

Chapter 9. Implementation and Logistical Considerations

J.L. Bodkin and M.T. Tinker

Introduction

Based on a review of the history of sea otter translocations (Chapter 2), and our current combined knowledge and experience with the capture, holding and transport of sea otters, we have prepared an analysis of two general strategies for the reintroduction of sea otters to the waters of Oregon. One follows the strategy employed by all but one historic reintroduction and consists of the simultaneous release of groups of animals into vacant, but previously occupied exposed or semi protected coastal habitats (Jameson et al. 1982). The other strategy follows a recently-described procedure of sequential reintroduction of single or small groups of sea otters over several years into an estuary (Mayer et al. 2019)¹. We wish to emphasize that these two strategies are not mutually exclusive, and a combination of the two may be most appropriate. For each strategy we provide the underlying rationale and discuss the pros and cons. The presentation of alternative strategies is intended to provide a broad range of possibilities to consider. We begin by describing factors that should be considered when selecting a release site, followed by a review of alternatives for selection of source or donor populations.

Depending on release strategies and source population alternatives, the capture/holding and transport, and to some extent, release and monitoring protocols may differ. Those differences and similarities will be presented and discussed in each release strategy and source population alternative.

Various factors require consideration in evaluating the potential suitability of release sites for successfully reintroducing sea otters into Oregon, either along the open coast or into estuarine habitats. These include: 1) suitable and appropriate habitats, 2) availability of appropriate and sufficient prey, 3) access to suitable resting habitats, either protected waters or canopy forming kelps, and 4) refuge from disturbance or sources of injury or mortality. We will briefly consider each of these habitat requirements in the discussion below, as is related to potential sea otter release strategies: a more comprehensive assessment of habitat suitability is provided in Chapter 6 of this report.

The present distribution and abundance of sea otters in the coastal north Pacific suggests that all coastal habitat types less than about 50 m in depth represent potential habitats for sea otters, but also that all habitat types do not support equal densities of sea otters. It has generally been regarded that exposed rocky reef habitats support greater densities than open coast sand coastlines (Kenyon 1969, Riedman and Estes 1990), with reported densities in rocky habitats in California more than 5 times greater than along sandy shoreline (Laidre et al. 2001, Tinker et al. 2021). However, relatively high densities of sea otters can be found in mixed substrate habitats, particularly along complex shorelines that provide sheltered habitats, including bays, lagoons, sounds and estuaries. Examples of such include Kachemak Bay, Prince William Sound, Izembek Lagoon, and Glacier Bay in Alaska, and Barkley Sound in British Columbia (Bodkin 2015). Sea otter densities along high energy, sandy shores typical of much of Oregon and Washington are generally lower than densities in other coastal habitats (Kone et al. 2021, Tinker et al. 2021), and may represent a less-preferred habitat type. It should be recognized that even in these less-preferred habitats, high sea otter densities may be achieved during the process of colonization

¹ The published example of estuarine release was Elkhorn Slough, an estuarine habitat in California that was already occupied by sea otters (although these were mostly male otters and at a density well below the local carrying capacity), and which therefore might reflect a different outcome than a similar release to an unoccupied estuary in Oregon.

resulting from elevated prey abundances achieved during the otters' absence, but that otter densities may subsequently become reduced as the highest quality prey become depleted. It is also worth noting that there is historical evidence from the fur harvest records that sea otters may have been relatively less abundant along the Oregon coast than either further north or south (Ogden 1941), although a more recent analysis by Kone et al (2021) suggests that Oregon coastal habitats could still support over 4000 sea otters.

Our primary goal in this Chapter is to identify options for reintroduction of sea otters to Oregon that will maximize the potential for the successful establishment of a self-sustaining population (Chapter 3) while minimizing potential conflicts with humans over competition with sea otters for marine resources (Chapter 7) and potential threats from human activities.

General Strategies

Open Coast. Traditional open coast release site(s) with on site, short-term holding pens.

Historically, most sea otter reintroductions were comprised of animals captured, transported, and released into exposed or semi-protected ocean coastal habitats where sea otters had occurred historically but had been absent for decades to a century or more (see Chapter 2). In part, this approach resulted from the fact that the only sea otters that survived the maritime fur harvest occurred in small groups along open exposed coastlines where human harvest may have been somewhat restricted. This strategy of exposed capture locations in early reintroductions was thus largely predicated on where surviving populations persisted, which created the perception of sea otters as an “exposed open coast” species. The rationale used to determine exactly where translocated sea otters would be released is less clear from historical information and published accounts. In most, if not all cases, logistics based on methods of transport would appear to have dictated feasible release locations.

Despite the failure of the initial reintroduction of sea otters to Oregon, suitable habitat for sea otters exists over much of the Oregon coast, although not all habitats in Oregon should be considered equivalent (Jameson 1975, Kone et al. 2021). Much of the north coast of Oregon consists of exposed sandy beach habitats that are likely to support low densities of sea otters. Prevailing thought and literature consider rocky reefs with canopy forming kelps as preferred habitats, supporting relatively high densities (4 - 6 otters per km²) of sea otters (Laidre et al. 2001, Tinker et al. 2021). Additional habitats include exposed unconsolidated substrates (sand or cobble shores) and protected estuarine habitats. Kone et al. (2021) suggest that the Oregon coast could support about 4,500 sea otters (range 1742 – 8976), with most of those along the outer coast in rocky reef habitats, but with more than 650 occurring in estuaries. Spatial and temporal variation in the potential densities of otters that could be supported in each area is likely related to differences in prey availability and productivity, as well as differences in access to sheltered habitat (e.g., kelp beds, nearby estuaries) for resting and pup rearing. Based on other reintroductions and examples of sea otter recovery, achieving carrying capacity in Oregon will be a prolonged process as sea otters demonstrate high fidelity to small home ranges and affinity to conspecifics. More detailed analyses are provided elsewhere in this report of the dynamics of population growth and recovery (Chapter 3) and habitat suitability along the Oregon coast (Chapter 6).

Perhaps the primary lesson to be learned from the history of past reintroductions is that a relatively small percentage of sea otters are likely to stay or become quickly established near where they are released (see Chapter 2). This was the case in the initial Oregon release, but also in all other open coast release attempts (excepting perhaps portions of southeast Alaska), despite the presence of abundant

and preferred prey and proximity to established kelp beds. It may be possible to improve retention of sea otters near release sites through temporary holding in large anchored net pens, although this technique has not been fully demonstrated. Animals at San Nicolas were initially held in anchored net pens, in an attempt to achieve improved retention, but deteriorating sea condition required premature release. Any open-coast “soft release” of sea otters using net pens is likely to be exposed to harsh and unpredictable sea conditions, and thus should be carefully considered.

