Southern sea otter - S

"We've got two otters, one's a recapture." The voice on the Department of Fish and Game (DFG) marine frequency belongs to R.C. Mitchell who at 67 is one the most senior scientific aids in DFG.

"OK, we'll have someone on the end of the pier in a few minutes," I reply.

By Dr. David Jessup

"Take your time; they're pretty calm and it'll take us 10 minutes to get there," says Mitchell. The great things about R.C. are that he will do anything you ask of him, he is a steady and calm boat driver, and he loves his work with DFG's Office of Spill Prevention and Response (OSPR) - Veterinary Services Program.

Out on the end of the pier Frank Wilhelm, a DFG-OSPR Fish and Wildlife Assistant, is setting up the series of ropes and net bags we need to raise the otters from the level of the pitching boat on the water, up and over the railing of the pier (about 30 feet). The davit and docking system on the pier that would allow us to go down a set of stairs to sea level, broken by the recent winter storms, have yet to be repaired and we need to improvise a little. It turns out that the sea otters don't mind the ride up in the net bag at all, and it is easier than carrying heavy and awkward kennels up the stairs from the water. Mitchell's rigid hull inflatable approaches the San Simeon pier with sea otters that have just been caught by the OSPR dive team of Mike Harris and Jack Ames. Ames is short and muscular with curly graying hair, and at 62, can lay claim to being DFG's oldest diver by quite a few years. Harris is in his mid-30s, at least 6 feet 5 inches, very thin and angular. Both are soft spoken and quiet. They have been working together for at least 10 years, and they make a very successful capture team. They have a friendly competition going with the United States Geological Survey-Biological Resources Division (USGS-BRD) dive team made up of Brian Hatfield and Mike Kenner. Another set of physical mismatches, they are also quiet but extremely skilled divers, otter biologists and capture specialists. Only eight or nine people in the United States are trained and permitted to capture sea otters from underwater using rebreathers, dive sleds and Wilson traps (named for OSPR's Ken Wilson).

The day's main goal is to capture as many of the tagged sea otters carrying VHF radio transmitters as possible, particularly those carrying the valuable time depth recorders (TDR). Add to that the effort to capture up to half a dozen new animals for the study. The study is a cooperative effort between DFG-OSPR, USGS, and researchers from various universities and non-profit agencies, involving capture, anesthesia and surgical implantation of monitoring instruments; biomedical evaluation and extensive sampling; then release and followup by ground and periodically aerial observations. The VHF transmitter allows researchers from USGS, headed up by Dr. Jim Estes and Tim Tinker, to locate the animal by radio telemetry and track its daily and seasonal movements for two to three years, observe its interactions with other otters and perhaps with people, and to find it when it dies.

The TDR records pressures that translate into how deep the animal is diving recorded against a very precise time clock. By combining the TDR data with direct observations made using powerful telescopes, Estes and Tinker can then determine how often and how deep otters dive, at what depths they find certain prey, and what underwater habitats (impossible to observe directly) and prey types are most important to them. Intensive periods of monitoring, including 24-hour continuous observations, allow the researchers to measure "time/activity budgets" — a standardized way of determining how much effort individual otters devote to feeding, and what the ecological consequences

entinel of the sea

Photo © Mike Brock

A VHF transmitter sends body temperature information and allows researchers to locate an otter by radio telemetry and track its daily and seasonal movements for two to three years, observe its interactions with other otters and perhaps with people, and to find it when it dies. Temperature changes have allowed illness in some animals to be detected before death.

DFG file photo

Jack Ames and diver Mike Harris prepare Wilson trap.

of that may be for the population.

