DRAFT U.S. PACIFIC MARINE MAMMAL STOCK ASSESSMENTS: 2011

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Draft stock assessment reports revised in 2011; all others will be reprinted in the as they appear in the 2010 Pacific Region Stock Assessment Reports (Carretta *et al.* 2011).

PREFACE

Under the 1994 amendments to the Marine Mammal Protection Act (MMPA), the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) are required to publish Stock Assessment Reports for all stocks of marine mammals within U.S. waters, to review new information every year for strategic stocks and every three years for non-strategic stocks, and to update the stock assessment reports when significant new information becomes available. The Draft 2011 Pacific marine mammal stock assessments include revised stock assessments for nine Pacific marine mammal stocks under NMFS jurisdiction, including four "strategic" stocks (Hawaiian monk seal, Southern Resident killer whale, Hawaii Insular false killer whale, Hawaii Pelagic false killer whale), and five "non-strategic" stocks (California sea lion, California harbor seal, Northern Oregon/Washington coast harbor porpoise, Washington Inland waters harbor porpoise, and Palmyra Atoll false killer whale). NMFS has received a petition to list the Hawaii Insular false killer whale as endangered under the Endangered Species Act. A Take Reduction Team was established in 2010 with the goal of reducing mortality and serious injury in the Hawaii Pelagic, Hawaii Insular, and Palmyra stocks of false killer whale (75 FR 2853, 19 January 2010). Details on the Take Reduction Plan and its proposed implementation were published in 2011 (76 FR 42082, 18 July 2011). New information on a population viability analysis for the stock of Hawaii Insular false killer whale is presented. New abundance estimates are available for four stocks (California sea lion, California harbor seal, Hawaiian monk seal, and Southern Resident killer whale). Updated information on human-caused mortality is presented for California sea lions, California harbor seals, two harbor porpoise stocks, and the three stocks of false killer whale. Information on the remaining 66 Pacific region stocks can be found in the final 2010 reports (Carretta *et al.* 2011). Stock Assessments for Alaska region marine mammals are published by the National Marine Mammal Laboratory (NMML) in a separate report.

Pacific region stock assessments include those studied by the Southwest Fisheries Science Center (SWFSC, La Jolla, California), the Pacific Islands Fisheries Science Center (PIFSC, Honolulu, Hawaii), the National Marine Mammal Laboratory (NMML, Seattle, Washington), and the Northwest Fisheries Science Center (NWFSC, Seattle, WA).

Draft versions of the 2011 stock assessment reports were reviewed by the Pacific Scientific Review Group at the November 2010 meeting in Kona, HI.

This is a working document and individual stock assessment reports will be updated as new information on marine mammal stocks and fisheries becomes available. Background information and guidelines for preparing stock assessment reports are reviewed in Wade and Angliss (1997). The authors solicit any new information or comments which would improve future stock assessment reports.

These Stock Assessment Reports summarize information from a wide range of original data sources and an extensive bibliography of all sources is given in each report. We strongly urge users of this document to refer to and cite *original* literature sources rather than citing this report or previous Stock Assessment Reports. If the original sources are not accessible, the citation should follow the format: [Original source], as cited in [this Stock Assessment Report citation].

References:

Carretta, J.V., K.A. Forney, E. Oleson, K. Martien, M.M. Muto, M.S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R.L. Brownell Jr., J. Robbins, D.K. Mattila, K. Ralls, and Marie C. Hill. 2011. U.S. Pacific Marine Mammal Stock Assessments: 2010. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-476, 352 p.

Revised ~~10/30/2007~~ 8/12/2011

CALIFORNIA SEA LION (*Zalophus californianus* ~~*californianus*~~): U.S. Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The California sea lion *Zalophus californianus* is now considered to be a full species, separated from Galapagos sea lion (*Z. wollebaeki*) and the extinct Japanese sea lion (*Z. japonicus*) (Brunner 2003, Wolf et al 2007, Schramm et al. 2009). ~~includes three subspecies: *Z. c. wollebaeki* (on the Galapagos Islands), *Z. c. japonicus* (in Japan, but now thought to be extinct), and *Z. c. californianus* (found from southern Mexico to southwestern Canada; herein referred to as the California sea lion).~~ The breeding areas of the California sea lion are on islands located in southern California, western Baja California, and the Gulf of California (Figure 1). Mitochondrial DNA analysis of California sea lions identified five genetically distinct geographic populations: (1) Pacific Temperate, (2) Pacific Subtropical, (3) Southern Gulf of California, (4) Central Gulf of California and (5) Northern Gulf of California (Schramm et al. 2009). In that study, the Pacific Temperate population included rookeries within U.S. waters and the Coronados Islands just south of U.S./Mexico border. Animals from the temperate population range north into Canadian waters, and some movement of animals between U.S. waters and Baja California waters has been documented though the distance between the major U.S. and Baja California rookeries is approximately 400 nmi. ~~These three geographic regions are used to separate this subspecies into three stocks: (1) the United States stock begins at the U.S./Mexico border and extends northward into Canada; (2) the Western Baja California stock extends from the U.S./Mexico border to the southern tip of the Baja California Peninsula; and (3) the Gulf of California stock which includes the Gulf of California from the southern tip of the Baja California peninsula and across to the mainland and extends to southern Mexico (Lowry et al. 1992). Some movement has been documented between these geographic stocks, but rookeries in the United States are widely separated from the major rookeries of western Baja California, Mexico.~~ Males from western Baja California rookeries may spend most of the year in the United States. ~~Genetic differences have been found between the U.S. stock and the Gulf of California stock (Maldonado et al. 1995).~~

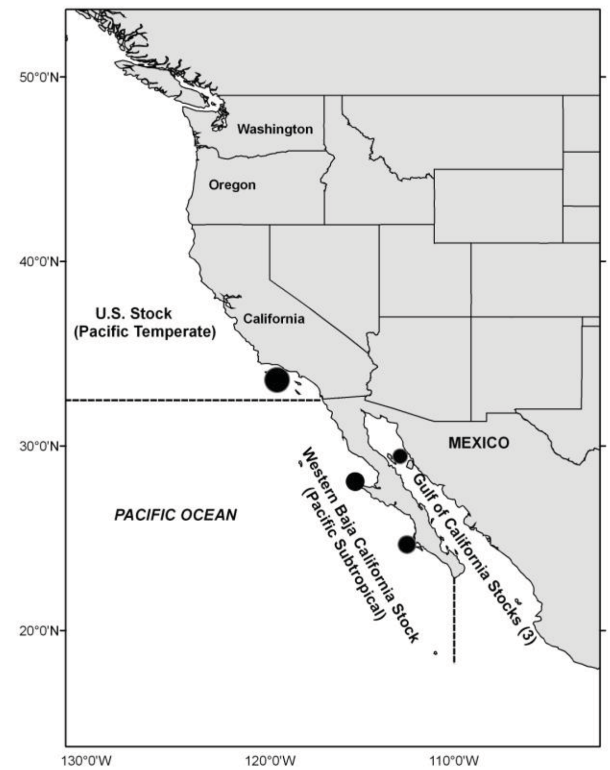

Figure 1. Geographic range of California sea lions showing stock boundaries and locations of major rookeries. The U.S. stock also ranges north into Canadian waters.

There are no international agreements for joint management of California sea lions between the U.S., Mexico, and Canada, and the number of sea lions at the Coronado Islands is not regularly monitored. Consequently, this stock assessment report considers only the U.S. Stock, i.e., sea lions at rookeries within the U.S. Pup production at the Coronado Islands is minimal (between 12 and 82 pups annually; Lowry and Maravilla-Chavez 2005) and does not represent a significant contribution to the overall size of the Pacific temperate population.

POPULATION SIZE

The entire population cannot be counted because all age and sex classes are not ashore at the same time. In lieu of counting all sea lions, pups are counted during the breeding season (because this is the only age class that is ashore in its entirety), and the number of births is estimated from the pup count. The size of the population is then estimated from the number of births and the proportion of pups in the population. Censuses are conducted in July after all pups have been born. To estimate the number of pups born, the pup count for rookeries in southern California in ~~2005 (48,277)~~ in 2008 (59,774) was adjusted for an estimated 15% pre-census mortality (Boveng 1988; Lowry et al. 1992), giving an estimated ~~55,519~~ 68,740 live births in the population. The fraction of newborn pups in the population ~~(23.3%)~~ (23.2%) was estimated from a life table derived for the northern fur seal (*Callorhinus ursinus*) (Boveng 1988, Lowry et al. 1992) which was modified to account for the growth rate of this California sea lion population (~~5.6%~~ 5.4% yr^{-1}, see below). Multiplying the number of pups born by the inverse of this fraction ~~(4.28)~~ (4.317) results in a population estimate of ~~238,000.~~ 296,750.

Minimum Population Estimate

The minimum population size was determined from counts of all age and sex classes that were ashore at all the major rookeries and haulout sites in southern and central California during the ~~2005~~ 2007 breeding season. The minimum population size of the U.S. stock is ~~141,842~~ 153,337 (NMFS unpubl. data). It includes all California sea lions counted during the July ~~2005~~ 2007 census at the Channel Islands in southern California and at haulout sites located between Point Conception and ~~the Oregon/California border~~ Point Reyes, California. An additional unknown number of California sea lions are at sea or hauled out at locations that were not censused.

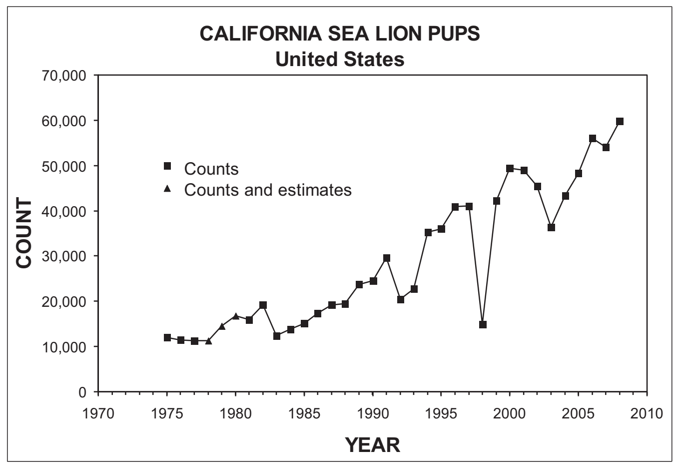

Figure 2. U.S. pup count index for California sea lions (1975-~~2005~~ 2008). Trends in pup counts from 1975 through 2008 are shown for four rookeries in southern California and for haulouts in central and northern California. Records of pup counts from 1975 to 2008 were compiled from Lowry and Maravilla (2005) and unpublished NMFS data.

Current Population Trend

~~Records of pup counts from 1975 to 2005 (Figure 2) were compiled from the literature, NMFS reports, unpublished NMFS data, and Lowry 1999 (the literature up to 2000 is listed in Lowry and Maravilla 2005).~~ Trends in pup ~~Pup~~ counts from 1975 through ~~2005~~ 2008 ~~were examined~~ are shown in Figure 2 for four rookeries in southern California and for haulouts in central and northern California. The number of pups at rookeries not counted were estimated using multiple regressions derived from counts of two neighboring rookeries using data from 1975-2000 (Lowry and Maravilla 2005): (1) 1980 at Santa Barbara Is.; (2) 1978-1980 at San Clemente Is.; and (3) 1978 and 1979 at San Nicolas Is. The mean was used when more than one count was available for a given rookery. ~~Four major declines in the number of pups counted occurred during El Niño events in 1983-1984, 1992-93, 1998, and 2003 (Figure 2).~~ A regression of the natural logarithm of the pup counts against year indicates that the counts of pups increased at an annual rate of ~~5.6%~~ 5.4% between 1975 and ~~2005~~ 2008, when pup counts for El Niño years (1983, 1984, 1992, 1993, 1998, and 2003) were removed from the 1975-2005 time series. Using 1975-2008 non-El Niño year data, the coefficient of variation for this average annual growth rate (CV = 0.04) was computed via bootstrap sampling of the count data. The 1975-~~2005~~ 2008 time series of pup counts shows the effect of four El Niño events on the sea lion population (Figure 2). Pup production decreased by 35 percent in 1983, 27 percent in 1992, ~~and~~ 64 percent in 1998, and 20% in 2003. After the 1992-93, ~~and~~ 1997-98 and 2003 El Niños, pup production rebounded to pre-El Niño levels within two years. In contrast, however, the 1983-1984 El Niño affected adult female survivorship (DeLong et al. 1991), which prevented an immediate rebound in pup production because there were fewer adult females available in the population to produce pups (it took five years for pup production to return to the 1982 level). Other characteristics of El Niños are higher pup and juvenile mortality rates (DeLong et al. 1991, NMFS unpubl. data) which affect future recruitment into the adult population for the affected cohorts. The 2002 and 2003 decline can be attributed to (1) reduced number of reproductive adult females being incorporated into the population as a result of the 1992-93 and 1997-98 El Niños, (2) domoic acid poisoning (Scholin et al. 2000, Lefebvre et al. 2000), (3) lower survivorship of pups due to hookworm infestations (Lyons et al. 2001), and (4) the 2003 El Niño.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A ~~generalized~~ standard logistic growth model indicated that the maximum population growth rate (R_{max}) was ~~6.52~~ 9.2 percent when pup counts from El Niño years (1983, 1984, 1992, 1993, 1998, and 2003) were removed (Figure 3). However, the apparent growth rate from the population trajectory underestimates the intrinsic growth rate because it does not consider human-caused mortality that was occurring during the time series. Here we use the default maximum net productivity rate for pinniped (12% per year).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (~~141,~~842 153,337) times one half the default maximum net growth rate for pinnipeds (½ of 12%) times a recovery factor of 1.0 (for a stock of unknown status that is growing, Wade and Angliss 1997); resulting in a PBR of ~~8,511~~ 9,200 sea lions per year.

ANNUAL HUMAN-CAUSED MORTALITY

Historical Depletion

Historic exploitation of California sea lions include harvest for food by native Californians in the Channel Islands 4,000-5,000 years ago (Stewart et al. 1993) and for oil and hides in the mid-1800s (Scammon 1874). More recent exploitation of sea lions for pet food, target practice, bounty, trimmings, hides, reduction of fishery depredation, and sport are reviewed in Helling (1984), Cass (1985), Seagers et al. (1985), and Howorth (1993). ~~Lowry et al. (1992) stated that there were~~ There are few historical records to document the effects of such exploitation on sea lion abundance (Lowry et al. 1992).

Fisheries Information

California sea lions are killed incidentally in set and drift gillnet fisheries (Hanan et al. 1993; Barlow et al. 1994; ~~Julian 1997;~~ Julian and Beeson, 1998, ~~Cameron and Forney 1999~~; Carretta et al. 2005~~a~~; ~~Table 1~~) and trawl fisheries along the U.S. west coast (Heery et al. 2010). Detailed information on these fisheries is provided in Appendix 1. Mortality estimates for the California set and drift gillnet fisheries and trawl fisheries are included in Table 1 for the five most recent years of monitoring~~, 2000-2004 (Carretta and Chivers 2004, Carretta et al. 2005a, 2005b).~~ (Carretta and Enriquez 2006, 2007, 2009a, 2009b, 2010, Heery et al. 2010). A controlled experiment during 1996-97 demonstrated that the use of acoustic warning devices (pingers) reduced sea lion entanglement rates considerably within the drift gillnet fishery (Barlow and Cameron 2003). However, entanglement rates increased again during the 1997 El Niño and continued during 1998. The reasons for the increase in entanglement rates are unknown. However, it has been suggested that sea lions may have foraged further offshore in response to limited food supplies near rookeries, which would provide opportunity for increased interactions with the drift gillnet fishery. Because of interannual variability in entanglement rates, additional years of data will be required to fully evaluate the effectiveness of pingers for reducing mortality of this particular species. ~~Mortality estimates from the drift gillnet fishery are based on 2000-2004 observer data (~20% observer coverage). In past years, the largest source of sea lion~~

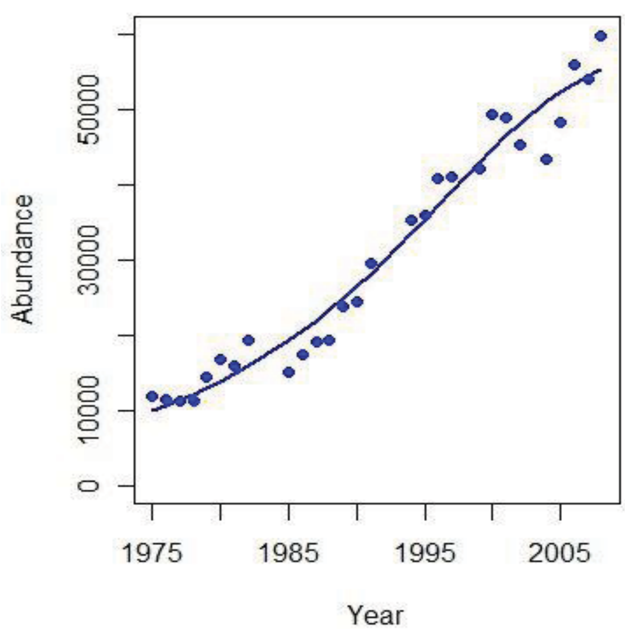

Figure 3. ~~Generalized logistic growth of California sea lion pup counts obtained during 1975-2005 (excluding El Niño years) indicating when Maximun Net Productivity Level (MNPL) was reached and that the population has reached carrying capacity (K).~~ Fit of standard logistic growth curve to California sea lion pup counts, 1975-2008 (excluding El Niño years).

~~mortality has been in the California halibut and angel shark set gillnet fishery, which currently operates south of Point Arguello, California and has not been observed throughout its range since 1994. Limited observer coverage occurred in Monterey Bay in 2000 and 2001, but represented less than 5% of the total fishing effort. Given the lack of recent observer data, it is not possible to estimate sea lion mortality for this fishery. Evidence from fisher self-reports (Table 1) indicates that mortality of sea lions still occurs in this fishery, but it is not possible to extrapolate these self reports to overall mortality because these self reports have been shown to be grossly underreported.~~ Historically, the majority of California sea lion gillnet mortality was in the California halibut and white seabass set gillnet fishery (Julian and Beeson 1998), but this fishery has undergone regulatory changes that has reduced its range to southern California waters south of Pt. Arguello and has shifted fishing effort to greater than 3 nmi from the mainland or 1 nmi from the islands. There has also been a considerable decline in fishing effort in this fishery since the early 1990s (see Figure 3 in Appendix 1). An observer program for the current fishery was in place during 2006 and 2007, although the only meaningful levels of observer coverage occurred in 2007. Annual estimates of bycatch mortality for this fishery are based solely on 2007 for that reason (Table 1). Logbook and observer data, and fishermen reports, indicate that mortality of California sea lions occurs, or has also occurred in the past in the following fisheries: (1) California, Oregon, and Washington salmon troll fisheries; (2) Oregon and Washington non-salmon troll fisheries; (3) California herring purse-seine fishery; (4) California anchovy, mackerel, and tuna purse-seine fishery; (5) California squid purse-seine fishery, (6) Washington, Oregon, California and British Columbia, Canada salmon net pen fishery, (7) Washington, Oregon, California groundfish trawl fishery, (8) Washington, Oregon and California commercial passenger fishing vessel fishery (NMFS 1995, M. Perez pers. comm, and P. Olesiuk pers. comm.) (9) the California small mesh drift gillnet fishery, and (10) the California purse-seine fishery for anchovy, mackerel, and tuna. ~~The OR Columbia River gillnet fishery has been reduced to such levels that California sea lion mortality, if any, is negligible (J. Scordino, per. comm.).~~ Not all of these fisheries continue to operate or have current observer programs. Those for which recent observations or estimates of bycatch mortality exist are summarized in Table 1. Stranding data from California, Oregon, and Washington during ~~2000-2004~~ 2005-2009 shows that an additional ~~66~~ 55 sea lions died from unknown entangling net fisheries (Table 1). Animals are typically found on the beach or sometimes at sea with portions of gillnet wrapped around the carcass. This represents a minimum number of animals killed, as many entanglements are likely unreported or undetected.

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, but no quantitative estimates of recent mortality are available. ~~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).~~

California sea lions injured by entanglement in gillnet and other man-made debris are observed at rookeries and haulouts (Stewart and Yochem 1987, Oliver 1991). The proportion of those entangled ranged from 0.08% to 0.35% of those hauled out, with the majority (52%) entangled in monofilament gillnets. Data from a marine mammal rehabilitation center showed that 87% of 87 rescued California sea lions were entangled in 4-4.5 inch square-mesh monofilament gillnet (Howorth 1994). Of California sea lions entangled in gillnets, 0.8% in set gillnets and 5.4% in drift gillnets were observed to be released alive from the net by fishers during 1991-1995 (Julian and Beeson 1998). Clearly, some are escaping from gillnets; however, the rate of escape from gillnets, as well as the mortality rate of these injured animals, is unknown.

California sea lions are also incidentally killed and injured by hooks from recreational and commercial fisheries. Sea lion deaths due to hook-and-line fisheries are often the result of complications resulting from ingestion of hooks, perforation of body cavities leading to infections, or the inability of the animal to feed. Many of the animals die post-stranding during rehabilitation or are euthanized as a result of their injuries. Between 2005 and 2009, there were 88 California sea lion deaths attributed to hook and line fisheries, or an annual average of 18 animals (NMFS Southwest and Northwest Regional Stranding Data, unpublished).

One sea lion mortality was reported in a tribal salmon gillnet in 2009 along the U.S. west coast.

Table 1. Summary of available information on the mortality and serious injury of California sea lions in commercial fisheries that might take this species (~~Carretta 2001; 2002,~~ ~~Carretta et al. 2005a, 2005b,~~ ~~Perez 2003~~, Carretta and Enriquez 2006, 2007, 2009a, 2009b, 2010; Heery et al. 2010; Appendix 1). Mean annual takes are based on ~~2000-2004~~ 2005-2009 data unless noted otherwise. ~~In past years, the set gillnet fishery for halibut and angel shark has been responsible for the majority of fishery-related mortality. However, this fishery has not been observed recently and thus, current estimates of mortality are unknown. Because current mortality estimates are lacking for this fishery, overall mean annual takes reported in Table 1 are negatively biased by an unknown amount.~~

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish large mesh drift gillnet fishery	~~2000~~ ~~2001~~ ~~2002~~ ~~2003~~ ~~2004~~ 2005 2006 2007 2008 2009	observer	~~22.9%~~ ~~20.4%~~ ~~22.1%~~ ~~20.2%~~ ~~20.6%~~ 20.9% 18.5% 16.4% 13.5% 13.3%	~~13~~ ~~2~~ ~~18~~ ~~4~~ ~~6~~ 1 12 8 7 5	~~50 (0.43)~~ ~~10 (0.67)~~ ~~81 (0.25)~~ ~~20 (0.50)~~ ~~29 (0.44)~~ 5 (0.97) 64 (0.43) 48 (0.65) 51 (0.52) 37 (0.83)	~~38 (0.18)~~ 41 (0.28)
CA ~~angel shark/~~ halibut and ~~other species large mesh (>3.5 in)~~ white seabass set gillnet fishery	~~2001~~ ~~2002~~ ~~2003~~ ~~2004~~ 2005 2006 2007 2008 2009 ~~2000-2004~~	~~No fishery-wide observer program since 1994~~ ~~MMAP self reports~~ 12 sets observed in 2006 and 248 sets observed in 2007	~~0%~~ ~~0%~~ ~~0%~~ ~~0%~~ 0% <1% 17.8% 0% 0% -	~~n/a~~ ~~n/a~~ ~~n/a~~ ~~n/a~~ n/a 0 34 n/a n/a ~~57~~	~~n/a~~ ~~n/a~~ ~~n/a~~ ~~n/a~~ n/a n/a 190 (0.68) n/a n/a ~~n/a~~	~~n/a~~ ~~≥11.4~~ 190 (0.68)[1]
CA small-mesh drift gillnet fishery for white seabass, yellowtail, barracuda, and tuna	2003~~[1]~~ 2004~~[1]~~	observer	11%~~[1]~~ 11%~~[1]~~	2 1	18 (0.71) 9 (0.94)	13.5 (0.57)
CA anchovy, mackerel, sardine, and tuna purse-seine fishery	~~2004[2]~~ 2004-2008	observer	~~n/a~~ ~5%	~~1~~ 2	~~≥ 1 (n/a)~~ n/a	~~≥ 1 (n/a)~~ ≥2 (n/a)
WA, OR, CA domestic groundfish trawl fishery ~~(At-sea processing Pacific whiting fishery only)~~ (includes at-sea hake and other limited-entry groundfish sectors)	~~2000~~ ~~2001~~ ~~2002~~ ~~2003~~ ~~2004~~ 2004 2005 2006 2007 2008	observer	~~80.6%~~ ~~96.2%~~ ~~100%~~ ~~100%~~ ~~100%~~ 99% to 100% of tows in at-sea hake fishery 18%-26% of landings in other groundfish sectors	~~0~~ ~~0~~ ~~1~~ ~~2~~ ~~2~~ 8 14 21 8 7	~~0~~ ~~0~~ ~~1~~ ~~2~~ ~~2 (n/a)~~ 13 (n/a) 21 (n/a) 95 (n/a) 31 (n/a) 13 (n/a)	~~1.2 (0)~~ 34.6 (n/a)
~~WA, OR, CA domestic groundfish trawl fishery (bottom trawl)~~	~~2000~~ ~~2001~~ ~~2002~~ ~~2003~~ ~~2004~~	~~observer~~	~~n/a~~	~~n/a~~ ~~8~~ ~~6~~ ~~24~~ ~~6~~	~~n/a~~	~~≥11~~

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
~~**WA, OR salmon net pen fishery**~~	~~2000~~ ~~2001~~ ~~2002~~ ~~2003~~ ~~2004~~	~~n/a~~	~~n/a~~	~~n/a~~	~~n/a~~	~~n/a~~
~~**Canada: BC salmon pen fishery**~~	~~2000~~ ~~2001~~ ~~2002~~ ~~2003~~ ~~2004~~	~~MMAP~~	~~n/a~~	~~225~~ ~~88~~ ~~19~~ ~~14~~ ~~6~~	~~225~~ ~~88~~ ~~19~~ ~~14~~ ~~6~~	~~≥70~~
Unknown entangling net fishery	~~2000-2004~~ 2005-2009	stranding	n/a	~~66~~ 55	n/a	~~13 (n/a)~~ ≥ 55 (n/a)
Unknown pot or trap fishery	2005-2009	stranding	n/a	1	n/a	≥ 1 (n/a)
Minimum total annual takes						~~≥159 (n/a)~~ ≥ 337 (0.56)

[1] ~~A pilot observer program existed for two years in the small mesh drift gillnet fishery, where observer coverage ranged between 11-17%, based on logbook effort data and 22 observed sets in 2003 and 2004, respectively.~~ Only 2007 data is included in the mean annual take calculation for the CA halibut and white seabass fishery, due to the low observer coverage (<1%) in 2006.

Other Mortality

Live strandings and dead beach-cast California sea lions are regularly observed with gunshot wounds in California (Lowry and Folk 1987, Deiter 1991, Barocchi et al. 1993, Goldstein et al. 1999, NMFS unpublished stranding data). A summary of records for ~~2000-2004~~ 2005-2009 from ~~the~~ California, ~~Marine Mammal Stranding Network (CMMSN) and the~~ Oregon, and Washington stranding databases shows the following non-fishery related human-caused mortality: boat collisions (~~17~~ 12 deaths), car collisions (6 deaths), entrainment in power plants (~~106~~ 158 deaths), shootings (~~237~~ 113 deaths), marine debris entanglement or ingestion (~~three~~ 13 deaths), research permit-related takes (3 deaths), and unknown sources (~~seven~~ 19 deaths). Stranding records are a gross under-estimate of injury and mortality because many animals and carcasses are never recovered. There are currently no estimates of the total number of California sea lions being killed or injured by guns, boat and car collisions, entrainment in power plants, marine debris, or gaffs, but the minimum number from ~~2000-2004~~ 2005-2009 was ~~370~~ 324, or an annual average of 65 animals. ~~The average annual non-fishery related mortality of sea lions from 2000-2004 is a minimum of the 370 deaths listed above, divided by 5 years = 74 sea lions annually.~~

~~Several Pacific Northwest treaty Indian tribes have promulgated tribal regulations allowing tribal members to exercise treaty rights for subsistence harvest of sea lions. Current estimates of annual take are zero to two animals per year.~~

Under authorization of MMPA Section 120, individually identifiable California sea lions have been killed or captured in response to their predation on endangered salmon and steelhead stocks in the Columbia River since 2008. Captured animals were transferred to aquaria and/or zoos. Between April 2008 and September 2010, 40 California sea lions were removed from this stock (30 lethal removals and 10 were transferred to aquaria and/or zoos). The average annual mortality due to direct removals for the period April 2008 to September 2010 is 17 animals per year (relocations to aquaria/zoos are treated the same as mortality because animals are effectively removed from the stock).

Between 2005 and 2009, 15 California sea lions were incidentally killed along the U.S. west coast during scientific trawl and longline operations conducted by NMFS (Southwest Regional Office Stranding Program, unpublished data). The average annual research-related mortality of California sea lions from 2005 to 2009 is 3.0 animals.

Sea lion mortality in 1998 along the central California coast has recently been linked to the algal-produced neurotoxin domoic acid (Scholin et al. 2000). Future mortality may be expected to occur, due to the sporadic occurrence of such harmful algal blooms.

STATUS OF STOCK

~~A generalized logistic growth model of pup counts obtained during 1975-2005 (excluding El Niño years) indicated that the population reached its Maximum Net Productivity Level (MNPL) of 39,800 pups in 1997 and has~~

~~reached carrying capacity (K) at 46,800 pups per year (z = 19.09, R_{max} = 0.0652, n_0 = 10,100, SE = 1,055) (Figure 3). This determination should be taken with caution until more years of data have been collected to verify whether the flattening of the generalized logistic curve persists in future years.~~ California sea lions in the U.S. are not listed as "endangered" or "threatened" under the Endangered Species Act or as "depleted" under the MMPA. The optimum sustainable population (OSP) status of this population has not been formally determined. ~~Even though current total human-caused mortality is unknown (due a lack of observer coverage in the California set gillnet fishery that historically has been the largest source of human-caused mortality),~~ The average annual commercial fishery mortality is 337 animals per year (Table 1). Other sources of human-caused mortality (shootings, direct removals, recreational hook and line fisheries, tribal takes, entrainment in power plant intakes, etc.) average 94 animals per year. Total human-caused mortality of this stock is at least 431 animals per year. California sea lions are not considered "strategic" under the MMPA because ~~(based on historical takes in the set gillnet fishery and current levels of fishing effort)~~ total human-caused mortality is ~~still likely to be~~ less than the PBR (~~8,511~~ 9,200). The total fishery mortality and serious injury rate (337 animals/year) for this stock ~~likely remains above~~ is less than 10% of the calculated PBR and, therefore, ~~cannot be~~ is considered to be insignificant and approaching a zero mortality and serious injury rate.

REFERENCES

Barlow, J., R. W. Baird, J. E. Heyning, K. Wynne, A. M. Manville II, L. F. Lowry, D. Hanan, J. Sease, and V. N. Burkanov. 1994. A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the USA and Canada and the east coast of the Russian Federation. Rept. Int. Whaling Comm., Special Issue 15:405-425.

Barlow, J. and G. A. Cameron. 2003. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift gillnet fishery. Marine Mammal Science 19(2):265-283.

Barocchi, M., L. E. Morgan, and K. D. Hanni. 1993. Frequency of fishery interactions among live stranded pinnipeds in central and northern California. (abstract). Tenth Biennial Conference on the Biology of Marine Mammals, Galveston TX, November 11-15, 1993.

