Revised 12/30/2019

HUMPBACK WHALE (*Megaptera novaeangliae*): Central North Pacific Stock

NOTE – NMFS is in the process of reviewing humpback whale stock structure under the Marine Mammal Protection Act (MMPA) in light of the 14 Distinct Population Segments established under the Endangered Species Act (ESA) (81 FR 62259, 8 September 2016). A complete revision of the humpback whale stock assessments will be postponed until this review is complete. In the interim, new information on humpback whale mortality and serious injury is provided within this report.

STOCK DEFINITION AND GEOGRAPHIC RANGE

The humpback whale is distributed worldwide in all ocean basins. In winter, most humpback whales occur in the subtropical and tropical waters of the Northern and Southern Hemispheres. Humpback whales in the high latitudes of the North Pacific Ocean are seasonal migrants that feed on euphausiids and small schooling fishes (Nemoto 1957, 1959; Clapham and Mead 1999). The humpback whale population was considerably reduced as a result of intensive commercial exploitation during the 20th century.

A large-scale study of humpback whales throughout the North Pacific was conducted from 2004 to 2006 (the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) project). Results from this project (Calambokidis et al. 2008, Barlow et al. 2011), including abundance estimates and movement information, have been reported in Baker et al. (2008, 2013) and are also summarized in Fleming and Jackson (2011); however, these results are still being considered for stock structure analysis.

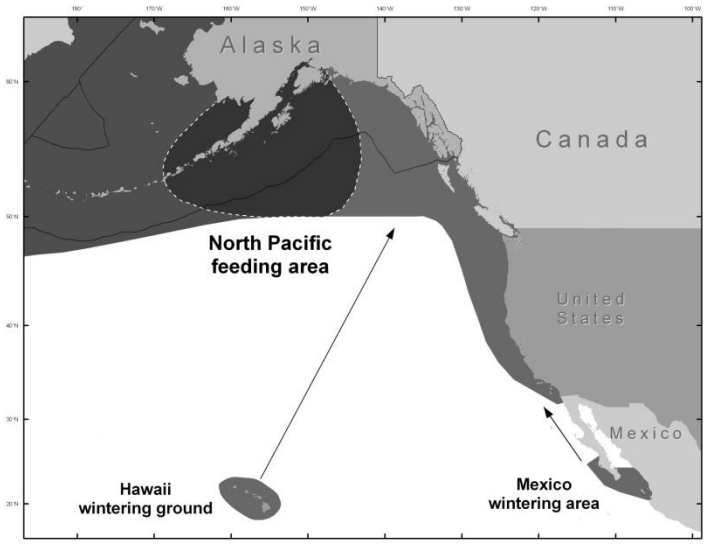

Figure 1. Approximate distribution of humpback whales in the eastern North Pacific (dark shaded areas). Feeding and wintering areas are presented above (see text). Area within the dotted line is known to be an area where the Central North Pacific and Western North Pacific stocks overlap. See Figure 1 in the Western North Pacific humpback whale Stock Assessment Report for distribution of humpback whales in the western North Pacific.

The historical summer feeding range of humpback whales in the North Pacific encompassed coastal and inland waters around the Pacific Rim from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk and north of the Bering Strait (Zenkovich 1954, Nemoto 1957, Tomlin 1967, Johnson and Wolman 1984). Historically, the Asian wintering area extended from the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands (Rice 1998). Humpback whales are currently found throughout this historical range. Most of the current winter range of humpback whales in the North Pacific is relatively well known, with aggregations of whales in Japan, the Philippines, Hawaii, Mexico, and Central America. The winter range includes the main islands of the Hawaiian archipelago, with the greatest concentration along the west side of Maui. In Mexico, the winter breeding range includes waters around the southern part of the Baja California peninsula, the central portions of the Pacific coast of mainland Mexico, and the Revillagigedo Islands off the mainland coast. The winter range also extends from southern Mexico into Central America, including Guatemala, El Salvador, Nicaragua, and Costa Rica (Calambokidis et al. 2008).

Photo-identification data, distribution information, and genetic analyses have indicated that in the North Pacific there are at least three breeding populations (Asia, Hawaii, and Mexico/Central America) that all migrate between their respective winter/spring calving and mating areas and their summer/fall feeding areas (Calambokidis et al. 1997, Baker et al. 1998). Calambokidis et al. (2001) further suggested that there may be as many as six subpopulations on the wintering grounds. From photo-identification and Discovery tag information there are known

connections between Asia and Russia, between Hawaii and Alaska, and between Mexico/Central America and California (Darling 1991, Darling and Cerchio 1993, Calambokidis et al. 1997, Baker et al. 1998). This information led to the designation of three stocks of humpback whales in the North Pacific: 1) the California/Oregon/Washington and Mexico stock, consisting of winter/spring populations in coastal Central America and coastal Mexico which migrate to the coast of California and as far north as southern British Columbia in summer/fall (Calambokidis et al. 1989, 1993; Steiger et al. 1991); 2) the Central North Pacific stock, consisting of winter/spring populations of the Hawaiian Islands which migrate primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands (Baker et al. 1990, Perry et al. 1990, Calambokidis et al. 1997) (Fig. 1) ; and 3) the Western North Pacific stock, consisting of winter/spring populations off Asia which migrate primarily to Russia and the Bering Sea/Aleutian Islands.

Information from the SPLASH project largely confirms this view of humpback whale distribution and movements in the North Pacific. For example, the SPLASH results confirm low rates of interchange between the three principal wintering regions (Asia, Hawaii, and Mexico). However, the full SPLASH results suggest that the current view of population structure is incomplete. The overall pattern of movements is complex but indicates a high degree of population structure. Whales from wintering areas at the extremes of their range on both sides of the Pacific migrate to coastal feeding areas that are on the same side of the Pacific: whales from Asia in the west migrate to Russia and whales from mainland Mexico and Central America in the east migrate to coastal waters off California/Oregon.

The SPLASH data now show the Revillagigedo whales are seen in all sampled feeding areas except northern California/Oregon and the south side of the Aleutians. They are primarily distributed in the Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia but are also found in Russia and southern British Columbia/Washington. The migratory destinations of humpback whales from Hawaii were found to be quite similar, and a significant number of matches (14) were seen during SPLASH between Hawaii and the Revillagigedos (Calambokidis et al. 2008). The SPLASH project also found that whales from the Aleutian Islands and Bering Sea, and perhaps the Gulf of Anadyr and the Chukotka Peninsula on the west side of the Bering Strait in Russia, have an unusually low resighting rate in winter areas compared to whales from other feeding areas. It is now believed that some of these whales have a winter migratory destination that was not sampled during the SPLASH project. Given the location of these feeding areas, the most parsimonious explanation would be that some of these whales winter somewhere between Hawaii and Asia, which would include the possibility of the Mariana Islands (southwest of the Ogasawara Islands), the Marshall Islands (approximately half-way between the Mariana Islands and the Hawaiian Islands), and the Northwestern Hawaiian Islands. Subsequent to the SPLASH project, a survey in 2007 documented humpback whales from a number of locations in the Northwestern Hawaiian Islands at relatively low densities (Johnston et al. 2007), but no sampling occurred there during the SPLASH project. Some humpback whales, including mother/calf pairs, have also been found in the Mariana Islands (Hill et al. 2016). Both of these locations are plausible migratory destinations for whales from the Aleutian Islands and Bering Sea. Which stock that whales in these locations would belong to is currently unknown.