It also seems likely that prior reintroductions to outer rocky coasts consisted of animals that had strong affinities to the home range they were removed from, although there is little data on age and sex composition in most reintroductions. This is evident from the rapid diminishment in abundance post release, and the resighting of marked animals that returned to original capture locations in an experimental relocation within California (Odemar and Wilson 1969) and again later during and following the San Nicolas Island translocation (Rathbun and Benz 1991, Rathbun et al. 2000, Carswell 2008). Evidence of a similar trend of post-release movements presented in Southeast Alaska, where southern reintroductions diminished in numbers while in the north numbers increased and population growth occurred shortly after the final reintroduction (Pitcher 1989, Esslinger and Bodkin 2009). It may be possible to improve retention through the selection of juvenile sea otters before they establish home ranges or establish long term social bonds. Such an approach has proven feasible in estuarine habitat through the surrogate rearing of stranded pups in California (Mayer et al. 2019), but has not been tested in open coastal or unoccupied habitats.

The general strategy that has proven most successful in establishing open coast populations of sea otters has been the release of large numbers of individuals at multiple release sites over several years. This is best exemplified in the reintroduction of 403 sea otters over 5 years into 6 separate areas of southeast Alaska (Esslinger and Bodkin 2009) that ultimately resulted in 3 or possibly 4 distinct populations across coastal Southeast Alaska. Annual rates of increase by 1987-88, about 20 years after the final reintroduction, averaged about 20% per year, and total abundance had approached 5,000 sea otters (Pitcher 1989, Tinker et al. 2019a). It is possible that the loss rate to emigration or mortality in the southeast Alaska reintroductions may have been less than in the more southern efforts, as animals dispersing from one release site may have encountered otters from another release. It is also possible that high reproductive output of animals at some release sites compensated for lower survival at others, thus explaining early increases in regional abundance. Unfortunately, lack of detailed post-release tracking of animals in southeast Alaska makes it impossible to assess either of these hypotheses with certainty.

Estuarine. Longer term temporary estuarine holding facility at release site

Broadly defined, estuaries are partially enclosed and protected bodies of water that interface the oceans sea water, with the fresh water that drains the continents. Such habitats occur throughout the sea otters’ range in the North Pacific. Because no populations that occupied estuaries survived the fur harvest, early work describing sea otter habitats (Barabash-Nikiforov 1947, Kenyon 1969) focused on open coast habitats, largely failing to recognize estuaries as important to sea otters. However, archeological evidence obtained from estuaries in Oregon and Washington (Moss and Losey 2011) and San Francisco Bay (Broughton 1994) identify sea otter as a predominant marine mammal remain in estuarine habitats, thus establishing estuaries as suitable and historically important habitats (Silliman et al. 2018). As sea otters have expanded their distribution through recolonization and translocation, we find they have occupied such habitats as they are encountered (Kvitek and Oliver 1988). These include

small estuaries, such as Clam lagoon on Adak Island in the Aleutian archipelago (Tinker and Estes 1996), Izembek Lagoon, one of Alaska's largest estuaries (384 km²) on the Alaska Peninsula, Orca Inlet in Prince William Sound (Bodkin et al. 2002, Coletti 2006), and Glacier Bay in SE Alaska, which supports in excess of 10,000 sea otters (Tinker et al. 2019a). As sea otters have expanded their range in California, they too have occupied the estuaries in Morro Bay and Elkhorn slough (Hughes et al. 2019), and Hughes et al. (2013) describe the role of sea otters in restoring the health of eelgrass beds in this estuary. Most recently, the Monterey Bay Aquarium with assistance from collaborators merged the complementary objectives of the rescue and rehabilitation of stranded juvenile sea otters, with the reintroduction of those animals into under-utilized habitat into the Elkhorn Slough within Monterey Bay (Mayer et al. 2019). This work in Elkhorn slough provides example of a previously unused strategy for release of reintroduced sea otters that potentially increases the low retention rate observed in most open coast releases.

Estuarine habitats clearly can provide suitable and abundant prey as well as adequate resting and pupping habitats (Eby et al. 2017, Espinosa 2018, Hughes et al. 2019). In addition, in some situations they can provide refuge from some large marine predators, such as killer whales (Estes et al. 1998) and possibly large sharks (Tinker et al. 2016). The recognition of estuaries as important sea otter habitat, and the success in supplementing an estuarine population using small numbers of rehabilitated juveniles, should be considered in reintroducing sea otter to the coast of Oregon. The details of the Elkhorn Slough reintroduction are important and distinctions from open coast releases require consideration. First, Elkhorn Slough had already been occupied by sea otters for several decades at the time that the reintroduction of juveniles began, although in numbers that were well-below carrying capacity (Tinker et al. 2021), and mostly by males with no intrinsic reproduction (Mayer et al. 2019). This example suggests that the presence of sea otters where releases occur may provide incentive for newly released individuals to remain. If this is true, then efforts to establish some presence of sea otters at a proposed release site may be facilitated by the enclosed nature of the estuary compared to the open coast, perhaps using net pens or other enclosures as a temporary measure to encourage residence. Second, it must be noted that the success of the Elkhorn Slough reintroduction required the recapture of most animals, for health or behavior reasons, some up to 4 times (Mayer et al. 2019). Thus, the ability to recapture animals that display stress or aberrant behaviors may be essential when translocating surrogate raised pups. Recapture is much more feasible in the protected waters of an estuary compared to the open coast. It may be possible that a captive population in a large, enclosed area within an estuary might mimic this situation.

Demographic considerations

Establishing the number and source of sea otters, as well as their age and sex composition and release sites in Oregon, will be critical in formulating a reintroduction plan. A web-based tool for evaluating many of these variables has been developed as part of this feasibility study (ORSO, Oregon Sea Otter Model), and is described in Chapter 3 (and see Appendix A). To demonstrate the feasibility of a proposed reintroduction plan, we somewhat arbitrarily consider a target of achieving an average population abundance of 200 animals after 30 years, with a 90% probability of at least 50 individuals by this time. Using the ORSO web app, we show that this might be achieved using a strategy of two release sites – one open coast site near Port Orford and one estuary site in Coos Bay – with an initial introduction of 50 animals near Port Orford and 25 individuals in Coos Bay, and supplementary additions of 3 juveniles per year for 10 years following the initial release. Another possible release strategy could

entail successive reintroductions with close monitoring of numbers, movements and age and sex composition to determine when and where subsequent release occur, until the desired founding population size, distribution, and growth rate is achieved. Such a strategy could (and should) incorporate a range of inputs and considerations from a broad base of relevant stakeholders and community groups.

