# SPERM WHALE (*Physeter macrocephalus*): North Atlantic Stock

## STOCK DEFINITION AND GEOGRAPHIC RANGE

The distribution of the sperm whale in the U.S. Exclusive Economic Zone (EEZ) occurs on the continental shelf edge, over the continental slope, and into mid-ocean regions (Figure 1). Waring et al. (1993, 2001) suggested that this offshore distribution is more commonly associated with the Gulf Stream edge and other features. However, the sperm whales that occur in the eastern U.S. Atlantic EEZ likely represent only a fraction of the total stock. The nature of linkages of the U.S. habitat with those to the south, north, and offshore is unknown. Historical whaling records compiled by Schmidly (1981) suggest an offshore distribution off the southeast U.S., over the Blake Plateau, and into deep ocean waters. In the southeast Caribbean, both large and small adults, as well as calves and juveniles of different sizes are reported (Watkins et al. 1985). Whether the northwestern Atlantic population is discrete from the northeastern Atlantic is currently unresolved. The International Whaling Commission recognizes one stock for the North Atlantic. Based on reviews of many types of stock studies (i.e., tagging, genetics, catch data, mark-recapture, biochemical markers, etc.), Reeves and Whitehead (1997), and Dufault et al. (1999) suggested that sperm whale populations have no clear geographic structure. Ocean-wide genetic studies (Lyrholm and Gyllensten 1998; Lyrholm et al. 1999) indicated low genetic diversity but strong differentiation between potential social (matrilineally related) groups. Further, Englehaupt et al. (2009) found no differentiation between mtDNA samples from the western North Atlantic and from the North Sea, but significant differentiation between samples from the Gulf of Mexico and from the Atlantic Ocean just outside the Gulf of Mexico. These ocean-wide findings, combined with observations from other studies, indicate stable social groups, site fidelity, and latitudinal range limitations in groups of females and juveniles (Whitehead 2002). In contrast, males migrate to polar regions to feed and move among populations to breed (Whitehead 2002, Englehaupt 2009). There exists one tag return of a male tagged off Browns Bank (Nova Scotia) in 1966 and returned from Spain in 1973 (Mitchell 1975). Another male taken off northern Denmark in August 1981 had been wounded the previous summer by whalers off the Azores (Reeves and Whitehead 1997). Steiner et al. (2012) reported on resightings of photographed individual male sperm whales between the Azores and Norway. In U.S. Atlantic EEZ waters, there appears to be a distinct seasonal cycle (CETAP 1982; Scott and Sadove 1997). In winter, sperm whales are concentrated east and northeast of Cape Hatteras. In spring, the center of distribution shifts northward to east of Delaware and Virginia and is widespread throughout the central portion of the mid-Atlantic Bight and the southern portion of Georges Bank. This is supported by acoustic studies in which detection of sperm whale vocalizations had a winter peak off Cape Hatteras, with the peak shifting farther north in the spring (Stanistreet et al. 2018). In summer, the distribution is similar but now also includes the area east and north of Georges Bank and into the Northeast Channel region, as well as the continental shelf (inshore of the 100-m isobath) south of New England. In the fall, sperm whales occur south of New England in relatively high numbers, and are alsopresent along the

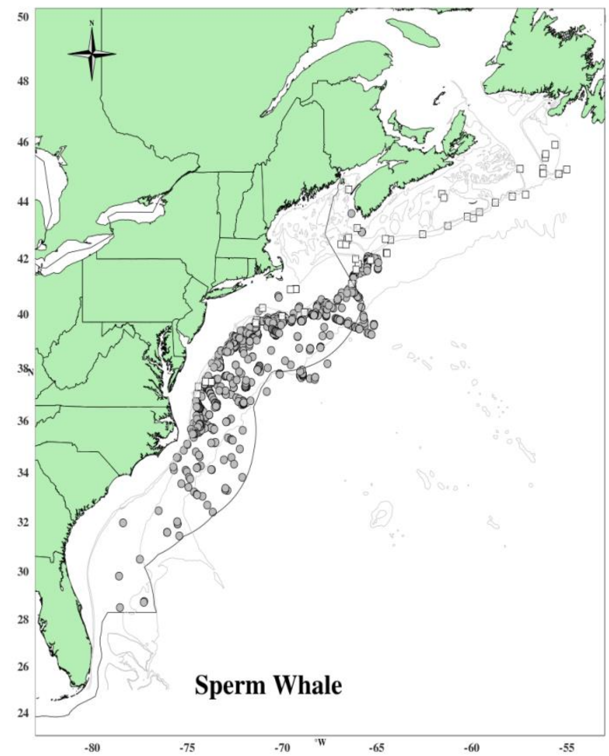


***Figure 1. Distribution of sperm whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summer in 1998, 1999, 2002, 2004, 2006, 2011, 2016 and 2021 and Department of Fisheries and Oceans Canada 2007 TNASS and 2016 NAISS surveys. Isobaths are the 100m, 1,000m, and 4,000m depth contours. Circle symbols represent shipboard sightings and squares are aerial sightings.***

continental shelf edge in the mid-Atlantic Bight. Similar inshore (<200 m) observations have been made on the southwestern (R.D. Kenney, pers. comm.) and eastern Scotian Shelf, particularly in the region of "the Gully" (Whitehead et al. 1991).

