Revised 04/9/2018

HUMPBACK WHALE (*Megaptera novaeangliae*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

NMFS has conducted a global Status Review of humpback whales (Bettridge *et al.* 2015), and recently revised the ESA listing of the species (81 FR 62259, September 8, 2016). NMFS is evaluating the stock structure of humpback whales under the MMPA, but no changes to current stock structure are presented at this time. However, effects of the ESA listing final rule on the status of the stock are discussed below.

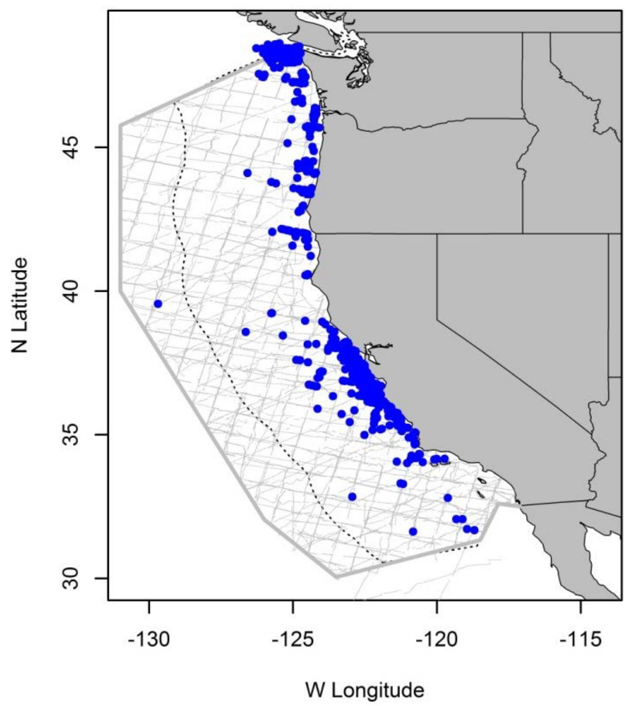

Figure 1. Humpback whale sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2014. Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined. See Appendix 2 for data sources and information on timing and location of survey effort.

Northern Hemisphere humpback whales (*M. novaeangliae kuzira*) comprise a distinct subspecies based on mtDNA and DNA relationships and distribution compared to North Atlantic humpback whales (*M n. novaeangliae*) and those in the Southern Hemisphere (*M. n. australis*) (Jackson *et al.* 2014). Humpback whales occur throughout the North Pacific, with multiple populations currently recognized based on low-latitude winter breeding areas (Baker *et al*. 1998, Calambokidis *et al*. 2001, Calambokidis *et al.* 2008, Barlow *et al.* 2011, Fleming and Jackson 2011). North Pacific breeding areas fall broadly into three regions, including the 1) western Pacific (Japan and Philippines); 2) central Pacific (Hawaiian Islands); and 3) eastern Pacific (Central America and Mexico) (Calambokidis *et al*. 2008). Exchange of animals between breeding areas rarely occurs, based on photo-identification data of individual whales (Calambokidis *et al*. 2001, Calambokidis *et al*. 2008). Photo-identification evidence also suggests strong site fidelity to feeding areas, but animals from multiple feeding areas converge on common winter breeding areas (Calambokidis *et al*. 2008). Baker *et al*. (2008) reported significant differences in mtDNA haplotype frequencies among different breeding and feeding areas in the North Pacific, reflecting strong matrilineal site fidelity to the respective migratory destinations. The most significant differences in haplotype frequencies were found between the California/Oregon feeding area and Russian and Southeastern Alaska feeding areas (Baker *et al*. 2008). Among breeding areas, the greatest level of differentiation was found between Okinawa and Central America and most other breeding grounds (Baker *et al*. 2008). Genetic differences between feeding and breeding grounds were also found, even for areas where regular exchange of animals between feeding and breeding grounds is confirmed by photo-identification (Baker *et al*. 2008).

