



## Appendix K – Sea Turtle Supplementary Material

## Appendix K, Sea Turtle Supplementary Material Ocean Wind Offshore Wind Farm COP

This appendix contains supplemental information on sea turtles, all of which are listed as endangered or threatened under the Endangered Species Act (ESA).

### 1. Green Sea Turtle

There are no current estimates of the total abundance of this population segment of green sea turtles (*Chelonia mydas*; which includes all life stages and both genders). However, the total number of nesting females has been estimated to include about 167,500 females over 73 nesting sites (81 FR 20077, 2016; also see Seminoff *et al.* 2015). There are also no estimates of green turtle densities in the Project Area.

#### 1.1 Diving and Social Behavior

Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, it is presumed that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (NMFS and USFWS 1998). The maximum recorded dive depth for an adult green turtle was 360.9 ft (110 m) (Berkson 1967 in Lutcavage and Lutz 1997), while subadults routinely dive 65.6 ft (20 m) for 9-23 minutes, with a maximum recorded dive of 66 minutes (Brill *et al.* 1995 in Lutcavage and Lutz 1997). Hochscheid (2014) performed a review of sea turtle dive behavior studies published from 1986 to 2013; the maximum reported duration of green turtle dives was 307.0 minutes (Broderick *et al.* 2007 in Hochscheid 2014), and maximum depth was 138.0 m (Rice and Balazs 2008 in Hochscheid 2014).

#### 1.2 Vocalizations and Hearing

Information on green turtle hearing is very limited. Ridgway *et al.* (1969) studied the auditory evoked potentials of three green sea turtles (in air and through mechanical stimulation of the ear) and concluded that their maximum sensitivity occurred from 300 to 400 hertz (Hz) with rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1,000 Hz. This is similar to estimates for loggerhead sea turtles, which had most sensitive hearing between 250 and 1,000 Hz, with rapid decline above 1,000 Hz (Bartol *et al.* 1999). In a study of the auditory brainstem responses of subadult green sea turtles responded to frequencies between 100 and 500 Hz, with highest sensitivity between 200 and 400 Hz (Bartol and Ketten 2006). Two of the turtles studied had hearing sensitivities that were slightly broader in range: they responded to sounds at frequencies from 100 to 800 Hz, with highest hearing sensitivities from 600 to 700 Hz.

These hearing sensitivities are similar to the results produced by Ridgway *et al.* (1969), pond turtles (*Pseudemys scripta*; studied by Wever and Vernon 1956) and wood turtles (*Chrysemys insculpta*; studied by Patterson 1966). Pond turtles are reported to have best hearing responsiveness between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz and almost no sensitivity above 3,000 Hz (Wever and Vernon 1956) the latter had sensitivities up to about 500 Hz, followed by a rapid decline above 1,000 Hz and almost no responses beyond 3,000 or 4,000 Hz (Peterson 1966). The turtles studied by Ridgway *et al.* (1969) could be exposed to an upper limit of 2,000 Hz without injury of 2000 Hz with a practical limit of about 1,000 Hz.

## 2. Kemp's Ridley Sea Turtle

Similar to the other turtle species discussed here, there are no current estimates of the total abundance of the Kemp's ridley sea turtle (*Lepidochelys kempii*, which includes all life stages and both genders). However, the total number of nesting females has been estimated to include about 188,500 females with a global population estimate of about 1 million (Gallaway *et al.* 2013). However, the decline in the number of Kemp's ridley nests following 2012 suggest that these may overestimate the true abundance. There are no estimates of Kemp's ridley sea turtle densities in the Project Area.

### 2.1 Diving and Social Behavior

Information about the diving behavior of this species is limited to small-scale tagging studies with limited sample sizes. For example, three Kemp's ridley sea turtles instrumented with radio and satellite-tracked tags spent the majority (94-95 percent) of their time submerged, and remained at a constant depth at- or near-bottom, during submergence events, with a maximum dive duration of 217 minutes (Gitschlag 1996). Tagged turtles spent more time at the surface during daylight hours than at night in all seasons, and spent longer periods at the surface in spring than in other seasons (Gitschlag 1996).

### 2.2 Vocalizations and Hearing

There is no information on the vocalizations or hearing of Kemp's ridley sea turtles. However, using green and loggerhead turtle and pond and wood turtles as proxies, their best hearing sensitivity would be in the low frequency range: from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies. Their hearing would probably have a practical upper limit of about 1,000 Hz (Bartol *et al.* 1999, Ridgway *et al.* 1969).

## 3. Leatherback Sea Turtle

Similar to the other turtle species discussed here, there are no current estimates of the total abundance of leatherback sea turtles (*Dermochelys coriacea*, which includes all life stages and both genders). The most recent population size estimate of the adult leatherback population (male and female) in the North Atlantic ranges from 34,000 to 94,000 adults (TEWG 2007, NMFS and USFWS 2013).

