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SPERM WHALE (*Physeter macrocephalus*): North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The sperm whale is one of the most widely distributed marine mammal species, perhaps exceeded in its global range only by the killer whale and humpback whale (Rice 1989). In the North Pacific Ocean, sperm whales were depleted by extensive commercial whaling over a period of more than a hundred years, and the species was the primary target of illegal Soviet whaling in the second half of the 20th century (Ivashchenko et al. 2013, 2014). Systematic illegal catches were also made on a large scale by Japan in both the North Pacific and Antarctic in at least the late 1960s (Ivashchenko and Clapham 2015, Clapham and Ivashchenko 2016).

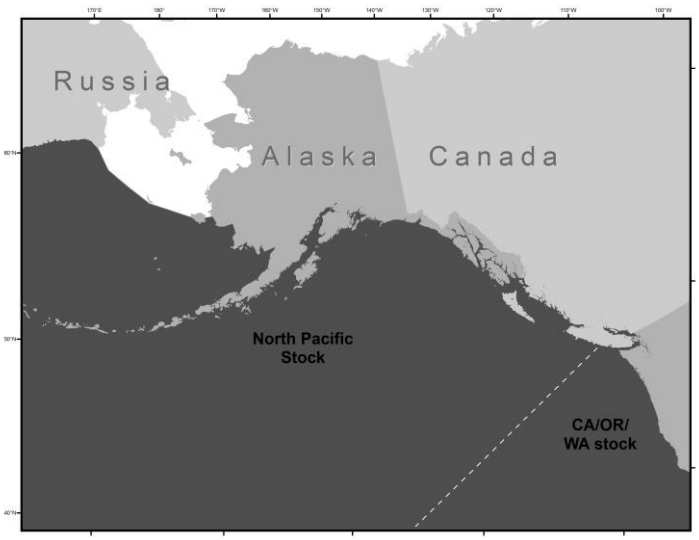

Figure 1. The approximate distribution of sperm whales in the North Pacific includes deep waters south of 62°N to the equator.

Sperm whales feed primarily on medium-sized to large-sized squids but also consume substantial quantities of large demersal and mesopelagic sharks, skates, and fishes (Rice 1989). In the North Pacific, sperm whales are distributed widely (Fig. 1). Although females and young sperm whales were thought to remain in tropical and temperate waters year-round, Mizroch and Rice (2006) and Ivashchenko et al. (2014) showed that there were extensive catches of female sperm whales above 50°N; Soviet catches of females were made as far north as Olyutorsky Bay (62°N) in the western Bering Sea, as well as in the western Aleutian Islands. Mizroch and Rice (2013) also showed movements by females into the Gulf of Alaska and western Aleutians. During summer, males are found in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Kasuya and Miyashita 1988, Mizroch and Rice 2013, Ivashchenko et al. 2014). Sighting surveys conducted by the Alaska Fisheries Science Center's Marine Mammal Laboratory (MML) in the summer months between 2001 and 2010 found sperm whales to be the most frequently sighted large cetacean in the coastal waters around the central and western Aleutian Islands (MML, unpubl. data). Acoustic surveys, from fixed autonomous hydrophones, detected the presence of sperm whales year-round in the Gulf of Alaska, although they appear to be approximately two times as common in summer than in winter (Mellinger et al. 2004). This seasonality of detections is consistent with the hypothesis that sperm whales generally move to higher latitudes in summer and to lower latitudes in winter (Whitehead and Arnbom 1987).

Discovery tags implanted in sperm whales in the 1960s could, when recovered from a dead whale, provide useful information on historical movements. Mizroch and Rice (2013) examined 261 Discovery tag recoveries from the days of commercial whaling and found extensive movements from U.S. and Canadian coastal waters into the Gulf of Alaska and Bering Sea. The U.S. tagged 176 sperm whales from 1962 to 1969 off southern California and northern Baja California (Mizroch and Rice 2013). Seven of those tagged whales were recovered in locations ranging from offshore California, Oregon, and British Columbia to the western Gulf of Alaska. A male sperm whale tagged by Canadian researchers moved from near Vancouver Island, British Columbia, to the Aleutian Islands near Adak. A whale tagged by Soviet researchers moved from coastal Michoacán, mainland Mexico, to a location about 1,300 km offshore of Washington State. Discovery tag data show extensive movements throughout the North Pacific and along the U.S. west coast into the Gulf of Alaska and Bering Sea/Aleutian Islands region (Mizroch and Rice 2013). Similar extensive movements have also been demonstrated by satellite-tagging studies (Straley et al. 2014). Three adult males satellite tagged off southeastern Alaska moved far south, one to coastal Baja California, one into the north-central Gulf of California, and the third to a location near the Mexico-Guatemala border (Straley et al. 2014).