Geographic distribution of sperm whales may be linked to their social structure and their low reproductive rate. Both of these factors have management implications. Several basic groupings or social units are generally recognized—nursery schools, harem or mixed schools, juvenile or immature schools, bachelor schools, bull schools or pairs, and solitary bulls (Best 1979; Whitehead et al. 1991; Christal et al. 1998). These groupings have distinct geographical distributions, with females and juveniles generally based in tropical and subtropical waters, and males more wide-ranging and occurring at higher latitudes. Male sperm whales are present off and sometimes on the continental shelf along the entire east coast of Canada south of Hudson Strait whereas females rarely migrate north of the southern limit of the Canadian EEZ (Reeves and Whitehead 1997; Whitehead 2002). Off the northeastern U.S., Cetacean and Turtle Assessment Program (CETAP) and NEFSC sightings in shelf-edge and off-shelf waters included many social groups with calves/juveniles (CETAP 1982; Waring et al. 1992, 1993). The basic social unit of the sperm whale appears to be a mixed group of adult females plus their calves and some juveniles of both sexes, normally numbering a total of 20–40 animals. There is evidence that some social bonds persist for many years (Christal et al. 1998).

## POPULATION SIZE

Several estimates from selected regions of sperm whale habitat exist for select time periods; however, at present there is no reliable estimate of total sperm whale abundance for the entire North Atlantic. Sightings have been almost exclusively in the continental shelf edge and continental slope areas (Figure 1); however, there has been little or no survey effort beyond the slope. The best recent abundance estimate for sperm whales is the sum of the 2021 surveys described below—5,895 (CV=0.29).

### Recent Surveys and Abundance Estimates

Abundance estimates of 3,321 (CV=0.35), and 1,028 (CV=0.35) sperm whales were generated from vessel surveys conducted in U.S. waters of the western North Atlantic during the summer of 2016 (Table 1; Garrison 2020; Palka 2020). One survey was conducted from 27 June to 25 August in waters north of 38ºN latitude (Central Virginia) and consisted of 5,354 km of on-effort trackline along the shelf break and offshore to the outer limit of the U.S. EEZ (NEFSC and SEFSC 2018). The second vessel survey covered waters from Central Florida to approximately 38ºN latitude between the 100-m isobath and the outer limit of the U.S. EEZ during 30 June–19 August. A total of 4,399 km of trackline was covered on effort (NEFSC and SEFSC 2018). Both surveys utilized two visual teams and an independent observer approach to estimate detection probability on the trackline (Laake and Borchers 2004). Mark-recapture distance sampling was used to estimate abundance. Estimates from the two surveys were combined and CVs pooled to produce a species abundance estimate for the stock area.

More recent abundance estimates of 3,789 (CV=0.38) and 2,106 (CV=0.44) sperm whales were generated from vessel surveys conducted in U.S. waters of the western North Atlantic during the summer of 2021 (Table 1; Garrison and Aichinger-Dias 2023; Palka 2023). One survey was conducted from 16 June to 23 August in waters north of 36ºN latitude and consisted of 5,871 km of on-effort trackline along the shelf break and offshore to the outer edge of the U.S. EEZ (NEFSC and SEFSC 2022). The second vessel survey covered waters from central Florida (25ºN latitude) to approximately 38ºN latitude between the 200-m isobaths and the outer edge of the U.S. EEZ during 12 June–31 August. A total of 5,659 km of trackline was covered on effort (NEFSC and SEFSC 2022). Both surveys utilized two visual teams and an independent observer approach to estimate detection probability on the trackline (Laake and Borchers 2004). Mark-recapture distance sampling was used to estimate abundance. Estimates from the two surveys were combined and CVs pooled to produce a species abundance estimate for the stock area.

