Revised 04/15/2020

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

STOCK DEFINITION AND GEOGRAPHIC RANGE

NMFS has conducted a global Status Review of humpback whales and recently revised the ESA listing of the species (Bettridge *et al*. 2015, NOAA 2016a). 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.

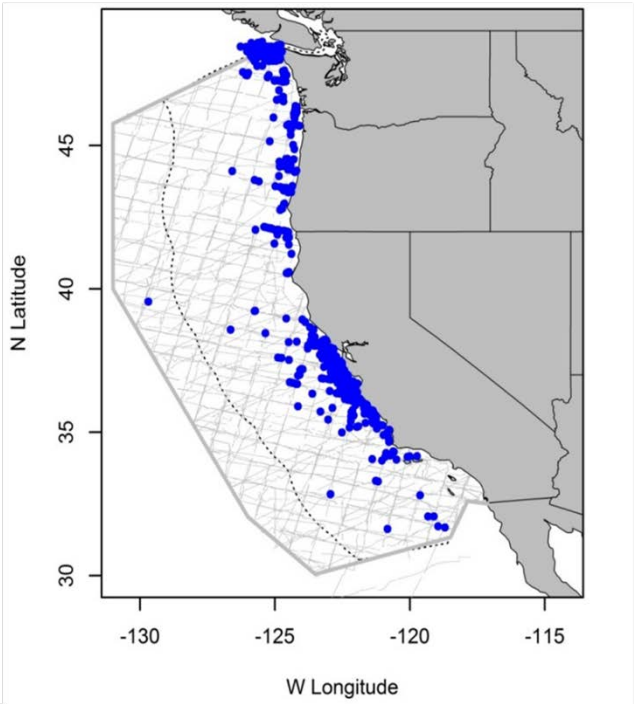

Figure 1. Humpback whale sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2014. Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined.

North Pacific 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 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: 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 occurs rarely, 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 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*. 2013). Among breeding areas, the greatest level of differentiation was found between Okinawa and Central America and most other breeding grounds (Baker *et al*. 2013). 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*. 2013).

Along the U.S. West Coast, NMFS currently recognizes one humpback whale stock that includes two separate feeding groups: (1) a California and Oregon feeding group of whales that includes whales from the endangered Central American and threatened Mexican distinct population segments (DPSs) defined under the ESA (NOAA 2016a), and (2) a northern Washington and southern British Columbia feeding group that primarily includes whales from the threatened Mexican DPS, but also small numbers of whales from the unlisted Hawaii and endangered Central American DPSs (Calambokidis *et al*. 2008, Barlow *et al*. 2011, Wade *et al*. 2016, Wade 2017). Very few photographic matches between these feeding groups are documented (Calambokidis *et al*. 2008). Calambokidis *et al*. (2017) report that approximately 70% of whales photographed in the southern Mexico and Central America breeding grounds have been matched to California and Oregon waters. 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. Humpback whales have increasingly reoccupied areas inside of Puget Sound (the 'Salish Sea'), a region where they were historically abundant prior to whaling (Calambokidis *et al*. 2017). Sightings from large-scale research vessel surveys are largely concentrated near shelf waters (Fig. 1).

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 Pacific region stock assessment reports: (1) Central North Pacific Stock (with feeding areas from Southeast Alaska to the Alaska Peninsula), (2) Western North Pacific Stock (with feeding areas from the Aleutian Islands, the Bering Sea, and Russia), and (3) American Samoa Stock in the South Pacific (with largely undocumented feeding areas as far south as the Antarctic Peninsula). The relationship of MMPA stocks to ESA distinct population segments (DPSs) is complex. Whales from three different DPSs (Central America, Mexico, and Hawaii) are included in the MMPA stock identified in this report as the "California/Oregon/Washington Stock". Most humpbacks that feed in California and Oregon waters in summer originate from the threatened Mexico DPS, while a much smaller fraction originate from the endangered Central American DPS (Wade *et al.* 2016, Wade 2017). In Washington and southern British Columbia waters, all three DPSs (Hawaii, Mexico, and Central America) occur. Appropriate risk assessment for both MMPA stocks and ESA DPSs requires a combination of appropriate stock delineation and PBR calculation under the MMPA, which is currently pending. Also, assignment of observed and estimated anthropogenic impacts to the appropriate DPS and MMPA stocks will be required where possible (NMFS 2016).

POPULATION SIZE

Based on whaling data, the pre-1905 population of humpback whales in the North Pacific was estimated at 15,000 (Rice 1978), but whaling reduced this population to approximately 1,200 whales by 1966 (Johnson and Wolman 1984). A 2004 to 2006 photo-identification study estimated humpback whale abundance in the entire Pacific Basin at 21,808 (CV=0.04) (Barlow *et al*. 2011). Barlow (2016) estimated 3,064 (CV= 0.82) humpback whales from a 2014 summer/fall ship line-transect survey of California, Oregon, and Washington waters. Line-transect estimates of humpback whales in this region have less precision than corresponding estimates from mark-recapture studies, and for that reason, estimates of population size for this stock are based on mark-recapture estimates detailed below.

