Science Foundation Chapter 5
Appendix 5.1 – Case Study
North American river otter (*Lontra canadensis*)

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DESCRIPTION OF THE SPECIES

The North American river otter (*Lontra canadensis*) is a semi-aquatic mustelid endemic to North America north of Mexico (Melquist et al. 2003). River otters were abundant prior to and during the California gold rush (1848–1855) and were harvested for their pelts. By the early 1900s, the North America population had been severely reduced throughout much of its historic range, resulting from overharvest, pollution, and urbanization (Serfass et al. 1993; Larivière and Walton 1998). The California river otter has been part of this large decline. In 1961, the California Fish and Game Commission banned commercial trapping of river otters and granted Protected Furbearer status. California river otter populations likely have increased since being protected (Jameson and Peeters 2004); however, range-wide or San Francisco Estuary Watershed estimates have not occurred.

River otters exhibit sexual dimorphism, with females being smaller than males. They range in length from 900 to 1,300 millimeters and weigh 5to 14 kilograms (Johnson 2000). Both sexes mature around age 2, but do not become prime breeders until age 4 or 5 (Hooper and Ostenson 1949). In the Sacramento Valley, mating is thought to occur spring through fall (Grinnell 1937), with females commonly gestating annually. Exactly when fertilization and embryonic development begins is unknown (Hooper and Ostenson 1949), and the species exhibits delayed implantation. Gestation lasts 10 to 12 months and typically results in 1 to 5 pups. Life expectancy ranges from 12 to 15 years. Based on life expectancy and gestation length, estimated fecundity ranges from 10 to 50 pups per female over a lifetime. Juvenile to adulthood survival has not been studied.

River otters are opportunistic predators (Mason and Macdonald 1986) that forages near the apex of the trophic pyramid, and thus readily accumulates high levels of pollutants (Clark 1981; Halbrook et al. 1996; Duffy et al. 1993, 1994; Ben-David et al. 2001a, 2001b). Its diet exhibits high seasonal variability. River otters consume 15 to 20 percent (1 to 1.4 kg, or 2 to 3 pounds) of its body weight daily (North American River Otter Husbandry Notebook 2008). On average, one river otter consumes between 365 to 511 kilograms (730 to 1,095 pounds) of prey per year.

Fish are its most important prey (Cote et al. 2008; Penland and Black 2009), especially in winter (Grenfell 1974), and this includes a high composition of salmonids (Modafferi and Yocom 1980; Durbin 1997; Ludwig et al. 2002). On Redwood Creek in California's Humboldt County, fish reportedly were the primary prey in freshwater and estuarine summer diets, occurring in 86 percent of 51 freshwater scats and 81 percent of 36 estuarine scats (Reeves 1988). River otter predation is higher on stocked and hatchery-reared trout than wild trout (Berg and Jørgensen 1991; Yom-Tov et al. 2006), and it is known to decimate hatchery releases (Knudsen and Hale 1968). Planting o introduced fishes (*Oncorhynchus* spp.) and non-native crayfish (*Pacifastacus* spp.) in high mountain lakes (greater than elevation 1,100 meters) likely facilitated the expansion of the river otter's range by supplying new prey sources (Garwood et al. 2013).

River otter also consume reptiles (Manning 1990), birds (Albertson and Evens 2000; LSA Associates 2000), and amphibians, insects, and plants (Grenfell 1974). Clapper rail eggs (Albertson and Evens 2000), terns and gulls (Duffy 1995), and brown pelicans (Salman 2007) are recorded avian prey. In San Francisco Bay near Rodeo, the fall diet was dominated by brown pelicans, with the winter and spring diet composed of fish (Salman 2007). Otters that live near the ocean appear to rely more on rock crabs and nearshore benthic fish; whereas those living near bays and rivers may rely more on other types of fish.

River otter is highly mobile. Movements of more than 4 kilometers per day (km/day) are common, and individuals are known to move up to 42 km/day (Melquist and Hornocker 1983), with females known to disperse 60 to 90 km (Blundell et al. 2002). It requires riverine and/or estuarine, riparian, and even marine habitats to forage, disperse, and raise young. Isolation by distance is the main mechanism for genetic divergence in river otter, in both freshwater and marine ecosystems (Latch et al. 2008; Seymore et al. 2012). Terrestrial habitats, however, are limited to within 30 meters of water, although dens have been reported up to 0.8 km inland (Allen and Mortenson 2011). Dens can be subterranean, in tree stumps, in large woody debris accumulations, or in similar protective habitats that provide cover from predators and weather. Shore-based habitat is influenced by den characteristics, preferably dense brush, riparian, or forest lands to avoid predators. Predators in the San Francisco Bay Area may include coyotes, bobcats, mountain lions, and domestic dogs. Blundell et al. (2002) suggests that predation pressure for river otters is low and not likely to vary seasonally.