***Table 1. Summary of abundance estimates for the western North Atlantic sperm whale (*Physeter macrocephalus*). Month, year, and area covered during each abundance survey, and resulting abundance estimate ($N_{best}$) and coefficient of variation (CV). The estimate considered best is in bold font.***

| Month/Year | Area | $N_{best}$ | CV |
|---|---|---|---|
| Jun–Aug 2016 | Central Virginia to lower Bay of Fundy | 3,321 | 0.35 |
| Jun–Aug 2016 | Central Florida to Virginia | 1, 028 | 0.35 |
| Jun–Aug 2016 | Central Florida to lower Bay of Fundy (COMBINED) | 4,349 | 0.28 |

| Month/Year | Area | $N_{best}$ | CV |
|---|---|---|---|
| Jun–Aug 2021 | New Jersey to lower Bay of Fundy | 3,789 | 0.38 |
| Jun–Aug 2021 | Central Florida to New Jersey | 2,106 | 0.44 |
| **Jun–Aug 2021** | **Central Florida to lower Bay of Fundy (COMBINED)** | **5,895** | **0.29** |

### Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for sperm whales is 5,895 (CV=0.29). The minimum population estimate for the western North Atlantic sperm whale is 4,639.

### Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV > 0.30) remains below 80% (alpha = 0.30) unless surveys are conducted on an annual basis (Taylor et al. 2007). There is current work to standardize the strata-specific previous abundance estimates to consistently represent the same regions and include appropriate corrections for perception and availability bias. These standardized abundance estimates will be used in state-space trend models that incorporate environmental factors that could potentially influence the process and observational errors for each stratum.

## CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. Some life history and vital rates information is available for the Northwest Atlantic. These include: calving interval is 4–6 years; lactation period is 24 months; gestation period is 14.5–16.5 months; births occur mainly in July to November; length at birth is 4.0 m; length at sexual maturity 11.0–12.5 m for males and 8.3–9.2 m for females; mean age at sexual maturity is 19 years for males and 9 years for females; and mean age at physical maturity is 45 years for males and 30 years for females (Best 1974; Best et al. 1984; Lockyer 1981; Rice 1989).

For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow et al. 1995).

## POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 4,639 (Table 2). The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor, which accounts for endangered, depleted, threatened stocks, or stocks of unknown status relative to optimum sustainable population (OSP) is assumed to be 0.10 because the sperm whale is listed as endangered under the Endangered Species Act (ESA). PBR for the western North Atlantic sperm whale is 9.28.

***Table 2. Best and minimum abundance estimates for the western North Atlantic sperm whale with Maximum Productivity Rate ($R_{max}$), Recovery Factor ($F_r$) and PBR.***

| $N_{est}$ | CV | $N_{min}$ | $F_r$ | $R_{max}$ | PBR |
|---|---|---|---|---|---|
| 5,895 | 0.29 | 4,639 | 0.1 | 0.04 | 9.28 |

## ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

There are no documented reports of fishery-related mortality or serious injury to this stock during 2017–2021, though one stranding mortality in Florida in 2021 was attributed to ingestion of plastics including fishing net.

***Table 3. The total annual observed average human-caused mortality and serious injury for the western North Atlantic sperm whale (Physeter macrocephalus).***

| Years | Source | Annual Avg. |
|---|---|---|
| 2017−2021 | Fishery entanglements | 0 |
| 2017−2021 | Vessel strikes | 0 |
| 2017−2021 | Other (plastic ingestion, see Table 4) | 0.2 |
| TOTAL | | 0.2 |

**Fishery Information**

Detailed fishery information is reported in Appendix III.

**Other Mortality**

Vessel strikes are another source of human-caused mortality (McGillivary et al. 2009; Carrillo and Ritter 2010). In May 1994 a vessel-struck sperm whale was observed south of Nova Scotia (Reeves and Whitehead 1997), in May 2000 a merchant ship reported a strike in Block Canyon, and in 2001 the U.S. Navy reported a vessel strike within the EEZ. In 2006, a sperm whale was found dead from vessel-strike wounds off Portland, Maine. In spring, the Block Canyon region is part of a major pathway for sperm whales entering southern New England continental shelf waters in pursuit of migrating squid (CETAP 1982; Scott and Sadove 1997). A 2012 Florida stranding mortality was classified as a vessel strike mortality.

**STATUS OF STOCK**

This is a strategic stock because the species is listed as endangered under the ESA. Total fishery-related mortality and serious injury for this stock is less than 10% of the calculated PBR, and therefore can be considered to be insignificant and approaching a zero mortality and serious injury rate. The status of this stock relative to OSPis unknown. There are insufficient data to determine population trends. The current stock abundance estimate was based upon a small portion of the known stock range. A Recovery Plan for sperm whales was finalized in 2010 (NMFS 2010).

**OTHER FACTORS THAT MAY BE AFFECTING THE STOCK**

**Strandings**

During 2017–2021, 10 sperm whale strandings were documented along the U.S. Atlantic coast within the EEZ (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 October 2022; Table 4). Two of these strandings were classified as human interactions, both due to plastic ingestion (Table 3); however, in only one case was the plastic clearly the cause of death.

