Revised 5/14/2024

SPERM WHALE (*Physeter macrocephalus*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Sperm whales are distributed across the entire North Pacific and into the southern Bering Sea in summer, but the majority are thought to be south of 40^{o}N in winter (Rice 1974; Rice 1989; Gosho *et al.* 1984; Miyashita *et al.* 1995). The International Whaling Commission (IWC) historically divided the North Pacific into two management regions (Donovan 1991) defined by a zig-zag line which starts at 150^{o}W at the equator, is 160^{o}W between 40-50^{o}N, and ends up at 180^{o}W north of 50^{o}N; however, the IWC has not reviewed this stock boundary recently (Donovan 1991). Sperm whales are found year-round in California waters (Dohl *et al.* 1983; Barlow 1995; Forney *et al.* 1995), but they reach peak abundance from April through mid-June and from the end of August through mid-November (Rice 1974). Sperm whales are seen off Washington and Oregon in every season except winter (Green *et al.* 1992). Of 176 sperm whales that were marked with Discovery tags off southern California in winter between 1962 and 1970, only three were recovered by whalers: one off northern California in June, one off Washington in June, and another far off British Columbia in April (Rice 1974). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993) show that although sperm whales are widely distributed in the tropics, their relative abundance declines westward towards the middle of the tropical Pacific (near the IWC stock boundary at 150^{o}W) and declines northward towards the tip of Baja California. Sperm whale population structure in the eastern tropical Pacific is unknown, but the only photographic matches of known individuals from this area have been between the Galapagos Islands and coastal waters of South America (Dufault and Whitehead 1995) and between the Galapagos Islands and the southern Gulf of California (Jaquet *et al.* 2003), suggesting that eastern tropical Pacific animals constitute a distinct stock. No apparent distributional hiatus was found between the U.S. Exclusive Economic Zone (EEZ) off California and Hawaii during a survey designed specifically to investigate stock structure and abundance of sperm whales in the northeastern temperate Pacific (Barlow and Taylor 2005). Sperm whales in the California Current have been identified as demographically independent from animals in Hawaii and the Eastern Tropical Pacific, based on genetic analyses of single-nucleotide polymorphisms (SNPs), microsatellites, and mtDNA (Mesnick *et al.* 2011). For the Marine Mammal Protection Act (MMPA) stock assessment reports, sperm whales within the Pacific U.S. EEZ are divided into three discrete, non-contiguous areas: 1) California, Oregon and Washington waters (this report), 2) waters around Hawaii, and 3) Alaska waters.

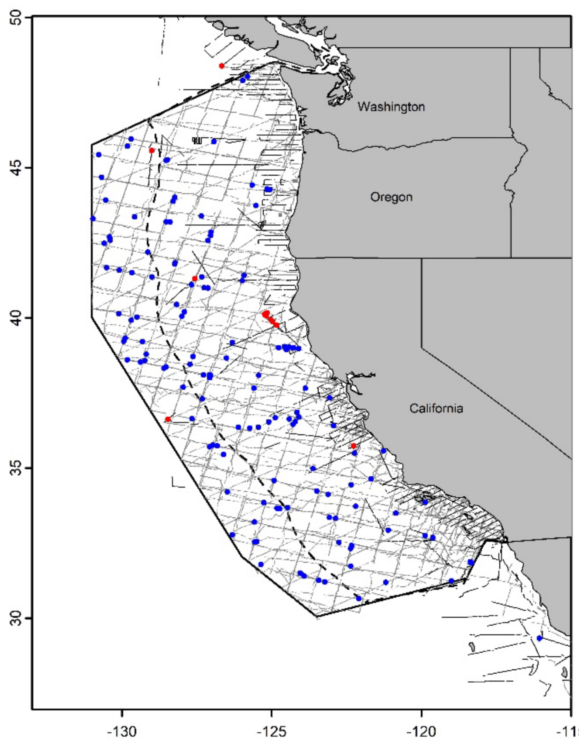

Figure 1. Sperm whale sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2018. Dashed line represents U.S. EEZ, thin lines indicate completed transect effort (gray = 1991-2014, black = 2018). Sightings from the 2018 survey are shown in red.