We note that there are several demographic and logistical considerations that should factor into a decision of one vs. multiple release locations. Clearly there would be greater logistical and financial costs associated with multiple release sites, which argues in favor of a single location. On the other hand, multiple release sites might act as an insurance policy against failure of one of the releases, thereby reducing the overall failure risk of the reintroduction program. Perhaps more importantly for the long-term success of a reintroduction is the fact that having two or more “nodes” of population growth can greatly increase the overall rate of population recovery, due to the combination of local density-dependent population regulation and the limited potential for range expansion in sea otters (Tinker 2015). This phenomenon is perhaps most clearly demonstrated by the rapid rate of recovery in southeast Alaska, which was facilitated by having several spatially distinct nodes of population growth, resulting from multiple release sites (see Chapters 2 and 3 of this report, and Bodkin 2015, Tinker et al. 2019a). The demographic consequences of multiple nodes of population growth may be even more dramatic in the case of a narrow, “one-dimensional” coastline such as Oregon or California, where the rate of population growth and range expansion is constrained by the linear configuration of habitat (Tinker 2015). At the same time, the potential for more rapid growth and colonization must be weighed against the potential social and economic impacts at the different prospective release locations (see Chapter 7 of this report).

Source population considerations

Several options for source populations for reintroduction to Oregon exist, including Southeast Alaska, Washington, and California. Each of these, singularly or in combination, will entail consideration of existing state and federal law (Chapter 8), implications for source populations and their management (Chapter 3), population genetics (Chapter 4), as well as logistical factors. In the following paragraphs we consider primarily the logistical considerations but include relevant information on history and biology of source populations wherever beneficial. Note that, because of legal complexities associated with transporting sea otters across international boundaries, we do not consider British Columbia sea otters as a likely source population, despite their abundance (> 8,000) and proximity to Oregon. Other than these administrative challenges, we note that sea otters from British Columbia would seem to be highly suitable as a source for reintroduction to Oregon.

Sea otters that reside in Washington would appear to provide the most immediate source for the open coast reintroduction to Oregon, based on their abundance, proximity, and state protected status, and under the assumption that the state of Washington and the USFWS would be cooperative. Washington sea otters currently number approximately 3,000 individuals and occupy about 100 km of coastline south of Cape Flattery. Their long-term rate of change is approximately 10% annually (Jeffries et al. 2017), a rate reduced from the early years of recolonization (Bodkin et al. 1999) but continuously positive. Annual removals of 100 individuals would represent approximately 3% of the population and 33% of the annual growth increment in the Washington population, sufficient to have a measurable impact on growth but probably not sufficient to cause a decline (see Chapter 3 for a more in-depth analysis). Transportation of animals captured in Washington would be relatively straight forward and consist primarily of transport by air-conditioned vans or trucks from a port such as La Push to temporary

holding facilities in Oregon (see below) via interstate highway. It is also likely that the habitats occupied by sea otters in Washington most closely resemble those that sea otters will experience in Oregon. However, sea otters in Washington presently occupy habitats that are often exposed to sea surface conditions that render capture difficult and possibly hazardous to both otters and humans. This could result in a prolonged effort to capture the targeted number of animals. In addition, the proximity of a release site to animals captured in Washington may serve to encourage sea otters to return to their home range. The potential for this latter eventuality is speculative, but suggested by some prior translocation efforts within their established range in California (Odemar and Wilson 1969).

It is also possible that the state of Alaska would be a willing donor of sea otters to a reintroduction effort into Oregon. Southeast Alaska likely supports 30 - 40 thousand sea otters in 2020, occupying 1000's of km of coastline (Tinker et al. 2019a): annual removals of 100 animals would have no measurable effect on population viability at the regional scale, and would also be sustainable at a sub-regional scale depending on specific locations of captures (see Chapter 3). Transporting a large number of sea otters to Oregon from Alaska would entail additional effort requiring the use of air transport, and thus additional costs. However, the abundance of sea otters and protected nature of the habitat occupied in Southeast Alaska would likely entail reduced capture effort and risks, possibly offsetting higher transportation costs. It may also be possible, based on population abundance and distribution, to target and capture mostly subadult sea otters in Southeast Alaska from habitats that are qualitatively similar to the habitats at proposed release sites in Oregon, thereby maximizing the potential for retention of animals near release sites. Further, the state of Alaska may be more likely to support sea otter removals to support the Oregon effort if they help achieve local resource management objectives (e.g., removing sea otters from localized areas that support valuable shellfish resources for subsistence or commercial fisheries). If so, a multi-state collaboration could increase availability of crucial resources needed to implement the capture and translocation of animals.

Animals residing in Washington and Southeast Alaska appear to have readily adapted to the habitats, prey assemblages and environments along those coastlines, based on long term positive rates of increase in abundance. It is expected that animals from either source would encounter similar conditions in Oregon, although Oregon and Washington share more similar, open coastlines with relatively little coastline complexity compared to Southeast Alaska. One additional difference between Washington and southeast Alaska, is that southeast Alaska (and British Columbia) originated from two donor populations, Amchitka Island and Prince William Sound, in the Gulf of Alaska. This mixing of donors resulted in increased genetic diversity, the highest measured for any extant sea otter population (Larson et al. 2002, Larson et al. 2012), to some extent restoring genetic diversity lost as a consequence of the population bottlenecks induced by the Maritime fur trade (Bodkin et al. 1999, Larson et al. 2015). Thus, the use of southeast Alaska as a source population might best achieve goals of maximizing genetic diversity near the southern end of the sea otter's distribution (Chapter 4).

Given the ESA listing and demographic status of sea otters in California, it seems likely that taking a large number of animals annually (~ 100) from the population adequate to establish a viable population in Oregon would likely have measurable negative impacts on the conservation and recovery of the California population, depending on where the captures were conducted (see Chapter 3). However, depending on the preferred release strategy, a case could be made for inclusion of some sea otters from California based on at least two considerations. First, sea otters that resided historically in Oregon, or at least the southern half of the state, appear to have been more closely related genetically to southern

sea otters (see Chapter 4). As a result, including a genetic component of California sea otters into Oregon would likely aid in the recovery of lost genetic diversity that resulted from the Maritime fur trade. This would theoretically provide future benefit to sea otters in both California and those further north, as Oregon could become a bridge that would reunite the long-fragmented sea otter species (Larson et al. 2012, Larson et al. 2015, Wellman et al. 2020). In turn this may eventually benefit sea otters isolated in California by restoring some portion of their lost genetic diversity. Inserting a California genetic component into an Oregon reintroduction could be accomplished through a relatively small number of animals contributing to an Oregon reintroduction. On the other hand, mixing source populations would also add considerable legal and administrative complications (refer to Chapter 8). It is perhaps worth noting here that a regionally coordinated strategy that might achieve the same genetic benefits while avoiding some of the legal complications could involve pairing an Oregon reintroduction using northern sea otter source with a northern California reintroduction using a southern sea otter source, thereby allowing for future mixing of these genetic stocks.

