spent defending or tending to nests and eggs (Picciulin et al., 2010; Bruintjes and Radford, 2013), intraspecific aggression and territoriality interactions (Sebastianutto et al., 2011; Bruintjes and Radford, 2013), foraging behavior (Purser and Radford, 2011; Bracciali et al., 2012; Voellmy et al., 2014a,b), vocalization patterns (Picciulin et al., 2008, 2012), and overall frequency of movement (Buscaino et al., 2010). These studies also demonstrated that the behavioral changes generally were temporary or that fish habituated to the noises. Some studies noted changes in the blood chemistry of several fish species (e.g., European sea bass [*Dicentrarchus labrax*], gilthead seabream [*Sparus aurata*], red drum [*Sciaenops ocellatus*], spotted sea trout [*Cynoscion nebulosus*]) in response to vessel noise (Buscaino et al., 2010; Spiga et al., 2012).

Auditory masking and TTS in fish exposed to vessel noise has been demonstrated in a few studies. Auditory thresholds have been shown to increase by as much as 40 dB when fish are exposed to vessel noise playbacks (Wysocki and Ladich, 2005; Vasconcelos et al., 2007; Codarin et al., 2009). The degree of auditory masking or TTS generally depends on the hearing sensitivity of the fish, the frequency, and the noise levels tested (Wysocki and Ladich, 2005). The impact of auditory masking and TTS indicate that vessel noise can lower the ability of fish to detect biologically relevant sounds. However, the effects were found to be temporary and hearing abilities returned to normal after cessation of the vessel noise.

Modeled acoustic ranges for DP vessel noise (Denes et al., 2021a) showed that Atlantic sturgeon are only at exposure risk to behavioral level thresholds up to 135 m from an operating DP vessel. Acoustic ranges to physiological thresholds were 0 m (**Table 4-12**). It is also unlikely that sturgeon would be exposed to DP vessel noise associated with Project Activities because of their sparse spatial distribution and habitat preference of estuaries and rivers adjacent to, and occasionally in, coastal and shelf waters. Given these factors, impacts of DP vessel noise on Atlantic sturgeon would be ***negligible***.

5.3.1.2 Impact Pile Driving

Impact pile driving is an impulsive noise source that is likely to cause barotrauma (Halvorsen 2012a,b). Because the effect of changing pressure on the swim bladder is the underlying cause of barotrauma, fish without swim bladders like elasmobranchs (i.e., sharks, skates, rays) and flatfish are not as vulnerable to underwater noise. Atlantic sturgeon have a relatively small swim bladder, which is not directly connected to the inner ear, and they are able to release swim bladder gas. Therefore, the risk of barotrauma due to exposure to impulsive signals from impact pile driving is low relative to their proximity to the pile and relative to fish species that cannot release swim bladder gas.

Anticipated noise levels during impact pile driving are likely to exceed behavioral thresholds for fish, including Atlantic sturgeon, and may elicit a behavioral avoidance response as observed for some fish species (Becker et al., 2013). Stress responses may also occur which involve elevated levels of stress hormones (i.e., corticosteroids) or increased heart rate upon exposure to elevated SPLs (Graham and Cooke, 2008), and have been documented at continuous SPLs of 153 to 170 dB re 1 μPa (Smith et al., 2004; Wysocki et al., 2006).

Elevated noise levels are expected to cause some mobile fish species to temporarily vacate the area (Krebs et al., 2016), resulting in a temporary disruption of feeding, mating, and other essential activities. Less mobile species and benthic early life stages are expected to be more susceptible to noise effects than more mobile species as they will not be able to leave the area as quickly (Gill and Kimber, 2005). Atlantic sturgeon have been shown to avoid impact pile driving activities in the Hudson River and based on this, they were not expected to be exposed to noise above the SEL_{cum} thresholds (Krebs et al., 2016). The same avoidance response is expected should Atlantic sturgeon be present during impact pile driving activities at the SFWF because this species is highly mobile.

The modeled acoustic range to the SPL_{pk} threshold for a Atlantic sturgeon was 84 m with 10 dB attenuation applied (**Table 4-7**). Given the placement of noise attenuation devices, such as a BBC, no Atlantic sturgeon are expected to be exposed to noise above the SPL_{pk} threshold. Modeled acoustic ranges to SEL_{cum} mortality thresholds for Atlantic sturgeon ranged from 7,264 to 9,230 m for the standard and difficult pile schedule with 10 dB attenuation applied, respectively (**Table 4-8**). Mean acoustic ranges to behavioral thresholds with 10 dB attenuation applied extend just over 8 km (**Table 4-9**). As discussed in earlier sections, exposure to behavioral thresholds does not constitute behavioral responses nor are they expected to create any biologically significant consequences.

Impacts to Atlantic sturgeon from impact pile driving are expected to be ***negligible*** to ***minor***, considering they are an anadromous species that primarily utilize rivers, bays, estuaries, coastal, and shallow continental shelf waters. However, since Atlantic sturgeon are a demersal species that could potentially be present in the SFWF area where impact pile driving activities are planned, short-term direct behavioral impacts could occur.

5.3.1.3 Vibratory Pile Driving

Vibratory pile driving generally poses less of an acoustic impact to fish compared to impact pile driving because of the non-impulsive nature of the underwater noise produced by vibratory pile driving. Unlike impact pile driving, which is classified as an impulsive sound source, the sound energy produced by vibratory pile driving rises more gradually and produces noise that is typically 10 to 20 dB lower than that of impact pile driving (Buehler et al., 2015).

Vibratory pile driving is not known to produce underwater noise levels that cause mortality in fish. As such, there are no biological thresholds for mortality associated with non-impulsive noise sources. Modeled acoustic to physiological and behavioral thresholds for Atlantic sturgeon were estimated at 63 m and 779 m, respectively (**Table 4-11**). Atlantic sturgeon that may be present within the area ensonified and exposed to SPL_{rms} exceeding the behavioral threshold are expected to move away from the noise source, and are expected to be able to avoid the area where the physiological threshold would be exceeded during vibratory pile driving.

