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

STOCK DEFINITION AND GEOGRAPHIC RANGE

Although the International Whaling Commission (IWC) only considered one stock (Donovan 1991), there is now good evidence for multiple populations of humpback whales in the North Pacific (Johnson and Wolman 1984; Baker et al. 1990). Aerial, vessel, and photo-identification surveys, and genetic analyses indicate that within the U.S. EEZ, there are at least three relatively separate populations that migrate between their respective summer/fall feeding areas and winter/spring calving and mating areas (Calambokidis et al. 2001, Baker et al. 1998): 1) winter/spring populations in coastal Central America and Mexico which migrate to the coast of California to southern British Columbia in summer/fall (Steiger et al. 1991, Calambokidis et al. 1996) - referred to as the eastern North Pacific stock (Figure 1); 2) winter/spring populations of the Hawaiian Islands which migrate to northern British Columbia/Southeast Alaska and Prince William Sound west to Kodiak (Baker et al. 1990, Perry et al. 1990, Calambokidis et al. 2001) - referred to as the central North Pacific stock; and 3) winter/spring populations of Japan which, based on Discovery Tag information, probably migrate to waters west of the Kodiak Archipelago (the Bering Sea and Aleutian Islands) in summer/fall (Berzin and Rovnin 1966, Nishiwaki 1966, Darling 1991) - referred to as the western North Pacific stock. Winter/spring populations of humpback whales also occur in Mexico's offshore islands; the migratory destination of these whales is not well known (Calambokidis et al. 2001), but Norris et al. (1999) speculate that they may travel to the Bering Sea or Aleutian Islands. This stock structure represents the predominant migration patterns, but there is not a perfect correspondence between the breeding and feeding areas that are paired above. For example, some individuals migrate from Mexico to the Gulf of Alaska and others migrate from Japan to British Columbia. In general, interchange occurs (at low levels) between breeding areas, but fidelity is extremely high among the feeding areas (Calambokidis et al. 2001).

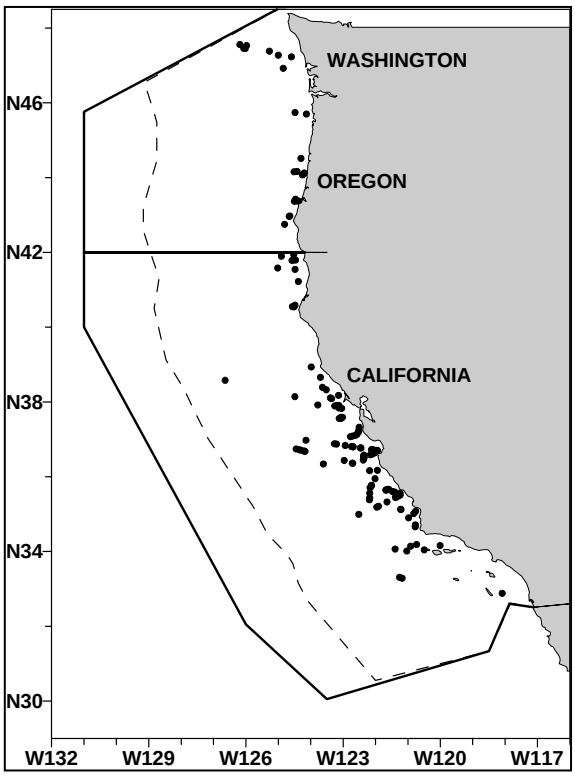

Figure 1. Humpback whale sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2001. Dashed line represents the U.S. EEZ, thick line indicates the outer boundary of all surveys combined. See Appendix 2 for data sources and information on timing and location of survey effort.

Significant levels of genetic differences were found between the California and Alaska feeding groups based on analyses of mitochondrial DNA (Baker et al. 1990) and nuclear DNA (Baker et al. 1993). The genetic exchange rate between California and Alaska is estimated to be less than 1 female per generation (Baker 1992). Two breeding areas (Hawaii and coastal Mexico) showed fewer genetic differences than did the two feeding areas (Baker 1992). This is substantiated by the observed movement of individually identified whales between Hawaii and Mexico (Baker et al. 1990). There have been no individual matches between 597 humpbacks photographed in California and 617 humpbacks photographed in Alaska (Calambokidis et al. 1996). Only two of the 81 whales photographed in British Columbia have matched with a California catalog (Calambokidis et al. 1996), indicating that the U.S./Canada border is an approximate geographic boundary between feeding populations.