The winter distribution of the Central North Pacific stock is primarily in the Hawaiian archipelago. In the SPLASH study, sampling occurred on Kauai, Oahu, Penguin Bank (off the southwest tip of the island of Molokai), Maui, and the island of Hawaii (the Big Island). Interchange within Hawaii was extensive. Although most of the Hawaii identifications came from the Maui sub-area, identifications from the Big Island and Kauai at the eastern and western end of the region showed a high rate of interchange with Maui.

In summer, the majority of whales from the Central North Pacific stock are found in the Aleutian Islands, Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia. High densities of humpback whales are found in the eastern Aleutian Islands, particularly along the northern side of Unalaska Island, and along the Bering Sea shelf edge and break to the north towards the Pribilof Islands. Small numbers of humpback whales are known from a few locations not sampled during the SPLASH study, including northern Bristol Bay and the Chukchi and Beaufort seas. In the Gulf of Alaska, high densities of humpback whales are found in the Shumagin Islands, south and east of Kodiak Island, and from the Barren Islands through Prince William Sound. Although densities in any particular location are not high, humpback whales are also found in deep waters south of the continental shelf from the eastern Aleutians through the Gulf of Alaska. Relatively high densities of humpback whales occur throughout much of Southeast Alaska and northern British Columbia.

NMFS conducted a global Status Review of humpback whales (Bettridge et al. 2015) and revised the ESA listing of the species (81 FR 62259, September 8, 2016); the effects of the ESA-listing final rule on the status of the stock are discussed below.

POPULATION SIZE

Prior to the SPLASH study, the most complete estimate of abundance for humpback whales in the North Pacific was from data collected from 1991 to 1993, with a best mark-recapture estimate of 6,010 (CV = 0.08) for the entire North Pacific, using a winter-to-winter comparison (Calambokidis et al. 1997). Estimates for Hawaii and Mexico were higher, using marks from summer feeding areas with recaptures on the winter grounds, and totaled almost 10,000 summed across all winter areas. In the SPLASH study, fluke photographs were collected by over 400 researchers in all known feeding areas from Russia to California and in all known wintering areas from Okinawa and the Philippines to the coast of Central America and Mexico from 2004 to 2006. Over 18,000 fluke identification photographs were collected, and these have been used to estimate the abundance of humpback whales in the entire North Pacific Basin. Based on a comparison of all winter identifications to all summer identifications, the Chapman-Petersen estimate of abundance is 21,808 (CV = 0.04) (Barlow et al. 2011). A simulation study identifies significant biases in this estimate from violations of the closed population assumption (+5.3%), exclusion of calves (-10.3%), failure to achieve random geographic sampling (+1.5%), and missed matches (+9.8%) (Barlow et al. 2011). Sex-biased sampling favoring males in wintering areas does not add significant bias if both sexes are proportionately sampled in the feeding areas. The bias-corrected estimate is 20,800 after accounting for a net positive bias of 4.8%. This estimate is likely to be lower than the true abundance due to two additional sources of bias: individual heterogeneity in the probability of being sampled (unquantified) and the likely existence of an unknown and unsampled wintering area (-7.2%).

The Central North Pacific stock of humpback whales winters in Hawaiian waters (Baker et al. 1986). Preliminary mark-recapture abundance estimates from the SPLASH data were calculated in Calambokidis et al. (2008), using a multistrata Hilborn model. The best estimate for Hawaii (as chosen by AICc) was 10,103; no confidence limit or coefficient of variation (CV) was calculated for that estimate. This estimate is more than 8 years old and is outdated for use in stock assessments; however, because this population is increasing in localized areas in Alaska, e.g., Prince William Sound (Teerlink et al. 2015), this is still considered a valid minimum population estimate (NMFS 2016).

In the SPLASH study, the number of unique identifications in different regions during 2004 and 2005 included 63 in the Aleutian Islands (defined as everything on the south side of the islands), 491 in the Bering Sea, 301 in the western Gulf of Alaska (including the Shumagin Islands), and 1,038 in the northern Gulf of Alaska (including Kodiak and Prince William Sound), with a few whales seen in more than one area (Calambokidis et al. 2008). The SPLASH combined estimates ranged from 6,000 to 19,000 for the Aleutian Islands, Bering Sea, and Gulf of Alaska, a considerable increase from previous estimates that were available (e.g., Waite et al. 1999, Moore et al. 2002, Witteveen et al. 2004, Zerbini et al. 2006). However, the SPLASH surveys covered areas not covered in those previous surveys, such as parts of Russian waters (Gulf of Anadyr and Commander Islands), the western and central Aleutian Islands, offshore waters in the Gulf of Alaska and Aleutian Islands, and Prince William Sound. Additionally, mark-recapture estimates can be higher than line-transect estimates because they estimate the total number of whales that have used the study area during the study period, whereas, line-transect surveys provide a snapshot of average abundance in the survey area at the time of the survey. For the Aleutian Islands and Bering Sea (including the Commander Islands and Gulf of Anadyr in Russia), the SPLASH estimates ranged from 2,889 to 13,594; for the Gulf of Alaska (from Prince William Sound to the Shumagin Islands, including Kodiak Island), the SPLASH estimates ranged from 2,845 to 5,122. Given known overlap in the distribution of the Western and Central North Pacific humpback whale stocks, estimates for these feeding areas may include whales from the Western North Pacific stock.

The SPLASH study showed a relatively high rate of interchange between Southeast Alaska and northern British Columbia, so they are considered together. Humpback whale studies have been conducted since the late 1960s in Southeast Alaska. Straley et al. (2009) examined data for the northern portion of Southeast Alaska from 1994 to 2000 and provided an updated abundance estimate of 961 (CV = 0.12). Using 1992 to 2006 photo-identification data and an SIR Jolly-Seber model, Ford et al. (2009) estimated an abundance of 2,145 humpback whales (95% CI: 1,970-2,331) in British Columbia waters. During the SPLASH study, 1,115 unique identifications were made in Southeast Alaska and 583 in northern British Columbia, for a total of 1,669 individual whales, after subtracting whales seen in both areas (1,115+583-13-16 = 1,669) (Calambokidis et al. 2008). From the SPLASH study, the estimates of abundance for Southeast Alaska/northern British Columbia ranged from 2,883 to 6,414. The estimates from SPLASH are considerably larger than the estimate from Straley et al. (2009). This is because the SPLASH estimates included areas not part of the Straley et al. (2009) estimate, including southern Southeast Alaska, northern British Columbia, and offshore waters of both British Columbia and Southeast Alaska.