Abundance estimates from photographic mark-recapture surveys in California and Oregon waters every year from 1991 through 2014 represent the most precise estimates (Calambokidis *et al*. 2017). These estimates include only whales photographed in California and Oregon waters and exclude whales from the Washington state and southern British Columbia feeding group (Calambokidis *et al*. 2009, 2017a). California and Oregon estimates range from 1,400 to 2,400 animals, depending on the choice of mark-recapture model and sampling period (Fig. 2). The best estimate of abundance for California and Oregon waters is the 2011 to 2014 Chao estimate of 2,374 (CV=0.03) whales. This estimate is considered the best of those mark-recapture estimates reported because it accounts for individual capture heterogeneity (Calambokidis *et al*. 2017). This estimate includes virtually the entire Central American DPS, which, depending on choice of mark-recapture model, was estimated to include between 431 (CV=0.34) and 783 (CV=0.17) whales, based on 2004 to 2006 photographic mark-recapture data (Wade *et al*. 2016, Wade 2017). However, abundance estimates for the Central American DPS are ≥ 8 years old and are not considered reliable estimates of current abundance (NOAA 2016b).

Calambokidis *et al*. (2017) estimated the northern Washington and southern British Columbia feeding group population size to be 526 (CV=0.23) animals based on 2013 and 2014 mark-recapture data.

Combining abundance estimates from both the California/Oregon and Washington/southern British Columbia feeding groups (2,374 + 526) yields an estimate of 2,900 animals for the California/Oregon/Washington stock. A coefficient of variation for both feeding groups combined can be calculated as a weighted-mean CV of the 2 estimates, or $CV_{N1+N2} = \text{sqrt}((CV_1*N1)^2 + (CV_2*N2)^2) / (N1+N2)$ or CV = 0.048.

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 2,784 whales.

Current Population Trend

Ship surveys indicate that humpback whale abundance probably increased in California waters between 1979/80 and 1991 (Barlow 1994) and between 1991 and 2014 (Barlow 2016), but this increase was not linear, and short-term declines were apparent in 2001 and 2008. Mark-recapture population estimates had shown a long-term

increase of approximately 8% per year (Calambokidis *et al*. 2009, Fig. 2), but more recent estimates suggest a possible leveling-off of the population size (Fig. 2), depending on the choice of model and time frame used (Calambokidis and Barlow 2013, Calambokidis *et al*. 2017). Population estimates for the entire North Pacific have also increased substantially from 1,200 in 1966 to approximately 18,000 to 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 the 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 between 1995 and 1997 a greater proportion of calves were identified, and the 1997 reproductive rates for this population were closer to those reported for other humpback whale populations (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.

