

## Sea Otter Studies at WERC

Sea otter research by scientists at the Santa Cruz Field Station of the USGS Western Ecological Research Center (WERC) focuses on this smallest marine mammal's population biology and its role as a keystone species in the nearshore marine community. WERC scientists conducting long-term research in California and Alaska seek to answer complex ecological questions such as how sea otters impact near-shore marine food webs, why California's threatened sea otter population is growing so slowly, and what are the consequences of the rapid sea otter decline in the Aleutian Islands. We work with state, federal, and local partners throughout the species' range.

Sea otters once ranged from the central Pacific coast of Baja California, Mexico, to northern Japan, probably in high densities more or less continuously throughout the region. The Pacific maritime fur trade, beginning with the discovery of Alaska and the Aleutian Islands by the Bering Expedition in the mid-1700s, brought sea otters to near extinction by the beginning of the 20th century. After 150 years of being intensively hunted for their valuable fur, sea otters had been extirpated from most of their range. Passage of the International Fur Seal Treaty in 1911 protected remaining sea otters from further hunting, but their distribution was severely fragmented, with remnant populations surviving in Alaska and along the rugged Big Sur coast of California. Later

### Research is still needed to:

- Elucidate the complex relationships between nutritional stress, pollution and pathogen exposure, and how these factors translate into elevated mortality in southern sea otters
- Provide managers with the information they need to ensure sea otter population recovery and maintain the integrity of near-shore marine ecosystems
- Better understand the ultimate drivers of sea otter population collapse in western Alaska

relocations of sea otters restored populations to some areas, including Southeast Alaska, British Columbia, Washington and San Nicolas Island, California.

### A Keystone Species

WERC's sea otter research program has used this fragmented distribution for large-scale studies, contrasting similar habitats with and without sea otters and documenting changes through time as populations became reestablished and grew. Early work demonstrated that sea otters, by limiting populations of herbivorous invertebrates such as sea urchins and large gastropods, played a keystone role in preventing kelp forests from being overgrazed. Subsequent research has focused on the broader influences of this otter-herbivore-kelp trophic cascade, including both the indirect effects on other coastal species and ecosystem processes, and the evolutionary consequences over longer periods of time.

Sea otters are unusual among marine mammals in that they live outside of their zone of thermal neutrality and consequently have extremely high metabolic demands. As a result they require a high rate of food intake, up to 30% of their body weight per day, and they have limited capacity to cope with reduced food availability or additional physiological challenges. Moreover, a large proportion of their diet consists of filter-feeding benthic invertebrates, which tend to concentrate both contaminants and disease-causing pathogens that flow into near-shore waters from land. With their elevated metabolic rates, sea otters must consume large quan-



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tities of these invertebrates and thus they have high exposure rates to the associated parasites and pollutants. The net result of all these traits is that sea otters are especially susceptible to human-induced stressors in their environment, and like the proverbial “canary in a coal mine,” they represent effective sentinels of the health of coastal oceans. Their utility as a sentinel (or indicator) of ecosystem health is further increased by their near-shore distribution, their extraordinary appeal to the general public (a fact that generates community support for monitoring efforts), and because they are relatively easy to observe.

### Research Collaborations

WERC researchers are involved in collaborative studies with scientists from the USGS Alaska Science Center, California Department of Fish and Game, Monterey Bay Aquarium, University of California at Santa Cruz, University of California at Davis, and Smithsonian Institute. To learn more about the ecology of the southern sea otter, scientists have implanted VHF radio transmitters and time-depth recorders (TDRs) in sea otters at multiple sites throughout the range. These radio-tagged otters are then followed closely by fieldworkers for up to 5 years to monitor their survival, reproductive success, behavior and vital signs as they dive and forage for food. Their rates of energy acquisition are calculated based on observed prey capture success, in conjunction with detailed nutritional analyses of prey species. Energy expenditure can be calculated from the dive data collected by the TDRs, in conjunction with information on the metabolic costs of diving and swimming measured using captive study animals at the University of California at Santa Cruz and Monterey Bay Aquarium.