Minimum Population Estimate

A total of 2,367 unique individuals were seen in the Hawaiian wintering areas during the 2-year period (3 winter field seasons, 2004 to 2006) of the SPLASH study. As discussed above, point estimates of abundance for Hawaii from SPLASH ranged from 7,469 to 10,103: the estimate from the best model was 10,103, but no associated CV was calculated. The 1991 to 1993 abundance estimate for Hawaii using similar (but less) data had a CV of 0.095. Therefore, it is unlikely the CV of a SPLASH estimate would be greater than 0.300. The minimum population estimate (N_{MIN}) for this stock is calculated according to Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of 10,103 from the best fit model and an assumed conservative CV(N) of 0.300 results in an N_{MIN} for the Central North Pacific humpback whale stock of 7,891. The 2016 guidelines for preparing Stock Assessment Reports (NMFS 2016) recommend that N_{MIN} be considered unknown if the abundance estimate is more than 8 years old, unless there is compelling evidence that the stock has not declined since the last estimate. Because this population is increasing in localized areas in Alaska, e.g., Prince William Sound (Teerlink et al. 2015), this is still considered a valid minimum population estimate.

Although the Southeast Alaska/northern British Columbia feeding aggregation is not formally considered a stock, the calculation of what a PBR would be for this area is useful for management purposes. The total number of unique individuals seen during the SPLASH study was 1,669 (1,115 in Southeast Alaska). The abundance estimate of Straley et al. (2009) had a CV of 0.12, and the SPLASH abundance estimates are unlikely to have a much higher CV. Using the lowest population estimate (N) of 2,883 and an assumed worst case CV(N) of 0.300, N_{MIN} for this aggregation is 2,252. Similarly, for the Aleutian Islands and Bering Sea, using the lowest SPLASH estimate of 2,889 with an assumed worst-case CV of 0.300 results in an N_{MIN} of 2,256. For the Gulf of Alaska (from Prince William Sound to the Shumagin Islands, including Kodiak Island), using the lowest SPLASH estimate of 2,845 with an assumed worst-case CV of 0.300 results in an N_{MIN} of 2,222. Estimates for these feeding areas may include whales from the Western North Pacific stock and the Mexican breeding population.

Current Population Trend

Comparison of the estimate for the entire stock provided by Calambokidis et al. (1997) with the 1981 estimate of 1,407 (95% CI: 1,113-1,701) from Baker et al. (1987) suggests that abundance increased in Hawaii between the early 1980s and early 1990s. Mobley et al. (2001) estimated a trend of 7% per year for 1993 to 2000 using data from aerial surveys that were conducted in a consistent manner for several years across all of the Hawaiian Islands and were developed specifically to estimate a trend for the Central North Pacific stock. Mizroch et al. (2004) estimated survival rates for North Pacific humpback whales using mark-recapture methods, and a Pradel model fit to data from Hawaii for the years 1980 to 1996 resulted in an estimated rate of increase of 10% per year (95% CI: 3-16%). For shelf waters of the northern Gulf of Alaska, Zerbini et al. (2006) estimated an annual rate of increase for humpback whales from 1987 to 2003 of 6.6% (95% CI: 5.2-8.6%). The SPLASH abundance estimate for the total North Pacific represents an annual increase of 4.9% over the most complete estimate for the North Pacific for 1991 to 1993. Comparisons of SPLASH abundance estimates for Hawaii to estimates for 1991 to 1993 gave estimates of annual increase that ranged from 5.5 to 6.0% (Calambokidis et al. 2008). No confidence limits were calculated for these rates of increase from SPLASH data. It is also clear that the abundance has increased in Southeast Alaska, although a trend for the Southeast Alaska portion of this stock cannot be estimated from the data because of differences in methods and areas covered.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Using a birth-interval model, Barlow and Clapham (1997) have estimated a population growth rate of 6.5% (SE = 1.2%) for the well-studied humpback whale population in the Gulf of Maine, although there are indications that this rate has slowed over the last decade (Clapham et al. 2003). Estimated rates of increase for the Central North Pacific stock include values for Hawaii of 7.0% (from aerial surveys), 5.5-6.0% (from mark-recapture abundance estimates), and 10% (95% CI: 3-16%) (from a model fit to mark-recapture data) and a value for the northern Gulf of Alaska of 6.6% (95% CI: 5.2-8.6%) from ship surveys (Calambokidis et al. 2008). Although there is no estimate of the maximum net productivity rate (R_{MAX}) for the Central North Pacific stock, it is reasonable to assume that R_{MAX} for this stock would be at least 7%. Until additional data become available for the Central North Pacific humpback whale stock, 7% will be used as R_{MAX} for this stock.

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum estimated net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The default recovery factor (F_R) for this

stock is 0.1, the recommended value for cetacean stocks listed as endangered under the ESA (NMFS 2016; see Status of Stock section below regarding ESA listing status); however, a recovery factor of 0.3 is used in calculating the PBR for this stock based on the suggested guidelines of Taylor et al. (2003). The default value of 4% for R_{MAX} is replaced by 7%, which is the best estimate of the current rate of increase and is considered a conservative estimate of R_{MAX}. For the Central North Pacific stock of humpback whales, using the SPLASH study abundance estimate from the best fit model for 2004 to 2006 for Hawaii of 10,103 with an assumed CV of 0.300 and its associated N_{MIN} of 7,891, PBR is calculated to be 83 whales (7,891 × 0.035 × 0.3).

At this time, stock structure of humpback whales is under consideration and revisions may be proposed within the next few years. For informational purposes, PBR calculations are completed here for the feeding area aggregations. For Southeast Alaska and northern British Columbia, the smallest abundance estimates from the SPLASH study were used with an assumed worst-case CV of 0.300 to calculate PBRs for feeding areas. Using the suggested guidelines presented in Taylor et al. (2003), it would be appropriate to use a recovery factor of 0.3 for the Southeast Alaska/northern British Columbia feeding aggregation since this aggregation has an N_{MIN} greater than 1,500 and less than 5,000 and has an increasing population trend. A recovery factor of 0.1 is appropriate for the Aleutian Islands and Bering Sea feeding aggregation and the Gulf of Alaska feeding aggregation because the N_{MIN} is greater than 1,500 and less than 5,000 and has an unknown population trend. If we calculated a PBR for the Southeast Alaska/northern British Columbia feeding aggregation it would be 24 (2,252 × 0.035 × 0.3). If we calculated a PBR for the Aleutian Islands and Bering Sea, it would be 7.9 (2,256 × 0.035 × 0.1). If we calculated a PBR for the Gulf of Alaska, it would be 7.8 (2,222 × 0.035 × 0.1). However, note that the actual PBR for the Central North Pacific stock is 83 based on the breeding population size in Hawaii, as calculated above.

