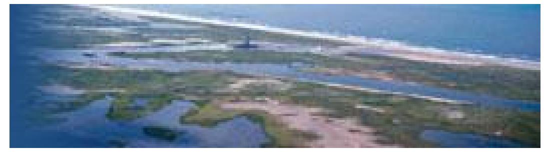
From: Victoria Bogdan Tejeda [mailto:vbogdantejeda@biologicaldiversity.org]
Sent: Tuesday, March 21, 2023 3:27 PM
To: CityClerk <CityClerk@longbeach.gov>
Subject: CBD Sources, 4.2

-EXTERNAL-

Attached:
USGS (2003)
USFS, Southern Sea Otter

Victoria Bogdan Tejeda (*she/her*)
Staff Attorney, Climate Law Institute
Center for Biological Diversity
1212 Broadway, Suite 800
Oakland, CA 94612
Ph: 510.844.7103 ext. 303



Coastal & Marine Geology Program

Search

Coastal & Marine Geology Program > National Assessment of Coastal Change Hazards > Open File Report 03-337

An Overview of Coastal Land Loss: With Emphasis on the Southeastern United States

USGS Open File Report 03-337

by: Robert A. Morton

Role of Human Activities: Hydrocarbon & Groundwater Extraction

Land subsidence can be induced by any one of several different activities that involve large volume extraction of underground resources (water, oil and gas, sulfur, salt). Land loss associated with induced subsidence is actually more common than most people realize, especially where large volumes of fluids are removed from underground formations. This induced subsidence, which is either sub-regional or local in extent, has its greatest impact on flat coastal plains and wetlands near sea level where minor lowering of the land surface results in permanent inundation. For more information about induced subsidence, see Subsidence and Fault Activation Related to Fluid Energy Production, Gulf Coast Basin Project.

Subsidence around the Goose Creek Oil field near Houston, Texas was the first evidence that rapid, large volume extraction of hydrocarbons was capable of causing the ground to sink around the producing wells. The induced subsidence, which was discovered shortly after field development began in 1917, indicated that accelerated withdrawal of oil, gas, and associated water from shallow unconsolidated reservoirs could lower the land elevation, cause minor earthquakes, and activate faults around the periphery of producing fields (Pratt and Johnson, 1926).

One of the most dramatic cases of land subsidence caused by oil and gas production occurred at the Wilmington Field in Long Beach, California. As the oil reservoirs were depleted, sand compaction caused almost 9 m of land subsidence that flooded streets and wharfs and caused structural damage to bridges, railroads, and other harbor facilities (Poland and Davis, 1969). However, the subsidence did not cause widespread land loss because the subsidence bowl only covered about 35 km^2.

Induced subsidence in the Houston-Galveston area, which covers more than 12,000 km^2, has lowered the land surface as much as 3 m. This subsidence bowl is largely a result of long-term industrial ground-water withdrawal from shallow aquifers (Gabrysch, 1984) and deeper oil and gas extraction (White et al., 1985). Near the center of the subsidence bowl, more than 200 homes in a middle class neighborhood of Baytown, Texas were destroyed after groundwater extracted for the petrochemical industry caused the area to subside, flooding the entire subdivision (Fig. 8). Subsidence induced by fluid withdrawal is usually an irreversible process because it usually involves sediment compaction and dewatering of interbedded clays.

In the Gulf Coast region, subsidence induced around large, mature oil and gas fields is also locally concentrated along linear trends that coincide with faults (White and Morton, 1997). Extraction of hydrocarbons and formation water causes a decline in pore pressure within the reservoirs and alters the state of stress near the faults. Because of the slope of the fault plane and its intersection with the land surface, fault-plane subsidence may be surficially expressed more than 2 km away from the producing wells.

Relatively little is known about the severity of land loss caused by induced subsidence and the relationship of land loss to production history, fluid composition, local geology, and near-surface conditions prior to hydrocarbon or groundwater production. Except along the northern Gulf of Mexico and in southern California, land losses associated with subsurface fluid withdrawal are minor. But continued withdrawal and concomitant decline in fluid pressure from hydrocarbon extraction and ground-water pumping could eventually cause even greater lowering of land elevations. This would augment the effects of relative sea-level rise and lead to additional land losses near the coast.

continue to Climate Alteration

Coastal & Marine Geology Program > National Assessment of Coastal Change Hazards > Open File Report 03-337

[an error occurred while processing this directive]

Southern Sea Otter
(Enhydra lutris nereis)

5-Year Review:
Summary and Evaluation

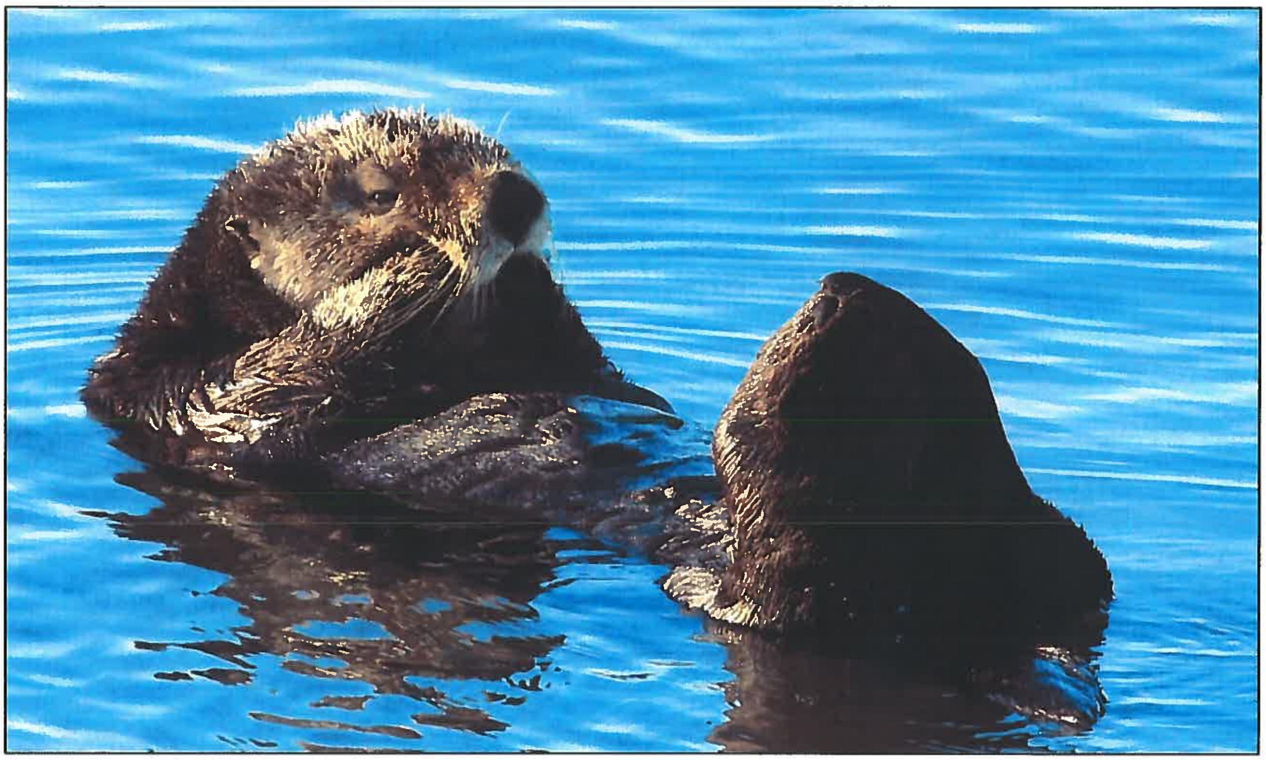


Photo credit: Lilian Carswell/Service

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

September 15, 2015

5-YEAR REVIEW

Southern Sea Otter (*Enhydra lutris nereis*)

I. GENERAL INFORMATION

Purpose of 5-Year Reviews

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview

The sea otter (*Enhydra lutris*) is the largest member of the family Mustelidae and the smallest species of marine mammal in North America. An important predator in the nearshore marine ecosystems of the North Pacific Ocean, the sea otter is generally considered to be a "keystone" species in these communities. Sea otters exert a strong limiting influence on their prey populations, including a wide variety of nearshore marine invertebrates, and have large-scale community effects disproportionate to their abundance (Estes and Palmisano 1974, Palmisano and Estes 1977, Estes et al. 1978, Duggins 1980, Palmisano 1983, Estes and Harrold 1988).

Sea otters once ranged along the North Pacific rim from the northern Japanese islands to mid-Baja California, Mexico. Following near-extinction as a result of the fur trade during the 18th and 19th centuries, sea otters were legally protected in 1911 by the International Fur Seal Treaty (Service 2003). There are three recognized subspecies of sea otters: the Russian or Asian sea otter (*E. l. lutris*); the Alaskan or northern sea otter (*E. l. kenyoni*); and the California or southern sea otter (*E. l. nereis*). The southern sea otter has the most southerly range of the three recognized subspecies and currently occurs in only two areas of California, the mainland coastline from San Mateo County to Santa Barbara County and San Nicolas Island, Ventura County. Historically, 16,000-20,000 sea otters are believed to have resided in the area that is now California (California Department of Fish and Game (CDFG) 1976).[1] The population index for

[1] As of January 2013, the California Department of Fish and Game was renamed the California Department of Fish and Wildlife. We refer to that agency by its previous name when the document or action we are referring to was produced or undertaken prior to January 2013.

2014 is 2,944 animals (U.S. Geological Survey-Western Ecological Research Center (USGS-WERC) 2014).

Methodology Used to Complete This Review

This review was prepared by the Ventura Fish and Wildlife Office (VFWO), following the Region 8 guidance issued in March 2008. We used information from the recovery plan for the southern sea otter (Service 2003), survey information from USGS, peer-reviewed scientific publications, personal communications with experts, and information submitted in response to our Federal Notice initiating this 5-year review to update the species' status and threats (74 FR 12878). This 5-year review contains updated information on the species' biology and threats and an assessment of that information compared to what was known at the time of listing or since the last 5-year review. We focus on current threats to the species that are attributable to the Act's five listing factors. The review synthesizes this information to evaluate the listing status of the species and to provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

Contact Information

Lead Regional Office: Michael Long, Division Chief, Endangered Species, Region 8, Pacific Southwest; (916) 414-6464.

Lead Field Office: Lilian Carswell, Southern Sea Otter Recovery and Marine Conservation Coordinator, and Catherine Darst, Assistant Field Supervisor, Listing and Recovery, Ventura Fish and Wildlife Office; (805) 644-1766.

Federal Register (FR) Notice Citation Announcing Initiation of This Review

A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register on March 25, 2009 (74 FR 12878). We received three submissions of information during the 60-day period.

Listing History

Original Listing
FR Notice: 42 FR 2965, January 14, 1977
Entity Listed: the subspecies *Enhydra lutris nereis*
Classification: Threatened

State Listing
Enhydra lutris nereis was listed by the State of California as "fully protected" in 1913.

Associated Rulemakings

On August 11, 1987, we issued a final rule to establish and manage an experimental population of southern sea otters at San Nicolas Island, California, under the authorities and guidelines of Public Law 99-625, 100 Stat. 3500 (1986) (52 FR 29754). In 2012, we determined formally that the translocation program, which included the requirement to maintain a management or "no-otter" zone in the Southern California Bight had failed; the experimental population designation was removed upon termination of the translocation program and its respective translocation and management zones by a rulemaking published in the Federal Register on December 19, 2012 (77 FR 75266).

Review History

On September 27, 1982, we requested new and relevant information on the status of the southern sea otter (47 FR 42387). The 5-year review notice generated a large volume of comments, and the comment period was extended to May l, 1983. Among the comments received was a formal petition from the Friends of the Sea Otter to reclassify the southern sea otter as endangered. After the close of the comment period, Save Our Shellfish, the Greater Los Angeles Council of Divers, and the Pacific Legal Foundation jointly submitted a petition to delist the southern sea otter (the petition was dated February 3, 1984). The information provided with these petitions was considered in the Service's 5-year review, which was completed in 1984 (Service 1984). The review recognized the deteriorated state of the population (no growth and possibly a decline over the previous 10 years) and additional threats, including encroachment of outer-continental-shelf oil and gas development and incidental drowning in gill and trammel set nets. It also recognized the importance of moving forward with major recovery tasks, including establishment of at least one additional population. However, it did not recommend a change in listing status. Subsequent 5-year reviews were noticed on July 7, 1987 (52 FR 25523), and November 6, 1991 (56 FR 56882). In these reviews, all then-listed species were evaluated simultaneously, with no in-depth assessment of the factors pertaining to the status of each species or its progress towards recovery. Neither of these reviews resulted in a recommendation to change the status of the species, and no summaries were published. The current review constitutes the first species-specific 5-year review of the southern sea otter since 1984.

Species' Recovery Priority Number at Start of 5-Year Review

The recovery priority number for *Enhydra lutris nereis* is 9C, based on a 1C-18 ranking system where 1C is the highest-ranked recovery priority and 18 is the lowest (48 FR 43098; September 21, 1983). The number "9" indicates that the taxon is a subspecies that faces a moderate level of threat and has a high potential for recovery. The letter "C" indicates conflict with economic activity.