Berdegué, J. 2002. Depredación de las especies pelágicas reservadas a la pesca deportiva y especies en peligro de extinción con uso indiscriminado de artes de pesca no selectivas (palangres, FAD's, trampas para peces y redes de agallar fijas y a la deriva) por la flota palangrera Mexicana. Fundación para la conservación de los picudos. A.C. Mazatlán, Sinaloa, 21 de septiembre.

Boveng, P. 1988. Status of the California sea lion population on the U.S. west coast. Admin. Rep. LJ-88-07. Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 26 pp.

Brown, R. F. and S. J. Jeffries. 1993. Preliminary report on estimated marine mammal mortality in Columbia River fall and winter salmon gillnet fisheries, 1991-1992. Columbia River Area Marine Mammal Observer Program, 53 Portway St., Astoria, OR. 13 pp.

Brunner, S. 2003. Fur seals and sea lions (Otariidae): Identification of species and species review. Systematics and Biodiversity 1:339-439.

Carretta, J.V. and L. Enriquez. 2010. Marine mammal and sea turtle bycatch in the California/Oregon swordfish and thresher shark drift gillnet fishery in 2009. Administrative Report LJ-10-03, available from Southwest Fisheries Science Center, 3333 North Torrey Pines Ct., La Jolla, California, 92037. 11p.

Carretta, J.V. and L. Enriquez. 2009a. Marine mammal and seabird bycatch in observed California commercial fisheries in 2007. Administrative Report LJ-09-01, available from Southwest Fisheries Science Center, 3333 North Torrey Pines Ct., La Jolla, California, 92037. 12 p.

Carretta, J.V. and L. Enriquez. 2009b. Marine mammal bycatch in the California/Oregon swordfish and thresher shark drift gillnet fishery in 2008. Administrative Report LJ-09-03, available from Southwest Fisheries Science Center, 3333 North Torrey Pines Ct., La Jolla, California, 92037. 10 p.

Carretta, J.V. and L. Enriquez. 2007. Marine mammal and sea turtle bycatch in the California / Oregon thresher shark and swordfish drift gillnet fishery in 2006. Administrative Report LJ-07-06, available from Southwest Fisheries Science Center, 3333 North Torrey Pines Ct., La Jolla, California, 92037. 9 p.

Carretta, J.V. and L. Enriquez. 2006. Marine mammal bycatch and estimated mortality in California commercial fisheries during 2005. Administrative Report LJ-06-07, available from Southwest Fisheries Science Center, 3333 North Torrey Pines Ct., La Jolla, California, 92037. 14 p.

~~Carretta, J.V. and S.J. Chivers. 2004. Preliminary estimates of marine mammal mortality and biological sampling of cetaceans in California gillnet fisheries for 2003. Paper SC/56/SM1 presented to the IWC Scientific~~

~~Committee, June 2004 (unpublished). [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA].~~

~~Carretta, J.V., S.J. Chivers, and K. Danil. 2005a. Preliminary estimates of marine mammal bycatch, mortality, and biological sampling of cetaceans in California gillnet fisheries for 2004. Administrative Report LJ-05-10, available from Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, California, 92037. 17 p.~~

Carretta, J.V., T. Price, D. Petersen, and R. Read. 2005~~b~~. Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996-2002. Marine Fisheries Review 66(2):21-30.

Cass, V.L. 1985. Exploitation of California sea lions, Zalophus californianus, prior to 1972. Marine Fisheries Review 47:36-38.

Deiter, R. L. 1991. Recovery and necropsy of marine mammal carcasses in and near the Point Reyes National Seashore, May 1982-March 1987. In J. E. Reynolds III and D. K. Odell (editors), Marine mammal strandings in the United States, Proceedings of the second marine mammal stranding workshop, Miami, Florida, December 3-5-1987. p. 123-141. NOAA Technical Rept. NMFS 98.

Goldstein, T., S. P. Johnson, A. V. Phillips, K. D. Hanni, D. A. Fauquier, and F. M. D. Gulland. 1999. Aquatic Mammals 25:43-51.

DeLong, R. L., G. A. Antonelis, C. W. Oliver, B. S. Stewart, M. S. Lowry, and P. K. Yochem. 1991. Effects of the 1982-1983 El Niño on several population parameters and diet of California sea lions on the California Channel Islands. In F. Trillmich and K. A. Ono (editors), Pinnipeds and El Niño: Responses to environmental stress. p. 166-172. Springer-Verlag, Berlin Heidelberg New York.

~~Hanan, D. A., and S. L. Diamond. 1989. Estimates of sea lion, harbor seal, and harbor porpoise mortality in California set net fisheries for the 1986-87 fishing year. Final Report. Cooperative agreement No. NA-86-ABH-00018. NOAA/NMFS SWR, January 1989. 10 pp.~~

Hanan, D. A., D. B. Holts, and A. L. Coan, Jr. 1993. The California drift gill net fishery for sharks and swordfish, 1981-82 through 1990-91. Calif. Dept. Fish and Game Fish. Bull. No. 175. 95 p.

~~Hanan, D. A., J. P. Scholl, and S. L. Diamond. 1988. Estimates of sea lion and harbor seal mortality in California set net fisheries for 1983, 1984, and 1985. Final Report. Cooperative agreement No. NA-86-ABH-00018. NOAA/NMFS SWR October 1988. 10 pp.~~

Helling, H.E. 1984. A follow-up report on available data for California and Stellar sea lion (Zalophus californianus), Eumetopias jubata) exploitation prior to 1950. Administrative Report LJ-84-45C. National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, CA 92037. 10pp.

Heery, E., Bellman, M.A., and J. Majewski. 2010. Estimated bycatch of marine mammals, seabirds, and sea turtles in the 2002-2008 U.S. west coast commercial groundfish fishery. West Coast Groundfish Observer Program. NWFSC, 2725 Montlake Blvd E., Seattle, WA 98112. 106 p.

Holts, D. and O. Sosa-Nishizaki. 1998. Swordfish, *Xiphias gladius*, fisheries of the eastern North Pacific Ocean. *In*: I. Barrett, O. Sosa-Nishizaki and N. Bartoo (eds.). Biology and fisheries of swordfish, *Xiphias gladius*. Papers from the International Symposium on Pacific Swordfish, Ensenada Mexico, 11-14 December 1994. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 142, 276 pp.

Howorth, P.C. 1993. Commercial collection of pinnipeds in the California Channel Islands, 1877-1981. *In:* Hochberg, F. G. (editor), Third California Islands Symposium: Recent Advances in Research in the California Islands. Santa Barbara, CA, Santa Barbara Museum of Natural History. pp.

Howorth, P. C. 1994. Entanglement of marine mammals in synthetic debris. In W. L. Halvorson and G. J. Maender (editors), The Fourth California Islands Symposium: Update on the status of resources, p. 111-121.

~~Julian, F. 1997. Cetacean mortality in California gill net fisheries: Preliminary estimates for 1996. Paper SC/49/SM02 presented to the International Whaling Commission, September 1997 (unpublished). 13 pp.~~

Julian, F. And M. Beeson. 1998. Estimates for marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-1995. Fish. Bull. 96:271-284.

Lefebvre, K. C. Powell, G. Doucette, J. Silver, P. Miller, P. Hughes, M. Silver, and R. Tjeerdemma. 2000. Domoic acid-producing diatoms: probable cause of neuroexcitotoxicity in California sea lions. Marine Environmental Research 50:485-488.

Lowry, M. S. 1999. Counts of California sea lion (*Zalophus californianus*) pups from aerial color photographs and from the ground: a comparison of two methods. Marine Mammal Science 15:143-158.

Lowry, M. S. and R. L. Folk. 1987. Feeding habits of California sea lions from stranded carcasses collected at San Diego County and Santa Catalina Island, California. Admin. Rep. LJ-87-15. Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 33 pp.

Lowry, M. S., P. Boveng, R. J. DeLong, C. W. Oliver, B. S. Stewart, H. DeAnda, and J. Barlow. 1992. Status of the California sea lion (*Zalophus californianus californianus*) population in 1992. Admin. Rep. LJ-92-32. Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, CA 92038. 34 pp.

Lowry, M. S. and O. Maravilla-Chavez. 2005. Recent abundance of California sea lions in western Baja California, Mexico and the United States. *In* D. K. Garcelon and C. A. Schwemm (editors), Proceedings of the Sixth California Islands Symposium, Ventura, California, December 1-3, 2003. p. 485-497. National Park Service Technical Publication CHIS-05-01, Institute for Wildlife Studies, Arcata, California.

Lyons, E. T., S. R. Melin, R. L. DeLong, A. J. Orr, F. M. Gulland, and S.C. Tolliver. 2001. Current prevalence of adult *Uncinaria* spp. in northern fur seal (*Callorhinus ursinus*) and California sea lion (*Zalophus californianus)* pups on San Miguel Island, California, with notes on the biology of hookworms. Veterinary Parasitology 97:309-318.

Maldonado, J. E., F. O. Davila, B. S. Stewart, E. Greffen, and R. K Wayne. 1995. Intraspecific genetic differentiation in California sea lions (*Zalophus californianus*) from southern California and the Gulf of California. Mar. Mamm. Sci. 11(1):46-58.

Miller, D. J., M. J. Herder, and J. P. Scholl. 1983. California marine mammal-fishery interaction study, 1979-1981. Administrative Rept. LJ-83-13C. Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA. 233 p.

NMFS. 1995. Environmental assessment of proposed regulations to govern interactions between marine mammals and commercial fishing operations, under Section 118 of the Marine Mammal Protection Act. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, June 1995. 139 pp. + 4 Appendices.

Oliver, C. W. 1991. 1988-1991 field studies on pinnipeds at San Clemente Island. Admin. Rep. LJ-91-27. Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 33 pp.

Perez, M. 2003. Compilation of marine mammal incidental take data from the domestic and joint venture groundfish fisheries in the U.S. EEZ of the North Pacific, 1989-2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-138. 145 pp.

Scammon, C.M. 1874. The marine mammals of the north-western coast of North America, described and illustrated: Together with an account of the American whale fishery. John H. Carmany and Company, San Francisco, CA. 319p.

Scholin, C. A., Gulland, F., Doucette, G. J., Benson, S., Busman, M., Chavez, F. P., Cordaro, J., DeLong, R., De Vogelaere, A., Harvey, J., Haulena, M., Lefebvre, K., Lipscomb, T., Loscutoff, S., Lowenstine, L. J., Marin III, R., Miller, P. E., McLellan, W. A., Moeller, P. D. R., Powell, C. L., Rowles, T., Silvagni, P., Silver, M., Spraker, T., Trainer, V., and Van Dolah, F. M. 2000. Mortality of sea lions along the central California coast linked to a toxic diatom bloom. Nature, 403:80-84.

Schramm, Y., S.L. Mesnick, J. de la Rosa, D.M. Palacios, M.S. Lowry, D. Aurioles-Gamboa, H.M. Snell, and S. Escorza-Treviño. 2009. Phylogeography of California and Galapagos sea lions and population structure within the California sea lion. Marine Biology 156:1375-1387.

Seagers, D.J., D.P. DeMaster, and R.L. DeLong. 1985. A survey of historic rookery sites for California and northern sea lions in the Southern California Bight. Administrative Report LJ-85-13, National Marine Fisheries Service, Southwest Fisheries Center, 8604 La Jolla Shores Dr., La Jolla, CA.

Stewart, B. S. and P. K. Yochem. 1987. Entanglement of pinnipeds in synthetic debris and fishing net and line fragments at San Nicolas and San Miguel Islands, California, 1978-1986. Marine Pollution Bulletin 18:336-339.

Stewart, B.S., P.K.Yochem, R.L. DeLong, and G.A. Antonelis. 1993. Trends in Abundance and Status of Pinnipeds on the Southern California Channel Islands. *In:* Hochberg, F. G. (editor), Third California Islands Symposium: Recent Advances in Research in the California Islands. Santa Barbara, CA, Santa Barbara Museum of Natural History. pp 501_516.

Wolf, J. B.W., D. Tautz, and F. Trillmich. 2007. Galapagos and California sea lions are separate species: Genetic analysis of the genus *Zalophus* and its implications fro conservation management. Frontiers in Zoology: 4:20.

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HARBOR SEAL (*Phoca vitulina richardii*): California Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Harbor seals (*Phoca vitulina*) are widely distributed in the North Atlantic and North Pacific. Two subspecies exist in the Pacific: *P. v. stejnegeri* in the western North Pacific, near Japan, and *P. v. richardii* in the eastern North Pacific. The latter subspecies inhabits near-shore coastal and estuarine areas from Baja California, Mexico, to the Pribilof Islands in Alaska. These seals do not make extensive pelagic migrations, but do travel 300-500 km on occasion to find food or suitable breeding areas (Herder 1986; ~~D. Hanan, unpublished data~~ Harvey and Goley *in press*). In California, approximately 400-600 harbor seal haulout sites are widely distributed along the mainland and on offshore islands, including intertidal sandbars, rocky shores and beaches (Hanan 1996; Lowry et al. ~~2005~~ 2008).

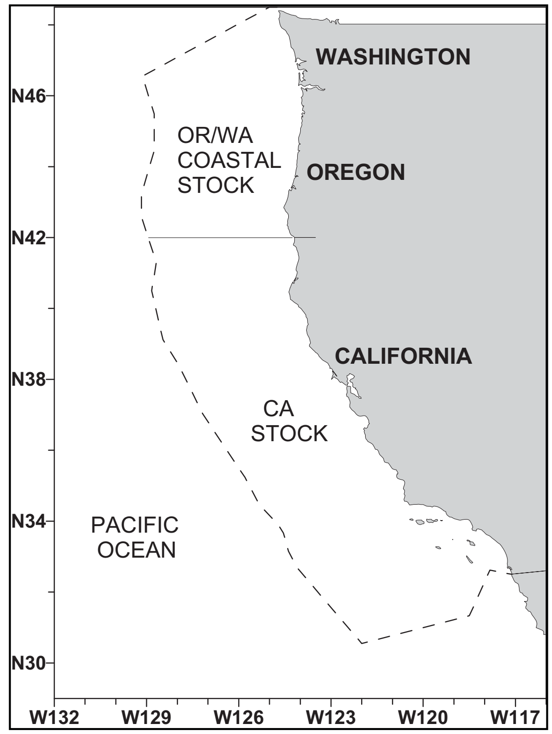

Figure 1. Stock boundaries for the California and Oregon/Washington coastal stocks of harbor seals. Dashed line represents the U.S. EEZ.

Within the subspecies *P. v. richardii*, abundant evidence of geographic structure comes from differences in mitochondrial DNA (Huber et al. 1994; Burg 1996; Lamont et al. 1996; Westlake and O'Corry-Crowe 2002; O'Corry-Crowe et al. 2003), mean pupping dates (Temte 1986), pollutant loads (Calambokidis et al. 1985), pelage coloration (Kelly 1981) and movement patterns (Jeffries 1985; Brown 1988). LaMont (1996) identified four discrete subpopulation differences in mtDNA between harbor seals from Washington (two locations), Oregon, and California. Another mtDNA study (Burg 1996) supported the existence of three separate groups of harbor seals between Vancouver Island and southeastern Alaska. Although we know that geographic structure exists along an almost continuous distribution of harbor seals from California to Alaska, stock boundaries are difficult to draw because any rigid line is (to a greater or lesser extent) arbitrary from a biological perspective. Nonetheless, failure to recognize geographic structure by defining management stocks can lead to depletion of local populations. Previous assessments of the status of harbor seals have recognized three stocks along the west coast of the continental U.S.: 1) California, 2) Oregon and Washington outer coast waters, and 3) inland waters of Washington. Although the need for stock boundaries for management is real and is supported by biological information, the exact placement of a boundary between California and Oregon was largely a political/jurisdictional convenience. An unknown number of harbor seals also occur along the west coast of Baja California, at least as far south as Isla Asuncion, which is about 100 miles south of Punta Eugenia. Animals along Baja California are not considered to be a part of the California stock because it is not known if there is any demographically significant movement of harbor seals between California and Mexico and there is no international agreement for joint management of harbor seals. Lacking any new information on which to base a revised boundary, the harbor seals of California will be again treated as a separate stock in this report (Fig. 1). Other Marine Mammal Protection Act (MMPA) stock assessment reports cover the ~~five~~ other stocks that are recognized along the U.S. west coast: Oregon/Washington outer coastal waters, Washington inland waters, and three stocks in Alaska coastal and inland waters.

POPULATION SIZE

A complete count of all harbor seals in California is impossible because some are always away from the haulout sites. A complete pup count (as is done for other pinnipeds in California) is also not possible because harbor seals are precocial, with pups entering the water almost immediately after birth. Population size is estimated by counting the number of seals ashore during the peak haul-out period (May to July) and by multiplying this count by a correction factor equal to the inverse of the estimated fraction of seals on land. ~~Boveng (1988) reviewed studies estimating the proportion of seals hauled out to those in the water and suggested that a correction factor for harbor seals is likely to be between 1.4 and 2.0. Huber (1995) estimated a mean correction factor of 1.53 (CV=0.065) for harbor seals in Oregon and Washington during the peak pupping season. Hanan (1996) estimated that 83.3% (CV=0.17) of harbor seals haul out at some time during the day during the May/June molt, and he estimated a correction factor of 1.20 based on those data. Neither correction factor is directly applicable to an aerial photographic count in California: the 1.53 factor was measured at the wrong time of year (when fewer seals are hauled out) and in a different area and the 1.20 factor was based on the fraction of seals hauled out over an entire 24-hour day (correction factors for aerial counts should be based on the fraction of seals hauled out at the time of the survey). Hanan (pers. comm.) revised his haul-out correction factor to 1.3 by using only those seals hauled out between 0800 and 1700 hrs which better corresponds to the timing of his surveys.~~ Harvey and Goley (*in press*) calculated a correction factor of 1.54 (CV=0.157) based on 180 seals radio-tagged in California. This correction factor is based on the mean of four date-specific correction factors (1.31, 1.38, 1.62, 1.84) calculated for central and northern California. Based on the most recent harbor seal counts (~~26,333~~ 19,608 in May-July ~~2004~~ 2009; NMFS unpublished data ~~Lowry et al. 2005~~) and ~~Hanan's~~ the ~~revised~~ Harvey and Goley (in press) correction factor, the harbor seal population in California is estimated to number ~~34,233~~ 30,196 seals (CV=0.157).

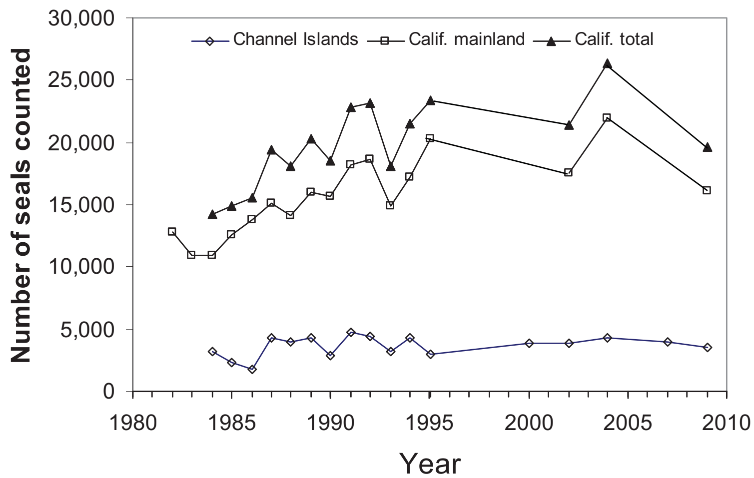

Figure 2. Harbor seal haulout counts in California during May/June (Hanan 1996; R. Read, CDFG unpubl. data; Lowry et al 2008, NMFS unpubl. data ~~from 2002 and 2004~~ 2009 surveys).

Minimum Population Estimate

~~Because of the way it was calculated (based on the fraction of seals hauled out at any time during a 24 hr day), Hanan's (1996) correction factor of 1.2 can be viewed as a minimum estimate of the fraction hauled out at a given instant. A population size estimated using this correction factor provides a reasonable assurance that the true population is greater than or equal to that number, and thus fulfills the requirement of a minimum population estimate. The minimum size of the California harbor seal population is therefore 31,600.~~ The minimum population size is estimated from the number of seals counted hauled out in 2009 (19,608), multiplied by the lower 20th percentile of the correction factor (1.36), or 26,667 seals.

Current Population Trend

Counts of harbor seals in California ~~showed a rapid~~ increased from ~~approximately 1972 (when the MMPA was first passed)~~ 1981 to ~~1990~~ 2004 (Fig. 2). ~~Net production rates appeared to be decreasing from 1982 to 1994 (Fig. 3).~~ The maximum statewide count in the 1981-2009 time series occurred in 2004 (Fig. 2). ~~Although earlier analyses were equivocal (Hanan 1996) and there has been no formal determination that the California stock has reached OSP (Optimal Sustainable Population level as defined by the MMPA), the decrease in population growth rate has occurred at the same time as a decrease in human-caused mortality and may indicate that the population is approaching its environmental carrying capacity. Population growth has also slowed or stopped for the harbor seal stock on the outer coasts of Oregon and Washington (see separate Stock Assessment Report).~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A realized rate of increase was calculated for the 1982-1995 period (when annual counts were available) by linear regression of the natural logarithm of total count versus year. The slope of this regression line was 0.035 (s.e.=0.007) which gives an annualized growth rate estimate of 3.5%. The ~~current~~ true rate of net production is greater than this observed growth rate because fishery and other human-caused mortality removes a fraction of the net production. Annual gillnet mortality may have been as high as 5-10% of the California harbor seal population in the mid-1980s; a kill this large would have depressed population growth rates appreciably. Net productivity was therefore calculated for 1980-1994 as the realized rate of population growth (increase in seal counts from year *i* to year *i*+1, divided by the seal count in year *i*) plus the human-caused mortality rate (fishery mortality in year *i* divided by population size in year *i*). Between 1983 and 1994, the net productivity rate for the California stock averaged 9.2% (Fig. 3). A regression shows a decrease in net production rates, but the decline is not statistically significant. Maximum net productivity rates cannot be estimated because measurements were not made when the stock size was very small. A current estimate of net production for the California harbor seal stock is difficult to determine because the fishery that was responsible for the most mortality (California halibut and white seabass set gillnet) has only been intermittently observed since the mid-1990s, and statewide annual counts of seals at rookeries are not available after 1995 (Fig. 2).

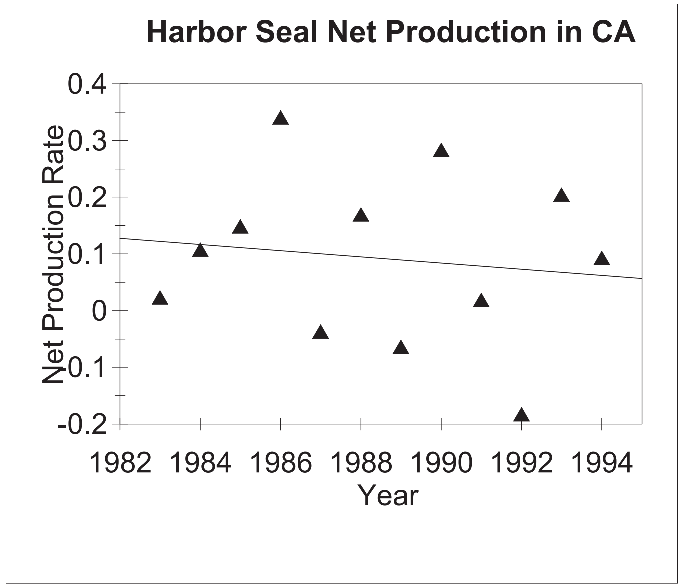

Figure 3. Net production rates and regression line estimated from haulout counts and fishery mortality.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (~~31,600~~ 26,667) times one half the default maximum net productivity rate for pinnipeds (½ of 12%) times a recovery factor of 1.0 (for a stock of unknown status that is growing or for a stock at OSP, Wade and Angliss 1997), resulting in a PBR of ~~1,896~~ 1,600.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Historical Takes

Prior to state and federal protection and especially during the nineteenth century, harbor seals along the west coast of North America were greatly reduced by commercial hunting (Bonnot 1928, 1951; Bartholomew and Boolootian 1960). Only a few hundred individuals survived in a few isolated areas along the California coast (Bonnot 1928). In the last half of this century, the population has increased dramatically.

Fishery Information

A summary of known fishery mortality and injury for this stock of harbor seals is given in Table 1. More detailed information on these fisheries is provided in Appendix 1. ~~Because the vast majority of harbor seal mortality in California fisheries occurs in the set gillnet fishery, because that fishery has undergone dramatic reductions and redistributions of effort, and because the entire fishery has not been observed since 1994, average annual mortality cannot be accurately estimated for the recent years (1999-2003). Rough estimates for 1999-2003 have been made by extrapolation of prior kill rates using recent effort estimates and observations in the Monterey portion of the fishery from 1999 and 2000 (Table 1). Observations from the Monterey Bay portion of the fishery included 57 and 24 harbor seals taken in 1999 and 2000,~~

~~respectively.~~ Historically, the set gillnet fishery for halibut and white seabass was the largest source of fishery mortality and remains the most likely fishery in California to interact with harbor seals today. Julian and Beeson (1998) reported a range of annual mortality estimates from 227 to 1,204 seals (mean = 584) from 1990 to 1994, based on 5% to 15% fishery observer coverage. Regulations implemented in 1994 moved the fishery farther offshore in southern California, which may have reduced harbor seal entanglements in this region. The fishery was not observed again until 1999 and 2000 in Monterey Bay, although annual mortality estimates of 300-400 seals were still calculated based on 1990-1994 bycatch rates and 1999-2000 fishing effort (Cameron and Forney 2000, Cameron and Forney 2001, Carretta 2002, 2003). The observer program for this fishery was discontinued after 2000. In 2002 the fishery was subject to further area restrictions that effectively eliminated fishing north of Point Arguello, California. In 2006, the fishery was again observed at low levels (12 sets out of an estimated 1,300) with one observed mortality. In 2007, 248 sets were observed (~17% observer coverage) with 2 harbor seal deaths observed and a resulting mortality estimate of 11 animals (Table 1). Total effort in the set gillnet fishery has declined from approximately 4,000 sets annually to approximately 1,300 (Carretta and Enriquez 2009a). Stranding data ~~reported to the California Marine Mammal Stranding Network~~ ~~1999-2003~~ from California between 2005 and 2009 include eight harbor seal deaths ~~and injuries~~ caused by hook-and-line fisheries ~~(four deaths, two injuries) and gillnet fisheries (two deaths, two injuries). The locations and timing of harbor seal strandings attributed to gillnet fisheries suggest that the halibut/angel shark or white seabass set gillnet fishery are responsible for the interactions (see Appendix 1 for fishery descriptions).~~ The total annual human-caused mortality from 2005 to 2009 from commercial fisheries is 18 animals per year (Table 1). There were also 7 harbor seal deaths attributed to recreational hook and line fisheries between 2005 and 2009 (NMFS, unpublished stranding data).

Other Mortality

~~The California Marine Mammal Stranding database maintained by the National Marine Fisheries Service, Southwest Region, contains the following records of human-related harbor seal mortality and injuries in 1999-2003: (1) boat collision (eight deaths, two injuries), (2) entrainment in power plants (26 deaths), (3) shootings (15 deaths), and (4) all-terrain vehicle (ATV) collision (one injury).~~ NMFS stranding records for California for the period 2005-2009 include the following human-caused mortality not included in Table 1: shootings (2), ship/vessel strikes (1), entrainment in power plants (52), and research-related deaths (3). This results in an annual average of 12 harbor seal deaths per year for the years 2005-2009.

Table 1. Summary of available information on the mortality and serious injury of harbor seals (California stock) in commercial fisheries that might take this species ~~(Cameron and Forney 2000; Carretta 2001, 2002; Carretta et al. 2003; Carretta and Chivers 2004).~~ (Carretta and Enriquez 2006, 2009; Heery et al. 2010). n/a indicates that data are not available. Mean annual takes are based on ~~1999-2003~~ 2005-2009 data unless noted otherwise.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
~~CA/OR thresher shark/swordfish drift gillnet fishery~~	~~1998-2003~~	~~observer data~~	~~20-23%~~	~~0~~	~~0,0,0,0,0~~	~~0~~
CA ~~angel shark/~~halibut and ~~other species large mesh (>3.5")~~ white seabass set gillnet fishery	~~1999-2003~~ 2005 2006 2007 2008 2009	~~observer data~~ ~~extrapolated Estimate~~ 12 sets observed in 2006 and 248 sets observed in 2007	~~4.0%~~[3] ~~1.7%~~[3] ~~0.0%~~[3] ~~0.0%~~[3] ~~0.0%~~[3] 0% <1% 17.8% 0% 0%	~~57~~ ~~24~~ - - 0 0 2 0 0	~~662 (0.10)~~[1] ~~415 (0.08)~~[1] ~~329 (0.09)~~[1] ~~337 (0.11)~~[1] ~~186 (0.09)~~[1] n/a n/a 11 (0.73) n/a n/a	~~386 (0.05)~~[1] 11 (0.73)[1]
~~CA, OR, and WA salmon troll fishery~~	~~1990-92~~	~~logbook data~~	-		~~Avg. Annual take = 7.33~~	~~n/a~~
~~CA herring purse seine fishery~~	~~1990-92~~	~~logbook data~~	-		~~Avg. Annual take = 0~~	~~n/a~~
CA anchovy, mackerel, sardine, and tuna purse seine fishery	~~1990-92~~ 2004-2006	~~logbook data~~ observer data	- ~2%	0	~~Avg. Annual take = 0.67~~ 0	~~n/a~~ 0
WA, OR, CA groundfish trawl (includes at-sea hake and other limited-entry groundfish sectors)	~~1999~~ ~~2000~~ ~~2001~~ ~~2002~~ ~~2003~~ ~~1999-2003~~ 2004 2005 2006 2007 2008	observer ~~data unmonitored Hauls~~	~~68.6%~~ ~~80.6%~~ ~~96.2%~~ ~~100%~~ ~~100%~~ 99% to 100% of tows in at-sea hake fishery; 18%-26% of landings in other groundfish sectors	~~0~~ ~~2~~ ~~0~~ ~~0~~ ~~0~~ ~~1~~ 1 1 1 0 4	~~0~~ ~~3 (0.21)~~ ~~0~~ ~~0~~ ~~0~~ ~~1~~ 1 (n/a) 1 (n/a) 1 (n/a) 0 (n/a) 29 (n/a)	~~0.6 (0.21)~~ 6.4 (n/a)
CA squid purse seine fishery	~~1997-2001~~ 2004-2006	~~logbook data~~ observer data	~~Warden obs 2-3 trips/month~~ ~5%	~~0~~ 0	~~Avg. Annual take = 0~~ 0	~~n/a~~ 0
(unknown net ~~and hook~~ fisheries)	~~1999-2003~~ 2005-2009	stranding data	n/a	~~6~~ 4	n/a	~~1.5~~ ≥0.8
Total annual takes						~~388 (0.05)~~ 18 (0.73)

[1]~~The CA set gillnets were not observed after 1994, except for Monterey Bay, where the fishery was observed in 1999 and 2000. Mortality in other regions was extrapolated from current (1999-2003) effort estimates and 1990-94 entanglement rates, thus the CV of the mortality estimate for this fishery is likely to be underestimated by an unknown amount. There was no observer coverage in this fishery in 2001-2003.~~ Only 2007 data is included in the mean annual take calculation for the CA halibut and white seabass fishery, due to the low observer coverage (<1%) in 2006.