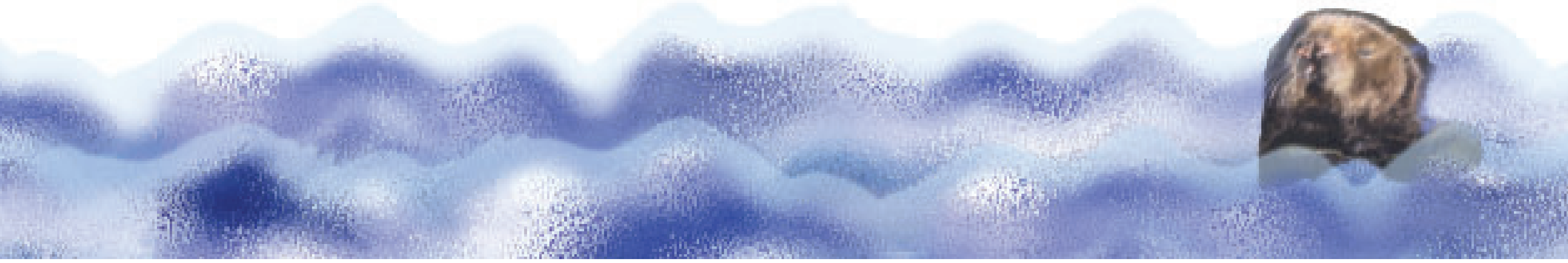
The ultimate goal is to assess the ecological limitations and health of the southern sea otter and its nearshore environment, and to gather sufficient information to foster and guide sea otter recovery. This complex project has been going on for three years and will continue up to another three. Many organizations and individuals are participating in the project. The lead veterinary surgeon of the group is Dr. Mike Murray of the Monterey Bay Aquarium (MBA). Michelle Staedler of MBA is an indispensable biologist who has the most experience with color-coded flipper tags, body measurements and a long history of working with all the other partners. Dr. Chris Kreuder of the U.C. Davis School of Veterinary Medicine-Wildlife Health Center serves as a second surgeon (with two dive teams, there are often two animals under anesthesia at once), and she is doing her doctoral thesis on the epidemiology of sea otter diseases. Dr. Kreuder has a veterinary student intern with her who is getting her first exposure to wildlife medicine. The U.S. Fish and Wildlife Service's otter program coordinator, Greg Sanders, dives for the project. Staff and volunteers from University of California, Santa Cruz are doing various jobs setting up equipment, spotting potential target animals from shore, helping to handle the excited otters as well as the sleeping ones and processing blood and fecal samples.

As we push our wheeled cart with two sea otters in specially rebuilt kennels off the land end of the pier and into the cluster of trucks and two mobile veterinary labs Dr. Murray says, "If you want to anesthetize them, I'll cut on the first one, the recapture, and Chris will do the second. Then, if you can scrub in, I could use an assistant."

What this means is that since these are the 7th and 8th animals we will have done today, the regular lab crew is busy processing blood samples. Others have made a run to catch Federal Express so the delicate cultures and specimens that we have collected can be sent to the reference and research labs on time. Again, we are improvising and I'll need to be his assistant surgeon.

"O.K., this big boy weighs 40 kilos so we'll need 1 cc of fentanyl and 1/2 cc of valium," I tell the record keeper as I draw up the drugs that will make an aggressive 90 pound aquatic relative of the weasel fall deeply asleep. The narcotic fentanyl provides very good pain relief and a very quick induction (knock down) and is balanced by the excellent muscle relaxation provided by the tranquilizer valium. Valium also causes transient amnesia in many species, further reducing the potential trauma of the event. Once sedated we carefully weigh and measure the otters, extract a tiny premolar tooth for aging, tag them, take an extensive set of blood samples for as many as 8 to 10 different studies, and often other swabs and noninvasive samples, too. These samples will tell us many things about the otters' general health, contaminant exposure levels, presence of and exposure to a variety of pathogenic organisms, immune function, genetics and other health indicators. The otters are then taken inside one of DFG's 25-foot mobile veterinary labs where endotracheal tubes are placed in their windpipes so breathing can be controlled and anesthesia deepened with isoflourane.

