SOUTHERN SEA OTTER (*Enhydra lutris nereis*)

U.S. Fish and Wildlife Service, Ventura, California

STOCK DEFINITION AND GEOGRAPHIC RANGE

Southern sea otters occupy nearshore waters along the mainland coastline of California from San Mateo County to Santa Barbara County (Figure 1). A subpopulation of southern sea otters also exists at San Nicolas Island, Ventura County, as a result of translocation efforts initiated in 1987.

Historically, southern sea otters ranged from present-day Punta Abreojos, Baja California, Mexico, to at least as far north as Newport, Oregon (Valentine et al. 2008). The killing of sea otters for their pelts during the fur trade of the 18th and 19th centuries extirpated the subspecies throughout most of its range. A small number of southern sea otters survived near Bixby Creek in Monterey County, California (Bryant 1915). Since receiving protection under the International Fur Seal Treaty in 1911, southern sea otters have gradually expanded northward and southward along the central California coast, reclaiming approximately 13 percent of their historic range (U.S. Fish and Wildlife Service 2015). The estimated carrying capacity of California is approximately 16,000 animals (Laidre et al. 2001). The carrying capacity of the remainder of the southern sea otter's historic range has not been determined.

Figure 1. Current range of the southern sea otter (2015 census). Source: Tinker and Hatfield 2015

Sea otter abundance varies considerably across the range, with the highest densities occurring in the central portion (Seaside to Cayucos), where sea otters have been present the longest. Sea otter densities tend to be most stable from year to year in rocky, kelp-dominated areas, which are primarily occupied by females, dependent pups, and territorial males. In contrast, sandy and soft-bottom habitats (in particular those in Monterey Bay, Estero Bay, and Pismo Beach to Pt. Sal) tend to be occupied by non-territorial males and sub-adult animals of both sexes (and only rarely by adult females and pups) and are more variable in abundance from year to year. This variation is driven in part by the long-distance movements and seasonal redistribution of males (Tinker et al. 2008b). Many males migrate to the range peripheries during winter and early spring, apparently to take advantage of more abundant prey resources, but then return to the range center in search of estrous females (Jameson 1989, Ralls et al. 1996, Tinker et al. 2008b). Mating and pupping occur year round, with a birth peak from October to January and a secondary peak in March and April.[1]

All sea otters of the subspecies *Enhydra lutris nereis* are considered to belong to a single stock because of their recent descent from a single remnant population. Southern sea otters are geographically isolated from the other two recognized subspecies of sea otters, *E. l. lutris* and *E. l. kenyoni*, and have been shown to be distinct from these subspecies in studies of cranial morphology (Wilson et al. 1991) and variation at the molecular level (Sanchez 1992; Cronin et al. 1996; Larson et al. 2002).

POPULATION SIZE

Data on population size have been gathered for more than 50 years. In 1982, a standardized survey technique was adopted to ensure that subsequent counts were comparable (Estes and Jameson 1988). This survey method involves a shore-based census of approximately 60 percent of the range, with the remainder surveyed from the air. Counts of the mainland range are conducted each spring. At San Nicolas Island, counts are conducted from shore in spring and fall, with the spring count taken as the official count for the year. Since termination of the experimental status of the San Nicolas Island sea otter population in 2012 (77 FR 75266; December 19, 2012), the island and mainland counts have been combined to arrive at an annual range-wide index of abundance, which consists of the 3-year running average of the combined spring counts. In 2015, the range-wide index of abundance was 3,054 (Tinker and Hatfield 2015).

Minimum Population Estimate

The minimum population estimate for the southern sea otter stock is taken as the lesser of the latest combined raw counts from the mainland range and San Nicolas Island or the latest 3-year running average of the combined counts. In 2015, the combined raw count was 3,254, but the combined 3-year running average was only 3,054. Therefore, the minimum population estimate is 3,054 animals (2,990 along the mainland and 64 at San Nicolas Island).

Current Population Trend

As recommended in the Final Revised Recovery Plan for the Southern Sea Otter (U.S. Fish and Wildlife Service 2003), 3-year running averages are used to characterize trends to dampen the effects of anomalous counts in any given year. Based on 3-year running averages of the annual spring counts, the rangewide (combined mainland and island) population growth trend over the past 5 years is 2.2 percent per year (Tinker and Hatfield 2015; Figure 2). This trend is strongly influenced by increases in sea otter numbers observed in 2015 in the center portion of the range (Seaside to Cayucos), an area that has been considered to be at or near carrying capacity for several years. The increase in sea otter numbers in this area may be due to increased juvenile survival and the immigration of males from the range peripheries in response to an unusually high abundance of sea urchins since 2013 (Tinker and Hatfield 2015).