Underwater noise produced during vibratory pile driving for installation and removal of steel sheet piles for the cofferdam would be intermittent and short-term, and the potential acoustic impacts to Atlantic sturgeon posed by cofferdam installation and removal would no longer be present once completed. Based on these factors and the results of acoustic modeling (Denes et al., 2021a), which demonstrate the relatively small spatial extent of potential acoustic impacts, as well as the likely avoidance of this activity by Atlantic sturgeon, the acoustic impacts to this species during vibratory pile driving for the SFEC are expected to be ***negligible***.

5.3.1.4 Turbine Operations

The underwater noise produced by WTGs is within the hearing ranges of fish. Depending on the noise intensity, such noises could disturb or displace fish within the surrounding area or cause auditory masking (MMS, 2007). However, with generally low noise levels, fish would be impacted only at close ranges (within 100 m) (Thomsen et al., 2006). Thomsen et al. (2006) reviewed the observations of fish behaviors in proximity to an operational WTG and found varying results from no perceived changes in swimming behavior (European eels [*Anguilla anguilla*]) to both increased and decreased catch rates of cod within 100 m of the WTGs. Therefore, in addition to the fact that Atlantic sturgeon are an anadromous species that primarily utilize rivers, bays, estuaries, coastal, and shallow continental shelf waters, impacts are expected to be ***negligible***.

5.3.2 Vessel Traffic

The potential for Atlantic sturgeon to be struck by boats is high, and vessel strikes with this species are fairly common. Between 2005 and 2008, surveys in the Delaware estuary reported a total of 28 Atlantic sturgeon mortalities, of which 50% were the result of apparent vessel strikes (Brown and Murphy, 2010). Similarly, five Atlantic sturgeon were reported to have been struck by commercial vessels within the James River, VA in 2005, and one strike every five years is reported for the Cape Fear River, NC. The majority of vessel strikes have occurred near busy ports where entrance channels narrow or a significant portion of estuary and river habitat must be transited by commercial vessels entering a port (Brown and Gregory, 2011).

Project vessel traffic during the construction of the SFWF and SFEC would slightly increase the volume of vessel traffic within the area; however, it represents a very small contribution to overall vessel traffic in the region. Construction vessels will generally transit to the work location and remain in the area until installation is complete. These large vessels will move slowly and over short distance between work locations. Transport vessels will travel between several ports and the SFWF over the course of the construction period. These vessels will range in size from smaller crew transport boats to tug and barge vessels.

Dependent on the time of year, the Project-related increase in vessel traffic would not be significant when compared to other vessel operations within the region and most vessels will be slow moving. Considering the previous analysis and that Atlantic sturgeon are Endangered, potential impacts to Atlantic sturgeon from vessel traffic would be ***negligible***; however, in the unlikely event that an Atlantic sturgeon is struck, and injury or mortality occurs, impacts would be ***minor*** due to its Endangered status.

5.4 ANIMAL NOISE EXPOSURE

Acoustic exposures from Project activities that could result in physiological impacts to species are largely dependent upon the potential for marine mammals, sea turtles, and Atlantic sturgeon to be in the ensonified area while the noise is being produced, and to be exposed for durations of 24 h or more. As described in **Section 5.0**, these conditions are not expected to be met with noise attenuation applied during impact pile driving, and due to general animal movement and behavior. However, the large physiological isopleths require further investigation regarding the potential exposures to species in the Project Area. Therefore, animal movement and exposure modeling was conducted for impact pile driving activities in SFWF using predicted densities in the SFWF area and known behaviors of individual species (Denes et al., 2021b). As opposed to static calculations that assume a stationary animal is continuously exposed to noise over a full 24 h period within the maximum ensonified area (i.e., acoustic range), employing animal movement and exposure models estimates the "dosage" of sound energy received by an animal moving within the modeled three-dimensional sound field.

The conventional assessment for behavioral exposures is dependent solely on the presence or absence of species within the ensonified area. Realistically, exposure to an SPL_{rms} at a specified threshold level does not equate to a behavioral response or biological consequence. Therefore, while animal movement and exposure modeling will better estimate the number of animals exposed to noise that may exceed behavioral thresholds, it does not provide information on assessing the behavioral response, if any.

Behavioral responses to acoustic exposure generally are more variable, context-dependent, and less predictable than effects of noise exposure on hearing or physiology (Southall et al., 2007). There is no consensus on the appropriate noise exposure metric for assessing behavioral reactions, and thus it is recognized that many variables other than exposure level affect the nature and extent of responses to a particular stimulus (Ellison et al., 2012; Southall et al., 2007). In addition, it is often difficult to differentiate brief, minor, biologically unimportant reactions from profound, sustained, and/or biologically meaningful responses related to growth, survival, and reproduction (National Research Council, 2005; Southall et al., 2007). Consequently, there is a trend toward adopting continuous functions for behavioral responses rather than simple thresholds (U.S. Department of the Navy, 2001; Finneran and Jenkins, 2012; Wood et al., 2012).

Sensitivity to behavioral responses will vary by species as well as within individual behavioral types. Key contextual information should be included in the assessment of any potential behavioral disturbance. The context that influences the biological consequence from disturbance include:

- Seasonality;
- Listing status of the species;
- Population demographics and life stages;
- Habitat use and availability; and
- Individual sensitivities.

5.4.1 Marine Species Distribution, Abundance, and Seasonality

Visual and photographic aerial surveys and acoustic surveys conducted in the RI-MA WEA, within which the SFWF is located, were conducted between October 2011 and June 2015 (Kraus et al., 2016). Results of this study showed that large whale sightings occurred year-round with peaks in the spring and summer. Four species (humpback whale, fin whale, sei whale, and minke whale) were sighted during all seasons, while North Atlantic right whales were sighted only during the winter and spring, and sperm whales were only sighted in the winter, fall, and summer. Feeding was most commonly observed during spring for large whales sighted within the RI-MA WEA (Kraus et al., 2016). Calves were present during spring and summer months and courtship behavior was observed in North Atlantic right whales as well as a single humpback whale primarily during the spring (Kraus et al., 2016).