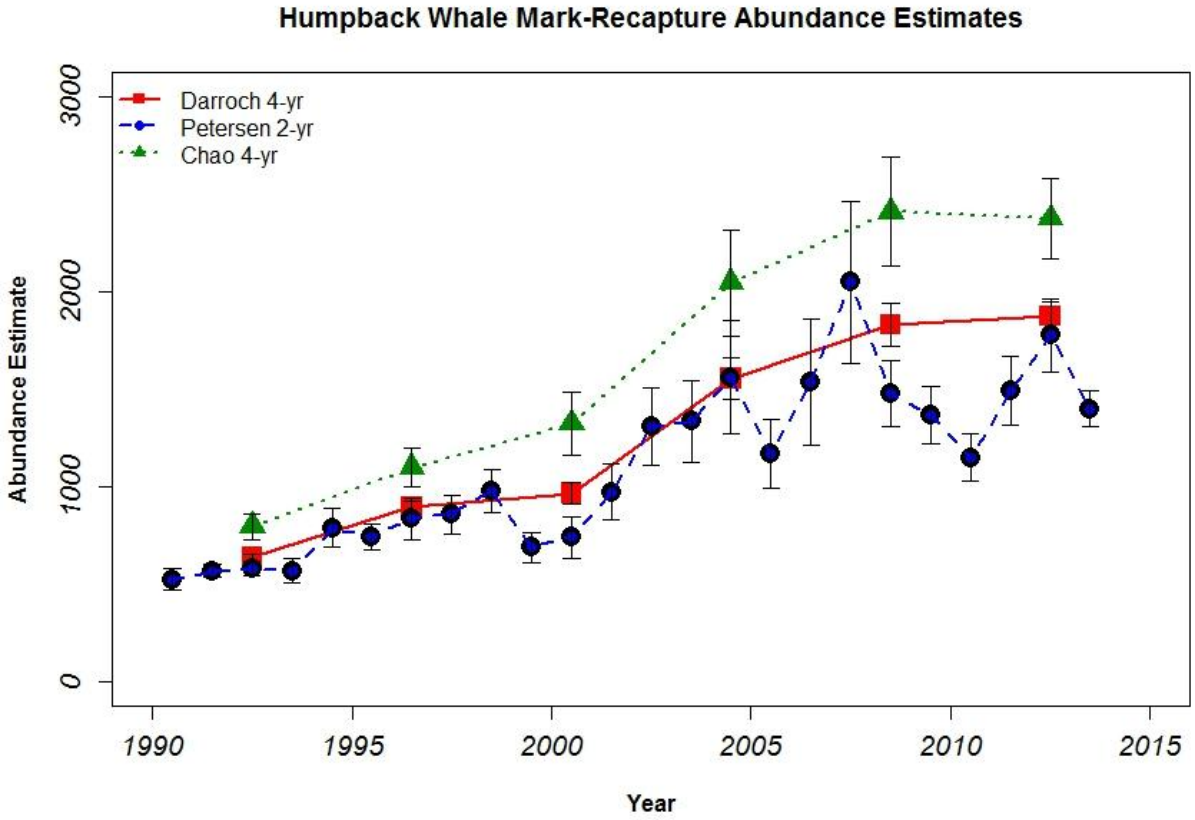

Figure 2. Mark-recapture estimates of humpback whale abundance in California and Oregon, 1991-2014, based on 3 different mark-recapture models and sampling periods (Calambokidis *et al*. 2017). Vertical bars indicate ±2 standard errors of each abundance estimate. Darroch and Chao models use 6 consecutive non-overlapping sample years. Estimates of humpback whale abundance in Washington and southern British Columbia waters are not shown, but the most-recent estimate is 526 (CV=0.23) whales for the 2-year period 2013-2014 (Calambokidis *et al*. 2017).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (2,784) 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; with N_{min} > 1,500 and CV(N_{min}) < 0.50, Taylor *et al*. 2003), resulting in a PBR of 33.4. Because this stock spends approximately half its time outside the U.S. Exclusive Economic Zone

(EEZ), the PBR in U.S. waters is 16.7 whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

A total of 138 human-related interactions involving humpback whales are summarized for the five-year period of 2013 to 2017 by Carretta *et al.* (2019a). These records include serious injuries, non-serious injuries, and mortality involving pot/trap fisheries (n=62), unidentified fishery interactions (56), vessel strikes (14), gillnet fisheries (4) and marine moorings (1). The number of serious injuries and mortalities in each category are summarized below. In addition to interactions with humpback whales, 20 entanglements involving 'unidentified whales' (totaling 15.5 serious injuries and mortalities) occurred from 2013 to 2017, some of which were certainly humpback whales (Carretta 2018, Carretta *et al*. 2019a). The number of human-related deaths and injuries for each humpback whale feeding group are unknown, but based on the proportion of the overall abundance (2,900 whales) belonging to the California-Oregon (82%) and Washington and southern British Columbia (18%) feeding groups, a majority of cases likely involve whales from the California-Oregon feeding group that includes nearly all of the Central American DPS (Calambokidis *et al*. 2017).

Fishery Information

Pot and Trap Fisheries

Pot and trap fishery entanglements are the most frequently-documented source of serious injury and mortality of humpback whales in U.S. west coast waters and reported entanglements increased considerably in 2014 (Carretta *et al*. 2013, 2019a). From 2013 to 2017, 62 observed interactions with pot and trap fisheries were observed (Carretta *et al.* 2019a). Two records include serious injuries totaling 1.75 whales in recreational Dungeness crab pot gear and one record includes a serious injury in Washington tribal crab pot gear, which are excluded from Table 1 commercial fishery totals, but are summarized in the 'Other Mortality' section of this report. Nineteen records involved non-serious injuries resulting from human intervention to remove gear, or cases where animals were able to free themselves. Three records involved dead whales, including one humpback recovered in sablefish pot gear in Oregon, one case where severed humpback flukes were found entangled in California Dungeness crab gear (whale presumed dead) and a third case of an entangled humpback in California Dungeness crab gear in declining health that was detected over several months, before eventually being found dead without attached gear. This was a well-marked individual that was readily identifiable by the whale-watching community (Carretta *et al.* 2019a). The remaining 37 pot/trap fishery injury cases, once evaluated per the NMFS serious injury policy, resulted in a total of 30.75 serious injuries / 5 years, or 6.15 humpback whales annually (Table 1). Documented five-year mortality, serious injury, plus prorated injury totals (*i.e.* entangled humpback whales with an injury score < 1) for pot/trap fisheries, in order of frequency are: California Dungeness crab pot (19.25), unidentified pot/trap fishery (7.0), Washington/Oregon/California sablefish pot fishery (2.5), California spot prawn (2.5), Washington Dungeness crab pot (1.75), and Oregon Dungeness crab pot (0.75) (Table 1). The totals above represent minimum observed cases from opportunistic at-sea sightings or stranding records, except for bycatch estimates based on systematic observer program data. It is recognized that entanglement totals do not represent all cases due to incomplete detection of incidents and no method is currently available to correct for undetected entanglements. An effort is made where possible to account for this negative bias. For example, total entanglement mortality and serious injury in the WA/OR/CA sablefish pot fishery is parsed out into statistical estimates from observer program data and opportunistically-detected records derived from strandings and at-sea sightings linked to the same fishery. In this case, the annual statistical bycatch estimates and at-sea and stranding observations are nearly-equal, despite the fact that the latter category is uncorrected for undetected cases. In commercial pot and trap fisheries, the mean annual mortality and serious injury between 2013 and 2017 is the sum of observer program derived estimates (9.5), plus opportunistically detected animals (32.75) = 42.25 whales / 5 years = 8.45 whales.