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[1] Personal communication, M. Tim Tinker, 2008. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

We use the 5-year population trend to characterize current net productivity rates. During the past 5 years, growth of the mainland population averaged approximately 1.7 percent per year, whereas growth of the San Nicolas Island population averaged approximately 13 percent per year (Tinker and Hatfield 2015). Because most of the population occurs along the mainland coastline, the rangewide population growth trend of 2.2 percent per year is heavily influenced by the mainland population trend.

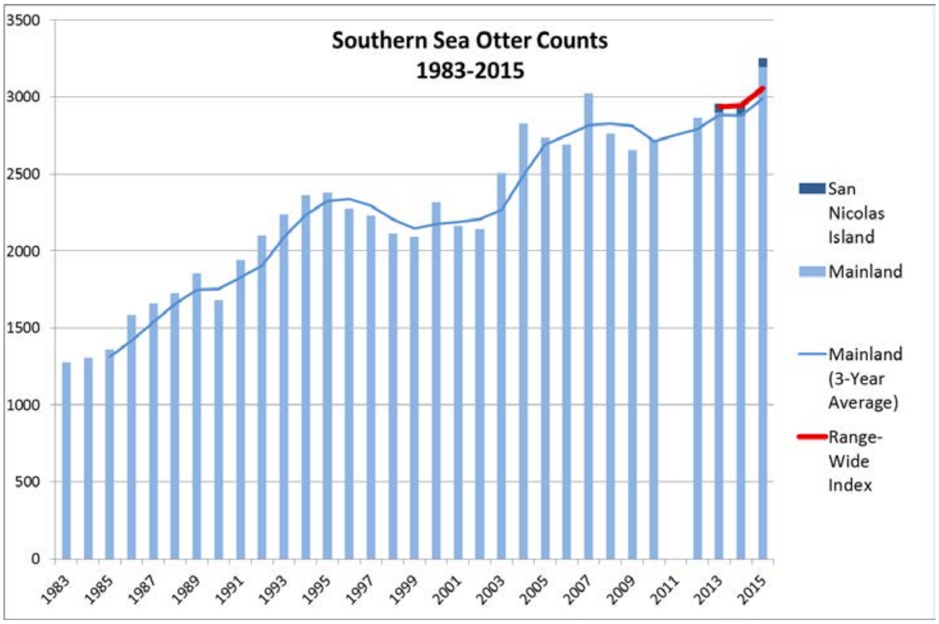

Figure 2. Southern sea otter counts 1983-2015. Bars show raw counts for each year, whereas lines represent 3-year running averages. The mainland census was not completed in 2011. Data source: Tinker and Hatfield 2015

The maximum growth rate (R_{max}) for southern sea otters along the mainland coastline since the early 1980s (when reliable trend data first become available) appears to be 6 percent per year, although localized sub-populations have been observed to grow at much higher rates immediately after re-colonization.[2] In contrast, recovering or translocated populations at Attu Island, southeast Alaska, British Columbia, and Washington state all exhibited growth rates of up to 17 or 20 percent annually during the early stages of recovery (Estes 1990, Jameson and Jeffries 1999, Jameson and Jeffries 2005). Although there has been speculation that the slower rate of population growth observed for the southern sea otter reflects a fundamental difference in survival or reproduction relative to northern sea otter populations, recent data and analyses indicate that the emphasis on differential rates of population growth may be misplaced. First, a variety of evidence supports the conclusion that sea otters throughout much of central California have been at or very near the carrying capacity of the local environment in recent years, which explains the lack of growth in these areas (*i.e.*, further growth has been limited by available food resources) (Tinker et al. 2006b, Tinker et al. 2008a). Second, radio-tagging studies report age- and sex-specific rates of survival and reproduction that are comparable for southern sea otters and northern sea otters when status with respect to carrying capacity is accounted for (Monson et al. 2000, Tinker et al. 2006b). Finally, recent modeling analyses indicate that the spatial configuration of available habitat (the long narrow strip of coastal shelf characteristic of the

[2] Personal communication, M. Tim Tinker, 2013. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

mainland California sea otter range versus the bays, islands, and complex matrices of inland channels characteristic of the habitat in British Columbia and Alaska), combined with the high degree of spatial structure in sea otter populations (due to the limited mobility of reproductive females), result in greatly different expected population growth rates over the long term and may account in large part for the differences in trends between the southern sea otter and northern sea otter populations.[3]

From the early 1900s to the mid-1970s, the southern sea otter population is thought to have increased at about 5 percent annually (Estes 1990), although consistent surveys and trend data from early years are lacking. From 1983 to 1995, annual growth averaged about 6 percent. The population declined during the late 1990s, resumed growth in the early 2000s, and ceased growth again beginning in 2008. Growth rates at San Nicolas Island averaged approximately 9 percent annually from the early 1990s to the mid-2000s and approximately 13 percent over the past 5 years.