Harbor porpoises and five species of dolphins (common bottlenose dolphin, common dolphin, Atlantic white-sided dolphin, Risso's dolphin, and long-finned pilot whale) were positively identified during aerial surveys. Atlantic white-sided dolphins, common bottlenose dolphins, and unidentified dolphins were seen regularly across all seasons. The number of Risso's dolphin and long-finned pilot whale sightings was low and only occurred in the spring and summer. Common dolphin sightings peaked in the summer and harbor porpoise sightings peaked in the winter and spring.

The acoustic presence of large whales overlapped with their visual detection records. North Atlantic right whales showed strong seasonality in acoustic detection records during the Kraus et al. (2016) study with 67% of signature "up calls" recorded in February and March. The annual trend in right whale acoustic presence peaked in March, then steadily declined to nearly zero in August followed by an incremental rise. Call rates vary by species and activity, so abundance estimates based on vocal rates are not used in predicted density estimation. However, because vocalizations can often be detected for rare or cryptic species, call distributions provide some insight to presence and activities, and can often provide information regarding the timing of arrival and departures to specific sites. Fin whale calls were detected in all months at relatively consistent levels with some recognizable increase from April through July. Humpback whale calls were also present year-round with the highest detection rates from January to June. Minke whale calls were also detected year-round with peak numbers in April. A low number of blue whale vocalizations were detected in August, September, and November through to February, but no blue whales were visually observed (Kraus et al., 2016).

Cetacean density data for the Project Area are derived from marine mammal habitat density models developed by the Marine Geospatial Ecology Lab at Duke University (Roberts et al., 2016; Roberts, 2018). These models incorporate sightings data with environmental data to determine preferred habitat for each species which can then be used to estimate species densities within 100 km^2 blocks for each month. Roberts (2020) further updated model results for North Atlantic right whales by implementing three major changes: increasing spatial resolution, generating monthly estimates on three time periods of survey data, and dividing the study area into five discrete regions. These changes are designed to produce estimates that better reflect the most current, regionally specific data, and to provide better coastal resolution.

Seal density data are variable. The U.S. Navy OPAREA Density Estimate Reports for the Northeast U.S. region (DON, 2007) provide estimates for harbor and gray seals; however, these data are not likely reflective of current or future seal densities in this region due to the overall significant population recovery in seal species and increased observations of seals throughout the mid-Atlantic region (NMFS, 2020). The most dependable seal density estimates are derived from the updated marine mammal habitat density models developed by the Marine Geospatial Ecology Lab at Duke University (Roberts, 2018). This dataset provides information for all species of seals that may be encountered in the region. However, due to the difficulty in distinguishing between seal species during visual surveys, they have been grouped together in the model and species-specific density estimates are unavailable. Monthly density estimates are also unavailable for seals, and they have instead been grouped into two seasons; summer (June to August) and winter (September to May), based on expected seasonality provided in NMFS SARs for the harbor seal (Roberts, 2018).

Three species of sea turtle (loggerhead, leatherback, and Kemp's ridley) were identified during visual and photogrammetric aerial surveys conducted in the RI-MA WEA by Kraus et al. (2016). All species were most abundant in the fall and summer with no sightings recorded during the winter months. In studies conducted within the New York OPA by Normandeau and APEM (2019) the most common sea turtle species identified was the loggerhead with results showing the highest abundance during the summer and fall. Like the seal density data, sea turtle density estimates are available from the U.S. Navy OPAREA Density Estimate database on the Strategic Environmental Research and Development Program Spatial Decision Support System (DON, 2007, 2012) and Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles (Kraus et al., 2016). However, although these densities were used for this assessment, some of this information may be out of date and not fully reflective of current or future sea turtle abundances in the SFWF and SFEC areas. Seasonal densities were highest for all species assessed in the fall, with 0.873 animals km^{-2} for leatherbacks, 0.755 animals km^{-2} for loggerheads, and 0.0093 animals km^{-2} for Kemp's ridley in the SFWF area (Denes et al., 2021b).

The Atlantic sturgeon may possibly be present within the SFWF area from October to May, when juveniles and adults return to the ocean after spawning in estuarine and riverine environments. While no abundance estimates for the offshore population segment exist, the Atlantic sturgeon stock assessment (ASMFC, 2017) lists the New York Bight DPS as depleted but recovering. However, as previously discussed in **Section 4.2.2.1**, no animal movement modeling information is currently available for Atlantic sturgeon so exposures were not calculated for this species.

5.4.2 Exposure Estimates for Impact Pile Driving

Acoustic exposure estimates and ZOIs presented in this COP exposure analysis use a single modeling scenario and activity duration that represents sufficient information to assess the magnitude of potential impacts to marine mammals, sea turtles, and Atlantic sturgeon resulting from installation of monopiles for the SFWF as described in Section 3 of the COP. The exposure estimates and ZOIs for marine mammals presented here may not be equivalent to the final defined ZOIs and number of takes authorized under MMPA and ESA consultation with NMFS as defined in the IHA and associated Biological Opinion issued at the time of construction.

Animal movement and exposure modeling of impact pile driving for the SFWF was conducted for 19 potentially affected marine mammal and sea turtle species using the densities in COP Appendix P2 (Denes et al., 2021b). Movement and exposure modeling was not conducted for Atlantic sturgeon due to lack of density and behavioral information. The full Animal Exposure Modeling Report (Denes et al., 2021b) is available in COP Appendix P2. This assessment presents the results only for those species considered likely to occur in the SFWF area, as identified in **Section 3.0**. The mean number of animals that may be exposed to noises exceeding acoustic thresholds were calculated for two design scenarios; one representing the most likely scenario (one pile every other day), and one representing a more aggressive, or maximum scenario (six piles every 7 days) (Denes et al., 2021b). The most likely scenario assumes that three foundations are installed per week with an average of one pile installed every other day. The maximum scenario assumes six monopile foundations are installed per week with one pile installation per day. Within each of the design scenarios, a single difficult-to-drive pile was included in the model assumptions to account for the potential for additional strikes (Denes et al., 2021b).