Recovery Plan

Name of Plan: Final Revised Recovery Plan for the Southern Sea Otter (*Enhydra lutris nereis*)
Date Approved: February 24, 2003

Dates of Previous Revisions: The first recovery plan for the southern sea otter was completed in 1982. A draft revised recovery plan was made available for public comment in 1991 but never finalized because of the controversy associated with its recommendation that, in the absence of information needed to quantify particular risks, the threshold for delisting should be equivalent to the lower limit of the optimum sustainable population level under the Marine Mammal Protection Act of 1972, as amended (MMPA). A second revised draft, based on population viability analysis and modeled oil spill risk scenarios, was released in 1996. Because of the nature and magnitude of public comments on the 1996 draft, a third draft plan was released to the public in 2000. The 2000 draft plan was made final in 2003 (Service 2003).

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy

The Act defines "species" as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. The 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Act (61 FR 4722; February 7, 1996) clarifies the interpretation of the phrase "distinct population segment" for the purposes of listing, delisting, and reclassifying species under the Act.

The 1977 listing of the southern sea otter was at the subspecies level (42 FR 2965; January 14, 1977). Published analyses subsequent to the 1977 listing support this taxonomic status (Wilson et al. 1991, Sanchez 1992, Cronin et al. 1996, Larson et al. 2002a). No portion of the southern sea otter population has been designated a DPS, nor have we undertaken a formal assessment of whether any portion of the southern sea otter population should be designated a DPS.

Sea otter populations exhibit a high degree of spatial structure due to the limited mobility of reproductive females. Very limited mixing of adult and sub-adult females between habitat areas only 50 kilometers (km) (31 miles (mi)) apart occurs, and many of the factors driving population trends, such as per-capita prey availability and point-source pollution, can vary at small spatial scales (Tinker et al. 2013b). The translocated San Nicolas Island population is geographically distinct from the mainland population, although the geographic separation is not expected to preclude occasional exchanges of animals (most likely adult males or sub-adult animals of either sex) between the two populations. Population growth rates and body condition differ considerably between San Nicolas Island and the mainland range due to ecological factors such as higher per-capita prey abundance at the island (Tinker et al. 2008a) and, presumably, the absence or insignificance of shark attacks as a mortality factor there. Despite these ecological differences, there is currently no expectation (or evidence) of genetic or morphological discontinuity between the two populations because the translocated animals that founded the island population were drawn from the mainland population. We will consider these and other data in any potential future consideration of DPS status for a portion of the southern sea otter population.

Information on the Species and its Status

Species' Biology and Life History

Southern sea otters reach adult length at approximately 4-6 years of age, with females averaging 118 centimeters (cm) (46.5 inches (in)) and males averaging 127 cm (50 in). Females reach adult weight at around this same age, averaging 21 kilograms (kg) (46 pounds (lbs)), whereas males continue to gain muscle mass until approximately 8 years of age, when they weigh, on average, 29 kg (64 lbs) (Tinker et al. 2013b). Typical life spans are 12-18 years for females and 10-15 years for males (Tinker pers. comm. 2014). However, one female sea otter translocated to San Nicolas Island in 1987 as a juvenile was documented (in 2006) to have reached at least 19 years of age in the wild (USGS unpublished data).

Unlike most other marine mammals, sea otters have little subcutaneous fat. They depend on their clean, dense, water-resistant fur for insulation against the cold. Contamination of the fur by oily substances can destroy its insulating properties and lead to hypothermia and death (Costa and Kooyman 1982). Sea otters also maintain a high level of internal heat production to compensate for their lack of blubber. Consequently, their energetic requirements are high, and they consume an amount of food equivalent to 20–25 percent of their body mass per day (Costa and Kooyman 1982, Kenyon 1969, Morrison et al. 1974). Depending on factors such as habitat, sex, reproductive status, and per-capita prey availability, obtaining this quantity of food requires that sea otters spend, on average, 20–50 percent of the day foraging (Estes et al. 1986, Ralls and Siniff 1990, Staedler 2011, Tinker et al. 2008a, Yeates et al. 2007, Tinker et al. 2013b).

Mating and pupping occur throughout the year. The gestation period lasts approximately 6 months, consisting of a phase of 2-3 months during which the embryo remains unattached to the uterine wall (delayed implantation) and an implanted phase of 4 months (Jameson and Johnson 1993). A peak period of pupping occurs from October to January, with a secondary peak in March and April (Tinker pers. comm. 2014). Females typically give birth to a single pup, with care provided solely by the female for the approximately 6 months until weaning (Riedman and Estes 1990, Jameson and Johnson 1993). Pup rearing and provisioning impose high energetic costs on females, requiring them to increase foraging effort during this period and leaving them highly susceptible to stressors they may encounter when they come into estrous after weaning, such as parasite infections or aggression by males (Tinker et al. 2013b, Thometz et al. 2014).

Sea otters rest alone or in groups called "rafts," which may range from 2 to 20 or more animals, with larger groups more common among males. They tend to prefer areas with surface kelp canopies but will also rest in open water (Riedman and Estes 1990). Sea otters sometimes haul out, although opportunities for hauling out vary spatially and temporally. Hauling out likely reduces thermal flux and thus overall energy requirements; as such, it may be especially important in times of nutritional stress, such as for end-lactation stage females (females that have recently weaned a pup and are entering estrous), which in areas of low per-capita prey abundance may be in poor body condition with minimal energy reserves (Tinker et al. 2013b).

Spatial Distribution

The fur trade of the 18th and 19th centuries reduced the range of sea otters from a broad arc along the North Pacific Rim to a number of scattered remnant colonies. The historical northern range limit of the southern sea otter appears to have been at least as far north as Newport, Oregon (Valentine et al. 2008) but probably south of Neah Bay, Washington (Larson et al. 2002b). The historical southern range limit was Punta Abreojos, Baja California. All present-day southern sea otters descended from a small group that survived the fur trade near Bixby Creek in Monterey County, California, which numbered approximately 50 animals in 1914 (Bryant 1915).

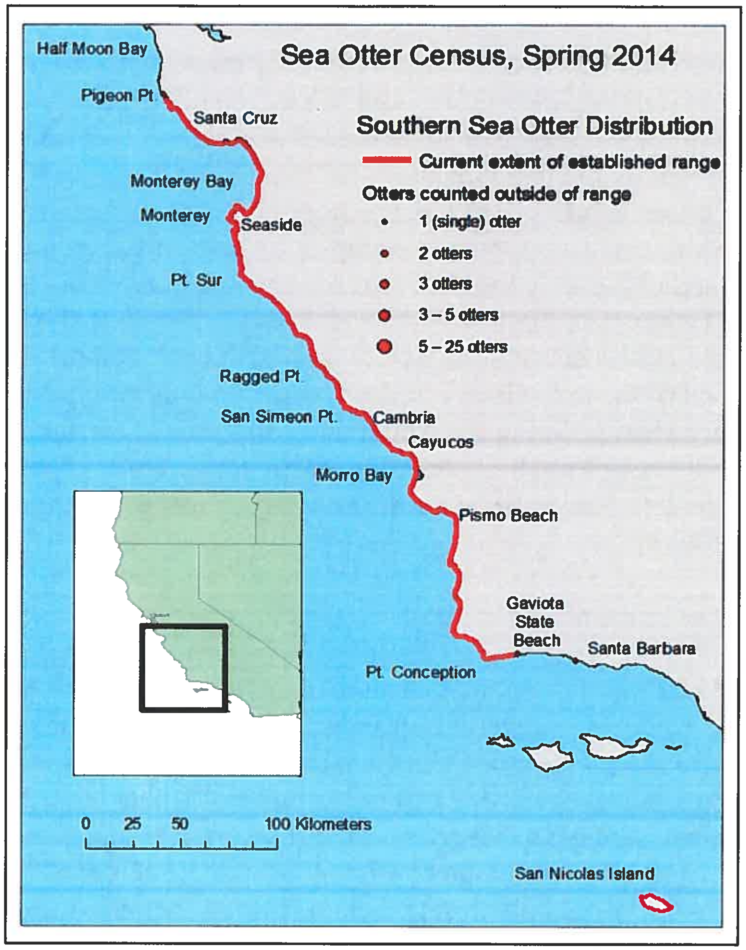


Figure 1. Current range of the southern sea otter (USGS-WERC 2014)

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. Data on range extent by year through the mid-1980s are summarized by Lubina and Levin (1988). At the time of listing in 1977, the southern sea otter range spanned 293 linear km (182 linear mi) of coastline from Soquel Point near the city of Santa Cruz, Santa Cruz County, to Pt. San Luis, near Avila Beach, San Luis Obispo County. By 2009, the mainland sea otter range extended about 523 km (325 mi), from the Tunitas Creek mouth near Half Moon Bay, San Mateo County, to Coal Oil Point, Santa Barbara County.[2] Since that time, the range ends have retracted, to approximately 2.5 km (1.5 mi) southeast of Pigeon Pt. in the north and 5 km (3 mi) west of Gaviota State Beach in the south (USGS-WERC 2014). A small, geographically distinct population resulting from translocation efforts from 1988-1990 occurs at San Nicolas Island, Ventura County (Figure 1). Southern sea otters are occasionally found well beyond the limits of the established range and have been documented as far south as Baja California, Mexico (Schramm et al. 2014).

[2] The range limits have been defined since 2008 as "the points farthest from the range center (to the north and south) at which 5 or more otters are counted within a 10-km contiguous stretch of coastline (as measured along the 10-m bathymetric contour) during the two most recent spring censuses, or at which these same criteria were met in the previous year" (USGS-WERC 2014). This definition has been adopted to standardize annual reporting of range boundaries in light of the variability of the location of the terminal, mostly male, groups that usually mark the ends of the range.

Sea otter abundance varies across the range, with the highest densities occurring in the center portion (Seaside to Cayucos), where sea otters have been present for the longest. Rocky, kelp-dominated areas that are occupied primarily by females, dependent pups, and territorial males generally maintain the most stable sea otter densities from year to year, whereas sandy and soft-bottom habitats (particularly those in Monterey Bay, Estero Bay, and from Pismo Beach to Pt. Sal), which are typically occupied by non-territorial males and sub-adult animals of both sexes (and only rarely by adult females and pups), are more variable in abundance from year to year (Tinker et al. 2008b). This variation is driven in part by the long-distance movements and seasonal redistribution of males (Tinker et al. 2008b). The variability of counts at the southern end of the range is also related to seasonal movements: many males migrate to the range peripheries during the winter and early spring, apparently to take advantage of more abundant prey resources, but then return to the range center during the period when most breeding occurs (June to November) in search of estrous females (Jameson 1989, Ralls et al. 1996, Tinker et al. 2008b).

The home ranges of southern sea otters appear to reflect coastal bathymetry and the distribution of resources as well as reproductive strategy. The maximum home range area in Monterey Bay, 45.22 km^2 (17.46 mi^2), is more than twice that in Big Sur, 20.11 km^2 (7.77 mi^2), presumably due to the greater travel distances and ultimately prohibitive energy expenditures required to access resources distributed along a narrow coastal shelf, like that off Big Sur, rather than along a wide continental shelf, like that off Monterey (Tinker et al. 2013b). Males exhibit two distinct home range strategies that reflect their reproductive status: territorial males maintain strong site fidelity to a small home range consisting of a single center of use, whereas males that are non-territorial (or territorial only during certain parts of the year) move between multiple range centers over a larger total area and over a longer span of coastline (Tinker et al. 2013b). Female home range characteristics fall between those of the two groups of males (Tinker et al. 2013b). Compared to males, most female southern sea otters are more sedentary, with adult females rarely dispersing more than 20 km (12 mi) within a 1-year period (Tinker et al. 2013b), although occasionally females travel longer distances of 40-50 km (25-31 mi) (Tinker et al. 2006a). Juvenile males move further from natal groups than do juvenile females. Aggressive behavior exhibited towards the juvenile males by breeding males may be partially responsible for their more extensive travels (Ralls et al. 1996). Jameson (1998) noted that territorial males exclude juvenile and subordinate males from their territories. However, females move freely across these territories.

Abundance

The estimated historic abundance of sea otters in California is between 16,000 and 20,000 animals (CDFG 1976). According to information submitted by CDFG prior to the subspecies' listing, the population had grown from its remnant population size of approximately 50 in 1914 (Bryant 1915) to approximately 1,760 animals in 1975 (42 FR 2965).

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 shore-based censuses of approximately 60 percent of the range, with the remainder surveyed from the air. These surveys are conducted each spring.

As recommended in the Final Revised Recovery Plan for the Southern Sea Otter (Service 2003), 3-year running averages are used to characterize population trends to dampen the effects of anomalous counts in any given year. Because the population at San Nicolas Island is no longer considered an experimental population (77 FR 75266, December 19, 2012), beginning in 2013 the San Nicolas Island counts have been added to those for the mainland range in order to arrive at a California-wide index of abundance. The 3-year running average for 2014 is 2,944, which represents the combined 3-year running averages for the mainland population and San Nicolas Island, 2,881 and 68, respectively (USGS-WERC 2014).

Whereas the trend in abundance for the mainland population over the past 5 years remains essentially flat, the San Nicolas Island population has begun to grow rapidly, averaging approximately 16 percent annually over the past 5 years (Figure 2) (USGS-WERC 2014).