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 between 2013 and 2017 is listed, by marine mammal stock, in Delean et al. (2020); 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 Delean et al. (2020). The minimum estimated mean annual level of human-caused mortality and serious injury for Central North Pacific humpback whales between 2013 and 2017 is 25 whales: 9.5 in U.S. commercial fisheries, 0.4 in recreational fisheries, 0.4 in subsistence fisheries, 7.7 in unknown (commercial, recreational, or subsistence) fisheries, 2.6 in marine debris, and 4.3 due to other causes (ship strikes and entanglement in a ship's ground tackle, an Alaska Department of Fish and Game (ADF&G) salmon net pen, and mooring gear); however, this estimate is considered a minimum because no observers have been assigned to several fisheries that are known to interact with this stock and, due to limited Canadian observer program data, mortality and serious injury incidental to Canadian commercial fisheries (i.e., those similar to U.S. fisheries known to interact with humpback whales) is uncertain. Assignment of mortality and serious injury to both the Central North Pacific and Western North Pacific stocks of humpback whales, when stock is unknown and events occur within the area where the stocks are known to overlap, may result in overestimating stock specific mortality and serious injury. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include ship strikes and entanglement in fishing gear.

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.

No incidental mortality or serious injury of Central North Pacific humpback whales was observed in federally-managed U.S. commercial fisheries in Alaska waters between 2013 and 2017; however, one Central North Pacific humpback whale was seriously injured in the Hawaii deep-set longline fishery in 2014, resulting in a mean annual mortality and serious injury rate of 0.9 whales in this fishery between 2013 and 2017 (Table 1; Bradford and Forney 2017; Bradford 2018; NMFS-PIFSC, unpubl. data).

In 2012 and 2013, the Alaska Marine Mammal Observer Program placed observers on independent vessels in the state-managed Southeast Alaska salmon drift gillnet fishery to assess mortality and serious injury of marine mammals. Areas around and adjacent to Wrangell and Zarembo Islands (ADF&G Districts 6, 7, and 8) were observed during the 2012 and 2013 programs (Manly 2015). In 2013, one humpback whale was seriously injured. Based on the one observed serious injury, 11 serious injuries were estimated for Districts 6, 7, and 8 in 2013, resulting in an estimated mean annual mortality and serious injury rate of 5.5 Central North Pacific humpback

whales in 2012 and 2013 (Table 1). Since these three districts represent only a portion of the overall fishing effort in this fishery, we expect this to be a minimum estimate of mortality and serious injury for the fishery.

Mortality and serious injury due to entanglements in Southeast Alaska commercial salmon purse seine gear (one serious injury in both 2013 and 2015, each prorated at 0.75), Kodiak Island commercial salmon set gillnet (one serious injury in 2015, prorated at 0.75), Prince William Sound commercial salmon drift gillnet (two serious injuries in 2015, each prorated at 0.75), Southeast Alaska salmon drift gillnet (nine serious injuries between 2013 and 2017 in ADF&G Districts that were not observed in 2012 and 2013 (i.e., districts with no observer data), including eight serious injuries prorated at 0.75), Bering Sea/Aleutian Islands commercial pot gear (one mortality in 2015), Southeast Alaska commercial pot gear (two serious injuries in 2015, each prorated at 0.75, including the dependent calf of a seriously injured whale), and Alaska State-managed commercial cod pot gear parallel fishery (one serious injury in 2017) was reported to the NMFS Alaska Region stranding network and by Marine Mammal Authorization Program (MMAP) fisherman self-reports between 2013 and 2017, as well as a serious injury (prorated at 0.52) from a ship strike by an Alaska/Washington/Oregon/California commercial passenger fishing vessel in 2017 (Table 2; Delean et al. 2020). Because observer data are not available for these fisheries, these reports of mortality and serious injury are used to calculate a minimum mean annual mortality and serious injury rate of 3.1 humpback whales in U.S. commercial fisheries in Alaska waters between 2013 and 2017 (Table 2). Mortality and serious injury in events that occurred in the area where the two stocks overlap was assigned to both the Central North Pacific and Western North Pacific stocks of humpback whales (as noted in Table 2). These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand or are self-reported nor are all stranded animals found, reported, or have the cause of death determined.

The minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries for the Central North Pacific stock between 2013 and 2017 (or the most recent data available) is 9.5 humpback whales, based on observer data from Alaska (Table 1: 5.5 in the state-managed Southeast Alaska salmon drift gillnet fishery), observer data from Hawaii (Table 1: 0.9), and MMAP fishermen self-reports and reports, in which the commercial fishery is confirmed, to the NMFS Alaska Region stranding network (Table 2: 3.1).

Table 1. Summary of incidental mortality and serious injury of Central North Pacific humpback whales due to U.S. commercial fisheries between 2013 and 2017 (or the most recent data available) and calculation of the mean annual mortality and serious injury rate for Alaska fisheries (Manly 2015) and Hawaii fisheries (Bradford and Forney 2017; Bradford 2018; NMFS-PIFSC, unpubl. data). Methods for calculating percent observer coverage for Alaska fisheries are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Southeast Alaska salmon drift gillnet (Districts 6, 7, 8)	2012 2013	obs data	6.4 6.6	0 1	0 11	5.5 (CV = 1.0)
Hawaii deep-set longline	2013 2014 2015 2016 2017	obs data	20 20 20 20 20	0 1 0 0 0	0 5 0 0 0	0.9 (CV = 2.1)
Minimum total estimated annual mortality					Southeast Alaska: Hawaii: Total:	5.5 0.9 6.4 (CV = 0.88)

Reports of swimming, floating, or beachcast humpback whales entangled in fishing gear or with injuries caused by interactions with gear, which may be from commercial, recreational, or subsistence fisheries, are another source of information on fishery-related mortality and serious injury. Mortality and serious injury in events that occurred in the area where the two stocks overlap was assigned to both the Central North Pacific and Western North Pacific stocks (as noted in Table 2). These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand or are self-reported nor are all stranded animals found, reported, or have the cause of death determined. In 2015, two

humpback whales (each with a serious injury prorated at 0.75) entangled in Gulf of Alaska recreational pot fisheries gear (1 in Dungeness crab pot gear and 1 in shrimp pot gear) were reported to the NMFS Alaska Region stranding network, resulting in a minimum mean annual mortality and serious injury rate of 0.4 whales in recreational gear in Alaska waters between 2013 and 2017 (Table 2; Delean et al. 2020). Whales with serious injuries (prorated at 0.75) entangled in Southeast Alaska subsistence halibut longline gear (one in 2015) and in unidentified subsistence gillnet (one in 2016) were reported to the NMFS Alaska Region stranding network between 2013 and 2017, resulting in a minimum mean annual mortality and serious injury rate of 0.4 humpback whales in subsistence fisheries (Table 2; Delean et al. 2020). Additional entanglements in unknown (commercial, recreational, or subsistence) fisheries gear reported to the NMFS stranding networks between 2013 and 2017 resulted in a minimum mean annual mortality and serious injury rate of 7.7 humpback whales: 1.4 reported to the NMFS Alaska Region stranding network (Table 2; Delean et al. 2020) and 6.3 reported to the NMFS Pacific Islands Region stranding network (Table 3; Bradford and Lyman 2018, 2019).

