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CALIFORNIA SEA LION (*Zalophus 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 the Galapagos sea lion (*Z. wollebaeki*) and the extinct Japanese sea lion (*Z. japonicus*) (Brunner 2003, Wolf *et al*. 2007, Schramm et al. 2009). 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 Pacific Temperate population range north into Canadian waters, and 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 at least 400 nmi. Males from western Baja California rookeries may spend most of the year in the United States.

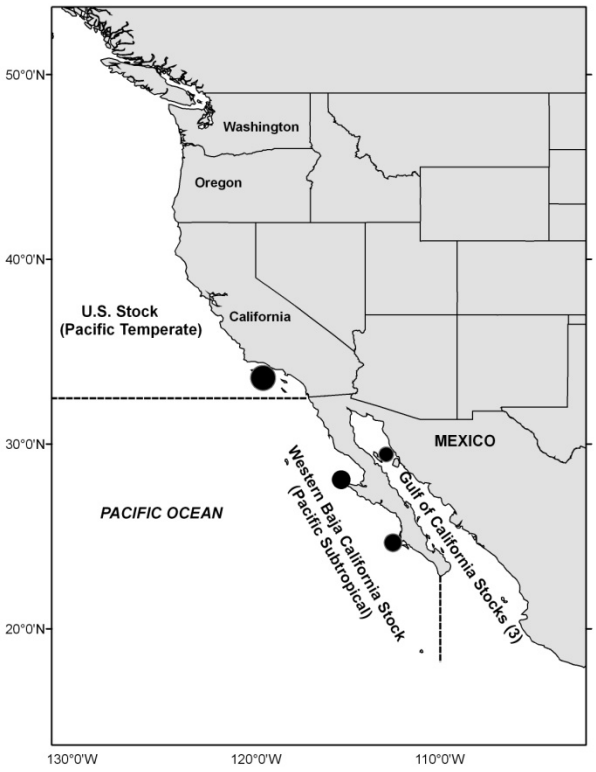

Figure 1. Geographic range of California sea lions showing stock boundaries and locations of major rookeries. The U.S. stock also ranges north into Canadian waters.

There are no international agreements between the U.S., Mexico, and Canada for joint management of California sea lions, 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 2008 (59,774) was adjusted for an estimated 15% pre-census mortality (Boveng 1988; Lowry et al. 1992), giving an estimated 68,740 live births in the population. The fraction of newborn pups in the population (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 (5.4% yr^{-1}, see below). Multiplying the number of pups born by the inverse of this fraction (4.317) results in a population estimate of 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 2007 breeding season. The minimum population size of the U.S. stock is 153,337 (NMFS unpubl. data). It includes all California sea lions counted during the July 2007 census at the Channel Islands in southern California and at haulout sites located between Point Conception and Point Reyes, California. An additional unknown number of California sea lions are at sea or hauled out at locations that were not censused.

Current Population Trend

Trends in pup counts from 1975 through 2008 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. A regression of the natural logarithm of the pup counts against year indicates that the counts of pups increased at an annual rate of 5.4% between 1975 and 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- 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% in 1983, 27% in 1992, 64% in 1998, and 20% in 2003. After the 1992-93, 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.

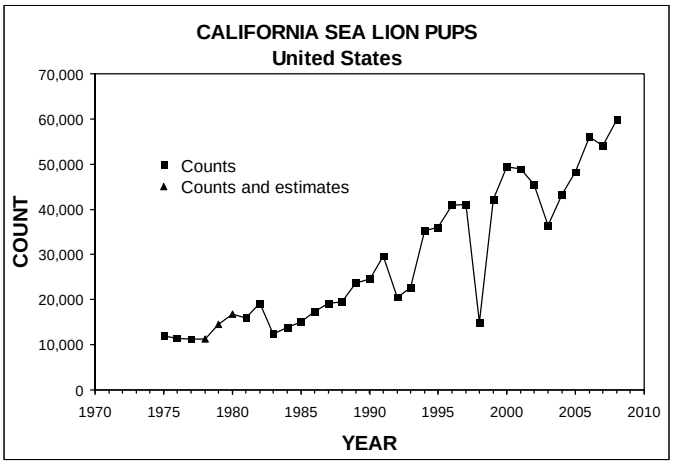

Figure 2. U.S. pup count index for California sea lions (1975-2005 2008). Trends in pup counts from 1975 through 2008 are shown for four rookeries in southern California and for haulouts in central and northern California. Records of pup counts from 1975 to 2008 were compiled from Lowry and Maravilla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

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A standard logistic growth model indicated that the maximum population growth rate (R_{max}) was 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 pinnipeds (12% per year).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (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 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). 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 and Beeson, 1998; Carretta et al. 2005) 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 (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.