STATUS OF STOCK

A review of harbor seal dynamics through 1991 concluded that their status relative to OSP could not be determined with certainty (Hanan 1996). ~~They~~ California harbor seals are not listed as "endangered" or "threatened" under the Endangered Species Act nor as "depleted" under the MMPA. ~~Total fishing mortality cannot be accurately estimated for recent years, but extrapolations from past years indicate that fishing mortality (388 per year)~~ Annual human-caused mortality from commercial fisheries (18/yr) and other human-caused sources (13/year) is 31 animals, which is less than the calculated PBR for this stock (~~1,896~~ 1,600), and thus they would not be considered a "strategic" under the MMPA. The fishery that historically removed the largest numbers of harbor seals (halibut and white seabass set gillnet) has been observed only intermittently in recent years, but annual bycatch from 2007 when the fishery had ~18% observer coverage indicates that current rates of absolute bycatch are much lower than during the 1990s. The average annual rate of incidental commercial fishery mortality (18 animals) is ~~likely to be greater~~ less than 10% of the calculated PBR (1,600 animals); therefore, fishery mortality ~~cannot be~~ is considered insignificant and approaching zero mortality and serious injury rate. The population appears to be stabilizing at what may be its carrying capacity and the fishery mortality is declining. There are no known habitat issues that are of particular concern. Two unexplained harbor seal mortality events occurred in Point Reyes National ~~Park~~ Seashore involving at least 90 seals in 1997 and 16 seals in 2000. Necropsy of three seals in 2000 showed severe pneumonia; tests for morbillivirus were negative, but attempts are being made to identify another virus isolated from one of the three (F. Gulland, pers. comm.). All west-coast harbor seals that have been tested for morbilliviruses were found to be seronegative, indicating that this disease is not endemic in the population and that this population is extremely susceptible to an epidemic of this disease (Ham-Lammé et al. 1999).

REFERENCES

Barlow, J., R. W. Baird, J. E. Heyning, K. Wynne, A. M. Manville, II, L. F. Lowry, D. Hanan, J. Sease, and V. N. Burkanov. 1994. A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the U.S. and Canada and the east coast of the Russian Federation. Rep. Int. Whal. Commn, Special Issue 15:405-425.

Bartholomew, G. A., R. A. Boolootian. 1960. Numbers and population structure of the pinnipeds on the California Channel Islands. J. Mammal. 41:366-375.

Bonnot, P. 1928. Report on the seals and sea lions of California. Fish Bulletin Number 14. California Division of Fish and Game.

Bonnot, P. 1951. The sea lions, seals and sea otter of the California coast. California Fish and Game 37(4):371-389.

~~Boveng, P. 1988. Status of the Pacific harbor seal population on the U.S. west coast. Admin. Rep. LJ-88-06. Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 43 pp.~~

Brown, R. F. 1988. Assessment of pinniped populations in Oregon. Processed Report 88-05, National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Seattle, Washington.

Burg, T. M. 1996. Genetic analysis of eastern Pacific harbor seals (*Phoca vitulina richardsi*) from British Columbia and parts of Alaska using mitochondrial DNA and microsatellites. Masters Thesis, Univ. of British Columbia, Vancouver, British Columbia. 77pp.

Calambokidis, J., S. M. Speich, J. Peard, G. H. Steiger, and J. C. Cubbage. 1985. Biology of Puget Sound marine mammals and marine birds: population health and evidence of pollution effects. U.S. Dep. Commer., NOAA Tech. Memo. NOS-OMA-18. 159 pp.

Carretta, J.V. and L. Enriquez. 2006. Marine mammal bycatch and estimated mortality in California commercial fisheries during 2005. Administrative Report LJ-06-07, available from Southwest Fisheries Science Center, 3333 North Torrey Pines Ct., La Jolla, California, 92037. 14 p.

Carretta, J.V. and L. Enriquez. 2009. Marine mammal and seabird bycatch in observed California commercial fisheries in 2007. Administrative Report LJ-09-01, available from Southwest Fisheries Science Center, 3333 North Torrey Pines Ct., La Jolla, California, 92037. 12 p.

~~Cameron, G. A. and K. A. Forney. 1999. Preliminary estimates of cetacean mortality in the California gillnet fisheries for 1997 and 1998. Paper SC/51/O4 presented to the International Whaling Commission, May 1999 (unpublished). 14 pp.~~

~~Cameron, G.A. and K.A. Forney. 2000. Preliminary Estimates of Cetacean Mortality in California/Oregon Gillnet Fisheries for 1999. Paper SC/52/O24 presented to the International Whaling Commission, 2000 (unpublished). 12 pp. Available from NMFS, Southwest Fisheries Science Center, P.O. Box 271, La Jolla, California, 92038, USA.~~

~~Carretta, J.V. 2001. Preliminary estimates of cetacean mortality in California gillnet fisheries for 2000. Report SC/53/SM9 presented to the Scientific Committee of the International Whaling Commission, June 2001 (unpublished). 21p. [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Dr., La Jolla, CA 92037, USA.]~~

~~Carretta, J.V. 2002. Preliminary estimates of cetacean mortality in California gillnet fisheries for 2001. Report SC/54/SM12 presented to the Scientific Committee of the International Whaling Commission, April 2002 (unpublished). 22p. [Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Dr., La Jolla, CA 92037, USA.]~~

~~Carretta, J. V. and S. J. Chivers. 2003. Preliminary estimates of marine mammal mortality and biological sampling of cetaceans in California gillnet fisheries for 2002. Paper SC/55/SM3 presented to the International Whaling Commission (unpublished). 21pp.~~

~~Carretta, J. V. and S. J. Chivers. 2004. Preliminary estimates of marine mammal mortality and biological sampling of cetaceans in California gillnet fisheries for 2003. Paper SC/56/SM1 presented to the International Whaling Commission (unpublished). 20pp~~.

Forney, K.A., J. Barlow, M.M. Muto, M. Lowry, J. Baker, G. Cameron, J. Mobley, C. Stinchcomb, and J.V. Carretta. 2000. U.S. Pacific Marine Mammal Stock Assessments: 2000. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-300. 276p.

Ham-Lammé, K. D., D. P. King, B. C. Taylor, C. House, D. A. Jessup, S. Jeffries, P. K Yochem, F. M. D. Gulland, D. A. Ferrick, and J. L. Stott. 1999. The application of immuno-assays for serological detection of morbillivirus exposure in free ranging harbor seals (*Phoca vitulina*) and sea otters (*Enhydra lutris*) from the western coast of the United States. Mar. Mamm. Sci. 15(2):601-608.

Hanan, D. A. 1993. Status of the Pacific harbor seal population on the coast of California in 1992. Final Report to the National Marine Fisheries Service, Southwest Region. 27pp.

Hanan, D. A. 1996. <u>Dynamics of Abundance and Distribution for Pacific Harbor Seal, *Phoca vitulina richardsi*, on the Coast of California.</u> Ph.D. Dissertation, University of California, Los Angeles. 158pp.

Hanan, D. A., and S. L. Diamond. 1989. Estimates of sea lion, harbor seal, and harbor porpoise mortality in California set net fisheries for the 1986-87 fishing year. Final Report. Cooperative agreement No. NA-86-ABH-00018. NOAA/NMFS SWR, January 1989. 10 pages.

Hanan, D. A., D. B. Holts, and A. L. Coan, Jr. 1993. The California drift gill net fishery for sharks and swordfish, 1981-82 through 1990-91. Calif. Dept. Fish and Game Fish. Bull. No. 175. 95pp.

Hanan, D. A., J. P. Scholl, and S. L. Diamond. 1988. Estimates of sea lion and harbor seal mortality in California set net fisheries for 1983, 1984, and 1985. Final Report. Cooperative agreement No. NA-86-ABH-00018. NOAA/NMFS SWR October 1988. 10 pages.

Harvey, J.T. and D. Goley. *In press*. Determining a correction factor for aerial surveys of harbor seals in California. Marine Mammal Science *In press*.

Heery, E., Bellman, M.A., and J. Majewski. 2010. Estimated bycatch of marine mammals, seabirds, and sea turtles in the 2002-2008 U.S. west coast commercial groundfish fishery. West Coast Groundfish Observer Program. NWFSC, 2725 Montlake Blvd E., Seattle, WA 98112. 106 p.

Herder, M. J. 1986. Seasonal movements and hauling site fidelity of harbor seals, *Phoca vitulina richardsi*, tagged at the Russian River, California. MS Thesis. Humbolt State Univ. 52 pages.

~~Huber, H. 1995. The abundance of harbor seals (*Phoca vitulina richardsi*) in Washington, 1991-1993. MS Thesis, Univ. of Washington, Seattle, Washington. 56 pp.~~

Huber, H., S. Jeffries, R. Brown, and R. DeLong. 1994. Harbor seal stock assessment in Washington and Oregon 1993. Annual report to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910.

Jeffries, S. J. 1985. Occurrence and distribution patterns of marine mammals in the Columbia River and adjacent coastal waters of northern Oregon and Washington. *In*: Marine Mammals and Adjacent Waters, 1980-1982. Processed Report 85-04, National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Seattle, Washington.

Julian, F. And M. Beeson. 1998. Estimates for marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-1995. Fish. Bull. 96:271-284.

Kelly, B. P. 1981. Pelage polymorphism in Pacific harbor seals. Can. J. Zool. 59:1212-1219.

~~Lowry, M.S., J.V. Carretta, and K.A. Forney. 2005. Pacific harbor seal, Phoca vitulina richardsi, census in California during May - July 2004. Administrative Report LJ-05-06, available from Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037. 38 p.~~

Lowry, M. S., J. V. Carretta and K. A. Forney. 2008. Pacific harbor seal census in California during May-July 2002 and 2004. California Fish and Game: 94:180-193.

Lamont, M. M., J. T. Vida, J. T. Harvey, S. Jeffries, R. Brown, H. H. Huber, R. DeLong, and W. K. Thomas. 1996. Genetic substructure of the Pacific harbor seal (*Phoca vitulina richardsi*) off Washington, Oregon, and California. Mar. Mamm. Sci. 12(3):402-413.

Miller, D. J., M. J. Herder, and J. P. Scholl. 1983. California marine mammal-fishery interaction study, 1979-1981. Admin. Rep. LJ-83-13C. Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 233 pp.

NMFS. 1995. Environmental assessment of proposed regulations to govern interactions between marine mammals and commercial fishing operations, under Section 118 of the Marine Mammal Protection Act. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, June 1995. 139 p. + 4 Appendices.

O'Corry-Crowe, G. M., K. K. Martien, and B. L. Taylor. 2003. The analysis of population genetic structure in Alaskan harbor seals, Phoca vitulina, as a framework for the identification of management stocks. Administrative Report LJ-03-08. Southwest Fisheries Sceeince Center, 8604 La Jolla Shores Drive, La Jolla, CA, 92037.

Perkins, P., J. Barlow, and M. Beeson. 1994. Report on pinniped and cetacean mortality in California gillnet fisheries: 1988-90. Admin. Rep. LJ-94-11. Southwest Fisheries Science Center, National Marine Fisheries Service, P. O. Box 271, La Jolla, California, 92038. 16 pp.

Temte, J. L. 1986. Photoperiod and the timing of pupping in the Pacific harbor seal (*Phoca vitulina richardsi*) with notes on reproduction in northern fur seals and Dall's porpoises. Masters Thesis, Oregon State Univ., Corvallis, Oregon.

Westlake, R. L. and G. M. O'Corry-Crowe. 2002. Macrogeographic structure and patterns of genetic diversity in harbor seals (Phoca vitulina) from Alaska to Japan. Journal of Mammalogy 83(4): 1111-1126.

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HAWAIIAN MONK SEAL (*Monachus schauinslandi*)

STOCK DEFINITION AND GEOGRAPHIC RANGE

Hawaiian monk seals are distributed predominantly in six Northwestern Hawaiian Islands (NWHI) subpopulations at French Frigate Shoals, Laysan and Lisianski Islands, Pearl and Hermes Reef, and Midway and Kure Atoll. ~~Small numbers~~ They also occur at Necker, Nihoa, and the main Hawaiian Islands (MHI). Genetic variation among NWHI monk seals is extremely low and may reflect both a long-term history at low population levels and more recent human influences (Kretzmann et al. 1997, 2001, Schultz et al. 2009). On average, 10-15% of the seals migrate among the NWHI subpopulations (Johnson and Kridler 1983; Harting 2002). Thus, the NWHI subpopulations are not isolated, though the different island subpopulations have exhibited considerable demographic independence. Observed interchange of individuals among the NWHI and MHI regions is uncommon ~~rare~~, and ~~yet preliminary~~ genetic stock structure analysis (Schultz et al. in press ~~in review~~) ~~suggests~~ supports management of the species ~~is appropriately managed~~ as a single stock.

POPULATION SIZE

The best estimate of the total population size is ~~1,161~~ 1,125. This estimate is the sum of estimated abundance at the six main Northwestern Hawaiian Islands subpopulations, an extrapolation of counts at Necker and Nihoa Islands, and an estimate of minimum abundance in the main Hawaiian Islands. The number of individual seals identified was used as the population estimate at NWHI sites where total enumeration was achieved according to the criteria established by Baker et al. (2006). Where total enumeration was not achieved, capture-recapture estimates from Program CAPTURE were used (Baker 2004; Otis et al. 1978, Rexstad & Burnham 1991, White et al. 1982). When no reliable estimator was obtainable in Program CAPTURE (i.e., the model selection criterion was < 0.75, following Otis et al. 1978), the total number of seals identified was the best available estimate. Finally, sometimes capture-recapture estimates are less than the known minimum abundance (Baker 2004), and in these cases the total number of seals actually identified was used. In 2008, total enumeration was ~~not definitively~~ achieved at Laysan Island and ~~any site, however~~ analysis of discovery curves (Baker et al. 2006) suggested that nearly all seals were identified at Lisianski Island, Pearl and Hermes Reef, and Midway Atoll. ~~Laysan Island and Kure Atoll. Except at Midway Atoll, capture-recapture analysis either found no suitable estimator was available or the estimate was lower than known minimum abundance.~~ Capture-recapture estimates larger than known minimum abundance were available for French Frigate Shoals, Lisianski Island and Kure Atoll. Thus, abundance at the six main subpopulations was estimated to be ~~914~~ 855 (including ~~138~~ 118 pups). Monk seals also occur at Necker and Nihoa Islands, where counts are conducted from zero to a few times in a single year. Abundance is estimated by correcting the mean of all beach counts accrued over the past five years. The mean (±SD) of all counts (excluding pups) conducted between ~~2004~~ 2005 and ~~2008~~ 2009 was ~~15.5 (±5.1)~~ 16.7 (±5.6) at Necker Island and ~~27.1 (±5.7)~~ 29.2 (±6.4) at Nihoa Island (Johanos and Baker ~~in press~~, in prep., Johanos in prep.). The relationship between mean counts and total abundance at the reproductive sites indicates that the total abundance can be estimated by multiplying the mean count by a correction factor of 2.89 (NMFS unpubl. data). Resulting estimates (plus the average number of pups known to have been born during ~~2004-2008)~~ 2005-2009 are ~~47.8 (±14.7)~~ 51.3 (±16.2) at Necker Island and ~~86.5 (±16.5)~~ 93.4 (±18.5) at Nihoa Island.

The only complete, systematic surveys for monk seals in the MHI were conducted in 2000 and 2001 (Baker and Johanos 2004). NMFS continues to collect~~s~~ information on seal sightings reported by a variety of sources, including a volunteer network, reports from the public and directed NMFS observation effort. ~~Recently, the number of such reports has increased and related database improvement efforts have been underway.~~ The total number of individually identifiable seals documented ~~in this way~~ in ~~2008~~ 2009 was ~~113~~ 125, the current best minimum abundance estimate for the MHI.

Minimum Population Estimate

The total number of seals (~~913~~ 849) identified at the six main NWHI reproductive sites is the best estimate of minimum population size at those sites. Minimum population sizes for Necker and Nihoa Islands (based on the formula provided by Wade and Angliss (1997)) are ~~37 and 74~~ 40 and 79, respectively. The minimum abundance estimate for the main Hawaiian Islands in 2008 is ~~113~~ 125 seals. The minimum population size for the entire stock (species) is the sum of these estimates, or ~~1,136~~ 1,093 seals.

Current Population Trend

Current population trend is based solely on the six NWHI subpopulations because these sites have historically comprised virtually the entire species, while information on the remaining smaller seal aggregations have been inadequate to reliably evaluate abundance or trends. The total of mean non-pup beach counts at the six main reproductive NWHI subpopulations in 2008 is 68% lower than in 1958. The trend in total abundance at the six main NWHI subpopulations estimated as described above is shown in Figure 1. A log-linear regression of estimated abundance on year for the past 10 years (~~1999-2008~~2000-2009) estimates that abundance declined -4.5% yr^{-1} (95% CI = ~~-5.0~~-5.1% to -3.9% yr^{-1}).

The MHI monk seal population appears to be increasing with an intrinsic population growth rate estimated at ~~5.6%~~ 6.5% per year based upon ~~Leslie matrix analysis~~ simulation modeling (Baker et al., ~~in review~~2010). Likewise, sporadic beach counts at Necker and especially Nihoa Islands, suggest positive growth. While these sites have historically comprised a small fraction of the total species abundance, the decline of the six main NWHI subpopulations, coupled with growth at Necker, Nihoa and the MHI may mean that these latter three sites now substantially influence the total abundance trend. The MHI, Necker and Nihoa Islands estimates, uncertain as they are, comprised 24% of the stock's estimated total abundance in 2009. Unfortunately, because we lack reliable abundance estimates for these areas, their influence cannot currently be determined. A remote camera system is slated for installation in 2011 on Nihoa Island, which should result in improved abundance information at this site.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Trends in abundance vary considerably among subpopulations. Mean non-pup beach counts are used as a long-term index of abundance for years when data are insufficient to estimate total abundance as described above. Prior to 1999, beach count increases of up to 7% yr^{-1} were observed at Pearl and Hermes Reef, and this is the highest estimate of the maximum net productivity rate (R_{max}) observed for this species. Since 2000, low juvenile survival, thought to be due largely to food limitation, has resulted in population decline in the six main NWHI subpopulations (Fig. 1).

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is designed to allow stocks to recover to, or remain above, the maximum net productivity level (MNPL) (Wade 1998). An underlying assumption in the application of the PBR equation is that marine mammal stocks exhibit certain dynamics. Specifically, it is assumed that a depleted stock will naturally grow toward OSP (Optimum Sustainable Population), and that some surplus growth could be removed while still allowing recovery. The Hawaiian monk seal population is far below historical levels and has declined 4.5% yr^{-1} on average since ~~1999~~2000. Thus, the stock's dynamics do not conform to the underlying model for calculating PBR such that PBR for the Hawaiian monk seal is undetermined.

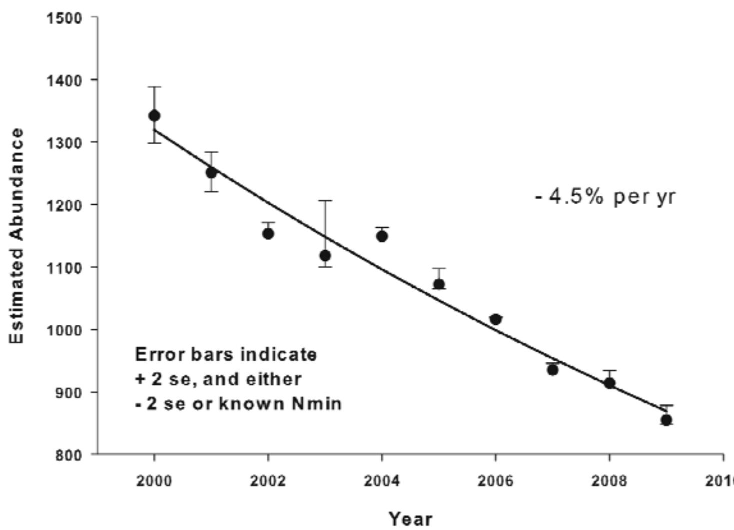

Figure 1. Trend in abundance of monk seals at the six main Northwestern Hawaiian Islands subpopulations, based on a combination of total enumeration and capture–recapture estimates. Error bars indicate ±2 s.e. (from variances of capture-recapture estimates). Fitted log-linear regression line is shown.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Human-related mortality has caused two major declines of the Hawaiian monk seal (Ragen 1999). In the 1800s, this species was decimated by sealers, crews of wrecked vessels, and guano and feather hunters (Dill and Bryan 1912; Wetmore 1925; Bailey 1952; Clapp and Woodward 1972). Following a period of at least partial recovery in the first half of the 20th century (Rice 1960), most subpopulations again declined. This second decline has not been fully explained, but trends at several sites appear to have been determined by human disturbance from military or U.S. Coast Guard activities (Ragen 1999; Kenyon 1972; Gerrodette and Gilmartin 1990). Currently, human activities in the NWHI are limited and human disturbance is relatively rare, but human-seal interactions, have become an important issue in the MHI. Three seals (including a pregnant female) were shot and killed in the MHI in 2009 (Baker et al. 2010). This level of intentional killing is unprecedented in recent decades and represents a disturbing new threat to the species.

Fishery Information

Fishery interactions with monk seals can include direct interaction with gear (hooking or entanglement), seal consumption of discarded catch, and competition for prey. Entanglement of monk seals in derelict fishing gear, which is believed to originate outside the Hawaiian archipelago, is described in a separate section below.

Fishery interactions are a serious concern in the MHI, especially involving State of Hawaii managed nearshore fisheries. Three seals have been found dead in nearshore (non-recreational) gillnets (in 1994, 2006, and 2007), and a seal was found dead in 1995 with a hook lodged in its esophagus. A total of ~~52~~ 64 seals have been observed with embedded hooks in the MHI during 1989-~~2008~~2009 (including ~~9~~ 12 in ~~2008~~ 2009, of which ~~3~~ 4 constituted serious injuries entered in Table 1) . Several incidents, including the dead hooked seal mentioned above, involved hooks used to catch ulua (jacks, *Caranx* spp.). Interactions in the MHI appear to be on the rise, as most reported hookings have occurred since 2000, and five seals have been observed entangled in nearshore gillnets during 2002-~~2008~~ 2009 (NMFS unpubl. data). ~~The MHI bottomfish handline fishery may also interact indirectly with monk seals as evidenced by the aforementioned fatty acid research, though no~~ No mortality or serious injuries have been attributed to the MHI bottomfish handline fishery (Table 1). Published studies on monk seal prey selection based upon scat/spew analysis and seal-mounted video revealed some evidence that monk seals fed on families of bottomfish which contain commercial species (many prey items recovered from scats and spews were identified only to the level of family; Goodman-Lowe 1998, Longenecker et al. 2006, Parrish et al. 2000). Recent quantitative fatty acid signature analysis (QFASA) results support previous studies illustrating that monk seals consume a wide range of species (Iverson et al. 2011). However, deepwater-slope species, including two commercially targeted bottomfishes and other species not caught in the fishery, were estimated to comprise a large portion of the diet for some individuals. Similar species were estimated to be consumed by seals regardless of location, age or gender, but the relative importance of each species varied. Diets differed considerably between individuals. These results highlight the need to better understand potential ecological interactions with the ~~Hawaiian~~ MHI bottomfish handline fishery.

~~In the past, Monk seal interactions with fisheries in the NWHI were documented, but direct interactions have since become rare or non-existent~~ There are no fisheries operating in or near the NWHI.~~, and issues related to competition have also somewhat abated~~. In the past, interactions between the Hawaii-based domestic pelagic longline fishery and monk seals were documented (NMFS 2002). This fishery targets swordfish and tunas and does not compete with Hawaiian monk seals for prey. In October 1991, in response to 13 unusual seal wounds thought to have resulted from interactions with this fishery, NMFS established a Protected Species Zone extending 50 nautical miles around the NWHI and the corridors between the islands. Subsequently, no additional monk seal interactions with either the swordfish or tuna components of the longline fishery have been observed. Possible reduction of monk seal prey by the NWHI lobster fishery has also been raised as a concern, though whether the fishery indirectly ~~impacted~~ affected monk seals remains unresolved. However, the NWHI lobster fishery closed in 2000. ~~and on June 15,~~ In 2006, the Northwestern Hawaiian Islands (later renamed *Papahanaumokuokea*) Marine National Monument was established. Subsequent regulations prohibited commercial fishing in the Monument, except for the bottomfish fishery (and associated pelagic species catch), which ~~may~~ had potential to continue until 2011 (U.S. Department of Commerce and Department of the Interior, 2006). However, in 2009 the remaining permit holders surrendered their permits to NMFS in exchange for compensation from the Federal Government and the fishery was closed. The total NWHI bottomfish catch in 2009 was 29 metric tons. ~~The NWHI bottomfish handline fishery landed between 66 and 201 metric tons per year from 1989-2008 (Kawamoto 1995; Kawamoto, pers. comm.) and the number of vessels is currently capped at 9 (8 made NWHI trips in 2008 , Kawamoto, pers. comm.). Nitta and Henderson (1993) documented reports of seals taking bottomfish and bait off fishing lines, and reports of seals attracted to discarded bycatch. A Federal observer program of the fishery began in the fourth quarter of 2003 and no monk seal interactions were observed through the program's conclusion in 2006. NMFS prepared a Section 7 Biological Opinion on the Fishery Management Plan for the bottomfish fishery, and concluded that the operation of this fishery is not likely to jeopardize the continued existence of the Hawaiian monk seal nor would it likely destroy or adversely modify the monk seal's critical habitat (NMFS 2002). The Biological Opinion has no incidental take statement. An EIS for the bottomfish fishery management plan has also been prepared. Fishermen indicate that they have engaged in mitigating activity over the past several years, e.g., holding discards on board, etc. (NMFS pers. comm.). The ecological effects of this fishery on monk seals (e.g., competition for prey or alteration of prey assemblages) are unknown. However,~~

Table 1. Summary of mortality and serious injury of Hawaiian monk seals due to fisheries and calculation of annual mortality rate. n/a indicates that sufficient data are not available.

Fishery Name	Year	Data Type	% Obs. coverage	Observed/Reported Mortality/Serious Injury	Estimated Mortality/ Serious Injury	Mean Takes (CV)
Pelagic Longline	~~2004~~ 2005 2006 2007 2008 2009	observer observer observer observer observer	~~24.6%~~ 26.1% & 100%[1] 22.1% & 100%[1] 20.1% & 100%[1] 21.7% & 100%[1] 20.6% & 100%[1]	0 0 0 0 0	0 0 0 0 0	0 (0)
NWHI Bottomfish	2004 2005 2006	observer observer observer	18.3% 25.0% 3.9%	0 0 0	0 0 0	0 (0)
MHI Bottomfish[2]	~~2004~~ 2005 2006 2007 2008 2009	Incidental observations of seals	none	0 0 0 0 0	n/a	n/a
Nearshore[2]	~~2004~~ 2005 2006 2007 2008 2009	Incidental observations of seals	none	~~2~~ 1 1 1 3 4	n/a	n/a

Fishery Mortality Rate

Total fishery mortality and serious injury cannot be considered to be insignificant and approaching a rate of zero. Monk seals are being hooked and entangled in the MHI at a rate which has not been reliably assessed but is certainly greater than zero. The information above represents only reported direct interactions, and without purpose-designed observation effort the true interaction rate cannot be estimated. Monk seals also die from entanglement in fishing gear and other debris throughout their range (likely originating from various countries), and NMFS along with partner agencies is pursuing a program to mitigate entanglement (see below). Indirect interactions (i.e., involving competition for prey or consumption of discards) remain the topic of ongoing investigation.

Entanglement in Marine Debris

Hawaiian monk seals become entangled in fishing and other marine debris at rates higher than reported for other pinnipeds (Henderson 2001). A total of ~~289~~ 298 cases of seals entangled in fishing gear or other debris have been observed from 1982 to ~~through 2008~~ 2009 (Henderson 2001; NMFS, unpubl. data), including eight documented deaths resulting from entanglement in marine debris (Henderson 1990, 2001; NMFS, unpubl. data). The fishing gear fouling the reefs and beaches of the NWHI and entangling monk seals only rarely includes types used in Hawaii fisheries. For example, trawl net and monofilament gillnet accounted for approximately 35% and 34% of the debris removed from reefs in the NWHI by weight, and trawl net alone accounted for 88% of the debris by frequency (Donohue et al. 2001). Yet, trawl fisheries have been prohibited in Hawaii since the 1980s.

The NMFS and partner agencies continue to mitigate impacts of marine debris on monk seals as well as turtles, coral reefs and other wildlife. Marine debris is removed from beaches and entangled seals during annual population assessment activities at the main reproductive sites. Since 1996, annual debris survey and removal efforts in the NWHI coral reef habitat have been ongoing (Donohue et al. 2000, Donohue et al. 2001, Dameron et al. 2007).

Other Mortality

From ~~Since~~ 1982 to 1994, 23 seals died during rehabilitation efforts ~~that ceased in 1994~~. Additionally, two

[1] Observer coverage for deep and shallow-set components of the fishery, respectively

[2] Data for MHI bottomfish and nearshore fisheries are based upon incidental observations (i.e., hooked seals). All hookings not clearly attributable to either fishery with certainty were attributed to the bottomfish fishery, and hookings which resulted in injury of unknown severity were classified as serious.

died in captivity, two died when captured for translocation, one was euthanized (an aggressive male known to cause mortality), four died during captive research and four died during field research (Baker and Johanos 2002; NMFS unpubl. data). Other sources of mortality that impede recovery include food limitation (see Habitat Issues below), single and intra-species multiple-male aggression (mobbing), shark predation, and disease/parasitism. Multiple-male aggression has primarily been identified as a problem at Laysan and Lisianski Islands, though it has also been documented at other subpopulations. Past removals of adult males from Laysan Island effectively reduced, but did not entirely eliminate, male-aggression caused mortality at this site (Johanos et al. 2010).~~In 1994, 22 adult males were removed from Laysan Island, and 11 seals are thought to have died from multiple-male aggression at this site since their removal (1995-2008).~~

Attacks by single adult male seals have resulted in several monk seal deaths, most notably at French Frigate Shoals in 1997, where at least 8 pups died from this cause. Many more pups were likely killed in the same way but the cause of their deaths could not be confirmed. Two males that killed pups in 1997 were translocated to Johnston Atoll, 870 km to the southwest. Subsequently, mounting injury to pups has decreased.

Shark-related injury and mortality incidents appeared to have increased in the late 1980s and early 1990s at French Frigate Shoals, but such mortality was probably not the primary cause of the decline at this site (Ragen 1993). However, shark predation has accounted for a significant portion of pup mortality in recent years. At French Frigate Shoals in 1999, 17 pups were observed injured by large sharks, and at least 3 were confirmed to have died from shark predation (Johanos and Baker 2001). As many as 22 pups of a total 92 born at French Frigate Shoals in 1999 were likely killed by sharks. After 1999, losses of pups to shark predation have been fewer, but this source of mortality remains a serious concern. Various mitigation efforts have been undertaken by NMFS (Gobush 2010), yet shark predation remains a serious problem at French Frigate Shoals. While disease effects on monk seal demographic trends are uncertain, there is concern that diseases of livestock, feral animals, pets or humans could be transferred to naïve monk seals in the MHI and potentially spread to the core population in the NWHI. In 2003 and 2004, two deaths of free-ranging monk seals were attributable to diseases not previously found in the species: leptospirosis and toxoplasmosis (R. Braun, pers. comm.). *Leptospira* bacteria are found in many of Hawaii's streams and estuaries and are associated with livestock and rodents. Cats, domestic and feral, are a common source of toxoplasma.

STATUS OF STOCK

In 1976, the Hawaiian monk seal was designated depleted under the Marine Mammal Protection Act of 1972 and as endangered under the Endangered Species Act of 1973. The species is well below its OSP and has not recovered from past declines. Therefore, the Hawaiian monk seal is characterized as a strategic stock.