The minimum average annual mortality and serious injury rate due to interactions with all fisheries between 2013 and 2017 is 18 Central North Pacific humpback whales (9.5 in commercial fisheries + 0.4 in recreational fisheries + 0.4 in subsistence fisheries + 7.7 in unknown fisheries).

Table 2. Summary of mortality and serious injury of Central North Pacific humpback whales, by year and type, reported to the NMFS Alaska Region marine mammal stranding network and by Marine Mammal Authorization Program (MMAP) fisherman self-reports between 2013 and 2017 (Delean et al. 2020). 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 Delean et al. (2020).

Cause of injury	2013	2014	2015	2016	2017	Mean annual mortality
Entangled in Southeast Alaska commercial salmon purse seine gear	0.75[a]	0	0.75	0	0	0.3
Entangled in Kodiak Island commercial salmon set gillnet	0	0	0.75[b]	0	0	0.2
Entangled in Prince William Sound commercial salmon drift gillnet	0	0	1.5	0	0	0.3
Entangled in Southeast Alaska commercial salmon drift gillnet	0.75	3.25[c]	0.75	2.25	0	1.4
Entangled in Bering Sea/Aleutian Is. commercial pot gear	0	0	1[b]	0	0	0.2
Entangled in Southeast Alaska commercial pot gear	0	0	0.75	0	0	0.2
Dependent calf of animal seriously injured in Southeast Alaska commercial pot gear	0	0	0.75	0	0	0.2
Entangled in Alaska State-managed commercial cod pot gear (parallel fishery)	0	0	0	0	1[b]	0.2
Ship strike by AK/WA/OR/CA commercial passenger fishing vessel	0	0	0	0	0.52[b]	0.1
Entangled in Gulf of Alaska recreational Dungeness crab pot gear	0	0	0.75[b]	0	0	0.2
Entangled in Gulf of Alaska recreational shrimp pot gear	0	0	0.75[b]	0	0	0.2
Entangled in Southeast Alaska subsistence halibut longline gear	0	0	0.75	0	0	0.2
Entangled in unidentified subsistence gillnet	0	0	0	0.75	0	0.2
Entangled in Prince William Sound shrimp pot gear*	0	1[b]	0	0	0	0.2

Cause of injury	2013	2014	2015	2016	2017	Mean annual mortality
Entangled in Southeast Alaska unidentified fishing gear*	0	0	1.5	0	0	0.3
Dependent calf of animal seriously injured in Southeast Alaska unidentified fishing gear*	0	0	0.75	0	0	0.2
Entangled in Southeast Alaska unidentified net*	0.75	0	1.5	0	0	0.5
Entangled in unidentified fishing gear*	0	0	0	0	1	0.2
Entangled in marine debris	1.5	4.5[d]	1.75	4.25[d]	0.75	2.6
Entangled in ADF&G salmon net pen	0	0	0	0.75	0	0.2
Entangled in mooring gear	0	0	0	0.75	0	0.2
Entangled in ship's ground tackle	1[b]	0	0	0	0	0.2
Ship strike[e]	1.14	4.72	2.8	1.2	1.68	2.3
Total in commercial fisheries						3.1
Total in recreational fisheries						0.4
Total in subsistence fisheries						0.4
*Total in unknown (commercial, recreational, or subsistence) fisheries						1.4
Total in marine debris						2.6
Total due to other sources (entangled in salmon net pen, entangled in mooring gear, entangled in ship's ground tackle, ship strike)						2.9

[a]MMAP fisherman self-report.
[b]Mortality and serious injury assigned to both the Central North Pacific (CNP) and Western North Pacific (WNP) stocks.
[c]One of the serious injuries, prorated at 0.75, was reported by MMAP fisherman self-report.
[d]Marine debris mortality and serious injury (prorated values) assigned to both the CNP and WNP stocks: 0.75 whales in 2014 and 2 in 2016.
[e]Ship strike mortality and serious injury (prorated values) assigned to both the CNP and WNP stocks: 1.2 whales in 2014 and 0.2 in 2016.

Table 3. Summary of mortality and serious injury of Central North Pacific humpback whales reported to the NMFS Pacific Islands Region stranding network between 2013 and 2017 (Bradford and Lyman 2018, 2019).

Cause of injury	2013	2014	2015	2016	2017	Mean annual mortality
Entangled in Alaska shrimp pot gear*	0	1	0	0	0	0.2
Entangled in Alaska king crab, tanner crab, or finfish pot gear*	0	0.75	0	0	0	0.2
Entangled in longline gear*	1	1	0	0	0	0.4
Entangled in unidentified fishing gear*	5.25	6.5	7.75	2.5	5.25	5.5
Ship strike	3.56	1	1.2	0.2	1.2	1.4
*Total in unknown (commercial, recreational, or subsistence) fisheries						6.3
Total due to other sources (ship strike)						1.4

However, these estimates of mortality and serious injury levels should be considered minimums. No observers have been assigned to several fisheries that are known to interact with this stock, making the estimated mortality and serious injury rate an underestimate of actual mortality and serious injury. Further, due to limited Canadian observer program data, mortality and serious injury incidental to Canadian commercial fisheries (i.e., those similar to U.S. fisheries known to interact with humpback whales) is uncertain. Though interactions are thought to be minimal, data regarding the level of humpback whale mortality and serious injury related to commercial fisheries in northern British Columbia are not available, again indicating that the estimated mortality and serious injury incidental to commercial fisheries is underestimated for this stock.

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska are not authorized to take from this stock of humpback whales, and no takes were reported between 2013 and 2017.

Other Mortality

In 2015, increased mortality of large whales was observed along the western Gulf of Alaska (including the areas around Kodiak Island, Afognak Island, Chirikof Island, the Semidi Islands, and the southern shoreline of the Alaska Peninsula) and along the central British Columbia coast (from the northern tip of Haida Gwaii to southern Vancouver Island). NMFS declared an Unusual Mortality Event (UME) for large whales that occurred from 22 May to 31 December 2015 in the western Gulf of Alaska and from 23 April 2015 to 16 April 2016 in British Columbia (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed December 2019). Forty-six large whale deaths attributed to the UME included 12 fin whales and 22 humpback whales in Alaska and 5 fin whales and 7 humpback whales in British Columbia. Based on the findings from the investigation, the UME was likely caused by ecological factors (i.e., the 2015 El Niño, Warm Water Blob, and Pacific Coast Domoic Acid Bloom).