Along the U.S. west coast, one stock is currently recognized, including two separate feeding groups: 1) a California and Oregon feeding group of whales that belong to the Central American and Mexican distinct population segments (DPSs) defined under the ESA (81 FR 62259, September 8, 2016), 2) a northern Washington and southern British Columbia feeding group that primarily includes whales from the Mexican DPS but also includes a small number of whales from the Hawaii and Central American DPSs (Calambokidis *et al*. 2008, Barlow *et al*. 2011, Wade *et al*. 2016). Very few photographic matches between these feeding groups have been documented (Calambokidis *et al*. 2008). Seven 'biologically important areas' for humpback whale feeding are identified off the U.S. west coast by Calambokidis *et al*. (2015), including five in California, one in Oregon, and one in Washington.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, the California/Oregon/Washington Stock is defined to include humpback whales that feed off the west coast of the

United States, including animals from both the California-Oregon and Washington-southern British Columbia feeding groups (Calambokidis *et al*. 1996, Calambokidis *et al*. 2008, Barlow *et al*. 2011). Three other stocks are recognized in the U.S. MMPA Pacific stock assessment reports: the Central North Pacific Stock (with feeding areas from Southeast Alaska to the Alaska Peninsula), the Western North Pacific Stock (with feeding areas from the Aleutian Islands, the Bering Sea, and Russia), and the American Samoa Stock in the South Pacific (with largely undocumented feeding areas as far south as the Antarctic Peninsula).

POPULATION SIZE

Based on whaling statistics, the pre-1905 population of humpback whales in the North Pacific was estimated to be 15,000 (Rice 1978), but this population was reduced by whaling to approximately 1,200 by 1966 (Johnson and Wolman 1984). A photo-identification study in 2004-2006 estimated the abundance of humpback whales in the entire Pacific Basin to be 21,808 (CV=0.04) (Barlow *et al*. 2011). Barlow (2016) recently estimated 3,064 (CV= 0.82) humpback whales from a 2014 summer/fall ship line-transect survey of California, Oregon, and Washington waters. Abundance estimates from photographic mark-recapture surveys conducted in California and Oregon waters every year from 1991 through 2011 represent the most precise estimates (Calambokidis 2013). These estimates include only animals photographed in California and Oregon waters and not animals that are part of the separate feeding group found off Washington state and southern British Columbia (Calambokidis *et al*. 2009). California and Oregon estimates range from approximately 1,100 to 2,600 animals, depending on the choice of recapture model and sampling period (Figure 2). The best estimate of abundance for California and Oregon waters is taken as the 2008-2011 Darroch estimate of 1,729 (CV = 0.03) whales, which is also the most precise estimate (Calambokidis and Barlow 2013). This estimate includes virtually the entire Central American DPS, which was recently estimated to include 411 (CV=0.3) whales based on 2004-2006 photographic mark-recapture data (Wade *et al*. 2016).

Calambokidis *et al*. (2008) reported a range of photographic mark-recapture abundance estimates (145 – 469) for the northern Washington and southern British Columbia feeding group most recently in 2005. The best model estimate from that paper (lowest AIC_c score) was reported as 189 (CV not reported) animals. This estimate is more than 8 years old and is outdated for use in stock assessments; however, because west-coast humpback whale populations are growing (Calambokidis and Barlow 2013), this is still a valid minimum population estimate.

Combining abundance estimates from both the California/Oregon and Washington/southern British Columbia feeding groups (1,729 + 189) yields an estimate of 1,918 (CV $\approx$ 0.03) animals for the California/Oregon/Washington stock. The approximate CV of 0.03 for the combined estimate reflects that a vast majority of the variance is derived from the California and Oregon estimate (CV=0.03) and that no CV was provided for the Washington state and southern British Columbia estimate.

Minimum Population Estimate

The minimum population estimate for humpback whales in the California/Oregon/Washington stock is taken as the lower 20th percentile of the log-normal distribution of the combined mark-recapture estimate for both feeding groups given above, or 1,876 animals.