Gillnet and Unidentified Fisheries

Gillnet (n= 4) and unidentified fisheries (n= 56) accounted for 60 humpback whale interactions between 2013 and 2017 (Carretta *et al.* 2019a). 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 gear (Carretta *et al*. 2019a). Three records involved dead whales. The remaining 57 records, once evaluated per the NMFS serious injury policy, resulted in six non-serious injuries and 41.25 serious injuries. The total annual mortality and serious injury due to unidentified and gillnet fisheries is the sum of observed deaths (3) and serious injuries (41.25), or 44.25 whales. The five-year annual mean serious injury and mortality due to gillnet and unidentified fisheries during

2013 to 2017 is therefore 44.25 / 5 = 8.85 whales.

Table 1. Observed and estimated incidental mortality and serious injury of humpback whales (California/Oregon/Washington stock) in commercial fisheries that are likely to take this species (Carretta *et al.*, 2019a, 2019b, Jannot *et al*. 2018). Mean annual takes are based on 2013 to 2017 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 + Serious Injury	Estimated mortality and serious injury (CV)	Mean Annual mortality and serious injury (CV)
WA/OR/CA Sablefish Pot	2012 2013 2014 2015 2016	observer	35% 14% 31% 61% 71%	0 0 1 0 0	0.12 (n/a) 0.19 (n/a) 1.15 (n/a) 0.08 (n/a) 0.06 (n/a)	0.32 (n/a)
WA/OR/CA Sablefish Pot	2013-2017	Strandings / sightings	n/a	0 + 1.5	n/a[1]	≥ 0.30 (n/a)
Open Access Fixed Gear Pot	2012 2013 2014 2015 2016	observer	7% 9% 8% 6% 7%	0 0 0 0 0 + 0.75	1.12 (n/a) 0.67 (n/a) 1.3 (n/a) 2.03 (n/a) 2.76 (n/a)	1.58 (n/a)
CA swordfish and thresher shark drift gillnet fishery	2013-2017	observer	23%	0[2]	<0.1 (1.9)	<0.1 (1.9)
CA halibut/white seabass and other species large mesh (≥3.5") set gillnet fishery	2013-2017	observer	<10%	0	0	0 (n/a)
CA spot prawn pot	2013-2017	Strandings / sightings	n/a	0 + 2.5	n/a	≥ 0.50 (n/a)
Unspecified pot or trap fisheries (includes generic 'Dungeness' crab gear not attributed to a specific state fishery)	2013-2017	Strandings / sightings	n/a	0 + 7.0	n/a	≥ 1.4 (n/a)
CA Dungeness crab pot	2013-2017	Strandings / sightings	n/a	2 + 17.25	n/a	≥ 3.85 (n/a)
OR Dungeness crab pot[3]	2013-2017	Strandings / sightings	n/a	0 + 0.75	n/a	≥ 0.15 (n/a)
WA Dungeness crab pot	2013-2017	Strandings / sightings	n/a	0 + 1.75	n/a	≥ 0.35(n/a)
unidentified fisheries (includes 'unidentified gillnet')	2013-2017	Strandings / sightings	n/a	3 + 41.25	n/a	≥ 8.85 (n/a)
Total Annual Takes						≥ 17.3 (n/a)

Three humpback whale entanglements (all released alive) were observed in the CA swordfish drift gillnet fishery from 8,956 fishing sets monitored between 1990 and 2017 (Carretta *et al.* 2019b). Some opportunistic sightings of free-swimming humpback whales entangled in gillnets may originate from this fishery. The most recent model-based estimate of humpback whale bycatch in this fishery for 2013 to 2017 is 0.2 whales (CV=1.2), but due to three of four observations resulting in non-serious injury releases from gear, it is estimated that only one-quarter of these entanglements represent serious injuries (Carretta *et al.* 2019b). The corresponding ratio estimate of bycatch for the same time period is zero (Carretta *et al.* 2019b). The model-based estimate is considered superior because it utilizes

[1] No estimate of total bycatch has been generated for this fishery.