Habitat Issues

Poor juvenile survival rates and variability in the relationship between weaning size and survival suggest that prey availability is likely limiting recovery of NWHI monk seals (Baker and Thompson 2007, Baker et al. 2007, Baker 2008). A variety of strategies for improving juvenile survival are being considered and will be developed through an experimental approach in coming years (Baker and Littnan 2008). NMFS is currently developing a Programmatic Environmental Impact Statement on current and future anticipated research and enhancement activities. A major habitat issue involves loss of terrestrial habitat at French Frigate Shoals, where pupping and resting islets have shrunk or virtually disappeared (Antonelis et al. 2006). Projected increases in global average sea level may further significantly reduce terrestrial habitat for monk seals in the NWHI (Baker, Littnan and Johnston, 2006).

Goodman-Lowe (1998) provided information on prey selection using hard parts in scats and spewings. Information on at-sea movement and diving is available for seals at all six main subpopulations in the NWHI using satellite telemetry (Stewart et al. 2006). Preliminary studies to describe the foraging habitat of monk seals in the MHI are reported in Littnan et al. (2006).

~~Tern Island is the site of a USFWS refuge station and is one of two sites in the NWHI accessible by aircraft. During World War II, the U.S. Navy enlarged the island to accommodate the runway, and a sheet-pile seawall was constructed to maintain the modified shape of the island.~~ Degradation of the seawall at Tern Island, French Frigate Shoals, created entrapment hazards for seals and other wildlife and~~. Erosion of the sea wall also~~ raised concerns about the potential release of toxic wastes into the ocean. The USFWS began construction on the Tern Island sea wall in 2004 to reduce entrapment hazards and protect the island shoreline. Vessel groundings pose a continuing threat to monk seals and their habitat, through potential physical damage to reefs, oil spills, and release of debris into habitats.

Monk seal abundance is ~~likely~~ increasing in the main Hawaiian Islands (Baker et al. ~~in review~~2010).

Further, the excellent condition of pups weaned on these islands suggests that there may be ample prey resources available, perhaps in part due to fishing pressure that has reduced monk seal competition with large fish predators (sharks and jacks) (Baker and Johanos 2004). If the monk seal population continues to expand in the MHI, it may bode well for the species' recovery and long-term persistence. In contrast, there are many challenges that may limit the potential for growth in this region. The human population in the MHI is approximately 1.2 million compared to fewer than 100 in the NWHI, so that the potential impact of disturbance in the MHI is great. Intentional killing of seals (noted above) poses a very serious new concern. Also, the same fishing pressure that may have reduced the monk seal's competitors, is a source of injury and mortality. Finally, vessel traffic in the populated islands carries the potential for collision with seals and impacts from oil spills. Thus, issues surrounding monk seals in the main Hawaiian Islands will likely become an increasing focus for management and recovery of this species.

REFERENCES

Antonelis, G. A., J. D. Baker, T. C. Johanos, R. C. Braun, and A. L. Harting.2006. Hawaiian monk seal (*Monachus schauinslandi*): Status and Conservation Issues.Atoll Res. Bull. 543:75-101.Bailey, A. M. 1952. The Hawaiian monk seal. Museum Pictorial, Denver Museum of Natural History 7:1-32.

Baker, J. D. 2004. Evaluation of closed capture-recapture methods to estimate abundance of Hawaiian monk seals, *Monachus schauinslandi*. Ecological Applications 14:987-998.

Baker JD. 2008. Variation in the relationship between offspring size and survival provides insight into causes of mortality in Hawaiian monk seals. Endangered Species Research 5:55-64.

Baker, J.D., A.L. Harting, and T.C. Johanos. 2006. Use of discovery curves to assess abundance of Hawaiian monk seals. Marine Mammal Science 22:847-861.

~~Baker, J.D., A.L. Harting, T.A. Wurth, and T.C. Johanos. In review. Dramatic shifts in Hawaiian monk seal distribution and abundance are predicted to result from divergent regional trends. Marine Mammal Science.~~

Baker J.D., A. L. Harting, T. A. Wurth, and T. C, Johanos. 2010. Dramatic shifts in Hawaiian monk seal distribution predicted from divergent regional trends. Marine Mammal Science Published Online: May 26 2010 2:27AM DOI: 10.1111/j.1748-7692.2010.00395.x.

Baker, J.D. and T. C. Johanos. 2003. Abundance of Hawaiian monk seals in the main Hawaiian Islands. Biological Conservation 116:103-110.

Baker, J.D. and T. C. Johanos. 2002. Effects of research handling on the endangered Hawaiian monk seal. Mar. Mamm. Sci. 18:500-512.

Baker J.D., and Littnan CL. 2008. Report of the Hawaiian Monk Seal Captive Care Workshop, Honolulu, Hawaii, June 11–13, 2007. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-08-02, 42 p.

Baker J.D., C. L. Littnan, and D. W. Johnston. 2006. Potential effects of sea-level rise on the terrestrial habitats of endangered and endemic megafauna in the Northwestern Hawaiian Islands. Endangered Species Research 4:1-10.

Baker, J.D., J.J. Polovina, and E.A. Howell. 2007. Effect of variable oceanic productivity on the survival of an upper trophic predator, the Hawaiian monk seal, Monachus schauinslandi. Marine Ecology Progress Series 346:277-283.

Baker J.D. and P.M. Thompson. 2007. Temporal and spatial variation in age-specific survival rates of a long-lived mammal, the Hawaiian monk seal. Proceedings of the Royal Society B 274:407-415.

Clapp, R. B., and P. W. Woodward. 1972. The natural history of Kure Atoll, Northwestern Hawaiian Islands, Atoll Res. Bull. 164:303-304.

Dameron OJ, Parke M, Albins M, Brainard R. 2007. Marine debris accumulation in the Northwestern Hawaiian Islands: An examination of rates and processes. Marine Pollution Bulletin 54(4): 423-433.

Dill, H. R., and W. A. Bryan. 1912. Report on an expedition to Laysan Island in 1911. U.S. Dept. of Agric. Surv. Bull. 42:1-30.

Donohue, M. J., R. Brainard, M. Parke, and D. Foley. 2000. Mitigation of environmental impacts of derelict fishing gear through debris removal and environmental monitoring. *In* Hawaiian Islands Humpback Whale National Marine Sanctuary, Proceedings of the International Marine Debris Conference on Derelict Fishing Gear and the Ocean Environment, 6-11 August 2000, Honolulu, Hawaii. p. 383-402. http://hawaiihumpbackwhale.noaa.gov/special_offerings/sp_off/proceedings.html.

Donohue, M.J., R.C. Boland, C.M. Sramek, and G.A. Antonelis. 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Marine Pollution Bulletin 42(12):1301_1312.

Forney, K.A., J. Barlow, M.M. Muto, M. Lowry, J. Baker, G. Cameron, J. Mobley, C. Stinchcomb, and J.V.

Carretta. 2000. U.S. Pacific Marine Mammal Stock Assessments: 2000. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-SWFSC-300. 276 p.
Gerrodette, T. M., and W. G. Gilmartin. 1990. Demographic consequences of changed pupping and hauling sites of the Hawaiian monk seal. Conserv. Biol. 4:423-430.
Gobush, K. S. 2010. Shark predation on Hawaiian monk seals: Workshop II & post-workshop developments, November 5-6, 2008. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-21, 43 p. + Appendices.
Goodman-Lowe, G. D. 1998. Diet of the Hawaiian monk seal (*Monachus schauinslandi*) from the northwestern Hawaiian islands during 1991 to 1994. Marine Biology 132:535-546.
Harting, A.L. 2002. Stochastic simulation model for the Hawaiian monk seal. PhD thesis, Montana State University, 328 p.
Henderson, J. R. 1990. Recent entanglements of Hawaiian monk seals in marine debris. In R. S. Shomura and M. L. Godfrey (eds.), Proceedings of the Second International Conference on Marine Debris, April 2-7, 1989, Honolulu, Hawaii, p. 540-553. U.S. Dep. Commer., NOAA, Tech. Memo. NMFS-SWFSC-154.
Henderson, J.R. 2001. A Pre_ and Post_MARPOL Annex V Summary of Hawaiian Monk Seal Entanglements and Marine Debris Accumulation in the Northwestern Hawaiian Islands, 1982_1998. Marine Pollution Bulletin 42:584_589.
Iverson, S., J. Piché, and W. Blanchard. 2011. Hawaiian monk seals and their prey: assessing characteristics of prey species fatty acid signatures and consequences for estimating monk seal diets using Quantitative Fatty Acid Signature Analysis. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-23, 114 p. + Appendices.
Johanos, T. C. and J. D. Baker (editors). 2001. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1999. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-310, 130 p.
~~Johanos, T. C. and J. D. Baker (editors). In press. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2004. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-PIFSC-XXX, XXX p.~~
Johanos, T. C. and J. D. Baker (editors). In prep. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2005. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-PIFSC-XXX, XXX p.
Johanos, T. C. and J. D. Baker (editors). In prep. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2006. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-PIFSC-XXX, XXX p.
Johanos, T. C. (editor). In prep. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2007. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-PIFSC-XXX, XXX p.
Johanos, T. C. (editor). In prep. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2008. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-PIFSC-XXX, XXX p.
Johanos T. C., B. L. Becker, J. D. Baker, T. C. Ragen, W. G. Gilmartin, and T. Gerrodette. 2010. Impacts of sex ratio reduction on male aggression in the critically endangered Hawaiian monk seal *Monachus schauinslandi.* Endangered Species Research 11: 123–132.
Johnson, A. M., and E. Kridler. 1983. Interisland movement of Hawaiian monk seals. 'Elepaio 44(5):43-45.
~~Kawamoto, K. E. 1995. Northwestern Hawaiian Islands bottomfish fishery, 1994. Admin. Rep. H-95-07. Southwest Fisheries Science Center, National Marine Fisheries Service, 2570 Dole St., Honolulu, HI 96822-2396. 26 pp.~~
Kenyon, K. W. 1972. Man versus the monk seal. J. Mammal. 53(4):687-696.
Kretzmann, M. B., W. G. Gilmartin, A. Meyer, G. P. Zegers, S. R. Fain, B. F. Taylor, and D. P. Costa. 1997. Low genetic variability in the Hawaiian monk seal. Conserv. Biol. 11(2):482-490.
Kretzmann, M. B., N. J. Gemmell, and A. Meyer. 2001. Microsatellite analysis of population structure in the endangered Hawaiian monk seal. Conserv. Biol. 15(2):457-466.
Littnan, C. L., B. S. Stewart, P. K. Yochem, and R. Braun. 2006. Survey for selected pathogens and evaluation of disease risk factors for endangered Hawaiian monk seals in the main Hawaiian Islands. EcoHealth 4.
Goodman-Lowe, G. D. 1998. Diet of the Hawaiian monk seal (*Monachus schauinslandi*) from the Northwestern Hawaiian islands during 1991 to 1994. Marine Biology 132:535-546.
~~National Marine Fisheries Service. 2002. Biological Opinion for the Management of the Bottomfish and Seamount Groundfish Fisheries in the Western Pacific Region According to the Fishery Management Plan for the Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region.~~
~~Nitta, E. T., and J. R. Henderson. 1993. A review of interactions between Hawaii's fisheries and protected species. Mar. Fish. Rev. 55(2):83-92.~~
Otis, D. L., K. P. Burnham, G. C. White, and D. R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildl. Monogr. 62:1-135.

Parrish, F. A., M. P. Craig, T. J. Ragen, G. J. Marshall, and B. M. Buhleier. 2000. Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera. Mar. Mamm. Sci. 16:392-412.

Pooley, S. G., and K. E. . 1998. Annual report of the 1995-97 western Pacific lobster fishery. Admin. Rep. H-98-09. Southwest Fisheries Science Center, National Marine Fisheries Service, 2570 Dole St., Honolulu, HI 96822-2396. 34 pp.

Ragen, T. J. 1993. Status of the Hawaiian monk seal in 1992. Admin. Rep. H-93-05. Southwest Fisheries Science Center, National Marine Fisheries Service, 2570 Dole St., Honolulu, HI 96822-2396. 79 pp.

Ragen, T.J. 1999. Human activities affecting the population trends of the Hawaiian monk seal. Pages 183-194 *in* J.A. Musick, ed. Life in the slow lane: Ecology and conservation of long-lived marine animals. American Fisheries Society Symposium 23, American Fisheries Society, Bethesda, MD.

Rexstad, E. A., and K. P. Burnham. 1991. User's manual for interactive Program CAPTURE. Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, CO. 29 pp.

Rice, D. W. 1960. Population dynamics of the Hawaiian monk seal. J. Mammal. 41:376-385.

Schultz JK, Baker JD, Toonen RJ, Bowen BW. 2009. Extremely low genetic diversity in the endangered Hawaiian monk seal (*Monachus schauinslandi*). Journal of Heredity 100:25-33.

~~Schultz JK, Baker JD, Toonen RJ, Bowen BW (in review) Weak stock structure in a sea of connectivity: the case of the critically endangered Hawaiian monk sea. Conservation Biology .~~

Schultz J.K., Baker J.D., Toonen RJ, Harting AL, Bowen BW (in press) Range-wide genetic connectivity of the Hawaiian monk seal and implications for translocation. Conservation Biology .

Stewart B. S., G. A. Antonelis, J. D. Baker, and P.Y.Yochem. 2006. Foraging biogeography of the Hawaiian monk seal in the Northwestern Hawaiian Islands. Atoll Res Bull 543:131-145.

U.S. Department of Commerce and Department of the Interior. 2006. Northwestern Hawaiian Islands Marine National Monument. Federal Register 71:51,134-51,142.

Wade, P. R. and R. P. Angliss. 1997. Guidelines for Assessing Marine Mammal Stocks: Report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

Wade, P. R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Marine Mammal Science 14:1-37.

Wetmore, A. 1925. Bird life among lava rock and coral sand. The Natl. Geograp. Mag. 48:77-108.

White, G. C., D. R. Anderson, K. P. Burnham, and L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, Los Alamos, New Mexico.

HARBOR PORPOISE (*Phocoena phocoena vomerina*): Northern Oregon/Washington Coast Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, harbor porpoise are found in coastal and inland waters from Point Barrow, along the Alaskan coast, and down the west coast of North America to Point Conception, California (Gaskin 1984). Harbor porpoise are known to occur year-round in the inland trans-boundary waters of Washington and British Columbia, Canada (Osborne et al. 1988), and along the Oregon/Washington coast (Barlow 1988, Barlow et al. 1988, Green et al. 1992). Aerial survey data from coastal Oregon and Washington, collected during all seasons, suggest that harbor porpoise distribution varies by depth (Green et al. 1992). Although distinct seasonal changes in abundance along the west coast have been noted, and attributed to possible shifts in distribution to deeper offshore waters during late winter (Dohl et al. 1983, Barlow 1988), seasonal movement patterns are not fully understood.

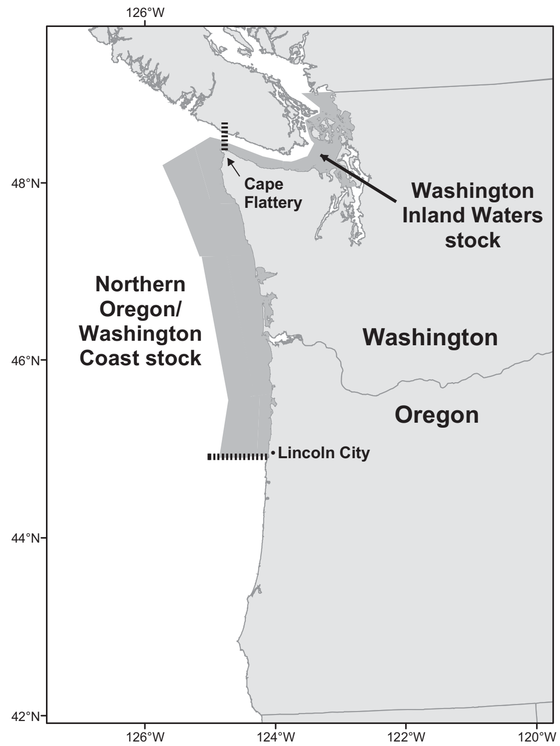

Figure 1. Stock boundaries (dashed lines) and approximate distribution (shaded areas) of harbor porpoise along the coasts of Washington and northern Oregon.

Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991). Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992) and is summarized in Osmek et al. (1994). Two distinct mtDNA groupings or clades exist. One clade is present in California, Washington, British Columbia, and Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Further genetic testing of the same data, along with additional samples, found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al. 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory and that movement is sufficiently restricted that genetic differences have evolved. Recent preliminary genetic analyses of samples ranging from Monterey Bay, California, to Vancouver Island, British Columbia, indicate that there is small-scale subdivision within the U.S. portion of this range (Chivers et al. 2002, 2007). This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic, where numerous stocks have been delineated with clinal differences over areas as small as the waters surrounding the British Isles.

Using the 1990-1991 aerial survey data of Calambokidis et al. (1993) for water depths <50 fathoms, Osmek et al. (1996) found significant differences in harbor porpoise mean densities ($Z=6.9$, $P<0.001$) between the waters of coastal Oregon/Washington and inland Washington/southern British Columbia, Canada (i.e., Strait of Juan de Fuca/San Juan Islands). Following a risk averse management strategy, two stocks were recognized in the waters of Oregon and Washington, with a boundary at Cape Flattery, Washington. Based on recent genetic evidence, which suggests that the population of eastern North Pacific harbor porpoise is more finely structured (Chivers et al. 2002, 2007), stock boundaries on the Oregon/Washington coast have been revised, resulting in three stocks in Oregon/Washington waters: a Northern California/Southern Oregon stock (Point Arena, CA, to Lincoln City, OR), a Northern Oregon/Washington Coast stock (Lincoln City, OR, to Cape Flattery, WA), and the Washington Inland

Waters stock (in waters east of Cape Flattery). Additional analyses are needed to determine whether to adjust the stock boundaries for harbor porpoise in Washington inland waters (Chivers et al. 2007).

In their assessment of California harbor porpoise, Barlow and Hanan (1995) recommended two stocks be recognized in California, with the stock boundary at the Russian River. Based on recent genetic findings (Chivers et al. 2002, 2007), California coast stocks were re-evaluated and significant genetic differences were found among four identified sampling sites. Revised stock boundaries, based on these genetic data and density discontinuities identified from aerial surveys, resulted in six California/Oregon/Washington stocks where previously there had been four (e.g., Carretta et al. 2001): 1) the Washington Inland Waters stock, 2) the Northern Oregon/Washington Coast stock, 3) the Northern California/Southern Oregon stock, 4) the San Francisco-Russian River stock, 5) the Monterey Bay stock, and 6) the Morro Bay stock. The stock boundaries for animals that occur in northern Oregon/Washington waters are shown in Figure 1. This report considers only the Northern Oregon/Washington Coast stock. Stock assessment reports for Washington Inland Waters, Northern California/Southern Oregon, San Francisco-Russian River, Monterey Bay, and Morro Bay harbor porpoise also appear in this volume. Stock assessment reports for the three harbor porpoise stocks in the inland and coastal waters of Alaska, including 1) the Southeast Alaska stock, 2) the Gulf of Alaska stock, and 3) the Bering Sea stock, are reported separately in the Stock Assessment Reports for the Alaska Region. The harbor porpoise occurring in British Columbia have not been included in any of the U.S. stock assessment reports.

POPULATION SIZE

In August and September 2002, an aerial survey of Oregon, Washington, and southern British Columbia coastal waters, from shore to 200 m depth, resulted in an uncorrected abundance estimate of 4,583 (CV=0.145) harbor porpoise in U.S. waters between Lincoln City, Oregon, and Cape Flattery, Washington (J. Laake, unpublished data). Using a correction factor of 3.42 (1/g(0); g(0)=0.292, CV=0.366) (Laake et al. 1997a), to adjust for groups missed by aerial observers, the corrected estimate of abundance for harbor porpoise in the coastal waters of northern Oregon (north of Lincoln City) and Washington is 15,674 (CV=0.394).

Minimum Population Estimate

The minimum population estimate for this stock is calculated as the lower 20th percentile of the log-normal distribution (Wade and Angliss 1997) of the 2002 population estimate of 15,674, which is 11,383 harbor porpoise.

Current Population Trend

There are no reliable data on population trends of harbor porpoise for coastal Oregon, Washington, or British Columbia waters; however, the uncorrected estimates of abundance for the Northern Oregon/Washington Coast stock in 1997 (6,406; SE=826.5) and 2002 (4,583) were not significantly different (Z=-1.73, P=0.08), although the survey area in 1997 (Regions I-S through III) was slightly larger than in 2002 (Strata D-G) (Laake et al. 1998a; J. Laake, unpublished data).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently not available for harbor porpoise. Therefore, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% (Wade and Angliss 1997) be employed for the Northern Oregon/Washington Coast harbor porpoise stock.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (11,383) <u>times</u> one-half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.5 (for a stock of unknown status, Wade and Angliss 1997), resulting in a PBR of 114 harbor porpoise per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Within the EEZ boundaries of the coastal waters of northern Oregon and Washington, harbor porpoise deaths are known to occur in the northern Washington marine set (tribal) gillnet fishery. Total fishing effort in this fishery (areas 4, 4A, 4B, ~~and~~ 5, and 6C) is conducted within the range of both harbor porpoise stocks (Northern Oregon/Washington Coast and Washington Inland Waters) occurring in Washington State waters (Gearin et al 1994). Some movement of harbor porpoise between Washington's coastal and inland waters is likely, but it is currently not possible to quantify the extent of such movements. For the purposes of this stock assessment report, the animals taken in waters south and west of Cape Flattery, Washington (areas 4 and 4A), are assumed to have belonged to the Northern Oregon/Washington Coast stock, and Table 1 includes data only from that portion of the fishery. There has been a reduction in fishing effort in the coastal portion of this fishery due to reduced numbers of chinook salmon (a target species) in coastal waters. No fishing effort occurred in the coastal portion of the fishery in ~~2001-2003 or~~ 2005-2007 or 2009 (N. Pamplin, unpublished data; Jon Scordino, unpublished data). Observers monitored 100% of the fishing effort in coastal area 4A in 2008 but no harbor porpoise deaths were reported (Jon Scordino, unpublished data). No fishing effort has occurred in coastal area 4 since 2004. ~~Complete records of observer coverage and fishing effort in 2004 are not available; however, one vessel fished at least 60 net days (1 net day equals a 100-fathom-length net set for 24 hours) in areas 4 and 4A and the vessel operator reported two harbor porpoise deaths (P. Gearin, unpublished data; N. Pamplin, unpublished data).~~ The mean estimated mortality for this fishery in ~~2001-2005~~ 2005-2009 is 0 (CV=0) harbor porpoise per year from observer data ~~plus 0.4 porpoise per year from fisher self-reports~~.

Table 1. Summary of incidental mortality and serious injury of harbor porpoise (Northern Oregon/Washington Coast stock) in commercial and tribal fisheries that might take this species and calculation of the mean annual mortality rate; n/a indicates that data are not available. Mean annual takes are based on ~~2003-2007~~ 2005-2009 data unless noted otherwise.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
Northern WA marine set gillnet (tribal test fishery in coastal waters: area~~s 4 and~~ 4A)	~~2001~~ ~~2002~~ ~~2003~~ ~~2004~~ 2005 2006 2007 2008 2009	observer data	~~no fishery~~ ~~no fishery~~ ~~no fishery~~ ~~unknown[2]~~ no fishery no fishery no fishery 100% no fishery	~~0~~ ~~0~~ ~~0~~ ~~n/a~~ 0 0 0 0 0	~~0 (0)~~ ~~0 (0)~~ ~~0 (0)~~ ~~n/a~~ 0 (0) 0 (0) 0 (0) 0 (0) 0 (0)	~~0 (0)[1]~~ 0 (0)
	~~2004~~	~~fisher self-reports~~		~~2~~		~~≥0.4 (n/a)~~
Tribal steelhead gillnet fishery	2006	fisherman self-report		1	n/a	≥0.2 (n/a)
Unknown West Coast fisheries	~~2007~~ 2005-2009	stranding data		0, 0, 2, 1, 3	n/a	~~≥0.4 (n/a)~~ ≥1.2 (n/a)
Minimum total annual takes						~~≥0.8 (n/a)~~ ≥1.4 (n/a)

~~[1]The 2001-2003 and 2005 mortality estimates are included in the average.~~
~~[2]Complete records of observer coverage in 2004 are not available.~~

In 1995-1997, data were collected for the coastal portions (areas 4 and 4A) of the northern Washington marine set gillnet fishery as part of an experiment, conducted in cooperation with the Makah Tribe, designed to explore the merits of using acoustic alarms to reduce bycatch of harbor porpoise in salmon gillnets. Results in 1995-1996 indicated that the nets equipped with acoustic alarms had significantly lower entanglement rates, as only 2 of the 49 deaths occurred in alarmed nets (Gearin et al. 1996, 2000; Laake et al. 1997b). In 1997, 96% of the sets were equipped with acoustic alarms and 13 mortalities were observed (Gearin et al. 2000; P. Gearin, unpublished data). Harbor porpoise were displaced by an acoustic buffer around the alarmed nets, but it is unclear whether the porpoise or their prey were repelled by the alarms (Kraus et al. 1997, Laake et al. 1998b). However, the acoustic alarms did not appear to affect the target catch (chinook salmon and sturgeon) in the fishery (Gearin et al. 2000). For the past decade, Makah tribal regulations have required nets set in coastal waters (areas 4 and 4A) to be equipped with acoustic alarms.

A harbor porpoise death was ~~also~~ reported in a tribal steelhead gillnet fishery in the Chehalis River in 2006 (NMFS, Northwest Regional Office, unpublished data), resulting in an average annual mortality of 0.2 for this fishery.

~~The Marine Mammal Authorization Program (MMAP) fisher self-reports, required of commercial vessel operators by the MMPA, are an additional source of information on the number of harbor porpoise killed or seriously injured incidental to commercial fishery operations. Current MMAP data are not available; however, there were no fisher self-reports of harbor porpoise deaths from any MMAP-listed fishery operating within the range of the Northern Oregon/Washington Coast stock between 2001 and October 2005. Although these reports are considered incomplete (see details in Appendix 1), they represent a minimum mortality.~~

According to Northwest Marine Mammal Stranding Network records, maintained by the NMFS Northwest Region (NMFS, Northwest Regional Office, unpublished data), there were ~~two~~ six fishery-related strandings of harbor porpoise from this stock reported on the northern Oregon/southern Washington coast in ~~2007~~ 2005-2009 (2 in 2007, 1 in 2008, and 3 in 2009), resulting in an average annual mortality of ~~0.4~~ 1.2 harbor porpoise in ~~2003-2007~~ 2005-2009. Evidence of fishery interactions included net marks, rope marks, and knife cuts. Since these deaths could not be attributed to a particular fishery, and they were the only confirmed fishery-related deaths in this area in ~~2007~~ 2005-2009, they are listed in Table 1 as occurring in unknown West Coast fisheries. ~~Nine~~ Seven additional strandings reported in ~~2003-2007~~ 2005-2009 (~~5 in 2004,~~ 1 in 2006, ~~and~~ 3 in 2007, 1 in 2008, and 2 in 2009) were considered possible fishery-related strandings but were not included in the estimate of average annual mortality. This estimate is considered a minimum because not all stranded animals are found, reported, or examined for cause of death (via necropsy by trained personnel).

Other Mortality

A significant increase in the number of harbor porpoise strandings reported throughout Oregon and Washington in 2006 prompted the Working Group on Marine Mammal Unusual Mortality Events to declare an Unusual Mortality Event (UME) on 3 November 2006 (Huggins 2008). A total of 114 harbor porpoise strandings were reported and confirmed throughout Oregon/Washington coast and Washington inland waters in 2006 and 2007 (Huggins 2008). The cause of the UME has not been determined and several factors, including contaminants, genetics, and environmental conditions, are still being investigated. Cause of death, determined for 48 of 81 porpoise that were examined in detail, was attributed mainly to trauma and infectious disease. Suspected or confirmed fishery interactions were the primary cause of adult/subadult traumatic injuries, while birth-related trauma was responsible for the neonate deaths. Although six of the Northern Oregon/Washington Coast harbor porpoise ~~mortalities~~ deaths examined as part of the UME were suspected to have been caused by fishery interactions, only two could be confirmed as fishery-related deaths; these two deaths are listed in Table 1 as occurring in unknown West Coast fisheries in 2007.

STATUS OF STOCK

Harbor porpoise are not listed as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Based on the currently available data, the level of human-caused mortality and serious injury (~~1.0~~ 1.4) does not exceed the PBR (114). Therefore, the Northern Oregon/Washington Coast stock of harbor porpoise is not classified as "strategic." The total fishery mortality and serious injury for this stock (~~1.0~~ 1.4: based on self-reported fisheries information (~~0.6~~ 0.2) and stranding data (~~0.4~~ 1.2) where observer data were not available or failed to detect harbor porpoise deaths) is not known to exceed 10% of the calculated PBR (11.4) and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate. The status of this stock relative to its Optimum Sustainable Population (OSP) level and population trends is unknown.

REFERENCES

Barlow, J. 1988. Harbor porpoise, *Phocoena phocoena,* abundance estimation for California, Oregon, and Washington: I. Ship surveys. Fish. Bull. 86:417-432.

Barlow, J., and D. Hanan. 1995. An assessment of the status of harbor porpoise in central California. Rep. Int. Whal. Commn. Special Issue 16:123-140.

Barlow, J., C. W. Oliver, T. D. Jackson, and B. L. Taylor. 1988. Harbor porpoise, *Phocoena phocoena,* abundance estimation for California, Oregon, and Washington: II. Aerial surveys. Fish. Bull. 86:433-444.

Calambokidis, J., and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California. Pp. 101-110, *In:* Reynolds, J. E., III, and D. K. Odell (eds.), Proceedings of the second marine mammal stranding workshop: 3-5 December 1987, Miami, Florida. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 98.

Calambokidis, J., J. C. Cubbage, J. R. Evenson, S. D. Osmek, J. L. Laake, P. J. Gearin, B. J. Turnock, S. J. Jeffries, and R. F. Brown. 1993. Abundance estimates of harbor porpoise in Washington and Oregon waters. Final

Report by Cascadia Research, Olympia, WA, to National Marine Mammal Laboratory, AFSC, NMFS, Seattle, WA. 55 pp.

Carretta, J. V., J. Barlow, K. A. Forney, M. M. Muto, and J. Baker. 2001. U.S. Pacific marine mammal stock assessments: 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-317. 280 pp.

Chivers, S. J., A. E. Dizon, P. J. Gearin, and K. M. Robertson. 2002. Small-scale population structure of eastern North Pacific harbour porpoises (*Phocoena phocoena*) indicated by molecular genetic analyses. J. Cetacean Res. Manage. 4(2):111-122.

Chivers, S. J., B. Hanson, J. Laake, P. Gearin, M. M. Muto, J. Calambokidis, D. Duffield, T. McGuire, J. Hodder, D. Greig, E. Wheeler, J. Harvey, K. M. Robertson, and B. Hancock. 2007. Additional genetic evidence for population structure of *Phocoena phocoena* off the coasts of California, Oregon, and Washington. Southwest Fisheries Science Center Administrative Report LJ-07-08. 14 pp. Available at SWFSC, NMFS, ~~8604 La Jolla Shores Drive~~ 3333 North Torrey Pines Road, La Jolla, CA 92037.

Dohl, T. P., R. C. Guess, M. L. Duman, and R. C. Helm. 1983. Cetaceans of central and northern California, 1980-1983: status, abundance, and distribution. OCS Study MMS 84-0045. Pacific OCS Region Minerals Management Service, 1340 Sixth Street, Los Angeles, CA 90014. 284 pp.

Gaskin, D. E. 1984. The harbour porpoise *Phocoena phocoena* (L.): regional populations, status, and information on direct and indirect catches. Rep. Int. Whal. Commn. 34:569-586.

~~Gearin, P. J. National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.~~

Gearin, P. J., S. R. Melin, R. L. DeLong, H. Kajimura, and M. A. Johnson. 1994. Harbor porpoise interactions with a chinook salmon set-net fishery in Washington State. Rep. Int. Whal. Commn. Special Issue 15:427-438.