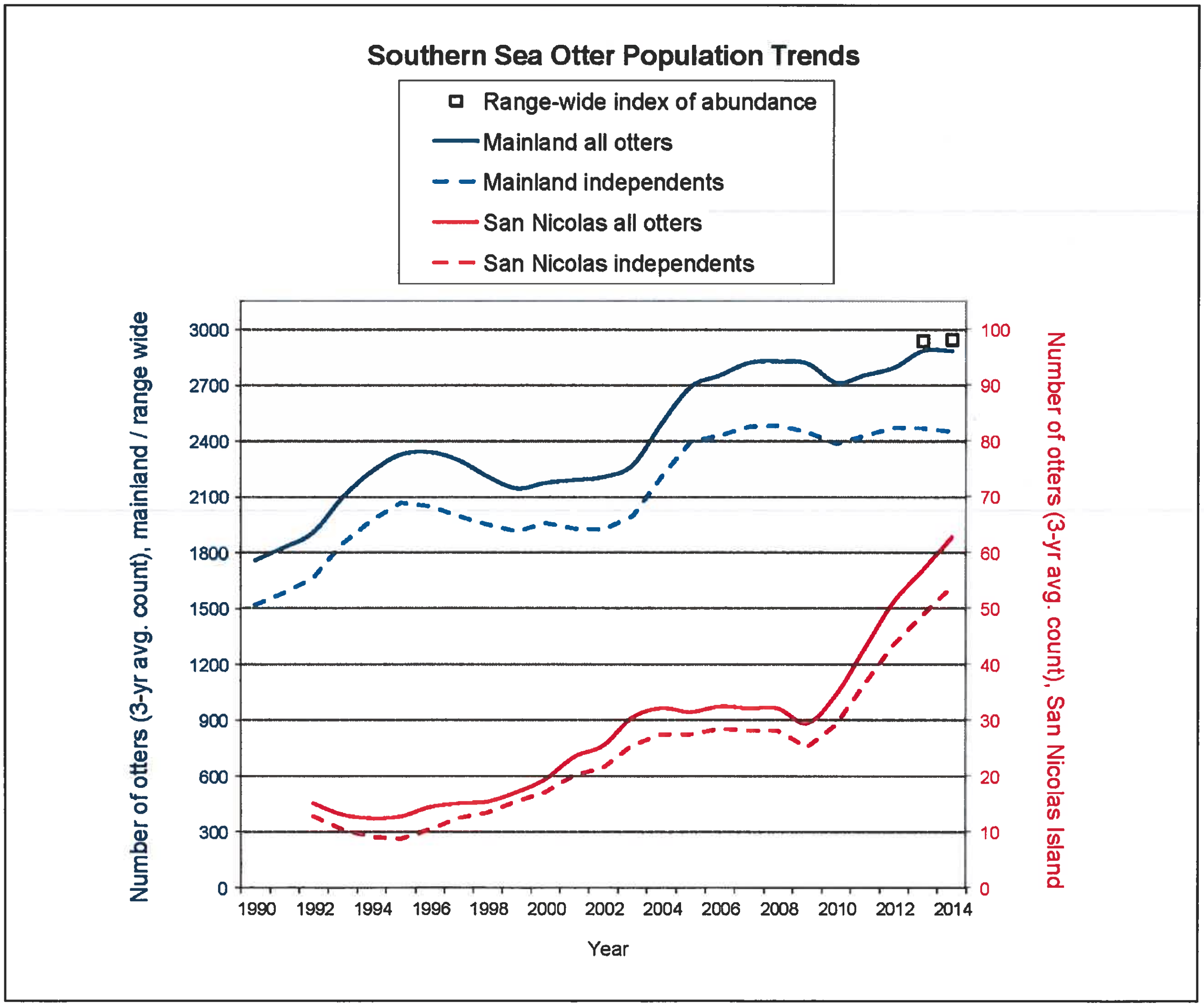


Figure 2. Trends in abundance of sea otters in California, based on 3-year running averages of raw counts. Data are shown for all sea otters (solid line) and independents (non-pups) only (broken line) for: the mainland range (left axis); San Nicolas Island (right axis); and the entire range after 2012 (left axis), when counts were combined to create an official index of abundance (USGS-WERC 2014).

Estes et al. (2003) reported that elevated mortality (rather than reduced fecundity) appeared to be the main reason for both sluggish growth and periods of decline in southern sea otters. The 2003 recovery plan emphasized the slow rate of population growth of the southern sea otter population relative to recovering northern sea otter (*E.l. kenyoni*) populations and the need to determine the causes of elevated mortality. Although rates of pupping were consistent across populations, the observed maximum population growth rates (calculated for each population as a whole) were very different (Service 2003). The maximum growth rate for the southern sea otter population along the mainland coastline has never been more than 6 percent per year since the early 1980s, when reliable trend data first became available, although localized sub-populations have been observed to grow at much higher rates immediately after re-colonization (Lafferty and Tinker 2014). 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).

However, recent data and analyses indicate that the emphasis on differential rates of population growth may be misplaced. First, a variety of evidence in recent years supports the conclusion that sea otters throughout much of the central portion of the range (between Seaside and Cayucos) are at or very near carrying capacity of the local environment, which explains the lack of growth in these areas (*i.e.,* additional population growth in this portion of the range is limited by available food resources) (Tinker et al. 2006b, Tinker et al. 2008a, Tinker et al. 2013b, Thometz et al. 2014, Lafferty and Tinker 2014). 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, at least when status with respect to carrying capacity is controlled 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 California 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 limited mobility of reproductive females), will 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 (Tinker pers. comm. 2013). The same demographic processes (r_{max}, dispersal, rate of range expansion and local equilibrium abundance) that explain the observed rate of recovery in Southeast Alaska are also consistent with the observed rate of recovery in California over the past 75 years (Tinker pers. comm. 2014).

Monitoring of stranding rates and causes of death allows for the detection of new or unexpected sources of mortality that may cause deviations from expected population growth. An effort to document all southern sea otter strandings (live and dead sea otters that wash ashore) has been underway since 1968. While nearly all stranded sea otters are found dead, a small proportion is retrieved alive and is included in the stranding database. Relative mortality (measured by dividing the number of carcasses retrieved in a given year by the number of sea otters counted in the mainland spring count for that same year) indicates that mortality was roughly constant at about 5 percent during the period when the population was growing (from about 1985-1995) but somewhat higher during periods of apparent decline (the early 1980s and from 1996-1999) (Figure 3). Whereas the 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). An unusually high number of stranded southern sea otters was recovered in 2003, prompting declaration of an Unusual Mortality Event under the MMPA for the period from May 23 to October 1, 2003. Intoxication by domoic acid produced by blooms of the alga *Pseudonitzschia australis* appears to have been an important contributor (Jessup et al. 2004), but no one cause was identified as being responsible. Relative mortality has exceeded even 2003 levels in recent years. 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 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 the associated 95-percent confidence bounds). White shark bites now account for more than 50 percent of recovered carcasses. These shark bites are non-consumptive and probably serve an investigatory function. 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 and/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).

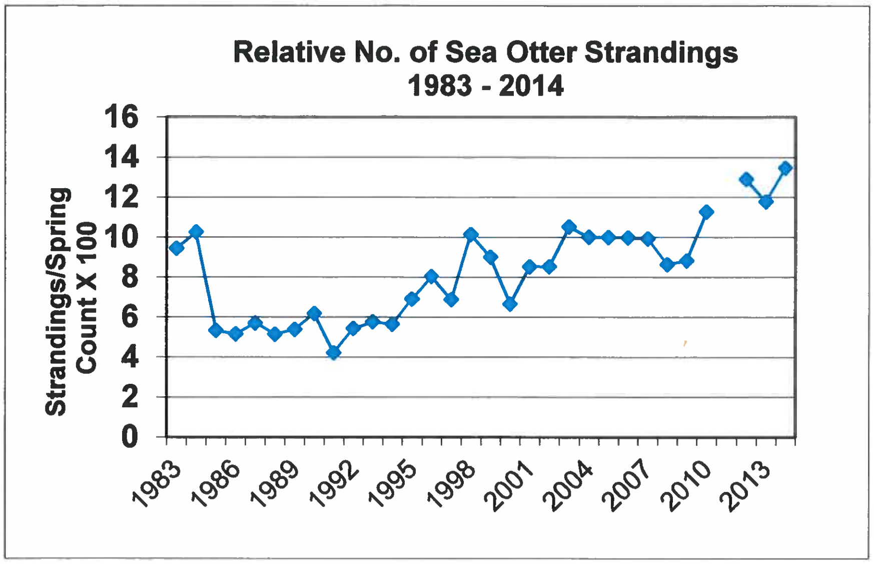


Figure 3. Strandings of southern sea otters relative to the spring count, 1983-2014. The entry for 2011 is missing because the spring survey was not completed that year. Source: USGS unpublished data.

Habitat or Ecosystem

Sea otter habitat is typically defined by the 40 m (131 ft) depth contour (Riedman and Estes 1990, Laidre et al. 2001). The total nearshore area in California (to the 40-m depth contour) is 7,569 km^2 (2,922 mi^2), of which 27 percent is rocky habitat, 51 percent is sandy habitat, and 22 percent is mixed habitat (Laidre et al. 2001). Depending on local bathymetry, most sea otters in California reside within 2 km (1.2 mi) of shore. Southern sea otters forage in both rocky and soft-sediment communities in water depths generally 25 m (82 ft) or less, although some animals utilize deeper waters. Sea otters occasionally make dives of up to 100 m (328 ft), but the vast majority of feeding dives (about 95 percent) occur in waters less than 40 m (131 ft) in depth (Tinker et al. 2006a). Dive depth and dive pattern vary by sex (males tend to make dives greater than 25 m (82 ft) more frequently than females), geographic location, and diet specialization (Tinker et al. 2006a, Tinker *et al.* 2007), as well as age and reproductive status (Tinker et al. 2013b).

The density of southern sea otters within most of the population's range is most likely related to substrate type. Rocky habitats that are topographically heterogeneous and support kelp forests are likely to support the greatest diversity and abundance of sea otter food resources, which include abalone, rock crabs, sea urchins, kelp crabs, clams, turban snails, mussels, octopus, barnacles, scallops, sea stars, and chitons. Rocky bottom habitats support an average equilibrium density of 4.65-5.62 individuals per km^2 (12.05-14.56 individuals per mi^2), whereas areas with sandy bottoms and areas of mixed habitat support average equilibrium densities of 0.84-1.32 and 0.44-1.16 individuals per km^2 (and 2.18-3.42 and 1.14-3.01 individuals per mi^2), respectively (Laidre et al. 2001). Based on these densities and the area consisting of these benthic habitat types, Laidre et al. (2001) estimated the carrying capacity of California as approximately 16,000 animals. The high densities of sea otters observed in Elkhorn Slough over recent years (USGS-WERC 2014) suggest that estuaries may serve as particularly valuable habitat.

Sea otters' mobility, forelimb dexterity, and ability to crush large invertebrates, either with their teeth or with rocks, enable them to prey on most invertebrates. The best refuges for invertebrates from predation by sea otters appear to be deep holes and crevices in rocky areas or deep water (*e.g.,* Lowry and Pearse 1973, Hines and Pearse 1982). Shallow water may also provide refuge for invertebrates; southern sea otters failed to find an "unusually dense concentration of Pismo clams (that occupied a very narrow band of habitat in the high intertidal (zone)) ... for several years" (CDFG 1999). The energetic inefficiency of consuming small prey items may protect invertebrates of small size, although specialists preying on small items appear to be able to compensate for low energetic return with increased efficiency (Tinker et al. 2006a, Tinker et al. 2007). Because of their ability to eat large quantities of marine invertebrates, sea otters play a significant role in nearshore marine ecosystems, enhancing not only kelp forests (Estes and Palmisano 1974, Palmisano and Estes 1977, Estes et al. 1978, Duggins 1980, Palmisano 1983, Estes and Harrold 1988) but also seagrass beds (Hughes et al. 2013).

Changes in Taxonomic Classification or Nomenclature

All sea otters of the subspecies *E. l. nereis* are descended 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. 2002a). No changes in the taxonomic classification of the southern sea otter have been proposed in the published literature since the time of listing.

Genetics

Genetic variation in the southern sea otter is among the lowest observed for any mammal (Aguilar et al. 2008) and is generally most similar to that seen in other species that have undergone known bottlenecks or persistent population declines, such as the northern elephant seal (*Mirounga anguistirostris*) and Mediterranean monk seal (*Monachus monachus*) (Larson et al. 2002a, Aguilar et al. 2008). The loss of genetic variation in sea otter populations is consistent with the bottleneck caused by the documented fur trade (Larson et al. 2002b, Larson et al. 2012) but may have begun earlier (up to 550 years ago), possibly as a result of intensive hunting by native people (Aguilar et al. 2008).

Species-Specific Research and/or Grant-Supported Activities

Extensive research has been undertaken by a range of federal, state, non-governmental, and academic entities since the listing of the southern sea otter. Because this body of work is vast, we do not provide a full account of it here. However, much of the important literature is referenced throughout this document. In what follows, we provide a summary of recent Service-supported federal, state, and other research and activities directed towards southern sea otter recovery.