To implant the VHF radio and time depth recorder (TDR) an incision is made just below the scar of the umbilicus (belly button). Because you can't shave the hair off the incision line (they would lose too much heat to the cold water), we scrub the area with the disinfectant betadine mixed with KY jelly and the hair is laboriously parted and combed aside. The 2-inch incision is made very carefully on the midline preserving and keeping track of all the layers of connective tissue and muscle. If the abdomen looks clean (no evidence of peritonitis from thorny headed worms), the sterile radio and TDR (both about the size of a D-cell battery) are inserted into the abdominal cavity and each of the five layers of tissue are



sutured back together with an absorbable suture material. The procedure sounds dangerous and complicated, but it is a lot like spay surgery on a dog. Hundreds of sea otters in Alaska and California have had this surgery over the last 15 years with very, very few problems. The whole operation takes about 45 minutes and heart rate, breathing, body temperature, oxygen and carbon dioxide levels are monitored throughout. When it's over the otter receives naltrexone, a narcotic reversal drug, and wakes up in a few minutes. So within an hour or so of when we first pushed them down the dock toward the vet labs, we are again pushing them back out toward to the end of the pier where a boat is waiting to take them back to where they were caught. There is one difference; we will be watching and listening to them and charting what they do for the next two to three years. If during that time they die, we will retrieve the body to find out why.

A bit of background on the sea otter

The southern sea otter (*Enhydra lutris nereis*) is listed as "threatened" under the Federal Endangered Species Act (ESA). Once thought to be extinct, the remnant Big Sur population of otters was rediscovered in the 1920s. They grew steadily during the early half of the 20th century and expanded

Photo © Mike Brock

The ultimate goal of the study is to assess the ecological limitations and health of the southern sea otter and its nearshore environment, and to gather sufficient information to foster and guide sea otter recovery.

DFG file photo

An otter is cooled off in the ocean and prepared for being raised up to the San Simeon Pier.

Frank Wilhelm, DFG fish and wildlife assistant, raises a sea otter from the boat in a net bag.

DFG file photos

Captured otter in net will be transported to the mobile veterinarian laboratory where it will be weighed and anesthetized.

their range to both the north and south. The recovery appeared to falter during the late 1970s, presumably due to incidental take in the gill net fishery. In the early 1980s after DFG restrictions moved net fisheries away from most sea otter habitats, the recovery continued. Recovery faltered again in 1995 with an approximately 12 percent decline in the ensuing four years. The overall trend of the sea otter population since 1995 has been fairly static; despite a record count of approximately 2,500 in the spring of 2003, there are only about 200 more sea otters now than there were eight years ago.

The sea otter is a "keystone species," which means it strongly influences the abundance and diversity of the other species within its kelp forest ecosystem, primarily by foraging on sea urchins and other herbivores which eat the kelp stipes and holdfasts. An imbalance in the sea otter to urchin ratio can reduce a kelp forest to an urchin barren. In the presence of sea otters and a more abundant kelp canopy, some fin fish and other kelp-dependent species may be more numerous, while most shellfish tend to be fewer in number and smaller in size. Highly prized shellfish such as abalone and Pismo clams may be particularly hard hit. Sea otters are also a very charismatic species; their antics, feeding and maternal behaviors are very attractive to people. Protection of sea otters may have the classic "umbrella species" effect. By providing a popular species with protection and habitat, some less noticeable, but nonetheless biologically important species, receive protection, too. The many relationships between the various species within these kelp forest ecosystems are quite complex and it is not entirely clear which species benefit by the presence of sea otters and which do not.

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Some small businesses catering to various facets of the tourist industry profit from the presence of sea otters. Many conservationists believe the negative impacts of sea otters on some commercial and recreational shellfish fisheries may be partly offset by more general benefits to tourism. Regardless of whether people see otters as "good" or "bad," scientists recognize that otters are a very important part of the Pacific nearshore marine ecosystem, serving as a critical sentinel species.

Sea otters as sentinels

The unique biology of sea otters makes them an excellent sentinel species, one that can tell us a lot about pollution problems and ecological changes. They are relatively local, foraging in the near shore ecosystem, usually at depths less than 25 meters, unlike seals and small whales that range widely making it more difficult to determine the sources of their exposure to contaminants or pathogens. Although male otters may range over larger areas, females generally show significant site fidelity, typically ranging along 20 km or so of coastline. Thus, the pathogens and contaminants they accumulate are more representative of those present locally rather than regionally.

