Appendix J – Marine Mammal Supplementary Material

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Ocean Wind Offshore Wind Farm COP

The following contains supplemental information on marine mammals listed as endangered or threated under the Endangered Species Act (ESA).

1. Blue Whales

Blue whales *(Balaenoptera musculus*) are found in all oceans, including at least two distinct populations inhabiting the eastern and western North Atlantic Ocean (Sears and Perrin 2018). Although blue whales spend most of their time in deep open ocean waters, there are summertime feeding aggregations of western North Atlantic blue whales in the Gulf of St. Lawrence, where animals target krill swarms in accessible shallow waters (McQuinn *et al*. 2016). Data from animals tagged in the St. Lawrence Estuary indicate that blue whales use other summer feeding grounds off of Nova Scotia and Newfoundland and also feed sporadically during the winter in the Mid-Atlantic Bight, occasionally venturing to waters along or shoreward of the continental shelf break (Lesage *et al.* 2017, 2018). Recent deployment of passive acoustic devices in the New York Bight yielded detections of blue whales during the months of January, February, and March (Muirhead *et al.* 2018). At least three subspecies of blue whales have been identified based on their body size and geographic distribution. Blue whales that occur in the Northern Hemisphere are *Balaenoptera m*. *musculus* (Ichihara 1966, Omura *et al*. 1970, Kato *et al.* 1995, Gilpatrick *et al*. 1997, Sears and Perrin 2018). The International Whaling Commission groups all blue whales in the North Atlantic Ocean into one “stock” (or “population stock”; Donovan 1991). Population size estimates for this “stock” are mainly derived from 1979–2009 Gulf of St. Lawrence photo-identification efforts, with a total of 402 blue whales cataloged (Ramp and Sears 2013, Hayes et al. 2020). It is suggested that this “stock” consists of between 400–600 individuals (Hayes et al. 2020).

1.1 Anthropogenic Threats

Whaling from the mid-19th to mid-20th century depleted blue whale numbers significantly. Contemporary human-induced threats to blue whales include entanglement in fishing gear, vessel strikes, pollution, and disruptions of pelagic food webs in response to changes in ocean temperatures and circulation processes (Hayes *et al.* 2020). There are no recent confirmed records of mortality or serious injury to blue whales in the U.S. Atlantic Exclusive Economic Zone (EEZ) (Henry *et al*. 2020).

1.2 Vocalizations and Hearing

Blue whales are considered low-frequency cetaceans in terms of their classification in the acoustic categories assigned by NMFS for the purposes of assessment of the potential for harassment or injury arising from exposure to anthropogenic noise sources, a group whose hearing is estimated to range from 7 hertz (Hz) to 35 (kilohertz) kHz (NMFS 2018). There are no direct measurements of blue whale hearing, but their vocalizations are typically in the 15-40 Hz range, and infrasonic signals between 10 and 20 Hz are well documented for this species (Ketten 2000). Blue whale vocalizations recorded on U.S. Navy hydrophone arrays in the North Atlantic were characterized by long, patterned sequences of low-frequency sounds in the 15–20 Hz band (Mellinger and Clark 2003). The repeated sequences of long-duration, very-low-frequency sound units were repeated every 1-2 minutes and are typical of blue whale sounds recorded in other parts of the world, but the specific frequency, duration, and repetition interval features of the North Atlantic sounds were different from those reported from other

regions, suggesting that blue whale vocalizations vary among geographically separate populations (Mellinger and Clark 2003).

1.3 Diving and Social Behavior

Generally, blue whales make 5-20 shallow dives at 12-20 second intervals followed by a deep dive of 3-30 minutes (Mackintosh 1965, Leatherwood *et al.* 1976, Maser *et al.* 1981, Yochem and Leatherwood 1985, Croll *et al.* 1999). Croll *et al.* (1999) found that the dive depths of blue whales foraging off the coast of California during the day averaged 433 ft (132 m) with a maximum recorded depth of 672 ft (204 m) and a mean dive duration of 7.2 minutes. Nighttime dives are generally less than 165 ft (50 m) in depth (Croll *et al.* 1999).