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of three elements: the minimum population estimate (N_{min}); half the maximum net productivity rate (0.5 R_{max}); and a recovery factor (F_r). This can be written as: PBR = (N_{min})(½ of R_{max})(F_r).

For the southern sea otter stock, N_{min} is 3,054 (2,990 along the mainland and 64 at San Nicolas Island). Because the maximum population growth rate appears to be tightly constrained by habitat configuration, we use an R_{max} of 6 percent for the mainland portion of the population and an R_{max} of 13 percent for the island portion of the population. We use a recovery factor of 0.1 for the southern sea otter stock because, although the population appears to be stable or growing, N_{min} is below 5,000, and the species is vulnerable to a natural or human-caused catastrophe, such as an oil spill, due to its restricted geographic distribution in nearshore waters (Taylor et al. 2003). Therefore, the PBR for the southern sea otter stock is 9.38 [(2,990 x 0.5 x 0.06 x 0.1) + (64 x 0.5 x 0.13 x 0.1)], which when rounded down to the nearest whole animal is 9. It is important to note that take of southern sea otters incidental to commercial fishing operations cannot be authorized under the MMPA. Thus, the provisions governing the authorization of incidental take in commercial fisheries at MMPA Sections 101(a)(5)(E) and 118, which include requirements to develop take reduction plans with the goal of reducing incidental mortality or serious injury of marine mammals to levels less than the PBR, do not apply with respect to southern sea otters.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Sea otters are susceptible to entanglement and drowning in gill nets. The set gill net fishery in California is estimated to have killed from 48 to 166 (average of 103) southern sea otters per year from 1973 to 1983 (Herrick and Hanan 1988) and 80 sea otters annually from June 1982 to June 1984 (Wendell et al. 1986). A 1991 closure restricted gill and trammel nets to waters deeper than 30 fathoms (55 meters) throughout most of the southern sea otter's range

[3] Personal communication, M. Tim Tinker, 2013. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

(California Senate Bill No. 2563). In 1990, NMFS started an observer program using at-sea observers, which provided data on incidental mortality rates relative to the distribution of fishing effort. The observer program was active through 1994, discontinued from 1995 to 1998, and reinstated in the Monterey Bay area in 1999 and 2000 because of concern over increased harbor porpoise mortality. Based on a detailed analysis of fishing effort, sea otter distributions by depth, and regional entanglement patterns during observed years, NMFS estimated southern sea otter mortality in the halibut set gill net fishery to have been 64 in 1990, zero from 1991 to 1994, 3 to 13 in 1995, 2 to 29 in 1996, 6 to 47 in 1997, 6 to 36 in 1998, 5 in 1999, and zero in 2000 (Cameron and Forney 2000; Carretta 2001; Forney et al. 2001). The increase in estimated mortality from 1995 to 1998 was attributed to a shift in set gill net fishing effort into areas where sea otters are found in waters deeper than 30 fathoms (55 meters).

Fishing with gill nets has since been further restricted throughout the range of the southern sea otter. An order prohibiting the use of gill and trammel nets year-round in ocean waters of 60 fathoms or less from Point Reyes, Marin County, to Point Arguello, Santa Barbara County was made permanent in September 2002. In the waters south of Point Arguello, the Marine Resources Protection Act of 1990 (California Constitution Article 10B) defined a Marine Resources Protection zone in which the use of gill and trammel nets is banned. This zone includes waters less than 70 fathoms (128 meters) or within one nautical mile (1.9 kilometers), whichever is less, around the Channel Islands, and waters generally within three nautical miles (5.6 kilometers) offshore of the mainland coast from Point Arguello to the Mexican border. Although sea otters occasionally dive to depths of 328 feet (100 meters), the vast majority (>99 percent) of dives are to depths of 131 feet (40 meters) or less.[4] Because of these restrictions and the current extent of the southern sea otter's range, southern sea otter mortalities resulting from entanglement in gill nets are likely to be at or near zero. Nevertheless, sea otters may occasionally transit areas that are not subject to closures, and levels of observer coverage of gill and trammel net fisheries are insufficient to confirm an annual incidental mortality and serious injury rate of zero in these fisheries (see Table 1) (Barlow 1989, Babcock et al. 2003). An estimated 50 vessels participate in the CA halibut/white seabass and other species set gillnet (>3.5" mesh) fishery (81 FR 20550, April 8, 2016). Approximately 30 vessels participate in the CA yellowtail, barracuda, and white seabass drift gillnet fishery (mesh size ≥3.5" and <14") (81 FR 20550, April 8, 2016). Approximately 18 vessels participate in the CA thresher shark/swordfish drift gillnet fishery (≥14" mesh) (81 FR 20550, April 8, 2016).