Federal: Through the Science Support Partnership program, in which USGS funds are directed to priority Service-research needs, the Service and USGS entered into a multi-year collaborative effort from 2001-2004 to investigate the mortality of southern sea otters. Funding was dedicated in the amount of $315,000 for this research. USGS's primary report on sea otter mortality was published in Marine Mammal Science (Estes et al. 2003). Another $23,500 was awarded in 2005 to study movement and foraging patterns of sea otters at San Nicolas Island. This study (Tinker et al. 2008a) contributed to our understanding of food limitation in the mainland range. For the past several years, the Service has allocated funding to support recovery-related research undertaken by USGS.

FY 2008 - $100K: Partial support for "Investigating the Consequences of Coastal Contamination and Anthropogenic Stressors for Sea Otter Recovery." The purpose of this 3-year study was to determine the impact of contaminants and pathogens on sea otters in food-limited areas.

FY 2009 - $65K: Partial support for "Investigating the Consequences of Coastal Contamination and Anthropogenic Stressors for Sea Otter Recovery"

FY 2010 - $30K: Partial support for "Investigating the Consequences of Coastal Contamination and Anthropogenic Stressors for Sea Otter Recovery"

FY 2011 - $42K: Partial support for "Territoriality, reproductive success, and dispersal in southern sea otters." The purpose of this research was to characterize patterns of male territoriality, to measure the degree of polygamy, to examine the factors affecting male reproductive success in southern sea otters, and to describe the patterns and predictors of long distance dispersal, all of which are relevant to determining equilibrium abundance of a given habitat and the rate of re-colonization of new habitat.

FY 2012 - $42K: Partial support for monitoring of sea otter movements and habitat use at the southern end of the range. This research was part of a larger study funded by the Bureau of Ocean Energy and Management (BOEM).

FY 2013 - $31.5K: Partial support for “Factors limiting sea otter recovery and range expansion into Santa Barbara Channel.” This research was part of a larger study funded by BOEM.

FY 2014 - $50K: Partial support for “Patterns and consequences of shark bite mortality in southern sea otters” ($30K) and “Southern sea otter recovery and ecosystem health in Elkhorn Slough” ($20K)

FY 2015 - $30.5K: Partial support for “Southern sea otter recovery and ecosystem health in Elkhorn Slough”

State: The Service has also awarded funds under section 6 of the Act and recovery funds for research and assistance related to sea otter recovery conducted by CDFW.

FY 2001 - $40K (Oil Spill Prevention and Response): Section 6 grant for personnel and programs to support recovery of the southern sea otter, including monitoring existing and translocated populations

FY 2002 - $46.2K: Section 6 grant to refine and report, in peer-reviewed literature, the aerial survey methodologies being developed and the influence of differing viewing conditions; to continue to assist with twice-yearly otter population counts; and to continue to retrieve, and conduct postmortem examination of otter carcasses to determine cause of death

FY 2006 - $56.5K: Section 6 grant for work in 2007 and 2008 to assist the Service with recovery of the southern sea otter. CDFW stated that they would participate in implementation of the Southern Sea Otter Recovery Plan, primarily by continuing to determine the cause for the high mortality rate of prime-age adults and the extent of the contribution of anthropogenic activities to this rate.

FY 2010 - $20K: CDFW necropsy services in support of the USGS-led study, “Investigating the Consequences of Coastal Contamination and Anthropogenic Stressors for Sea Otter Recovery”

FY 2011 - $30K: CDFW aerial surveys as part of southern sea otter rangewide counts

FY 2012 - $16.5K: Histopathology contract with University of Illinois to address CDFW necropsy case backlog

FY 2015 - $4.5K: Histopathology contract with University of Illinois to address CDFW necropsy case backlog

Other: The Service has awarded recovery funds to support other efforts related to sea otter research and recovery.

FY 2010 - $5K: Partial support for sea otter tagging technology workshop (Monterey Bay Aquarium)

FY 2011 - $40K: Labor and hardware required for research/development of 5 flipper tags for sea otters with electronics capable of collecting solar energy and data to determine an animal's position (Desert Star Systems). This contract was completed in February 2013.

FY 2015 - $50K: Support for *Be Sea Otter Savvy*, an education and outreach program to reduce sea otter disturbance from wildlife viewing activities and other forms of marine recreation

Five-Factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act. For the purposes of this analysis, we consider the current range and areas the species may expand into over the next several years.

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

In the listing rule, we identified the curtailment of range as an important factor in the designation of southern sea otters as threatened, citing the fact that the then-current range encompassed only about 10 percent of the southern sea otter's historic range (42 FR 2965; January 14, 1977). We also noted that the "remaining habitat and population [were] potentially jeopardized by oil spills, and possibly by pollution and competition" with human beings (42 FR 2965). In order to maintain consistency with the listing rule, in which we addressed oil spills under Factor E, we discuss non-oil-spill pollution and the curtailment of range here and oil spills and competition with human beings under Factor E.

<u>Non-Oil-Spill Pollution</u>

Non-oil-spill pollution in this context refers to chemical and biological contaminants. The recovery plan includes a number of sub-tasks that recommend evaluation of the effects of pollution under Task 4.3, "Determine concentrations and possible effects of disease, stress, toxic trace elements, and organochlorines on sea otters" (Service 2003). Significant progress has been made on most of these sub-tasks. Numerous studies have elucidated the effects of a suite of stressors on southern sea otter health and demographic trends.

Due to its proximity to coastlines densely occupied by humans, sea otter habitat is potentially subject to degradation resulting from anthropogenic activities and inputs, including contaminants and terrestrial disease-causing pathogens for which the sea otter is not a natural host (see Factor C for a discussion of pathogens). 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 an 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 dead stranded sea otters. While these studies suggest that chemical contaminants may influence susceptibility to disease, confounding factors (such as the mobilization of fat stores shortly before death) prevent any clear conclusions regarding causality. Jessup et al. (2010) found similar levels of persistent organic pollutants in serum from healthy free-ranging sea otters.

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. 2010b). Biotoxins released during harmful blooms include domoic acid, which is produced by marine diatoms of the genus *Pseudo-nitzschia*, 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. 2010a, Miller et al. 2013).

Anthropogenic inputs can have profound effects on sea otter health and survival, particularly when combined with other stressors. For instance, exposure to domoic acid may have increased the susceptibility of sea otters to the protozoal parasite *Sarcocystis neurona* (discussed further under Factor C) and worsened the resulting neurological symptoms during a mortality spike in Morro Bay in 2004 (Miller et al. 2010b). The body condition of sea otters in high-density areas of the range (i.e., areas with low per-capita prey availability) appears to strongly influence their susceptibility to additional stressors (Tinker et al. 2013b).

Because density-dependent resource limitation is the primary factor influencing demographic trends of sea otters in much of the central portion of the mainland range, reducing anthropogenic inputs could reduce cumulative health effects on sea otters, but it would not likely significantly increase survival rates in these high-density areas (Tinker et al. 2013b). For significant population growth to occur, range expansion into areas with higher per-capita prey availability is necessary.

Curtailment of Range

Restrictions on the natural range expansion of sea otters into their historic habitat in southern California waters were put in place in 1987. Ten years after listing the southern sea otter, the Service undertook a translocation program to establish a second population at San Nicolas Island in order to safeguard the species against catastrophic events, such as large oil spills. Legislation was enacted that specifically authorized the Service to establish a translocation program (Public Law 99-625, November 7, 1986). The legislation required, as a component of the program, the designation of a translocation zone and a management zone. It also specified the regulations to be associated with these zones. The program as implemented included a translocation zone around San Nicolas Island and a management zone, which was to be kept otter-free, that included all other southern California waters (52 FR 29754; August 11, 1987). However, the program was unsuccessful as a primary recovery action, and moving sea otters from the management zone proved to be more difficult than expected.[3] Sea otters were removed from the management zone until 1993, when maintenance was suspended. By 1998, many factors related to the status of the southern sea otter population had changed since initiation of the program, and the program did not appear to be meeting the recovery objectives outlined for it. We subsequently reinitiated Section 7 consultation under the Act. The resulting biological opinion (Service 2000) determined that containment of southern sea otters was not consistent with the requirement of the Act to avoid jeopardy to the species. In 2001, the Service issued a policy statement advising the public that we would not capture and remove southern sea otters from the management zone pending completion of our reevaluation of the translocation program against the established regulatory failure criteria and under the National Environmental Policy Act (66 FR 6649).

The recovery plan recommends under Task 5 that we "Evaluate the translocation program in light of changed circumstances and determine whether one or more failure criteria have been met" (Service 2003). We completed this evaluation in 2012. The translocation program, including its component translocation and management zones, was terminated by a rulemaking published in the Federal Register on December 19, 2012 (77 FR 75266). This decision retained sea otters at San Nicolas Island and eliminated the possibility that the southern sea otter range could be curtailed by resumed enforcement of a "no-otter" management zone. However, the decision is the subject of pending litigation. Any future establishment (through active means rather than by natural range expansion) of a new population of southern sea otters outside of their existing range, if undertaken under the authority of Public Law 99-625, would require the establishment of a new translocation zone and otter-free management zone. The current southern sea otter range—from approximately Pigeon Point, San Mateo County, in the north, to Gaviota State Beach, Santa Barbara County, in the south—spans roughly 500 km (310 mi) of linear coastline (Figure 4). As detailed above, an additional translocated population occurs at San Nicolas Island. The range has increased by approximately 210 km (130 mi) since the time of listing in 1977. The range at that time was estimated to be 293 km (182 mi) (Lubina and Levin 1988). If, as recent genetic studies suggest, the historic northern range limit is between Newport, Oregon, and Neah Bay, Washington (near the Straits of Juan de Fuca) (Larson et al. 2002b, Valentine et al. 2008), southern sea otters occupy approximately 13 percent of their historic range (assuming sea otters once occupied all offshore islands and San Francisco Bay, areas that may not have been included in the historic range estimate at the time of listing). The current population index for southern sea otters (2,944) constitutes approximately 19 percent of the carrying capacity of California as determined by Laidre et al. (2001). The population index represents an even smaller proportion of carrying capacity if historic southern sea otter range is viewed in its entirety, but this proportion is unknown because carrying capacity has not been determined for the historic southern sea otter range outside of California.

---

[3] The history of the program is described in detail in Appendix C to the Final Supplemental Environmental Impact Statement on the Translocation of Southern Sea Otters (Service 2012). It should also be noted that, subsequent to the 1982 recovery plan, the recovery strategy fundamentally changed, in part because of the results of the translocation program. The 2003 recovery plan recommends allowing population size to increase by means of natural range expansion and recommends against relocating sea otters.

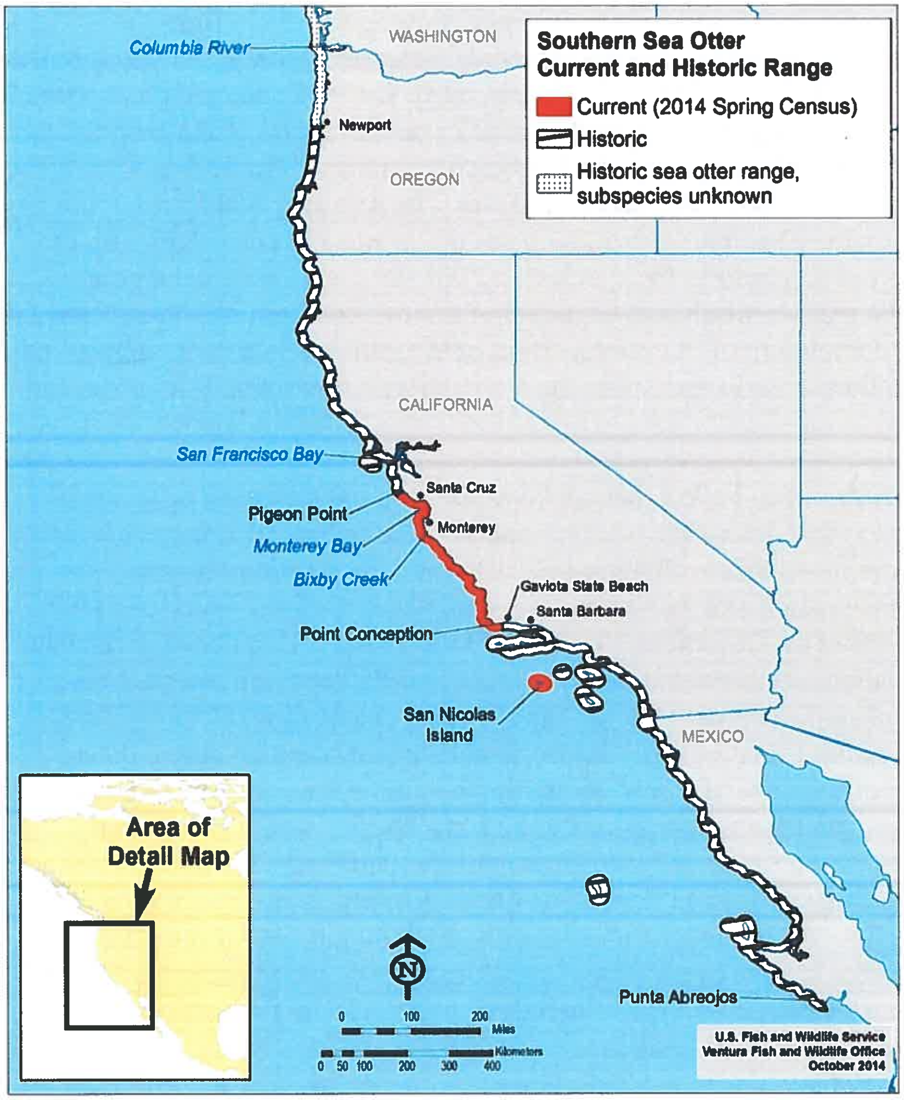


Figure 4. Current and historic range of the southern sea otter.