Virtual animals (animats) were modeled to move throughout the three-dimensional sound fields produced by each scenario for the entire construction period. For physiological exposures, both SPL_{pk} and SEL_{cum} were calculated for each species based on the corresponding acoustic criteria. Once an animat is taken within a 24-h period, the model does not allow it to be taken a second time in that same period but rather resets the 24-h period on a sliding scale across 7 days of exposure. An individual animal's exposure levels are summed over that 24-h period to determine its total received energy, and then compared to the threshold criteria. Potential behavioral exposures are estimated when an animat is within the area ensonified by a SPL_{rms} exceeding the corresponding thresholds. It should be noted that the estimated numbers of individuals exceeding any of thresholds is conservative because the 24-h evaluation window allows individuals to be counted on multiple days or can be interpreted as different individuals each 24-h period when it may in fact be the same individually experiencing repeated exposures (Denes et al., 2021b).

Exposure estimates for the entirety of impact pile driving activities for the SFWF can be found in COP Appendix P2 (Denes et al., 2021b). In summary, the potential for physiological-level acoustic exposures are low even with no sound attenuation. With 10 dB noise attenuation, all exposures drop to <1 individual for all affected species discussed in **Section 3.0** except:

- Fin whales, which had 1 individual exposed in May, June, July, August, September, or October;
- Minke whales, which had 1 individual exposed in May and June;
- Humpback whales, which had 1 individual exposed in July, August, November, or December; 2 individuals exposed in May, June or October; or 4 individuals exposed in September;

- Harbor porpoises, which had 1 individual exposed in May;
- Leatherback sea turtles, which had 1 individual exposed in November; and
- Loggerhead sea turtles, which had 12 individuals exposed in November; or 1 in December.

Because the total duration of impact pile driving required to install all 16 foundations for the SFWF is expected to be less than 30 days, seasonality is an important component of the exposure estimates due to the changing densities of animals across months, and this is further described in Denes et al. (2021b). For this assessment, the maximum number of modeled SEL_{cum} physiological-level and SPL_{rms} behavioral-level exposures for marine mammal and sea turtle species, based on the month with the greatest number of estimated exposures, are summarized in **Tables 5-1** and **Table 5-2**, respectively.

Table 5-1. Maximum modeled cumulative sound exposure level physiological-level exposures resulting from impact pile driving in the South Fork Wind Farm. Results are for a maximum design scenario (piling for 6 days in a 7 day period) between May 1st and December 31st including 1 difficult-to-drive pile and 0, 6, 10, and 12 dB broadband attenuation applied.

Species	Physiological-level Exposures by Noise Attenuation Level			
	0 dB attenuation	*6 dB attenuation*	*10 dB attenuation*	*12 dB attenuation*
Low-frequency Cetaceans				
Fin whale*	7	3	1	1
Minke whale	7	3	1	1
Sei whale*	1	<1	<1	<1
Humpback whale	21	9	4	3
North Atlantic right whale*	4	1	<1	<1
Blue whale*	<1	<1	<1	<1
Mid-frequency Cetaceans				
Sperm whale*	<1	<1	<1	<1
Atlantic spotted dolphin	<1	<1	<1	<1
Atlantic white-sided dolphin	<1	<1	<1	<1
Common bottlenose dolphin	<1	<1	<1	<1
Common dolphin	<1	<1	<1	<1
Risso's dolphin	<1	<1	<1	<1
Long-finned pilot whale	<1	<1	<1	<1
High-frequency Cetaceans				
Harbor porpoise	33	4	1	1
Phocid Pinnipeds in Water				
Gray seal	6	1	<1	<1
Harbor seal	8	2	<1	<1
Sea Turtles				
Kemp’s ridley sea turtle	1	<1	<1	<1
Leatherback sea turtle	108	18	1	1
Loggerhead sea turtle	125	29	12	12

*Species listed under the Endangered Species Act.

Table 5-2. Maximum modeled root-mean-square sound pressure level behavioral-level exposures resulting from impact pile driving at the South Fork Wind Farm using the maximum design scenario (piling for 6 days in a 7 day period) between May 1st and December 31st including 1 difficult-to-drive pile and 0, 6, 10, and 12 dB broadband attenuation applied.

Species	Behavioral-level Exposures by Noise Attenuation Level			
	0 dB attenuation	*6 dB attenuation*	*10 dB attenuation*	*12 dB attenuation*
Low-frequency Cetaceans				
Fin whale*	21	10	7	6
Minke whale	29	16	10	9
Sei whale*	2	1	1	1
Humpback whale	26	13	9	7
North Atlantic right whale*	16	7	4	3
Blue whale*	<1	<1	<1	<1
Mid-frequency Cetaceans				
Sperm whale*	<1	<1	<1	<1
Atlantic spotted dolphin	7	4	2	2
Atlantic white-sided dolphin	325	161	110	94
Common dolphin	1,331	464	207	164
Risso's dolphin	2	1	1	1
Common bottlenose dolphin	212	86	47	37
Long-finned pilot whale	<1	<1	<1	<1
High-frequency Cetaceans				
Harbor porpoise	273	129	78	66
Phocid Pinnipeds in Water				
Gray seal	322	120	59	50
Harbor seal	312	119	54	45
Sea Turtles				
Kemp’s ridley sea turtle*	6	3	2	1
Leatherback sea turtle*	584	318	205	152
Loggerhead sea turtle*	543	295	163	114

*Species listed under the Endangered Species Act.