Current Population Trend

Ship surveys provide some indication that humpback whales increased in abundance in California coastal waters between 1979/80 and 1991 (Barlow 1994) and between 1991 and 2014 (Barlow 2016), but this increase was not steady, and estimates showed slight dips in 2001 and 2008. Mark-recapture population estimates had shown a long-term increase of approximately 8% per year (Calambokidis *et al*. 2009, Figure 2), but more recent estimates show variable trends (Figure 2), depending on the choice of model and time frame used (Calambokidis and Barlow 2013). Population estimates for the entire North Pacific have also increased substantially from 1,200 in 1966 to approximately 18,000 - 20,000 whales in 2004 to 2006 (Calambokidis *et al*. 2008). Although these estimates are based on different methods and the earlier estimate is extremely uncertain, the growth rate implied by these estimates (6-7%) is consistent with growth rate of the California/Oregon/Washington stock.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The proportion of calves in the California/Oregon/Washington stock from 1986 to 1994 appeared much lower than previously measured for humpback whales in other areas (Calambokidis and Steiger 1994), but in 1995-97 a greater proportion of calves were identified, and the 1997 reproductive rates for this population are closer to those reported for humpback whale populations in other regions (Calambokidis *et al*. 1998). Despite the apparently low proportion of calves, two independent lines of evidence indicate that this stock was growing in the 1980s and early 1990s (Barlow 1994; Calambokidis *et al*. 2003) with a best estimate of 8% growth per year (Calambokidis *et al*. 1999). The current net productivity rate is unknown.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,876) times one half the estimated population growth rate for this stock of humpback whales (½ of 8%) times a recovery factor of 0.3 (for an endangered species; see Status of Stock section below regarding ESA listing status with $N_{min} > 1,500$ and $CV(N_{min}) < 0.50$), resulting in a PBR of 22. Because this stock spends approximately half its time outside the U.S. EEZ, the PBR allocation for U.S. waters is 11 whales per year.

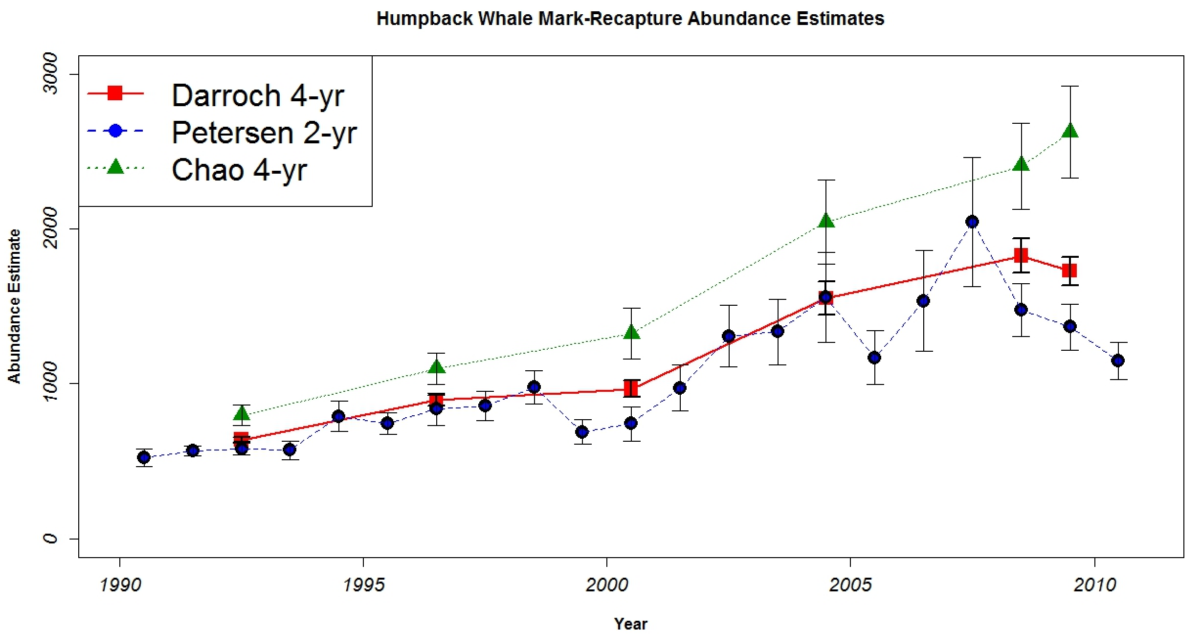

Figure 2. Mark-recapture estimates of humpback whale abundance in California and Oregon, 1991-2011, based on 3 different mark-recapture models and sampling periods (Calambokidis and Barlow 2013). Vertical bars indicate ±2 standard errors of each abundance estimate. Darroch and Chao models use 4 consecutive non-overlapping sample years, except for the last estimates, which use the four most recent years, but overlap with the next-to-last estimate (Calambokidis and Barlow 2013).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