The second consideration relates to the potential inclusion of surrogate raised stranded pups into a Oregon reintroduction strategy. Such a strategy would depend in part on the number of stranded sea otter pups that can be accommodated in existing long-term facilities in California and Oregon. Assuming that the methods described in Mayer et al. (2019) of using surrogate females to rehabilitate and prepare stranded sea otters for release into the wild would achieve similar success in Oregon, using such juveniles could relieve the strain of surplus stranding's in California, that at times requires sea otter pups and juveniles to be euthanized. If an estuarine release strategy is employed in all, or in part, in Oregon, those surrogate reared and rehabilitated pups would accomplish; 1) reducing euthanasia of sea otter in California, 2) demonstrating a mechanism for stranded pups in other US and possibly Canadian populations to contribute to the Oregon population, 3) aiding in the recovery of lost genetic diversity within sea otters, potentially across much of their range in the eastern Pacific, and 4) potentially improving the retention of rate of reintroduced sea otters to Oregon beyond that expected based on past translocation efforts.

In the following text we will present options for the capture, transport, holding and release of animals into the coastal waters of Oregon. This would require a sizeable, but not insurmountable level of effort and cooperation from state and federal governments and their agencies that have management responsibility for sea otters. It would also require consideration of the many potential and reasonably anticipated implications to source populations, and the social, economic, cultural, and ecological effects in Oregon that are considered elsewhere in this study.

Capture

There are three different methods used to capture living sea otters: 1) with handheld dip nets on land or in water, 2) with tangle nets that are set near concentrations of sea otters, and 3) with diver operated traps from below the sea surface (Wild and Ames 1974, Ames et al. 1986). We will discuss the benefits and liabilities associated with each of these methods. It should be recognized that the capture of sea otters is highly regulated requiring federal and in some cases state permits. Permittees are required to establish knowledge, skill and experience in the safe capture and handling of sea otters. The potential for injury or death exists to the sea otter during capture although probability varies among methods (discussed below). Additionally, capture and handling presents potential serious injury to those involved in capturing sea otters. No one should attempt to capture or handle a sea otter without appropriate training, experience and permitting.

Dip Nets: Large, commercially available dip nets can be used to capture sea otters either hauled out on land (rare) or on the sea surface. In general, capturing of sea otters on the water is restricted to naïve, juvenile sea otters that fail to evade capture. Capture is usually attempted from a small (17-20') skiff with a 50-100 hp outboard motor, with a team of two persons, one operating the vessel, and another on the bow with the long-handled dip net. Because juveniles occasionally loosely aggregate in open water, individuals can be rapidly approached and occasionally simply dipped out of the water before they dive. If they do dive, and the sea surface is relatively calm, they can be followed as they swim underwater either visually, or by tracking the air bubbles that are released as they descend, that float to the surface (this is a technique developed by Aleuts to hunt the sea otter, although without the outboard motor). If the otter does not dive too deep, they may be followed visually, or as they ascend while swimming to gain a breath. Once an animal is captured, they are brought aboard the vessel and placed in a net bag within a "capture" box that can be used for transport (Figure 9.1). This technique has been successfully used to capture sea otters for research purposes as well in the recent translocation to San Nicolas Island. One advantage to dip-netting is that the equipment is rather simple and requires only 2 persons. It may also have the advantage of targeting relatively young sea otters, that may be more likely to remain near their translocation site. In California and Alaska, typical weights of dip-netted sea otters were approximately 15-25 lbs. (often recently weaned pups), and if juvenile sea otters are a



Figure 9.1. Capture box used for the short-term holding and transport of sea otters to and from the capture site

target age group, some individuals may be captured this way. There are at least three potential disadvantages to dip netting. One is that catch rate can be relatively low, perhaps 0-4 animals/d per team under good conditions; the second is the method can be stressful to the otter if pursued for more than a few minutes and, in rare circumstances, collisions with the capture vessel may occur, with serious

injury or death possible; and third, the method requires relatively calm seas and clear waters where resting sea otters can be observed from afar and followed underwater while being chased.

Tangle Nets: Floating tangle nets represent the tool most likely responsible for a large majority of sea otter captures during translocations and for research in the 20th century. Tangle nets are typically 330' in length, about 9-15' in depth, constructed of #15 mono-filament line with a 9 1/4" stretch mesh size, commonly adapted from commercial king salmon fishing gear. Nets are kept afloat with a "cork-less" foam core float-line of 1 1/2" diameter along the length of the net and a #20 lead core lead-line. It is important that the "lead" line be heavy enough to sink and light enough so that a sea otter that becomes tangled below the surface can easily return to and remain at the surface. Research Nets Inc. of Redmond Washington has made, most if not all, of the nets made in the past 30 years used in sea otter capture work. The nets are set in proximity to aggregations of sea otter at rest, or in areas where sea otters are known to forage or travel between resting and foraging locations. Typically, from 1 to 3 nets are set at a time, depending on the density and distribution of otters, the types of habitats and sea conditions, and the number of people available to tend the nets. Nets are typically anchored at one end with a scope of 3-5 to 1 with a chain and line rode, with a large float on one, or both ends, and usually in waters from 20-60' depth and often in, or just adjacent to canopy forming kelp beds where sea otters are known to rest (Figure 9.2). In some instances where tide and current dictate, the net may be anchored at both ends, but with consideration of tidal change to permit the net to continuously float.



Figure 9.2 Illustration of the deployment of a tangle net for sea otter capture

Where sea otters are abundant nets might be deployed only during daylight hours and be watched continuously by a shore-based observer(s) with telescope. Where densities are low and sea conditions allow, nets may be allowed to remain overnight, but should still be checked periodically.