Until further information becomes available, three management units of humpback whales (as described above) are recognized within the U.S. EEZ of the North Pacific: the eastern North Pacific stock (this report), the central North Pacific stock, and the western North Pacific stock. The central and western North Pacific stocks are reported separately in the Stock Assessment Reports for the Alaska Region.

POPULATION SIZE

Based on whaling statistics, the pre-1905 population of humpback whales in the North Pacific was estimated to be 15,000 (Rice 1978), but this population was reduced by whaling to approximately 1,200 by 1966 (Johnson and Wolman 1984). The North Pacific total now almost certainly exceeds 6,000 humpback whales (Calambokidis et al. 1997). Estimates of the abundance of the eastern Pacific stock of humpback whales were made by aerial survey (Dohl 1983; Forney et al. 1995) and ship surveys (Barlow 1995), but those estimates are now over 9 years old and the aerial estimates did not include correction factors for diving whales that would be missed. More recent estimates are available from ship surveys and mark-recapture studies. Barlow (2003) estimated 1,314 (CV=0.30) humpbacks in California, Oregon, and Washington waters based on summer/fall ship line-transect surveys in 1996 and 2001. Calambokidis et al. (2004) estimated humpback whale abundance in these feeding areas from 1991 to 2003 using Petersen mark-recapture estimates based on photo-identification collections in adjacent pairs of years (Figure 2). These data show a general upward trend in abundance followed by a large (but not statistically significant) drop in the 1999/2000 and 2000/2001 estimates. The 2002/2003 population estimate (1,391, CV=0.22) is higher than any previous estimates and may indicate that the apparent decline in the previous two estimates exaggerates any real decline that might have occurred (Calambokidis et al. 2003) or that a real decline was followed by an influx of new whales from another area (Calambokidis et al. 2004). This latter view is substantiated by the greater fraction of new whales seen for the first time in 2003 (Calambokidis et al. 2004). In general, mark-recapture estimates are negatively biased due to heterogeneity in sighting probabilities (Hammond 1986); however, this bias is likely to be minimal because the above mark-recapture estimate is based on data from nearly half of the entire population (the 2002/2003 data contained 542 known individuals). The recent ship line transect estimate from 1996-2001 surveys is less precise than the mark-recapture estimates and is negatively biased because it does not include some humpback whales which could not be identified in the field and which were recorded as "unidentified large whale".

Minimum Population Estimate

The minimum population estimate for humpback whales in the California/Mexico stock is taken as the lower 20th percentile of the log-normal distribution of 2002/2003 abundance estimated from mark-recapture methods (Calambokidis et al. 2004) or approximately 1,158.

Current Population Trend

Ship surveys provide some indication that humpback whales increased in abundance in California coastal waters between 1979/80 and 1991 (Barlow 1994) and between 1991 and 1996 (Barlow 1997); however estimates declined between 1996 and 2001 (Barlow 2003). Mark-recapture population estimates increased steadily from 1988/90 to 1997-98 at about 8% per year (Calambokidis et al. 1999). The apparent dip in the 1999/2000 and 2000/2001 estimates may indicate that population growth is slowing, but the subsequent increases in 2001/2002 and 2002/2003 casts some doubt on this explanation. Population estimates for the entire North Pacific have also increased substantially from 1,200 in 1966 to 6,000-8,000 circa 1992. 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 recently observed growth rate of the eastern North Pacific stock.

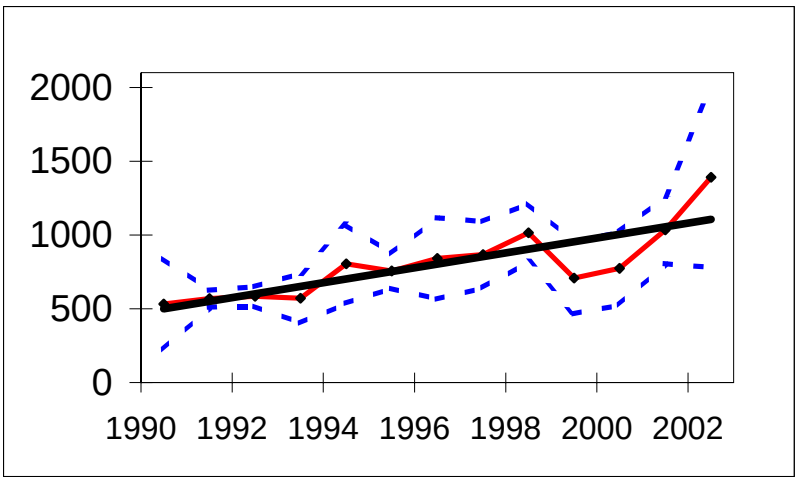

Figure 2. Mark-recapture estimates of the abundance of humpback whales feeding off California, Oregon, and Washington based on photo-identification studies (Calambokidis et al. 2004). Dotted lines indicate +/- 2 standard errors for each estimate. Straight, bold line indicates linear regression.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The proportion of calves in the California/Mexico stock from