A total of 71 human-related interactions involving humpback whales are summarized for the 5-year period 2011-2015 by Carretta *et al.* (2017a). These records include serious and non-serious injuries and mortality involving pot/trap fisheries (n=34), unidentified fishery interactions (26), vessel strikes (9), gillnet fisheries (1) and marine debris (1). The number of serious injuries and mortalities for each category are summarized below. In addition, there were 19 entanglement and vessel strike records of 'unidentified whales' (totaling 15 serious injuries) during 2011-2015, some of which were certainly humpback whales. The number of serious injuries of 'unidentified whales' during 2011-2015 was therefore, 15 / 5 = 3 animals annually.

Fishery Information

Pot and trap fisheries are the most commonly documented source of serious injury and mortality of humpback whales in U.S. west coast waters (Carretta *et al*. 2013, 2015, 2016a), and entanglement reports have increased considerably since 2014. From 2011 to 2015, there were 34 documented interactions with pot and trap fisheries (Carretta *et al.* 2017a, Jannot *et al.* 2016). Twelve records (3 CA spot prawn pot + 8 Dungeness crab pot + 1 lobster pot) involved non-serious injuries resulting from human intervention to remove gear, or cases where animals were able to free themselves. Two records involved dead whales, including one humpback recovered in sablefish pot gear in offshore Oregon waters and one case where severed humpback flukes were found in southern California waters entangled in California Dungeness crab gear (Carretta *et al.* 2016, 2017a). The remaining 20 cases, once evaluated per the NMFS serious injury policy, resulted in a total of 15.5 serious injuries / 5 years, or 3.1

humpback whales annually (Table 1). This includes 10.25 serious injuries (from 13 cases) in unidentified trap/pot fisheries, 2.25 serious injuries (from 3 cases) in California Dungeness crab pot, 1.5 serious injuries (from 2 cases) in the CA recreational Dungeness crab pot fishery, 0.75 serious injury (from 1 case) in a generic Dungeness crab pot fishery (state unknown), and 0.75 serious injury (from 1 case) in the CA spot prawn trap fishery. Including the 2 deaths attributed to pot/traps, the minimum level of annual mortality and serious injury across all pot/trap fisheries is 15.5 serious injuries + 2 mortalities = 17.5 whales / 5 years = 3.5 whales annually. Two records (totaling 1.5 serious injuries are attributed to the *recreational* Dungeness crab fishery and thus, are not counted towards commercial fishery totals (but count against PBR, see Status of Stock Section). Thus, the number of *commercial* pot/trap fishery serious injuries and deaths totals 16 whales, or 16/5 = 3.2 whales annually (Table 1).

Table 1. Summary of available information on the incidental mortality and serious injury of humpback whales (California/Oregon/Washington stock) for commercial fisheries that are likely to take this species (Carretta *et al.* 2017a, Carretta *et al.* 2017b). Mean annual takes are based on 2011-2015 data unless noted otherwise. Serious injuries may include prorated serious injuries with values less than one (NOAA 2012), thus the sum of serious injury and mortality may not be a whole number.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality (and serious injury)	Estimated mortality and serious injury (CV)	Mean Annual Takes (CV)
CA swordfish and thresher shark drift gillnet fishery	2011-2015	observer	24%	0[1]	0.1 (3)	< 0.02 (3)
CA halibut/white seabass and other species large mesh (≥3.5") set gillnet fishery	2010-2014	observer	9%	0	0	0 (n/a)
CA spot prawn pot	2011-2015	Strandings / sightings	n/a	0 (0.75)	n/a	≥ 0.15
Unspecified pot or trap fisheries (includes generic 'Dungeness' crab gear not attributed to a specific state fishery)	2011-2015	Strandings / sightings	n/a	0 (11)	n/a	≥ 2.2
CA Dungeness crab pot	2011-2015	Strandings / sightings	n/a	1 (2.25)	n/a	≥ 0.65
OR Dungeness crab pot[2]	2011-2015	Strandings / sightings	n/a	0 (0)	n/a	≥ 0
WA coastal Dungeness crab pot	2011-2015	Strandings / sightings	n/a	0 (0)	n/a	≥ 0
WA/OR/CA limited entry sablefish pot	2014	observer	31%	1 (0)	n/a[3]	≥ 0.2
unidentified fisheries	2011-2015	Strandings / sightings	n/a	3 (19)	n/a	≥ 4.4
Total Annual Takes						≥ 7.6