Tangle nets can be highly efficient in capturing sea otters under conditions where they are abundant. It might be expected under the right conditions to safely capture 5-10 sea otters per net per day. However, where they are in low density, one might go days without capturing a single animal. It is important to have local knowledge of the abundance, distribution, and behavior of sea otters in areas where nets will be deployed; reconnaissance is essential for efficiency and for safety of both the otters and the capturers. While nets can be highly effective under a range of conditions, they also present several risks. Foremost is the ability to safely access and remove animals that become entangled. There have been instances where adverse sea conditions have prevented researchers from getting to their nets and animals have remained entangled for extended periods. Often more than one animal becomes entangled at a time and multiple animals entangled may act aggressively toward one another. Occasionally, an animal that is free may behave aggressively toward an animal that is entangled. It is therefore essential that the nets be monitored continuously, and that the net tending crew are able to access their nets rapidly, at any time. Another potential hazard lies in the net or lead line becoming entangled with the bottom or some other feature that prevents an animal that becomes tangled from coming to the surface. In this case the animal is likely to drown within a few minutes. High current areas provide yet another opportunity for tangled sea otters to drown in a net that remains submerged because the current is stretching and holding the net below the surface. Yet another potential for hazard in the use of nets is un-expected encumbrance of the net with debris, algae, or other substances. In a protected bay in Prince William Sound, a tangle net became so saturated with diatoms that much of it sank. Only because the crew was in close proximity were they able to bring the net to the surface and release an animal that was submerged for several minutes. It usually takes a crew of three to operate 1-3 nets when they are deployed and retrieved daily. However, it is not unusual for these nets to become laden with seagrass or kelps that may take many hours to clean and prepare for re-setting, and there is also the risk of by-catch of fishes, birds, and other mammals. These incidences can result in injury or death to the bycatch, with potential serious injury to those tending the nets when a sea lion or fur seal is tangled. For the reasons stated above, only those with extensive experience with floating tangle nets should employ these to capture sea otters, and even then, not all risk can be eliminated. Compared to southeast Alaska, or British Columbia, the Washington coast probably provides the least amenable habitat, environment, and access to capturing sea otters with tangle nets.

Wilson Traps: In large part because of the risk presented by floating tangle nets, the state of California in 1972 experimented with a diver held device, to capture sea otters from below in what would come to be known as the Wilson Trap (Figure 9.3). The original device consisted of a large, lightweight aluminum frame into which a net, opened at one end was attached with a purse line (Ames et al. 1986). The frame and net were attached to a long pole that a team of divers carried as they swam to a position beneath a resting sea otter. They would then swim up to the otter whose initial reaction to disturbance would be to dive into the trap, that would immediately be closed by the purse string, entrapping the otter, that would soon be picked up by the dive tender. While early efforts with the trap proved feasible, in many cases the otter would be disturbed by the divers' exhaust bubbles and easily avoid capture. Over the years several modifications and improvements have been made to the Wilson trap technique, making this in many cases the preferred method of capture. These improvements include: a shift to oxygen rebreathers (a closed-circuit scuba system) that remove the scent and disturbance created by divers' bubbles; waterproof vhf radios that allow spotters to communicate with the divers; and the replacement of the wooden rod with a battery powered underwater propulsion device that extends the

range and speed of the divers. Under average to good capture conditions of abundant animals, clear and calm seas, expected capture rates by a team of 3-4 should approximate 3-6 animals/day.



Figure 9.3 Scuba diver operating an underwater propulsion device with Wilson trap

Regardless of the method of sea otter capture, it is essential that once a sea otter is captured that it be placed in a container that will restrain escape, protect captors from injury and provide a safe environment for transport and temporary holding. Over the years a “capture” box designed to hold any sea otter, has been proven to meet these needs (Figure 9.1). It is constructed of marine grade plywood, with a sliding lid, holes for drainage and air or water exchange and can hold ice to keep animals cool. A frame of tubular PVC can be placed on the bottom to keep the sea otter off the bottom of the box, thereby reducing potential for soiling of fur. If animals are required to be held for any period of time

prior to or during transport, the capture boxes can be placed in the water and secured to a vessel or platform, allowing for an adequate breathing area above the waterline for the otter to float, so that water can flow through the drainage holes. An otter in a capture box that has been set in this “soaking” position has ample room to rest or groom inside the box, thus aiding in thermoregulation and maintenance of pelage integrity.

Transport and Holding

Planes, trains, boats (from large ships to small skiffs), trucks, helicopters and humans have all been used to transport sea otters for reintroductions, with runways, rail tracks, roads and anchorages playing a role in determining where they might be released. Transport, beyond capture, will be dependent on location, distances, and available logistics. In the following we will discuss the advantages and disadvantages of the modes of transport likely to be used in a translocation. Small, trailered skiffs, 5-7m in length, are required for each of the capture methods described above. Solid-hull and rigid-hull inflatables, powered by 50-150 hp outboard motors and generally center consoled, are typically employed. Adequate room is needed for 2-4 persons and capture equipment that might include nets, dive equipment and at least 2 capture boxes. The 17’ and 20’ center console Boston Whaler skiffs have been used for much sea otter research requiring capture using each of the methods described above, as have the extremely seaworthy rigid hull inflatables available today. These capture skiffs will provide initial transport of captured animals to shore or designated transport skiffs for further transport. Early efforts at sea otter translocation revealed the critical need throughout holding and transport for captured animals to be kept cool and to retain the ability to maintain the thermal integrity of their fur. Aboard the capture or transport vessels, this can be accomplished by periodically placing the capture box (with the otter inside) into the water, while the box is secured to the side of the vessel and ensuring there is room in the box for the otter to groom its fur at the surface (this is often referred to as “soaking” the captured animal). Extended travel, beyond an hour or two, may require individual sea otters to be moved into a standard large animal kennel, with a raised platform that aids the sea otter in maintaining a clean pelage. It is critical that the sea otter retain the ability to thermoregulate body temperature throughout holding and transport. Ice is often added to the holding container to aid in thermoregulation, and close monitoring of animal health status and body temperature during transport (by a qualified veterinarian or animal husbandry specialist) is strongly recommended. For some recent captures, tiny subcutaneous Passive Integrated Transponders (“PIT tags”) with thermal recording capability have been implanted into animals after capture; these allow veterinary staff to obtain an internal temperature reading from an animal from a few meters away using a PIT tag reader. Transport from initial holding facilities to release site facilities will be by truck and aircraft or vessel, depending on distances and logistics.