[2] There were no observations of humpback whales in this fishery during 2013-2017, but the model-based estimate of bycatch for this period results in a positive estimate of bycatch (Carretta *et al*. 2019b).

[3] There were 3 additional non-serious injuries involving humpback whales that were successfully disentangled from OR Dungeness crab pot gear between 2013 and 2017; these would have been serious injuries without the disentanglement response.

all 28 years of data for estimation, in contrast to the ratio estimate that uses only 2013 to 2017 data. The average annual estimated serious injury and mortality in the CA swordfish drift gillnet fishery is <0.1 whales.

Unidentified whales represent approximately 15% of entanglement cases along the U.S. West Coast, (Carretta 2018). Observed entanglements may lack species identifications (IDs) due to rough seas, distance from whales, or a lack of cetacean identification expertise. In older stock assessments, these unidentified entanglements were not assigned to species, which results in underestimation of entanglement risk, especially for commonly-entangled species. To remedy this negative bias, a cross-validated species identification model was developed from known-species entanglements ('model data'). The model is based on several variables (location + depth + season + gear type + sea surface temperature) found to be statistically-significant predictors of known-species entanglement cases (Carretta 2018). The species model was used to assign species ID probabilities for 20 unidentified whale entanglement cases ('novel data') from 2013 to 2017 (Carretta 2018). The sum of species assignment probabilities for this five-year period result in an additional 13.7 humpback whale entanglements for 2013 to 2017. Unidentified whale entanglements typically involve whales seen at-sea with unknown gear configurations that are prorated to represent 0.75 serious injuries per entanglement case. Thus, it is estimated that at least 13.7 x 0.75 = 10.3 additional humpback serious injuries are represented from the 20 unidentified whale entanglement cases, or 2.1 humpback whales annually.

Total commercial fishery serious injury and mortality of humpback whales from 2013 to 2017 is the sum of pot/trap fishery records (42.25), plus gillnet and unidentified fishery records (44.25), plus prorated unidentified whale entanglements (10.3), or 96.8 total whales. The mean annual serious injury and mortality (observed and estimated) from commercial fisheries is 96.8 whales / 5 years = 19.4 whales from 2013 to 2017 (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 11.5 additional serious injuries over the five-year period 2013 to 2017, or an additional 2.3 humpback whales annually (Carretta *et al.* 2019a).

Ship Strikes

Fourteen humpback whales (totaling eight deaths, 2.8 serious injuries, and two non-serious injuries) were reported struck by vessels between 2013 and 2017 (Carretta *et al.* 2019a). The observed average annual serious injury and mortality of humpback whales due to ship strikes is 2.2 whales per year (eight deaths, plus 2.8 serious injuries = 10.8 / 5 years). Ship strike mortality was estimated for humpback whales in the U.S. West Coast EEZ (Rockwood *et al*. 2017), using an encounter theory model (Martin *et al.* 2016) that combined species distribution models of whale density (Becker *et al*. 2016), vessel traffic characteristics (size + speed + spatial use), and whale movement patterns obtained from satellite-tagged animals in the region to estimate whale/vessel interactions that would result in mortality. The estimated number of annual ship strike deaths was 22 humpback whales, though this includes only the period July – November when whales are most likely to be present in the U.S. West Coast EEZ and the time of year that overlaps with cetacean habitat models generated from line-transect surveys (Becker *et al*. 2016, Rockwood *et al*. 2017). This estimate was based on an assumption of a moderate level of vessel avoidance (55%) by humpback whales, as measured by the behavior of satellite-tagged whales in the presence of vessels (McKenna *et al*. 2015). The estimated mortality of 22 humpback whales annually due to ship strikes represents approximately 0.7% of the estimated population size of the stock (22 deaths / 2,900 whales). The results of Rockwood *et al*. (2017) also include a no-avoidance encounter model that results in a worst-case estimate of 48 annual humpback whale ship strike deaths, representing 1.6% of the estimated population size. The number of vessel strikes attributable to each breeding ground DPS (Central America, Mexico) is unknown. Using the moderate level of avoidance model from Rockwood *et al.* (2017), estimated vessel strike deaths of humpback whales are 22 per year. A comparison of average annual vessel strikes observed over the period 2013 to 2017 (2.2/yr) *versus* estimated vessel strikes (22/yr) indicates that the rate of reporting for humpback whale vessel strikes is approximately 10%.