<u>Summary</u>

The southern sea otter range, though less restricted than at the time of listing, remains curtailed: only approximately 13 percent of historic range is occupied. The current level of range curtailment reflects the legacy of the fur trade, the slow pace of sea otter range expansion along a linear coastline, the factors discussed in this section, and other natural and anthropogenic factors discussed under Factors C and E. Because sea otters in the central portion of the mainland range have reached equilibrium densities (increasing their susceptibility to natural and anthropogenic stressors and limiting the potential for additional population growth in that area), significant growth of the population as a whole will require range expansion into currently unoccupied habitat.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization for Commercial Purposes

Overutilization for commercial purposes (intentional direct lethal take) was the cause of the near-extinction of sea otters throughout the North Pacific rim, but state, federal, and international laws had protected southern sea otters from commercial exploitation by the time of listing. Therefore, overutilization for commercial purposes was not considered to be a factor in the 1977 listing rule (42 FR 2965), nor would it become a factor if sea otters were delisted under the Act, because MMPA and state protections would remain in place.

Overutilization for Recreational Purposes

Overutilization for recreational purposes (in the form of recreational hunting) is not currently an issue, nor would it become an issue if sea otters were delisted under the Act, because MMPA and state protections that prevent the recreational hunting of sea otters would remain in place. However, the disturbance of sea otters by kayakers, ecotour operators, and photographers (including videographers and filmmakers) in the form of close approaches that disrupt natural sea otter behaviors is occurring daily throughout portions of the sea otter's range, despite existing MMPA protections against harassment. The disturbance of resting sea otters depletes their energy reserves by increasing their need for metabolic heat production and may be especially harmful to nutritionally compromised sea otters, such as end-lactation-stage females (Yeates et al. 2007, Thometz et al. 2014). Education and outreach, when combined with the presence of on-the-water staff, have proven effective in reducing instances of harassment (Gunvalson 2011). To date an education/enforcement presence has not been available in most cases, but in 2015 a program called *Be Sea Otter Savvy* was initiated to improve education and outreach. It is not known whether the levels of disturbance that are currently occurring are having demographically significant effects.

Overutilization for Scientific or Educational Purposes

Overutilization for scientific or educational purposes is not currently an issue, nor would it become an issue if sea otters were delisted under the Act, because MMPA and State protections would remain in place. MMPA permitting requirements are discussed under Factor D below.

Summary

Overutilization for commercial, recreational, scientific, or educational purposes is not currently an issue, nor would it become an issue if sea otters were delisted under the Act, because MMPA and state protections and permitting requirements would remain in place. However, repeated disturbance of sea otters is occurring despite MMPA protections against harassment, reflecting a lack of enforcement capability and a lack of education and outreach. It is not known whether the levels of harassment currently occurring are having demographically significant effects.

FACTOR C: Disease or Predation

We did not identify disease or predation as serious threats in the listing rule (42 FR 2965). Since that time, however, disease and white shark attacks have been identified as important mortality factors for southern sea otters. Gerber et al. (2004) found, based on analysis of beach-cast carcasses, that the two causes of death most important for limiting southern sea otter population growth were infectious disease and white shark attacks. We address these issues in turn.

Disease

Detailed necropsies of sea otters conducted from 1992-95 revealed an unexpectedly high occurrence of infectious diseases, including protozoal encephalitis, acanthocephalan peritonitis, coccidioidomycosis, and various bacterial infections (Thomas and Cole 1996). Sub-tasks 4.3.4 and 4.3.5 in the recovery plan recommend additional research into the prevalence and sources of disease agents and stressors to which southern sea otters are exposed (Service 2003). A significant number of studies have since further elucidated the agents, routes of exposure, frequency of occurrence, and effects of these diseases.

Important disease-causing pathogens in sea otters include the protozoal parasites *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. 2010b). 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 (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).

As with contaminants and biotoxins, the susceptibility of sea otters to pathogens and parasites appears to be related synergistically to other factors. As noted under Factor A, susceptibility to *Sarcocystis neurona* may be increased by concurrent domoic acid exposure (Miller et al. 2010b). Nutritional stress is a particularly important factor in this regard. Lower per-capita food availability leads to poorer body condition and greater reliance on sub-optimal prey, which increases exposure and susceptibility to novel disease-causing pathogens (Johnson et al. 2009, Tinker et al. 2013b).

White Shark Attacks

Shark attacks have long been an important mortality factor for southern sea otters, particularly at the northern end of the mainland range, but a recent dramatic increase in mortality resulting from non-consumptive shark-bites, especially in the southern portion of the mainland range (from Estero Bay to Point Conception), appears to be inhibiting southern sea otter recovery and may prevent recovery for the foreseeable future if it continues unabated (Tinker et al. 2015). According to a modeling analysis (Tinker et al. 2013a), if the rate of shark bite mortality had not increased after 2000, the current population size would now be approximately 3,400, well above the delisting criterion identified in the recovery plan (Service 2003). If shark bite mortality continues at current levels (and if other parameters remain the same), the probability of reaching the delisting criterion based on population growth in the mainland range alone, even 25 years from now, is close to zero (during this same period, it may approach, but is not expected to dip below, the uplisting criterion of 1,850) (Tinker et al. 2013a).

The reasons for the increase in shark bite mortality are not well understood. Adult white sharks, whose diet is composed primarily of marine mammals, are associated with pinniped rookeries, primarily those at Año Nuevo and the South Farallon Islands (reviewed in Dewar et al. 2004). It may be that increasing populations of elephant seals and California sea lions are playing a role in shifting the distribution and abundance of white sharks. The Southern California Bight serves primarily as a summer pupping area for pregnant females and a nursery ground for young sharks (reviewed in Dewar et al. 2004). Because young white sharks do not eat mammals but rather invertebrates and fish (reviewed in Dewar et al. 2004), it is possible that as the sea otter range expands further into southern California waters, sea otters there will have a lower risk of mortality from white shark bites than those in most of the currently established range. Despite the high levels of shark-related mortality and declining sea otter numbers in the portion of the range from Cayucos to Point Conception, the small portion of the mainland range southeast of Point Conception has experienced a positive trend in sea otter numbers over the past five years (USGS-WERC 2014, Lafferty and Tinker 2014). Shark bite mortality is not currently known to be a factor at San Nicolas Island.

Summary

Infectious disease is an important cause of death for southern sea otters. Increased susceptibility to pathogens and parasites appears to be the consequence of poor body condition resulting from low per-capita prey availability in portions of the range that are at or near local carrying capacity. White shark attacks are currently the single most important cause of mortality for southern sea otters. Shark bite mortality has long been an important factor at the northern end of the mainland range, but it has increased dramatically over the past 10 years in the southern portion of the mainland range between Cayucos and Point Conception.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

In the listing rule, we determined that existing federal and state laws were adequate to protect southern sea otters from direct taking but stated that these laws did not afford sufficient habitat protection, a situation that would be improved through application of section 7 of the Act (42 FR 2965, January 14, 1977).

The legal protections that apply to southern sea otters throughout most of their current range are similar to those in effect at the time of listing. The regulatory mechanisms that currently afford protection to southern sea otters include the Act, the MMPA (under which southern sea otters are considered a "depleted" species), and the Fish and Wildlife Code of the State of California, (under which southern sea otters are listed as a "fully protected" mammal (section 4700) and protected marine mammal (section 4500)). New state laws and regulations have been enacted since listing that provide additional protection to sea otters from fisheries-related impacts. The protections afforded to sea otters by federal and state legislation were reduced in the waters south of Point Conception as a result of translocation program criteria specified in Public Law 99-625, which was passed subsequent to the listing, but upon termination of the program in 2012, these provisions ceased to apply (see discussion below).

Endangered Species Act

Since the species' listing, the Service has analyzed the potential effects of federal projects under section 7(a)(2) of the Act, which requires federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 C.F.R. § 402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize the impact of incidental take of listed animal species associated with a project. Incidental take refers to taking of listed animal species that results from, but is not the purpose of, carrying out an otherwise lawful activity by a federal agency or applicant (50 C.F.R. § 402.02). In cases where some incidental take is unavoidable, the Service works with the agency to include additional conservation measures to minimize negative impacts. For projects without a federal nexus that may result in incidental take of listed animal species, the Service may issue incidental take permits pursuant to section 10(a)(1)(B). To qualify for an incidental take permit, applicants must develop, fund, and implement a Service-approved habitat conservation plan (HCP) that details measures to minimize and mitigate the impacts of the take of listed species resulting from the project. Regional HCPs are often coordinated with Natural Community Conservation Plans approved under the State of California's Natural Community Conservation Planning Act. In order to authorize incidental take of a marine mammal under section 7(a)(2), the Service must first authorize such take under the more protective MMPA (discussed below). As a result, the Service has only rarely authorized incidental take of southern sea otters under section 7(a)(2). To date, the Service has not issued any permits for the incidental take of sea otters under section 10(a)(1)(B). Take for research purposes is permitted under section 10(a)(1)(A) of the Act but also requires authorization under the MMPA. Since the subspecies' listing, the Service has routinely issued threatened marine mammal research permits.

Marine Mammal Protection Act

The MMPA was enacted on October 21, 1972, and protects all marine mammals. The MMPA prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S. Congress passed the MMPA of 1972 based on the following findings and policies: some marine mammal species or stocks may be in danger of extinction or depletion as a result of human activities; these species or stocks must not be permitted to fall below their optimum sustainable population level ("depleted"); measures should be taken to replenish these species or stocks; there is inadequate knowledge of the ecology and population dynamics; and marine mammals have proven to be resources of great international significance. The MMPA was amended substantially in 1994 to provide for: certain exceptions to the take prohibitions, such as for Alaska Native subsistence and permits and authorizations for scientific research; a program to authorize and control the taking of marine mammals incidental to commercial fishing operations (however, the applicable section of the MMPA, section 118, does not govern the incidental taking of California sea otters, and thus the take of southern sea otters in commercial fisheries cannot be authorized); the preparation of stock assessments for all marine mammal stocks in waters under U.S. jurisdiction; and studies of pinniped-fishery interactions. Sections 101(a)(5)(A) and (D) of the MMPA, as amended (16 U.S.C. 1371 (a)(5)(A) and (D)), authorize the Secretary of the Interior to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region, provided that we make certain findings and either issue regulations or, if the taking is limited to harassment, provide a notice of a proposed authorization to the public for review and comment. To date, the Service has issued two Incidental Harassment Authorizations under the MMPA for the incidental harassment of southern sea otters.

California Fish and Wildlife Code

CDFW classifies the southern sea otter as a fully protected species (section 4700). A fully protected species may not be taken or possessed at any time, and no licenses or permits may be issued for their take except for collecting for necessary scientific research. Hence, incidental take and purposeful take are not authorized for a fully protected species except for collecting for necessary scientific research (and relocation of the bird species for the protection of livestock, but this provision is not applicable to southern sea otters). California Fish and Wildlife Code (section 4500) states that it is unlawful to take any marine mammal except in accordance with provisions of the MMPA or provisions of Title 50 of the Code of Federal Regulations, or until such time as federal laws or regulations permit the state to assume jurisdiction over marine mammals, at which point the Fish and Game Commission may adopt regulations governing marine mammals and the taking thereof.

Public Law 99-625

Public Law 99-625 was enacted on November 7, 1986. It authorized the Secretary of the Interior to develop and implement a southern sea otter translocation program and mandated a regulatory regime that would accompany the program if it were implemented. In 1987, the Service initiated the program, designating the area surrounding San Nicolas Island as a translocation zone and all other waters south of Point Conception as a management zone (52 FR 29754; August 11, 1987). Under Public Law 99-625, sea otters in the translocation zone were to be treated as a threatened species, except with respect to defense-related agency actions, in which case they were to be treated as a species that was proposed to be listed.[4] Additionally, any sea otters found in the

[4] For species that are proposed to be listed, federal agencies are not required to consult under Section 7 of the Act but only to conference with the Service (or the National Marine Fisheries Service, as appropriate) if a proposed action is likely to jeopardize the continued existence of the species.

management zone were required to be non-lethally removed and, while in the management zone, were also to be treated as a proposed species. Any incidental taking that occurred during the course of an otherwise lawful activity within the management zone was not to be considered a violation of either the Act or the MMPA. Regulatory mechanisms otherwise available to avoid or minimize the impacts of incidental take of sea otters in southern California waters would thus have remained absent had the translocation program continued. Although Public Law 99-625 has not been repealed, the translocation program to which it applied (including the translocation and management zones and their associated regulatory regimes) was terminated by regulation on December 19, 2012 (77 FR 75266).

State Laws and Regulations

Several state laws and regulations have been enacted to protect sea otters from injury or mortality in fisheries since the time of listing. A 1991 closure restricted gill and trammel nets to waters deeper than 30 fathoms throughout most of the southern sea otter's range (California Senate Bill No. 2563). Fishing with set 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 110 m (60 fathoms) or less from Point Reyes in Marin County to Point Arguello in 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 128 m (70 fathoms) or within 1.6 km (1 mile), whichever is less, around the Channel Islands, and waters generally within three nautical miles offshore of the mainland coast from Point Arguello to the Mexican border. This closure generally encompasses the depths (less than 40 m or 131 ft) to which sea otters most commonly dive (Tinker et al. 2006a).