5.4.3 Exposure Estimates for Vibratory Pile Driving

Predicting exposure estimates resulting from vibratory pile driving is complicated by the nearshore location, short duration of cofferdam installation, large isopleth created by a low behavioral threshold, and static species density data that are not indicative of animals transiting the nearshore environment. As detailed in **Section 4.2**, the large acoustic range for marine mammal behavioral criteria (~36 km) is the result of a very conservative, and likely outdated, unweighted SPL_{rms} threshold of 120 dB re 1 μPa. This exaggerated range suggests that all species within it will experience behavioral impacts from vibratory pile driving for this Project, which is very likely not the case and ignores the complexity of factors involved for a receptor or group of receptors to be exposed to any one sound source in the ocean.

Species composition and densities will be different at the cofferdam location than in the SFWF or along offshore portion so the SFEC routes. Few large whale species are wholly coastal and therefore their abundance at the cofferdam location is estimated to be very low. Some species, including the blue whale, long-finned pilot whale, and Risso’s dolphin are predominantly distributed offshore not expected to be present in this location. Available sea turtle densities are fairly uniform between the SFWF and SFEC and are expected to be uniform at the cofferdam location, although density coverages do not extend to the shoreline and some seasonal differences in distribution are expected.

Animal movement and exposure modeling was not used to determine potential exposures from vibratory pile driving as it is expected that exposures would be very low, if present at all. To assess potential exposures for vibratory pile driving, the 100 km^2 density blocks from Roberts et al. (2016), Roberts (2018, 2020), and Department of Navy (DON, 2017) encompassing the cofferdam location out to 36 km were reviewed to establish presence or absence of species within immediate vicinity. It should be noted the species densities represented in the Roberts et al. (2016) and Roberts (2018, 2020) are monthly estimates, and the DON (2017) are seasonal estimates, and are therefore not indicative of single-day distributions of animals within the potential ensonified area that would be more appropriate for the short duration of vibratory pile driving activity.

To account for the lower densities, transitory nature of marine mammals, and the very short duration of vibratory pile driving, only a single group of any species is expected to be exposed to SPL_{rms} exceeding behavioral thresholds that would subsequently result in some level of disturbance or reaction. Marine mammal species in this region are not expected to remain in proximity to the cofferdam location for an extended amount of time. Additionally, documented aversion responses in many marine mammal species indicate they are likely to avoid the area while vibratory pile driving activities occur (Ellison et al., 2012). Seals and sea turtles are only expected to be seasonally present in the region, and there are no known rookeries or sea turtle nesting events documented near the cofferdam location. Seals typically haul-out for some portion of their daily activities, often in large groups (Hayes et al., 2017); however, the in-water median group size is estimated to be 1 to 3 animals depending on the distance to shore (Herr et al., 2009) with larger groups typically being associated with direct proximity to a haul-out site. There are a few documented haul-out sites around Long Island, New York, but the nearest site is in Montauk Point, approximately 20 km northeast of the cofferdam location where they are primarily observed in winter (CRESLI, 2019). While beaches landward of the cofferdam may occasionally be used by seals, it is unlikely seals will approach shore or haul-out during vibratory pile driving because of prevalent human activity.

The maximum estimated number of behavioral-level exposures during 2 days of vibratory pile driving is provided in **Table 5-3**.

Table 5-3. Estimated number of behavioral-level acoustic exposures resulting from vibratory pile driving during cofferdam installation for the South Fork Export Cable. Species with no predicted exposures are not included in the table.

Species/Stock	Predicted number of behavioral exposures[1]
Low-frequency cetaceans	
Fin whale	2
Minke whale	3
Sei whale	1
Humpback whale	1
North Atlantic right whale	6
Mid-frequency cetaceans	
Atlantic white sided dolphin	1
Common dolphin	4
Common bottlenose dolphin	2,007
High-frequency cetaceans	
Harbor porpoise	11
Phocid Pinnipeds in Water	
Gray seal	1,305
Harbor seal	1,305

Table 5-3. (Continued).

Species/Stock	Predicted number of behavioral exposures[1]
Sea turtles	
Kemp's ridley sea turtle	1
Leatherback sea turtle	1
Loggerhead sea turtle	1

[1]Predicted exposures for vibratory pile driving for sei whales based on mean group size derived from the following references:

- Sei whale: Kenney and Vigness-Raposa, 2010.
- Sea Turtles: Barkaszi and Kelly, 2018.

5.4.4 Aversion and Exposure Estimates

Aversion is a common response of marine mammals to sound, particularly at relatively high sound levels (Ellison et al., 2012). Species have varying sensitives to received sound and therefore will have varying aversive reactions to sound sources (Ellison et al., 2012; Wood et al., 2012). As the received sound levels generally decreases with distance from a source, this aspect of natural behavior can strongly influence the estimated maximum sound levels an animal is predicted to receive, and significantly affects the probability of more pronounced direct or subsequent behavioral effects. Additionally, animals are less likely to respond to sound levels distant from a source, even when those levels elicit a response at closer ranges; both proximity and received levels are important factors in the aversion response (Dunlop et al., 2017).

Aversion was modeled for impact pile driving and it showed a decrease in potential exposures based on the behavior of the virtual animals within the sound field (Denes et al., 2021b). Therefore, it is expected that the maximum number of estimated exposures would not be met for either impact or vibratory pile driving, even if the noise is audible to the species at threshold levels. More importantly, any behavioral reactions are expected to be short-term and not biologically significant, with normal behavior returning soon after impact or vibratory pile driving is completed.

