Revised 7/31/2015

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°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°W at the equator, is 160°W between 40-50°N, and ends up at 180°W north of 50°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 1962-70, 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). Recent 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°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. 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

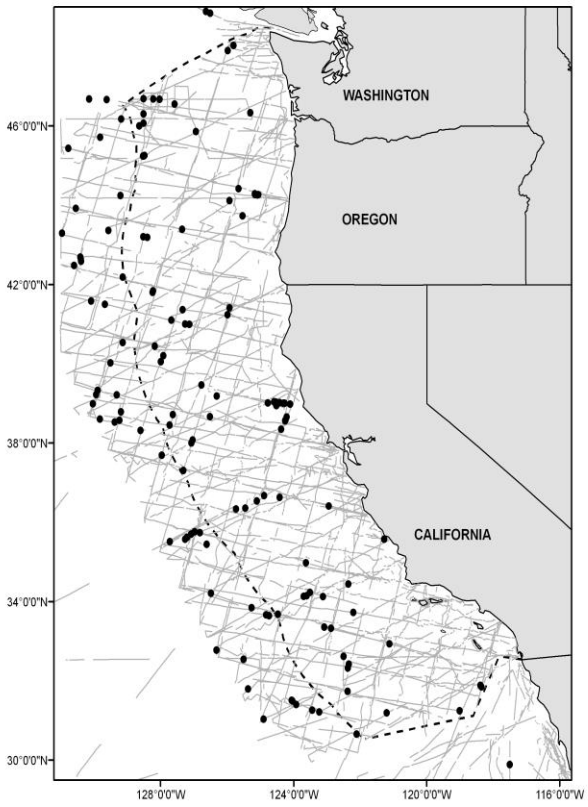

Figure 1. Sperm whale sighting locations from shipboard surveys off California, Oregon, and Washington, 1991-2008. Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined. See Appendix 2 for data sources and information on timing and location of survey effort.

discrete, non-contiguous areas: 1) California, Oregon and Washington waters (this report), 2) waters around Hawaii, and 3) Alaska waters.

POPULATION SIZE

Previous estimates of sperm whale abundance from 2005 (3,140, CV=0.40, Forney 2007) and 2008 (300, CV=0.51, Barlow 2010) show a ten-fold difference that cannot be attributed to human-caused or natural population declines and likely reflect inter-annual variability in movement of animals into and out of the study area. New estimates of sperm whale abundance in California, Oregon, and Washington waters out to 300 nmi are available from a trend-model analysis of line-transect data collected from six surveys conducted from 1991 to 2008 (Moore and Barlow 2014), using methods similar to previous abundance trend analyses for fin whales (Moore and Barlow 2011) and beaked whales (Moore and Barlow 2013). Abundance trend models incorporate information from the entire 1991-2008 time series to obtain each annual abundance estimate, yielding estimates with less inter-annual variability. The trend model also uses improved estimates of group size and trackline detection probability (Moore and Barlow 2014). Sperm whale abundance estimates based on the trend-model ranged between 2,000 and 3,000 animals for the 1991-2008 time series (Moore and Barlow 2014). The best estimate of sperm whale abundance in the California Current is the trend-based estimate corresponding to the most recent survey (2008), or 2,106 animals (CV=0.58). This estimate is corrected for diving animals not seen during surveys.

Minimum Population Estimate

The minimum population estimate for sperm whales is taken as the lower 20th percentile of the posterior distribution of abundance estimated from 2008 or 1,332 whales (Moore and Barlow 2014).

Current Population Trend

Moore and Barlow (2014) report that sperm whale abundance appeared stable from 1991 to 2008 (Figure 2), but that reliable conclusions on population trends could not be made because the precision of estimated growth rates was poor. However, they also reported that trends in the detection of single animals (presumably large, solitary males) apparently doubled over this time period. The authors could not determine if the apparent increase in sightings of single animals reflected an increase in the number of adult male sperm whales in the population or merely increased use of the U.S. west coast waters by adult males in recent years.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no published estimates of the growth rate for any sperm whale population (Best 1993).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,332) 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; Taylor et al. 2003), resulting in a PBR of 2.7 animals per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

