A R T I C L E

SEA OTTER (*Enhydra lutris*) REINTRODUCTION TO THE OREGON COAST, UNITED STATES: CHALLENGES AND UNANSWERED QUESTIONS

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Abstract: Sea otters (*Enhydra lutris*), listed as Endangered by the IUCN, are an important keystone species. They have been absent from the Oregon coast of the United States for more than 100 years. The conservation community in western North America is exploring the possibility of reintroducing sea otters to this large section of their historic range. The U.S. Fish and Wildlife Service and the non-profit organization Elakha Alliance completed feasibility assessments and determined that reintroduction is feasible. Many challenges and questions remain. The question of which founder source to use, northern or southern, wild or surrogate-reared, is yet to be answered. An adaptive process during reintroduction allows scientists to optimize the founder source. Dispersal of reintroduced otters is often detrimental to translocation attempts. Dispersal may be mitigated by releasing juveniles that have not developed strong home range fidelity. Ecological risk assessments such as shark bite or predation (being researched), and disease and domoic acid exposure (assessed once a reintroduction site is determined) are important aspects of planning. Economic and technical concerns remain. Red sea urchin fisheries are expected to be negatively impacted by sea otter reintroduction. Other concerns yet to be resolved comprise funding and support infrastructure, including monitoring, stranding response, veterinary care, oil-response, and a possible surrogacy program. Not all questions can be answered before a reintroduction occurs. Previous reintroductions in North America account for more than 30% of the global sea otter population. These reintroductions were accomplished with considerably less information about sea otters than is known today, illustrating that success is possible even with unanswered questions.

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INTRODUCTION

Sea otters (*Enhydra lutris*), are listed as Endangered by the IUCN (IUCN, 2024). Currently, the conservation community in the western United States is exploring the possibility of reintroducing sea otters along the Oregon coast. Sea otters have been absent from there for over 100 years and a previous reintroduction attempt in Oregon in 1970-71 was not successful (Bodkin et al., 2022). Reintroductions are inherently complex, time intensive and expensive. To maximize the chances of a successful reintroduction, the U.S. Fish and Wildlife Service and the nonprofit Elakha Alliance have both undertaken feasibility assessments as a first step (Elakha Alliance, 2022; U.S. Fish and Wildlife Service, 2022). These two thorough assessments covered: the objectives of reintroductions, biological, socioeconomic, and legal feasibility, costs, risk factors, and much more.

Despite the determination that sea otter reintroduction to the Oregon coast is feasible, both assessments also raised many questions. These queries fall into three broad categories: challenges related to sea otter biology, ecological threats, and economic and technical concerns. In terms of sea otter biology, what subspecies of sea otter should be used in the reintroduction? How can dispersal, a common cause of reintroduction failure, be mitigated? In terms of ecological challenges, do sharks, harmful algae blooms and disease pose a threat to a reintroduced sea otter population and how can those threats be minimized? And finally, for economic and technical concerns, how will shellfisheries be impacted and what infrastructure is required to support a reintroduced sea otter population?

In this paper I explain why sea otters are an important keystone species, the historical context of sea otters and the impact of the maritime fur trade, and then discuss some of the many questions remaining about a possible reintroduction. Much research is being done to find answers to these questions. Several other questions cannot be answered until a potential reintroduction is attempted.

SECTION ONE: SEA OTTER BIOLOGY, IMPORTANCE, AND NEAR EXTINCTION

What is a Sea Otter?

Sea otters (*Enhydra lutris*) are the largest mustelids in the world, mammals characterized by elongated bodies, short legs, and thick fur (Law et al., 2019). As the smallest marine mammal in North America, sea otters measure around 1.2 m (4 feet) in length. The three subspecies of sea otter differ in geographic location and skull morphology. Those are: Asian (*Enhydra lutris lutris*) in Russia, northern (*Enhydra lutris kenyoni*) in Alaska, British Columbia, and Washington state, and southern (*Enhydra lutris neresis*) in California (Wilson et al., 1991). Southern sea otters are smaller than their northern and Asian counterparts. Female sea otters average 21-33 kg (46-77 lbs), males 29-39 kg (64-85 lbs), depending on subspecies (U.S. Fish and Wildlife Service, 2021). Females tend to live longer, around 15-20 years in the wild, compared to 10-15 years for males (Riedman and Estes, 1990).

Sea otters are related to badgers and wolverines (Fish and Stein, 1991). Instead of terrestrial prey, sea otters forage on marine invertebrates such as clams (e.g., *Protothaca staminea*), crabs (*Cancer* spp.), and sea urchins (e.g., *Strongylocentrotus purpuratus*) (Watson and Root, 1996). They consume a large volume of invertebrates, about 25% of their body weight, daily (Kenyon, 1969). Bringing their prey to the surface to consume it, sea otters use rocks as tools to break open shelled prey (Combs, 2019).