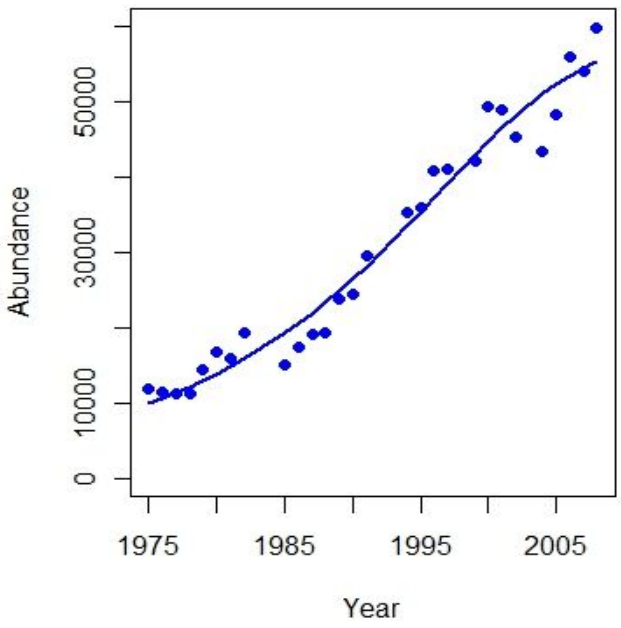

Figure 3. Fit of standard logistic growth curve to California sea lion pup counts, 1975-2008 (excluding El Niño years).

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 set gillnet 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 occurred in the past in the following fisheries: (1) California, Oregon, and Washington salmon troll; (2) Oregon and Washington non-salmon troll; (3) California herring purse-seine; (4) California anchovy, mackerel, and tuna purse-seine; (5) California squid purse-seine; (6) Washington, Oregon, California and British Columbia, Canada salmon net pen ; (7) Washington, Oregon, and California groundfish trawl; (8) Washington, Oregon and California commercial passenger fishing vessels (NMFS 1995, M. Perez pers. comm, and P. Olesiuk pers. comm.) (9) California small mesh drift gillnet fishery, and (10) California anchovy, mackerel, and tuna purse-seine. 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 2005-2009 show that an additional 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.

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 to 4.5-inch 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 death 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 and Enriquez 2006, 2007, 2009a, 2009b, 2010; Heery et al. 2010; Appendix 1). Mean annual takes are based on 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 large mesh drift gillnet fishery	2005 2006 2007 2008 2009 2008	observer	20.9% 18.5% 16.4% 13.5% 13.3%	1 12 8 7 5	5 (0.97) 64 (0.43) 48 (0.65) 51 (0.52) 37 (0.83)	41 (0.28)
CA halibut and white seabass set gillnet fishery	2005 2006 2007 2008 2009	12 sets observed in 2006 and 248 sets observed in 2007	0% <1% 17.8% 0% 0%	n/a 0 34 n/a n/a	n/a n/a 190 (0.68) n/a n/a	190 (0.68)[1]
CA small-mesh drift gillnet fishery for white seabass, yellowtail, barracuda, and tuna	2003 2004	observer	11% 11%	2 1	18 (0.71) 9 (0.94)	13.5 (0.57)
CA anchovy, mackerel, sardine, and tuna purse-seine fishery	2004-2008	observer	~5%	2	n/a	≥2 (n/a)

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
WA, OR, CA domestic groundfish trawl fishery (includes at-sea hake and other limited-entry groundfish sectors)	2004 2005 2006 2007 2008	observer	99% to 100% of tows in at-sea hake fishery 18%-26% of landings in other groundfish sectors	8 14 21 8 7	13 (n/a) 21 (n/a) 95 (n/a) 31 (n/a) 13 (n/a)	34.6 (n/a)
Unknown entangling net fishery	2005-2009	stranding	n/a	55	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						≥ 337 (0.56)

[1] 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 2005-2009 from California, Oregon, and Washington stranding databases shows the following non-fishery related human-caused mortality: boat collisions (12 deaths), car collisions (6 deaths), entrainment in power plants (158 deaths), shootings (113 deaths), marine debris entanglement or ingestion (13 deaths), research permit- related takes (3 deaths), and unknown sources (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 2005-2009 was 324, or an annual average of 65 animals.

Under authorization of MMPA Section 120, individually identifiable California sea lions have been killed or captured since 2008 in response to their predation on endangered salmon and steelhead stocks in the Columbia River. 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 relocations 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

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. 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 total human-caused mortality is less than the PBR (9,200). The total fishery mortality and serious injury rate (337 animals/year) for this stock is less than 10% of the calculated PBR and, therefore, is considered to be insignificant and approaching a zero mortality and serious injury rate.

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