CRITERIA FOR SELECTION OF THE SPECIES

As an apex predator, river otter is a proven indicator of overall watershed health (Lunnon and Reynolds 1991; Kruuk 1995; Larivière and Walton 1998; Elliot et al. 2008; Black 2009; Mowry 2011) and can be used to monitor the effects of climate change in the Baylands and elsewhere. Its absence in specific areas of watersheds has been associated with a decline in water quality and the presence of chemical contaminants (Mason and Madsen 1993), while its presence has been correlated with undisturbed and unpolluted habitat (Prenda et al. 2001). River otter habitat is vulnerable to aspects of long-term change, especially sea level rise, and to elevated water and ambient temperatures. Its prey also will be affected by these factors, with some species of prey additionally vulnerable to the effects of ocean acidification.

OTHER INFORMATION ABOUT THE SPECIES

River otter is found in the Central, South, and San Pablo bays, Carquinez Strait, Suisun Bay, and most tributaries in the Baylands. Both Marin County and the Grizzly Island Wildlife Area report having the largest populations in the San Francisco Estuary Watershed. River otter range and population appear to be increasing in the Baylands (see http://www.riverotterecology.org/otter-spotter-interactive-map-of-bay-area-sightings.html). The species inhabits virtually every creek and reservoir, but favors water treatment plants and any location with plentiful juvenile salmonids (SFgate.com 2012). In January 2013, a river otter dubbed "Sutro Sam" began inhabiting the Sutro baths on the beach in San Francisco, being the first river otter seen in the city in decades. Otter crossing signs have been recently posted in Marin County because of incidences of river otters being struck by motorists. Anecdotal observations support the belief that the river otter population in the Baylands has greatly increased and expanded.

REVIEW OF CLIMATE CHANGE EFFECTS ON THE SPECIES

Evolutionarily, global climate change may affect animals in two opposite ways: those sensitive to heat may have a decrease in body size, as predicted by Bergmann's rule; shorter and warmer winters may save energy on maintenance and increase food availability, and consequently may affect body size (Yom-Tov et al. 2006).

Aquatic mammalian carnivores can inflict major predation effects on fish and invertebrate populations. Mammalian carnivores are endothermic, requiring them to consume far more prey on a per-capita basis than their predatory fish counterparts. Therefore, in addition to their population densities, the individual diet preferences of mammalian carnivores can strongly affect their impacts on particular prey species in any given time and place (Tinker et al. 2008).

Potential regional effects of climate change on river otters include: 1) effects on denning habitat caused by changes in sea level rise and shoreline vegetation; and 2) changes in prey abundance and species composition. River otters are eurythermal, ranging from colder, temperate marine, and mountain streams to warmer lowland streams and estuaries. They appear euryhaline and seem to tolerate a wide range of salinities because marine-dwelling otters have been documented throughout their distribution.

River otters are tethered to habitats near water bodies, and their dens usually occur within 30 meters of water. Consequently, any change to sea level rise has the potential to alter the availability of den habitat upslope. If upslope habitat lacks dense vegetation for denning, then river otters are unlikely to remain in an area. Predator avoidance is one reason for its residing in dense vegetation when onshore.

River otter feed on a wide range of prey, but fish and invertebrates are its dominant food sources. Any change in nearshore fish and invertebrate abundance or composition has the potential to affect otter presence and may cause otters to leave an area, if insufficient food is available to support the otters and their young. Although otters will eat a wide range of prey, high caloric content is important for sustaining gestation and nursing young.

Monitoring the presence of pathogens and trends in pathogen prevalence over time is important in studying the health of an ecosystem and the effects of climate change. Changes in pathogen prevalence and the emergence of new diseases in sea otters (*Enhydra lutra*) have been associated with large-scale stressors in the coastal ecosystem of California, including: increased pathogen presence and runoff into waterways from domestic animal hosts; increased host vulnerability to disease because of prey availability; and diminished water and habitat quality from human development and discharge (Conrad et al. 2005; Johnson et al. 2009).

FACTORS THAT MAY AFFECT SPECIES RESILIENCE

River otter resilience is probably low. Small planktivorous fish are a vital link in the nearshore marine and estuarine food chain, and when populations decrease, it affects the fish, birds, and mammals that depend on that species assemblage for food. These small schooling fish species are predicted to decline with changes in climate regionally (see section on estuarine and marine fishes). Sea level rise likely will eliminate or shift den distribution, which will redistribute the river otter population farther upstream into the Delta, along Sacramento and San Joaquin rivers and tributaries.