Sea otters live their lives exclusively at sea, even giving birth in the ocean (Riedman and Estes, 1990). Their habitat is a variety of marine nearshore environments, from rocky to sandy bottomed, as well as estuaries (Tarjan and Tinker, 2016). Preferred habitat is rocky reefs with canopy forming kelp (Laidre et al., 2001; Tinker et al., 2021c). Sea otters roll themselves in kelp to keep in place while resting or grooming (Riedman and Estes, 1990) and hide in the kelp canopy from shark attack (Nicholson et al., 2018). Sea otters are also found in areas without kelp (Mayer et al., 2019).

Sea otters dive to the seafloor to forage. Limited by where they can find prey and how deep they can dive, sea otters can dive up to 100 m but prefer to dive less than 25 m (Tarjan and Tinker, 2016). Not only are they limited in depth, but also in home range. Home range is defined as "that area traversed by an individual in its normal activities of food gathering, mating, and caring for the young" (Burt, 1943). Sea otters usually occupy home ranges around 7 km^2 (3 mi^2) that are no more than a couple of kilometers (1.2 mi) from shore (Riedman and Estes, 1990; Tinker et al., 2019). In fact, as a narrow band near shore, theirs is the smallest home range of any marine mammal (Loughlin, 1980).

Unlike other marine mammals, sea otters do not have an insulating blubber layer to keep them warm from the surrounding frigid water (Cohn 1998). Instead, they meticulously groom their thick fur coat. Their interlocking hairs and sebaceous glands create a waterproof air layer that protects the sea otter's skin from getting wet (Williams et al., 1992; Perrin et al., 2008; Bentall et al., 2016), much like a dry suit used by cold-water divers (Jessup et al., 2012). Sea otters have the densest fur in the animal kingdom with over 100,000 hairs/cm^2 (or one million hairs/in^2) (Cohn, 1998; Kenyon, 1969; Perrin et al., 2008). However, their thick coat is not sufficient to keep them warm in their cold ocean environment. Because they live in water 21-38 °C (50-70 °F) below their body temperature (Jessup et al., 2012), sea otters must also have a high metabolic rate to maintain their body temperature. Sea otter metabolic rate is approximately three times that of an equivalently sized land mammal (Wright et al., 2021).

As social animals, sea otters form groups called rafts (Lubina and Levin, 1988). While rafts vary in number of otters, they tend to be separated by gender (Riedman and Estes, 1990). This is because dominant males defend territories containing resources that attract females in a reproductive system called resource defense polygyny (Pearson and Davis, 2021).

Why are Sea Otters Important?

Sea otters are a keystone species, a species that has an impact on its ecosystem disproportionate to its abundance (Paine, 1995). Just a few sea otters greatly affect the numbers of other marine species. Therefore, sea otters play a key role in structuring communities and ecosystems (Estes and Palmisano, 1974). Some say sea otters are the most ecologically influential animal in the nearshore environment (Bailey and Hatch, 2023).

In the kelp forest, sea otters predate sea urchins, which eat kelp. Left unchecked, urchins can overgraze a kelp forest ecosystem (Larson et al., 2015) and leave behind an urchin barren (Jessup et al., 2004). Sea otters play a role in the recovery of kelp forests (Lee et al., 2016) and sea grass beds (Hughes et al., 2019). In areas where otters were once absent but then recolonized, urchin abundance decreases, and kelp increases dramatically (Estes and Duggins, 1995).

In an estuary with seagrass, the presence of sea otters promotes growth and expansion of eel grass (*Zostera marina*) (Hughes et al., 2013). The otters eat crabs (e.g., *Cancer* spp.) that predate mesograzers like sea slugs (e.g., *Phyllaplysia taylori*). This controls the population of crabs and releases the sea slugs from predation. Sea slugs consume algae from the eel grass and the grass increases in density.

Both kelp forests and estuaries have recovered quickly when sea otters repopulate areas where they were long absent (Burt et al., 2018, Hughes et al., 2019). Reoccupied areas have consistently shown increased ecosystem function, overall biodiversity, and genetic diversity of associated species (Estes and Palmisano, 1974; Estes and Duggins, 1995; Reisewitz et al., 2006; Hughes et al., 2013; Estes, 2015; Markel and Shurin, 2015; Lee et al., 2016; Burt et al., 2018; Foster et al., 2021; Estes and Tinker, 2022; U.S. Fish and Wildlife Service, 2022). By consuming invertebrates, sea otters have a trophic effect on the abundance and distribution of both kelp and sea grass. This chain of events has widespread implications for other species that rely on kelp or sea grass for food, shelter, or substrate (U.S. Fish and Wildlife Service, 2022). For example, kelp forests provide important nurseries for salmonids, herring and rockfish (Markel and Shurin, 2015; Shaffer et al., 2020), and estuaries provide important nurseries for crab and other invertebrate species (Beck et al., 2001).