Gearin, P. J., M. E. Gosho, L. Cooke, R. DeLong, and J. Laake. 1996. Acoustic alarm experiment in the 1995 northern Washington marine setnet fishery: methods to reduce by-catch of harbor porpoise. Paper SC/48/SM10 presented to the International Whaling Commission, June 1996 (unpublished). 15 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Gearin, P. J., M. E. Gosho, J. L. Laake, L. Cooke, R. L. DeLong, and K. M. Hughes. 2000. Experimental testing of acoustic alarms (pingers) to reduce bycatch of harbour porpoise, *Phocoena phocoena*, in the state of Washington. J. Cetacean Res. Manage. 2(1):1-9.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnel, and K. C. Balcomb, III. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Ch. 1, *In:* Brueggeman, J. J. (ed.), Oregon and Washington marine mammal and seabird surveys. Final Report, OCS Study MMS 91-0093, Minerals Management Service, U.S. Dept. of Interior, Los Angeles, CA.

Huggins, J. 2008. Request for event closure: 2006-2007 Northwest harbor porpoise unusual mortality event. Unpublished report by Cascadia Research Collective to NMFS, Northwest Regional Office. 11 pp. Available at NMFS, Northwest Regional Office, 7600 Sand Point Way NE, Seattle, WA 98115.

Kraus, S. D., A. J. Read, A. Solow, K. Baldwin, T. Spradlin, E. Anderson, and J. Williamson. 1997. Acoustic alarms reduce porpoise mortality. Nature 388:525.

Laake, J. L. National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Laake, J. L., J. Calambokidis, S. D. Osmek, and D. J. Rugh. 1997a. Probability of detecting harbor porpoise from aerial surveys: estimating g(0). J. Wildl. Manage. 61(1):63-75.

Laake, J. L., P. J. Gearin, M. E. Gosho, and R. L. DeLong. 1997b. Evaluation of effectiveness of pingers to reduce incidental entanglement of harbor porpoise in a set gillnet fishery. Pp. 75-81, *In:* Hill, P. S., and D. P. DeMaster (eds.), MMPA and ESA implementation program, 1996. AFSC Processed Report 97-10. 255 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Laake, J., J. Calambokidis, and S. Osmek. 1998a. Survey report for the 1997 aerial surveys for harbor porpoise and other marine mammals of Oregon, Washington and British Columbia outside waters. Pp. 77-97, *In:* Hill, P. S., and D. P. DeMaster (eds.), MMPA and ESA implementation program, 1997. AFSC Processed Report 98-10. 246 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Laake, J. L., D. J. Rugh, and L. S. Baraff. 1998b. Observations of harbor porpoise in the vicinity of acoustic alarms on a set gillnet. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-84. 40 pp.

NMFS, Northwest Regional Office, 7600 Sand Point Way NE, Seattle, WA 98115.

Osborne, R., J. Calambokidis, and E. M. Dorsey. 1988. A Guide to Marine Mammals of Greater Puget Sound. Island Publishers, Anacortes, WA. 191 pp.

Osmek, S., P. Rosel, A. Dizon, and R. DeLong. 1994. Harbor porpoise, *Phocoena phocoena*, population assessment in Oregon and Washington, 1993. Pp. 1-14, *In:* Braham, H. W., and D. P. DeMaster (eds.), Marine mammal assessment program: status of stocks and impacts of incidental take, 1993. National

Marine Mammal Laboratory – MMPA Studies of 1993, NMML, AFSC, NMFS, NOAA. 153 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.
Osmek, S., J. Calambokidis, J. Laake, P. Gearin, R. DeLong, J. Scordino, S. Jeffries, and R. Brown. 1996. Assessment of the status of harbor porpoise, *Phocoena phocoena,* in Oregon and Washington waters. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-76. 46 pp.
Pamplin, Nate. Makah Fisheries Management, P.O. Box 115, Neah Bay, WA 98357.
Rosel, P. E. 1992. Genetic population structure and systematic relationships of some small cetaceans inferred from mitochondrial DNA sequence variation. Ph.D. Thesis, University of California - San Diego, La Jolla, CA. 191 pp.
Rosel, P. E., A. E. Dizon, and M. G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, *Phocoena phocoena*, on inter-oceanic and regional scales. Can. J. Fish. Aquat. Sci. 52:1210-1219.
Scordino, Jon. Makah Fisheries Management, P.O. Box 115, Neah Bay, WA 98357.
Wade, P. R., and R. P. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

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HARBOR PORPOISE (*Phocoena phocoena vomerina*): Washington Inland Waters Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, harbor porpoise are found in coastal and inland waters from Point Barrow, along the Alaskan coast, and down the west coast of North America to Point Conception, California (Gaskin 1984). Harbor porpoise are known to occur year-round in the inland trans-boundary waters of Washington and British Columbia, Canada (Osborne et al. 1988), and along the Oregon/Washington coast (Barlow 1988, Barlow et al. 1988, Green et al. 1992). Aerial survey data from coastal Oregon and Washington, collected during all seasons, suggest that harbor porpoise distribution varies by depth (Green et al. 1992). Although distinct seasonal changes in abundance along the west coast have been noted, and attributed to possible shifts in distribution to deeper offshore waters during late winter (Dohl et al. 1983, Barlow 1988), seasonal movement patterns are not fully understood.

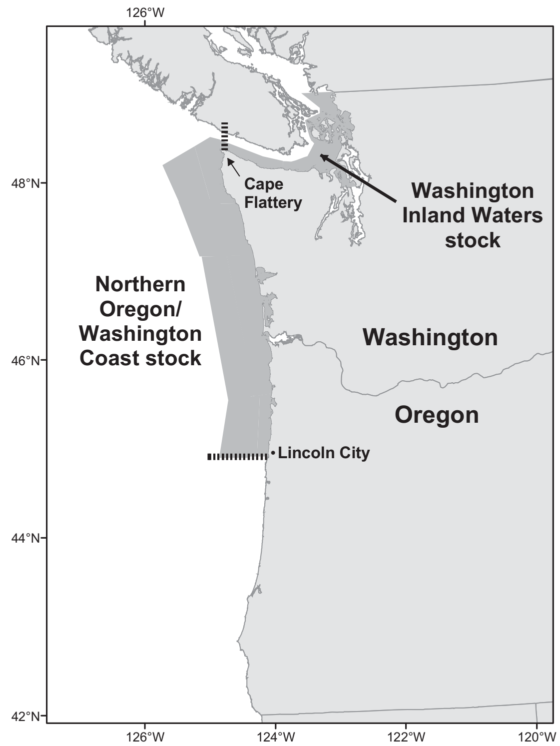

Figure 1. Stock boundaries (dashed lines) and approximate distribution (shaded areas) of harbor porpoise along the coasts of Washington and northern Oregon.

Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991). Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992) and is summarized in Osmek et al. (1994). Two distinct mtDNA groupings or clades exist. One clade is present in California, Washington, British Columbia, and Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Further genetic testing of the same data, along with additional samples, found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al. 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory and that movement is sufficiently restricted that genetic differences have evolved. Recent preliminary genetic analyses of samples ranging from Monterey Bay, California, to Vancouver Island, British Columbia, indicate that there is small-scale subdivision within the U.S. portion of this range (Chivers et al. 2002). This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic, where numerous stocks have been delineated with clinal differences over areas as small as the waters surrounding the British Isles.

Using the 1990-1991 aerial survey data of Calambokidis et al. (1993) for water depths <50 fathoms, Osmek et al. (1996) found significant differences in harbor porpoise mean densities ($z=5.9$, $p<0.01$) between the waters of coastal Oregon/Washington and inland Washington/southern British Columbia, Canada (i.e., Strait of Juan de Fuca/San Juan Islands). Although differences in density exist between coastal Oregon/Washington and inland Washington waters, a specific stock boundary line cannot be identified based upon biological or genetic differences. However, harbor porpoise movements and rates of intermixing within the eastern North Pacific are restricted, and there has been a significant decline in harbor porpoise sightings within southern Puget Sound since the 1940s; therefore, following a risk averse management strategy, two stocks are recognized: the Oregon/Washington Coast stock (between Cape Blanco, OR, and Cape Flattery, WA) and the Washington Inland Waters stock (in waters east of Cape Flattery) (see Fig. 1). Recent genetic evidence suggests that the population of eastern North Pacific harbor porpoise is more finely structured than is currently recognized (Chivers et al. 2002). All relevant data (e.g., genetic samples, contaminant studies, and satellite tagging) will be reviewed to determine whether to adjust the stock boundaries for harbor porpoise in Oregon and Washington waters.

In their assessment of California harbor porpoise, Barlow and Hanan (1995) recommended two stocks be recognized in California, with the stock boundary at the Russian River. Based on recent genetic findings (Chivers et al. 2002), California coast stocks were re-evaluated and significant genetic differences were found among four identified sampling sites. Revised stock boundaries, based on these genetic data and density discontinuities identified from aerial surveys, resulted in six California/Oregon/Washington stocks where previously there had been four (Carretta et al. 2001): 1) the Washington Inland Waters stock, 2) the Oregon/Washington Coast stock, 3) the Northern California/Southern Oregon stock, 4) the San Francisco-Russian River stock, 5) the Monterey Bay stock, and 6) the Morro Bay stock. The stock boundaries for animals that occur in Washington/northern Oregon waters are shown in Figure 1. This report considers only the Washington Inland Waters stock. Stock assessment reports for Oregon/Washington Coast, Northern California/Southern Oregon, San Francisco-Russian River, Monterey Bay, and Morro Bay harbor porpoise also appear in this volume. Stock assessment reports for the three harbor porpoise stocks in the inland and coastal waters of Alaska, including 1) the Southeast Alaska stock, 2) the Gulf of Alaska stock, and 3) the Bering Sea stock, are reported separately in the Stock Assessment Reports for the Alaska Region. The harbor porpoise occurring in British Columbia have not been included in any of the U.S. stock assessment reports.

POPULATION SIZE

Aerial surveys of the inside waters of Washington and southern British Columbia were conducted during August of 2002 and 2003 (J. Laake, unpubl. data). These aerial surveys included the Strait of Juan de Fuca, San Juan Islands, Gulf Islands, and Strait of Georgia, which includes waters inhabited by the Washington Inland Waters stock of harbor porpoise as well as harbor porpoise from British Columbia. An average of the 2002 and 2003 estimates of abundance in U.S. waters results in an uncorrected abundance of 3,123 (CV= 0.10) harbor porpoise in Washington inland waters (J. Laake, unpubl. data). When corrected for availability and perception bias, using a correction factor of 3.42 (1/g(0); g(0)=0.292, CV=0.366) (Laake et al. 1997), the estimated abundance for the Washington Inland Waters stock of harbor porpoise is 10,682 (CV=0.38) animals (J. Laake, unpubl. data).

Minimum Population Estimate

The minimum population estimate for this stock is calculated as the lower 20th percentile of the log-normal distribution (Wade and Angliss 1997) of the average of the 2002 and 2003 population estimates (10,682), which is 7,841 harbor porpoise.

Current Population Trend

There are no reliable data on long-term population trends of harbor porpoise for most waters of Oregon, Washington, or British Columbia, however, the uncorrected estimate of abundance in Washington inland waters was significantly greater in 2002/2003 than in 1996 (3,123 vs. 1,025; Z=6.16, P<0.0001) (Calambokidis et al. 1997; J. Laake, unpubl. data).

~~A different situation exists i~~In southern Puget Sound, ~~where~~ harbor porpoise ~~are rarely observed, in contrast to 1942 when they~~ were common in ~~those waters~~ the 1940s (Scheffer and Slipp 1948)~~. Although quantitative data for this area are lacking~~, but marine mammal surveys ~~effort~~ (Everitt et al. 1980), stranding records since the early 1970s (Osmek et al. 1995), and ~~the results of~~ harbor porpoise surveys ~~of~~ in 1991 (Calambokidis et al. 1992) and 1994 (Osmek et al. 1995) indicated that harbor porpoise abundance ~~has~~ had declined in southern Puget Sound. In 1994, a total of 769 km of vessel survey effort and 492 km of aerial survey effort conducted during favorable sighting conditions produced no sightings of harbor porpoise in southern Puget Sound. Reasons for the apparent decline are unknown, but it may ~~be~~ have been related to fishery interactions, pollutants, vessel traffic, or other factors (Osmek et al. 1995). ~~Recently, however, there have been confirmed sightings of harbor porpoise in central Puget Sound (R. DeLong, pers. comm.).~~ In 2009 and 2010, however, increased numbers of harbor porpoise have been sighted during vessel surveys throughout Puget Sound and increased numbers of strandings have also been documented, suggesting a return of animals to this region (J. Calambokidis, unpublished data; B. Hanson, unpublished data).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is not currently available for harbor porpoise. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% (Wade and Angliss 1997) be employed for the Washington Inland Waters harbor porpoise stock.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (7,841) times one-half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.40 (for a stock of unknown status with a mortality rate $CV \geq 0.80$, Wade and Angliss 1997), resulting in a PBR of 63 harbor porpoise per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Fishing effort in the northern Washington marine ~~set~~ gillnet tribal fisher~~y~~ies (areas 4, 4A, 4B, ~~and~~ 5, and 6C) is conducted within the range of both harbor porpoise stocks (Northern Oregon/Washington Coast and Washington Inland Waters) occurring in Washington State waters (Gearin et al. 1994). Some movement of harbor porpoise between Washington's coastal and inland waters is likely, but it is currently not possible to quantify the extent of such movements. For the purposes of this stock assessment report, the animals taken in waters east of Cape Flattery, WA (areas 4B~~ and~~, 5, and 6C) are assumed to have belonged to the Washington Inland Waters stock, and Table 1 includes data only from that portion of the fishery. ~~NMFS observers monitored 58% of the 36 net days (1 net day equals a 100-fathom length net set for 24 hours) of fishing effort in inland waters in 2000. There was no observer program in 1999 or 2001-2003 in inland waters; fishing effort was 4, 46, 4.5, and 7 net days (respectively) in those years, and no harbor porpoise takes were reported (Gearin et al. 1994; 2000; P. Gearin, unpubl. data).~~ There was no observer coverage in the northern Washington marine set gillnet tribal fishery in areas 4B and 5 in 2005-2009; however, there were two fisherman self-reports of harbor porpoise deaths in area 4B in 2008 and both occurred in nets that were equipped with alarms (Jon Scordino, unpublished data). ~~No mortality was reported in the inland portion of the fishery between 1999 and 2003, thus, t~~The mean estimated mortality for this fishery in 2005-2009 is ~~zero~~ 0.4 harbor porpoise per year from ~~this stock~~ fisherman self-reports.

Fishing effort in the northern Washington marine drift gillnet tribal fishery (areas 4B, 5, and 6C) is also conducted within the range of the Washington Inland Waters stock of harbor porpoise. This fishery is not observed; however, there was one fisherman self-report of a harbor porpoise death in area 5 in 2008 (Jon Scordino, unpublished data). The mean estimated mortality for this fishery in 2005-2009 is 0.2 harbor porpoise per year from fisherman self-reports. There were also fisherman self-reports of six unidentified small odontocete deaths in area 5 of this fishery in 2005 (N. Pamplin, unpublished data); these animals may have been harbor porpoise but are not included in the mortality estimate for this fishery.

In 1993, as a pilot for future observer programs, NMFS in conjunction with the Washington Department of Fish and Wildlife (WDFW) monitored non-treaty components (areas 7, 7A, 7B/7C, 8A/8D, 10/11, and 12/12A/12B) of the Washington Puget Sound Region salmon gillnet fishery (Pierce et al. 1994). Observer coverage was ~~1.5~~1.3% overall, ranging from 0.9% to 7.3% for the various components of the fishery. No harbor porpoise mortality was reported ~~(Table 1)~~. Pierce et al. (1994) cautioned against extrapolating this mortality to the entire Puget Sound fishery due to the low observer coverage and potential biases inherent in the data. The area 7/7A sockeye landings represented the majority of the non-treaty salmon landings in 1993, approximately 67%. Results of this pilot study were used to design the 1994 observer programs discussed below.

In 1994, NMFS in conjunction with WDFW conducted an observer program during the Puget Sound non-treaty chum salmon gillnet fishery (areas 10/11 and 12/12B). A total of 230 sets were observed during 54 boat trips, representing approximately 11% observer coverage of the 500 fishing boat trips comprising the total effort in this fishery, as estimated from fish ticket landings (Erstad et al. 1996). No harbor porpoise were reported within 100 m of observed gillnets. The Puget Sound treaty chum salmon gillnet fishery in Hood Canal (areas 12, 12B, and 12C) and Puget Sound treaty sockeye/chum gillnet fishery in the Strait of Juan de Fuca (areas 4B, 5, and 6C) were also monitored in 1994 (NWIFC 1995). No harbor porpoise mortality was reported in the observer programs covering these treaty salmon gillnet fisheries, where observer coverage was estimated at 2.2% (based on % of total catch observed) and approximately 7.5% (based on % of observed trips to total landings), respectively.

Also in 1994, NMFS in conjunction with WDFW and the Tribes conducted an observer program to examine seabird and marine mammal interactions with the Puget Sound treaty and non-treaty sockeye salmon gillnet fishery (areas 7 and 7A). During this fishery, observers monitored 2,205 sets, representing approximately 7% of the estimated 33,086 sets occurring in the fishery (Pierce et al. 1996). There was one observed harbor porpoise mortality (one other was entangled and released alive with no indication that it was injured), resulting in a mortality rate of 0.00045 harbor porpoise per set, which extrapolates to 15 deaths (CV=1.0) for the entire fishery.

It should be noted that the 1994 observer programs did not sample all segments of the entire Washington Puget Sound Region salmon set/drift gillnet fishery and, further, the extrapolations of total kill did not include effort for the unobserved segments of this fishery. Although the percentage of the overall Washington Puget Sound Region salmon set/drift gillnet fishery effort that was observed in 1994 was not quantified, the observer programs covered those segments of the fishery which had the highest salmon catches, the majority of vessel participation, and the highest likelihood of interaction with harbor porpoise (Joe Scordino, pers. comm.). Harbor porpoise takes in the Washington Puget Sound Region salmon drift gillnet fishery are unlikely to have increased since the fishery was last observed in 1994, due to reductions in the number of participating vessels and available fishing time (see details in Appendix 1). Fishing effort and catch have declined throughout all salmon fisheries in the region due to management efforts to recover ESA-listed salmonids.

In 1996, Washington Sea Grant Program conducted a test fishery in the non-treaty sockeye salmon gillnet fishery (area 7) to compare entanglement rates of seabirds and marine mammals and catch rates of salmon using three experimental gears and a control (monofilament mesh net). The experimental nets incorporated highly visible mesh in the upper quarter (50 mesh gear) or upper eighth (20 mesh gear) of the net or had low-frequency sound emitters attached to the corkline (Melvin et al. 1997). In 642 sets during 17 vessel trips, 2 harbor porpoise were killed in the 50 mesh gear.

Table 1. Summary of incidental mortality and serious injury of harbor porpoise (Washington Inland Waters stock) due to commercial and tribal fisheries that might take this species and calculation of the mean annual mortality rate; n/a indicates that data are not available. Mean annual takes are based on ~~2000-2004~~ 2005-2009 data unless noted otherwise.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
Northern WA marine set gillnet (tribal fishery in inland waters: areas 4B and 5)	~~1999~~ ~~2000~~ ~~2001~~ ~~2002~~ ~~2003~~ 2005 2006 2007 2008 2009	observer data	~~0%~~ ~~58%~~ ~~0%~~ ~~0%~~ ~~0%~~ 0% 0% 0% 0% 0%	~~n/a~~ ~~0~~ ~~n/a~~ ~~n/a~~ ~~n/a~~ n/a n/a n/a n/a n/a	~~n/a~~ ~~0~~ ~~n/a~~ ~~n/a~~ ~~n/a~~ n/a n/a n/a n/a n/a	~~0~~[1] n/a
	2008	fisherman self-reports		2	n/a	≥0.4 (n/a)
Northern WA marine drift gillnet (tribal fishery in inland waters: areas 4B, 5, 6C)	2008	fisherman self-reports		1	n/a	≥0.2 (n/a)
WA Puget Sound Region salmon set/drift gillnet (observer programs listed below covered segments of this fishery):	-	-	-	-	-	-
Puget Sound non-treaty salmon gillnet (all areas and species)	1993	observer data	1.3%	0	0	see text[1]
Puget Sound non-treaty chum salmon gillnet (areas 10/11 and 12/12B)	1994	observer data	11%	0	0	~~0~~ see text[1]

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
Puget Sound treaty chum salmon gillnet (areas 12, 12B, and 12C)	1994	observer data	2.2%	0	0	~~0~~ see text[1]
Puget Sound treaty chum and sockeye salmon gillnet (areas 4B, 5, and 6C)	1994	observer data	7.5%	0	0	~~0~~ see text[1]
Puget Sound treaty and non-treaty sockeye salmon gillnet (areas 7 and 7A)	1994	observer data	7%	1	15	~~15 (1.0)~~ see text[1]
Puget Sound non-treaty salmon drift gillnet (area 5)	2006	fisherman self-reports		2	n/a	≥0.4 (n/a)
Unknown Puget Sound Region fishery	~~2000-2004~~ 2005-2009	stranding data		~~1, 0, 0, 0, 0~~ 0, 1, 1, 0, 4	n/a	~~≥0.2 (n/a)~~ ≥1.2 (n/a)
Minimum total annual takes						~~≥15.2 (1.0)~~ ≥2.2 (n/a)

~~[1]Only the 2000 mortality estimate is included in the average.~~

[1]This fishery has not been observed since 1994 (see text); these data are not included in the calculation of recent minimum total annual takes.

~~Combining the estimates from the 1994 observer programs (15) with the northern Washington marine set gillnet fishery (zero) results in an estimated mean mortality rate in observed fisheries of 15 harbor porpoise per year from this stock. It should be noted that the 1994 observer programs did not sample all segments of the entire Washington Puget Sound Region salmon set/drift gillnet fishery and, further, the extrapolation of total kill did not include effort for the unobserved segments of this fishery. Therefore, 15 is an underestimate of the harbor porpoise mortality due to the entire fishery. Although the percentage of the overall Washington Puget Sound Region salmon set/drift gillnet fishery effort that was observed in 1994 was not quantified, the observer programs covered those segments of the fishery which had the highest salmon catches, the majority of vessel participation, and the highest likelihood of interaction with harbor porpoise (J. Scordino, pers. comm.). Since the Washington Inland Waters stock of harbor porpoise occurs primarily in the Strait of Juan de Fuca and the San Juan Islands, it is unlikely that many harbor porpoise are taken in other areas of the Washington Puget Sound Region salmon gillnet fishery (i.e., Hood Canal and southern Puget Sound). Harbor porpoise takes in the Washington Puget Sound Region salmon drift gillnet fishery are unlikely to have increased since the fishery was last observed in 1994, due to reductions in the number of participating vessels and available fishing time (see details in Appendix 1). Fishing effort and catch have declined throughout all salmon fisheries in the region due to management efforts to recover ESA-listed salmonids.~~

There were two fisherman self-reports of harbor porpoise deaths in the Puget Sound Region salmon drift gillnet fishery in area 5 in 2006, resulting in an estimated mean annual mortality rate of 0.4 harbor porpoise from fisherman self-reports. There was also a fisherman self-report of an unidentified neonate or juvenile porpoise death in the Puget Sound Region drift gillnet fishery in 2006; this animal may have been a harbor porpoise but was not included in the mortality estimate for the fishery.

Combining estimates from the northern Washington marine set gillnet tribal fishery (0.4), the northern Washington marine drift gillnet tribal fishery (0.2), and the Puget Sound Region drift gillnet fishery (0.4) results in an estimated mean annual mortality rate of 1.0 harbor porpoise from this stock from fisherman self-reports.

~~The Marine Mammal Authorization Program (MMAP) fisher self-reports, required of commercial vessel operators by the MMPA, are an additional source of information on the number of harbor porpoise killed or seriously injured incidental to commercial fishery operations. Between 2000 and 2004, there were no fisher self-reports of harbor porpoise mortality from any MMAP-listed Washington Puget Sound Region salmon set/drift gillnet fishery. Unlike the 1994 observer program data, the self-reported fisheries data cover the entire fishery. Although these reports are considered incomplete (see details in Appendix 1), they represent a minimum mortality.~~

Strandings of harbor porpoise wrapped in fishing gear or with serious injuries caused by interactions with gear are a final source of fishery-related mortality information. According to Northwest Marine Mammal Stranding Network records, maintained by the NMFS Northwest Region (NMFS, Northwest Regional Office, unpublished data), there were six ~~one~~ fishery-related strandings of ~~a~~ harbor porpoise ~~occurred in 2000 in Bellingham Harbor~~

from this stock in 2005-2009 (1 in 2006, 1 in 2007, and 4 in 2009), resulting in an average annual mortality of 1.2 harbor porpoise. Evidence of fishery interactions included entanglement in gillnet, net marks, and rope marks. Since these deaths ~~As the stranding~~ could not be attributed to a particular fishery, and were the only confirmed fishery-related deaths in this area in 2005-2009, they are listed ~~it has been included~~ in Table 1 as occurring in an unknown Puget Sound Region fishery. ~~Fishery-related strandings during 2000-2004 resulted in an estimated annual mortality of 0.2 harbor porpoise from this stock.~~ One additional harbor porpoise stranding reported in 2007 was considered a possible fishery-related death but was not included in the estimate of average annual mortality. This estimate is considered a minimum because not all stranded animals are found, reported, or examined for cause of death (via necropsy by trained personnel).

Although, commercial gillnet fisheries in Canadian waters are known to have taken harbor porpoise in the past (Barlow et al. 1994, Stacey et al. 1997), few data are available because the fisheries were not monitored. In 2001, the Department of Fisheries and Oceans, Canada, conducted a federal fisheries observer program and a survey of license holders to estimate the incidental mortality of harbor porpoise in selected salmon fisheries in southern British Columbia (Hall et al. 2002). Based on the observed bycatch of porpoise (2 harbor porpoise deaths) in the 2001 fishing season, the estimated mortality for southern British Columbia in 2001 was 20 porpoise per 810 boat days fished or a total of 80 harbor porpoise. However, it is not known how many harbor porpoise from the Washington Inland Waters stock are currently taken in the waters of southern British Columbia.

~~The minimum estimated fishery mortality and serious injury for this stock is 15.2 harbor porpoise per year, based on observer program data (15) and stranding data (0.2) in U.S. waters.~~

Other Mortality

According to Northwest Marine Mammal Stranding Network records, maintained by the NMFS Northwest Region (NMFS, Northwest Regional Office, unpublished data), ~~one~~ two human-caused harbor porpoise ~~mortality was~~ deaths were reported from non-fisheries sources in ~~2000-2004~~ 2005-2009. ~~An~~ One animal was struck by a ship in ~~2001~~ 2007 and one was entangled in rope in 2009, resulting in an estimated mortality of ~~0.2~~ 0.4 harbor porpoise per year from this stock.

A significant increase in the number of harbor porpoise strandings reported throughout Oregon and Washington in 2006 prompted the Working Group on Marine Mammal Unusual Mortality Events to declare an Unusual Mortality Event (UME) on 3 November 2006 (Huggins 2008). A total of 114 harbor porpoise strandings were reported and confirmed throughout Oregon/Washington coast and Washington inland waters in 2006 and 2007 (Huggins 2008). The cause of the UME has not been determined and several factors, including contaminants, genetics, and environmental conditions, are still being investigated. Cause of death, determined for 48 of 81 porpoise that were examined in detail, was attributed mainly to trauma and infectious disease. Suspected or confirmed fishery interactions were the primary cause of adult/subadult traumatic injuries, while birth-related trauma was responsible for the neonate deaths. Although five of the Washington Inland Waters harbor porpoise deaths examined as part of the UME were suspected to have been caused by fishery interactions, only four could be confirmed as fishery-related deaths; two harbor porpoise deaths were self-reported by the Puget Sound Region salmon gillnet fishery in 2006 and the other two deaths (1 in 2006 and 1 in 2007) are listed in Table 1 as occurring in an unknown Puget Sound Region fishery.

STATUS OF STOCK

Harbor porpoise are not listed as “depleted” under the MMPA or listed as “threatened” or “endangered” under the Endangered Species Act. Based on currently available data, the total level of human-caused mortality and serious injury (~~15.2 + 0.2 = 15.4~~) (2.2 + 0.4 = 2.6) is not known to exceed the PBR (63). Therefore, the Washington Inland Waters harbor porpoise stock is not classified as “strategic.” The minimum total fishery mortality and serious injury for this stock (~~15.2~~) (2.2) does not exceed~~s~~ 10% of the calculated PBR (6.3) and, therefore, can~~not~~ be considered to be insignificant and approaching zero mortality and serious injury rate. The status of this stock relative to its Optimum Sustainable Population (OSP) level and population trends is unknown~~,~~. A~~a~~lthough harbor porpoise sightings in southern Puget Sound ~~have~~ declined ~~since~~ from the 1940s through the 1990s, harbor porpoise have been sighted in southern Puget Sound in recent vessel surveys.

This stock is not recognized as “strategic,” however, the current mortality rate is based on fisherman self-reports and stranding data, since ~~on observer data from a subset of~~ the Washington Puget Sound Region salmon set/drift gillnet fishery ~~that was last~~ has not been observed since ~~in~~ 1994. Evaluation of the estimated take level is complicated by a lack of knowledge about the extent to which harbor porpoise from U.S. waters frequent the waters of British Columbia and are, therefore, subject to fishery-related mortality. ~~Given that the estimated take level is from 1994, i~~It is appropriate to consider whether the current take level is different from the take level in 1994, when the fishery was last observed. No new information is available about mortality per set, but 1) fishing effort has decreased in recent years and 2) analysis of data from aerial surveys in 2002 and 2003 indicates that abundance has increased since 1996.

REFERENCES

Barlow, J. 1988. Harbor porpoise, *Phocoena phocoena,* abundance estimation for California, Oregon, and Washington: I. Ship surveys. Fish. Bull. 86:417-432.

Barlow, J., and D. Hanan. 1995. An assessment of the status of harbor porpoise in central California. Rep. Int. Whal. Commn. Special Issue 16:123-140.

Barlow, J., C. W. Oliver, T. D. Jackson, and B. L. Taylor. 1988. Harbor porpoise, *Phocoena phocoena,* abundance estimation for California, Oregon, and Washington: II. Aerial surveys. Fish. Bull. 86:433-444.

Barlow, J., R. W. Baird, J. E. Heyning, K. Wynne, A. M. Manville, II, L. F. Lowry, D. Hanan, J. Sease, and V. N. Burkanov. 1994. A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the USA and Canada and the east coast of the Russian Federation. Rep. Int. Whal. Commn. Special Issue 15:405-425.

Calambokidis, John. Cascadia Research Collective, 218 1/2 W 4th Avenue, Olympia, WA 98501.

Calambokidis, J., and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California. Pp. 101-110, *In:* Reynolds, J. E., III, and D. K. Odell (eds.), Proceedings of the second marine mammal stranding workshop: 3-5 December 1987, Miami, Florida. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 98.

Calambokidis, J., J. R. Evenson, J. C. Cubbage, P. J. Gearin, and S. D. Osmek. 1992. Harbor porpoise distribution and abundance off Oregon and Washington from aerial surveys in 1991. Final Report by Cascadia Research, Olympia, WA, to National Marine Mammal Laboratory, AFSC, NMFS, Seattle, WA. 44 pp.

Calambokidis, J., J. C. Cubbage, J. R. Evenson, S. D. Osmek, J. L. Laake, P. J. Gearin, B. J. Turnock, S. J. Jeffries, and R. F. Brown. 1993. Abundance estimates of harbor porpoise in Washington and Oregon waters. Final Report by Cascadia Research, Olympia, WA, to National Marine Mammal Laboratory, AFSC, NMFS, Seattle, WA. 55 pp.