Vessel strikes within the U.S. West Coast EEZ continues to be a threat to all large whale populations (Redfern *et al*. 2013; 2019; Moore *et al*. 2018). However, a complex of vessel types, speeds, and destination ports all contribute to variability in ship traffic and these factors may be influenced by economic and regulatory changes. For example, Moore *et al*. (2018) found that primary routes travelled by ships changed when emission control areas (ECAs) were established off the U.S. West Coast. They also found that large vessels typically reduced their speed by 3-6 kts in ECAs between 2008 and 2015. The speed reductions are thought to be a strategy to reduce operating costs associated with more expensive, cleaner burning fuels required within the ECAs. In contrast, Moore *et al*. (2018) noted that some vessels increased their speed when they transited longer routes to avoid the ECAs. Further research is necessary to

understand how variability in vessel traffic affects ship strike risk and mitigation strategies, though Redfern *et al*. (2019) note that a combination of vessel speed reductions and expansion of areas to be avoided should be considered.

Other human-caused mortality and serious injury

A humpback whale was entangled in a research marine mooring buoy in 2014. The whale is estimated to have been entangled for three weeks and had substantial necrotic tissue around the caudal peduncle. Although the whale was fully disentangled, this animal was categorized as a serious injury 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.* 2019a). Additionally, two humpback whales were entangled in recreational Dungeness crab pot gear, resulting in a total of 1.75 serious injuries (Carretta *et al.* 2019a). One humpback whale was entangled and seriously-injured in Washington tribal crab pot gear in 2017 (Carretta *et al.* 2019a). The total number of serious injuries from marine moorings (1), recreational fisheries (1.75), and tribal fisheries (1) from 2013 to 2017 is 3.75 whales, or 0.75 whales annually.

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, is a habitat concern for whales, as it can reduce acoustic space used for communication (masking) (Clark *et al.* 2009, NOAA 2016c). 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).

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 U.S. Endangered Species Conservation Act of 1969. This protection was transferred to the U.S. 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 observed annual mortality and serious injury due to commercial fishery entanglements in 2013 to 2017 (17.3/yr) (Table 1), non-fishery entanglements (0.2/yr), recreational crab pot fisheries (0.35/yr), tribal fisheries (0.2/yr), serious injuries assigned to unidentified whale entanglements (2.1/yr), plus observed ship strikes (2.2/yr), equals 22.35 animals, which exceeds the PBR in U.S. waters of 16.7 animals. *Estimated* vessel strike deaths are 22 humpback whales annually (Rockwood *et al*. 2017), but this does not include vessel strikes that occur outside of the U.S. West Coast EEZ. Using this estimate of vessel strike deaths instead of the observed 2.2/yr observed value noted above, the total annual human-caused mortality of humpback whales is the sum of commercial fishery (17.3) + recreational fishery (0.35) + tribal fishery (0.2/yr) + non-fishery entanglements (0.2/yr) + serious injuries assigned to unidentified whale entanglements (2.1/yr) + vessel strikes (22/yr) or 42.1 humpback whales annually. This exceeds the range-wide PBR estimate of 33.4 humpback whales. Other than the vessel strike estimates, 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 undocumented fraction of anthropogenic injuries and deaths to humpback whales on the U.S. west coast, but for vessel strikes, a comparison of observed vs. estimated annual vessel strikes suggests that approximately 10% of vessel strikes are documented. Based on strandings and at-sea observations, annual humpback whale mortality and serious injury in commercial fisheries (17.3/yr) exceeds 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 through 2014 indicate a leveling-off of the population size (Calambokidis *et al.* 2017).

REFERENCES

Andrew, R. K., B. M. Howe, J. A. Mercer, and M. A. Dzieciuch. 2002. Ocean ambient sound: comparing the 1960's with the 1990's for a receiver off the California coast. Acoustic Research Letters Online 3:65-70.

Au,W.W.L., A.A. Pack, M.O. Lammers, L.M. Herman, M.H. Deakos, K. Andrews. Acoustic properties of humpback whale songs. J. Acoust. Soc. Am. 120 (2), August 2006.

Baker, C.S., D. Steel, J. Calambokidis, E.A. Falcone, U. González-Peral, J. Barlow, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, U. González-Peral, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán-R., P. Wade, D. Weller, B.H. Witteveen and M. Yamaguchi. 2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Marine Ecology - Progress Series 494:291-306.

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. 7:695-708.

Barlow, Jay, J. Calambokidis, E.A. Falcone, C.S. Baker, A.M. Burdin, P.J. Clapham, J.K.B. Ford *et al*. 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. *Marine Mammal Science* 27:793-818.

Barlow, J. 2016. Cetacean abundance in the California Current estimated from ship-based line-transect surveys in 1991-2014. Draft document PSRG-2016-06 presented to the Pacific Scientific Review Group, 25-26 February 2016, Seattle, WA.

Barlow, J. 1994. Abundance of large whales in California coastal waters: a comparison of ship surveys in 1979/80 and in 1991. Rept. Int. Whal. Commn. 44:399-406.