Blue whales are usually found swimming alone or in groups of two or three (Ruud 1956, Slijper 1962, Nemoto 1964, Mackintosh 1965, Pike and MacAskie 1969, Aguayo 1974, Sears and Perrin 2018). However, larger foraging aggregations and aggregations mixed with other species like fin whales are regularly reported (Schoenherr 1991, Fiedler *et al.* 1998). Little is known about the mating behavior of blue whales (Sears and Perrin 2018).

2. Fin Whales

In the North Atlantic Ocean, the International Whaling Commission recognizes seven management units or "stocks" of fin whales (*Balaenoptera physalus*): (1) Nova Scotia, (2) Newfoundland-Labrador, (3) West Greenland, (4) East Greenland- Iceland, (5) North Norway, (6) West Norway-Faroe Islands, and (7) British Isles-Spain-Portugal. In addition, the population of fin whales that resides in the Ligurian Sea, in the northwestern Mediterranean Sea, is believed to be genetically distinct from other fin whale populations (as used in this document, "populations" are isolated demographically, meaning, they are driven more by internal dynamics — birth and death processes — than by the geographic redistribution of individuals through immigration or emigration. Some usages of the term "stock" are synonymous with this definition of "population" while other usages of "stock" are not).

Regardless of how different authors structure the fin whale population, mark-recapture studies have demonstrated that individual fin whales migrate between management units (Mitchell 1974, Gunnlaugsson and Sigurjónsson 1989), which suggests that these management units are not geographically isolated populations.

Fin whales were listed as endangered under the ESA in 1970. In 1976, the International Whaling Commission protected fin whales from commercial whaling (Allen 1980). Fin whales are listed as endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Animals (Baillie and Groombridge 1996). They are also protected by the Convention on International Trade in Endangered Species of Wild Flora and Fauna and the Marine Mammal Protection Act (MMPA). Critical habitat has not been designated for fin whales. In waters off the Atlantic Coast of the U.S., individual fin whales or pairs represented about 75% of the fin whales observed during the Cetacean and Turtle Assessment Program (CeTAP) (Hain *et al.* 1992). Individual whales or groups of less than five individuals represented about 90% of the observations (out of 2,065 observations of fin whales, the mean group size was 2.9, the modal value was 1, and the range was 1 – 65 individuals, Hain *et al.* 1992).

2.1 Anthropogenic Threats

The primary human-caused threats to fin whales are ship strikes and entanglements in fishing gear. Fin whales are killed and injured in collisions with vessels more frequently than any other whale. Of 92 fin whales that

stranded along the Atlantic Coast of the U.S. between 1975 and 1996, 31 (33%) showed evidence of collisions with ships (Laist *et al.* 2001). Between 1999 and 2005, there were 15 reports of fin whales being struck by vessels along the Atlantic Coast of the U.S. and the Maritime Provinces of Canada (Cole *et al.* 2005, Nelson *et al.* 2007). Of these reports, 13 were confirmed as ship strikes which were reported as having resulted in the death of 11 fin whales. According to NMFS stranding records of fin whales from the Western North Atlantic stock from 2012–2016, seven were confirmed mortalities resulting from vessel strikes (Hayes *et al.* 2019). From 2008-2017, a total of 10 whales stranded along the coast of New Jersey (Hayes *et al.* 2020, Henry *et al.* 2020). Of these 10 whales, nine were determined to be the result of vessel strikes, with the remaining individuals being ruled an entanglement (Hayes *et al.* 2020).

Despite anecdotal observations from fishermen which suggest that large whales swim through their nets rather than get caught in them (NMFS 2000), fin whales have been entangled by fishing gear off Newfoundland and Labrador in small numbers: a total of 14 fin whales are reported to have been captured in coastal fisheries in those two provinces between 1969 and 1990 (Perkins and Beamish 1979, Lien 1994). Between 2012 and 2016, seven fin whales were observed in Canadian waters with injuries related to fishing gear entanglements (Hayes *et al.* 2020).