Calambokidis, J., S. D. Osmek, and J. L. Laake. 1997. Aerial surveys for marine mammals in Washington and British Columbia inside waters. Final Report by Cascadia Research, Olympia, WA, to National Marine Mammal Laboratory, AFSC, NMFS, Seattle, WA. 96 pp.

Carretta, J. V., J. Barlow, K. A. Forney, M. M. Muto, and J. Baker. 2001. U.S. Pacific marine mammal stock assessments: 2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-317. 280 pp.

Chivers, S. J., A. E. Dizon, P. J. Gearin, and K. M. Robertson. 2002. Small-scale population structure of eastern North Pacific harbour porpoises (*Phocoena phocoena*) indicated by molecular genetic analyses. J. Cetacean Res. Manage. 4(2):111-122.

~~DeLong, R. L. National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.~~

Dohl, T. P., R. C. Guess, M. L. Duman, and R. C. Helm. 1983. Cetaceans of central and northern California, 1980-1983: status, abundance, and distribution. OCS Study MMS 84-0045. Pacific OCS Region Minerals Management Service, 1340 Sixth Street, Los Angeles, CA 90014. 284 pp.

Erstad, P., S. J. Jeffries, and D. J. Pierce. 1996. 1994 Report for the Puget Sound fishery observer program in management areas 10/11 & 12/12B: nontreaty chum gill net fishery. Final Report, Washington Dept. Fish and Wildlife, Olympia, WA. 14 pp.

Everitt, R. D., C. H. Fiscus, and R. L. DeLong. 1980. Northern Puget Sound marine mammals. Interagency Energy/Environment R & D Program Report, U.S. EPA, EPA-600/7-80-139. U.S. EPA, Washington, D.C. 134 pp.

Gaskin, D. E. 1984. The harbour porpoise *Phocoena phocoena* (L.): regional populations, status, and information on direct and indirect catches. Rep. Int. Whal. Commn. 34:569-586.

~~Gearin, P. J. National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.~~

Gearin, P. J., S. R. Melin, R. L. DeLong, H. Kajimura, and M. A. Johnson. 1994. Harbor porpoise interactions with a chinook salmon set-net fishery in Washington State. Rep. Int. Whal. Commn. Special Issue 15:427-438.

~~Gearin, P. J., M. E. Gosho, J. L. Laake, L. Cooke, R. L. DeLong, and K. M. Hughes. 2000. Experimental testing of acoustic alarms (pingers) to reduce bycatch of harbour porpoise, *Phocoena phocoena*, in the state of Washington. J. Cetacean Res. Manage. 2(1):1-9.~~

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnel, and K. C. Balcomb, III. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Ch. 1, *In:* Brueggeman, J. J.

(ed.), Oregon and Washington marine mammal and seabird surveys. Final Report, OCS Study MMS 91-0093, Minerals Management Service, U.S. Dept. of Interior, Los Angeles, CA.

Hall, A., G. Ellis, and A. W. Trites. 2002. Harbour porpoise interactions with the 2001 selective salmon fisheries in southern British Columbia and license holder reported small cetacean by-catch. Unpubl. Report, Selective Salmon Fisheries Science Program, Fisheries and Oceans Canada. 51 pp.

Hanson, Brad. Northwest Fisheries Science Center, NMFS, 2725 Montlake Boulevard E, Seattle, WA 98112.

Huggins, J. 2008. Request for event closure: 2006-2007 Northwest harbor porpoise unusual mortality event. Unpublished report by Cascadia Research Collective to NMFS, Northwest Regional Office. 11 pp. Available at NMFS, Northwest Regional Office, 7600 Sand Point Way NE, Seattle, WA 98115.

Laake, J. L. National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Laake, J. L., J. Calambokidis, S. D. Osmek, and D. J. Rugh. 1997. Probability of detecting harbor porpoise from aerial surveys: estimating g(0). J. Wildl. Manage. 61(1):63-75.

Melvin, E. F., L. L. Conquest, and J. K. Parrish. 1997. Seabird bycatch reduction: new tools for Puget Sound drift gillnet salmon fisheries. 1996 Sockeye and 1995 Chum Salmon Test Fisheries Final Report, Washington Sea Grant Program, Seattle, WA. 48 pp.

Northwest Indian Fisheries Commission (NWIFC). 1995. Monitoring of marbled murrelet and marine mammal interactions with 1994 tribal gillnet fisheries in northern Puget Sound, Hood Canal, and the Strait of Juan de Fuca. Final Report to NMFS (Contract No. 52ABNF400087) and U.S. Fish and Wildlife Service. Unpubl. Report. 41 pp. Available at NWIFC, 6730 Martin Way E, Olympia, WA 98516.

Osborne, R., J. Calambokidis, and E. M. Dorsey. 1988. A Guide to Marine Mammals of Greater Puget Sound. Island Publishers, Anacortes, WA. 191 pp.

Osmek, S., P. Rosel, A. Dizon, and R. DeLong. 1994. Harbor porpoise, *Phocoena phocoena*, population assessment in Oregon and Washington, 1993. Pp. 1-14, *In:* Braham, H. W., and D. P. DeMaster (eds.), Marine mammal assessment program: status of stocks and impacts of incidental take, 1993. National Marine Mammal Laboratory – MMPA Studies of 1993, NMML, AFSC, NMFS, NOAA. 153 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Osmek, S., B. Hanson, J. L. Laake, S. Jeffries, and R. DeLong. 1995. Harbor porpoise *Phocoena phocoena* population assessment studies for Oregon and Washington in 1994. Pp. 141-172, *In:* DeMaster, D. P., H. W. Braham, and P. S. Hill (eds.), Marine mammal assessment program: status of stocks and impacts of incidental take, 1994. National Marine Mammal Laboratory – MMPA Studies of 1994, NMML, AFSC, NMFS, NOAA. 244 pp. Available at National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Osmek, S., J. Calambokidis, J. Laake, P. Gearin, R. DeLong, J. Scordino, S. Jeffries, and R. Brown. 1996. Assessment of the status of harbor porpoise, *Phocoena phocoena,* in Oregon and Washington waters. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-76. 46 pp.

Pierce, D. J., W. P. Ritchie, and R. Kreuziger. 1994. Preliminary findings of seabird interactions with the non-treaty salmon gill net fishery: Puget Sound and Hood Canal Washington. Unpubl. Report, Washington Dept. Fish and Wildlife, Olympia, WA. 39 pp. Available at WDFW, 600 Capitol Way N, Olympia, WA 98501.

Pierce, D. J., M. Alexandersdottir, S. J. Jeffries, P. Erstad, W. Beattie, and A. Chapman. 1996. Interactions of marbled murrelets and marine mammals with the 1994 Puget Sound sockeye gill net fishery. Final Report, Washington Dept. Fish and Wildlife, Olympia, WA. 21 pp. Available at WDFW, 600 Capitol Way N, Olympia, WA 98501.

Rosel, P. E. 1992. Genetic population structure and systematic relationships of some small cetaceans inferred from mitochondrial DNA sequence variation. Ph.D. Thesis, University of California - San Diego, La Jolla, CA. 191 pp.

Rosel, P. E., A. E. Dizon, and M. G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, *Phocoena phocoena*, on inter-oceanic and regional scales. Can. J. Fish. Aquat. Sci. 52:1210-1219.

Scheffer, V. B., and J. W. Slipp. 1948. The whales and dolphins of Washington State with a key to the cetaceans of the west coast of North America. Am. Midl. Nat. 39(2):257-337.

Scordino, Joe. National Marine Fisheries Service, Northwest Region, 7600 Sand Point Way NE, Seattle, WA 98115.

Scordino, Jon. Makah Fisheries Management, P.O. Box 115, Neah Bay, WA 98357.

Stacey, P. J., R. W. Baird, and D. A. Duffus. 1997. A preliminary evaluation of incidental mortality of small cetaceans in coastal fisheries in British Columbia, Canada. Mar. Mammal Sci. 13:321-326.

Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

KILLER WHALE (*Orcinus orca*): Eastern North Pacific Southern Resident Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975). Along the west coast of North America, killer whales occur along the entire Alaskan coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington State, where pods have been labeled as 'resident,' 'transient,' and 'offshore' (Bigg et al. 1990, Ford et al. 1994) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982, Baird and Stacey 1988, Baird et al. 1992, Hoelzel et al. 1998). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Matkin et al. 1999) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997).

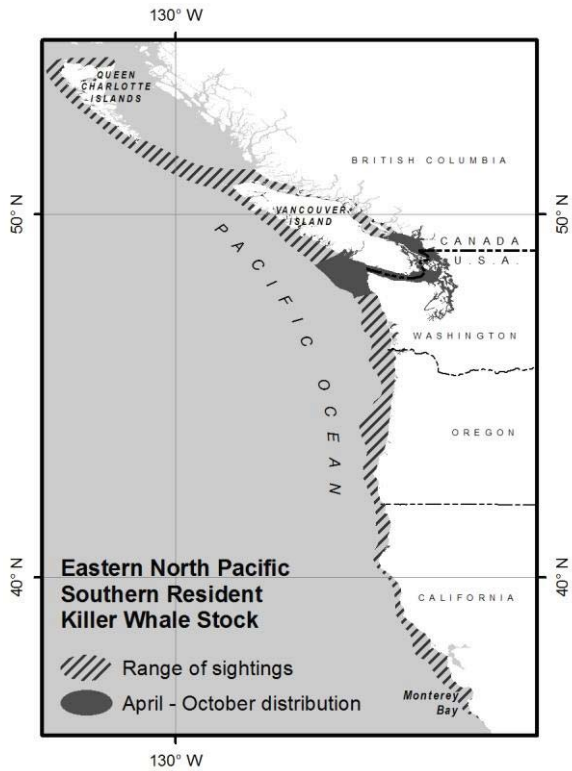

Figure 1. Approximate April - October distribution of the Eastern North Pacific Southern Resident killer whale stock (shaded area) and range of sightings (diagonal lines).

Studies on mtDNA restriction patterns provide evidence that the 'resident' and 'transient' types are genetically distinct (Stevens et al. 1989, Hoelzel 1991, Hoelzel and Dover 1991, Hoelzel et al. 1998). Analysis of 73 samples collected from eastern North Pacific killer whales from California to Alaska has demonstrated significant genetic differences among 'transient' whales from California through Alaska, 'resident' whales from the inland waters of Washington, and 'resident' whales ranging from British Columbia to the Aleutian Islands and Bering Sea (Hoelzel et al. 1998). However, low genetic diversity throughout this species world-wide distribution has hampered efforts to clarify its taxonomy. At an international symposium in cetacean systematics in May 2004, a workshop was held to review the taxonomy of killer whales. A majority of invited experts felt that the Resident- and Transient-type whales in the eastern North Pacific probably merited species or subspecies status (Reeves et al. 2004).

Most sightings of the Eastern North Pacific Southern Resident stock of killer whales have occurred in the summer in inland waters of Washington and southern British Columbia. However, pods belonging to this stock have also been sighted in coastal waters off southern Vancouver Island and Washington (Bigg et al. 1990, Ford et al. 2000, NWFSC unpubl. data). The complete winter range of this stock is uncertain. Of the three pods comprising this stock, one (J1) is commonly sighted in inshore waters in winter, while the other two (K1 and L1) apparently spend more time offshore (Ford et al. 2000). These latter two pods have been sighted as far south as Monterey Bay and central California in recent years (N. Black, pers. comm., K. Balcomb, pers. comm.) They sometimes have also been seen entering the inland waters of Vancouver Island from the north–through Johnstone Strait–in the spring (Ford et al. 2000), suggesting that they may spend time along the entire outer coast of Vancouver Island during the winter. In May 2003, these pods were sighted off the northern end of the Queen Charlotte Islands, the furthest north they had ever been documented (J. Ford, pers. comm.).

Based on data regarding association patterns, acoustics, movements, genetic differences and potential fishery interactions, five killer whale stocks are recognized within the Pacific U.S. EEZ: 1) the Eastern North Pacific Northern Resident stock - occurring from British Columbia through Alaska, 2) the Eastern North Pacific Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia (see Fig. 1), 3) the Eastern North Pacific Transient stock - occurring from Alaska through California, 4) the Eastern North Pacific Offshore stock - occurring from Southeast Alaska through California, and 5) the Hawaiian stock. The Stock Assessment Reports for the Alaska Region contain information concerning the Eastern North Pacific Northern Resident and Eastern North Pacific Transient stocks.

POPULATION SIZE

The Eastern North Pacific Southern Resident stock is a trans-boundary stock including killer whales in inland Washington and southern British Columbia waters. Photo-identification of individual whales through the years has resulted in a substantial understanding of this stock's structure, behaviors, and movements. In 1993, the three pods comprising this stock totaled 96 killer whales (Ford et al. 1994). The population increased to 99 whales in 1995, then declined to 79 whales in 2001, and most recently numbered ~~85~~ 86 whales in 2009 2010 (Fig. 2; Ford et al. 2000; Center for Whale Research, unpubl. data). The 2001-2005 counts included a whale born in 1999 (L-98) that was listed as missing during the annual census in May and June 2001 but was subsequently discovered alone in an inlet off the west coast of Vancouver Island (J. Ford, pers. comm.). L-98 remained separate from L pod until 10 March 2006 when he died due to injuries associated with a vessel interaction in Nootka Sound. L-98 has been subtracted from the official 2006 and subsequent population censuses. The most recent census includes ~~three~~ ~~two~~ four new calves and the deaths of ~~two~~ a post-reproductive adult female~~s~~ and ~~an~~ two adult males since 1 July ~~2008~~2009. It does not include a calf born last ~~fall summer~~ winter that did not survive to 1 July 2009 (Center for Whale Research, unpubl. data).

Minimum Population Estimate

The abundance estimate for this stock of killer whales is a direct count of individually identifiable animals. It is thought that the entire population is censused every year. This estimate therefore serves as both a best estimate of abundance and a minimum estimate of abundance. Thus, the minimum population estimate (N_{MIN}) for the Eastern North Pacific Southern Resident stock of killer whales is ~~85~~ 86 animals.

Current Population Trend

During the live-capture fishery that existed from 1967 to 1973, it is estimated that 47 killer whales, mostly immature, were taken out of this stock (Ford et al. 1994). The first complete census of this stock occurred in 1974. Between 1974 and 1993 the Southern Resident stock increased approximately 35%, from 71 to 96 individuals (Ford et al. 1994). This represents a net annual growth rate of 1.8% during those years. Since 1995, the population declined to 79 whales before increasing from 2002-2005 to a total of 91 whales. The population declined for three years to 85 whales but remained almost unchanged in ~~2009~~ 2010 (Ford et al. 2000; Center for Whale Research, unpubl. data).

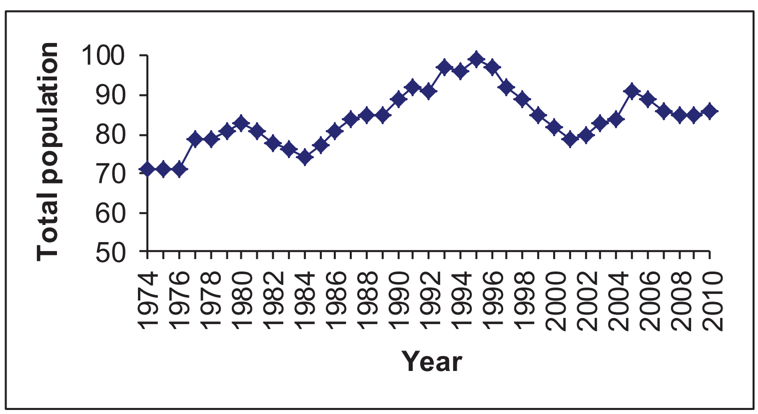

Figure 2. Population of Eastern North Pacific Southern Resident stock of killer whales, 1974-~~2009~~ 2010. Each year's count includes animals first seen and first missed; a whale is considered first missed the year after it was last seen alive (Ford et al. 2000; Center for Whale Research, unpubl. data).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this stock of killer whales. Studies of 'resident' killer whale pods in British Columbia and Washington waters resulted in estimated population growth rates of 2.92% and 2.54% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993). For southern resident killer whales, estimates of the population growth rate have been made during the three periods when the population has been documented increasing since monitoring began in 1974. From 1974 to 1980 the population increased at a rate of 2.6%/year, 2.3%/year from 1985 to 1996, and 3.6%/year from 2002 to

2005 (Center for Whale Research, unpubl. data). However, a population increases at the maximum growth rate (R_{MAX}) only when the population is at extremely low levels; thus, any of these estimates may be an underestimate of R_{MAX}. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (~~85~~ 86) <u>times</u> one-half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.1 (for an endangered stock, Wade and Angliss 1997), resulting in a PBR of 0.17 whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

NMFS observers have monitored the northern Washington marine set gillnet fishery since 1988 (Gearin et al. 1994, 2000; P. Gearin, unpubl. data). Observer coverage ranged from approximately 40 to 83% in the entire fishery (coastal + inland waters) between 1998 and 2002. There was no observer coverage in this fishery from 1999-2003. However, the total fishing effort was 4, 46, 4.5 and 7 net days (respectively) in those years, it occurred only in inland waters, and no killer whale takes were reported. No killer whale mortality has been recorded in this fishery since the inception of the observer program.

In 1993, as a pilot for future observer programs, NMFS in conjunction with the Washington Department of Fish and Wildlife (WDFW) monitored all non-treaty components of the Washington Puget Sound Region salmon gillnet fishery (Pierce et al. 1994). Observer coverage was 1.3% overall, ranging from 0.9% to 7.3% for the various components of the fishery. Encounters (whales within 10 m of a net) with killer whales were reported, but not quantified, though no entanglements occurred.

In 1994, NMFS and WDFW conducted an observer program during the Puget Sound non-treaty chum salmon gillnet fishery (areas 10/11 and 12/12B). A total of 230 sets were observed during 54 boat trips, representing approximately 11% observer coverage of the 500 fishing boat trips comprising the total effort in this fishery, as estimated from fish ticket landings (Erstad et al. 1996). No interactions with killer whales were observed during this fishery. The Puget Sound treaty chum salmon gillnet fishery in Hood Canal (areas 12, 12B, and 12C) and the Puget Sound treaty sockeye/chum gillnet fishery in the Strait of Juan de Fuca (areas 4B, 5, and 6C) were also monitored in 1994 at 2.2% (based on % of total catch observed) and approximately 7.5% (based on % of observed trips to total landings) observer coverage, respectively (NWIFC 1995). No interactions resulting in killer whale mortality was reported in either treaty salmon gillnet fishery.

Also in 1994, NMFS, WDFW, and the Tribes conducted an observer program to examine seabird and marine mammal interactions with the Puget Sound treaty and non-treaty sockeye salmon gillnet fishery (areas 7 and 7A). During this fishery, observers monitored 2,205 sets, representing approximately 7% of the estimated number of sets in the fishery (Pierce et al. 1996). Killer whales were observed within 10 m of the gear during 10 observed sets (32 animals in all), though none were observed to have been entangled.

Killer whale takes in the Washington Puget Sound Region salmon drift gillnet fishery are unlikely to have increased since the fishery was last observed in 1994, due to reductions in the number of participating vessels and available fishing time (see details in Appendix 1). Fishing effort and catch have declined throughout all salmon fisheries in the region due to management efforts to recover ESA-listed salmonids.

An additional source of information on the number of killer whales killed or injured incidental to commercial fishery operations is the self-reported fisheries information required of vessel operators by the MMPA. During the period between 1994 and 2004, there were no fisher self-reports of killer whale mortality from any fisheries operating within the range of this stock. However, because logbook records (fisher self-reports required during 1990-94) are most likely negatively biased (Credle et al. 1994), these are considered to be minimum estimates. Logbook data are available for part of 1989-1994, after which incidental mortality reporting requirements were modified. Under the new system, logbooks are no longer required; instead, fishers provide self-reports. Data for the 1994-1995 phase-in period is fragmentary. After 1995, the level of reporting dropped dramatically, such that the records are considered incomplete and estimates of mortality based on them represent minimums (see Appendix 7 in Angliss and Lodge 2002 for details).

Due to a lack of observer programs, there are few data concerning the mortality of marine mammals incidental to Canadian commercial fisheries. Since 1990, there have been no reported fishery-related strandings of killer whales in Canadian waters. However, in 1994 one killer whale was reported to have contacted a salmon gillnet but did not entangle (Guenther et al. 1995). Data regarding the level of killer whale mortality related to commercial fisheries in Canadian waters are not available, though the mortality level is thought to be minimal.

During this decade there have been no reported takes from this stock incidental to commercial fishing operations (D. Ellifrit, pers. comm.), no reports of interactions between killer whales and longline operations (as occurs in Alaskan waters; see Yano and Dahlheim 1995), no reports of stranded animals with net marks, and no photographs of individual whales carrying fishing gear. The total fishery mortality and serious injury for this stock is zero.

Other Mortality

According to Northwest Marine Mammal Stranding Network records, maintained by the NMFS Northwest Region, no human-caused killer whale mortality or serious injuries were reported from non-fisheries sources in 1998-2004. There was documentation of a whale-boat collision in Haro Strait in 2005 which resulted in a minor injury to a whale. In 2006, whale L98 was killed during a vessel interaction. It is important to note that L98 had become habituated to regularly interacting with vessels during its isolation in Nootka Sound. The annual level of human-caused mortality for this stock over the past five years is 0.2 animals per year (reflecting the vessel strike mortality of animal L98 in 2006).

STATUS OF STOCK

On November 15, 2005 NMFS listed Southern Resident killer whales as endangered under the ESA. Total annual fishery mortality and serious injury for this stock (0) is not known to exceed 10% of the calculated PBR (0.17) and, therefore, appears to be insignificant and approaching zero mortality and serious injury rate. The estimated annual level of human-caused mortality and serious injury of 0.2 animals per year exceeds the PBR (0.17). Southern Resident killer whales are formally listed as "endangered" under the ESA and consequently the stock is automatically considered as a "strategic" stock under the MMPA. This stock was considered "depleted" prior to its 2005 listing under the ESA.

Habitat Issues

Several of the potential risk factors identified for this population have habitat implications. The summer range of this population, the inland waters of Washington and British Columbia, is the home to a large commercial whale watch industry as well as high levels of recreational boating and commercial shipping. There continues to be concern about potential for masking effects by noise generated from these activities on the whales' communication and foraging. This population appears to be Chinook salmon specialists (Ford and Ellis 2006, ~~NWFSC unpubl.data~~ Hanson et al. 2010), and there is some evidence that changes in coast–wide Chinook abundance has affected this population (Ford et al. 2009). In addition, the high trophic level and longevity of the animals has predisposed them to accumulate levels of contaminants that are high enough to cause potential health impacts. In particular, there is recent evidence of extremely high levels of flame retardants in young animals (Krahn et. al 2007, 2009).

REFERENCES

Angliss, R. P., and K. L. Lodge. 2002. Alaska marine mammal stock assessments, 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-133. 224 pp.

Baird, R. W., and P. J. Stacey. 1988. Variation in saddle patch pigmentation in populations of killer whales (*Orcinus orca*) from British Columbia, Alaska, and Washington State. Can. J. Zool. 66 (11):2582-2585.

Baird, R. W., P. A. Abrams, and L. M. Dill. 1992. Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specializations in the genus *Orcinus*. Oecologia 89:125-132.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fish. Bull. 93:1_14.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Administrative Report LJ-97-11, Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 25 pp.

Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Pp. 386-406, *In:* Hammond, P. S., S. A. Mizroch, and G. P. Donovan (eds.), Individual Recognition of Cetaceans: Use of Photo-identification and Other Techniques to Estimate Population Parameters. Rep. Int. Whal. Commn. Special Issue 12.

Black, N. A. P.O. Box 52001, Pacific Grove, CA 93950.

Braham, H. W., and M. E. Dahlheim. 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whal. Commn. 32:643-646.

Brault, S., and H. Caswell. 1993. Pod-specific demography of killer whales (*Orcinus orca*). Ecology 74(5):1444-1454.

Center for Whale Research, 1359 Smugglers Cove Rd., Friday Harbor, WA 98250.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2003. Species Listing. Available at URL: http://www.cosewic.gc.ca/eng/sct0/index_e.cfm (access date - October 2003).

Credle, V. R., D. P. DeMaster, M. M. Merklein, M. B. Hanson, W. A. Karp, and S. M. Fitzgerald (eds.). 1994. NMFS observer programs: minutes and recommendations from a workshop held in Galveston, Texas, November 10-11, 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-94-1. 96 pp.

Dahlheim, M. E., D. K. Ellifrit, and J. D. Swenson. 1997. Killer whales of Southeast Alaska: a catalogue of photoidentified individuals. National Marine Mammal Laboratory, AFSC, NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115. 79 pp.

Ellifrit, D. Center for Whale Research, 1359 Smugglers Cove Rd., Friday Harbor, WA 98250.

Erstad, P., S. J. Jeffries, and D. J. Pierce. 1996. 1994 Report for the Puget Sound fishery observer program in management areas 10/11 & 12/12B: nontreaty chum gill net fishery. Final Report, Washington Dept. Fish and Wildlife, Olympia, WA. 14 pp.

Ford, J. K. B. Pacific Biological Station, Department of Fisheries and Oceans, Nanaimo, BC V9R 5K6.

Ford, J. K. B., and H. D. Fisher. 1982. Killer whale (*Orcinus orca*) dialects as an indicator of stocks in British Columbia. Rep. Int. Whal. Commn. 32:671-679.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 1994. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. University of British Columbia Press, Vancouver, BC, and University of Washington Press, Seattle. 102 pp.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 2000. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington. 2nd edition. University of British Columbia Press, Vancouver, BC, and University of Washington Press, Seattle. 104 pp.

Ford, J.K.B., and G.M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. Marine Ecology Progress Series, 316: 185–199.

Ford, J.K.B., G.M. Ellis, P.F. Olesiuk, and K.C. Balcomb. 2009. Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator? Biol. Lett. published online before print September 15, 2009, doi:10.1098/rsbl.2009.0468

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fish. Bull. 93:15_26.

Gearin, P. J. National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gearin, P. J., S. R. Melin, R. L. DeLong, H. Kajimura, and M. A. Johnson. 1994. Harbor porpoise interactions with a chinook salmon set-net fishery in Washington State. Rep. Int. Whal. Commn. Special Issue 15:427-438.

Gearin, P. J., M. E. Gosho, J. L. Laake, L. Cooke, R. L. DeLong, and K. M. Hughes. 2000. Experimental testing of acoustic alarms (pingers) to reduce bycatch of harbour porpoise, *Phocoena phocoena*, in the state of Washington. J. Cetacean Res. Manage. 2(1):1-9.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnel, and K. C. Balcomb. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Pp. 1-100, *In:* Brueggeman, J. J. (ed.), Oregon and Washington marine mammal and seabird surveys. Final Rep. OCS Study MMS 91-0093.

Guenther, T. J., R. W. Baird, R. L. Bates, P. M. Willis, R. L. Hahn, and S. G. Wischniowski. 1995. Strandings and fishing gear entanglements of cetaceans on the west coast of Canada in 1994. Paper SC/47/O6 presented to the International Whaling Commission, May 1995 (unpublished). 7 pp.

Hanson, M.B., R.W. Baird, J.K.B. Ford, J. Hempelmann-Halos, D. M.Van Doornik, J.R. Candy, C. K. Emmons, G. S. Schorr, B. Gisborne, K. L. Ayres, S. K. Wasser, K. C. Balcomb, K. Balcomb-Bartok, J. G. Sneva, and M. J. Ford. 2010. Species and stock identification of prey consumed by endangered “southern resident” killer whales in their summer range. Endangered Species Research 11: 69–82.

Hoelzel, A. R. 1991. Analysis of regional mitochondrial DNA variation in the killer whale; implications for cetacean conservation. Rep. Int. Whal. Commn. Special Issue 13:225-233.

Hoelzel, A. R., and G. A. Dover. 1991. Genetic differentiation between sympatric killer whale populations. Heredity 66:191-195.

Hoelzel, A. R., M. E. Dahlheim, and S. J. Stern. 1998. Low genetic variation among killer whales (*Orcinus orca*) in the Eastern North Pacific, and genetic differentiation between foraging specialists. J. Heredity 89:121-128.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2002. Status review of Southern Resident killer whales (*Orcinus orca*) under the Endangered Species Act. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-54. 133 pp.

Krahn, M. M.,, M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. Ylitalo, M. E. Dahlheim, J. E. Stein, and R. S. Waples. 2004. 2004 Status review of Southern Resident killer whales (*Orcinus orca*) under the Endangered Species Act. U.S. Dep. Commer., NOAA Tech. Memo NMFS-NWFSC-62. 73 pp.

Krahn,, M.M., M.B. Hanson, R.W. Baird, R.H. Boyer, D.G. Burrows, C.K. Emmons, J. K.B. Ford, L. L. Jones, D. P. Noren, P. S. Ross, G. S. Schorr, T.K. Collier. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales. Mar. Poll. Bull. 54 (2007) 1903–1911.

Krahn, Margaret M, M. Bradley Hanson, Gregory S. Schorr, Candice K. Emmons, Douglas G. Burrows, Jennie L. Bolton, Robin W. Baird, Gina M. Ylitalo. 2009. Effects of age, sex and reproductive status on persistent organic pollutant concentrations in "Southern Resident" killer whales. Marine Pollution Bulletin 58: 1522–1529.

Leatherwood, J. S., and M. E. Dahlheim. 1978. Worldwide distribution of pilot whales and killer whales. Naval Ocean Systems Center, Tech. Rep. 443:1-39.

Leatherwood, S., C. O. Matkin, J. D. Hall, and G. M. Ellis. 1990. Killer whales, *Orcinus orca*, photo_identified in Prince William Sound, Alaska 1976 to 1987. Can. Field Nat. 104:362_371.

Matkin, C., G. Ellis, E. Saulitis, L. Barrett-Lennard, and D. Matkin. 1999. Killer Whales of Southern Alaska. North Gulf Oceanic Society. 96 pp.

Mitchell, E. D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Bd. Can. 32:914-916.

Northwest Indian Fisheries Commission (NWIFC). 1995. Monitoring of marbled murrelet and marine mammal interactions with 1994 tribal gillnet fisheries in northern Puget Sound, Hood Canal, and the Strait of Juan de Fuca. Final Report to NMFS, Contract No. 52ABNF400087, and U.S. Fish and Wildlife Service. Unpubl. report. 41 pp. Available at NWIFC, 6730 Martin Way E, Olympia, WA 98516.

Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Commn. Special Issue 12:209-242.

Pierce, D. J., W. P. Ritchie, and R. Kreuziger. 1994. Preliminary findings of seabird interactions with the non-treaty salmon gill net fishery: Puget Sound and Hood Canal Washington. Unpubl. report. Washington Dept. Fish and Wildlife, Olympia, WA. 39 pp. Available at WDFW, 600 Capitol Way N, Olympia, WA 98501.

Pierce, D. J., M. Alexandersdottir, S. J. Jeffries, P. Erstad, W. Beattie, and A. Chapman. 1996. Interactions of marbled murrelets and marine mammals with the 1994 Puget Sound sockeye gill net fishery. Final Report, Washington Dept. Fish and Wildlife, Olympia, WA. 21 pp.

Reeves, R.R., W.F. Perrin, B.L. Taylor, C.S. Baker, and S.L. Mesnick. 2004. Report of the workshop on shortcomings of cetacean taxonomy in relation to needs of conservation and management, April 30 – May 2, 2004, La Jolla, California. U.S. Department of Commerce NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-363. 94pp. Available from Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA. 92037.

Ross, P. S., G. M. Ellis, M. G. Ikonomou, L. G. Barrett-Lennard, and R. F. Addison. 2000. High PCB concentrations in free-ranging Pacific killer whales, *Orcinus orca*: effects of age, sex and dietary preference. Mar. Pollut. Bull. 40(6):504-515.