Sea otters eat approximately 25 percent of their body weight per day in shellfish and other benthic (bottom-dwelling) invertebrates. These invertebrates and shellfish can concentrate and integrate a variety of chemical contaminants (like DDTs and PCBs) and biological contaminants like disease-causing bacteria and protozoa. Sea otters appear to be susceptible to a number of infectious pathogens and parasites that may origininate on land and from human sources. Shellfish may serve as an intermediary for some of these infections. Many of the shellfish otters

Photo © Bryant Austin

Sea otters eat approximately 25 percent of their body weight per day in shellfish and other benthic invertebrates.

DFG file photo

One otter comes in from the San Simeon Pier for surgery, while another goes out to the boat to be released where it was captured.

DFG file photo

Sea otters are carefully monitored during surgery.

eat are also harvested for human food and some of the organisms that we are finding in shellfish (like *Toxoplasma gondii*, *Salmonella* and *Pseudonitzchia,* a red tide algae containing the toxin domoic acid), and which cause disease and death of sea otters, are potentially serious or opportunistic human pathogens. Commercial and recreational fisheries value shellfish only if they are fit for human consumption. As a sentinel species, sea otter health has implications for human health, sustainability of some recreational shell fisheries, and overall health of the near shore marine ecosystem.

Marine ecosystem health — What sea otters are telling us

Marine ecosystem health is still a developing concept. Scientists generally agree that healthy ecosystems (marine or terrestrial) are those that do not have obvious environmental degradation, frequent pollution events or serious human-caused damage or over harvest; do not have a high frequency of new or emerging diseases/ intoxications with negative implications for human and wildlife health; have stable – or at least not declining – species abundance and diversity; and do not have frequent die-offs, particularly those involving "indicator" or "keystone" species. Overall, what we see in southern sea otters suggests their near shore California marine ecosystem may be "sick."

Previous work suggests that contaminants such as the very persistent DDT, PCBs and tributyl tin, an organometallic compound which has been used in marine paint formulations to prevent the accumulation of barnacles and slime on boat hulls, may predispose southern sea otters to dying from infectious diseases. Initial studies were quite limited in sample size and had serious spatial, temporal and age biases. The OSPR Veterinary Services Program, in partnership with the private non-profit organization CCLEAN, recently received a competitive grant from the State Water Resources Control Board to do a more definitive study of contaminants in tissues of dead sea otters.

Dead sea otters are a biased sample that can't tell us many things about the health of living animals. But, they can tell us much about what sea otters are encountering in their environment. Another study currently underway will look at contaminants in the live captured and apparently healthy sea otters. Samples from both live and dead otters are also being used to determine whether immune function appears to be normal and whether genetic problems or contaminant exposure might be fundamental to high disease rates in sea otters.

