Revised 6/1/2018

SPERM WHALE (*Physeter macrocephalus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Sperm whales are widely 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, 1989; Gosho *et al.* 1984; Miyashita *et al.* 1995). For management, the International Whaling Commission (IWC) had divided the North Pacific into two management regions (Donovan 1991) defined by a zig-zag line which starts at 150°W at the equator to 160°W between 40-50°N, and ending at 180°W north of 50°N; however, the IWC has not reviewed this stock boundary in many years (Donovan 1991). 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 tapers off markedly westward towards the middle of the tropical Pacific (near the IWC stock boundary at 150°W) and tapers off northward towards the tip of Baja California. The Hawaiian Islands marked the center of a major nineteenth century whaling ground for sperm whales (Gilmore 1959; Townsend 1935). Since 1936, at least 28 strandings have been reported from the Hawaiian Islands (Woodward 1972; Nitta 1991; Maldini *et al.* 2005, NMFS PIR Marine Mammal Response Network database), including 7 since 2007. Sperm whales have also been sighted throughout the Hawaiian EEZ, including nearshore waters of the main and Northwestern Hawaiian Islands (Rice 1960; Baird 2016, Barlow 2006, Lee 1993; Mobley *et al.* 2000, Shallenberger 1981). In addition, the sounds of sperm whales have been recorded throughout the year off Oahu (Thompson and Friedl 1982). Summer/fall shipboard surveys of waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 43 sperm whale sightings in 2002 and 46 in 2010 throughout the study area (Figure 1; Barlow 2006, Bradford *et al.* 2017).

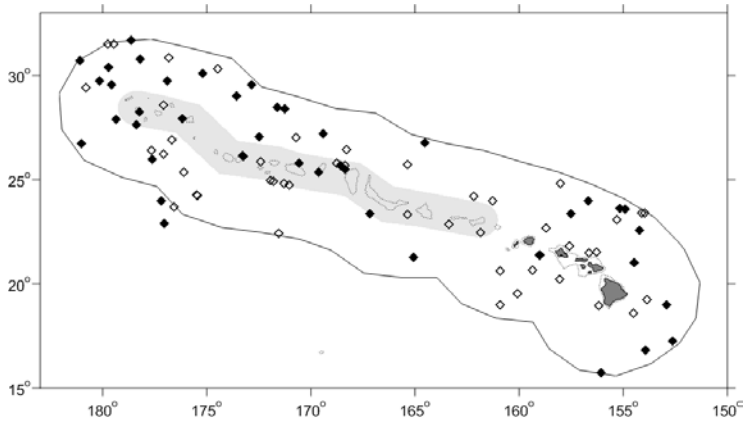

Figure 1. Sperm whale sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2017; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000 m isobaths.

The stock identity of sperm whales in the North Pacific has been inferred from historical catch records (Bannister and Mitchell 1980) and from trends in CPUE and tag-recapture data (Ohsumi and Masaki 1977). A 1997 survey designed specifically to investigate stock structure and abundance of sperm whales in the northeastern temperate Pacific revealed no apparent hiatus in distribution between the U.S. EEZ off California and areas farther west, out to Hawaii (Barlow and Taylor 2005). Recent genetic analyses revealed significant differences in mitochondrial and nuclear DNA and in single-nucleotide polymorphisms between sperm whales sampled off the coast of California, Oregon and Washington and those sampled near Hawaii and in the eastern tropical Pacific (ETP) (Mesnick et al 2011). These results suggest demographic independence between matrilineal groups found California, Oregon, and Washington, and those found elsewhere in the central and eastern tropical Pacific. Further, assignment tests identified male sperm whales sampled in the sub-Arctic with each of the three regions, suggesting mixing of males from potentially several populations during the summer (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 stocks: 1) waters around Hawaii (this report), 2) California, Oregon and Washington waters, and 3) Alaskan waters. The Hawaii stock includes animals found both within the

Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaii stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from a 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ was recently evaluated using Beaufort sea-state-specific trackline detection probabilities for sperm whales, resulting in an abundance estimate of 4,559 (CV = 0.33) sperm whales (Bradford *et al.* 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 6,919 (CV=0.81) sperm whales (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data. A large 1982 abundance estimate for the entire eastern North Pacific (Gosho *et al.* 1984) was based on a CPUE method which is no longer accepted as valid by the International Whaling Commission. A spring 1997 combined visual and acoustic line-transect survey conducted in the eastern temperate North Pacific resulted in estimates of 26,300 (CV=0.81) sperm whales based on visual sightings, and 32,100 (CV=0.36) based on acoustic detections and visual group size estimates (Barlow and Taylor 2005). Sperm whales appear to be a good candidate for acoustic surveys due to the increased range of detection; however, visual estimates of group size are still required (Barlow and Taylor 2005). In the eastern tropical Pacific, the abundance of sperm whales has been estimated as 22,700 (95% C.I.=14,800-34,600; Wade and Gerrodette 1993). However, it is not known whether any or all of these animals routinely enter the U.S. EEZ of the Hawaiian Islands.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) around the 2010 abundance estimate or 3,478 sperm whales within the Hawaiian Islands EEZ.

Current Population Trend

Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data on current or maximum net productivity rate are available.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of sperm whales is calculated as the minimum population size (3,478) within the U.S. EEZ of the Hawaiian Islands times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.2 (for an endangered species with N_{min} > 1,500 and CV_{Nmin} > 0.50, with low vulnerability to extinction; (Taylor *et al.* 2003), resulting in a PBR of 14 sperm whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. One stranded sperm whale was found with fishing line and netting its stomach, though it is unclear whether the gear caused its death, nor what fisheries the gear came from (NMFS PIR MMRN). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas Between 2011 and 2015, no sperm whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) and one was observed either hooked or entangled in the DSLL fishery (20-

21% observer coverage) (Bradford 2017, Bradford and Forney 2017). The observer could not determine whether the whale was hooked or entangled; however, the mainline came under tension when the animal surfaced. The whale was cut free with the hook, 0.5m wire leader, 45g weight, 12m of branchline, and 25-30 ft of mainline possibly attached. This interaction was prorated as 75% probability of serious injury because the whale was hooked or entangled but the exact nature of the injury could not be determined (Bradford & Forney 2017).

This determination is based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). The prorating of serious injury is based on the proportion of known outcomes for whales with similar fisheries interactions in other regions. Average 5-yr estimates of annual mortality and serious injury for sperm whales during 2011-2015 are zero sperm whales outside of U.S. EEZs, and 0.7 (CV = 0.9) within the Hawaiian Islands EEZ (Table 1, McCracken 2017).

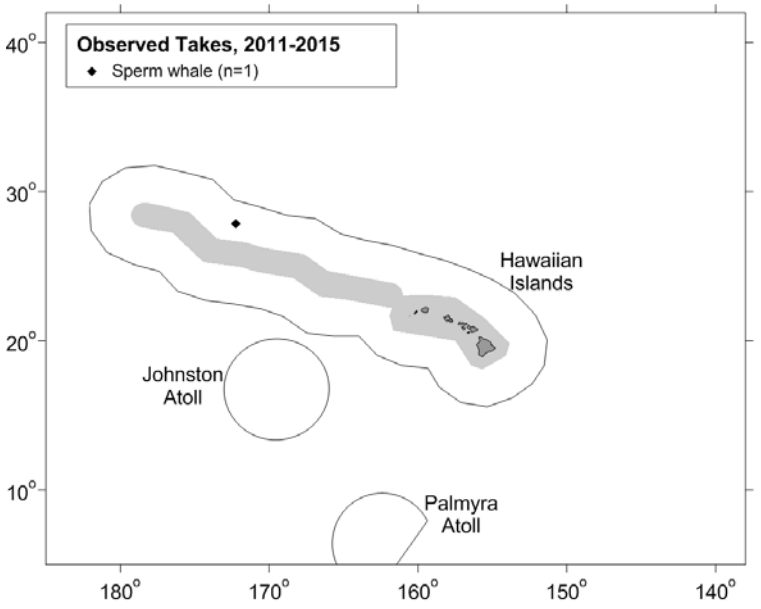

Figure 2. Locations of observed sperm whale bycatch (filled diamonds) in the Hawaii-based longline fishery, 2011-2015. Solid lines represent the U.S. EEZ. Gray shading notes areas closed to longline fishing. Fishery descriptions are provided in Appendix 1.