### 3.1 Diving and Social Behavior

Leatherback turtles are capable of extraordinarily protracted and deep dives. Hochscheid (2014) reported that the maximum recorded dive duration for leatherbacks was 86.5 minutes (López-Mendilaharsu *et al.* 2009, in Hochscheid 2014) and maximum recorded depth was 1,250 m (Houghton *et al.* 2008, in Hochscheid 2014). Dodge *et al.* (2014) analyzed the dive behavior of 20 leatherback turtles tagged off the coast of Massachusetts. Tagged turtles spent only 27% of their time at the surface when using Northwest Atlantic shelf habitat, and 90% of dives were shallower than 75 m and shorter than 32 minutes (Dodge *et al.* 2014). Fifteen turtles in the study dove deeper than 500 m, and males recorded the deepest dives (>1200 m, n=3 turtles) (Dodge *et al.* 2014). Leatherback turtles also appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting that maximum exploitation of the water column is of paramount importance to the leatherback (Eckert *et al.* 1989).

Migrating leatherback turtles also spend a majority of time at sea submerged, and they display a pattern of continual diving (Standora *et al.* 1984, in Southwood *et al.* 1999). Based on depth profiles of four leatherbacks tagged and tracked from Monterey Bay, California in 2000 and 2001, using satellite-linked dive recorders, most

of the dives were to depths of less than 328 ft (100 m) and most of the time was spent shallower than 262 ft (80 m). Based on preliminary analyses of the data, 75-90 percent of the time the leatherback turtles were at depths less than 262 ft (80 m).

### 3.2 Vocalizations and Hearing

There is no information on the vocalizations or hearing of leatherback sea turtles. However, using green and loggerhead turtle and pond and wood turtles as proxies, their best hearing sensitivity would be in the low frequency range: from 200 to 400 Hz with rapid declines for tones at lower and higher frequencies. Their hearing would probably have a practical upper limit of about 1,000 Hz (Bartol *et al.* 1999, Ridgway *et al.* 1969).

## 4. Loggerhead Sea Turtle

There are no current estimates of the total size of this population segment of loggerhead sea turtles (*Caretta caretta*, which includes all life stages and both genders).

### 4.1 Diving and Social Behavior

Studies of loggerhead diving behavior indicate varying mean depths and surface intervals, depending on whether they were located in shallow coastal areas (short surface intervals) or in deeper, offshore areas (longer surface intervals). Hochscheid (2014) reported a maximum dive duration for tagged loggerhead sea turtles of 614.4 minutes (Broderick *et al.* 2007 in Hochscheid 2014) and a maximum depth of 233.0 m (Sakamoto *et al.* 1990 in Hochscheid 2014).

Routine dive times for a post-nesting female were between 15 and 30 minutes, and for a subadult, between 19 and 30 minutes (Sakamoto *et al.* 1990 in Lutcavage and Lutz 1997). Two loggerheads tagged by Hawaii-based longline observers in the North Pacific and attached with satellite-linked dive recorders were tracked for about 5 months. Analysis of the dive data indicates that most of the dives were very shallow - 70 percent of the dives were no deeper than 16 ft (5 meters). In addition, the loggerheads spent approximately 40 percent of their time in the top meter and nearly all of their time at depths shallower than 328 ft (100 meters).

Polovina *et al.* (2004) reported that tagged turtles spent 40 percent of their time at the surface and 90 percent of their time at depths shallower than 131 ft (40 meters). On five percent of recorded dive days, loggerheads dove to depths greater than 328 ft (100 meters) at least once. In the areas that the loggerheads were diving, there was a shallow thermocline at 164 ft (50 meters). There were also several strong surface temperature fronts the turtles were associated with, one of 68 °F (20 °C) at 28°N latitude and another of 63°F (17°C) at 32°N latitude.

### 4.2 Vocalizations and Hearing

Like other sea turtle species discussed thus far, the information on loggerhead turtle hearing is limited. Bartol *et al.* (1999) studied the auditory evoked potential of loggerhead sea turtles that had been captured in pound nets in tributaries to the Chesapeake Bay in Maryland and Virginia and concluded that loggerhead sea turtles had most sensitive hearing between 250 and 1,000 Hz, with rapid decline above 1,000 Hz (Bartol *et al.* 1999). This is similar to the hearing of pond turtles and wood turtles summarized above (Ridgway *et al.* 1969, Wever and Vernon 1956. Lavender *et al.* (2014) performed behavioral and electrophysiological audiography tests to assess hearing in two different size classes (i.e., post-hatchling and juvenile) of loggerhead sea turtles. Results indicated that thresholds and sensitivity ranges were similar for post-hatchling and juvenile sea turtles, and that both post-hatchling and juvenile loggerhead sea turtles are low-frequency specialists (Lavender *et al.* 2014).

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