Mizroch and Rice (2013) analyzed whaling data and found that males and females historically concentrated seasonally along oceanic frontal zones, for example, in the subtropical frontal zone (ca. 28-34°N) and the subarctic frontal zones (ca. 40-43°N). Males also concentrated seasonally near the Aleutian Islands and along the Bering Sea shelf edge. More current research suggests sperm whales are likely relatively nomadic, with movements linked to geographical and temporal variations in the abundance of pelagic squids (Mizroch and Rice 2013). The authors also found no indication from Discovery tag or whaling data to indicate apparent divisions between separate demes or stocks within the North Pacific (Mizroch and Rice 2013). Analysis of Soviet catch data by Ivashchenko et al. (2014) showed broad agreement with these results, although they identified a sharp division at Amchitka Pass in the Aleutians, with mature males to the east and males and family groups to the west. There were four main areas of concentration in the Soviet catches: a large pelagic area (30-50°N) in the eastern North Pacific, including the Gulf of Alaska and western coast of North America; the northeastern and southwestern central North Pacific; and the southern Kuril Islands. Some of the catch distribution was similar to that of 19th-century Yankee whaling catches plotted by Townsend (1935), notably in the "Japan Ground" (in the pelagic western Pacific) and the "Coast of Japan Ground." Many females were caught in Olyutorsky Bay (western Bering Sea) and around the Commander Islands.

More recently, an International Whaling Commission (IWC)-sponsored survey operated by the Government of Japan recorded 284 sightings of sperm whales across the entire North Pacific between 2010 and 2016, but an abundance estimate was not calculated (IWC 2017).

The following information was considered in classifying stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: no apparent discontinuities based on Discovery tag data; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: genetic studies indicate the possibility of a "somewhat" discrete U.S. coastal stock (Mesnick et al. 2011). For management purposes, the IWC recognizes two management units of sperm whales in the North Pacific (eastern and western). However, the IWC has not reviewed its sperm whale stock boundaries in recent years (Donovan 1991). For management purposes, three stocks of sperm whales are currently recognized in U.S. waters: 1) Alaska (North Pacific stock); 2) California/Washington/Oregon; and 3) Hawaii. Mizroch and Rice (2013) suggest that this should be reviewed and updated to reflect additional data, but there is insufficient information to propose a reasonable alternative structure. The California/Oregon/Washington and Hawaii sperm whale stocks are reported in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

Current and historical abundance estimates of sperm whales in the North Pacific are based on limited data and are considered unreliable; caution should be exercised in interpreting published estimates. The abundance of sperm whales in the North Pacific was estimated to be 1,260,000 prior to exploitation, which by the late 1970s was thought to have been reduced to 930,000 whales (Rice 1989). Confidence intervals for these estimates do not exist. These estimates include whales from the California/Oregon/Washington stock, for which a separate abundance estimate is available (see the Stock Assessment Reports for the U.S. Pacific Region). Estimates for a large area of the eastern temperate North Pacific were produced from line-transect and acoustic survey data by Barlow and Taylor (2005); the acoustic data produced an estimate of 32,100 sperm whales (CV = 0.36). However, no more recent estimate exists for other areas, including for the central or western North Pacific.

Kato and Miyashita (1998) reported 102,112 sperm whales (CV = 0.155) in the western North Pacific, however, with the caveat that their estimate is likely positively biased. From surveys in the Gulf of Alaska in 2009 and 2015, Rone et al. (2017) estimated 129 (CV = 0.44) and 345 sperm whales (CV = 0.43) in each year, respectively. These estimates are for a small area that was unlikely to include females and juveniles and they are not considered reliable estimates.

As the data used in estimating the abundance of sperm whales in the entire North Pacific are more than 8 years old, a reliable estimate of abundance for the entire North Pacific stock is considered unavailable.

Minimum Population Estimate

A minimum population estimate (N_{MIN}) for this stock can be calculated according to Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the estimate (N) of 345 from surveys in the Gulf of Alaska in 2015 (Rone et al. 2017), and the associated coefficient of variation CV(N) of 0.43, results in an N_{MIN} of 244 sperm whales. However, this is an underestimate for the entire stock because it is based on surveys of a small portion of the stock's extensive range and it does not account for animals missed on the trackline or for females and juveniles in tropical and subtropical waters.