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

Calambokidis, J., J. Barlow, K. Flynn, E. Dobson, and G.H. Steiger. 2017. Update on abundance, trends, and migrations of humpback whales along the US West Coast. International Whaling Commission Paper SC/A17/NP/13. 17 p.

Calambokidis, J., G.H. Steiger, C. Curtice, J. Harrison, M.C. Ferguson, E. Becker, M. DeAngelis, and S.M. Van Parijs. 2015. Biologically Important Areas for Selected Cetaceans Within U.S. Waters – West Coast Region. Aquatic Mammals 41(1):39-53, DOI 10.1578/AM.41.1.2015.39

Calambokidis, J. and J. Barlow. 2013. Updated abundance estimates of blue and humpback whales off the US west coast incorporating photo-identifications from 2010 and 2011. Document PSRG-2013-13 presented to the Pacific Scientific Review Group, April 2013. 7 p.

Calambokidis, J., E. Falcone, A. Douglas, L. Schlender, and J. Huggins. 2009. Photographic identification of humpback and blue whales off the U.S. West Coast: results and updated abundance estimates from 2008 field season. Final Report for Contract AB133F08SE2786 from Southwest Fisheries Science Center. 18pp.

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. Urban, 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 from Cascadia Research.

Calambokidis J., Steiger G.H., Straley J.M. *et al.* 2001. Movements and population structure of humpback whales in the North Pacific. *Marine Mammal Science* 17:769-794.

Calambokidis, J., T. Chandler, K. Rasmussen, G. H. Steiger, and L. Schlender. 1999. Humpback and blue whale photo-identification research off California, Oregon and Washington in 1998. Final Contract Report to Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 35 pp.

Calambokidis, J., T. Chandler, L. Schlender, G. H. Steiger, and A. Douglas. 2003. Research on humpback and blue whale off California, Oregon and Washington in 2002. Final Contract Report to Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 49 pp.

Calambokidis, J., and G. H. Steiger. 1994. Population assessment of humpback and blue whales using photo-identification from 1993 surveys off California. Final Contract Report to Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA 92038. 31pp.

Calambokidis, J., G. H. Steiger, J. R. Evenson, K. R. Flynn, K. C. Balcomb, D. E. Claridge, P. Bloedel, J. M. Straley, C. S. Baker, O. von Ziegesar, M. E. Dahlheim, J. M. Waite, J. D. Darling, G. Ellis, and G. A. Green. 1996. Interchange and isolation of humpback whales in California and other North Pacific feeding grounds. Mar.