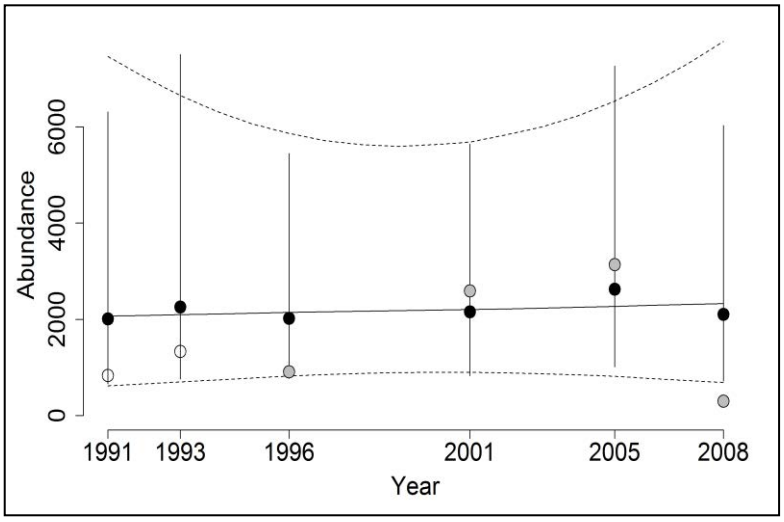

Figure 2. Trend-based estimates of sperm whale abundance in the California Current, 1991-2008 (Moore and Barlow 2014). Abundance estimates (posterior medians [●] and 95% CRIs) from the trend model, with fitted trend line and 95% CRIs for trend. For comparison, open and gray circles depict earlier published estimates from Barlow and Forney (2007) and Barlow (2010), with those for 1991 and 1993 [○] being for a smaller surveyed area.

Serious Injury Guidelines

NMFS uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to distinguis serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "injury that is more likely than not to result in mortality".

Fishery Information

The fishery most likely to directly take sperm whales from this stock is the California thresher shark/swordfish drift gillnet fishery (Julian and Beeson 1998, Carretta and Enriquez 2012). Observed serious injury and mortality has been rarely documented in the gillnet fishery (10 animals observed during ~8,500 observed sets between 1990 and 2014). Given the historic long-term average observer coverage of ~15% for this fishery (Carretta and Barlow 2011), annual estimates of bycatch will always be either zero (if no sperm bycatch is observed) or at least 7 (if ≥ 1 observed), for estimates made using within-year ratio methods [*e.g.,* estimated bycatch = observed bycatch/percent observer coverage]. If the true average annual mortality and serious injury is > 0, but less than a few animals per year, and if observer coverage generally remains low, then multiple years of data need to be pooled to for unbiased estimation of a mean annual bycatch rates (Carretta and Moore, 2014). Pooling more years reduces bias (estimates of mean annual bycatch approaches the true rate) and provides increased precision of bycatch estimates to better estimate long-term annual mortality and serious injury. Most marine mammal stock assessment reports utilize a 5-year time period for pooling bycatch estimates (NMFS 2005), but in the case of rare events, this 5-year time frame will yield biased estimates (systematic over- or underestimation of true bycatch) with insufficient precision (Carretta and Moore 2014, Moore and Merrick 2011). Since 2001, the drift gillnet fishery has been subject to a time/area closure that restricts most fishing to south of Point Conception, California, in waters generally shallower than 2,000 m, where bycatch risk to sperm whales is lower. The post-2000 time period best represents the current spatial state of the fishery and is used to calculate mean annual bycatch for sperm whales. Between 2001 and 2013, two sperm whales (one death and one serious injury in the same set) were entangled during 2,392 observed sets, resulting in a mean bycatch rate of 0.84 per 1,000 sets. Annual bycatch estimates for the 12-year period of 2001-2012 are presented for the drift gillnet fishery in Table 1 and are based on previously published estimates (Carretta et al. 2004, 2014a, Carretta and Chivers 2004, Carretta et al. 2005, Carretta and Enriquez 2006, 2007, 2009a, 2009b, 2010, 2012).

Although acoustic pingers are known to reduce the entanglement of cetaceans in the California drift gillnet swordfish fishery (Barlow and Cameron 2003, Carretta et al. 2008, Carretta and Barlow 2011), it is unknown whether pingers have any effect on sperm whale entanglement in this fishery due to low sample sizes. Sperm whales have been observed entangled 10 times in approximately 8,500 observed drift gillnet sets since 1990 (Carretta and Enriquez 2012). Six entanglements occurred prior to pinger use in this fishery. Two entanglements (1996 and 1998) occurred in sets that did not use a full complement of pingers, and two animals were entangled in 2010 in a single net where a full complement of 40 pingers was used (Carretta and Enriquez 2012).