Historically, whaling represented the greatest threat to every population of fin whales and was ultimately responsible for listing fin whales as an endangered species. As early as the mid-17th century, the Japanese were capturing fin, blue, and other large whales using a fairly primitive open-water netting technique (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species.

After blue whales were depleted in most areas, fin whales became the focus of whaling operations and more than 700,000 fin whales were landed in the Southern Hemisphere alone between 1904 and 1979 (International Whaling Commission 1995). As its legacy, whaling has reduced fin whales to a fraction of their historic population size and, as a result, makes it easier for other human activities to push fin whales closer to extinction. Otherwise, whaling currently does not threaten every fin whale population, although it may threaten specific populations. In the Atlantic Ocean, fin whales are also hunted in subsistence fisheries off West Greenland and Iceland.

2.2 Vocalizations and Hearing

The sounds fin whales produce underwater are one of the most studied *Balaenoptera* spp. sounds. Fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Watkins 1981, Watkins *et al.* 1987, Edds 1988, Thompson *et al.* 1992). The most typical signals are long, patterned sequences of short duration (0.5-2 seconds) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton 1964). Estimated source levels are as high as 190 decibels (dB) (Patterson and Hamilton 1964, Watkins *et al.* 1987, Thompson *et al.* 1992, McDonald *et al.* 1995). In temperate waters, intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998).

Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald *et al.* 1995). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

During the breeding season, fin whales produce a series of pulses in a regularly repeating pattern. These bouts of pulsing may last for longer than one day (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins *et al.* 1987), while the individual counter-calling data of McDonald *et al.* (1995) suggest that the more variable calls are contact calls. Some

authors feel there are geographic differences in the frequency, duration, and repetition of the pulses (Thompson *et al.* 1992).

As with other vocalizations produced by baleen whales, the function of fin whale vocalizations is unknown, although there are numerous hypotheses (which include: maintenance of inter-individual distance, species and individual recognition, contextual information transmission, maintenance of social organization, location of topographic features, and location of prey resources; see the review by Thompson *et al.* (1992) for more information on these hypotheses). Responses to conspecific sounds have been demonstrated in a number of baleen whales, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs in fin whales (Payne and Webb 1971, Edds-Walton 1997). Also, there is speculation that the sounds may function for long-range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

2.3 Diving and Social Behavior

The percentage of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5-20 shallow dives with each of these dives lasting 13-20 seconds followed by a deep dive lasting between 1.5 and 15 minutes (Gambell 1985). Other authors have reported that the fin whale's most common dives last between 2 and 6 minutes, with 2 to 8 blows between dives (Watkins 1981, Hain *et al.* 1992).

3. North Atlantic Right Whales

In the western Atlantic Ocean, North Atlantic right whales (*Eubalaena glacialis*) generally occur in northwest Atlantic waters west of the Gulf Stream and are most commonly associated with cooler waters (69.8°F [21° C]). North Atlantic right whales are most abundant in Cape Cod Bay between February and April (Watkins and Schevill 1982, Schevill *et al.* 1986, Hamilton and Mayo 1990), in the Great South Channel in May and June (Kenney *et al.* 1986, Payne *et al.* 1990), and off Georgia and Florida from mid-November through March (Slay *et al.* 1999). North Atlantic right whales also frequent the Bay of Fundy, Browns and Baccaro Banks (in Canadian waters), Stellwagen Bank and Jeffreys Ledge in the spring and summer months, and use mid-Atlantic waters as a migratory pathway between the winter calving grounds and their spring and summer nursery feeding areas in the Gulf of Maine. North Atlantic right whales are not found in the Caribbean Sea and have been recorded and sighted only rarely in the Gulf of Mexico (Ward-Geiger *et al*. 2011).

NMFS recognizes two extant groups of right whales in the North Atlantic Ocean (*E. glacialis*): an eastern population and a western population. A third population may have existed in the central Atlantic (migrating from east of Greenland to the Azores or Bermuda), but it appears to be extinct, if it existed as a distinct population at all (Perry *et al.* 1999).