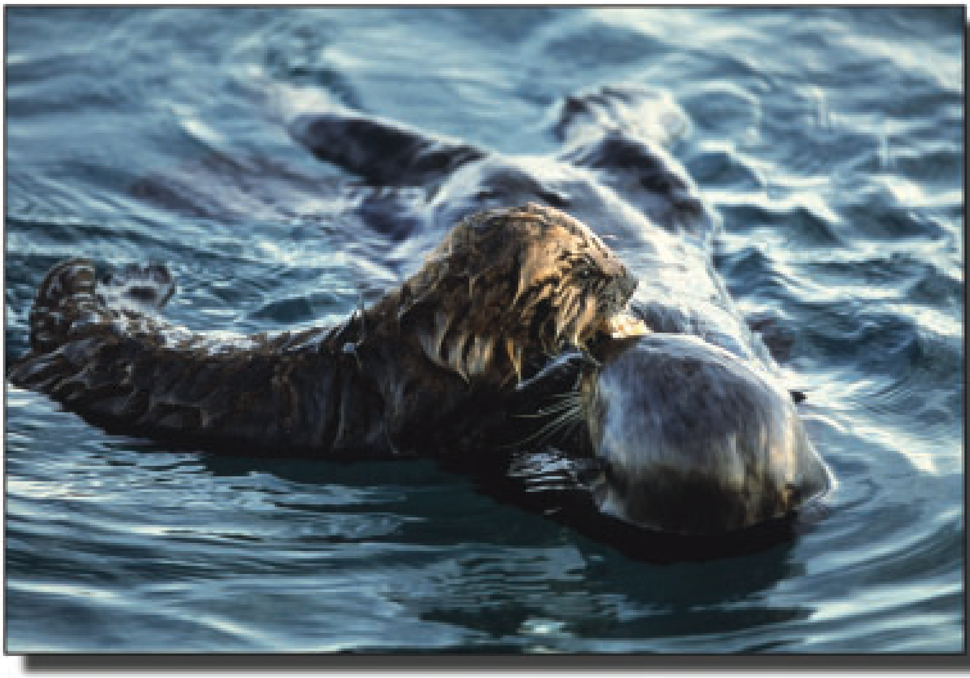
A network of state, federal, aquarium and private individuals pick up all the dead sea otters found in California and the OSPR Veterinary Services Program examines them. This can mean as many as 50 to 60 fresh dead animals are looked at annually in minute detail, and another 150 or more decomposed animals in less detail. As a result of laborious examination of dead sea otters by veterinary pathologists, several newly recognized diseases and intoxications have been identified. These include "amnesic shellfish poisoning" caused by harmful algal blooms that produce domoic acid. Coccidioidomycosis (San Joaquin Valley Fever), a soil-borne fungal disease of the lungs and other organs, has infected a small number of sea otters and cases are clustered in the southern end of their range. Soil disturbance due to agriculture and development may be the ultimate source of these fungi.

Approximately 40 percent of mortalities of freshly necropsied otters result from infectious diseases and parasites. Many of these animals are in good nutritional condition and in their prime reproductive years. Dr. Melissa Miller, a pathologist from University of California, Davis-Wildlife Health Center, has been working with DFG for five years on sea otter health and disease problems, and recently completed a doctorate on toxoplasmosis in sea otters. Her work has shown that infections with pathogenic protozoa *Toxoplasma gondii* and *Sarcocystis neurona* may be related to terrestrial runoff or human/domestic animal

pollution. Interestingly, otters that have been killed by white sharks commonly have pre-existing protozoal brain infections that probably impaired their ability to avoid predators.

Mortality due to these two organisms may be occurring at levels sufficient to preclude further recovery of the sea otter population. The first recognized cases in free-living marine mammals in California were reported in both harbor seals and sea otters in the early 1990s. The only common definitive host for *T. gondii* is the domestic cat. Humans, particularly those with weakened immune systems, can become seriously ill or die from toxoplasmosis. The opossum, another introduced species in California, is the definitive host for *S. neurona*. Infection with *Sarcocystis* is not known to occur in people but it causes a severe and usually fatal brain disease in horses. Again, sea otters act as sentinels for these pathogenic protozoa whose presence may be related to two introduced and invasive terrestrial species (cats and opossums), both associated with human activity and disturbed habitats.

As part of this research, Dr. Miller developed an immunofluorescent antibody test (IFAT) in the laboratory of Dr. Patricia Conrad at the U.C. Davis – School of Veterinary Medicine to confirm infection by the protozoal parasite *T. gondii*. IFAT has been used to screen serum from otters from California and Alaska. Results indicate



Sea otter with pup. *Photo © Bryant Austin*

DFG file photo

The sea otter fur is carefully parted for surgery.

DFG file photo

Surgical team works on an otter in the mobile veterinarian laboratory.

that 46 percent of the California otters and none of the Alaska otters have evidence of prior infection. Risk factor analysis shows locational effects (risk of exposure is increased nine times for animals in the Morro Bay area), and that fresh water input is associated with an approximately three times higher risk of exposure. The limitation of the study did not allow conclusions about sewer outfalls, but work is continuing and when completed, may allow us to understand whether storm and street runoff, sewage, or agricultural runoff are carrying the protozoa from the land to the sea. Molecular techniques are being used to compare isolates of *T. gondii* from sea otters to those from humans and other animals. This work should help confirm the sources of pathogens discovered in the marine environment, but to date isolates appear to be similar to those from humans and cats. Research done under Sea Grant funding by Dr. Kristen Arkush at Bodega Marine Lab has recently shown that mussels can concentrate the most environmentally resistant and infective stage of *T. gondii* and that they remain viable for a relatively long time.