Current Population Trend

There is no reliable information on trends in abundance for this stock (Braham 1992).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not available for the North Pacific stock of sperm whales. Until additional data become available, the cetacean maximum theoretical net productivity rate of 4% will be used for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is defined as the product of the minimum population estimate (N_{MIN}), one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the value for cetacean stocks which are classified as endangered (Wade and Angliss 1997). Using the estimate of 345 (CV = 0.43) from surveys in the Gulf of Alaska in 2015 (Rone et al. 2017), and the associated N_{MIN} of 244, PBR is calculated to be 0.5 sperm whales ($244 \times 0.02 \times 0.1$). However, because the N_{MIN} is for only a small portion of the stock's range and does not account for females and juveniles in tropical and subtropical waters, the calculated PBR is not a reliable index for the entire stock.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals in 2012-2016 is listed, by marine mammal stock, in Helker et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. Injury events lacking detailed injury information are assigned prorated values following injury determination guidelines described in NMFS (2012). A summary of information used to determine whether an injury was serious or non-serious, as well as a table of prorate values used for large whale reports with incomplete information, is reported in Helker et al. (in press). A minimum estimate of the total annual level of human-caused mortality and serious injury for North Pacific sperm whales in 2012-2016 is 4.4 whales in U.S. commercial fisheries. Sperm whales have been observed depredating both halibut and sablefish longline fisheries in the Gulf of Alaska and this is also widespread in sablefish longline fisheries in the central and eastern Gulf of Alaska; this depredation can lead to mortality or serious injury if hooking or entanglement occurs. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include entanglement in fishing gear and ship strikes due to increased vessel traffic (from increased shipping in higher latitudes).

Fisheries Information

Information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

In 2012-2016, five serious injuries of sperm whales were observed in the Gulf of Alaska sablefish longline fishery (two each in 2012 and 2013 and one in 2016) and one in the Bering Sea/Aleutian Islands Pacific halibut longline fishery (in 2015). Each of these injuries was prorated at a value of 0.75 and extrapolated to fishery-wide estimates when possible, resulting in a minimum average annual estimated mortality and serious injury rate of 4.4 sperm whales in U.S. commercial fisheries in 2012-2016 (Table 1; Breiwick 2013; MML, unpubl. data).

Table 1. Summary of incidental mortality and serious injury of North Pacific sperm whales due to U.S. commercial fisheries in 2012-2016 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports. Injury events lacking detailed injury information are assigned prorated values following injury determination guidelines described in NMFS (2012). A summary of information used to determine whether an injury was serious or non-serious, as well as a table of prorate values used for large whale reports with incomplete information, is reported in Helker et al. (in press).

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. Pacific halibut longline	2012	obs data	1.8	0	0	1.5 (CV=0.99)
	2013		13	0	0	
	2014		14	0	0	
	2015		15	0.75	7.6	
	2016		12	0	0	
Gulf of Alaska sablefish longline	2012	obs data	14	1.5	3.4	2.7 (+0.2)[c] (CV = 0.52)
	2013		14	0.75 (+0.75)[a]	6.2 (+0.75)[b]	
	2014		19	0	0	
	2015		20	0	0	
	2016		14	0.75	4.0	
Minimum total estimated annual mortality						4.4 (CV = 0.49)

[a]Total mortality and serious injury observed in 2013: 0.75 whales in sampled hauls + 0.75 whales in an unsampled haul.
[b]Total estimate of mortality and serious injury in 2013: 6.2 whales (extrapolated estimate from 0.75 whales observed in sampled hauls) + 0.75 whales (0.75 whales observed in an unsampled haul).
[c]Mean annual mortality and serious injury for fishery: 2.7 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).

Alaska Native Subsistence/Harvest Information

Sperm whales have never been reported to be taken by subsistence hunters (Rice 1989).