The degree to which the two extant populations of North Atlantic right whales are connected through immigration or emigration is unknown, but the two populations have historically been treated as if they are isolated populations. Nevertheless, on January 5, 2009, a North Atlantic right whale that had been observed in the Bay of Fundy on September 24, 2008, was observed in the Azores Islands, which demonstrates that at least one right whale migrated across the Atlantic (L. Steiner, post on MarMam, January 7, 2009).

Right whales (both *E. glacialis* and *E. australis*) were listed as endangered under the ESA in 1970. In April 2008, NMFS divided right whales into three separate listings: North Atlantic right whales (*E. glacialis*), North Pacific right whales (*E. japonica*), and Southern right whales (*E. australis*), all of which were listed as endangered. Since 1949,

the North Atlantic right whale has been protected from commercial whaling by the International Whaling Commission. They are also protected by the Convention on International Trade in Endangered Species of Wild Flora and Fauna and the MMPA. NMFS designated critical habitat for the North Atlantic population of right whales on June 3, 1994 (59 FR 28793), and revised that designation on January 27, 2016 (81 FR 4837). No critical habitat has been designated in or near the Project Area.

The legacy effects of whaling appear to have had and continue to have greatest effect on Northern Atlantic right whales by reducing them to a population size that is sufficiently small to experience "small population dynamics" (Lande 1993, Caughley 1994, Lande *et al.* 2003, Melbourne and Hastings 2008). The North Atlantic right whale has seen a nominal 2 percent recovery rate since it was listed as a protected species (Waring *et al.* 2015). This is a drastic difference from the stock found in the Southern Hemisphere, which has increased at a rate of 7 to 8 percent (Knowlton and Kraus 2001). Kraus *et al.* (2005) estimated that about 350 individual right whales, including about 70 mature females, occur in the western North Atlantic. Waring *et al.* (2008) reviewed the data from the recapture database and estimated that the right whale population in the western North Atlantic Ocean numbers about 325 whales. In 2015, the western North Atlantic population size was estimated to be at least 476 individuals (Waring et al. 2016). That population size estimate decreased to 458 individuals in 2017 (Hayes et al. 2017) with a median estimate of abundance of 451 in 2018 (Hayes et al. 2020). Additional information provided by Pace et al. (2017), indicates a 99.99 percent probability that the North Atlantic right whale population has declined since 2010. Data also indicate that the number of adult females dropped from 200 in 2010 down to 186 in 2015, while males dropped from 283 to 272 in the same timeframe. Also cause for concern is the confirmed mortality of 14 individuals in 2017 alone (Pace et al. 2017). As of writing, the most recent population estimate is 412 individuals (NMFS 2020).

3.1 Anthropogenic Threats

Contemporary anthropogenic threats to right whale populations include fishery entanglements and vessel strikes, although habitat loss, pollution, anthropogenic noise, and intense commercial fishing may also negatively impact their populations (Kenney 2018). Of these current threats, entanglement in commercial fishing gear and vessel strikes pose the greatest threat to the persistence of North Atlantic right whales. After the cessation of commercial whaling of this species, the North Atlantic right whale population increased at a slow place until 2010, when ecosystem shifts caused changes in right whale movements and foraging habits, resulting in increased interaction between whales and fishing gear (Hayes *et al.* 2018). Corkeron *et al.* (2018) compared calf counts of Southern right whales, *E. australis*, with those of North Atlantic right whales, from 1992 to 2016. The annual rate of increase for North Atlantic right whales was approximately one-third that of Southern right whales, and the authors attributed this difference to higher rates of anthropogenic mortality—particularly from entanglements in fishing gear and vessel strikes—for North Atlantic right whales (Corkeron *et al.* 2018). Right whales have difficulty maneuvering around boats and spend most of their time at the surface, feeding, resting, mating, and nursing, thereby increasing their vulnerability to collisions. In 2017, NMFS declared an unusual mortality event (UME) (UME Number 64) for the North Atlantic right whale (NOAA Fisheries 2021). To date, there have been 47 confirmed deaths of stranded right whales under the UME (NOAA Fisheries 2021). NMFS has tabulated all North Atlantic right whale stranding records from 2011 through 2021, and three of these cases occurred in the state of New Jersey. An animal in 2014 stranded in Atlantic City, New Jersey, with entanglement determined to be the cause of death. In June 2020, the calf of #3560 was found offshore of Elberon, New Jersey, with a sharp and blunt force trauma due to a vessel strike (NOAA Fisheries 2021). Additionally, a male North Atlantic right whale (#4680) was found off Sea Bright, New Jersey, in October 2020, with a serious injury due to entanglement (NOAA Fisheries 2021).