Entanglements in marine debris, an ADF&G salmon net pen, and mooring gear reported to the NMFS Alaska Region stranding network resulted in minimum mean annual mortality and serious injury rates of 2.6, 0.2, and 0.2 Central North Pacific humpback whales, respectively, between 2013 and 2017 (Table 2; Delean et al. 2020). Ship strikes and other interactions with vessels unrelated to fisheries occur frequently with humpback whales (Tables 2 and 3). The minimum mean annual mortality and serious injury rate due to ship strikes and entanglement in a ship's ground tackle reported in Alaska (Table 2: 2.5) and ship strikes reported in Hawaii (Table 3: 1.4) between 2013 and 2017 is 3.9 humpback whales. These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all animals strand nor are all stranded animals found, reported, or have the cause of death determined. Neilson et al. (2012) summarized 108 large whale ship-strike events in Alaska from 1978 to 2011, 25 of which are known to have resulted in the whale's death. Eighty-six percent of these reports involved humpback whales. Most ship strikes of humpback whales are reported from Southeast Alaska; however, there are also reports from the southcentral and Kodiak Island areas of Alaska (Delean et al. 2020). Many of the ship strikes occurring off Hawaii are reported from waters near Maui (Bradford and Lyman 2018, 2019). It is not known whether the difference in ship-strike rates between Southeast Alaska and the northern portion of this stock is due to differences in reporting, amount of vessel traffic, densities of animals, or other factors.

HISTORICAL WHALING

Rice (1978) estimated that the number of humpback whales in the North Pacific may have been approximately 15,000 individuals prior to exploitation; however, this was based upon incomplete data and, given the level of known catches (legal and illegal) since World War II, may be an underestimate. Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century. Humpback whales in the North Pacific were theoretically fully protected in 1965, but illegal catches by the U.S.S.R. continued until 1972 (Ivashchenko et al. 2013). From 1948 to 1971, 7,334 humpback whales were killed by the U.S.S.R., and 2,654 of these were illegally taken and not reported to the IWC (Ivashchenko et al. 2013). Many animals during this period were taken from the Gulf of Alaska and Bering Sea (Doroshenko 2000); additional illegal catches were made across the North Pacific, from the Kuril Islands to Haida Gwaii, and other takes may have gone unrecorded. The Soviet factory ship *Aleut* is known to have taken 535 humpback whales from 1933 to 1947 (Ivashchenko et al. 2013).

On the feeding grounds of the Central North Pacific stock after World War II, the highest densities of catches occurred around the western Aleutian Islands, in the eastern Aleutian Islands (and adjacent Bering Sea to the north and Pacific Ocean to the south), and British Columbia (Springer et al. 2006). Lower but still relatively high densities of catches occurred south of the Commander Islands, along the south side of the Alaska Peninsula, and around Kodiak Island. Lower densities of catches also occurred in the Gulf of Anadyr, in the central Aleutian Islands, in much of the offshore Gulf of Alaska, and in Southeast Alaska. No catches were reported in the winter grounds of the Central North Pacific stock in Hawaii nor in Mexican winter areas.

STATUS OF STOCK

NMFS recently concluded a global humpback whale Status Review (Bettridge et al. 2015). Although the estimated mean annual level of human-caused mortality and serious injury for the entire Central North Pacific stock (25 whales) is considered a minimum, it is unlikely that the total mean annual level of human-caused mortality and serious injury exceeds the PBR level (83) for the entire stock. The minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (9.5 whales) is more than 10% of the calculated PBR for the entire stock (10% of PBR = 8.3) and, therefore, cannot be considered insignificant and approaching a zero mortality and serious injury rate. The humpback whale ESA listing final rule (81 FR 62259, 8 September 2016) established 14 Distinct Population Segments (DPSs) with different listing statuses. The DPSs that occur in waters under the jurisdiction of the United States do not equate to the existing MMPA stocks. Some of the listed DPSs partially coincide with the currently defined Central North Pacific stock. Because we cannot manage one portion of an MMPA stock as ESA-listed and another portion of a stock as not ESA-listed, until such time as the MMPA stock delineations are reviewed in light of the DPS designations and Bettridge et al. (2015), NMFS continues to use the existing MMPA stock structure and considers this stock to be endangered and depleted for MMPA management purposes (e.g., selection of a recovery factor, stock status). As a result, the Central North Pacific stock of humpback whales is classified as a strategic stock. Humpback whale mortality and serious injury in Hawaii-based fisheries involves whales from the Hawaii DPS; this DPS is not listed as threatened or endangered under the ESA.

There are key uncertainties in the assessment of the Central North Pacific stock of humpback whales. New DPSs were recently identified under the ESA; however, stocks have not been revised. No estimate of variance is available for the abundance estimate. The feeding areas of the Central North Pacific stock and the Western North Pacific stock overlap in waters from British Columbia to the Bering Sea, so human-related mortality and serious injury estimates must be assigned to or prorated to multiple stocks. The current abundance estimate is calculated using data collected from 2004 to 2006; however, the N_{MIN} is still considered a valid minimum population estimate because the population is increasing (NMFS 2016). There is considerable site fidelity of humpback whales to particular feeding areas; human-related mortality and serious injury could have a disproportionate impact on a local feeding population even if the impacts to the DPS as currently described are low relative to the PBR level. Estimates of human-caused mortality and serious injury from stranding data and fisherman self-reports are underestimates because not all animals strand or are self-reported nor are all stranded animals found, reported, or have the cause of death determined.

HABITAT CONCERNS

This stock is the focus of a large whale-watching industry in its wintering grounds (Hawaii) and summering grounds (Alaska). Regulations concerning the minimum distance to keep from whales and how to operate vessels when in the vicinity of whales have been developed for Hawaii and Alaska waters in an attempt to minimize the effect of whale watching. Additional concerns have been raised in Hawaii about the effect of jet skis and similar fast waterborne tourist-related traffic, notably in nearshore areas inhabited by mothers and calves. In Alaska, NMFS issued regulations in 2001 to prohibit approaches to humpback whales within 100 yards (91.4 m: 66 FR 29502, 31 May 2001). In 2015, NMFS introduced a voluntary responsible viewing program called Whale SENSE to Juneau area whale-watch operators to provide additional protections for whales in Alaska (https://whalesense.org, accessed December 2019). The growth of the whale-watching industry is an ongoing concern as preferred habitats may be abandoned if disturbance levels are too high.

Other potential concerns for this stock include elevated levels of sound from anthropogenic sources (e.g., shipping, military sonars), harmful algal blooms (Geraci et al. 1989), possible changes in prey distribution 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.

The overall trend for most humpback whale populations found in U.S. waters is positive and points toward recovery (81 FR 62259; 8 September 2016), indicating that prey availability is not a major problem. However, a sharp decline in observed reproduction and encounter rates of humpback whales from the Central North Pacific stock between 2013 and 2018 has been related to oceanographic anomalies and consequent impacts on prey resources (Cartwright et al. 2019), suggesting that humpback whales are vulnerable to major environmental changes.

CITATIONS

Baker, C. S., L. M. Herman, A. Perry, W. S. Lawton, J. M. Straley, A. A. Wolman, G. D. Kaufman, H. E. Winn, J. D. Hall, J. M. Reinke, and J. Ostman. 1986. Migratory movement and population structure of humpback whales (*Megaptera novaeangliae*) in the central and eastern North Pacific. Mar. Ecol. Prog. Ser. 31:105-119.

Baker, C. S., A. Perry, and L. M. Herman. 1987. Reproductive histories of female humpback whales (*Megaptera novaeangliae*) in the North Pacific. Mar. Ecol. Prog. Ser. 41:103-114.