Three southern sea otter interactions with the California purse seine fishery for northern anchovy and Pacific sardine have been documented. In 2005, a contract observer in the NOAA Fisheries California Coastal Pelagic Species observer program documented the incidental, non-lethal capture of two sea otters that were temporarily encircled in a purse seine net targeting northern anchovy but escaped unharmed by jumping over the corkline. In 2006, a contract observer in the same program documented the incidental, non-lethal capture of a sea otter in a purse seine net targeting Pacific sardine. Again, the sea otter escaped the net at end of the haul without assistance.[5] There are no data available to assess whether sea otter interactions with

[4] Personal communication, M. Tim Tinker, 2008. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.
[5] Personal communication, Lyle Enriquez, 2006. Southwest Regional Office, NOAA, U.S. National Marine Fisheries Service, 501 West Ocean Boulevard, Long Beach, CA 90802.

purse-seine gear are currently resulting in mortality or serious injury. An estimated 65 vessels participate in the CA anchovy, mackerel, and sardine purse seine fishery (81 FR 20550, April 8, 2016).

The potential exists for sea otters to drown in traps set for crabs, lobsters, and finfish, but only limited documentation of mortalities is available. Hatfield and Estes (2000) summarize records of 18 sea otter mortalities in trap gear, 14 of which occurred in Alaska. With the exception of one sea otter, which was found in a crab trap, all of the reported Alaska mortalities involved Pacific cod traps and were either recorded by NMFS observers or reported to NMFS observers by fishers. As of 2000, four sea otters were known to have died in trap gear in California: one in a lobster trap near Santa Cruz Island in 1987; a mother and pup in a trap with a 10-inch diameter opening (presumed to be an experimental trap) in Monterey Bay in 1987; and one in a rock crab trap 0.5 miles off Pt. Santa Cruz, California (Hatfield and Estes 2000). In 1995, the U.S. Geological Survey began opportunistic efforts to observe the finfish trap fishery in California. These efforts were supplemented with observations by the California Department of Fish and Game (CDFG) in 1997 and two hired observers in 1999. No sea otters were found in the 1,624 traps observed (Hatfield and Estes 2000). However, a very high level of observer coverage would be required to see any indication of trap mortality, even if mortality levels were high enough to substantially reduce the rate of population growth (Hatfield et al. 2011). In 2016, a dead sea otter was found in a lobster trap pulled by California Department of Fish and Wildlife wardens in the Port San Luis Area near Avila Beach. The discovery occurred on April 8, several weeks after commercial lobster season had closed (March 16) and traps should have been removed from the water.[6]

Controlled experiments conducted by the U.S. Geological Survey and the Monterey Bay Aquarium demonstrated that sea otters would enter a baited commercial finfish trap with inner trap funnel openings of 5.5 inches in diameter (Hatfield and Estes 2000). Hatfield et al. (2011) confirmed that some sea otters exposed to finfish, lobster, and mock Dungeness crab traps in a captive setting would succeed in entering them. Based on experiments with carcasses and live sea otters, they concluded that finfish traps with 5-inch-diameter circular openings would largely exclude diving sea otters; that circular openings of 5.5 to 6 inches in diameter and rectangular openings 4 inches high (typical of Dungeness crab pots) would allow the passage of sea otters up to about 2 years of age; and that the larger fyke openings of spiny lobster pots and finfish traps with openings larger than 5 inches would admit larger sea otters. Reducing the fyke-opening height of Dungeness crab traps by one inch (to 3 inches) would exclude nearly all diving sea otters while not significantly affecting the number or size of harvested crabs (Hatfield et al. 2011). Since January 2002, CDFG has required 5-inch sea-otter-exclusion rings to be placed in live-fish traps used along the central coast from Pt. Montara in San Mateo County to Pt. Arguello in Santa Barbara County. No rings are required for live-fish traps used in the waters south of Point Conception, and no rings are currently required for lobster or crab traps regardless of their location in California waters. Estimates of the number of vessels participating in pot and trap fisheries off California are given in parentheses: CA Dungeness crab pot (570); CA rock crab pot (124); CA spiny lobster (194); and CA nearshore finfish live trap/hook-and-line (93) (81 FR 20550, April 8, 2016).