POPULATION SIZE

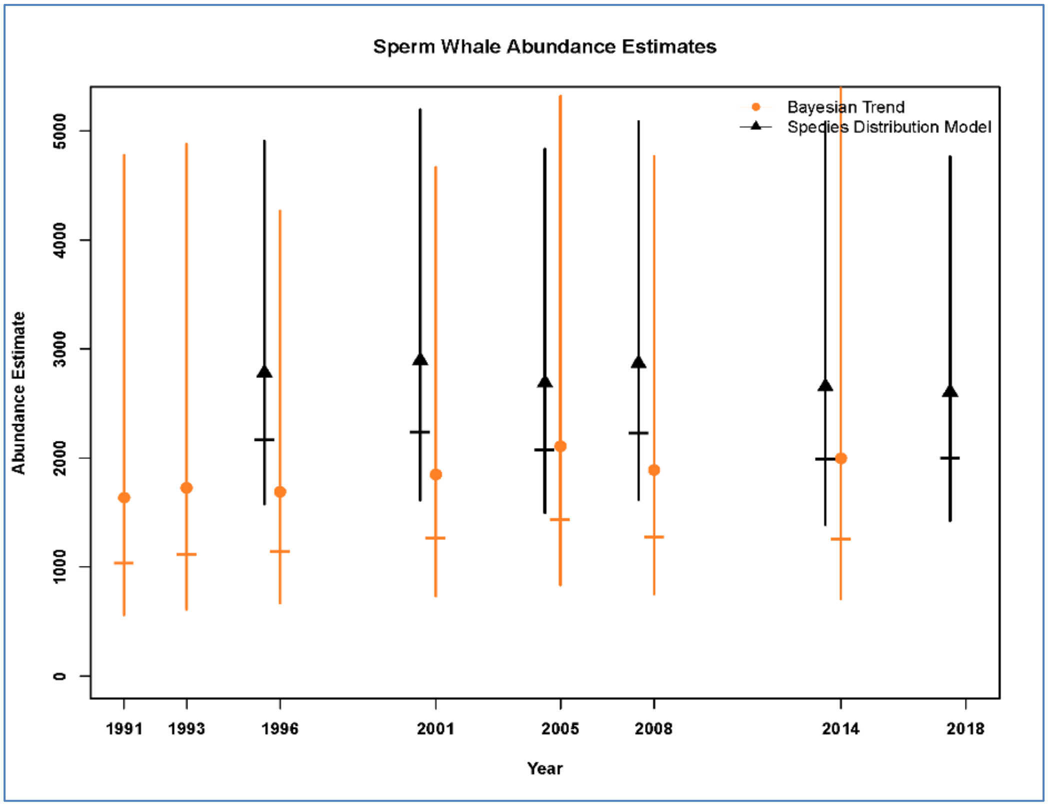

Figure 2. Trend-based and habitat-based abundance estimates of sperm whale abundance in the California Current, 1991-2018 (Moore and Barlow 2017, Becker *et al.* 2020). Abundance estimates (posterior medians [●] and 95% CRIs) from the trend model and mean estimated abundance [▲] and 95% confidence limits from the habitat model are shown. Horizontal hatch marks represent lower 80% percentiles of each estimate, corresponding to the minimum population estimate.

A series of abundance estimates are available from Bayesian trend models derived from line-transect surveys between 1991-2014 (Moore and Barlow 2017) and habitat-based density models from 1991-2018 (Becker *et al.* 2020) (Figure 2). Estimates from the two methods largely-overlap, though estimates from habitat models are, on average, higher. The most-recent estimate of sperm whale abundance for this stock is based on a 2018 survey and a habitat density model that is informed by 1991-2018 data, or 2,606 (CV = 0.135) whales (Becker *et al*. 2020).

Minimum Population Estimate

The minimum population estimate for sperm whales is taken as the lower 20th percentile of the 2018 abundance estimate, or 2,011 whales (Becker *et al*. 2020).

Current Population Trend

Moore and Barlow (2014) reported that sperm whale abundance appeared stable from 1991 to 2008 (Figure 2) and additional data from a 2014 survey does not change that conclusion (Moore and Barlow 2017). Estimated growth rates of the population include high uncertainty levels: the growth rate parameter from a Markov model has a posterior median and mean of +0.01 (SD = 0.06) with a broad 95% credible interval (CRI) ranging from -0.11 to +0.13 and a 60% chance of being positive. Another growth rate estimated from a regression model has a posterior mean of +0.01 with 95% CRI ranging from −0.06 to +0.07 (62% chance that growth has been positive), indicating that for the 1991-2014 study period, conclusions about whether the population has increased or decreased are uncertain (Moore and Barlow 2017). Habitat model estimate of abundance from Becker *et al.* (2020) show the same equivocal trend in abundance (Figure 2).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is not unavailable for the CA/OR/WA stock of sperm whales. Hence, until additional data become available, it is recommended that the cetacean maximum net productivity rate (R_{max}) of 4% be employed for this stock at this time (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (2,011) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.1 (for an endangered stock with N_{min} >1,500 and stable trend in abundance; Taylor *et al.* 2003), resulting in a PBR of 4 animals per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

The fishery most likely to injure or kill sperm whales from this stock is the California thresher shark/swordfish drift gillnet fishery (Julian and Beeson 1998, Carretta 2022). Observed serious injury and mortality is rarely observed in the fishery (10 animals from 6 events observed during >9,246 fishing sets between 1990 and 2021, Carretta 2022). While there has not been an observed entanglement of sperm whales in this fishery since 2010, there is a positive estimate of sperm whale bycatch in the fishery for the most-recent 5-year period of 2017-2021, based on a data model that uses 1990-2021 data (Carretta 2022). This estimate is 1.58 (CV=2.8) whales, or 0.32 whales annually (Carretta 2022).