Table 1. Summary of available information on incidental mortality and serious injury of sperm whales in commercial longline fisheries, within and outside of the U.S. EEZs (McCracken 2017). Mean annual takes are based on 2011-2015 data. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of sperm whales			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	2011	Observer data	20%	0	0 (-)	1/1*	3 (0.8)
	2012		20%	0	0 (-)	0	0 (-)
	2013		20%	0	0 (-)	0	0 (-)
	2014		21%	0	0 (-)	0	0 (-)
	2015		21%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV)					**0 (-)**		**0.7 (0.9)**
Hawaii-based shallow-set longline fishery	2011	Observer data	100%	0	0	0	0
	2012		100%	0	0	0	0
	2013		100%	0	0	0	0
	2014		100%	0	0	0	0
	2015		100%	0	0	0	0
Mean Annual Takes (100% coverage)							**0**
Minimum total annual takes within U.S. EEZ							**0.7 (0.9)**

*This injury was prorated 75% probability of being a serious injury based on known outcomes from other whales with this injury type (NOAA 2012).

Historical Mortality

Between 1800 and 1909, about 60,842 sperm whales were estimated taken in the North Pacific (Best 1976). The reported take of North Pacific sperm whales by commercial whalers between 1947 and 1987 totaled 258,000 (C. Allison, pers. comm.). Factory ships operated as far south as 20ºN (Ohsumi 1980). Ohsumi (1980) lists an additional 28,198 sperm whales taken mainly in coastal whaling operations from 1910 to 1946. Based on the massive under-reporting of Soviet catches, Brownell *et al.* (1998) estimated that about 89,000 whales were additionally taken by the Soviet pelagic whaling fleet between 1949 and 1979. Japanese coastal operations apparently also under-reported catches by an unknown amount (Kasuya 1998). Thus a total of at least 436,000 sperm whales were taken between 1800 and the end of commercial whaling for this species in 1987. Of this grand 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, IWC statistical Areas II and III), and 965 were reported taken in land-based U.S. West coast whaling operations between 1947 and 1971 (Ohsumi 1980). In addition, 13 sperm whales were taken by shore whaling stations in California between 1919 and 1926 (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 earlier, in 1980. Some of the whales taken during the whaling era were certainly from a population or populations that occur within Hawaiian waters.

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. The status of sperm whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Sperm whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the Hawaiian stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The estimated rate of fisheries related mortality or serious injury within the Hawaiian Islands EEZ (0.7 animals per year) is less than the PBR (13.9). Insufficient information is available to determine whether the total fishery mortality and serious injury for sperm whales is insignificant and approaching zero mortality and serious injury rate. The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson *et al.* 1995), particularly for deep-diving whales like sperm whales that feed in the oceans' "sound channel". One sperm whale stranded in the main Hawaiian Islands tested positive for both *Brucella* and *Morbillivirus* (Jacob *et al.* 2016). *Brucella* is a bacterial infection that if common in the population may limit recruitment by compromising male and female reproductive systems, and can also cause neurological disorders that may result in death (Van Bressem *et al.* 2009). *Morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem *et al.* 2009); however, investigation of the pathology of the stranded sperm whale suggests that *Brucella* was more likely the cause of death in this sperm whale. The presence of *Morbillivirus* in 10 species (Jacob *et al.* 2016) and *Brucella* in 3 species (Cherbov 2010) raises concerns about the history and prevalence of these diseases in Hawaii and the potential population impacts on Hawaiian cetaceans. It is not known if *Brucella or Morbillivirus* are common in the Hawaii stock.

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