[6] Personal communication, Todd Tognazzini, 2016. Patrol Lieutenant, San Luis Obispo/Southern Monterey Counties, California Department of Fish and Wildlife, 3196 South Higuera, Suite A, San Luis Obispo, CA 93401.

Available information on incidental mortality and serious injury of southern sea otters in commercial fisheries is very limited. Due to the lack of observer coverage, a reliable, science-based estimate of the annual rate of mortality and serious injury cannot be determined. Commercial fisheries believed to have the potential to kill or injure southern sea otters are listed in Table 1. Due to the nature of potential interactions (entrapment or entanglement followed by drowning), serious injury is unlikely to be detected prior to the death of the animal.

Table 1. Summary of available information on incidental mortality and serious injury of southern sea otters in commercial fisheries that have the potential to interact with southern sea otters.

Fishery Name	Category	Year(s)	Number of Vessels[1]	Data Type	Percent Observer Coverage[2]	Observed Mortality/ Serious Injury	Estimated Mortality/ Serious Injury	Mean Annual Mortality/ Serious Injury
CA halibut/white seabass and other species set gillnet (>3.5”)	2	2010 2011 2012 2013 2014	50	observer observer observer observer n/a	10.9% 8.3% 14.6% 11.3% not observed	0 0 0 0 n/a	n/a	n/a
CA yellowtail, barracuda, and white seabass drift gillnet (≥3.5” and <14”)	2	2010 2011 2012 2013 2014	30	n/a observer observer n/a n/a	not observed 3.3% 0.7% not observed not observed	n/a 0 0 n/a n/a	n/a	n/a
CA thresher shark/swordfish drift gillnet fishery (≥14”)	1	2010 2011 2012 2013 2014	18	observer	11.9% 19.5% 18.6% 37.2% 23.7%	0 0 0 0 0	0	0
CA anchovy, mackerel, and sardine purse seine	3	2010 2011 2012 2013 2014	65	n/a n/a n/a n/a n/a	not observed not observed not observed not observed not observed	n/a n/a n/a n/a n/a	n/a	n/a
CA Dungeness crab pot	2	2010 2011 2012 2013 2014	570	n/a	not observed	n/a	n/a	n/a
CA rock crab pot[3]	3	2010 2011 2012 2013 2014	124	n/a	not observed	n/a	n/a	n/a
CA spiny lobster[3, 5]	3	2010 2011 2012 2013 2014	194	n/a	not observed	n/a	n/a	n/a
CA nearshore finfish live trap/hook and line[3]	3	2010 2011 2012 2013 2014	93	n/a	not observed	n/a	n/a	n/a
Unknown hook and line	n/a	2010 2011 2012 2013 2014	n/a	stranding data	__	0 0 0 1 0	≥1	≥0.2
Unknown net	n/a	2010 2011 2012 2013 2014	n/a	stranding data	__	0 1[4] 0 0 0	≥1	≥0.2
TOTAL							n/a	n/a

Note: n/a indicates that data are not available or are insufficient to estimate mortality/serious injury.
[1] Vessel numbers are from the final List of Fisheries for 2016 (81 FR 20550, April 8, 2016).
[2] Personal communication, Jim Carretta, 2010, 2011, 2013, 2016. Southwest Fisheries Science Center, NOAA, U.S. National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.
[3] This fishery is classified as a Category III fishery (81 FR 20550, April 8, 2016). Category III fisheries are not required to accommodate observers aboard vessels due to the remote likelihood of mortality and serious injury of marine mammals.

[4] This sea otter was also shot, presumably after becoming entangled in the net.
[5] Observer coverage data are currently available only through 2014. Therefore, this table does not include the sea otter mortality reported by CDFW wardens in 2016 and described in the text. When additional observer coverage data become available, the table will be updated to include this mortality and other available information through 2016.