Historically, whaling represented the greatest threat to every population of right whales and was ultimately responsible for their listing as an endangered species. The North Atlantic right whale was the first species targeted during commercial whaling operations and was the first species to be greatly depleted as a result of whaling operations (Kenney 2018). North Atlantic right whales were hunted in southern New England until the early twentieth century. Shore-based whaling in Long Island involved catches of right whales year-round, with peak catches in spring during the northbound migration from calving grounds off the southeastern U. S. to feeding grounds in the Gulf of Maine (Kenney and Vigness-Raposa 2010). As its legacy, whaling reduced North Atlantic right whales to about 300 individuals in the western North Atlantic Ocean.

3.2 Vocalizations and Hearing

North Atlantic right whales produce a variety of sounds, including moans, screams, gunshots, blows, upcalls, downcalls, and warbles that are often linked to specific behaviors (Matthews *et al.* 2001, Laurinolli *et al.* 2003, Vanderlaan *et al.* 2003, Parks *et al.* 2005, Parks and Tyack 2005, Clark *et al.* 2010). Sounds can be divided into three main categories: (1) blow sounds, (2) broadband impulsive sounds, and (3) tonal call types (Parks and Clark 2007). Blow sounds are those coinciding with an exhalation; it is not known whether these are intentional communication signals or just produced incidentally (Parks and Clark 2007).

Broadband sounds include non-vocal slaps (when the whale strikes the surface of the water with parts of its body) and the “gunshot” sound; data suggests that the latter serves a communicative purpose (Parks and Clark 2007). Tonal calls can be divided into simple, low-frequency, stereo-typed calls and more complex, frequency-modulated, higher-frequency calls (Parks and Clark 2007). Most of these sounds range in frequency from 0.02 to 15 kHz (dominant frequency range from 0.02 to less than 2 kHz; durations typically range from 0.01 to multiple seconds) with some sounds having multiple harmonics (Parks and Tyack 2005).

Source levels for some of these sounds have been measured as ranging from 137 to 192 dB root-mean-square (rms) re 1 Pa-m (decibels at the reference level of one micro Pascal at one meter) (Parks *et al.* 2005, Parks and Tyack 2005). Parks and Clark (2005) suggested that the frequency of right whale vocalizations increases significantly during the period from dusk until dawn. Recent morphometric analyses of North Atlantic right whale inner ears estimate a hearing range of approximately 0.01 to 22 kHz based on established marine mammal models (Parks and Tyack 2005, Parks *et al.* 2005, 2007). In addition, Parks *et al.* (2007) estimated the functional hearing range for right whales to be 15 Hz to 18 kHz.

3.3 Diving and Social Behavior

North Atlantic right whales can dive to depths over 1,000 ft (300 m) (Mate *et al.* 1992). In the Great South Channel, average diving time is close to 2 minutes; average dive depth is 24 ft (7.3 m) with a maximum of 280 ft (85.3 m) (Winn *et al.* 1995). In the U.S. Outer Continental Shelf, the average diving time is about 7 minutes although maximum dive durations are considerably longer (CeTAP 1982). For example, Baumgartner and Mate (2003) reported right whale feeding dives were characterized by a rapid descent from the surface to a particular depth between 262 to 574 ft (80 to 175 m) with animals remaining at those depths for 5 to 14 minutes, then ascending quickly to the surface (Baumgartner *et al.* 2017). Longer surface intervals have been observed for reproductively active females and their calves (Baumgartner and Mate 2003, Baumgartner *et al*. 2017). North Atlantic right whales are primarily seen in groups of less than 12, most often singles or pairs (Jefferson *et al.* 1993). They may form larger groups while on feeding or breeding areas (Jefferson *et al.* 1993).