Gillnet (n=1) and unidentified fisheries (n=26) accounted for 27 interactions with humpback whales between 2011 and 2015 (Carretta *et al.* 2017a). Based on the proportion of humpback whale records where the type of fishing gear is positively identified, it is likely that most cases involving 'unidentified fisheries' represent pot and/or trap fisheries (Carretta *et al*. 2017a). Three records involved dead whales. The remaining 24 records, once evaluated per the NMFS serious injury policy, resulted in one non-serious injury and 19 serious injuries (16 cases x 0.75 = 12 prorated serious injuries, plus 7 non-prorated serious injuries). The total annual mortality and serious injury due to unidentified and gillnet fisheries from 2011 to 2015 sightings reports is 22 whales. The 5-year annual mean serious injury and mortality due to unidentified fisheries during this period is therefore 22 / 5 = 4.4 whales.

Three humpback whale entanglements (all released alive) were observed in the CA swordfish drift gillnet fishery from over 8,700 fishing sets monitored between 1990 and 2015 (Carretta *et al.* 2017b). Some opportunistic sightings of free-swimming humpback whales entangled in gillnets may also originate from this fishery. The most

[1] There were no observations of humpback whales in this fishery during 2011-2015, but the model-based estimate of bycatch for this period results in a positive estimate of bycatch (Carretta *et al*. 2017b).
[2] There were 3 non-serious injuries involving humpback whales with this fishery from 2011-2015.
[3] No estimate of total bycatch has been generated for this fishery.

recent model-based estimate of humpback whale bycatch in this fishery for 2011-2015 is 0.4 whales (CV= 2.0), but it is estimated that only one-quarter of these entanglements represent serious injuries (Martin *et al*. 2015). The corresponding ratio estimate of bycatch for the same time period is zero (Carretta *et al.* 2017b). The model-based estimate is considered superior because it utilizes all 26 years of data for estimation, in contrast to the ratio estimate that uses only 2011-2015 data. The average annual estimated serious injury and mortality in the CA swordfish drift gillnet fishery is 0.02 whales (0.1 whales / 5 years).

Total commercial fishery serious injury and mortality of humpback whales for the period 2011-2015 is the sum of pot/trap fishery records (16), plus unidentified fishery records (22), plus estimates from the CA swordfish drift gillnet fishery (0.02), or 38 total whales. The mean annual serious injury and mortality from commercial fisheries during 2011-2015 is 38 whales / 5 years = 7.6 whales (Table 1). Most serious injury and mortality records from commercial fisheries reflect opportunistic stranding and at-sea sighting data and thus, represent minimum counts of impacts, for which no correction factor is currently available.

Despite an overall increase in the number of reported entanglements in recent years, increasing efforts to disentangle humpback whales from fisheries has led to an increase in the fraction of cases reported as non-serious injuries, due to the removal of gear from humpback whales that otherwise appear healthy. In the absence of human intervention, these records would have represented at least 8 additional serious injuries over the 5-year period 2011-2015 (Carretta *et al.* 2017a).

Ship Strikes

Nine humpback whales (4 deaths, 1.56 serious injuries, and 3 non-serious injuries) were reported struck by vessels between 2011 and 2015 (Carretta *et al.* 2017a). In addition, there was one serious injury to an unidentified large whale from a ship strike during this time (Carretta *et al.* 2017a). The average annual serious injury and mortality of humpback whales attributable to ship strikes during 2011-2015 is 1.1 whales per year (4 deaths, plus 1.56 serious injuries = 5.6 per 5 years). Ship strike mortality was recently estimated for humpback whales in the California Current (Rockwood *et al*. 2017), using an encounter theory model (Martin *et al*. 2015) that combined species distribution models of whale density (Becker *et al*. 2016), vessel traffic characteristics (size + speed + spatial use), along with whale movement patterns obtained from satellite-tagged animals in the region to estimate encounters that would result in mortality. The results of this study were published while this report was being prepared and the results will be fully incorporated into the draft 2018 stock assessment report for this species.