Strandings of sperm whales are rare and it is expected that documented anthropogenic deaths and injuries due to entanglements within unknown fisheries or ingestion of marine debris represent a small fraction of the true number of cases, due to the low probability that the carcass of a highly-pelagic species washes ashore (Williams *et al.* 2011, Carretta *et al.* 2016a). Prior cases of observed mortality and serious injury of sperm whales due to interactions with unidentified fisheries and marine debris have been reported by Jacobsen *et al.* (2010) and Carretta *et al.* (2013, 2014). In the most recent 5-year period (2017 to 2021), there was one observation of a seriously-injured sperm whale in unidentified fishing gear (large gauge line) (Carretta *et al*. 2023). There were 3 reports of sperm whales feeding on catch in the limited entry sablefish hook and line fishery, but there was no evidence of entanglement or hooking (Carretta *et al*. 2023). Total mean annual commercial fishery-related serious injury and mortality of sperm whales from 2017-2021 is the sum of mean annual California drift gillnet fishery serious injury and mortality (0.32 whales), plus unidentified fisheries (0.2 whales), or 0.52 whales per year. (Table 1).

Table 1. Summary of available information on the incidental mortality and serious injury of sperm whales (CA/OR/WA stock) for commercial fisheries that might take this species. n/a indicates that data are not available. Mean annual serious injury and mortality for the California swordfish drift gillnet fishery are based on 2017-2021 data unless stated otherwise (Carretta 2022, Carretta *et al*. 2023, Jannot *et al*. 2022).

Fishery Name	Year(s)	Data Type	Observer Coverage	Observed mortality and (serious injury)	Estimated mortality and serious injury (CV)	Mean annual mortality and serious injury (CV)
CA thresher shark/swordfish drift gillnet fishery	2017 2018 2019 2020 2021	observer	0.186 0.251 0.226 0.222 0.228	0 0 0 0 0	1.58 (2.8) 0 (n/a) 0 (n/a) 0 (n/a) 0 (n/a) 0 (n/a)	0.32 (2.8)
CA/OR/WA limited entry sablefish hook and line	2015-2019	observer	n/a	0	0	0
Unidentified fishery	2020	Sighting	n/a	0 (1)	1 (n/a)	0.2
Total annual takes						0.52 (n/a)

Sperm whales from the North Pacific stock depredate longline sablefish catch in the Gulf of Alaska and sometimes incur serious injuries from becoming entangled in gear (Sigler *et al.* 2008, Allen and Angliss 2011). An unknown number of whales from the CA/OR/WA stock probably venture into waters where Alaska longline fisheries operate, but the amount of temporal and spatial overlap is unknown. Thus, the risk of serious injury to CA/OR/WA stock sperm whales resulting from longline fisheries cannot be quantified.

Vessel Strikes

For the most recent 5-year period of 2017-2021, no vessel strike deaths or serious injuries were observed, though one was recorded in 2007 (Carretta *et al.* 2013). Due to the low probability of a sperm whale carcass washing ashore, estimated vessel strike deaths are likely underestimated.

Other removals

Whaling removed at least 436,000 sperm whales from the North Pacific between 1800 and the end of legal commercial whaling for this species in 1987 (Best 1976; Ohsumi 1980; Brownell 1998; Kasuya 1998). Of this total, an estimated 33,842 were taken by Soviet and Japanese pelagic whaling operations in the eastern North Pacific from the longitude of Hawaii to the U.S. West coast, between 1961 and 1976 (Allen 1980), and approximately 1,000 were reported taken in land-based U.S. West coast whaling operations between 1919 and 1971 (Ohsumi 1980; Clapham *et al*. 1997). There has been a prohibition ban on taking sperm whales in the North Pacific since 1988, but large-scale pelagic whaling stopped in 1980.

STATUS OF STOCK

Sperm whales are listed as "endangered" under the U.S. Endangered Species Act (ESA), and consequently this stock is automatically considered as "depleted" and "strategic" under the MMPA. The status of sperm whales with respect to carrying capacity and optimum sustainable population (OSP) is unknown. The observed annual rate of documented mortality and serious injury ($\geq$ 0.52 per year) is less than the calculated PBR (4.0) for this stock, but anthropogenic mortality and serious injury is likely underestimated due to incomplete detection of carcasses and injured whales. Total human-caused mortality from commercial fisheries is greater than 10% of the calculated PBR and, therefore, is not insignificant and approaching zero mortality and serious injury rate. Increasing levels of anthropogenic sound in the world's oceans has been suggested to be a habitat concern for whales, particularly for deep-diving whales like sperm whales that feed in the ocean's sound channel.

OTHER FACTORS THAT MAY BE CAUSING A DECLINE OR IMPEDING RECOVERY

The NMFS (2015) 5-year review of sperm whale populations noted potential negative impacts to populations that include prey distribution and type changes due to climate change, anthropogenic sound, fishery interactions, oil spills, and pollutants, including heavy metals.

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