LIKELY CLIMATE CHANGE IMPACTS AND RISKS

Changes in the salinity distribution during winter can have a large impact on early survival and subsequent recruitment, on prey such as salmonids, striped bass, Pacific herring, threespine sticklebacks, gobies, and catfish. River otters exhibit strong, individual-level prey specializations (Ben-David et al. 2004; Tinker et al. 2008), yet little is known about the diet of these carnivores in California or the Baylands on either a population or individual level (Grenfell 1974). Nevertheless, river otters are documented to eat a diverse diet and may switch prey when preferred prey are depleted, as likely occurred in Rodeo Lagoon when fish-eating otters switched to eating waterfowl and brown pelicans (Fong, pers. comm., 2006 in Salman 2007). Impacts from climate change most likely will be associated with the redistribution of denning habitat and prey availability.

MANAGEMENT ACTIONS TO BE CONSIDERED

Increasing global temperatures correlate with trends of rising sea levels, and a greater variation in climatic events (Patz et al. 2005) could result in further isolation of coastal populations of semiaquatic animals, especially in heavily fragmented and urbanized coastal regions (Seymour et al. 2012) like the San Francisco Estuary Watershed. Sea level rise, habitat degradation, pollution (Guertin et al. 2010), and emergent diseases (Gaydos et al. 2007) may increase loss of genetic diversity.

Management actions for river otters should be based on current knowledge of distribution, population estimates, age structure, and sex ratio. Based on the scant information available, the following management actions are recommended in the San Francisco Estuary Watershed:

1. Develop a current distribution map to establish baseline conditions, using best available science, citizen monitoring groups, phone outreach efforts, and ground-truthing.
2. Assess population genetic structure, connectivity, and genetic effective population size, using standard methods. Is the recent increase in river otter population observed in the Baylands related to high juvenile survival or a shift in distribution resulting from poor upstream habitat and water quality in the Sacramento-San Joaquin rivers and Delta and the low prey to predator ratio? Investigate otter seasonal diet and predatory impact on ESA-listed juvenile Chinook salmon and Delta smelt using scat samples and otoliths from fish prey via strontium isotope analysis. Analysis of otoliths from scat samples could be used to determine predatory impact of river otters on wild versus hatchery-reared juvenile salmonids across spatiotemporal scales.
3. Analyze pathogen (cestodes, trematodes, nematodes, *Toxoplasma gondii,* Cryptosporidium, Vibrio) composition and abundance from scat samples to determine baseline river otter health and related water quality. Monitor changes in pathogen loading to identify shifts in host populations and exposure (e.g. decrease in *Schistocephalus solidus* associated with a decrease in fish populations).
4. Analyze contaminant (Organochlorine pesticides, PCBs, PBDEs, and PAHs) content from scat samples. Map the distribution of the contaminants to identify potential sources and cleanup sites, and restoration projects. The San Francisco Estuary Project recommended using the river otter in the Bay-Delta system as a watershed sentinel species, especially with regard to contaminates exposure.
5. Analyze fish scales and hair found in scat for total mercury (as a proxy for methyl mercury) and map concentrations across spatiotemporal scales. River otter hair found in scats will estimate total mercury concentrations.

6. Analyze the *Microcystis* presence from scat samples. Map the distribution of the contaminants to identify potential sources and cleanup sites, and restoration projects.
7. Take river otter predation into account when stocking is used as a measure for conserving endangered salmonid populations (Jacobsen and Hansen 1996). Investigate the relationship between the increase in the river otter population in the Baylands and recent changes in hatchery-reared juvenile Chinook salmon release sites in the Baylands.
8. Using EIAs, analyze estradiol, testosterone, and corticosterone metabolites in scat samples to understand the stress and reproductive health of the river otter population. Compare individuals living close to wastewater treatments plants and other discharge sites with those living in rural, undeveloped, and protected watersheds (e.g., Mendocino and Humboldt counties).
9. Consider habitat restoration in areas upslope of habitats where river otters currently occur but are at risk for sea level rise. Restoration may include planting dense vegetation for predator avoidance or addition of large woody debris as potential denning habitat. If suitable habitat is not available upslope, then land acquisition may be an alternative approach for creating habitat.

UNCERTAINTY AND KNOWLEDGE GAPS

The size and health of the river otter population is unknown. The distribution of river otters is relatively unknown. They currently are being observed in streams, ponds, and on beaches where they previously have not been observed or have been absent, indicating an increase, shift, or both in population.

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