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

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,158) times one half the estimated population growth rate for this stock of humpback whales (½ of 8%) times a recovery factor of 0.1 (for an endangered species with a total population size of less than 1,500), resulting in a PBR of 4.6. Because this stock spends approximately half its time outside the U.S. EEZ, the PBR allocation for U.S. waters is 2.3 whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Historic Whaling

The reported take of North Pacific humpback whales by commercial whalers totaled approximately 7,700 between 1947 and 1987 (C. Allison, IWC unpubl. data). In addition, approximately 7,300 were taken along the west coast of North America from 1919 to 1929 (Tonnessen and Johnsen 1982). Total 1910-1965 catches from the California-Washington stock includes at least the 2,000 taken in Oregon and Washington, the 3,400 taken in California, and the 2,800 taken in Baja California (Rice 1978). 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.

Fishery Information

A 1999-2003 summary of known fishery mortality and injury for this stock of humpback whales is given in Table 1. Detailed information on these fisheries is provided in Appendix 1. After the 1997 implementation of a Take Reduction Plan, which included skipper education workshops and required the use of pingers and minimum 6-fathom extenders, overall cetacean entanglement rates in the drift gillnet fishery dropped considerably (Barlow and Cameron 2003). Mean annual takes for this fishery (Table 1) are based on 1999-2003 data. This results in an average estimate of zero humpback whales taken annually. Some gillnet mortality of large whales may go unobserved because whales swim away with a portion of the net. The deaths of two humpback whales that stranded in the Southern California Bight have been attributed to entanglement in fishing gear (Heyning and Lewis 1990), and a humpback whale was observed off Ventura, CA in 1993 with a 20 ft section of netting wrapped around and trailing behind. During the period 1999-2003, a humpback cow-calf pair was seen entangled in a net off Big Sur, California (1999) and another lone humpback was seen entangled in line and fishing buoys off Grover City (2000), but the fate of these animals is not known (J. Cordero, NMFS unpubl. data). One humpback whale was entangled and released alive in the swordfish/thresher shark drift gillnet fishery in November of 1999 at N33^{o}17' W120^{o} 49' (set DN-SD-0949). Other unobserved fisheries may also result in injuries or deaths of humpback whales. In 2001, a humpback whale with "pot gear" wrapped around its flukes was seen free-swimming 8 miles offshore of Point Bonita, California (NMFS, Southwest Region, unpublished data). In 2003, there were five separate reports of humpback whales entangled in crab pot and/or polypropylene lines (J. Cordero, NMFS, unpubl. data). In March 2003, an adult female with a calf was seen off Monterey with crab pot line wrapped around its flukes. An adult humpback was seen in May 2003 in the Santa Barbara Channel with 100 feet of yellow polypropylene line wrapped around it pectoral fins and caudal peduncle. Another adult female with a calf was seen in August 2003 west of the Farallon Islands with crab pot line with floats wrapped around its caudal peduncle and fluke lobe; the adult was reported to be 'diving awkwardly'. In November 2003, there were two reports within four days near Crescent City and south of Humboldt Bay of single humpback whales with crab pot line wrapped around their 'torso'. These two reports may represent the same whale. The final status of all these whales is unknown.