Several types of systemic bacterial infections we have identified as causing sea otter deaths may have originally come from terrestrial habitats. In studies on the U.S. Atlantic coast, mussels, clams and oysters have been shown to concentrate protozoal pathogens that cause diarrhea in humans. If this also occurs in California, shellfish may be a source of intestinal infections for sea otters and humans. Two years ago, DFG and U.C. Davis did a small study to evaluate sea otters for certain types of intestinal protozoa and bacteria known to cause illness and mortality in humans and domestic animals. Sick humans and terrestrial animals may shed these infectious agents in their feces, and these feces could possibly end up in the near shore marine environment through sewage leaks.

Where these contamination incidents occur, the sea otter could serve as a sentinel species for "spill" detection, as it lives and feeds in the near shore marine environment and feeds almost exclusively on filter-feeding marine invertebrates, which may concentrate bacteria and protozoa. In the first phase of this study we examined fresh fecal samples from wild otters for the presence of infectious agents, including *Salmonella* spp., *Campylobacter* spp., *Clostridium perfringens* type A, *E.coli* type 0157, *Pleisomonas shigelloides*, *Vibrio* spp., *Cryptosporidium* spp. and *Giardia* spp. Most of these potential pathogens were detected in sea otters. Molecular techniques to directly compare bacterial and protozoal isolates obtained from sea otters with similar strains obtained from humans and domestic animals are underway. We have recently been awarded funds to continue this work and to expand it into the Moss Landing and Morro Bay areas *and* to do comparative work in more pristine areas. The details and implications are complex, but the bottom line is that, just as a large collaborative effort is going into understanding the ecology and health of live sea otters, a similar large collaborative effort goes into understanding the patterns and importance of contaminants and diseases and parasites of sea otters that die.

Current evidence suggests that no one single activity or organism is responsible for the sea otters problems. Several lines of evidence suggest connections to human activities. Mandates for this work include DFG Code 5650 and 5651, portions of the Marine Life Management Act, State Water Board statutes, and the Federal Endangered Species Act. We are working closely with the Regional Water Quality Control Board, other divisions of DFG, US Fish and Wildlife Service, U.S. Geological Survey, National Oceanic and Atmospheric Administration, and the Environmental Protection Agency to see that our research is translated into monitoring, policy making decisions and abatement. Conservationists have previously considered only

direct take (shooting, net entanglement and boat strike) as human-caused sea otter mortalities. But, human-induced changes in marine environments may be increasing the flow of pathogens into the system or increasing the susceptibility of sea otters to seemingly natural causes of death. From both ecological and regulatory perspectives, if human caused activities – including pathogen pollution or traditional chemical pollution from point sources or non-point sources – are shown to cause significant morbidity and mortality of sea otters at the population level, or other ecological changes, then new regulatory and management actions must be considered.

Dr. David Jessup is Senior Wildlife Veterinarian-Supervisor for DFG Marine Wildlife Veterinary Care and Research Center in Santa Cruz, CA. He was hired in 1977 as DFG's first full time wildlife veterinarian, and has worked on desert, forest and mountain species, and on marine animals and issues since 1992. He has also worked on wildlife health issues in Africa, India and Mexico; serves in a number of academic and conservation organization advisory roles; and has authored or coauthored over 200 popular or scientific articles, book chapters and publications.
For support of his current work on sea otters and marine ecosystem health he thanks the PKD Trust, Morris Animal Foundation, Oiled Wildlife Care Network, Friends of the Sea Otter, Otter Project, National Sea Grant Program, Central Coast Regional Water Quality Board, Monterey Bay Aquarium, Marine Mammal Center, U.C Davis and Santa Cruz, USFWSand USGS Resources Division.

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In the presence of sea otters and a more abundant kelp canopy, some fin fish and other kelp-dependent species may be more numerous, while most shellfish tend to be fewer in number and smaller in size.

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