Other Mortality

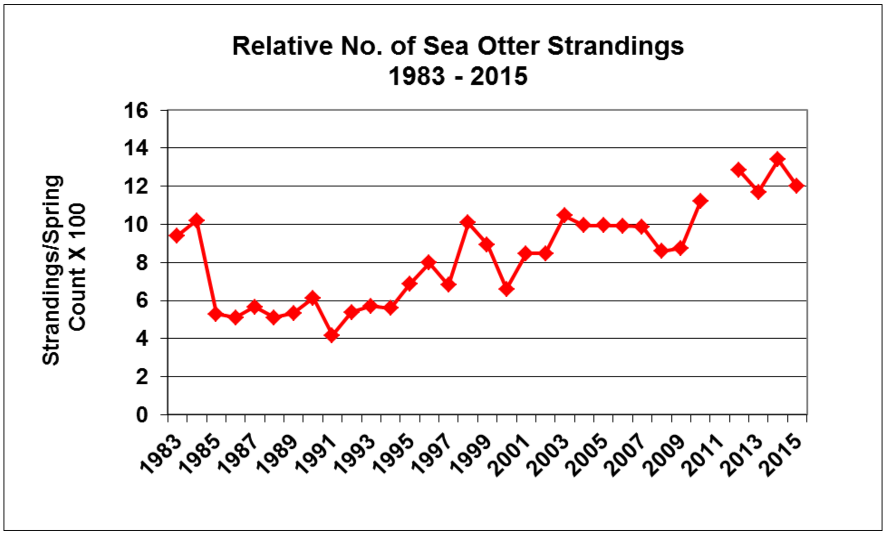

Figure 3. Strandings of southern sea otters relative to the spring count, 1983-2015. The entry for 2011 is missing because the spring survey was not completed that year. Source: U.S. Geological Survey unpublished data.

An effort to document all southern sea otter strandings (live and dead sea otters that wash ashore) has been underway since 1968. Relative mortality (measured by dividing the number of carcasses retrieved in a given year along the coastline by the number of sea otters counted in the spring count for that same year) indicates that mortality was roughly constant at about 5 percent during the period of population growth from 1985-1995 but somewhat higher during periods of apparent population decline (the early 1980s and 1996-1999) (Figure 3). Whereas the population decline during the early 1980s has been attributed to gill net mortality (Estes 1990), the cause of the decline during the late 1990s has not been determined (Estes et al. 2003). Unusually high numbers of stranded southern sea otters were recovered in 2003, prompting declaration of an Unusual Mortality Event. Intoxication by domoic acid produced by blooms of the alga *Pseudonitzschia australis* is believed to have been an important contributor (Jessup et al. 2004), but no one cause has been identified as being responsible.

Relative mortality has exceeded even 2003 levels in recent years, averaging 12.2 percent from 2010-2015 (Figure 3). These increases in relative mortality appear to be due largely to an accelerating increase in shark bite mortality, particularly in the northern and southern portions of the mainland range (north of Seaside and, most markedly, from Estero Bay to Point Conception) (Tinker et al. 2015). Rangewide, the estimated probability that a stranded sea otter will be shark-bitten has increased threefold, from 19 percent in 1990 to 61 percent in 2013; in the southern portion of the range this probability has increased eightfold, from 8 percent in 1990 to 68 percent in 2013 (see Tinker et al. 2015 for associated 95-percent confidence bounds). These shark bites are non-consumptive and probably investigatory. The reasons for the increase in shark bites in areas of the sea otter range not previously subject to high rates of shark-related mortality are not well understood, but they may reflect growing white shark (*Carcharodon carcharias*) numbers or changes in white shark behavior and distribution associated with increasing populations of northern elephant seals (*Mirounga angustirostris*) and California sea lions (*Zalophus californianus*) along the California coastline (Tinker et al. 2015).

Variation in reproductive success and survival rates of sea otters in the central portion of the mainland range (Seaside to Cayucos) appears to be influenced primarily by density-dependent resource limitation (Tinker et al. 2013). Physiological condition and nutritional status in turn influence the susceptibility of sea otters to environmental stressors (including pathogens, pollutants, and intoxicants produced during harmful algal blooms), which may result in death by a variety of proximate causes, including infectious disease, intra-specific aggression, intoxication, and other pathological conditions (Tinker et al. 2013). Lower per-capita food availability also leads to greater reliance on sub-optimal prey, which increases exposure and susceptibility to novel disease-causing pathogens (Johnson et al. 2009, Tinker et al. 2013).