6.0 Avoidance, Minimization, and Mitigation

This section describes the avoidance, minimization, and mitigation measures considered to reduce potential impacts resulting from exposure to underwater noise and vessel traffic during construction and O&M of the SFWF and SFEC. Orsted is developing a comprehensive Protected Species Mitigation and Monitoring Plan (PSMMP) for all their projects which will be applied to the SFWF Project. The PSMMP will align with all regulatory requirements from BOEM and NMFS by the time necessary for approval of the mitigation and monitoring plans. The mitigation measures employed for SFWF and SFEC construction are summarized below, and details of each measure will be provided in the final PSMMP:

- Noise attenuation;
- Seasonal restrictions;
- Establishment of exclusion zones;
- Visual and passive acoustic monitoring;
- Area clearance;
- Operational shutdowns and delays;
- Soft start procedures; and
- Vessel strike avoidance and other precautionary procedures.

The mitigation and monitoring protocols have been designed to provide protection to marine mammals, both individual species as well as species stocks, by minimizing exposure to potentially disruptive noise levels during construction activities. The proposed measures will further reduce any potential ship strikes to large whales in the area. In order to provide the most complete and comprehensive monitoring program, a combination of traditional techniques and new and innovative monitoring technologies, detailed in the following sections, is proposed for the duration of pile driving monitoring.

Project-specific training will be conducted for all vessel crew prior to the start of construction activities. Confirmation of the training and understanding of the requirements will be documented on a training course log sheet. Signing the log sheet will certify that the crew members understand and will comply with the necessary requirements throughout the construction activities.

6.1 NOISE ATTENUATION

A noise attenuation system will be used during impact pile driving to decrease the sound levels in the water near the source and thus reduce the potential impact on marine mammals. Attenuation levels vary by type of system, frequency band, and location. Small bubble curtains have been measured to reduce sound levels by approximately 10 dB to more than 20 dB, but they are highly dependent on water depth, current, and configuration and operation of the curtain (Koschinski and Lüdemann, 2013; Bellmann, 2014; Austin et al., 2016).

No noise attenuation will be used for vibratory pile driving due to its location, the short time period involved with installation and removal of the cofferdam, and very low risk of physiological exposures when other mitigations, as descried in the following sections, are employed.

6.2 SEASONAL RESTRICTIONS

SFW has agreed to seasonal restrictions for pile-driving activities, which will provide extra protection for protected species, particularly the North Atlantic right whale. Impact pile driving activities will not occur at the SFWF between January 1 and April 30 to minimize potential impacts to the North Atlantic right whale.

6.3 ESTABLISHMENT OF EXCLUSION ZONES

Exclusion zones (EZs) and monitoring zones (MZs) will be established in which Protected Species Observers (PSOs) monitor for the presence of marine mammals in the vicinity of activities that have the potential to cause harassment or injury. The size of the EZs and MZs will be based on the type of activity being conducted and the various protected species or species groups expected within the region. Marine mammals and sea turtles entering their corresponding EZ will initiate a shutdown for impact pile driving activities if there is no risk of pile loss.

6.4 VISUAL AND PASSIVE ACOUSTIC MONITORING

Visual monitoring of the established MZs will be performed by qualified and NMFS-approved PSOs. PSOs will be responsible visually monitoring and identifying marine mammals and sea turtles approaching the established EZs; notifying project personnel to the presence of marine mammals as well as communicating and enforcing the action(s) that are necessary to ensure mitigation and monitoring requirements are implemented as appropriate; and monitoring public right whale alert systems and any other publicly accessible data streams pertaining to marine mammals.

NMFS-approved PSOs, operating in shifts, will be employed by SFW and stationed on either the construction vessel or support vessel during the impact pile driving activities. PSOs will work in shifts such that no one monitor will work more than 4 consecutive hours without a 2-h break or longer than 12 h during any 24-h period. This method serves as the primary monitoring method for the EZ. PSOs will be equipped with reticle binoculars and will estimate distances to marine mammals located in proximity to the vessel and/or EZ. Alternative monitoring during nighttime hours will be conducted utilizing visual enhancement equipment such as night vision units or thermal imaging. The visual monitoring at night will be supplemented with passive acoustic monitoring (PAM) from either a buoy or support vessel.

PAM will be used to support visual monitoring efforts when visibility is limited or when nighttime operations are conducted. PAM operators will serve as acoustic PSOs and will communicate detections to project personnel to ensure the implementation of the appropriate mitigation measure.

6.5 AREA CLEARANCE

At the start of each impact pile driving activity, PSOs (and/or PAM operators) will clear the EZ before initiation of soft start procedures. A soft start may not be initiated if any marine mammal or sea turtle is observed within the EZ. If a marine mammal or sea turtle is observed within the EZ during the pre-clearance period, a soft start may not begin until the animal(s) has been observed exiting its respective EZ or until a designated time period has elapsed with no further sightings (e.g., 15 min for delphinoid cetaceans and pinnipeds, and 30 min for all other cetaceans).

6.6 SOFT START PROCEDURES

Soft start procedures are applicable to impact pile driving only. Every monopile installation will begin with a soft start procedure. The soft start procedure is detailed in **Table 4-4**. A soft start procedure is used to allow animals potentially in the EZ to detect the presence of the noise producing activities and to depart the area before full power impact pile driving activity begins. A soft start of impact pile driving will not begin until the EZ has been cleared by the PSOs (and PAM operators when applicable), as described above.

6.7 OPERATIONAL SHUTDOWNS AND DELAYS

If a sea turtle or marine mammal is observed entering or within the respective EZ after impact pile driving has commenced, an immediate shutdown of pile driving will be implemented unless SFW and/or its contractor determines shutdown is not feasible due to an imminent risk of injury or loss of life to an individual; or risk of damage to a vessel that creates risk of injury or loss of life for individuals. There are two scenarios, approaching pile refusal and pile instability, where this imminent risk could be a factor:

(i) If a shutdown is called for but SFW and/or its contractor determines shutdown is not feasible due to risk of injury or loss of life, reduced hammer energy must be implemented; and

(ii) After a shutdown, impact pile driving must only be initiated once all EZs are confirmed by PSOs to be clear of marine mammals and sea turtles for the minimum species-specific time periods.

6.8 VESSEL STRIKE AVOIDANCE MEASURES

To mitigate potential impacts of vessel strikes, SFW will adhere to the following *Base Conditions*.