Other Mortality

Sperm whales were the dominant species killed by the commercial whaling industry as it developed in the North Pacific in the years after World War II (Mizroch and Rice 2006, Ivashchenko et al. 2014). Between 1946 and 1967, most of the sperm whales were caught in waters near Japan and in the Bering Sea/Aleutian Islands (BSAI) region. The BSAI catches were dominated by males. After 1967, whalers moved out of the BSAI region and began to catch even larger numbers of sperm whales farther south in the North Pacific between 30° and 50°N latitude (Mizroch and Rice 2006: Figs. 7-9). The reported catch of sperm whales taken by commercial whalers operating in the North Pacific between 1912 and 2006 was 261,148 sperm whales, of which, 259,120 were taken between 1946 and 1987 (Allison 2012). This value underestimates the actual kill in the North Pacific as a result of under-reporting by U.S.S.R. and Japanese pelagic whaling operations. Berzin (2008) described extreme under-reporting and misreporting of Soviet sperm whale catches from the mid-1960s into the early 1970s, including enormous (and under-reported) whaling pressure on female sperm whales in the latter years of whaling. More recently, Ivashchenko et al. (2013, 2014) estimate that 157,680 sperm whales were killed by the U.S.S.R. in the North Pacific between 1948 and 1979, of which, 25,175 were unreported; the Soviets also extensively misreported the sex and length of catches. In addition, it is known that Japanese land-based whaling operations also misreported the number and sex of sperm whale catches during the post-World War II era (Kasuya 1999), and other studies indicate that falsifications also occurred on a large scale in the Japanese pelagic fishery (Cooke et al. 1983, Ivashchenko and Clapham 2015). The last year that the U.S.S.R. reported catches of sperm whales was in 1979 and the last year that Japan reported substantial catches was in 1987, but Japanese whalers reported catches of 48 sperm whales between 2000 and 2009 (IWC, BIWS catch data, October 2010 version, unpubl.). Although the Soviet data on catches of this species in the North Pacific have now been largely corrected (Ivashchenko et al. 2013), the North Pacific sperm whale data in the IWC's Catch Database (Allison 2012) are known to be incorrect (i.e., too low) because of falsified catch information from both the Japanese coastal and pelagic fisheries (Kasuya 1999, Ivashchenko and Clapham 2015).

From 2012 to 2016, one suspected human-related sperm whale mortality was reported to the NMFS Alaska Region stranding network (Helker et al. in press). A beachcast sperm whale was found in 2012 on a beach near Yakutat with a net from an unknown fishery wrapped around its lower jaw. However, due to the advanced decomposition of this whale, the cause of death could not be determined.

Other Issues

NMFS observers aboard longline vessels targeting both sablefish and halibut have documented sperm whales feeding off longline gear in the Gulf of Alaska (Hill and Mitchell 1998, Hill et al. 1999, Perez 2006, Sigler et al. 2008). Fishery observers recorded several instances during 1995-1997 in which sperm whales were deterred by fishermen (i.e., throwing seal bombs in the water).

Annual longline surveys have been recording sperm whale depredation on catch since 1998 (Hanselman et al. 2008). Sperm whale depredation in the sablefish longline fishery is widespread in the central and eastern Gulf of Alaska but rarely observed in the Bering Sea; interaction rates are increasing significantly in the East Yakutat/Southeast Alaska and Central Gulf management areas (Hanselman et al. 2018). More recent research suggests that sperm whales impacted catch rates at a more significant rate than earlier studies suggested (Straley et al. 2005, Sigler et al. 2008), and sperm whales are estimated to reduce commercial fishery and NMFS annual longline survey catch rates by approximately 15% - 26% (Peterson and Hanselman 2017, Hanselman et al. 2018).

STATUS OF STOCK

Sperm whales are listed as endangered under the Endangered Species Act of 1973 and, therefore, designated as depleted under the MMPA. As a result, this stock is classified as a strategic stock. However, on the basis of total abundance, current distribution, and regulatory measures that are in place, it is unlikely that this stock is in danger of extinction (Braham 1992). Reliable estimates of the minimum population, population trends, PBR, and status of the stock relative to its Optimum Sustainable Population are not available. A minimum estimate of the total annual level of human-caused mortality and serious injury is 4.4 whales in U.S. commercial fisheries. The minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate (4.4 whales) is more than 10% of the PBR (10% of PBR = 0.05) calculated from the 2015 abundance estimate (Rone et al. 2017) for a small portion of the stock's range. However, because the calculated PBR level is based on an N_{MIN} which is known to be an underestimate of the abundance of the population, the PBR level is considered unreliable and should not be used for management purposes.

There are key uncertainties in the assessment of the North Pacific stock of sperm whales. There is little current information about the broad-scale distribution of sperm whales in Alaska waters, and there is no current abundance estimate, N_{MIN}, PBR level, or trend in abundance for the entire stock.

HABITAT CONCERNS

Potential habitat concerns for this stock include elevated levels of sound from anthropogenic sources (e.g., shipping, military exercises), possible changes in prey distribution and quality with climate change, entanglement in fishing gear, ship strikes due to increased vessel traffic (e.g., from increased shipping in higher latitudes), and oil and gas activities.

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