Stevens, T. A., D. Duffield, E. Asper, K. Hewlett, A. Bolz, L. Gage, and G. Bossart. 1989. Preliminary findings of restriction fragment differences in mitochondrial DNA among killer whales (*Orcinus orca*). Can. J. Zool. 67:2592-2595.

Wade, P. R., and R. P. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

Yano, K., and M. E. Dahlheim. 1995. Killer whale, *Orcinus orca*, depredation on longline catches of bottomfish in the southeastern Bering Sea and adjacent waters. Fish. Bull. 93:355-372.

Ylitalo, G. M., C. O. Matkin, J. Buzitis, M. M. Krahn, L. L. Jones, T. Rowles, and J. E. Stein. 2001. Influence of life-history parameters on organochlorine concentrations in free-ranging killer whales (*Orcinus orca*) from Prince William Sound, AK. Sci. Total Environ. 281:183-203.

FALSE KILLER WHALE (*Pseudorca crassidens*): Pacific Islands Region Stock Complex - Hawaii Insular, Hawaii Pelagic and Palmyra Atoll Stocks

STOCK DEFINITIONS AND GEOGRAPHIC RANGES

False killer whales are found worldwide mainly in tropical and warm-temperate waters (Stacey et al. 1994). In the North Pacific, this species is well known from southern Japan, Hawaii, and the eastern tropical Pacific. There are six stranding records from Hawaiian waters (Nitta 1991; Maldini 2005). One on-effort sighting of false killer whales was made during a 2002 shipboard survey, and six during the 2010 shipboard survey of waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands (Figure 1; Barlow 2006, NMFS unpublished data). Group size ranged from 1 to 52 false killer whales during the 2010 survey. Smaller-scale surveys conducted around the main Hawaiian Islands (Figure 2) show that false killer whales are also encountered in nearshore waters (Baird et al. 2005, Mobley et al. 2000, Mobley 2001, 2002, 2003, 2004). This species also occurs in U.S. EEZ waters around Palmyra Atoll (Figure 1), Johnston Atoll (NMFS/PIR/PSD unpublished data), and American Samoa (Johnston et al. 2008, Oleson 2009).

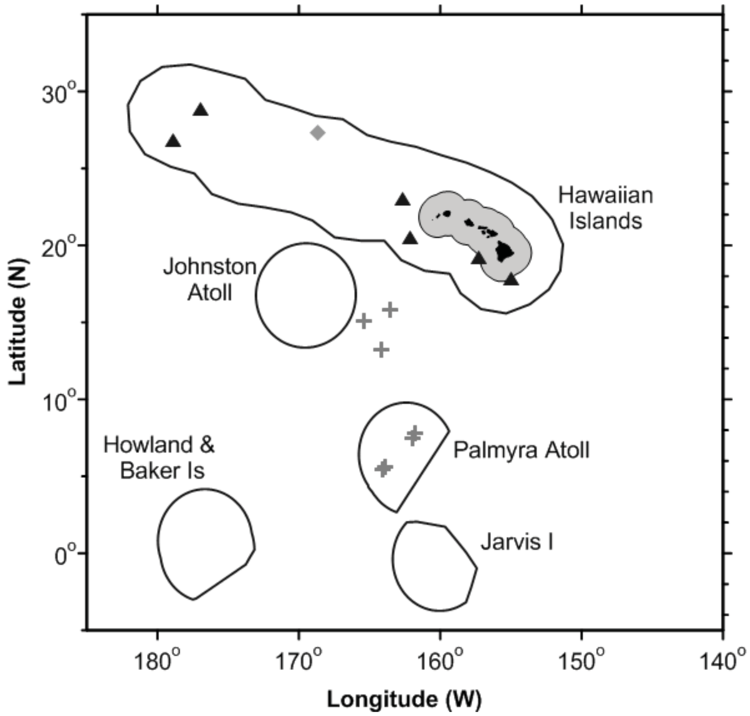

Figure 1. False killer whale on-effort sighting locations during standardized shipboard surveys of the Hawaiian U.S. EEZ (2002, ~~black~~ gray diamond, Barlow 2006; 2010, black triangles, NMFS unpublished data), the Palmyra U.S. EEZ and pelagic waters of the central Pacific south of the Hawaiian Islands (2005, ~~open squares~~ gray crosses, Barlow and Rankin 2007). Outer lines represent approximate boundary of U.S. EEZs; shaded gray area is the insular false killer whale stock area, including overlap zone between insular and pelagic false killer whale stocks.

Genetic analyses of tissue samples collected within the Indo-Pacific ~~Eastern North Pacific (ENP)~~ indicate restricted gene flow between false killer whales sampled near the main Hawaiian Islands and false killer whales sampled in all other regions ~~of the ENP~~ (Chivers et al. 2007, 2010). The recent update from Chivers et al. (2010) included additional samples and analysis of 8 nuclear DNA (nDNA) microsatellites, revealing strong phylogeographic patterns that are consistent with local evolution of haplotypes that are nearly unique to the separate insular population around the main Hawaiian Islands. Further, the recent analysis revealed significant differentiation, in both mitochondrial and nDNA, between pelagic false killer whales in the Eastern (ENP) and Central North Pacific (CNP) strata defined in Chivers et al. (2010), although the sample distribution to the east and west of Hawaii is insufficient to determine whether the sampled strata represent one or more stocks, and where stock boundaries would be drawn. An additional 24 samples collected during the 2010 shipboard survey in pelagic Hawaiian waters are currently being analyzed and will be used to further evaluate stock identity and boundaries. Since 2003, observers of the Hawaii-based longline fishery have ~~also~~ been collecting tissue samples of caught cetaceans for genetic analysis whenever possible. Between 2003 and ~~2008~~ 2010, ~~five~~ eight false killer whale samples, ~~three~~ four collected outside the Hawaiian EEZ and ~~two~~ four collected within the EEZ but more than 100 nautical miles (185km) from the main Hawaiian Islands (see Figure 3), were determined to have ~~ENP-like~~ Pacific pelagic haplotypes (Chivers et al. 2010). ~~Based on sighting locations and results of the genetic analyses, Chivers et al. (2008) suggested implementing a stock boundary coincident with the longline exclusion zone, which is at about 75 nmi (139 km) from the main Hawaiian Islands, until more information is available about the ecology of false killer whales, and especially the movement patterns of the insular stock animals.~~

~~For the 2008-2009 stock assessment reports, a provisional stock boundary for insular and pelagic stocks of false killer whales was recognized as the February-September longline exclusion boundary (at roughly 75 miles from the islands), with the expectation that this boundary would be refined as additional studies of false killer whale movements became available~~. Recent satellite telemetry studies, boat-based surveys, and photo-identification analyses of false killer whales around Hawaii have demonstrated that the insular and pelagic false killer whale ~~these two~~ stocks have overlapping ranges, rather than a clear separation in distribution. Insular false killer whales have been documented as far as ~~100~~ 112 km from the main Hawaiian Islands, and pelagic stock animals have been documented as close as 42 km to the islands (Baird et al. 2008, Baird 2009, Baird et al. 2010, Forney et al 2010). Based on a review of new information (Forney et al. 2010), ~~this~~ the 2010 stock assessment report recognized a new, overlapping stock structure for insular and pelagic stocks of false killer whales around Hawaii: animals within 40 km of the main Hawaiian Islands are considered to belong to the insular stock; animals beyond 140 km of the main Hawaiian Islands are considered to belong to the pelagic stock, and the two stocks overlap between 40 km and 140 km from shore (~~Figure 1~~Figure 2).

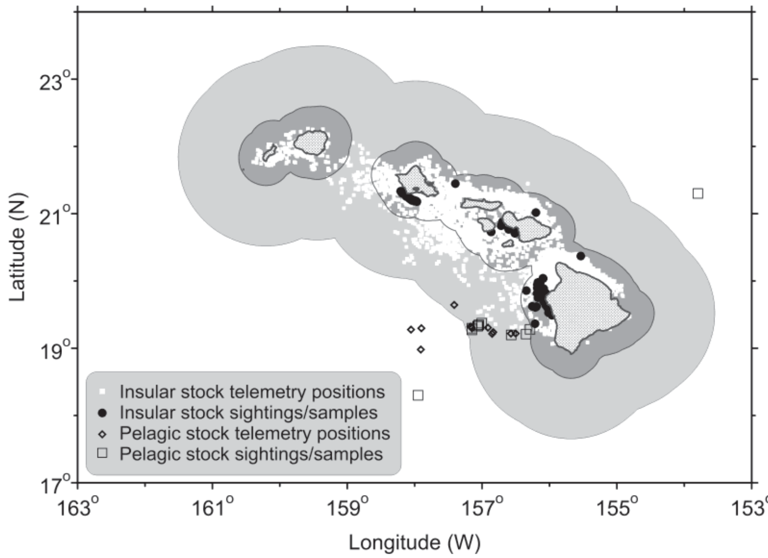

Figure 2. Sighting, biopsy, and telemetry records of false killer whales identified as being from insular (closed symbols) vs. pelagic (open symbols) stocks. The dark gray area is the 40-km insular stock core area; light gray area is the 40-km to 140-km overlap zone (Baird et al. 2010; Baird, unpublished data; reproduced from Forney et al. 2010).

~~This report also clarifies that the~~ The pelagic stock includes animals found both within the Hawaiian Islands EEZ and in adjacent international waters; however, because data on false killer whale abundance, distribution, and human-caused impacts are largely lacking for international waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). The Palmyra Atoll stock of false killer whales remains a separate stock, because comparisons amongst false killer whales sampled at Palmyra Atoll and those sampled from the insular stock of Hawaii and the pelagic ENP revealed restricted gene flow, although the sample size remains low for robust comparisons (Chivers et al. 2007, 2010). NMFS will continue to obtain and analyze additional tissue samples for genetic studies of stock structure, and will evaluate new information on stock ranges as it becomes available.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are currently four Pacific Islands Region management stocks (Chivers et al. 2008): 1) the Hawaii insular stock, which includes animals inhabiting waters within 140 km (approx. 75 nmi) of the main Hawaiian Islands, and 2) the Hawaii pelagic stock, which includes false killer whales inhabiting waters greater than 40 km (22 nmi) from the main Hawaiian Islands, 3) the Palmyra Atoll stock, which includes false killer whales found within the U.S. EEZ of Palmyra Atoll, and 4) the American Samoa stock, which includes false killer whales found within the U.S. EEZ of American Samoa. Estimates of abundance, potential biological removal, and status determinations for the first three stocks are presented below; the American Samoa Stock is covered in a separate report.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Interactions with cetaceans have been reported for Hawaii~~an~~-based pelagic fisheries and false killer whales have been identified in fishermen's logs and NMFS observer records as taking catches from pelagic longlines (Nitta and Henderson 1993, NMFS/PIR unpublished data). False killer whales have also been observed feeding on mahi mahi, *Coryphaena hippurus*, and yellowfin tuna, *Thunnus albacares*, and they have been reported to take large fish (up to 70 pounds) from the trolling lines of both commercial and recreational fishermen (Shallenberger 1981). There are anecdotal reports of interactions with marine mammals in the commercial Hawaii shortline fishery, which was developed to target bigeye tuna, *Thunnus obesus,* and lustrous pomfret, *Eumegistus illustris,* at Cross Seamount and may also set gear around the main Hawaiian Islands. Fishing is permitted through the State of Hawaii Commercial

Marine License program, and until recently there were no reporting systems in place to document marine mammal interactions. This fishery was added to the 2010 List of Fisheries as a Category II fishery (Federal Register Vol. 74, No. 219, p. 58859-58901, November 16, 2009), and efforts are underway to obtain further information on the extent of interactions between shortlines and marine mammals and to document the species involved. Baird and Gorgone (2005) documented a high rate of dorsal fin disfigurements that were consistent with injuries from unidentified fishing line for false killer whales belonging to the insular stock. At the present time, however, it is unknown whether these injuries might have been caused by longline gear, shortline gear, or other hook-and-line gear used around the main Hawaiian Islands.

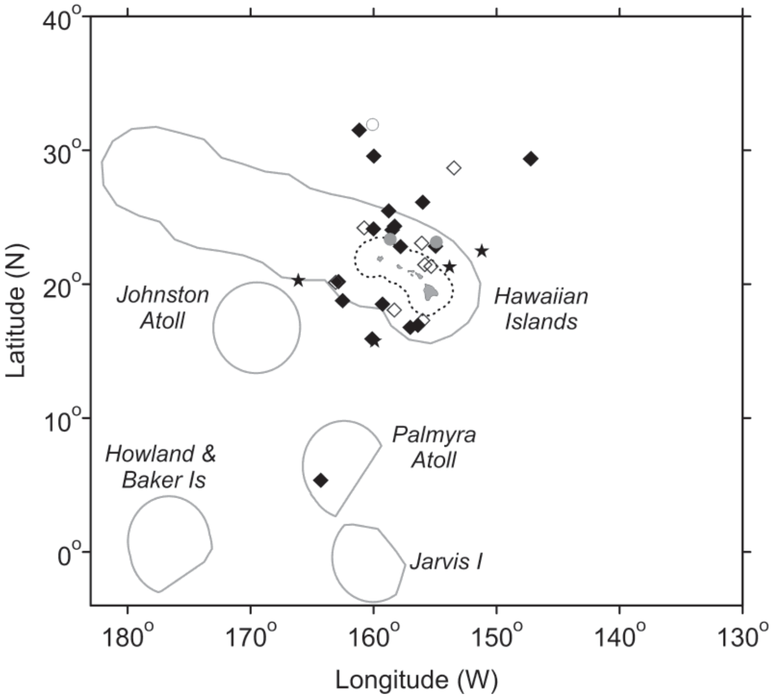

Figure 3. Locations of observed false killer whale takes (filled symbols) and possible takes of this species (open symbols) in the Hawaii-based longline fisheries, ~~2004-2008~~ 2005-2009. Deep-set fishery takes are shown in black; shallow-set fishery takes are shown in gray. Stars are locations of genetic samples from fishery-caught false killer whales. Solid gray lines represent the U.S. EEZ; the dotted line is the outer (140-km) boundary of the overlap zone between insular and pelagic false killer whale stocks. Fishery descriptions are provided in Appendix 1.

There are two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas, within the ranges of both insular and pelagic stocks. Between ~~2004 and 2008, one~~ 2005 and 2009, two false killer whales were ~~was~~ observed hooked or entangled in the SSLL fishery (100% observer coverage) within the U.S. EEZ of the Hawaiian Islands, and ~~19~~ 24 false killer whales were observed taken in the DSLL fishery (≥20% observer coverage) (Forney 2010a, b). Two ~~of the~~ false killer whale takes in the DSLL fishery ~~in Hawaiian EEZ waters~~ resulted in the death of the animal, one within the Hawaiian EEZ and the other in international waters. Based on an evaluation of the observer's description of each interaction and following the most recently developed criteria for assessing serious injury in marine mammals (Andersen et al. 2008), one ~~the single~~ animal taken in the SSLL fishery was considered not seriously injured and one was considered seriously injured. In the DSLL fishery, one false killer whale taken within the overlap zone ~~range~~ of the insular and pelagic stocks, one taken in Hawaiian waters within the range of the pelagic stock, and one taken in international waters were considered not seriously injured. For two false killer whales taken in the DSLL, one within the overlap zone of the insular and pelagic stocks and one taken in Hawaiian waters within the range of the pelagic stock, the level of injury could not be determined based on the observer descriptions. The remaining ~~15~~ 17 false killer whales taken in the DSLL fishery (~~six~~ nine in international waters, seven in the Hawaiian Islands EEZ pelagic stock range, and one in the EEZ of Palmyra Atoll) were considered seriously injured (Forney ~~2009~~ 2010a,b). ~~Eight~~ Nine additional unidentified cetaceans that may have been false killer whales were also seriously injured during ~~2004-2008~~ 2005-2009 (Forney ~~2009~~ 2010a,b). ~~Seven~~ Eight of these were taken in the DSLL fishery within U.S. EEZ waters, including two animals within the insular stock range, and one was taken in the SSLL fishery in international waters (Figure 3).

The total observed mortality and serious injury of cetaceans in the SSLL fishery (with 100% coverage), and the estimated annual and 5-yr average mortality and serious injury of cetaceans in the DSLL fishery (with approximately 20% coverage) are reported by ~~McCracken and Forney (2010)~~ McCracken (2010a,b). A number of recent changes are reflected in the methodology. All estimated takes of false killer whales, and observed takes for which an injury severity determination could not be made, are prorated based on the proportions of observed interactions that resulted in death or serious injury between the years 2000 and 2009 (~~89%~~ 92%), or non-serious injury (~~11%~~ 8%). Further, takes of false killer whales of unknown stock origin within the insular/pelagic stock overlap zone are prorated assuming that the density of the insular stock declines and the density of the pelagic stock increases with increasing distance from shore (McCracken 2010b).~~the density of each stock in that area~~. No genetic samples are available to establish stock identity for these takes, but both stocks are considered at risk of interacting with longline gear within this region. The pelagic stock is known to interact with longline fisheries in waters offshore of the overlap zone based on two genetic samples obtained by fishery observers (Chivers et al. 2008). Insular false killer whales have been documented via telemetry to move sufficiently far offshore (112km) to reach longline fishing areas, and animals from this stock have a high rate of dorsal fin disfigurements consistent with injuries from unidentified fishing line (Baird and Gorgone 2005). Based on these considerations, and as outlined in the NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005), bycatch within the overlap zone has been prorated based on the estimated densities of each stock (McCracken and Forney 2010). Finally, unidentified cetaceans, known to be either false killer whales or short-finned pilot whales (together termed "blackfish"), are prorated to each stock based on their distance from shore (McCracken 2010b). The distance-from-shore model was chosen following consultation with the Pacific Scientific Review Group based on the model's performance and simplicity relative to a number of other more complicated models with similar output (see McCracken 2010b for more information). ~~This~~ Proration of false killer whales takes within the overlap zone and of unidentified blackfish takes introduces ~~an~~ additional ~~element of~~ ,yet unquantified, uncertainty into the bycatch estimates, but until methods of determining stock identity for animals observed taken within the overlap zone are available, and all animals taken can be identified to species (e.g., photos, tissue samples), this approach ensures that potential impacts to all ~~both~~ stocks are assessed.

Based on these bycatch analyses, estimates of annual and 5-yr average annual mortality and serious injury of false killer whales, by stock and EEZ area, are shown in Table 1. Estimates of mortality and serious injury ~~do not~~ include a pro-rated portion of the animals categorized as unidentified blackfish (UB). Although M&SI estimates are shown as whole numbers of animals, the 5-yr average M&SI is calculated based on the unrounded annual estimates. ~~the unidentified animals that may have been false killer whales and are therefore minimum estimates. Efforts are currently underway to develop methods of prorating the unidentified animals by species and stock, taking into account geographic differences in their ranges and observed rates of documented interactions with each species.~~

Because of high rates of false killer whale mortality and serious injury in Hawaii-based longline fisheries, a Take-Reduction Team (TRT) was established in January 2010 (75 FR 2853, 19 January 2010). The scope of the TRT was to reduce mortality and serious injury in the Hawaii pelagic, Hawaii insular, and Palmyra stocks of false killer whales and across the DSLL and SSLL fisheries. The Team submitted a Draft Take-Reduction Plan to NMFS for consideration (Available at: http://www.nmfs.noaa.gov/pr/pdfs/interactions/fkwtrp_draft.pdf), and NMFS has recently proposed regulations based on this TRP (76 FR 42082, 18 July 2011).

Table 1. Summary of available information on incidental mortality and serious injury of false killer whales (Pacific Islands Stock Complex) and unidentified blackfish in commercial fisheries, by stock and EEZ area, as applicable (~~McCracken and Forney 2010~~ McCracken 2010a,b). Mean annual takes are based on ~~2004-2008~~ 2005-2009 estimates unless otherwise indicated. Information on all observed takes (T) and combined mortality events ~~(M),~~ & serious injuries (MSI) ~~and non-serious injuries (NSI)~~ is included. ~~, because t~~Total takes were prorated to deaths,

~~Fishery Name~~	~~Year~~	~~Data Type~~	~~Percent Observer Coverage~~	~~Observed mortality events (M), serious injuries (SI) and non-serious injuries (NSI), and total estimated mortality and serious injury (M&SI) of false killer whales by stock / EEZ region~~							
				~~Hawaii Pelagic Stock~~				~~Hawaii Insular Stock~~		~~Palmyra Atoll Stock~~	
				~~Outside of U.S. EEZs~~		~~Hawaiian Islands EEZ~~					
				~~Obs. M/SI/NSI~~	~~Estimated M&SI (CV)~~	~~Obs. M/SI/NSI~~	~~Estimated M&SI (CV)~~	~~Obs. M/SI/NSI~~	~~Estimated M&SI (CV)~~	~~Obs. M/SI/NSI~~	~~Estimated M&SI (CV)~~
~~Hawaii-based deep-set longline fishery~~	~~2004~~	~~Observer data~~	~~25%~~	~~0/3/0~~	~~13 (0.4)~~	~~1/2/0~~	~~12 (0.3)~~	~~0/0/0~~	~~0 (-)~~	~~0/0/0~~	~~0 (-)~~
	~~2005~~		~~28%~~	~~0/1/0~~	~~3 (1.6)~~	~~1/0/0~~	~~3 (1.9)~~	~~0/0/0~~	~~0 (-)~~	~~0/0/0~~	~~0 (-)~~
	~~2006~~		~~22%~~	~~0/2/0~~	~~8 (0.7)~~	~~0/1/1*~~	~~3 (1.7)~~	~~0/0/1*~~	~~3 (0.7)~~	~~0/0/0~~	~~0 (-)~~
	~~2007~~		~~20%~~	~~0/0/1~~	~~2 (3.7)~~	~~0/1/1~~	~~8 (0.8)~~	~~0/0/0~~	~~0 (-)~~	~~0/1/0~~	~~2 (0.7)~~
	~~2008~~		~~22%~~	~~0/0/0~~	~~0 (-)~~	~~0/3/1~~	~~11 (0.4)~~	~~0/0/0~~	~~0 (-)~~	~~0/0/0~~	~~0 (-)~~
~~Mean Estimated Annual Takes (CV)~~					~~5.3 (0.5)~~		~~7.3 (0.3)~~		~~0.6 (1.3)~~		~~0.3 (1.3)~~
~~Hawaii-based shallow-set longline fishery~~	~~2004~~	~~Observer data~~	~~100%~~	~~0/0/0~~	~~0~~	~~0/0/0~~	~~0~~	~~0/0/0~~	~~0~~	~~No fishing effort~~	
	~~2005~~		~~100%~~	~~0/0/0~~	~~0~~	~~0/0/0~~	~~0~~	~~0/0/0~~	~~0~~		
	~~2006~~		~~100%~~	~~0/0/0~~	~~0~~	~~0/0/0~~	~~0~~	~~0/0/0~~	~~0~~		
	~~2007~~		~~100%~~	~~0/0/0~~	~~0~~	~~0/0/0~~	~~0~~	~~0/0/0~~	~~0~~		
	~~2008~~		~~100%~~	~~0/0/0~~	~~0~~	~~0/0/1~~	~~0~~	~~0/0/0~~	~~0~~		
~~Mean Annual Takes (100% coverage)~~					~~0~~		~~0~~		~~0~~		
~~Minimum total annual takes within U.S. EEZs~~				~~7.3 (0.3)~~				~~0.6 (1.3)~~		~~0.3 (1.3)~~	

serious injuries, and non-serious injuries based on the observed proportions of each outcome (see (~~McCracken and Forney 2010~~ McCracken 2010a for details). Unidentified blackfish are pro-rated as either false killer whales or short-finned pilot whales according to their distance from shore (see McCracken 2010b for details). CVs are estimated based on the methods of McCracken & Forney (2010) and do not yet incorporate additional uncertainty introduced by prorating false killer whales in the overlap zone and prorating the unidentified blackfish.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed mortality events (M), serious injuries (SI) and non-serious injuries (NSI), and total estimated mortality and serious injury (M&SI) of false killer whales by stock / EEZ region							
				Hawaii Pelagic Stock				**Hawaii Insular Stock**		**Palmyra Atoll Stock**	
				Outside of U.S. EEZs		Hawaiian Islands EEZ					
				Obs. FKW T/MSI Obs. UB T/MSI	Estimated M&SI (CV)	Obs. FKW T/MSI Obs. UB T/MSI	Estimated M&SI (CV)	Obs. FKW T/MSI Obs. UB T/MSI	Estimated M&SI (CV)	Obs. FKW T/MSI Obs. UB T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	2005	Observer data	28%	1/1 0/0	3 (1.6)	1/1 1/1*	3 (1.9)	0/0 1/1*	0.5 (-)	0/0 0/0	0 (-)
	2006		22%	2/2 0/0	8 (0.7)	2/1* 2/2*	13 (1.7)	1/0* 1/1*	2.2 (0.7)	0/0 0/0	0 (-)
	2007		20%	1/0 0/0	2 (3.7)	2/1 0/0	8 (0.8)	0/0 0/0	0 (-)	1/1 0/0	2 (0.7)
	2008		22%	0/0 0/0	0 (-)	4/3 3/3	17 (0.4)	0/0 0/0	0 (-)	0/0 0/0	0 (-)
	2009		20%	7/7 0/0	39 (0.2)	2/2 0/0	12 (0.5)	0/0 0/0	0 (-)	0/0 0/0	0 (-)
Mean Estimated Annual Takes (CV)					**10.4 (0.31)**		**10.6 (0.4)**		**0.6 (1.67)**		**0.3 (1.67)**
Hawaii-based shallow-set longline fishery	2005	Observer data	100%	0/0 0/0	0	0/0 0/0	0	0/0 0/0	0	No fishing effort	
	2006		100%	0/0 0/0	0	0/0 0/0	0	0/0 0/0	0		
	2007		100%	0/0 0/0	0	0/0 0/0	0	0/0 0/0	0		
	2008		100%	0/0 1/1	0.5	1/0 0/0	0	0/0 0/0	0		
	2009		100%	0/0 0/0	0	1/1 0/0	1	0/0 0/0	0		
Mean Annual Takes (100% coverage)					**0.1**		**0.2**		**0**		
Minimum total annual takes within U.S. EEZs						**10.8 (0.4)**		**0.6 (1.67)**		**0.3 (1.67)**	

* False killer whale and unidentified blackfish ~~The single NSI~~ takes within the insular/pelagic stock overlap zone are ~~is~~ shown once for each stock, but total estimates derived from these ~~is~~ takes are prorated among potentially affected stocks based on the distance from shore of the take location ~~insular/pelagic false killer whale densities within the overlap zone~~ (see text above, and ~~McCracken and Forney 2010~~ McCracken 2010a,b).

HAWAII INSULAR STOCK

POPULATION SIZE

A mark-recapture study of photo-identification data obtained during 2000-2004 around the main Hawaiian Islands produced an estimate of 123 (CV=0.72) insular false killer whales (Baird et al. 2005). This abundance estimate is based in part on data collected more than 8 years ago, and is considered outdated for estimating current abundance (NMFS 2005). A Status Review for the insular stock (Oleson et al. 2010) used recent, unpublished estimates for two time periods, 2000-2004 and 2006-2009 in their Population Viability Analysis (PVA). The new estimates were based on more recent sighting histories and open population models, yielding more precise estimates for the two time periods. Two separate estimates for 2006-2009 were presented in the Status Review, 151 (CV=0.20) and 170 (CV=0.21), depending on whether animals photographed near Kauai are included in the estimate, as these animals have not been seen to associate with others in the insular population (Baird unpublished data). The best estimate of population size is taken as the larger estimate including those animals seen near Kauai given the geographic range currently defined for this stock. However, it should be noted that this is an overestimate, because missed matches were discovered after the mark-recapture analyses were complete (discussed in Oleson *et al.* 2010). The best estimate will be updated when a new mark-recapture estimate accounting for the missed matches is available.

Minimum Population Estimate

~~The minimum population estimate for the insular stock false killer whales is the number of distinct~~

~~individuals identified in this population during the 2002-2004 photo-identification studies, 76 individuals (Baird et al. 2005). This is similar to the log-normal 20th percentile of the mark-recapture abundance estimate, 71 false killer whales.~~ The minimum population estimate for the insular stock of false killer whales is the number of distinct individuals identified during 2005-2009 photo-identification studies, 110 false killer whales (Baird, unpublished data). Recent mark-recapture estimates (Oleson et al. 2010) of abundance are known to have an upwards bias of unknown magnitude, and therefore are not suitable for deriving a minimum abundance estimate.

Current Population Trend

A recent study (Reeves et al. 2009) summarized information on false killer whale sightings near Hawaii between 1989 and 2007, based on various survey methods, and suggested that the insular stock of false killer whales may have declined during the last two decades. More recently, Baird (2009) reviewed trends in sighting rates of false killer whales from aerial surveys conducted using consistent methodology around the main Hawaiian Islands between 1994 and 2003 (Mobley et al. 2000, Mobley 2001, 2002, 2003, 2004). Sighting rates during these surveys exhibited a statistically significant decline that could not be attributed to any weather or methodological changes. The recent Status Review of Hawaiian insular false killer whales (Oleson *et al.* 2010) presented a quantitative analysis of extinction risk using a Population Viability Analysis (PVA). The modeling exercise was conducted to evaluate the probability of actual or near extinction, defined as fewer than 20 animals, given measured, estimated, or inferred information on population size and trends, and varying impacts of catastrophes, environmental stochasticity and Allee effects. A variety of alternative scenarios were evaluated, with all plausible models indicating the probability of decline to fewer than 20 animals within 75 years as greater than 20%. Though causation was not evaluated, all models indicated current declines at an average rate of -9% since 1989 (95% probability intervals -5% to -12.5%; Oleson *et al.* 2010).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters. Obtaining information on rates of productivity for marine mammals is difficult (Wade 1998), and no estimate is available for this stock.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the insular false killer whale stock is calculated as the minimum population size ~~(76)~~ (110) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of ~~0.4~~ 0.10 resulting in a PBR of 0.2 false killer whales per year. The recovery factor was chosen to be 0.1 because the stock has been proposed for listing as endangered under the U.S Endangered Species Act (see below) and because of the significant recent decline experienced by this stock (Oleson et al. 2010). ~~(for a stock of unknown status with a human-caused mortality and serious injury rate CV>0.80; see Wade and Angliss 1997), resulting in a PBR of 0.61 false killer whales per year.~~

STATUS OF STOCK

The status relative to OSP of false killer whales belonging to the insular stock is unknown, although this stock appears to have declined during the past two decades (Oleson *et al.*2010, Reeves et al. 2009; Baird 2009). A recent study (Ylitalo et al. 2009) documented elevated levels of polychlorinated biphenyls (PCBs) in three of nine insular false killer whales sampled, and biomass of some false killer whale prey species may have declined around the main Hawaiian Islands (Oleson *et al* 2010, Boggs & Ito 1993, Reeves et al. 2009). Insular ~~F~~false killer whales ~~are not listed as "threatened" or~~ have been proposed for listing as "endangered" under the Endangered Species Act (1973)~~, nor as "depleted" under the MMPA~~ (75 FR 70169, 17 November 2010),. The proposed listing follows receipt of a petition from the Natural Resources Defense Council on October 1, 2009, requesting that Hawaiian insular false killer whales be listed as endangered under the ESA. NMFS determined that the petition presented substantial scientific information indicating that a listing may be warranted and thus was required to conduct an ESA status review of the stock (75 *FR* 316; January 5, 2010) and established a Biological Review Team (BRT) for this purpose. The Status Review report produced by the BRT (Oleson *et al.* 2010) found that Hawaiian insular false killer whales are a Distinct Population Segment (DPS) of the global false killer whale taxon based on behavioral, ecological, genetic, and cultural factors. The BRT evaluated risk to the population, including identification and ranking of threats to the population, quantitative assessment of extinction probability using a PVA, and an assessment of the overall risk of extinction to the population. The PVA analysis indicated the probability of near-extinction (less than 20 animals) within 75 years (3 generations) was greater than 20% for all biologically plausible models and given a wide range of input variables. Of the 29 indentified threats to the population, the BRT considered the effects of small population size, including inbreeding depression and Allee effects, exposure to environmental contaminants, competition for food with commercial fisheries, and hooking, entanglement, or intentional harm by fishers to be the most substantial threats to the population. The BRT concluded that Hawaiian insular false killer whale were at high risk of extinction. The final listing decision is not yet available. False killer whales are not listed as "depleted" under the MMPA. ~~In September 2009, a petition was submitted to NMFS to list the Hawaiian insular false killer whale stock as an endangered species under the ESA, and NMFS has initiated a status review to determine if such a listing is warranted.~~

Based on the best available scientific information (Oleson *et al*. 2010), Hawaiian insular false killer whales are declining, therefore the insular false killer whale stock is considered "strategic" under the 1994 amendments to the MMPA. The estimated average annual human-caused mortality and serious injury for this stock (0.60 animals per year) is ~~slightly less~~ greater than the PBR ~~(0.61)~~ (0.2), providing further support for the "strategic" designation. ~~therefore, the insular false killer whale stock is not considered "strategic" under the 1994 amendments to the MMPA. However, the current estimate of mortality and serious injury does not include additional unidentified animals that may have been false killer whales and were taken within the insular stock range, and the status of this stock is likely to change once methods have been developed to prorate these additional takes.~~

HAWAII PELAGIC STOCK

POPULATION SIZE

Analyses of a 2002 shipboard line-transect survey of the Hawaiian Islands EEZ (HICEAS survey) resulted in an abundance estimate of 236 (CV=1.13) false killer whales (Barlow 2006) outside of 75 nm of the main Hawaiian Islands. A recent re-analysis of the HICEAS data using improved methods and incorporating additional sighting information obtained on line-transect surveys south of the Hawaiian EEZ during 2005, resulted in a revised estimate of 484 (CV = 0.93) false killer whales within the Hawaiian Islands EEZ outside of about 75 nmi of the main Hawaiian Islands (Barlow & Rankin 2007). This ~~is the best available~~ abundance estimate for the pelagic stock of false killer whales is now more than 8 years old and therefore will no longer be used based on NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005). A new abundance survey was recently completed within the Hawaiian Islands EEZ and resulted in several acoustic and visual detections of false killer whales within the pelagic stock area. The detection process during the recent survey is different from that during the 2002 survey due to the inclusion of acoustic techniques; therefore a thorough analysis of the visual and acoustic detections will be required before a new abundance estimate will be available.