Non-fishery-related anthropogenic mortality of sea otters is a result of indirect and direct causes. Boat strikes typically cause several deaths each year. Shootings are a relatively low but persistent source of anthropogenic mortality. Other rare sources of anthropogenic mortality include debris entanglement and complications associated with research activities. Stranding data indicate that from 2010-2014, 5 were shot[7], 15 were struck by boats, and 1 was entangled in debris (U.S. Geological Survey and CDFG unpublished data). Total observed anthropogenic mortality for 2010-2014, excluding any fisheries-related mortality, is 21, yielding an estimated mortality of ≥21 and a mean annual mortality of ≥4.2. Disease is an important proximate cause of death in sea otters, but due to several complicating factors (including the complexity of the pathways by which sea otters are being exposed to land-borne pathogens, the synergistic relationship between sea otter susceptibility to disease and density-dependent resource limitation, and other factors), the anthropogenic contribution to disease-related mortality in sea otters is not well understood. Therefore, animals that died of disease are not included in the anthropogenic mortalities reported here.

The mean annual mortality/serious injury reported here and in Table 1 are minimum estimates.[8] Documentation of these sources of mortality comes primarily from necropsies of beach-cast carcasses, which constitute a subset (roughly half) of all dead southern sea otters and likely do not represent an unbiased sample with respect to cause of death because carcass deposition and retrieval are dependent on carcass size, location, wind, currents and other factors, including the cause of death itself (Gerber et al. 2004, Tinker et al. 2006a). Within this subset, the cause of death of many recovered carcasses is unknown, either because the carcass is too decomposed for examination or because cause of death cannot be determined (Gerber et al. 2004).[9] Because it is unknown to what extent the levels of human-caused mortality documented in beach-cast carcasses are representative of the relative contributions of known causes or of human-caused mortality as a whole, we are unable to give upper bounds for these estimates.

STATUS OF STOCK

The southern sea otter is designated a fully protected mammal under California State law (California Fish and Game Code §4700) and was listed as a threatened species in 1977 (42 FR 2965) pursuant to the federal Endangered Species Act, as amended (16 U.S.C. 1531 et seq.) (ESA). As a consequence of its threatened status, the southern sea otter is considered to be a “strategic stock” and “depleted” under the MMPA. Under Public Law 99-625, the San Nicolas Island colony was formerly considered to be an experimental population (52 FR 29754; August 11, 1987), but the experimental population designation was removed upon termination of the translocation program and its respective translocation and management zones (77 FR 75266; December 19, 2012). With the termination of the translocation program, the special status

[7] An additional animal, not included in this total, was also shot, apparently after becoming entangled in a net (fishery unknown).

[8] This statement applies to all causes of death mentioned here except research-related mortalities. Research-related mortalities are unlikely to be undetected because of the intensive monitoring that tagged sea otters receive.

[9] In 2012, the cause of death of approximately 35 percent of recovered carcasses was unknown. Personal communication, Brian Hatfield, 2013. Wildlife Biologist, USGS-Western Ecological Research Center, Hwy. 1, P.O. Box 70, San Simeon, CA 93452.

afforded to southern sea otters within the management and translocation zones pursuant to Public Law 99-625 also ended. However, the National Defense Authorization Act for Fiscal Year 2016 includes provisions directing the Secretary of the Navy to establish Southern Sea Otter Military Readiness Areas (Areas) at San Nicolas Island and San Clemente Island (where sea otters do not currently occur). Military readiness activities[10] conducted within these Areas are subject to certain exemptions under the ESA and MMPA. With respect to the ESA, Sections 4 and 9 do not apply to the incidental taking of any southern sea otter in the Areas in the course of conducting a military readiness activity, and any sea otter within the Areas is to be treated for the purposes of section 7 as a member of a species that is proposed to be listed as endangered or threatened under the ESA. With respect to the MMPA, Sections 101 and 102 do not apply with respect to the incidental taking of any sea otter in the Areas in the course of conducting a military readiness activity.

The status of the southern sea otter in relation to its optimum sustainable population (OSP) level has not been formally determined, but population counts are well below the estimated lower bound of the OSP level for southern sea otters, about 8,400 animals (U.S. Fish and Wildlife Service 2003), which is roughly 50 percent of the estimated carrying capacity of California (Laidre et al. 2001). Because of the lack of observer data for several commercial fisheries that may interact with sea otters, it is not possible to make a science-based determination of whether the total mortality and serious injury of sea otters due to interactions with commercial fisheries is insignificant and approaching a zero mortality and serious injury rate.