4. Sei Whales

Sei whales (*Balaenoptera borealis*) were listed as endangered under the ESA in 1973. In the North Pacific, the International Whaling Commission began management of commercial taking of sei whales in 1970, and sei whales were given full protection in 1985 (Allen 1980). Sei whales are also protected by the Convention on International Trade in Endangered Species of Wild Flora and Fauna and the MMPA. They are listed as endangered under the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for sei whales.

4.1 Anthropogenic Threats

The primary current threat to sei whales is vessel strikes from shipping activities. Between 2011 and 2017, nine mortalities resulting from vessel strikes were confirmed in the Western North Atlantic (Hayes *et al.* 2017, 2020).

Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species.

4.2 Vocalizations and Hearing

There is a limited amount of information on the vocal behavior of sei whales. McDonald *et al.* (2005) recorded sei whale vocalizations off the Antarctic Peninsula that included broadband sounds in the 100-600 Hz range with 1.5 second duration and tonal and upsweep call in the 200-600 Hz range 1-3 second duration. During visual and acoustic surveys conducted in the Hawaiian Islands in 2002, Rankin and Barlow (2007) recorded 107 sei whale vocalizations, which they classified as two variations of low-frequency downswept calls. The first variation consisted of sweeps from 100 Hz to 44 Hz, over 1.0 seconds. The second variation, which was more common (105 out of 107) consisted of low frequency calls which swept from 39 Hz to 21 Hz over 1.3 seconds. These vocalizations are different from sounds attributed to sei whales in the Atlantic and Southern Oceans but are similar to sounds that had previously been attributed to fin whales in Hawaiian waters.

4.3 Diving and Social Behavior

Generally, sei whales make 5-20 shallow dives of 20-30 seconds duration followed by a deep dive of up to 15 minutes (Gambell 1985). The depths of sei whale dives have not been studied; however, the composition of their diet suggests that they do not perform dives in excess of 984 ft (300 m). Sei whales are usually found in small groups of up to six individuals, but they commonly form larger groupings when they are on feeding grounds (Gambell 1985).

5. Sperm Whales

The population structure of sperm whales (*Physeter macrocephalus*) is largely unknown. Sperm whales may not form “populations” as that term is normally conceived. Jaquet (1996) outlined a hierarchical social and spatial structure that includes temporary clusters of animals, family units of 10 or 12 females and their young, groups of about 20 animals that remain together for hours or days, “aggregations” and “super-aggregations” of 40 or more whales, and “concentrations” that include 1,000 or more animals (Whitehead and Wielgart 1990, Whitehead *et al.* 1991).

The “family unit” forms the foundation for sperm whale society and most females probably spend their entire life in the same family unit (Whitehead 2018). The dynamic nature of these relationships and the large spatial areas

they are believed to occupy might complicate or preclude attempts to apply traditional population concepts, which tend to rely on group fidelity to geographic distributions that are relatively static over time.

Several investigators have suggested that the sperm whales that occupy the northern Gulf of Mexico are distinct from sperm whales elsewhere in the North Atlantic Ocean (Schmidly 1981, Fritts *et al.* 1983, Hansen *et al.* 1995), although the International Whaling Commission does not treat these sperm whales as a separate population or "stock."

Sperm whales were listed as endangered under the ESA in 1973. Sperm whales have been protected from commercial harvest by the International Whaling Commission since 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). They are also protected by the Convention on International Trade in Endangered Species of Wild Flora and Fauna and the MMPA. Critical habitat has not been designated for sperm whales.