Summary

The regulatory mechanisms currently in effect are generally adequate to protect the southern sea otter. Even if the southern sea otter were delisted under the Act, MMPA and state protections would remain in place.

FACTOR E: Other Natural or Manmade Factors Affecting its Continued Existence

In the listing rule, we identified oil spill risk as the most serious potential threat to the species (42 FR 2965). We discussed that the loss of genetic diversity and competition with humans are possible but unproven threats (42 FR 2965).

Oil spill risk

Sea otters are particularly vulnerable to oil contamination. When sea otters come into contact with oil, it causes their fur to mat, which prevents it from insulating their bodies. Without this natural protection from the frigid water, sea otters can quickly die from hypothermia. The toxicity of oil can also be harmful to sea otters, causing liver and kidney failure and damage to their lungs and eyes (Kooyman and Costa 1979, Siniff et al. 1982, Lipscomb et al. 1993).

Oil spill risk from tankers and other large vessels that transit the California coast remains a primary threat to the southern sea otter. The translocation program was undertaken, in part, to establish a colony sufficiently far from the existing population to minimize the likelihood of simultaneous loss from catastrophic events, such as oil spills. However, as the recovery plan notes, the *Exxon Valdez* oil spill demonstrated that San Nicolas Island was not sufficiently far from the mainland range to safeguard against an oil spill of that magnitude (Service 2003). The Deepwater Horizon oil spill of 2010 has since illustrated the potential for releases of oil of a much greater magnitude. The Deepwater Horizon spill released an estimated 4.9 million barrels of oil (of which about 800,000 barrels were captured by containment efforts), almost 19 times the amount of oil spilled during the *Exxon Valdez* disaster (about 261,905 barrels) (http://www.eoearth.org/article/Deepwater_Horizon_oil_spill). The rupture of a Plains All-American pipeline on May 19, 2015, released an estimated 2,500 barrels (101,000 U.S. gallons) of crude oil into the environment near Refugio Beach State Park, of which approximately 500 barrels (21,000 U.S. gallons) may have migrated to the water (http://www.refugioresponse.com/). Although the spill occurred just outside the current southern edge of the mainland range, and no sea otters are believed to have been directly affected by the spilled oil, the incident demonstrates the continuing potential for oil spills to occur in the southern sea otters' range.

Substantial volumes of crude oil and petroleum products continue to be transported off the California coast from Alaska, from foreign countries, and between California production sources. An increase in tankering and shipping activities is expected and may pose a growing threat (McCrary et al. 2003). In its evaluation of oil spill risk from vessel traffic, the West Coast Offshore Vessel Traffic Risk Management Project found that coastwise traffic density is higher along the section of the west coast between the Strait of Juan de Fuca (at the US/Canadian border) and Los Angeles/Long Beach than either north of the Strait or south of Los Angeles/Long Beach, with highest traffic densities specifically 1) between the Strait of Juan de Fuca and the Columbia River, and 2) between San Francisco and Los Angeles/Long Beach (http://library.state.or.us/repository/2010/201007070951103/index.pdf). The Los Angeles/Long Beach and San Francisco Bay harbors include some of the highest volume oil importing ports and refining facilities in the United States (http://resources.ca.gov/ocean/97Agenda/Chap5VTS.html). Although these ports are outside the current range of the southern sea otter, collisions or ship groundings off the California coast, or within congested ports or harbor areas, have the potential to occur as a result of these operations and to kill large numbers of sea otters if spilled oil enters the range. A vessel traffic management system was put in place in 2000 (http://montereybay.noaa.gov/vt/vtexec.html), reducing the risk of oil spills throughout the southern sea otter range, but it is clear that spills still have the potential to occur. This fact is exemplified by the *Cosco Busan* spill, which, although it occurred outside the current range, released 203,099 liters (53,653 gallons) of bunker fuel into the ocean when the container ship struck the San Francisco-Oakland Bay Bridge on November 7, 2007 (United States Coast Guard 2009).

Platform spills may also become a factor as the sea otter range expands into southern California waters because numerous offshore oil platforms are located in the Southern California Bight. However, the threat from oil produced at these platforms is expected to decrease over the next several decades as offshore oil production declines (McCrary et al. 2003). Even assuming continued production at late-20th-century levels, the volume of a future spill on the Pacific Outer Continental Shelf resulting from offshore oil production would likely be relatively small, probably less than 200 barrels (8,400 U.S. gallons), and almost certainly less than 500 barrels (21,000 U.S. gallons) (McCrary et al. 2003).

Despite significant advances in techniques for washing oiled sea otters made during the last 20 years at the CDFW's Marine Wildlife Veterinary Care and Research Center, it is clear that a spill of sufficient magnitude to cause population-level effects would overwhelm the capacity of rehabilitators to rescue sea otters and return them to the wild.

Loss of genetic diversity

Since the time of listing, a number of studies have identified low genetic diversity in sea otters generally and particularly low levels of genetic diversity in southern sea otters (Larson et al. 2002a, Larson et al. 2002b, Aguilar et al. 2008). Sea otter populations have a very low level of variation at major histocompatibility complex (MHC) genes (Aguilar et al. 2008). Low genetic variability has the potential to compromise the ability of southern sea otters to withstand environmental change and increase their susceptibility to land-borne (novel) pathogens. However, inbreeding depression in southern sea otters has not been demonstrated.

Competition

Because certain areas of the mainland sea otter range appear to be food-limited (Tinker *et al.* 2008a, Tinker et al. 2013b), it would be logical to surmise that reductions in prey abundance due to overfishing by humans could pose a threat to southern sea otters. However, there is currently no empirical evidence of direct effects of competition by human fishing on sea otters (Estes pers. comm. 2007).

Mortality in fishing gear

In the listing rule, we did not explicitly identify mortality in fishing gear as a threat to southern sea otters. However, it is clear that sea otters may become entangled/entrapped and drown in commercial fishing gear that is deployed or abandoned in the nearshore marine environment. A period of decline in the southern sea otter population from 1976 to 1984 was likely due to incidental mortality in set-net fisheries (Estes et al. 2003), although gill and trammel nets have since been restricted throughout most of the range of the southern sea otter. 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 National Marine Fisheries Service (NMFS) observers or reported to NMFS observers by fishers. Four sea otters are 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 0.8 km (0.5 mi) off Pt. Santa Cruz, California (Hatfield and Estes 2000). In 1995, USGS began opportunistic efforts to observe the finfish trap fishery in California. These efforts were supplemented with observations by CDFW 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).

Controlled experiments conducted by the USGS and the Monterey Bay Aquarium demonstrated that sea otters could enter a baited commercial finfish trap with inner trap funnel openings of 14 cm (5.5 in) 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 could succeed in entering them. Based on experiments with carcasses and live sea otters, they concluded that finfish traps with 13 cm (5 in) diameter circular openings would largely exclude diving sea otters; that circular openings of 14 to 15.2 cm to (5.5 to 6 in) in diameter and rectangular openings 10.2 cm (4 in) high (typical of Dungeness crab pots) could 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 13 cm (5 in) could admit larger sea otters. Reducing the fyke-opening height of Dungeness crab traps by 2.5 cm (1 in) to 7.6 cm (3 in) 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, CDFW has required 12.7 cm (5 in) 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.

Climate change

Climate change is a threat that has been identified since listing. Our analyses under the Act include consideration of ongoing and projected changes in climate. The terms “climate” and “climate change” are defined by the Intergovernmental Panel on Climate Change (IPCC). The term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements (IPCC 2013a). The term “climate change” thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, whether the change is due to natural variability or human activity (IPCC 2013a).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has increased since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (for these and other examples, see Solomon et al. 2007, IPCC 2013b, IPCC 2014). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate and is “very likely” (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (Solomon et al. 2007, IPCC 2013b). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2012), who concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl et al. 2007, Ganguly et al. 2009, Prinn et al. 2011). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increasing global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (Meehl et al. 2007, Ganguly et al. 2009, Prinn et al. 2011, IPCC 2013b). See IPCC 2013b, for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation.

Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as threats in combination and interactions of climate with other variables (for example, habitat fragmentation) (IPCC 2014). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (Glick et al. 2011, IPCC 2014). There is no single method for conducting such analyses that applies to all situations (Glick et al. 2011). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of the best scientific information available regarding various aspects of climate change.

Global climate projections are informative, and, in some cases, the only or the best scientific information available for us to use. However, projected changes in climate and related impacts can vary across and within different regions of the world (IPCC 2013b). Therefore, we use "downscaled" projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick et al. 2011 for a discussion of downscaling).

Coastal zones are particularly vulnerable to climate variability and change. In addition to sea level rise, climate change is also expected to affect rainfall-runoff patterns, with expected trends towards increased annual river runoff in the wintertime (Southern California Coastal Water Research Project 2009). Climate change may thus 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.

Summary

Numerous natural and anthropogenic factors not captured under Factors A-D continue to affect the southern sea otter. Of these, the most significant threats appear to be the potential for a large oil spill within the southern sea otter's range and the impacts that may result from climate change.

III. RECOVERY CRITERIA

Recovery plans provide guidance to the Service, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species, and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, overall, the threats have been minimized sufficiently, and the species is robust enough to downlist or delist. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made towards recovery since the species was listed by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

The Final Revised Recovery Plan was approved in 2003 (Service 2003). It establishes one recovery criterion: "The average population level over a 3-year period exceeds 3,090 animals. This criterion accounts for the number of southern sea otters that would be needed to ensure with reasonable certainty that an excess of 1,850 animals would survive following a major oil spill of the size of the Exxon Valdez oil spill (over 10 million gallons) and to ensure that a declining trend of 5 percent per year would be detected before the population reached the threshold level for endangered status. The threshold level for endangered status (1,850 animals) is based on the minimum number of animals needed to ensure a genetically effective population size of 500 if the ratio between effective population size and actual population size is 27 percent" (Service 2003).

The recovery criterion has not been met. The 3-year running average population level for 2014 is 2,944. Reaching the criterion may ensure that the subspecies remains above the criterion for endangered status in the event of an oil spill of the magnitude of the *Exxon Valdez* and afford the opportunity to detect a declining trend, but it does not specifically address the threats that are currently limiting population growth. Before delisting, a full five-factor analysis would be undertaken to determine whether threats to the subspecies have been ameliorated sufficiently to allow for the long-term conservation of the species.

IV. SYNTHESIS

The southern sea otter population has expanded considerably in range and number since its near-extinction by the end of the 19th century and since the time of listing in 1977. The 2014 population index of 2,944 animals is now within approximately 150 animals of the delisting threshold identified in the 2003 recovery plan. However, the subspecies remains restricted to a small fraction of its historic range. Despite progress in vessel management to avoid oil spills and advances in washing oiled sea otters, it remains possible that a large spill could occur, and it is likely that in the case of a large spill most oiled sea otters would die despite rescue efforts. Factors affecting the southern sea otter that have emerged or been recognized more fully since listing include shark-bite mortality, food limitation, disease/biotoxin intoxication, mortality in fishing gear, recreation-related harassment, and climate change. Some of these factors are known to operate synergistically. The limited genetic diversity in southern sea otters may conceivably impede the ability of the population to confront novel pathogens and to adapt to changes resulting from climate change, although there is currently no evidence to suggest that low genetic diversity is negatively affecting the population. Of the abovementioned factors, the most significant drivers of demographic trends along the mainland range (where the vast majority of southern sea otters occur) appear to be food limitation and shark bite mortality. Sea otter range expansion into areas that are not subject to food-limitation or high shark-bite mortality would allow for increased population growth and increase security from the effects of catastrophic or widespread events. However, natural range expansion has halted along the mainland in recent years, presumably due to the effects of shark-bite mortality on the once-growing population segment near the southern end of the range. Because the southern sea otter remains below the delisting criterion, and because of the ongoing effects of these other factors, we believe that the southern sea otter still meets the definition of threatened and recommend no status change at this time.

V. RESULTS

Recommended Listing Action:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (indicate reason for delisting according to 50 CFR 424.11):
    ____ *Extinction*
    ____ *Recovery*
    ____ *Original data for classification in error*
_X_ No Change

New Recovery Priority Number and Brief Rationale: No change. The recovery priority number remains 9C because the taxon is a subspecies that faces a moderate level of threat and has high potential for recovery. Although food limitation/disease and shark bite mortality are important factors influencing recovery, sea otters expanding their range into southern California waters are expected to encounter higher per-capita prey availability and lower shark bite risk than sea otters along the central California coast and thus to contribute to population growth in the future. The "C" indicates the potential for continuing conflict with economic activity.