Holding facility requirements will be dependent on release strategies. If sea otters are to be accumulated for group release, they will require holding facilities capable of supporting the intended number of animals for each release. In the San Nicolas Island translocation several days to weeks were required to capture the desired number of animals, which were transported from the capture location by air-conditioned van to holding facilities at the Monterey Bay Aquarium. Adequate holding facilities will be required, either near capture or release locations, or possibly both. If sea otters are to be held at the release site, large floating net pens suitable for holding the number to be held with platforms above water level suitable for hauling out will be required (See Figure 9.4).

A surrogate raised rehabilitation strategy will require holding and acclimatization facilities at either capture or release locations. Ideally, a long-term holding facility at the release site will aid in raising the

retention of released individuals and facilitate recapture of sea otters when needed. It may be advisable to acquire the capacity to hold adult female sea otters at the release site for the purpose of rearing juvenile sea otters under rehabilitation for release.



Figure 9.4. Photos of floating Net pens for holding sea otters at release site. TOP: view of a floating net pen deployed for testing in Monterey Bay; BOTTOM: releasing captured sea otter into floating net pen deployed at San Nicolas Island. Photos courtesy Colleen Young (CDFW) and Mike Kenner (USGS).

Release

Based on evidence from the earliest (Barabash-Nikiforov 1947) and latest (Mayer et al. 2019) reintroduction case studies, it may be possible to increase retention near the release site by providing for prolonged acclimatization to the habitat and prey populations, and this may be facilitated by allowing for recapture and holding of individuals as necessary. It appears likely that the development of socialization and relations among individuals could be important for achieving some level of cohesion between animals that will likely improve retention rates at or near the release site. If stranded, rehabilitated sea otters form a component or the core of a reintroduction in Oregon, this will necessitate a release strategy of single or small groups of individuals that may come from one or more captive sea otter institutions and require a holding facility at (or near) the release site to provide local acclimatization and bond development between individuals from different sources. Such a strategy may also require the capacity to recapture animals as needed, most likely using dip nets.

Monitoring

Post-release monitoring of reintroduced sea otters has proved to be a critical component of success in recent reintroductions (Rathbun et al. 2000, Carswell 2008, Mayer et al. 2019, Becker et al. 2020). Monitoring can be increasingly challenging the further that animals move from the release site, and the more erratic those movements. However, the use of remote sensing tags to each individual can help in locating animals that move even long distances. Implanted VHF telemetry tags (Williams and Siniff 1983) have a long history of use for tracking sea otters, although these tags are costly and relatively invasive to apply. GPS-enabled flipper tags are currently under development by USGS/NASA (J. Tomoleoni, personal communication) and may provide a less-invasive and cheaper alternative in the near future. In addition to telemetric monitoring, visual monitoring is valuable as it allows for assessments of individual health and status (e.g., determining if animal pelage looks well groomed), but visual monitoring may be more difficult for animals that are released on the open coast as compared to those released in estuaries (assuming that animals stay within the estuary). Frequent monitoring, daily or multiple times per day, can improve success of the reintroduction, particularly if recapture is required. Full-time teams of 2-4 trained and experienced observers may be required for initial monitoring. Depending on movements and degree of retention near release sites, intensive monitoring capabilities may be required throughout the duration of releases. On-call aircraft with VHF tracking capabilities, and staff capable of VHF and visual tracking from vehicle-accessible coastal locations, will likely be required if reintroduced animals move as expected. Note that there is a well-developed methodology and extensive literature on VHF tracking of tagged sea otters in coastal environments (Ralls and Siniff 1990, Siniff and Ralls 1991, Ralls et al. 1995, Bodkin and Ballachey 1996, Tinker et al. 2006, Tinker et al. 2019b, Becker et al. 2020). Aerial tracking is effective especially if some animals cannot be accounted for by ground-based teams and are believed to have moved greater distances. Aerial tracking of marine species is expensive and does entail safety considerations, and float-equipped aircraft may provide increased margins of safety for pilots and observers if tracking occurs more than a few km offshore.

Data Needs

The primary data need prior to a reintroduction will be the assessment of appropriate and adequate food and habitat resources (see Chapter 6). Such assessments will be dependent on the habitat available, and where sea otters become established (which may or may not be close to the area they are released). Although it is prudent to assess food resources and resting habitat in the area around the release site, the possibility that otters may move to a different location must be recognized, and so rapid

assessments of food/habitat at new locations may need to be made. It is likely that recreational and commercial fisheries will provide some data on prey species availability for various, clam, sea urchin, and crab species that are also part of sea otter diets. However, much of the otters' diet will include taxa that are not part of any commercial fishery, including species such as shore crabs, kelp crabs, other echinoderms, snails, worms, chitons, and limpets. Habitat resources can also be assessed using geospatial (GIS) data layers including bathymetry, substrate type, kelp canopy cover, and shoreline contours (to identify areas of complexity that may offer shelter and high-quality prey habitat). Published and unpublished research may provide further data on habitat and community level data important in evaluating the potential to support sea otter populations (e.g., Kone et al. 2021, Tinker et al. 2021).

Another data need relates to the status of the ecosystem before and after the reintroduction, to allow for informed assessments of ecological and socioeconomic impacts (Chapters 5 and 7). Previous translocations and natural recolonizations provide extensive examples of the power of experimental manipulation, or before-after contrasts, in understanding the effects of reestablishing sea otters into their historically occupied habitats (e.g., Estes and Palmisano 1974, Duggins 1980, Estes et al. 1982, Estes and Duggins 1995, Bodkin et al. 1999, Watson and Estes 2011, Hughes et al. 2013, Markel and Shurin 2015, Burt et al. 2018). To the extent possible, pre-treatment sampling of biological communities at or near selected reintroduction sites, should be carefully designed and considered for implementation. Existing monitoring programs should be leveraged wherever possible. Some examples might include description of communities, species and ecological relations expected to be influenced by the reintroduction of a long absent predator. Other studies might consider using data from established or recolonizing sea otter populations, in terms of behavior, physiology or population dynamics in the context of a space for time substitution.

Summary and Conclusion

Several strategies can be considered regarding the implementation of reintroducing sea otters to the Oregon Coast. These include options for both source populations, release locations and specific animal attributes. Likely source populations of sufficient numbers include Washington and Southeast Alaska. Sea otters from California may be considered to supplement animals from northern populations that would potentially benefit the conservation and recovery of southern sea otters as well as establish a genetic bridge between California and northern sub-species. Evidence from historic reintroductions suggest multiple introductions may improve the probability of establishing a successful population.