Baker, C. S., S. R. Palumbi, R. H. Lambertsen, M. T. Weinrich, J. Calambokidis, and S. J. O'Brien. 1990. Influence of seasonal migration on geographic distribution of mitochondrial DNA haplotypes in humpback whales. Nature 344:238-240.

Baker, C. S., L. Medrano-Gonzalez, J. Calambokidis, A. Perry, F. Pichler, H. Rosenbaum, J. M. Straley, J. Urban-Ramirez, M. Yamaguchi, and O. von Ziegesar. 1998. Population structure of nuclear and mitochondrial DNA variation among humpback whales in the North Pacific. Mol. Ecol. 7:695-707.

Baker, C. S., D. Steel, J. Calambokidis, J. Barlow, A. M. Burdin, P. J. Clapham, E. A. Falcone, J. K. B. Ford, C. M. Gabriele, U. González-Peral, R. LeDuc, D. Mattila, T. J. Quinn, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán-R., M. Vant, P. Wade, D. Weller, B. H. Witteveen, K. Wynne, and M. Yamaguchi. 2008. *geneSPLASH*: an initial, ocean-wide survey of mitochondrial (mt) DNA diversity and population structure among humpback whales in the North Pacific. Final Report for Contract 2006-0093-008 to the National Fish and Wildlife Foundation.

Baker, C. S., D. Steel, J. Calambokidis, E. Falcone, U. González-Peral, J. Barlow, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán, P. R. Wade, D. Weller, B. H. Witteveen, and M. Yamaguchi. 2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Mar. Ecol. Prog. Ser. 494:291-306. DOI: dx.doi.org/10.3354/meps10508 .

Barlow, J., and P. J. Clapham. 1997. A new birth-interval approach to estimating demographic parameters of humpback whales. Ecology 78(2):535-546.

Barlow, J., J. Calambokidis, E. A. Falcone, C. S. Baker, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. K. Mattila, T. J. Quinn, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R., P. Wade, D. Weller, B. H. Witteveen, and M. Yamaguchi. 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Mar. Mammal Sci. 27:793-818.

Bettridge, S., C. S. Baker, J. Barlow, P. J. Clapham, M. Ford, D. Gouveia, D. K. Mattila, R. M. Pace III, P. E. Rosel, G. K. Silber, and P. R. Wade. 2015. Status review of the humpback whale (*Megaptera novaeangliae*) under the Endangered Species Act. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-540, 240 p.

Bradford, A. L. 2018. Injury determinations for marine mammals observed interacting with Hawaii and American Samoa longline fisheries during 2015-2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-PIFSC-70, 27 p. DOI: dx.doi.org/10.7289/V5/TM-PIFSC-70 .

Bradford, A. L., and K. A. Forney. 2017. Injury determinations for marine mammals observed interacting with Hawaii and American Samoa longline fisheries during 2010-2014. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-PIFSC-62, 28 p. DOI: dx.doi.org/10.7289/V5/TM-PIFSC-62 .

Bradford, A. L., and E. Lyman. 2018. Injury determinations for humpback whales and other cetaceans reported to NOAA Response Networks in the Hawaiian Islands during 2013-2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-PIFSC-75, 24 p.

Bradford, A. L., and E. G. Lyman. 2019. Injury determinations for humpback whales and other cetaceans reported to NOAA response networks in the Hawaiian Islands during 2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-PIFSC-81, 18 p. DOI: dx.doi.org/10.25923/7csm-h961 .

Calambokidis, J., G. H. Steiger, J. C. Cubbage, K. C. Balcomb III, and P. Bloedel. 1989. Biology of humpback whales in the Gulf of the Farallones. Report to Gulf of the Farallones National Marine Sanctuary, San Francisco, CA, by Cascadia Research Collective, 218½ West Fourth Avenue, Olympia, WA. 93 p.

Calambokidis, J., G. H. Steiger, and J. R. Evenson. 1993. Photographic identification and abundance estimates of humpback and blue whales off California in 1991-92. Final Contract Report 50ABNF100137 to Southwest Fisheries Science Center, La Jolla, CA 92037. 67 p.

Calambokidis, J., G. H. Steiger, J. M. Straley, T. Quinn, L. M. Herman, S. Cerchio, D. R. Salden, M. Yamaguchi, F. Sato, J. Urban R., J. Jacobson, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, N. Higashi, S. Uchida, J. K. B. Ford, Y. Miyamura, P. Ladrón de Guevara, S. A. Mizroch, L. Schlender, and K. Rasmussen. 1997. Abundance and population structure of humpback whales in the North Pacific basin. Final Contract Report 50ABNF500113 to Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, CA 92037. 72 p.

Calambokidis, J., G. H. Steiger, J. M. Straley, L. M. Herman, S. Cerchio, D. R. Salden, J. Urban R., J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladrón de Guevara P., M. Yamaguchi, F. Sato, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, and T. J. Quinn II. 2001. Movements and population structure of humpback whales in the North Pacific. Mar. Mammal Sci. 17(4):769-794.

Calambokidis, J., E. A. Falcone, T. J. Quinn, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R., D. Weller, B. H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney. 2008. SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final Report for Contract AB133F-03-RP-00078. 58 p.
Available online: http://www.cascadiaresearch.org/files/publications/SPLASH-contract-Report-May08.pdf . Accessed December 2019.

Cartwright, R., A. Venema, V. Hernandez, C. Wyels, J. Cesere, and D. Cesere. 2019. Fluctuating reproductive rates in Hawaii's humpback whales, *Megaptera novaeangliae*, reflect recent climate anomalies in the North Pacific. Roy. Soc. Open Sci. 6:181463. DOI: dx.doi.org/10.1098/rsos.181463 .

Clapham, P. J., and J. G. Mead. 1999. *Megaptera novaeangliae*. Mamm. Species 604:1-9.

Clapham, P. J., J. Barlow, M. Bessinger, T. Cole, D. Mattila, R. Pace, D. Palka, J. Robbins, and R. Seton. 2003. Abundance and demographic parameters of humpback whales from the Gulf of Maine, and stock definition relative to the Scotian Shelf. J. Cetacean Res. Manage. 5:13-22.

Darling, J. D. 1991. Humpback whales in Japanese waters. Ogasawara and Okinawa. Fluke identification catalog 1987-1990. Final Contract Report, World Wide Fund for Nature, Japan. 22 p.

Darling, J. D., and S. Cerchio. 1993. Movement of a humpback whale (*Megaptera novaeangliae*) between Japan and Hawaii. Mar. Mammal Sci. 1:84-89.

Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.

Doroshenko, N. V. 2000. Soviet catches of humpback whales (*Megaptera novaeangliae*) in the North Pacific, p. 48-95. *In* A. V. Yablokov and V. A. Zemsky (eds.), Soviet Whaling Data (1949-1979), Center for Russian Environmental Policy, Marine Mammal Council, Moscow.

Fleming, A., and J. Jackson. 2011. Global review of humpback whales (*Megaptera novaeangliae*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-474, 206 p.