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

The recovery plan outlines seven main tasks. A number of tasks/subtasks have been completed, as described in the "Review Analysis" portion of this report. For ongoing tasks, emphasis should be placed on continued implementation of the following activities, in coordination between the Service and our partners:

- Monitor existing and translocated populations (Task 1; this action includes the development of new tagging technologies);
- Implement plans to reduce the probability of an oil spill in the sea otter range and minimize effects of a spill on the otter population, in the event that one occurs (Task 2);
- Monitor the incidental take of sea otters in commercial fisheries (Sub-task 3.1.1) and minimize intentional take of southern sea otters (Sub-task 3.2);
- Develop and implement a public education and outreach program (Task 7; this action should include significant new efforts 1) to minimize recreation-related and other harassment (i.e., the *Be Sea Otter Savvy* program) and 2) to increase public understanding of the broad range of sea otter community effects and ecosystem services).

The following actions are not addressed in the Recovery Plan but should be initiated, in coordination between the Service and our partners, during the next 5 years:

- Complete spatially explicit Integrated Population Model (incorporating results from Sub-task 4.3) to prioritize recovery actions with rigorous demographic sensitivity analyses;
- Determine the cause(s) of the geographic shift/increase in shark-bite mortality;
- Develop and implement a plan to enhance natural range expansion through releases of small numbers of rehabilitated live-stranded sea otters.

VII. REFERENCES CITED

Aguilar, A., D.A. Jessup, J. Estes, and J.C. Garza. 2008. The distribution of nuclear genetic variation and historical demography of sea otters. Animal Conservation 11:35-45.

Bacon, C.E. 1994. An ecotoxicological comparison of organic contaminants in sea otters among populations in California and Alaska. Master's Thesis, University of California, Santa Cruz.

Bacon, C.E., W.M. Jarman, J.A. Estes, M. Simon, and R.J. Norstrom. 1999. Comparison of organochlorine contaminants among sea otter (*Enhydra lutris*) populations in California and Alaska. Environmental Toxicology and Chemistry 18:452-458.

Bryant, H.C. 1915. Sea otters near Point Sur. California Department of Fish and Game Bulletin 1:134-135.

Burge, C.A., C.M. Eakin, C.S. Friedman, et al. 2014. Climate change influences on marine infectious diseases: implications for management and society. Annual Review of Marine Science 6:249-277.

California Department of Fish and Game. 1976. A proposal for sea otter protection and research, and request for the return of management to the state of California. Sacramento, California. 270 pp.

California Department of Fish and Game. 1999. Letter to Michael Spear, U.S. Fish and Wildlife Service, regarding the draft evaluation of the southern sea otter translocation program and the draft biological opinion on the containment program for the southern sea otter. Dated May 11. Sacramento, California.

Conrad P.A., M.A. Miller, C. Kreuder, E.R. James, J. Mazet, H. Dabritz, D.A. Jessup, F. Gulland, M.E. Grigg. 2005. Transmission of toxoplasma: clues from the study of sea otters as sentinels of *Toxoplasma gondii* flow into the marine environment. International Journal for Parasitology 35:1155–1168.

Costa, D.P. and G.L. Kooyman. 1982. Oxygen consumption, thermoregulation, and the effect of fur oiling and washing on the sea otter, *Enhydra lutris*. Canadian Journal of Zoology 60:2761-2767.

Cronin, M.A., J. Bodkin, B. Ballachey, J. Estes, J.C. Patton. 1996. Mitochondrial-DNA variation among subspecies and populations of sea otters (*Enhydra lutris*). Journal of Mammalogy 77:546-557.

Dewar, H., M. Domeier, and N. Nasby-Lucas. 2004. Insights into young of the year white shark, *Carcharodon carcharias*, behavior in the Southern California Bight. Environmental Biology of Fishes 70:133–143.

Dubey, J.P., N.L. Miller, and D.K. Frenkel. 1970. *Toxoplasma gondii* life cycle in cats. Journal of the American Veterinary Medical Association 157:1767–1770.

Duggins, D.O. 1980. Kelp beds and sea otters: an experimental approach. Ecology 61:447-53.

Estes, J.A. 1990. Growth and equilibrium in sea otter populations. Journal of Animal Ecology 59:385-401.

Estes, J.A. and R.J. Jameson. 1988. A double-survey estimate for sighting probability of sea otters in California. Journal of Wildlife Management 52:70-76.

Estes, J.A. and J.F. Palmisano. 1974. Sea otters: their role in structuring nearshore marine communities. Science 185:1058-60.

Estes, J.A., N.S. Smith, and J.F. Palminsano. 1978. Sea otter predation and community organization in the western Aleutian islands, Alaska. Ecology 59:822-833.

Estes, J.A. and C. Harrold. 1988. Sea otters, sea urchins, and kelp beds: some questions of scale. Pp. 116-150, *in* G.R. Van Blaricom and J.A. Estes, eds., The Community Ecology of Sea Otters. Berlin: Springer-Verlag.

Estes, J.A., K.E. Underwood, and M.J. Karmann. 1986. Activity-time budgets of sea otters in California. Journal of Wildlife Management 50:626-636.

Estes, J.A., B.B. Hatfield, K. Ralls, and J. Ames. 2003. Causes of mortality in California sea otters during periods of population growth and decline. Marine Mammal Science 19:198-216.

Ganguly, A.R., K. Steinhaeuser, D.J. Erickson III, M. Branstetter, E.S. Parish, N. Singh, J.B. Drake, and L. Buja. 2009. Higher trends but larger uncertainty and geographic variability in 21st century temperature and heat waves. Proceedings of the National Academy of Sciences 106:15555-15559.

Gazeau F., L.M. Parker, S. Comeau, et al. 2013. Impacts of ocean acidification on marine shelled molluscs. Marine Biology 160:2207-45.

Gerber, L.R., M.T. Tinker, D.F. Doak, J.A. Estes, and D.A. Jessup. 2004. Mortality sensitivity in life-stage simulation analysis: a case study of southern sea otters. Ecological Applications 14:1554-1565.

Glick, P., B.A. Stein, and N.A. Edelson, eds. 2011. Scanning the conservation horizon: a guide to climate change vulnerability assessment. National Wildlife Federation, Washington, D.C.

Gunvalson, M.M. 2011. Reducing disturbances to marine mammals by kayakers in the Monterey Bay. Master's Thesis. San Jose State University, San Jose, California.

Hatfield, B.B. and J.A. Estes. 2000. Preliminary results of an evaluation of the potential threat to sea otters posed by the nearshore finfish trap fishery. Unpublished. 6 pp. + appendices.

Hatfield, B.B., J.A. Ames, J.A. Estes, M.T. Tinker, A.B. Johnson, M.M. Staedler, and M.D. Harris. 2011. Sea otter mortality in fish and shellfish traps: estimating potential impacts and exploring possible solutions. Endangered Species Research 13:219–229.

Hines, A.H. and J.S. Pearse. 1982. Abalones, shells, and sea otters: dynamics of prey populations in central California. Ecology 63:1547-1560.

Huber, M., and R. Knutti. 2012. Anthropogenic and natural warming inferred from changes in Earth's energy balance. Nature Geoscience 5:31–36.

Hughes, B.B., R. Eby, E. Van Dyke, M.T. Tinker, C.I. Marks, K.S. Johnson, and K. Wasson. 2013. Recovery of a top predator mediates negative eutrophic effects on seagrass. Proceedings of the National Academy of Sciences 110:15313-15318.

Intergovernmental Panel on Climate Change. 2013a. Annex III: Glossary. P. 1450 *in* T.F. Stocker, D. Qin, G.-K. Plattner, et al., eds., Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York: Cambridge University Press.

__________. 2013b. Summary for policymakers. Pp. 3-29 *in* T.F. Stocker, D. Qin, G.-K. Plattner, et al., eds., Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York: Cambridge University Press.

__________. 2014. Summary for policymakers. Pp. 1-32 in Field, C.B., V.R. Barros, D.J. Dokken, et al., eds., Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York: Cambridge University Press..

Jameson, R.J. 1998. Sexual segregation in sea otters and its role in range expansion. The Otter Raft 60:6-8.

Jameson, R.J. 1989. Movements, home range, and territories of male sea otters off central California. Marine Mammal Science 5:159-172.

Jameson, R.J. and S. Jeffries. 1999. Results of the 1999 survey of the Washington sea otter population. Unpublished. 5 pp.

Jameson, R.J. and S. Jeffries. 2005. Results of the 2005 survey of the reintroduced Washington sea otter population. Unpublished. 6 pp.

Jameson, R. J. and A.M. Johnson. 1993. Reproductive characteristics of female sea otters. Marine Mammal Science 9:156–167.

Jessup D.A., M.A. Miller, M. Harris, B.B. Hatfield, and J.A. Estes. 2004. The 2003 southern sea otter (*Enhydra lutris nereis*) unusual mortality event: a preliminary report to NOAA and USFWS. Unpublished. 38 pp.

Jessup D.A., C.K. Johnson, J. Estes, D. Carlson-Bremer, W.M. Jarman, S. Reese, E. Dodd, M.T. Tinker, M.H. Ziccardi. 2010. Persistent organic pollutants in the blood of free-ranging sea otters (*Enhydra lutris* ssp.) in Alaska and California. Journal of Wildlife Diseases 46: 1214–1233.

Johnson, C.K., M.T. Tinker, J.A. Estes, P.A. Conrad, M. Staedler, M.A. Miller, D.A. Jessup, and J.A.K. Mazet. 2009. Prey choice and habitat use drive sea otter pathogen exposure in a resource-limited coastal ecosystem. Proceedings of the National Academy of Sciences 106:2242-2247.

Kannan, K., E. Perrotta, and N.J. Thomas. 2006. Association between perfluorinated compounds and pathological conditions in southern sea otters. Environmental Science & Technology 40:4943-4948.

Kannan, K., E. Perrotta, N.J. Thomas, and K.M. Aldous. 2007. A comparative analysis of polybrominated diphenyl ethers and polychlorinated biphenyls in southern sea otters that died of infectious diseases and noninfectious causes. Archives of Environmental Contamination and Toxicology 53:293-302.

Kannan K., K.S. Guruge, N.J. Thomas, S. Tanabe, J.P. Giesy. 1998. Butyltin residues in southern sea otters (*Enhydra lutris nereis*) found dead along California coastal waters. Environmental Science and Technology 32:1169-1175.

Kenyon, K.W. 1969. The sea otter *Enhydra lutris* in the eastern Pacific Ocean. North American Fauna 68:1-352.

Kooyman, G.L. and D.P. Costa. 1979. Effects of oiling on temperature regulation in sea otters. Yearly progress report, Outer Continental Shelf Energy Assessment Program.

Kreuder, C., M.A. Miller, D.A. Jessup, L.J. Lowenstein, M.D. Harris, J.A. Ames, T.E. Carpenter, P.A. Conrad, and J.A.K. Mazet. 2003. Patterns of mortality in southern sea otters (*Enhydra lutris nereis*) from 1998-2001. Journal of Wildlife Diseases 39:495-509.

Kreuder, C., M.A. Miller, L.J. Lowenstine, P.A. Conrad, T.E. Carpenter, D.A. Jessup, and J.A.K. Mazet. 2005. Evaluation of cardiac lesions and risk factors associated with myocarditis and dilated cardiomyopathy in southern sea otters (*Enhydra lutris nereis*). American Journal of Veterinary Research 66:289-299.

Kroeker, K. J., R.L. Kordas, R. N. Crim, and G.G. Singh. 2010. Meta-analysis reveals negative yet variable effects of ocean acidification on marine organisms. Ecology Letters 13:1419-1434.

Kudela, R.M., J.Q. Lane, W.P. Cochlan. 2008. The potential role of anthropogenically derived nitrogen in the growth of harmful algae in California, USA. Harmful Algae 8:103-110.

Kurihara, H., and Y. Shirayama. 2004. Effects of increased atmospheric CO2 on sea urchin early development. Marine Ecology Progress Series 274:161-169.

Kurihara, H., M. Matsui, H. Furukawa, M. Hayashi, and A. Ishimatsu. 2008. Long-term effects of predicted future seawater CO2 conditions on the survival and growth of the marine shrimp *Palaemon pacificus*. Journal of Experimental Marine Biology and Ecology 367:41-46.

Lafferty, K.D. and M.T. Tinker. 2014. Sea otters are recolonizing southern California in fits and starts. Ecosphere 5.5:1-11.

Laidre, K.L., R.J. Jameson, and D.P. DeMaster. 2001. An estimation of carrying capacity for sea otters along the California coast. Marine Mammal Science 17:294-309.

Larson, S., R. Jameson, J. Bodkin, M. Staedler, and P. Bentzen. 2002a. Microsatellite DNA and mitochondrial DNA variation in remnant and translocated sea otter (*Enhydra lutris*) populations. Journal of Mammalogy 83:893-906.

Larson, S., R. Jameson, M. Etnier, M. Fleming, and P. Bentzen. 2002b. Loss of genetic diversity in sea otters (*Enhydra lutris*) associated with the fur trade of the 18th and 19th centuries. Molecular Ecology 11:1899-1903.

Larson, S., R. Jameson, M. Etnier, T. Jones, and R. Hall. 2012. Genetic diversity and population parameters of sea otters, *Enhydra lutris*, before fur trade extirpation from 1741–1911. PLoS ONE 7(3): e32205. doi:10.1371/journal.pone.0032205.

Lipscomb, T.P., R.K. Harris, R.B. Moeller, J.M. Pletcher, R.J. Haebler, and B.E. Ballachey. 1993. Histopathologic lesions in sea otters exposed to crude oil. Veterinary Pathology 30:1-11.