Other human-caused mortality and serious injury

A humpback whale was entangled in a research wave rider buoy in 2014. The whale is estimated to have been entangled for 3 weeks and had substantial necrotic tissue around the caudal peduncle. Although the whale was fully disentangled by a whale entanglement team, this animal was categorized as a serious injury[4] because of the necrotic condition of the caudal peduncle and the possibility that the whale would lose its flukes due to the severity of the entanglement (NOAA 2012, Carretta *et al.* 2016, 2017a).

STATUS OF STOCK

Approximately 15,000 humpback whales were taken from the North Pacific from 1919 to 1987 (Tonnessen and Johnsen 1982), and, of these, approximately 8,000 were taken from the west coast of Baja California, California, Oregon and Washington (Rice 1978), presumably from this stock. Shore-based whaling apparently depleted the humpback whale stock off California twice: once prior to 1925 (Clapham *et al*. 1997) and again between 1956 and 1965 (Rice 1974). There has been a prohibition on taking humpback whales since 1966. As a result of commercial whaling, humpback whales were listed as "endangered" under the Endangered Species Conservation Act of 1969. This protection was transferred to the Endangered Species Act (ESA) in 1973. The humpback whale ESA listing final rule (81 FR 62259, September 8, 2016) established 14 distinct population segments (DPSs) with different listing statuses. The CA/OR/WA humpback whale stock primarily includes whales from the endangered Central American DPS and the threatened Mexico DPS, plus a small number of whales from the non-listed Hawaii DPS. Humpback whale stock delineation under the MMPA is currently under review, and until this review is complete, the CA/OR/WA stock will continue to be considered endangered and depleted for MMPA management purposes (e.g., selection of a recovery factor, stock status). Consequently, the California/Oregon/ Washington stock is automatically considered as a "strategic" stock under the MMPA. The

[4] This whale was initially listed as a non-serious injury in Carretta *et al.* (2016a) due to insufficient detail in the preliminary reporting. It is considered a serious injury for purposes of this stock assessment report.

estimated annual mortality and serious injury due to commercial fishery entanglements in 2011-2015 (7.6/yr) , non-fishery entanglements (0.2/yr), recreational crab pot fisheries (0.3/yr), plus ship strikes (1.1/yr), equals 9.2 animals. Although this is less than the stock's PBR (11) for U.S. waters, not all entangled or ship-struck whales are detected and the true rate of mortality and serious injury is almost certainly greater than 9.2. Most data on human-caused serious injury and mortality for this population is based on opportunistic stranding and at-sea sighting data and represents a minimum count of total impacts. There is currently no estimate of the fraction of anthropogenic injuries and deaths to humpback whales that are undocumented on the U.S. west coast. In addition to incidents involving humpback whales, an additional number of 'unidentified whales' (3/yr) were seriously injured between 2011-2015, some of which were certainly humpback whales, based on the observed proportion (40%) of all large whale injury cases identified as humpbacks during this period (Carretta *et al.* 2017a). Based on strandings and at sea observations, annual humpback whale mortality and serious injury in commercial fisheries (7.6/yr) is greater than 10% of the PBR; therefore, total fishery mortality and serious injury is not approaching zero mortality and serious injury rate. The California/Oregon/Washington stock showed a long-term increase in abundance from 1990 through approximately 2008 (Figure 2), but more recent estimates have shown variable trends.

Habitat Concerns

Increasing levels of anthropogenic sound in the world's oceans (Andrew *et al*. 2002), such as those produced by shipping traffic, or LFA (Low Frequency Active) sonar, have been identified as a habitat concern for whales, as it can reduce acoustic space used for communication (masking) (Clark *et al.* 2009, NOAA 2016). This can be particularly problematic for baleen whales that may communicate using low-frequency sound (Erbe 2016). Based on vocalizations (Richardson *et al*. 1995; Au *et al*. 2006), reactions to sound sources (Lien *et al*. 1990, 1992; Maybaum 1993), and anatomical studies (Hauser *et al*. 2001), humpback whales also appear to be sensitive to mid-frequency sounds, including those used in active sonar military exercises (U.S. Navy 2007).

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