Combining all this information, the scientists estimate the degree to which individual sea otters are meeting or exceeding their basic energetic requirements, and thereby resolve the question of whether sea otter populations are limited by the abundance of food resources in some areas. This research has also highlighted the extreme degree of individual dietary specialization in the southern sea otter, and the significance of such specialization for individual fitness and population dynamics. In addition, detailed health profiles are being developed for the radio-tagged study animals and beached carcasses are being examined and tissues analyzed, in an effort to determine important causes of death in sea otters. Using



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these data, WERC scientists and their collaborators are learning how specific behaviors or diet specializations may predispose sea otters to exposure to risk factors such as infectious disease and contaminants.

### Studies for Recovery in California

In California, efforts are currently directed toward understanding reasons for the depressed and inconsistent recovery rate of the threatened southern sea otter population. The WERC monitoring program detected a significant decline between 1994 and 1999, and population models developed by WERC scientists indicated that the demographic driver of this decline was a rapid increase in female mortality in the north and central portions of the range, with juvenile mortality playing a greater role in the north and adult mortality having a greater impact in the south. Since 1999 the population as a whole has resumed a slow rate of increase; however, this growth is primarily attributable to increases in male-dominated portions of the population, particularly near the range peripheries, while female-dominated portions of the population in the center of the range have grown very slowly or remained approximately stable.

Ongoing collection and analyses of demographic data by WERC scientists are aimed at understanding the underlying reasons for these variable population trends. This information has been important to the U.S. Fish and Wildlife Service in its recovery planning process, to the California Department of Fish and Game, California Coastal Conservancy, Monterey Bay Aquarium, associated conservation organizations, and a diffuse group of fisheries organizations.

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### Decline in the Aleutian Archipelago

Long-term research by WERC scientists has documented the extensive and precipitous decline of sea otters in southwest Alaska, particularly in the Aleutian Islands. Sea otter populations in the Aleutian archipelago have decreased by more than 90% since the 1980s. Untangling the chain of events that led to the collapse of this sea otter/kelp forest system, WERC scientists discovered that the collapse was driven by increased killer whale predation, and ultimately caused by events in the oceanic ecosystem. Their findings led the U.S. Fish and Wildlife Service to list the northern sea otter in southwest Alaska as threatened under the Endangered Species Act. The lead scientist at the WERC Santa Cruz Field Station is a member of the Endangered Species Recovery Team for this listed population, and WERC scientists are contributing long-term databases and analytical expertise towards developing an effective recovery plan.

### Comparing Sea Otter Populations

WERC scientists are learning how southern sea otters feed, live and die in central California, and contrasting this information with similar data collected in the 1980s when the population was more stable. Comparisons are also being made between the populations at the center of the range and San Nicolas Island (located in the Santa Barbara channel), where sea otters were introduced in the late 1980s. In contrast with the stagnant growth seen in central California, the small population of sea otters at San Nicolas Island is increasing steadily, with an average rate of 9% per year since 1992.

To discover why these rates vary so greatly, WERC scientists and their collaborators are comparing the behavior, diet, health profiles, and population biology of the San Nicolas population with that in central California. This comparative approach is being further expanded to include populations in Washington and Alaska: the scientists hope to determine the demographic mechanisms responsible for the different rates of population change, and to identify which behav-



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ioral and demographic characteristics are associated with rapidly growing populations and which are more typical of those that are either stable or in decline. In addition, a recent comparative project has taken WERC scientists and collaborators to the Commander Islands, Russia at the westernmost end of the Aleutian Island chain, where the sea otter population is thriving in stark contrast to the eastern portion of the archipelago. The data collected from these various sea otter populations are used to develop predictive models that help to understand the factors responsible for population trends, and to evaluate management alternatives.

To learn more about sea otter research at WERC, visit our web site at <http://www.werc.usgs.gov/otters/>.

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