Base Conditions:

- **Training**: All personnel working offshore will receive training on marine mammal, sea turtle, and Atlantic sturgeon awareness.

- **Speed/Approach Constraints**: All vessels will adhere to current NOAA vessel guidelines and regulations in place.

- **Approach Constraints**: Vessels will maintain, to the extent practicable, separation distances of 500 m for North Atlantic right whales, 100 m for other whales, and 50 m for dolphins, porpoises, seals, and sea turtles.

- **Monitoring/Mitigation**: Vessel operators and crew will maintain a vigilant watch for marine mammals and sea turtles, and slow down or maneuver their vessels as appropriate to avoid a potential intersection with a marine mammal or sea turtle.

- **Situational Awareness/Common Operating Picture**: SFW will establish a situational awareness network for marine mammal and sea turtle detections through the integration of sighting communication tools such as Mysticetus, Whale Alert, WhaleMap, etc. Sighting information will be made available to all project vessels through the established network. SFW's Marine Coordination Center will serve to coordinate and maintain a Common Operating Picture. In addition, systems within the Marine Coordination Center, along with field personnel, will:
  - Monitor the NMFS North Atlantic right whale reporting systems daily;
  - Monitor Coast Guard VHF Channel 16 throughout the day to receive notifications of any sighting; and
  - Monitor any existing real-time acoustic networks.

In addition to the above *Base Conditions*, SFW will implement a *Standard Plan* or an *Adaptive Plan* as presented below. SFW intends for these plans to be interchangeable and implemented throughout both the construction and operations phases of the project.

Standard Plan:

- Implement *Base Conditions* described above.

- Vessels of all sizes will operate port to port at 10 knots or less between November 1 and April 30, except for vessels while transiting in Narragansett Bay or Long Island Sound which have not been demonstrated by best available science to provide consistent habitat for North Atlantic right whales.

- Vessels of all sizes will operate at 10 knots or less in any Dynamic Management Areas (DMAs).

Adaptive Plan:

An *Adaptive Plan* will be developed in consultation with NMFS to allow modification of speed restrictions for vessels. Should SFW chose not to implement this *Adaptive Plan* or a component of the *Adaptive Plan* is offline (e.g., equipment technical issues), SFW will default to the *Standard Plan* (described above).

Proposed measures may include:

- Implement *Base Conditions* described above.

- A semi-permanent acoustic network comprising near real-time bottom mounted and/or mobile acoustic monitoring platforms will be installed year-round such that confirmed North Atlantic right whale detections are regularly transmitted to a central information portal and disseminated through the situational awareness network.

- Year-round, if any DMA is established that overlaps with an area where a project vessel would operate, that vessel, regardless of size when entering the DMA, will transit that area at a speed of 10 knots or less unless a trained, dedicated person-on-watch and alternative visual detection system (e.g., thermal cameras) are present.

- If PAM and/or thermal systems are offline, the *Standard Plan* measures will apply for the respective zone (where PAM is offline) or vessel (if thermal systems offline).

- The transit corridor and wind development area (WDA) will be divided into detection action zones.

- Localized detections of North Atlantic right whales in an action zone would trigger a slow-down to 10 knots or less in the respective zone for the following 12 h. Each subsequent detection would trigger a 12-h reset. A zone slow-down expires when there has been no further visual or acoustic detection in the past 12 h within the triggered zone.

- A trained, dedicated person-on-watch and alternative visual detection system (e.g., thermal cameras) will be stationed on all vessels during transits that intend to operate at greater than 10 knots from November 1 through April 30. The primary role of the person-on-watch is to alert the vessel navigation crew to the presence of marine mammals and sea turtles and to report transit activities and protected species sightings to the designated SFW information system.

6.9 SEA TURTLE MITIGATION

Visual monitoring will be conducted by PSOs or vessel crew who have training and experience in the detection and identification of sea turtles. Visual PSOs or vessel crew will concurrently monitor for sea turtles and marine mammals. PSOs or vessel crew will record all sea turtles inside and outside designated EZs and will advise operations regarding appropriate mitigation measures. Sea turtle observations will be recorded and reported utilizing digital data recording platforms and applicable electronic reporting systems. The following information will be recorded during each sea turtle observation:

- Species;
- Life stage (e.g., adult, juvenile, hatchling);
- Time entered and duration within the EZ (if applicable);
- Range and bearing at first and last detection;
- Activity and swim speed; and
- Closest point of approach to activity.

6.9.1 Impact Pile Driving

Proposed mitigation measures to be implemented for sea turtles during impact pile driving include:

- An EZ of either the SEL_{cum} or SPL_{pk} physiological threshold distance (whichever is greater) from the pile will be established.

- A noise mitigation system (NMS) will be used, and if the NMS extends beyond the EZ, then the EZ will be the extent of the NMS.

- Two PSOs will conduct watch from the construction vessel and two PSOs will conduct watch from a secondary, dedicated PSO vessel.

- PSOs will use reticle binoculars and naked eye during daylight visual conditions; at night and during low-visibility conditions, PSOs will use mounted infrared (IR) cameras and wearable night vision scopes.

- Prior to and during deployment of an NMS, the area will be surveyed visually for sea turtles that could become entrained in the NMS.

- NMS placement will be delayed if any sea turtles are present in the area between the NMS and pile.

- No impact pile driving shall take place if there is a sea turtle detected inside the NMS.

- Monitoring of the clearance zone will begin 60 min prior to the planned start of impact pile driving activities. The clearance zone must be free of sea turtles for 30-min, either by PSOs confirming the sea turtles have left the clearance zone or no new sightings in the clearance zone, prior to initiating any pile driving.

- Soft start will be delayed until sea turtles have been confirmed outside the EZ or 30 min have elapsed since the last sighting.