A 2005 survey (Barlow and Rankin 2007) ~~also~~ resulted in a separate abundance estimate of 906 (CV=0.68) false killer whales in international waters south of the Hawaiian Islands EEZ and within the EEZ of Johnston Atoll, but it is unknown how many of these animals might belong to the Hawaii pelagic stock.

Minimum Population Estimate

The log-normal 20th percentile of the 2002 abundance estimate for the Hawaiian Islands EEZ outside of 75 nmi from the main Hawaiian Islands (Barlow & Rankin 2007) is 249 false killer whales. This minimum population estimate is more than 8 years old, and therefore would generally be considered outdated under NMFS Guidelines for Assessing Marine Mammal Stocks (2005) unless there was compelling evidence that the abundance has not dropped below the 2002 level within the EEZ of the Hawaiian Islands. The 2010 survey had a significantly higher encounter rate than the 2002 survey (6 on-effort sightings versus one) for approximately the same level of effort and in the same study area. Although the detection process has been improved with the inclusion of acoustic methods designed to increase the probability of detection for false killer whales, NMFS considers the significant increase in the encounter rate during the 2010 survey as evidence that the abundance in the EEZ has not dropped below the 2002 minimum estimate. Therefore, the minimum estimate will be retained at this time, particularly given that a new minimum estimate will be available following thorough analysis of data collected during the 2010 HICEAS survey.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters. Obtaining information on rates of productivity for marine mammals is difficult (Wade 1998), and no estimate is available for this stock.

POTENTIAL BIOLOGICAL REMOVAL

Following the NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005), the PBR is calculated only within the U.S. EEZ of the Hawaiian Islands, because estimates of human-caused mortality and serious injury are not available from all U.S. and non-U.S. sources in international waters where this stock may occur. The potential biological removal (PBR) level for the Hawaii pelagic stock of false killer whale is thus calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (249) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of ~~0.50~~ 0.48 (for a stock of unknown status with a Hawaiian Islands EEZ mortality and serious injury rate CV~~≤0.30~~ between 0.30 and 0.60; Wade and Angliss 1997), resulting in a PBR of ~~2.5~~ 2.4 false killer whales per year.

STATUS OF STOCK

The status of the Hawaii pelagic stock of false killer whale relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. They are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. Following the NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005), the status of this transboundary stock of false killer whales is assessed based on the estimated abundance and estimates of mortality and serious injury within the U.S. EEZ of the Hawaiian Islands, because estimates of human-caused mortality and serious injury from all U.S. and non-U.S. sources in international waters are not available, and because the geographic range of this stock beyond the Hawaiian Islands EEZ is poorly known. Because the rate of mortality and serious injury to false killer whales within the Hawaiian Islands EEZ (~~7.3~~ 10.8 animals per year) exceeds the PBR (~~2.5~~ 2.4 animals per year), this stock is considered a "strategic stock" under the 1994 amendments to the MMPA. ~~Furthermore, additional injury or mortality of unidentified cetaceans that may have been false killer whales is known to occur in the U.S. longline fisheries, but these animals have not yet been included in the Hawaii pelagic stock status assessment.~~ The total fishery mortality and serious injury for the Hawaii pelagic stock of false killer whales cannot be considered to be insignificant and approaching zero, because it has exceeded~~s~~ the PBR for more than 10 years.

The National Marine Fisheries Service recognizes that the assessment of this transboundary stock based only on abundance and human-caused mortality and serious injury within the U.S. EEZ of Hawaii introduces uncertainty, and has considered whether the status assessment would change if animals outside the Hawaiian Islands EEZ are considered. Using all available peer-reviewed information on the abundance of false killer whales on the high-seas and within the EEZ of Johnston Atoll , a PBR can be calculated as the lower 20th percentile of the Barlow and Rankin (2007) abundance estimate (530), times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of ~~0.5~~ 0.48 (for a stock of unknown status with a mortality and serious injury rate CV~~≤0.30~~ between 0.30 and 0.60; Wade and Angliss 1997), resulting in ~~5.3~~ 5.1 false killer whales per year. This abundance estimate may be based on a smaller geographic area than the (unknown) full range of the pelagic stock, because areas to the north of the Hawaiian Islands EEZ are not included; however, the estimate meets the definition of a 'minimum population estimate' under the MMPA. Bycatch information for the high seas is incomplete, because the levels of false killer whale takes in non-U.S. fisheries are not known. The average annual estimated mortality and serious injury by U.S. longline vessels operating on the high seas and within the EEZ of Johnston Atoll is ~~5.4~~ 10.4 (CV=0.31; ~~McCracken and Forney 2010~~ McCracken 2010). This value is greater than the PBR of ~~5.3~~ 5.1, and the combined U.S. and international mortality and serious injury is likely substantially higher, because fishing effort by foreign vessels may be up to six times greater than that of the US fleet (NMFS, unpublished data). Better information on the full geographic range of this stock and quantitative estimates of bycatch in international fisheries are needed to reduce the uncertainties regarding impacts of false killer whale takes on the high seas, but these uncertainties do not change the current assessment that the pelagic false killer whale stock is strategic.

PALMYRA STOCK

POPULATION SIZE

Recent line transect surveys in the U.S. EEZ waters of Palmyra Atoll produced an estimate of 1,329 (CV = 0.65) false killer whales (Barlow & Rankin 2007). This is the best available abundance estimate for false killer whales within the Palmyra Atoll EEZ.

Minimum Population Estimate

The log-normal 20th percentile of the 2002 abundance estimate for the Palmyra Atoll EEZ (Barlow & Rankin 2007) is 806 false killer whales.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Palmyra Atoll waters. Obtaining information on rates of productivity for marine mammals is difficult (Wade 1998), and no estimate is available for this stock.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Palmyra Atoll false killer whale stock is calculated as the minimum population size (806) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.40 (for a stock of unknown status with a mortality and serious injury rate CV >0.80; Wade and Angliss 1997), resulting in a PBR of 6.4 false killer whales per year.

STATUS OF STOCK

The status of false killer whales in Palmyra Atoll EEZ waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. They are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. The rate of mortality and serious injury to false killer whales within the Palmyra Atoll EEZ in the Hawaii-based longline fishery (0.3 animals per year) does not exceed the PBR (6.4) for this stock and thus, this stock is not considered "strategic" under the 1994 amendments to the MMPA. The total fishery mortality and serious injury for Palmyra Atoll false killer whales is less than 10% of the PBR and, therefore, can be considered to be insignificant and approaching zero. Additional injury and mortality of false killer whales is known to occur in U.S and international longline fishing operations in international waters, and the potential effect on the Palmyra stock is unknown.

REFERENCES

Baird, R.W. 2009. A review of false killer whales in Hawaiian waters: biology, status, and risk factors. Report prepared for the U.S. Marine Mammal Commission under Order No. E40475499, December 23, 2009. 40p.

Baird, R.W., A.M. Gorgone, D.J. McSweeney, D.L. Webster, D.R. Salden, M.H. Deakos, A.D. Ligon, G.S. Schorr, J. Barlow and S.D. Mahaffy. 2008~~c~~. False killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands: long-term site fidelity, inter-island movements, and association patterns. Marine Mammal Science 24:591-612

Baird, R.W., A.M. Gorgone, D.L. Webster, D.J. McSweeney, J.W. Durban, A.D. Ligon, D.R. Salden, and M.H. Deakos. 2005. False killer whales around the main Hawaiian Islands: An assessment of inter-island movements and population size using individual photo-identification. Contract Report JJ133F04SE0120 prepared for the Pacific Islands Fisheries Science Center, National Marine Fisheries Service, 2570 Dole Street, Honolulu, Hawaii, 96822. 24pp.

Baird, R.W., and A.M. Gorgone. 2005. False killer whale dorsal fin disfigurements as a possible indicator of long-line fishery interactions in Hawaiian waters. Pacific Science 59:593-601.

Baird, R.W, G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2010. Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands. Endangered Species Research 10:107-121.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22: 446–464.

Barlow, J. and S. Rankin. 2007. False killer whale abundance and density: Preliminary estimates for the PICEAS study area south of Hawaii and new estimates for the US EEZ around Hawaii. Administrative Report LJ-07-02. Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

Boggs, C.H. and R.Y. Ito. 1993. Hawaii's pelagic fisheries. In: Boehlert GW (ed.). The fisheries of Hawaii and U.S.-associated Pacific Islands. Mar. Fish. Rev. 55(2): 61-68.

Chivers, S. J., R. W. Baird, D. J. McSweeney, D. L. Webster, N. M. Hedrick, and J. C. Salinas. 2007. Genetic variation and evidence for population structure in eastern North Pacific false killer whales (*Pseudorca crassidens*). Can. J. Zool. 85: 783-794.

Chivers, S. J., R. W. Baird, K. M. Martien, B. Taylor, L., E. Archer, A. M. Gorgone, B. L. Hancock, N. Hedrick, M., D. K. Mattila, D. J. McSweeney, E. M. Oleson, C. L. Palmer, V. Pease, K. M. Robertson, J. Robbins, J. C. Salinas, G. S. Schorr, M. Schultz, J. L. Theileking and D. L. Webster. 2010. Evidence of genetic differentiation for Hawai'i insular false killer whales (*Pseudorca crassidens*). 44p.

Chivers S. J., K. A. Forney, and D. Johnston. 2008. Rationale for the 2008 revision to Hawaiian stock boundaries for false killer whales, Pseudorca crassidens. SWFSC Administrative Report LJ-08-04. Available from

SWFSC, 8604 La Jolla Shores Drive, La Jolla, CA 92038. 5p.
Forney, K.A. 2010a. Serious-injury determinations for cetaceans caught in Hawaii longline fisheries during 1994-2008. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-462. 19p.

Forney, K.A. 2010b. Serious-injury determinations for cetaceans caught in Hawaii-based longline fisheries, January 2009 through October 2010. Draft document PSRG-2010-15 presented to the Pacific Scientific Review Group, November16-18, 2010, Kona, HI.

Forney, K. A., R. W. Baird, and E. M. Oleson. 2010. Rationale for the 2010 revision of stock boundaries for the Hawai'i insular and pelagic stocks of false killer whales, *Pseudorca crassidens*. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-471. 7p.

Johnston, D. W., J. Robbins, M. E. Chapla, D. K. Mattila & K. R. Andrews. 2008. Diversity, habitat associations and stock structure of odontocete cetaceans in the waters of American Samoa, 2003-2006. Journal of Cetacean Research and Management 10: 59-66.

Maldini, D., L. Mazzuca, and S. Atkinson. 2005. Odontocete stranding patterns in the main Hawaiian Islands (1937-2002): How do they compare with live animal surveys? Pacific Science 59(1):55-67.

McCracken, M. L. and K.A. Forney. 2010. Preliminary assessment of incidental interactions with marine mammals in the Hawaii longline deep and shallow set fisheries. NMFS, Pacific Islands Fisheries Science Center Working Paper WP-10-001. 27p.

McCracken, M.L. 2010a. Assessment of incidental interactions with marine mammals in the Hawaii longline deep and shallow set fisheries from 2005 though 2009, NMFS, Pacific Islands Fisheries Science Center Working paper WP-10-006, 26p.

McCracken, M.L. 2010b. Adjustments to false killer whale and short-finned pilot whale bycatch estimates. NMFS, Pacific Islands Fisheries Science Center Working paper WP-10-007, 23p.

Miyashita, T. 1993. Abundance of dolphin stocks in the western North Pacific taken by the Japanese drive fishery. Rep. Int. Whal. Commn. 43:417-437.

Mobley, J.R. , Jr, S. S. Spitz, K. A. Forney, R. A. Grotefendt, and P. H. Forestall. 2000. Distribution and abundance of odontocete species in Hawaiian waters: preliminary results of 1993-98 aerial surveys Admin. Rep. LJ-00-14C. Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 26 pp.

Mobley, J.R. 2001. Results of 2001 aerial surveys north of Kauai. Report to North Pacific Acoustic Laboratory program. 20 pp. Available as downloadable pdf file at: http://socrates.uhwo.hawaii.edu/SocialSci/jmobley/2001NPAL.pdf

Mobley, J.R. 2002. Results of 2002 aerial surveys north of Kauai. Report to North Pacific Acoustics Laboratory program. 20 pp. Available as downloadable pdf file at: http://socrates.uhwo.hawaii.edu/SocialSci/jmobley/2002NPAL.pdf

Mobley, J.R. 2003. Results of 2003 aerial surveys north of Kauai. Report to North Pacific Acoustics Laboratory program. 20 pp. Available as downloadable pdf file at: http://socrates.uhwo.hawaii.edu/SocialSci/jmobley/2003NPAL.pdf

Mobley, J.R. 2004. Results of 2004 aerial surveys north of Kauai. Report to North Pacific Acoustics Laboratory program. 25 pp. Available as downloadable pdf file at: http://socrates.uhwo.hawaii.edu/SocialSci/jmobley/2004NPAL.pdf

Nitta, E. 1991. The marine mammal stranding network for Hawaii: an overview. *In*: J.E. Reynolds III, D.K. Odell (eds.), Marine Mammal Strandings in the United States, pp.56-62. NOAA Tech. Rep. NMFS 98, 157 pp.

Nitta, E. and J. R. Henderson. 1993. A review of interactions between Hawaii's fisheries and protected species. Mar. Fish. Rev. 55(2):83-92.

NMFS. 2005. Revisions to Guidelines for Assessing Marine Mammal Stocks. 24 pp. Available at: http://www.nmfs.noaa.gov/pr/pdfs/sars/gamms2005.pdf

NMFS, Pacific Islands Region, Observer Program, 1602 Kapiolani Blvd, Suite 1110, Honolulu, HI 96814.

NMFS, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92027.

Oleson, E.M. 2009. Assessment of American Samoa longline fishery and estimates of cetacean bycatch, 2006-2008. ~~Draft document PSRG-2009-14 presented to the Pacific Scientific Review Group, Nov 3-5, 2009, Del Mar, CA. 14p~~ NMFS, Pacific Islands Fisheries Science Center Working Paper WP-09-006, 12p.

Oleson, E.M., C.H. Boggs, K.A. Forney, M.B. Hanson, D.R. Kobayashi, B.L. Taylor, P.R. Wade, and G.M. Ylitalo. 2010. Status Review of Hawaiian Insular False Killer Whales (*Pseudorca crassidens*) under the Endangered Species Act. U.S Dep. Commerc. NOAA Tech Memo., NOAA-TM-NMFS-PIFSC-22. 140 p. + Appendices.

Perrin, W.F., G. P. Donovan and J. Barlow. 1994. Gillnets and Cetaceans. Rep. Int. Whal. Commn., Special Issue 15, 629 pp.

Reeves, R.R., S. Leatherwood, and R.W. Baird. 2009. Evidence of a possible decline since 1989 in false killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands. Pacific Science 63(2): 253–261.~~in press.~~

Shallenberger, E.W. 1981. The status of Hawaiian cetaceans. Final report to U.S. Marine Mammal Commission. MMC-77/23, 79pp.

Stacey, P. J., S. Leatherwood, and R. W. Baird. 1994. *Pseudorca crassidens*. Mamm. Spec. 456:1-6.

Wade, P. R. and R. P. Angliss. 1997. Guidelines for Assessing Marine Mammal Stocks: Report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12. 93 pp.

Wade,, P.R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Marine Mammal Science 14(1): 1.-37.

Ylitalo, G. M., R. W. Baird, G. K. Yanagida, D. L. Webster, S. J. Chivers, J. L. Bolton, G. S. Schorr and D. J. McSweeney. 2009. High levels of persistent organic pollutants measured in blubber of island-associated false killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands. *Marine Pollution Bulletin* 58: 1932-1937.

Appendix 3. 2011 Draft Pacific Marine Mammal Stock Assessment Reports summary.
Shaded lines indicate reports revised in 2011.

Species	Stock Area	NMFS Center	N est	CV N est	N min	R max	Fr	PBR	Total Annual Mortality + Serious Injury	Annual Fishery Mortality + Serious Injury	Strategic Status	Recent Abundance Surveys			SAR Last Revised
California sea lion	U.S.	SWC	~~238,000~~	n/a	~~141,842~~	0.12	1	~~8,511~~	~~≥232~~	~~≥159~~	N	~~2003~~	~~2004~~	~~2005~~	~~2007~~
			296,750		153,337			9,200	≥431	≥337		2006	2007	2008	2011
Harbor seal	California	SWC	~~34,233~~	n/a	~~31,600~~	0.12	1	~~1,896~~	~~≥389~~	~~389~~	N	~~1995~~	~~2002~~	~~2004~~	~~2005~~
			30,196		26,667			1,600	31	18		2002	2004	2009	2011
Harbor seal	Oregon/Washington Coast	AKC	unk	unk	unk	0.12	1	unk	≥3.8	≥1.8	N	1999			2010
Harbor seal	Washington Inland Waters	AKC	unk	unk	unk	0.12	1	unk	≥13.0	≥3.8	N	1999			2010
Northern Elephant Seal	California breeding	SWC	124,000	n/a	74,913	0.117	1	4,382	≥10.4	≥8.8	N	2001	2002	2005	2007
Guadalupe Fur Seal	Mexico to California	SWC	7,408	n/a	3,028	0.12	0.5	91	0	0	Y	1993			2000
Northern Fur Seal	San Miguel Island	AKC	9,968	n/a	5,395	0.12	1	324	1.2	0	N	2004	2005	2007	2010
Monk Seal	Hawaii	PIC	~~1,161~~	n/a	~~1,136~~	0.07	0.1	undet	~~unk~~	unk	Y	~~2005~~	~~2006~~	~~2008~~	~~2010~~
			1,125		1,093				≥3.0			2007	2008	2009	2011
Harbor porpoise	Morro Bay	SWC	2,044	0.40	1,478	0.04	~~0.4~~	15	0	0	N	1999	2002	2007	2009
Harbor porpoise	Monterey Bay	SWC	1,492	0.4	1,079		0.45	10	≥1.0	≥1.0	N	1999	2002	2007	2009
Harbor porpoise	San Francisco – Russian River	SWC	9,189	0.38	6,745	0.04	0.5	67	0	0	N	1999	2002	2007	2009
Harbor porpoise	Northern CA/Southern OR	SWC	39,581	0.39	28,833	0.04	1	577	≥4	≥4	N	1999	2002	2007	2009
Harbor porpoise	Northern Oregon/Washington Coast	AKC	15,674	0.39	11,383	0.04	0.5	114	~~≥1.0~~	~~≥0.8~~	N	1991	1997	2002	~~2009~~
									≥1.4	≥1.4					2011
Harbor porpoise	Washington Inland Waters	AKC	10,682	0.38	7,841	0.04	0.4	63	~~15.2~~	~~15.4~~	N	1996	2002	2003	~~2006~~
									≥2.2	≥2.6					2011
Dall's porpoise	California/Oregon/Washington	SWC	42,000	0.33	32,106	0.04	0.4	257	≥0.4	≥0.4	N	2001	2005	2008	2010
Pacific white-sided dolphin	California/Oregon/Washington	SWC	26,930	0.28	21,406	0.04	0.45	193	15.1	10.5	N	2001	2005	2008	2010
Risso's dolphin	California/Oregon/Washington	SWC	6,272	0.30	4,913	0.04	0.4	39	1.6	1.6	N	2001	2005	2008	2010
Common Bottlenose dolphin	California Coastal	SWC	323	0.13	290	0.04	0.5	2.4	0.2	0.2	N	2000	2004	2005	2008
Common Bottlenose dolphin	California/Oregon/Washington Offshore	SWC	1,006	0.48	684	0.04	0.4	5.5	≥0.2	≥0.2	N	2001	2005	2008	2010
Striped dolphin	California/Oregon/Washington	SWC	10,908	0.34	8,231	0.04	0.5	82	0	0	N	2001	2005	2008	2010
Common dolphin, short-beaked	California/Oregon/Washington	SWC	411,211	0.21	343,990	0.04	0.5	3,440	64	64	N	2001	2005	2008	2010
Common dolphin, long-beaked	California	SWC	27,046	0.59	17,127	0.04	0.48	164	13	13	N	2001	2005	2008	2010
Northern right whale dolphin	California/Oregon/Washington	SWC	8,334	0.40	6,019	0.04	0.4	48	4.8	3.6	N	2001	2005	2008	2010
Killer whale	Eastern North Pacific Offshore	SWC	240	0.49	162	0.04	0.5	1.6	0	0	N	2001	2005	2008	2010
Killer whale	Eastern North Pacific Southern Resident	AKC	~~85~~	und	~~85~~	0.04	0.1	0.17	0.2	0	Y	~~2006~~	~~2008~~	~~2009~~	~~2010~~
			86		86							2008	2009	2010	2011
Short-finned pilot whale	California/Oregon/Washington	SWC	760	0.64	465	0.04	0.4	4.6	0	0	N	2001	2005	2008	2010
Baird's beaked whale	California/Oregon/Washington	SWC	907	0.49	615	0.04	0.5	6.2	0	0	N	2001	2005	2008	2010
Mesoplodont beaked whales	California/Oregon/Washington	SWC	1,024	0.77	576	0.04	0.5	5.8	0	0	N	2001	2005	2008	2010
Cuvier's beaked whale	California/Oregon/Washington	SWC	2,143	0.65	1,298	0.04	0.5	13	0	0	N	2001	2005	2008	2010
Pygmy Sperm whale	California/Oregon/Washington	SWC	579	1.02	271	0.04	0.5	2.7	0	0	N	2001	2005	2008	2010
Dwarf sperm whale	California/Oregon/Washington	SWC	unk	unk	unk	0.04	0.5	undet	0	0	N	2001	2005	2008	2010
Sperm whale	California/Oregon/Washington	SWC	971	0.31	751	0.04	0.1	1.5	0.4	0.2	Y	2001	2005	2008	2010

unk = unknown; undet = undetermined; n/a = not applicable

Appendix 3. 2011 Draft Pacific Marine Mammal Stock Assessment Reports summary.
Shaded lines indicate reports revised in 2011.

Species	Stock Area	NMFS Center	N est	CV N est	N min	R max	Fr	PBR	Total Annual Mortality + Serious Injury	Annual Fishery Mortality + Serious Injury	Strategic Status	Recent Abundance Surveys			SAR Last Revised
Humpback whale	California/Oregon/Washington	SWC	2,043	0.10	1,878	0.08	0.3	11.3	≥ 3.6	≥ 3.2	Y	2001	2005	2008	2010
Blue whale	Eastern North Pacific	SWC	2,497	0.24	2,046	0.04	0.3	3.1	1.0	0	Y	2001	2005	2008	2010
Fin whale	California/Oregon/Washington	SWC	3,044	0.18	2,624	0.04	0.3	16	1.0	0	Y	2001	2005	2008	2010
Sei whale	Eastern North Pacific	SWC	126	0.53	83	0.04	0.1	0.17	0	0	Y	2001	2005	2008	2010
Minke whale	California/Oregon/Washington	SWC	478	1.36	202	0.04	0.5	2.0	0	0	N	2001	2005	2008	2010
Rough-toothed dolphin	Hawaii	SWC	8,709	0.45	6,067	0.04	0.5	61	unk	unk	N			2002	2010
Rough-toothed dolphin	American Samoa	PIC	unk	unk	unk	0.04	0.5	unk	unk	unk	unk	n/a	n/a	n/a	2010
Risso's dolphin	Hawaii	SWC	2,372	0.97	1,195	0.04	0.5	12	0	0	N			2002	2010
Common Bottlenose dolphin	Hawaii Pelagic	SWC	3,178	0.59	2,006	0.04	0.45	18	≥0.4	≥0.4	N			2002	2010
Common Bottlenose dolphin	Kaua'I and Ni'ihau	SWC	147	0.11	134	0.04	0.5	1.3	unk	unk	N	2003	2004	2005	2010
Common Bottlenose dolphin	O'ahu	SWC	594	0.54	388	0.04	0.5	3.9	unk	unk	N	2002	2003	2006	2010
Common Bottlenose dolphin	4 Islands Region	SWC	153	0.24	125	0.04	0.5	1.3	unk	unk	N	2002	2003	2006	2010
Common Bottlenose dolphin	Hawaii Island	SWC	102	0.13	91	0.04	0.5	0.9	unk	unk	N	2002	2003	2006	2010
Pantropical Spotted dolphin	Hawaii	PIC	8,978	0.48	6,701	0.04	0.5	61.0	0	0	N			2002	2010
Spinner dolphin	Hawaii Pelagic	PIC	3,351	0.74	1,920	0.04	0.5	19	0	0	N		2002	2004	2010
Spinner dolphin	Hawaii Island	PIC	unk	unk	unk	0.04	0.5	unk	unk	unk	N			1994	2010
Spinner dolphin	Oahu / 4 Islands	PIC	unk	unk	unk	0.04	0.5	unk	unk	unk	N	1993	1995	1998	2010
Spinner dolphin	Kaua'I / Ni'ihau	PIC	unk	unk	unk	0.04	0.04	unk	unk	unk	N	1993	1995	1998	2010
Spinner dolphin	Kure / Midway	PIC	unk	unk	unk	0.04	0.04	unk	unk	unk	N	n/a	n/a	1998	2010
Spinner dolphin	Pearl and Hermes Reef	PIC	unk	unk	unk	0.04	0.04	unk	unk	unk	N	n/a	n/a	n/a	2010
Spinner dolphin	American Samoa	PIC	unk	unk	unk	0.04	0.04	unk	unk	unk	unk	n/a	n/a	n/a	2010
Striped dolphin	Hawaii Pelagic	PIC	13,143	0.46	9,088	0.04	0.45	82	unk	unk	N			2002	2010
Fraser's dolphin	Hawaii	PIC	10,226	1.16	4,700	0.04	0.5	47	0	0	N			2002	2010
Melon-headed whale	Hawaii	PIC	2,950	1.17	1,350	0.04	0.5	14	0	0	N			2002	2010
Pygmy killer whale	Hawaii	PIC	956	0.83	520	0.04	0.5	5.2	0	0	N			2002	2010
False killer whale	Hawaii Pelagic	PIC	484	0.93	249	0.04	~~0.5~~	~~2.5~~	~~7.3~~	~~7.3~~	Y			2002	~~2010~~
							0.48	2.4	10.8	10.8					2011
False killer whale	Palmyra Atoll	PIC	1,329	0.65	806	0.04	0.4	6.4	0.3	0.3	N			2005	~~2010~~
															2011
False killer whale	Hawaii Insular	PIC	~~123~~	~~0.72~~	~~76~~	0.04	~~0.4~~	~~0.61~~	0.6	0.6	~~N~~	~~2000~~	~~2002~~	~~2004~~	~~2010~~
			170	0.21	110		0.1	0.2			Y	2007	2008	2009	2011
False killer whale	American Samoa	PIC	unk	unk	unk	0.04	0.5	unk	unk	unk	unk	n/a	n/a	n/a	2010
Killer whale	Hawaii	PIC	349	0.98	175	0.04	0.5	1.8	0	0	N			2002	2010
Pilot whale, short-finned	Hawaii	PIC	8,846	0.49	5,986	0.04	0.4	48	0.7	0.7	N			2002	2010
Blainville's beaked whale	Hawaii	PIC	2,872	1.17	1,314	0.04	0.5	13.0	0	0	N			2002	2010
Longman's Beaked Whale	Hawaii	PIC	1,007	1.25	443	0.04	0.5	4.4	0	0	N			2002	2010
Cuvier's beaked whale	Hawaii	PIC	15,242	1.43	6,269	0.04	0.5	63	0	0	N			2002	2010
Pygmy sperm whale	Hawaii	PIC	7,138	1.12	3,341	0.04	0.5	33	0	0	N			2002	2010

unk = unknown; undet = undetermined; n/a = not applicable

Appendix 3. 2011 Draft Pacific Marine Mammal Stock Assessment Reports summary.
Shaded lines indicate reports revised in 2011.

Species	Stock Area	NMFS Center	N est	CV N est	N min	R max	Fr	PBR	Total Annual Mortality + Serious Injury	Annual Fishery Mortality + Serious Injury	Strategic Status	Recent Abundance Surveys			SAR Last Revised
Dwarf sperm whale	Hawaii	PIC	17,519	0.74	10,043	0.04	0.5	100	0	0	N			2002	2010
Sperm whale	Hawaii	PIC	6,919	0.81	3,805	0.04	0.1	7.6	0	0	Y			2002	2010
Blue whale	Central North Pacific	PIC	unk	unk	unk	0.04	0.1	undet	0	0	Y			2002	2010
Fin whale	Hawaii	PIC	174	0.72	101	0.04	0.1	0.2	0	0	Y			2002	2010
Bryde's whale	Hawaii	PIC	469	0.45	327	0.04	0.5	3.3	0	0	N			2002	2010
Sei whale	Hawaii	PIC	77	1.06	37	0.04	0.1	0.1	0	0	Y			2002	2010
Minke whale	Hawaii	PIC	unk	unk	unk	0.04	0.5	undet	0	0	N			2002	2010
Humpback whale	American Samoa	SWC	unk	unk	150	0.106	0.1	0.4	0	0	Y	2006	2007	2008	2009

unk = unknown; undet = undetermined; n/a = not applicable