The status and trend of sperm whales at the time of this summary is largely unknown. No information was available to support estimates of sperm whale status and trends in the western North Atlantic Ocean (Waring *et al.* 2004, Hayes *et al.* 2020), the Indian Ocean (Perry *et al.* 1999), or the Mediterranean Sea. The information available on the status and trend of sperm whales do not allow making a definitive statement about the extinction risks facing sperm whales as a species or particular populations of sperm whales.

5.1 Anthropogenic Threats

Current threats to sperm whales include entanglement in fishing gear, including pelagic longlines, and vessel strikes (Waring *et al*. 2015, Hayes *et al.* 2020). From 2009-2010, there were three sperm whale mortalities in the North Atlantic resulting from entanglement in fishing gear (Waring *et al.* 2015). In May 1994, a sperm whale that had been struck by a ship was observed south of Nova Scotia (Reeves and Whitehead 1997) and in May 2000, a merchant ship reported a strike in Block Canyon (NMFS, unpublished data), which is a major pathway for sperm whales entering southern New England continental shelf waters in pursuit of migrating squid (CeTAP 1982, Scott and Sadove 1997). In 2006, a sperm whale was found dead from ship strike wounds off Portland, Maine, and in 2012, a Florida stranding mortality was classified as a vessel strike mortality (Waring *et al.* 2015). From 2013 to 2017, 12 sperm whale strandings were documented along the U.S. Atlantic coast within the EEZ (Hayes *et al*. 2020).

Historically, whaling represented the greatest threat to every population of sperm whales and was ultimately responsible for listing sperm whales as an endangered species. Although the International Whaling Commission protected sperm whales from commercial harvest in 1981, whaling operations along the Japanese coast continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). More recently, the Japanese Whaling Association began hunting sperm whales for research.

5.2 Vocalizations and Hearing

Sperm whales produce loud broad-band clicks from about 0.1 to 20 kHz (Weilgart and Whitehead 1993, 1997, Goold and Jones 1995). These have source levels estimated at 171 dB re 1 µPa (Levenson 1974). Current evidence suggests that the disproportionately large head of the sperm whale is an adaptation to produce these vocalizations (Norris and Harvey 1972, Cranford 1999, but see Clarke 1979). This suggests that the production of these loud low frequency clicks is extremely important to the survival of individual sperm whales. The function of these vocalizations is relatively well-studied (Weilgart and Whitehead 1993, 1997, Goold and Jones 1995). Long series of monotonous. regularly spaced clicks are associated with feeding and are thought to be produced for

echolocation. Distinctive, short, patterned series of clicks, called codas, are associated with social behavior and intragroup interactions; they are thought to facilitate intra-specific communication, perhaps to maintain social cohesion with the group (Weilgart and Whitehead 1993).

The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate (Carder and Ridgway 1990). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz.

5.3 Diving and Social Behavior

Sperm whales are probably the deepest and longest diving mammal: they can dive to depths of at least 6,562 ft (2,000 m) and may remain submerged for an hour or more (Watkins *et al.* 1993). Typical foraging dives last 40 minutes and descend to about 1,312 ft (400 m) followed by about 8 minutes of resting at the surface (Gordon 1987, Papastavrou *et al.* 1989). However, dives of over 2 hours and as deep as 9,842 ft (3,000 m) have been recorded (Clarke 1976, Watkins *et al.* 1985). Descent rates recorded from echo-sounders were approximately 5.6 ft/seconds and nearly vertical (Goold and Jones 1995). There are no data on diurnal differences in dive depths in sperm whales. However, like most diving vertebrates for which there are data (e.g., rorqual whales, fur seals, chinstrap penguins), sperm whales probably make relatively shallow dives at night when organisms from the ocean's deep scattering layers move toward the ocean's surface.

The groups of closely related females and their offspring develop dialects specific to the group (Weilgart and Whitehead 1997) and females other than birth mothers will guard young at the surface (Whitehead 1996) and will nurse young calves (Reeves and Whitehead 1997).

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