Ford J. K. B., A. L. Rambeau, R. M. Abernethy, M. D. Boogaards, L. M. Nichol, and L. D. Spaven. 2009. An assessment of the potential for recovery of humpback whales off the Pacific coast of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/015. iv + 33 p.

Geraci, J. R., D. M. Anderson, R. J. Timperi, D. St. Aubin, G. A. Early, J. H. Prescott, and C. A. Mayo. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. Can. J. Fish. Aquat. Sci. 46(11):1895-1898. DOI: dx.doi.org/10.1139/f89-238 .

Hill, M. C., E. M. Oleson, S. Baumann-Pickering, A. M. Van Cise, A. D. Ligon, A. R. Bendlin, A. C. Ü, J. S. Trickey, and A. L. Bradford. 2016. Cetacean monitoring in the Mariana Islands Range Complex, 2015. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-16-01. 36 p. + appendix.

Ivashchenko, Y. V., R. L. Brownell, Jr., and P. J. Clapham. 2013. Soviet whaling in the North Pacific: revised catch totals. J. Cetacean Res. Manage. 13:59-71.

Johnson, J. H., and A. A. Wolman. 1984. The humpback whale, *Megaptera novaeangliae*. Mar. Fish. Rev. 46:30-37.

Johnston, D. W., M. E. Chapla, L. E. Williams, and D. K. Mattila. 2007. Identification of humpback whale *Megaptera novaeangliae* wintering habitat in the Northwestern Hawaiian Islands using spatial habitat modeling. Endang. Species Res. 3:249-257.

Manly, B. F. J. 2015. Incidental takes and interactions of marine mammals and birds in districts 6, 7 and 8 of the Southeast Alaska salmon drift gillnet fishery, 2012 and 2013. Final Report to NMFS Alaska Region. 52 p.

Mizroch, S. A., L. M. Herman, J. M. Straley, D. Glockner-Ferrari, C. Jurasz, J. Darling, S. Cerchio, C. Gabriele, D. Salden, and O. von Ziegesar. 2004. Estimating the adult survival rate of central North Pacific humpback whales. J. Mammal. 85(5):963-972.

Mobley, J. M., S. Spitz, R. Grotefendt, P. Forestell, A. Frankel, and G. Bauer. 2001. Abundance of humpback whales in Hawaiian waters: results of 1993-2000 aerial surveys. Report to the Hawaiian Islands Humpback Whale National Marine Sanctuary. 16 p.

Moore, S. E., J. M. Waite, N. A. Friday, and T. Honkalehto. 2002. Distribution and comparative estimates of cetacean abundance on the central and south-eastern Bering Sea shelf with observations on bathymetric and prey associations. Prog. Oceanogr. 55(1-2):249-262.

National Marine Fisheries Service (NMFS). 2012. Process for distinguishing serious from non-serious injury of marine mammals. 42 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-policies-guidance-and-regulations . Accessed December 2019.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed December 2019.

Neilson, J. L., C. M. Gabriele, A. S. Jensen, K. Jackson, and J. M. Straley. 2012. Summary of reported whale-vessel collisions in Alaskan waters. J. Mar. Biol. 2012: Article ID 106282. 18 p. DOI: dx.doi.org/10.1155/2012/106282 .

Nemoto, T. 1957. Foods of baleen whales in the northern Pacific. Sci. Rep. Whales Res. Inst. Tokyo 12:33-89.

Nemoto, T. 1959. Food of baleen whales with reference to whale movements. Sci. Rep. Whales Res. Inst. 14:149-290.

Perry, A., C. S. Baker, and L. M. Herman. 1990. Population characteristics of individually identified humpback whales in the central and eastern North Pacific: a summary and critique. Rep. Int. Whal. Comm. (Special Issue 12):307-317.

Rice, D. W. 1978. The humpback whale in the North Pacific: distribution, exploitation and numbers, Appendix 4, p. 29-44. *In* K. S. Norris and R. R. Reeves (eds.), Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii. U.S. Dep. Commer., Natl. Tech. Info. Serv. PB-280794. Springfield, VA.

Rice, D. W. 1998. Marine Mammals of the World: Systematics and Distribution. Soc. Mar. Mammal. Spec. Publ. No. 4.

Springer, A. M., G. B. van Vliet, J. F. Piatt, and E. M. Danner. 2006. Whales and whaling in the North Pacific Ocean and Bering Sea: oceanographic insights and ecosystem impacts, p. 245-261. *In* J. A. Estes, R. L. Brownell, Jr., D. P. DeMaster, D. F. Doak, and T. M. Williams (eds.), Whales, Whaling and Ocean Ecosystems. University of California Press. 418 p.

Steiger, G. H., J. Calambokidis, R. Sears, K. C. Balcomb, and J. C. Cubbage. 1991. Movement of humpback whales between California and Costa Rica. Mar. Mammal Sci. 7:306-310.

Straley, J. M., C. M. Gabriele, and T. J. Quinn II. 2009. Assessment of mark recapture models to estimate the abundance of a humpback whale feeding aggregation in Southeast Alaska. J. Biogeogr. 36:427-438.

Taylor, B. L., M. Scott, J. Heyning, and J. Barlow. 2003. Suggested guidelines for recovery factors for endangered marine mammals. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-354, 6 p.

Teerlink, S. F., O. von Ziegesar, J. M. Straley, T. J. Quinn II, C. O. Matkin, and E. L. Saulitis. 2015. First time series of estimated humpback whale (*Megaptera novaeangliae*) abundance in Prince William Sound. Environ. Ecol. Stat. 22:345. DOI: dx.doi.org/10.1007/s10651-014-0301-8 .

Tomlin, A. G. 1967. Mammals of the USSR and Adjacent Countries. Vol. 9. Cetacea. Israel Program for Scientific Translations No. 1124, Natl. Tech. Info. Serv. TT 65-50086. Springfield, VA. 717 p. (Translation of Russian text published in 1957.)

Waite, J. M., M. E. Dahlheim, R. C. Hobbs, S. A. Mizroch, O. von Ziegesar-Matkin, J. M. Straley, L. M. Herman, and J. Jacobsen. 1999. Evidence of a feeding aggregation of humpback whales (*Megaptera novaeangliae*) around Kodiak Island, Alaska. Mar. Mammal Sci. 15:210-220.

Witteveen, B. H., J. M. Straley, O. von Ziegesar, D. Steel, and C. S. Baker. 2004. Abundance and mtDNA differentiation of humpback whales (*Megaptera novaeangliae*) in the Shumagin Islands, Alaska. Can. J. Zool. 82:1352-1359.

Zenkovich, B. A. 1954. Vokrug sveta za kitami, Vol. Gosudarstvennoe Izdatel'stvo Geograficheskoi Literatury, Moscow.

Zerbini, A. N., J. M. Waite, J. L. Laake, and P. R. Wade. 2006. Abundance, trends and distribution of baleen whales off western Alaska and the central Aleutian Islands. Deep-Sea Res. I 53(11):1772-1790.