Other fisheries may injure or kill sperm whales through entanglement or ingestion of marine debris. Three separate sperm whale strandings in 2008 showed evidence of fishery interactions (Jacobsen et al. 2010; NMFS, unpublished stranding data). Two whales died from gastric impaction as a result of ingesting multiple types of floating polyethylene netting (Jacobsen *et al*. 2010). The variability in size and age of the ingested net material suggests that it was ingested as surface debris and was not the result of fishery depredation (Jacobsen *et al*. 2010). Net types recovered from the whales' stomachs included portions of gillnet, bait nets, and fish/shrimp trawl nets. A third whale in 2008 showed evidence of entanglement scars (NMFS, unpublished stranding data). Two sperm whales also died in 2004 as a result of marine debris ingestion (NMFS, unpublished data): one animal had monofilament gillnet in its stomach and the second animal had nets of differing types in its stomach. Mean annual takes for all fisheries (Table 1) are based on 2001-2012 observer and stranding data (Carretta and Enriquez 2006, 2007, 2009a, 2009b, 2010, 2012, Carretta et al. 2005, Carretta and Chivers 2004, Carretta et al. 2004, 2014a, Jacobsen et al. 2010, NMFS unpublished stranding data). Including estimates from fishery observer programs (16 animals/12 years = 1.3/yr) and strandings data (5 animals/12 years = 0.4/yr), results in an average estimate of 1.7 sperm whale deaths per year due to fishery-related causes for the period 2001 to 2012. The mean

annual mortality from strandings represents a minimum value, as not all carcasses come ashore or are detected.

Table 1. Summary of available information on the incidental mortality and 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 takes are based on 2001-2012 data unless noted otherwise.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed mortality (and serious injury in parentheses)	Estimated mortality and serious injury (CV in parentheses)	Mean annual takes (CV in parentheses)
CA thresher shark/swordfish drift gillnet fishery	2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012	observer	20.4% 22.1% 20.0% 21.0% 21.0% 18.5% 16.4% 13.5% 13.3% 11.9% 19.5% 18.7%	0 0 0 0 0 0 0 0 0 1 (1) 0 0	0 0 0 0 0 0 0 0 0 16 (0.95) 0 0	1.3 (0.95)
Unknown fishery	2001-2012	stranding	n/a	5	≥5	≥ 0.4
Total annual takes						≥ 1.7 (0.95)

Sperm whales from the North Pacific stock are known to depredate on 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.

Ship Strikes

One sperm whale died as the result of a ship strike in Oregon in 2007 (NMFS Northwest Regional Stranding data, unpublished). Another sperm whale was struck by a 58-foot sablefish longline vessel in 2007 while at idle speed (Jannot et al. 2011). The observer noted no apparent injuries to the whale. Based on the size and speed of the vessel relative to the size of a sperm whale, this incident was categorized as a non-serious injury (Carretta et al. 2013). For the most recent 5-year period of 2008 to 2012 for which data are available, no ship strikes of sperm whales were documented (Carretta et al. 2014b) and the mean annual average mortality and serious injury is zero whales. Ship strikes are assessed over the most recent 5-year period to reflect the degree of shipping risk to large whales since ship traffic routes changed in response to new ship pollution rules implemented in 2009 (McKenna *et al*. 2012, Redfern *et al*. 2013).

STATUS OF STOCK

The only estimate of the status of North Pacific sperm whales in relation to carrying capacity (Gosho et al. 1984) is based on a CPUE method which is no longer accepted as valid. 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 on taking sperm whales in the North Pacific since 1988, but large-scale pelagic whaling stopped in 1980. Sperm whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the California to Washington stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The

status of sperm whales with respect to carrying capacity and optimum sustainable population (OSP) is unknown. Including both fishery and ship-strike mortality, the annual rate of kill and serious injury (1.7 per year) is less than the calculated PBR for this stock (2.7). Total human-caused mortality is greater than 10% of the calculated PBR and, therefore, cannot be considered to be 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".

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