- If a sea turtle is observed within the EZ, piling will be shutdown[1]. Impact pile driving will not recommence until the sea turtle is observed outside the EZ or not re-sighted for 30 min (**Section 6.7**).

- Field measurements will be conducted on at least the first pile driven to confirm the range to physiological and behavioral thresholds for sea turtles.

6.9.2 Vibratory Pile Driving

Proposed mitigation measures to be implemented during vibratory pile driving include:

- An EZ equal to the SEL_{cum} physiological threshold distance from the sheet pile will be established.

- Two PSOs will conduct watch from the construction vessel.

- PSOs will use reticle binoculars and naked eye during daylight visual conditions; at night and during low-visibility conditions, PSOs will use mounted IR cameras and wearable night vision scopes.

- Monitoring of the clearance zone will begin 60 min prior to the planned start of pile driving. The clearance zone must be free of sea turtles for 30-min, either by PSOs confirming the sea turtles have left the clearance zone or no new sightings in the clearance zone, prior to initiating any vibratory pile driving.

- Soft start will be delayed until sea turtles have been confirmed outside the EZ or 30 min have elapsed since the last sighting

- If a sea turtle is observed within the EZ, piling will be stopped when practicable. Vibratory pile driving will not recommence until the sea turtle is observed outside the EZ or not re-sighted for 30 min.

6.9.3 Vessel Transits

SFW will adhere to Lease stipulations specific to sea turtles ensuring that vessel operators and crew maintain a vigilant watch for sea turtles and will slow down the vessel to avoid striking these protected species. All vessels will comply with the sea turtle specific Lease conditions except under extraordinary circumstances when the safety of the vessel or crew are in doubt or the safety of life at sea is in question. SFW has implemented the sea turtle specific Lease stipulations for all vessel operations since 2016, year-round, without incident. General vessel strike avoidance measures are described in **Section 6.8**. In addition to the *Base Conditions* described in **Section 6.8**, the following protection measures for sea turtles will be implemented for vessel transits:

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[1]If a sea turtle or marine mammal is observed entering or within the respective EZ after impact pile driving has commenced, an immediate shutdown of pile driving will be implemented unless SFW and/or its contractor determines shutdown is not feasible due to an imminent risk of injury or loss of life to an individual; or risk of damage to a vessel that creates risk of injury or loss of life for individuals. There are two scenarios, approaching pile refusal and pile instability, where this imminent risk could be a factor:
(i) If a shutdown is called for but SFW and/or its contractor determines shutdown is not feasible due to risk of injury or loss of life, reduced hammer energy must be implemented.
(ii) After a shutdown, impact pile driving must only be initiated once all EZs are confirmed by PSOs to be clear of sea turtles for the minimum species-specific time periods.

- All vessel crew members will be briefed in the identification of sea turtles and in regulations and best practices for avoiding vessel strikes. Reference materials will be available aboard all project vessels for identification of sea turtles. The expectation and process for reporting of sea turtles (including live, entangled, and dead individuals) will be clearly communicated and posted in highly visible locations aboard all project vessels.

- Crew members conducting watch will be trained to recognize changing sea turtle habitat that could indicate a higher risk of sea turtles (e.g., high jellyfish density, large *Sargassum* mats).

- SFW will ensure all vessels maintain a separation distance of 50 m or greater from any sighted sea turtle.

- Between June 1 and November 30, a trained, dedicated person-on-watch will watch for sea turtles during vessel transits operating above 10 knots. If a person-on-watch is already in place for North Atlantic right whale monitoring, they will concurrently watch for marine mammals and sea turtles; therefore, an additional person-on-watch is not required for sea turtles.

- SFW will establish an internal communication/situational awareness system to record sightings and provide awareness of recent sea turtle sightings in the area to project vessels.

- Vessels will avoid, as practicable, transiting through visibly high jellyfish aggregations and *Sargassum* mats.

6.9.4 Reporting

SFW will adhere to all NMFS reporting requirements in the event of a vessel strike or sighting of a dead or injured sea turtle. If the project nears a take number threshold of having 80% of the allowable ESA takes, SFW will alert the appropriate agencies. SFW will compile and submit draft monthly reports that include a summary of all project activities carried out in the previous month, including vessel transits and piles installed, and all observations of sea turtles. SFW will also contribute all recorded sea turtle sightings, as reported, to an agency-approved centralized database in coordination with the monthly reports.

6.10 OTHER PROTECTION MEASURES

IPFs that may pose a lesser risk to marine mammals, sea turtles, and Atlantic sturgeon have associated protection measures that will further protect these species from realized impacts. These mitigation and prevention measures are not species-specific and include actions and operational procedures that will minimize the impact potential from marine debris, bottom disturbance, oil spills and discharges, and EMF. These measures include:

- All personnel working offshore will receive training on marine debris awareness and prevention.

- SFW will require all construction and operations vessels to comply with regulatory requirements related to the prevention and control of spills and discharges.

- Accidental spill or release of oils or other hazardous materials will be managed through an Oil Spill Response Plan.

- The SFWF inter-array cable and SFEC will be buried to a target depth of 1.2 to 1.8 m.

- Installation of the offshore sections of the SFEC will occur using equipment such as a mechanical cutter, mechanical plow, and/or jet plow. Compared to open cut dredging, this method will minimize turbidity and total suspended solids.

- Use of monopiles with associated scour protection will minimize impacts to benthic habitat, compared to other foundation types.

- Use of DP vessels for cable installation for the SFWF inter-array cable and SFEC will minimize impacts to finfish and essential fish habitat (EFH) resources, as compared to use of a vessel relying on multiple-anchors.

SFW is committed to collaborative science with the commercial and recreational fishing industries, agencies, non-governmental organizations, and marine mammal, sea turtle, and sturgeon scientists to improve and expand the knowledge of these species and their interaction with offshore wind development. All protected species data collected by SFW during marine construction activities will be provided to NMFS, BOEM, and other interested government agencies. In addition, the data, upon request, will be made available to educational institutions and environmental groups.

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