Although sea otters can be expected to eventually occupy all nearshore habitats within their range, not all habitats will support equivalent densities. In general, shallow, high relief rocky habitats that support canopy forming kelp canopies may be preferred. High densities of sea otters also occur in many estuarine and shallow soft sediment habitats throughout their range. Selection of release locations should take into consideration habitat preferences, but sites that allow for access to both exposed and sheltered shorelines (or estuaries) may increase potential for success. It is critical to realize that in past translocations sea otters have often not remained where they were released but have become established many km from release sites.

Although not explicitly demonstrated, the sex and age composition of reintroduced sea otters may be important to success. There is reason to suspect that younger animals may not have well established home ranges they will try to return to, and so may be more likely to become established at or near the release site. It is also possible that a sex ratio biased toward females will contribute to the reproductive

potential of the founding population. The ORSO population model (Chapter 3) can be used to evaluate the likely effects of varying the age/sex ratio of the founding population.

A variety of capture methods are available that can contribute to achieving the desired abundance and age/sex composition. These include dip nets, tangle nets and scuba-operated Wilson traps. Appropriate care and monitoring of the health status of captured animals during transport and holding is critically important, and intensive post-release monitoring of animals will also help ensure success.

Literature Cited

- Ames, J. A., R. A. Hardy, and F. E. Wendell. 1986. A simulated translocation of sea otters, *Enhydra lutris*, with a review of capture, transport and holding techniques. California Fish and Game, Marine Resources Technical Report No. 52.
- Barabash-Nikiforov, L. L. 1947. The sea otter. Translated from Russian by A. Birron and Z.S. Cole for the National Science Foundation by the Israel program for scientific translations, Jerusalem, 1962.
- Becker, S. L., T. E. Nicholson, K. A. Mayer, M. J. Murray, and K. S. Van Houtan. 2020. Environmental factors may drive the post-release movements of surrogate-reared sea otters. *Frontiers in Marine Science* **7**.
- Bodkin, J. L. 2015. Historic and Contemporary Status of Sea Otters in the North Pacific. Pages 43-61 in S. Larson, J. L. Bodkin, and G. R. VanBlaricom, editors. *Sea Otter Conservation*. Academic Press, Boston.
- Bodkin, J. L., and B. E. Ballachey. 1996. Monitoring the status of the wild sea otter population: field studies and techniques. *Endangered Species Update* **13**:14-19.
- Bodkin, J. L., B. E. Ballachey, M. A. Cronin, and K. T. Scribner. 1999. Population demographics and genetic diversity in remnant and translocated populations of sea otters. *Conservation Biology* **13**:1378-1385.
- Bodkin, J. L., B. E. Ballachey, T. A. Dean, A. K. Fukuyama, S. C. Jewett, L. McDonald, D. H. Monson, C. E. O'Clair, and G. R. VanBlaricom. 2002. Sea otter population status and the process of recovery from the 1989 'Exxon Valdez' oil spill. *Marine Ecology-Progress Series* **241**:237-253.
- Broughton, J. M. 1994. Declines in mammalian foraging efficiency during the late Holocene, San Francisco Bay, California. *Journal of Anthropological Archaeology* **13**:371-401.
- Burt, J. M., M. T. Tinker, D. K. Okamoto, K. W. Demes, K. Holmes, and A. K. Salomon. 2018. Sudden collapse of a mesopredator reveals its complementary role in mediating rocky reef regime shifts. *Proc. R. Soc. B* **285**:20180553.
- Carswell, L. P. 2008. How Do Behavior and Demography Determine the Success of Carnivore Reintroductions? A Case Study of Southern Sea Otters, *Enhydra Lutris Nereis*, Translocated to San Nicholas Island. University of California, Santa Cruz.
- Coletti, H. A. 2006. Correlating sea otter density and behavior to habitat attributes in Prince William Sound, Alaska: A model for prediction. University of New Hampshire, Durham, NH.
- Duggins, D. O. 1980. Kelp beds and sea otters: an experimental approach. *Ecology* **61**:447-453.
- Eby, R., R. Scoles, B. B. Hughes, and K. Wasson. 2017. Serendipity in a salt marsh: detecting frequent sea otter haul outs in a marsh ecosystem. *Ecology* **98**.
- Espinosa, S. M. 2018. Predictors of sea otter salt marsh use in Elkhorn Slough, California. Masters thesis. UC Santa Cruz, Santa Cruz, CA.

- Esslinger, G. G., and J. L. Bodkin. 2009. Status and trends of sea otter populations in Southeast Alaska, 1969–2003. U.S. Geological Survey Scientific Investigations Report 2009-5045., Reston, VA.
- Estes, J. A., and D. O. Duggins. 1995. Sea otters and kelp forests in Alaska: Generality and variation in a community ecological paradigm. *Ecological Monographs* **65**:75-100.
- Estes, J. A., R. J. Jameson, and E. B. Rhode. 1982. Activity and prey selection in the sea otter - influence of population status on community structure. *American Naturalist* **120**:242-258.
- Estes, J. A., and J. F. Palmisano. 1974. Sea otters: their role in structuring nearshore communities. *Science* **185**:1058-1060.
- Estes, J. A., M. T. Tinker, T. M. Williams, and D. F. Doak. 1998. Killer whale predation on sea otters linking oceanic and nearshore ecosystems. *Science (Washington D C)* **282**:473-476.
- 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 of the United States of America* **110**:15313-15318.
- Hughes, B. B., K. Wasson, M. T. Tinker, S. L. Williams, L. P. Carswell, K. E. Boyer, M. W. Beck, R. Eby, R. Scoles, M. Staedler, S. Espinosa, M. Helsing-Lewis, E. U. Foster, K. M. Beheshti, T. M. Grimes, B. H. Becker, L. Needles, J. A. Tomoleoni, J. Rudebusch, E. Hines, and B. R. Silliman. 2019. Species recovery and recolonization of past habitats: lessons for science and conservation from sea otters in estuaries. *PeerJ* **7**:e8100.
- Jameson, R. J. 1975. An evaluation of attempts to reestablish the sea otter, in Oregon. Oregon State University, Corvallis, OR.
- Jameson, R. J., K. W. Kenyon, A. M. Johnson, and H. M. Wight. 1982. History and status of translocated sea otter populations in North America. *Wildl. Soc. Bull.* **10**:100-107.
- Jeffries, S., D. Lynch, S. Thomas, and S. Ament. 2017. Results of the 2017 survey of the reintroduced sea otter population in Washington state. Washington Department of Fish and Wildlife, Wildlife Science Program, Marine Mammal Investigations, Lakewood, Washington.
- Kenyon, K. W. 1969. The sea otter in the eastern Pacific Ocean. *North American Fauna* **68**:1-352.
- Kone, D., M. T. Tinker, and L. Torres. 2021. Informing sea otter reintroduction through habitat and human interaction assessment. *Endangered Species Research* **44**:159-176.
- Kvitek, R. G., and J. S. Oliver. 1988. Sea Otter Foraging Habits and Effects on Prey Populations and Communities in Soft-Bottom Environments. *in* G. R. Vanblaricom and J. A. Estes, editors. *The Community Ecology of Sea Otters*. Springer Verlag Inc., New York.
- 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. 2002. 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, 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**:e32205.
- Larson, S. E., K. Ralls, and H. Ernest. 2015. Sea otter conservation genetics. Pages 97-120 *Sea Otter Conservation*. Elsevier.
- Markel, R. W., and J. B. Shurin. 2015. Indirect effects of sea otters on rockfish (*Sebastes* spp.) in giant kelp forests. *Ecology* **96**:2877-2890.
- Mayer, K. A., M. T. Tinker, T. E. Nicholson, M. J. Murray, A. B. Johnson, M. M. Staedler, J. A. Fujii, and K. S. Van Houtan. 2019. Surrogate rearing a keystone species to enhance population and ecosystem restoration. *Oryx*:1-11.