Drift gillnet fisheries for swordfish and sharks exist along the entire Pacific coast of Baja California, Mexico and may take animals from the same population. Quantitative data are available only for the Mexican swordfish drift gillnet fishery, which uses vessels, gear, and operational procedures similar to those in the U.S. drift gillnet fishery, although nets may be up to 4.5 km long (Holts and Sosa-Nishizaki 1998). The fleet increased from two vessels in 1986 to 31 vessels in 1993 (Holts and Sosa-Nishizaki 1998). The total number of sets in this fishery in 1992 can be estimated from data provided by these authors to be approximately 2700, with an observed rate of

marine mammal bycatch of 0.13 animals per set (10 marine mammals in 77 observed sets; Sosa-Nishizaki et al. 1993). This overall mortality rate is similar to that observed in California driftnet fisheries during 1990-95 (0.14 marine mammals per set; Julian and Beeson, 1998), but species-specific information is not available for the Mexican fisheries. Previous efforts to convert the Mexican swordfish driftnet fishery to a longline fishery have resulted in a mixed-fishery, with 20 vessels alternately using longlines or driftnets, 23 using driftnets only, 22 using longlines only, and seven with unknown gear type (Berdegué 2002).

Table 1. Summary of available information on the incidental mortality and injury of humpback whales (eastern North Pacific stock) for commercial fisheries that might take this species (Cameron and Forney 2000; Carretta 2001, 2002; Carretta and Chivers 2003, 2004). Injury includes any entanglement that does not result in immediate death and may include serious injury resulting in death. n/a indicates that data are not available. Mean annual takes are based on 1999-2003 data unless noted otherwise.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality (and injury)	Estimated mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	1999 2000 2001 2002 2003	Observer data	20.0% 22.9% 20.4% 20.0% 20.3%	0 0 0 0 0	Mortality 0,0,0,0,0 Injury 0,0,0,0,0	Mortality 0 Injury 0
CA angel shark/halibut and other species large mesh (>3.5") set gillnet fishery	1990-94 1999 2000 2001 2002 2003	Observer data	10-15% 23.1%[2] 26.9%[2] 0% 0% 0%	0,0,0,0,0 0[2] 0[2] 0[1] 0[1] 0[1]	0,0,0,0,0 0[2] 0[2] 0[1] 0[1] 0[1]	0[1]
Unidentified fisheries	1999-2003	Stranding& sightings	n/a	0 (6)	n/a	> 1.2
Total Annual Takes						> 1.2

[1] The CA set gillnets were not observed in 1995-98, and observations in 1999-2000 only included Monterey Bay; mortality for unobserved areas and times was extrapolated from effort estimates and 1991-94 entanglement rates. The fishery was not observed in 2001-2002, owing to area closures that reduced fishing effort to negligible levels.

[2] Observer coverage and observed mortality in 1999-2000 only includes the observed portion of the fishery in Monterey Bay. Observer coverage throughout the entire fishery was only 4.0% and 1.8%, respectively.

Ship Strikes

Ship strikes were implicated in the deaths of at least two humpback whales in 1993, one in 1995, and one in 2000 (J. Cordaro, NMFS unpubl. data). During 1999-2003, there were an additional 5 injuries and 2 mortalities of unidentified large whales attributed to ship strikes. Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not have obvious signs of trauma. Several humpback whales have been photographed in California with large gashes in their dorsal surface that appear to be from ship strikes (J. Calambokidis, pers. comm.). The average number of humpback whale deaths by ship strikes for 1999-2003 is at least 0.2 per year.

Other human-caused mortality

A humpback whale died and stranded near Moss Landing in 2000 with synthetic (possibly nylon) line wrapped around its flukes. The origin of this line (fishery or other anthropogenic source) is unknown. The average number of humpback deaths from unknown anthropogenic sources is 0.2 per year from 1999-2003.

STATUS OF STOCK

Humpback whales in the North Pacific were estimated to have been reduced to 13% of carrying capacity (K) by commercial whaling (Braham 1991). Clearly the North Pacific population was severely depleted. The initial abundance has never been estimated separately for the eastern North Pacific stock, but this stock was also depleted (probably twice) by whaling (Rice 1974; Clapham et al. 1997). Humpback whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the California/Mexico stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The estimated annual mortality

and injury due to entanglement (1.2/yr), other anthropogenic sources (0.2/yr), plus ship strikes (0.2/yr) in California is less than the PBR allocation of 2.3 for U.S. waters. The three humpbacks that were entangled at sea may have been seriously injured. Based on strandings and gillnet observations, annual humpback whale mortality and serious injury in California's drift gillnet fishery is probably greater than 10% of the PBR; therefore, total fishery mortality may not be approaching zero mortality and serious injury rate. The eastern North Pacific stock appears to be increasing in abundance. The increasing levels of anthropogenic noise in the world's oceans, such as those produced by ATOC (Acoustic Thermometry of Ocean Climate) or LFA (Low Frequency Active) Sonar, have been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound.

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