Habitat Issues

Food limitation and nutritional deficiencies appear to be primary drivers of sea otter mortality, either directly or as a consequence of dietary specialization (Bentall 2005, Tinker et al. 2006b, Tinker et al. 2008a, Johnson et al. 2009, Tinker et al. 2013). Poor body condition increases susceptibility to environmental stressors, such as pathogens, pollutants, and intoxicants produced during harmful algal blooms (Tinker et al. 2013). Important disease-causing pathogens include the protozoal parasite *Toxoplasma gondii*, which is shed in the feces of both wild and domestic cats (Dubey et al. 1970, Miller et al. 2002, Miller et al. 2004, Miller et al. 2008) and *Sarcocystis neurona*, which is shed in the feces of opossums (*Didelphis virginiana* and *D. albiventris*) (Kreuder et al. 2003, Miller et al. 2010). Both of these pathogens can cause severe encephalitis in sea otters. Protozoal encephalitis was identified as the primary cause of death in approximately 23 percent of beach-cast sea otter carcasses examined between 1998 and 2001 (Kreuder et al. 2003). Encephalitis caused by *T. gondii* in particular has been associated with shark attack and cardiac disease (Kreuder et al. 2003). A seroprevalence analysis updated through 2004 revealed that 52 percent of 305 freshly dead, beach-cast sea otters and 38 percent of 257 live sea otters sampled along the California coast were infected with *T. gondii* (Conrad et al. 2005). Infection by acanthocephalan parasites (*Profilicollis* spp.) was reported as the direct or indirect cause of mortality in 13 percent of 162 beach-cast carcasses sampled from 1997-2001

[10] According to the NDAA, "The term 'military readiness activity' has the meaning given that term in section 315(f) of the Bob Stump National Defense Authorization Act for Fiscal Year 2003 (16 U.S.C. 703 note) and includes all training and operations of the armed forces that relate to combat and the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use."

(Mayer et al. 2003) and the primary cause of death in 16.2 percent of 105 beach-cast carcasses sampled from 1998-2001 (Kreuder et al. 2003).

Harmful algal or cyanobacterial blooms, which are exacerbated in some cases by anthropogenic inputs of nitrogen or phosphorus into coastal watersheds and the nearshore marine environment (Mos 2001, Kudela et al. 2008, Vezie et al. 2002), can cause acute, subacute, or chronic effects in exposed sea otters (Kreuder et al. 2003, Miller et al. 2010). Biotoxins released during harmful blooms include domoic acid, which is produced by marine diatoms of the genus *Pseudonitzschia*, and microcystin, which is produced by freshwater cyanobacteria of the genus *Microcystis*. Domoic acid intoxication of sea otters was first reported in 2003 (Kreuder et al. 2003) and has subsequently been associated with cardiac disease (Kreuder et al. 2005). Microcystin has been implicated as either a primary or contributing cause in the deaths of more than 40 sea otters through 2013 (with the earliest known case occurring in 1999 and the greatest number of cases occurring in 2007) (Miller et al. 2010, Tinker et al. 2013).

Sea otters are particularly vulnerable to oil contamination (Kooyman and Costa 1979; Siniff et al. 1982), and oil spill risk from large vessels that transit the California coast remains a primary threat to the southern sea otter. Studies of contaminants have documented accumulations of dichlorodiphenyltrichloro-ethane (DDT), dichlorodiphenyl-dichloroethylene (DDE) (Bacon 1994; Bacon et al. 1999), and polychlorinated biphenyls (PCBs) in stranded sea otters (Nakata et al. 1998), as well as the presence of butyltin residues, which are known to be immunosuppressant (Kannan *et al*. 1998). Kannan et al. (2006, 2007) found a significant association between infectious diseases and elevated concentrations of perfluorinated contaminants and polychlorinated biphenyls (PCBs) in the livers of sea otters, suggesting that chemical contaminants may influence patterns of sea otter mortality.

Climate change may affect southern sea otters by modifying hydrological processes that influence the transport of pathogens and contaminants from land to the nearshore marine environment (Walther et al. 2002). It also has the potential to alter (in unknown ways) the frequency of algal blooms in both freshwater and the marine environment. Increasing ocean temperatures may increase the incidence and spread of disease among marine organisms (Burge et al. 2014), with potentially negative or positive effects on sea otters depending on the particular ecological relationships affected. In addition to increasing ocean temperatures, changes in the carbonate chemistry of the oceans due to increasing atmospheric CO_2 levels (ocean acidification) may pose a serious threat to marine organisms, particularly calcifying organisms (Kroeker et al. 2010, Kurihara et al. 2004, Kurihara et al. 2008, Stumpp et al. 2011, Gazeau et al. 2013), many of which are important prey for sea otters. Because of the apparent synergistic relationship between food limitation and disease, potential climate-driven declines in food availability may in turn result in increased susceptibility to disease.

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