***Table 4. Sperm whale (*****Physeter macrocephalus*****) reported strandings along the U.S. and Canada Atlantic coast 2017–2021.***

| Stranding State or Province | 2017 | 2018 | 2019 | 2020 | 2021 | Total |
|---|---|---|---|---|---|---|
| Newfoundland/Labrador[a] | 01 | 1 | 2 | 1 | 3 | 7 |
| Nova Scotia[b] | 1 | 0 | 0 | 2 | 1 | 3 |
| Massachusetts | 0 | 1 | 0 | 0 | 0 | 2 |
| New York | 0 | 1 | 0 | 0 | 0 | 1 |
| Maryland**c** | 0 | 0 | 1 | 0 | 0 | 1 |
| Virginia | 0 | 0 | 0 | 0 | 0 | 0 |
| North Carolina | 1 | 0 | 0 | 0 | 0 | 1 |
| South Carolina | 0 | 1 | 0 | 0 | 0 | 1 |
| Florida[d] | 1 | 1 | 0 | 1 | 1 | 4 |

| Stranding State or Province | 2017 | 2018 | 2019 | 2020 | 2021 | Total |
|---|---|---|---|---|---|---|
| **TOTAL U.S.** | **2** | **4** | **3** | **1** | **1** | **11** |

a. Data provided by Whale Release and Strandings, Tangly Whales Inc. Newfoundland, Canada (Ledwell et al. 2018, Ledwell et al. 2021a, 2021b).
b. Data supplied by Nova Scotia Marine Animal Response Society (pers. comm.).
c. Maryland 2019 animal coded as HI due to plastic ingestion, although not clearly the cause of death.
d. Florida 2021 animal coded as HI due to ingestion of fishing net and other plastic as well as FI entanglement.

Mass strandings have been reported in many oceanic regions (Rice et al. 1986; Kompanje and Reumer 1995; Evans et al. 2002; Fujiwara et al. 2007; Pierce et al. 2007; Mazzariol et al. 2011). Reasons for the strandings are unknown, although multiple causes (e.g., topography, changes in geomagnetic field, solar cycles, vessel strikes, global changes in water temperature and prey distribution, and pollution) have been suggested (Kirschvink et al. 1986; Brabyn and Frew 1994; Holsbeek et al. 1999; Mazzariol et al. 2011).

**Habitat Issues**

The chronic impacts of contaminants (polychlorinated biphenyls [PCBs] and chlorinated pesticides [DDT, DDE, dieldrin, etc.]) on marine mammal reproduction and health are of concern (e.g., Pierce et al. 2008; Jepson et al. 2016; Hall et al. 2018; Murphy et al. 2018), but research on contaminant levels for the North Atlantic stock of sperm whales is lacking.

Anthropogenic sound in the world's oceans has been shown to affect marine mammals, with vessel traffic, seismic surveys, and active naval sonars being the main anthropogenic contributors to low- and mid-frequency noise in oceanic waters (e.g., Nowacek et al. 2015; Gomez et al. 2016; NMFS 2018). More recent studies have documented changes in dive patterns and acoustic behavior of sperm whales in response to anthropogenic noise (Farmer et al. 2018; Isojunno et al. 2020; Stanistreet et al. 2022). The long-term and population consequences of these impacts are less well-documented and likely vary by species and other factors. Impacts on marine mammal prey from sound are also possible (Carroll et al. 2017), but the duration and severity of any such prey effects on marine mammals are unknown.

Climate-related changes in spatial distribution and abundance, including poleward and depth shifts, have been documented in or predicted for plankton species and commercially important fish stocks (Nye et al. 2009; Head et al. 2010; Pinsky et al. 2013; Poloczanska et al. 2013; Hare et al. 2016; Grieve et al. 2017; Morley et al. 2018) and cetacean species (e.g., MacLeod 2009; Sousa et al. 2019). There is uncertainty in how, if at all, the distribution and population size of this species will respond to these changes and how the ecological shifts will affect human impacts to the species.

Chavez-Rosales et al. (2022) documented an overall 178 km northeastward spatial distribution shift of the seasonal core habitat of Northwest Atlantic cetaceans that was related to changing habitat/climatic factors. Results varied by season and species. This study used sightings data collected during seasonal aerial and shipboard line transect abundance surveys during 2010 to 2017. During this time, the weighted centroid of sperm whale core habitat moved farthest during fall (255 km towards the northeast) and least during winter (71 km). There is uncertainty in how, if at all, the changes in distribution and population size of cetacean species may interact with changes in distribution of prey species and how the ecological shifts will affect human impacts to the species.

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