Mamm. Sci. 12(2):215-226.
Carretta, J.V., S. Wilkin, M.M. Muto, and K. Wilkinson. 2013. Sources of human-related injury and mortality for U.S. Pacific West Coast marine mammal stock assessments, 2007-2011. NOAA-TM-NMFS-SWFSC-514. 91 p.
Carretta, J.V. 2018. A machine-learning approach to assign species to 'unidentified' entangled whales. Endangered Species Research Vol. 36: 89–98.
Carretta J.V., V. Helker, M.M. Muto, J. Greenman, K.Wilkinson, D. Lawson, J. Viezbicke, and J. Jannot. 2019a. Sources of Human-related Injury and Mortality for U.S. Pacific West Coast Marine Mammal Stock Assessments, 2013-2017. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-616. 150 p.
Carretta, J.V., J.E. Moore, and K.A. Forney. 2019b. Estimates of marine mammal, sea turtle, and seabird bycatch from the California large-mesh drift gillnet fishery: 1990-2017. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-619. 76 p.
Clapham, P. J., S. Leatherwood, I. Szczepaniak, and R. L. Brownell, Jr. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Marine Mammal Science 13(3):368-394.
Clark C.W., Ellison W.T., Southall B.L., Hatch L.T., Van Parijs S.M., Frankel A., Ponirakis D. (2009) Acoustic masking in marine ecosystems: intuitions, analysis and implication. Mar. Ecol. Prog. Ser. 395:201–22.
Erbe, C., Reichmuth C., Cunningham K. , Lucke K., Dooling R. (2016) Communication masking in marine mammals: A review and research strategy. Mar. Poll. Bull. 103 (1–2): 15–38.
Fleming, A. and J. Jackson. 2011. Global review of humpback whales (*Megaptera novaeangliae*). U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-474, 206 pp.
Hauser, D.S., D.A. Helweg, and P.W.B. Moore, 2001. A bandpass filter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals 27:82-91.
Jackson, J. A., D. J. Steel, P. Beerli, B. C. Congdon, C. Olavarria, M. S. Leslie, C. Pomilla, H. Rosenbaum and C. S. Baker. 2014. Global diversity and oceanic divergence of humpback whales (*Megaptera novaeangliae*). Proceedings of the Royal Society B 281, 20133222:1-10.
Jannot, J.E., K.A. Somers,V. Tuttle, J. McVeigh, J.V. Carretta, and V. Helker. 2018. Observed and Estimated Marine Mammal Bycatch in U.S. West Coast Groundfish Fisheries, 2002–16. U.S. Department of Commerce, NWFSC Processed Report 2018-03.
Johnson, J. H., and A. A. Wolman. 1984. The humpback whale, *Megaptera novaeangliae*. Mar. Fish. Rev. 46(4):30-37.
Lien, J., S. Todd and J. Guigne. 1990. Inferences about perception in large cetaceans, especially humpback whales, from incidental catches in fixed fishing gear, enhancement of nets by "alarm" devices, and the acoustics of fishing gear. P. 347-362 *in* J.A. Thomas, R.A. Kastelein and A.Ya. Supin (eds.), Marine mammal sensory systems. Plenum, New York.
Lien, J., W. Barney, S. Todd, R. Seton and J. Guzzwell. 1992. Effects of adding sounds to cod traps on the probability of collisions by humpback whales. P. 701-708 *in* J.A. Thomas, R.A. Kastelein and A.Ya. Supin (eds.), Marine mammal sensory systems. Plenum, New York.
Martin, J., Sabatier, Q., Gowan, T.A., Giraud, C., Gurarie, E., Calleson, C.S., Ortega-Ortiz, J.G., Deutsch, C.J., Rycyk, A. and Koslovsky, S.M., 2016. A quantitative framework for investigating risk of deadly collisions between marine wildlife and boats. Methods in Ecology and Evolution, 7(1), pp.42-50.
Maybaum, H.L. 1993. Responses of humpback whales to sonar sounds. J. Acoust. Soc. Am. 94(3, Pt. 2): 1848-1849.
Moore, T.J., J.V. Redfern, M. Carver, S. Hastings, J.D. Adams, and G.K. Silber. 2018. Exploring ship traffic variability off California. Ocean and Coastal Management 163:515-527.
NMFS. 2016. West Coast Region's Endangered Species Act Implementation and considerations about "take" given the September 2016 humpback whale DPS status review and species-wide revision of listings. Paper PSRG-2017-B03 reviewed by the Scientific Review Group. Honolulu, Hawaii, February 2017.
NOAA. 2012. Federal Register 77:3233. National Policy for Distinguishing Serious From Non-Serious Injuries of Marine Mammals.
NOAA. 2016a. Federal Register Final Rule 9/8/2016. Endangered and Threatened Species; Identification of 14 Distinct Population Segments of the Humpback Whale (*Megaptera novaeangliae*) and Revision of Species-Wide Listing.
NOAA 2016b. Guidelines for Preparing Stock Assessment Reports Pursuant to Section 117 of the Marine Mammal Protection Act.
NOAA. 2016c. NOAA Ocean Noise Strategy Roadmap.
Rice, D. W. 1974. Whales and whale research in the eastern North Pacific. pp. 170-195 In: W. E. Schevill (ed.). The

Whale Problem: A Status Report. Harvard Press, Cambridge, MA.
Rice, D. W. 1978. The humpback whale in the North Pacific: distribution, exploitation, and numbers. pp. 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. Contr. Rept. to U. S. Marine Mammal Commn. NTIS PB-280-794. 90pp.
Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press.
Rockwood, R.C., J. Calambokidis, J. Jahncke. 2017. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. PLoS ONE 12(8): e0183052.
Taylor, B.L., M. Scott, J. Heyning, and J. Barlow. 2003. Suggested guidelines for recovery factors for endangered marine mammals. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-SWFSC-354. 6p.
Tonnessen, J. N., and A. O. Johnsen. 1982. The History of Modern Whaling. Univ. Calif. Press, Berkeley and Los Angeles. 798pp.7:306-310.
U.S. Department of the Navy (Navy). 2007. Composite Training Unit Exercises and Joint Task Force Exercises Draft Final Environmental Assessment/Overseas Environmental Assessment. Prepared for the Commander, U.S. Pacific Fleet and Commander, Third Fleet. February 2007.
Wade, P.R ., T.J. Quinn, J. Barlow, C.S. Baker, A.M. Burden, J. Calambokidis, P.J. Clapham, E.A. Falcone, J.K.B. Ford, C.M. Gabriele, D.K. Mattila, L. Rojas-Bracho, J.M. Straley, B. Taylor, J. Urban, D. Weller B.H. Witteveen, and M. Yamaguchi. 2016. Estimates of abundance and migratory destination for north Pacific humpback whales in both summer feeding areas and winter mating and calving areas. Paper SC/66b/IA21 presented to the International Whaling Commission Scientific Committee.
Wade, P.R. 2017. Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas – revision of estimates in SC/66b/IA21. Paper SC/A17/NP11 presented to the International Whaling Commission Scientific Committee.