- Moss, M. L., and R. J. Losey. 2011. Native American use of seals, sea lions, and sea otters in estuaries of northern Oregon and southern Washington. Human Impacts on Seals, Sea Lions, and Sea Otters, edited by TJ Braje and TC Rick:167-195.
- Odemar, M., and K. Wilson. 1969. Results of sea otter capture, tagging and transporting operations by the California Department of Fish and Game. Pages 1-113 in Sixth Ann. Conf. on Biol. Sonar and Diving Mammals, Stanford Res. Inst., Menlo Park, Calif., Proc.
- Ogden, A. 1941. The California Sea Otter Trade. University of California Press.
- Pitcher, K. W. 1989. Studies of Southeastern Alaska Sea Otter Populations: Distribution, Abundance, Structure, Range Expansion, and Potential Conflicts with Shellfisheries. Alaska Department of Fish Game, and U.S. Fish Wildlife Service.
- Ralls, K., B. B. Hatfield, and D. B. Siniff. 1995. Foraging patterns of California sea otters as indicated by telemetry. Canadian Journal of Zoology **73**:523-531.
- Ralls, K., and D. B. Siniff. 1990. Time budgets and activity patterns in California sea otters. Journal of Wildlife Management **54**:251-259.
- Rathbun, G. B., and C. T. Benz. 1991. Third year of sea otter translocation completed in California. Endangered Species Technical Bulletin **14**:1-6.
- Rathbun, G. B., B. B. Hatfield, and T. G. Murphey. 2000. Status of translocated sea otters at San Nicolas Island, California. Southwestern Naturalist **45**:322-328.
- 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 **90**:1-126.
- Silliman, B. R., B. B. Hughes, L. C. Gaskins, Q. He, M. T. Tinker, A. Read, J. Nifong, and R. Stepp. 2018. Are the ghosts of nature's past haunting ecology today? Current Biology **28**:R532-R537.
- Siniff, D. B., and K. Ralls. 1991. Reproduction, survival and tag loss in California sea otters. Marine Mammal Science **7**:211-229.
- Tinker, M. T. 2015. The Use of Quantitative Models in Sea Otter Conservation. Pages 257-300 in S. Larson, J. L. Bodkin, and G. R. Vanblaricom, editors. Sea Otter Conservation. Academic Press, Boston, MA.
- Tinker, M. T., D. F. Doak, J. A. Estes, B. B. Hatfield, M. M. Staedler, and J. L. Bodkin. 2006. Incorporating diverse data and realistic complexity into demographic estimation procedures for sea otters. Ecological Applications **16**:2293-2312.
- Tinker, M. T., and J. A. Estes. 1996. The population ecology of sea otters at Adak Island, Alaska. Final Report to the Navy, Contract # N68711-94-LT-4026, Santa Cruz, CA.
- Tinker, M. T., V. A. Gill, G. G. Esslinger, J. L. Bodkin, M. Monk, M. Mangel, D. H. Monson, W. E. Raymond, and M. Kissling. 2019a. Trends and Carrying Capacity of Sea Otters in Southeast Alaska. Journal of Wildlife Management **83**:1073-1089.
- Tinker, M. T., B. B. Hatfield, M. D. Harris, and J. A. Ames. 2016. Dramatic increase in sea otter mortality from white sharks in California. Marine Mammal Science **32**:309-326.
- Tinker, M. T., J. A. Tomoleoni, B. P. Weitzman, M. Staedler, D. Jessup, M. J. Murray, M. Miller, T. Burgess, L. Bowen, A. K. Miles, N. Thometz, L. Tarjan, E. Golson, F. Batac, E. Dodd, E. Berberich, J. Kunz, G. Bentall, J. Fujii, T. Nicholson, S. Newsome, A. Melli, N. LaRoche, H. MacCormick, A. Johnson, L. Henkel, C. Kreuder-Johnson, and P. Conrad. 2019b. Southern sea otter (*Enhydra lutris nereis*) population biology at Big Sur and Monterey, California --Investigating the consequences of resource abundance and anthropogenic stressors for sea otter recovery. US Geological Survey Open-File Report No. 2019-1022. US Geological Survey Open-File Report, Reston, VA.
- Tinker, M. T., J. L. Yee, K. L. Laidre, B. B. Hatfield, M. D. Harris, J. A. Tomoleoni, T. W. Bell, E. Saarman, L. P. Carswell, and A. K. Miles. 2021. Habitat features predict carrying capacity of a recovering marine carnivore. Journal of Wildlife Management **85**:303-323.

- Watson, J., and J. A. Estes. 2011. Stability, resilience, and phase shifts in rocky subtidal communities along the west coast of Vancouver Island, Canada. *Ecological Monographs* **81**:215-239.
- Wellman, H. P., R. M. Austin, N. D. Dagtas, M. L. Moss, T. C. Rick, and C. A. Hofman. 2020. Archaeological mitogenomes illuminate the historical ecology of sea otters (*Enhydra lutris*) and the viability of reintroduction. *Proceedings of the Royal Society B* **287**:20202343.
- Wild, P. W., and J. A. Ames. 1974. A report on the sea otter, *Enhydra lutris* L., in California.
- Williams, T., and D. B. Siniff. 1983. Surgical implantation of radio telemetry devices in the sea otter. *Journal of the American Veterinary Medical Association* **11**:1290-1291.