Lowry, L.F. and J.S. Pearse. 1973. Abalones and sea urchins in an area inhabited by sea otters. Marine Biology 23:213-219.

Lubina, J. and S. Levin, 1988. The spread of a reinvading species: range expansion in the California sea otter. American Naturalist 131:526-543.

Mayer, K.A., M.D. Dailey, and M.A. Miller. 2003. Helminth parasites of the southern sea otter *Enhydra lutris nereis* in central California: abundance, distribution, and pathology. Diseases of Aquatic Organisms 53:77-88.

McCrary, M.D., D.E. Panzer, and M.O. Pierson. 2003. Oil and gas operations offshore California: status, risks, and safety. Marine Ornithology 31:43-49.

Meehl, G.A., T.F. Stocker, W.D. Collins, et al. 2007. Global climate projections. *In* S. Solomon, D. Qin, M. Manning, et al., eds., Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York: Cambridge University Press.

Miller, M.A., E. Dodd, E. Berberich, F. Batac, L. Henkel, J. Kunz, and T. Tinker. 2013. Preliminary findings from necropsy of tagged sea otters from the Monterey-Big Sur study. Pp. 206-234, *in* M.T. Tinker, ed., Sea otter population biology at Big Sur and Monterey California: Investigating the consequences of resource abundance and anthropogenic stressors for sea otter recovery. Draft Final Report to California Coastal Conservancy and U.S. Fish and Wildlife Service. University of California, Santa Cruz, 242 pp.

Miller, M. A., M. E. Grigg, C. Kreuder, E. R. James, A. C. Melli, P. R. Crosbie, D. A. Jessup, J. C. Boothroyd, D. Brownstein, and P. A. Conrad. 2004. An unusual genotype of *Toxoplasma gondii* is common in California sea otters (*Enhydra lutris nereis*) and is a cause of mortality. International Journal for Parasitology 34:275-284.

Miller, M.A., I.A. Gardner, C. Kreuder, D.M. Paradies, K.R. Worcester, D.A. Jessup, E. Dodd, M.D. Harris, J.A. Ames, A.E. Packham, and P.A. Conrad. 2002. Coastal freshwater runoff is a risk factor for *Toxoplasma gondii* infection of southern sea otters (*Enhydra lutris nereis*). International Journal for Parasitology 32:997-1006.

Miller, M.A., R.M. Kudela, A. Mekebri, D. Crane, S.C. Oates, M.T. Tinker, M. Staedler, W.A. Miller, S. Toy-Choutka, C. Domink, D. Hardin, G. Langlois, M. Murray, K. Ward and D.A. Jessup. 2010a. Evidence for a novel marine harmful algal bloom: cyanotoxin (Microcystin) transfer from land to sea otters. PLoS ONE 5:e12576.

Miller, M.A., P.A. Conrad, M. Harris, B. Hatfield , G. Langlois, D.A. Jessup, S.L. Magargal, A.E. Packham, S. Toy-Choutka, A.C. Melli, M.A. Murray, F.M. Gulland and M.E. Grigg. 2010b. A protozoal-associated epizootic impacting marine wildlife: mass-mortality of southern sea otters (*Enhydra lutris nereis*) due to *Sarcocystis neurona* infection. Veterinary Parasitology 172:183–194.

Miller, M.A., W.A. Miller, P.A. Conrad, E.R. James, A.C. Melli, C.M. Leutenegger, H.A. Dabritz, A.E. Packham, D. Paradies, M. Harris, J. Ames, D.A. Jessup, K. Worcester, M.E. Grigg. 2008. Type X *Toxoplasma gondii* in a wild mussel and terrestrial carnivores from coastal California: new linkages between terrestrial mammals, runoff and toxoplasmosis of sea otters. International Journal of Parasitology 38(11):1319-28.

Monson, D., J.A. Estes, D.B. Siniff, and J.L. Bodkin. 2000. Life history plasticity and population regulation in sea otters. Oikos 90:457-468.

Morrison, P., M. Rosenmann, and J.A. Estes. 1974. Metabolism and thermoregulation in the sea otter. Physiological Zoology 47:218-229.

Mos, L. 2001. Domoic acid: a fascinating marine toxin. Environmental Toxicology and Pharmacology 9:79-85.

Nakata, H., K. Kannan, L. Jing, N. Thomas, S. Tanabe, and J.P. Giesy. 1998. Accumulation pattern of organochlorine pesticides and polychlorinated biphenyls in southern sea otters (*Enhydra lutris nereis*) found stranded along coastal California, USA. Environmental Pollution 103:45-53.

Palmisano, J.F. and J.A. Estes. 1977. Ecological interactions involving the sea otter. P. 527, *in* M.S. Merritt and R.G. Fuller, eds., The Environment of Amchitka Island, Alaska. U.S. Energy Research and Development Administration, Springfield, Virginia.

Palmisano, J.F. 1983. Sea otter predation: its role in structuring rocky intertidal communities in the Aleutian Islands, Alaska USA. Acta Zoologica Fennica 174: 209-11.

Prinn, R., S. Paltsev, A. Sokolov, M. Sarofim, J. Reilly, H. Jacoby. 2011. Scenarios with MIT integrated global systems model: significant global warming regardless of different approaches. Climatic Change 104:515-537.

Ralls, K. and D.B. Siniff. 1990. Time budgets and activity patterns in California sea otters. Journal of Wildlife Management 54:251-259.

Ralls, K., T.C. Eagle, and D.B. Siniff. 1996. Movement and spatial use patterns of California sea otters. Canadian Journal of Zoology 74:1841-1849.

Riedman, M.L. and J.A. Estes. 1990. The sea otter (*Enhydra lutris*): behavior, ecology, and natural history. U.S. Fish and Wildlife Service, Biological Report. 126 pp.

Sanchez, M.S. 1992. Differentiation and variability of mitochondrial DNA in three sea otter, *Enhydra lutris*, populations. Master's Thesis, University of California, Santa Cruz.

Schramm, Y., G. Heckel, A. Sáenz-Arroyo, E. López-Reyes, A. Baez-Flores, G. Gómez-Hernández, A. Lazo-de-la-Vega-Trinker, D. Lubinsky-Jinich, and M. de los Ángeles Milanés-Salinas. 2014. New evidence for the existence of southern sea otters (*Enhydra lutris nereis*) in Baja California, Mexico. Marine Mammal Science 30:1264-1271.

Staedler, M.M. 2011. Maternal care and provisioning in the southern sea otter (*Enhydra lutris nereis*): reproductive consequences of diet specialization in an apex predator. Master's Thesis, University of California, Santa Cruz.

Stumpp, M., J. Wren, Frank Melzner, M. C. Thorndyke, and S. T. Dupont. 2011. CO_2 induced seawater acidification impacts sea urchin larval development I: elevated metabolic rates decrease scope for growth and induce developmental delay. Comparative Biochemistry and Physiology, Part A: Molecular & Integrative Physiology 160:331-340.

Southern California Coastal Water Research Project. 2009. <http://www.sccwrp.org/view.php?id=251>.

Siniff, D.B., T.D. Williams, A.M. Johnson, and D.L. Garshelis. 1982. Experiments on the response of sea otters, *Enhydra lutris*, to oil contamination. Biological Conservation 2: 261-272.

Solomon, S., D. Qin, M. Manning, et al. 2007. Technical summary. *In* Solomon, S., D. Qin, M. Manning, et al., eds., Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York: Cambridge University Press.

Thomas, N.J., and R.A. Cole. 1996. The risk of disease and threats to the wild population. Endangered Species Update 13:23-27.

Thometz, N.M., M.T. Tinker, M.M. Staedler, K.A. Mayer, and T.M. Williams. 2014. Energetic demands of immature sea otters from birth to weaning: implications for maternal costs, reproductive behavior and population-level trends. Journal of Experimental Biology 217:2053-2061.

Tinker, M. T., G. Bentall, and J. A. Estes. 2008a. Food limitation leads to behavioral diversification and dietary specialization in sea otters. Proceedings of the National Academy of Sciences of the United States of America 105:560-565.

Tinker, M.T., D.F. Doak, and J.A. Estes. 2008b. Using demography and movement behavior to predict range expansion of the southern sea otter. Ecological Applications 18:1781–1794.

Tinker M.T., D.P. Costa, J.A. Estes, N. Wieringa. 2007. Individual dietary specialization and dive behavior in the California sea otter: Using archival time-depth data to detect alternative foraging strategies. Deep Sea Research II 54:330–342.

Tinker, M.T., B.B. Hatfield, M.D. Harris, and J.A. Ames. 2013a. When the shark bites: implications of increasing white shark attacks for southern sea otters. Paper presented at the Seattle Aquarium Sea Otter Conservation Workshop VIII, March 22-24, 2013.

Tinker, M.T., B.B. Hatfield, M.D. Harris, and J.A. Ames. 2015. Dramatic increase in sea otter mortality from white sharks in California. Marine Mammal Science. doi:10.1111/mms.12261.

Tinker, M.T., J.A. Estes, K. Ralls, T.M. Williams, D. Jessup, and D.P. Costa. 2006a. Population dynamics and biology of the California sea otter (*Enhydra lutris nereis*) at the southern end of its range. MMS OCS Study 2006-007. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara. MMS Cooperative Agreement Number 14-35-0001-31063.

Tinker, M.T., D.F. Doak, J.A. Estes, B.B. Hatfield, M.M. Staedler, and J. Bodkin. 2006b. Incorporating diverse data and realistic complexity into demographic estimation procedures for sea otters. Ecological Applications 16:2293-2312.

Tinker, M.T., et al., eds. 2013b. Sea otter population biology at Big Sur and Monterey California: investigating the consequences of resource abundance and anthropogenic stressors for sea otter recovery. Draft Final Report to California Coastal Conservancy and U.S. Fish and Wildlife Service. University of California, Santa Cruz, 243 pp.

U.S. Coast Guard. 2009. Report of investigation into the collision of the *Cosco Busan* with the Delta tower of the San Francisco-Oakland Bay Bridge in San Francisco Bay, November 7, 2007. MISLE Activity Number: 3095030. Washington, DC. 34 pp. + appendix. <http://www.uscg.mil/foia/coscobuscan/coscobusanfinal030609.pdf>

U.S. Fish and Wildlife Service. 1984. Assessment of significant points of concern relative to the southern sea otter (SSO) 5-year review, the Friends of the Sea Otter petition to reclassify the SSO as endangered, and the Save Our Shellfish, Greater Los Angeles Council of Divers, and Pacific Legal Foundation Joint Petition to delist the SSO. 38 pp.

U.S. Fish and Wildlife Service. 2000. Reinitiation of formal consultation on the containment program for the southern sea otter (1-8-99-FW-81). California/Nevada Operations Office. 19 July.

U.S. Fish and Wildlife Service. 2003. Final Revised Recovery Plan for the Southern Sea Otter (*Enhydra lutris nereis*). Portland, Oregon. xi + 165 pp.

U.S. Fish and Wildlife Service. 2012. Final Supplemental Environmental Impact Statement on the Translocation of Southern Sea Otters. Ventura Fish and Wildlife Office, Ventura, California. 348 pp. + front matter and appendices.

U.S. Geological Survey-Western Ecological Research Center. 2014. California sea otter surveys and research. U.S. Geological Survey, Sacramento, CA. Available at <http://www.werc.usgs.gov/seaottercount>.

Valentine, K., D.A. Duffield, L.E. Patrick, D.R. Hatch, V.L. Butler, R.L. Hall, and N. Lehman. 2008. Ancient DNA reveals genotypic relationships among Oregon populations of the sea otter (*Enhydra lutris*). Conservation Genetics 9:933-938.

Vezie, C., J. Rapala, J. Vaitomaa, J. Seitsonen, and K. Sivonen. 2002. Effect of nitrogen and phosphorus on growth of toxic and nontoxic *Microcystis* strains and on intracellular microcystin concentrations. Microbial Ecology 43:443-454.

Walther, G.-R, E. Post, P. Convey, A. Menzel, C. Parmesank, T.J.C. Beebee, J.-M. Fromentin, O. Hoegh-Guldberg, and F. Bairlein. 2002. Ecological responses to recent climate change. Nature 416:389-395.

Wilson, D.E., M.A. Bogan, R.L. Brownell, Jr., A.M. Burdin, and M.K. Maminov. 1991. Geographic variation in sea otters, *Enhydra lutris*. Journal of Mammalogy 72:22-36.

Yeates, L.C., T.M. Williams, and T.L. Fink. 2007. Diving and foraging energetics of the smallest marine mammal, the sea otter (*Enhydra lutris*). Journal of Experimental Biology 210:1960-1970.

PERSONAL COMMUNICATIONS

Carretta, Jim. 2008. Southwest Fisheries Science Center, NOAA, U.S. National Marine Fisheries Service, La Jolla, CA.

Tinker, M. Tim. U.S. Geological Survey-Western Ecological Research Center and Depratment of Ecology and Evolutionary Biology, University of California, Santa Cruz.

Estes, James A. 2007. Department of Ecology and Evolutionary Biology, University of California, Santa Cruz.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW

Southern sea otter (*Enhydra lutris nereis*)

Current Classification: Threatened

Recommendation Resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Review Conducted By: Lilian Carswell

FIELD OFFICE APPROVAL:

Approve ______________________________ *Date* September 15, 2015
Field Supervisor, Ventura Fish and Wildlife Office