Kelp also stores (sequesters) carbon that can lessen the effects of climate change (Wilmers et al., 2012), provides habitat for a myriad of invertebrate and fish species (Markel and Shurin, 2015; Teagle et al., 2017; Morris et al., 2020), reduces localized ocean acidification (Hirsh et al., 2020), and protects shorelines from erosion (Morris et al., 2020). Sea grass also sequesters carbon (Krause-Jensen and Duarte, 2016). Therefore, certain key wildlife species, including sea otters, have been modeled to have substantial indirect effects on mitigating climate change (Wilmers et al., 2012; Schmitz et al., 2023).

Why did Sea Otters almost go Extinct?

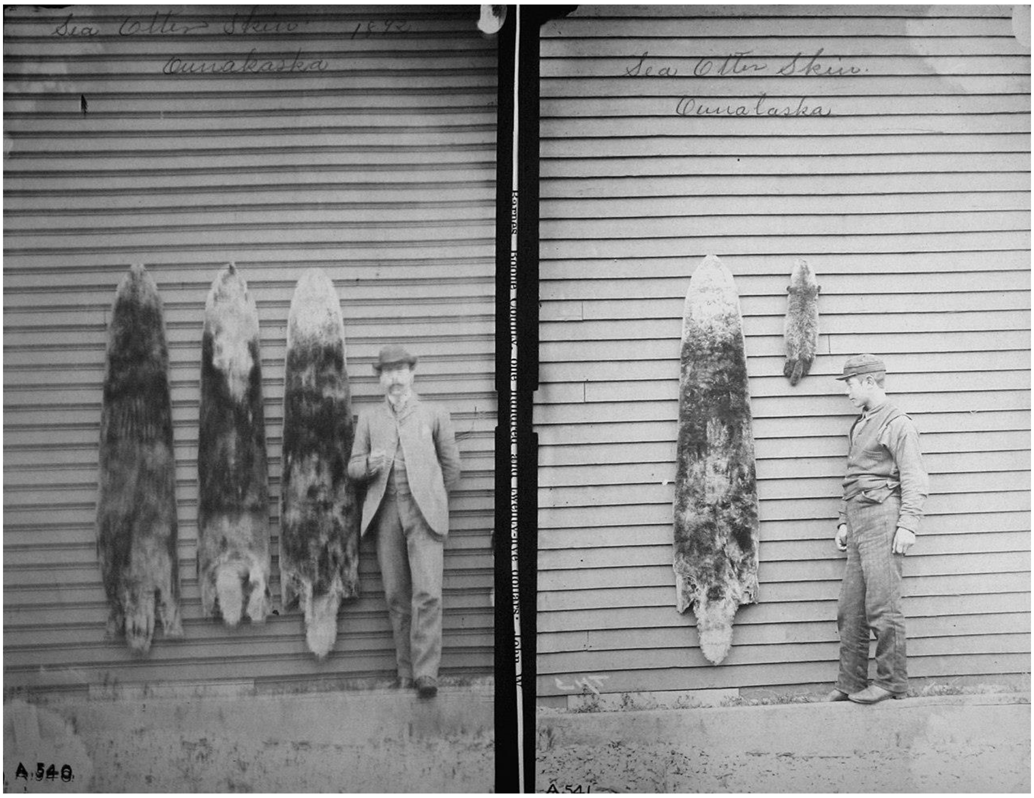

Figure 1. The skins of sea otters circa 1892. (Source: public domain.)

Prior to the industrial fur trade, global sea otter abundance was estimated to be 150,000-300,000 (Kenyon, 1969). International trade in sea otter pelts started in 1780 and the 150-year industry reached its peak during the first half of the nineteenth century (Fig. 1) (Szpak et al., 2012). Otter pelts brought over $1000 apiece in the early 20th century ($35,000 in today's currency) (Armstrong, 1979). The pelts were known as "soft gold" (Silverstein et al., 1995). A driving force behind Russia selling Alaska to the United States so cheaply, was that the land appeared worthless because there were no sea otters left to trap (Armstrong, 1979). Ultimately, by killing approximately a million sea otters (Armstrong, 1979) the maritime fur trade industry wiped out 99% of the sea otter population, leaving about 1,000-2,000 otters scattered in 13 locations along the Pacific coast (Fig. 2) (Szpak et al., 2012).

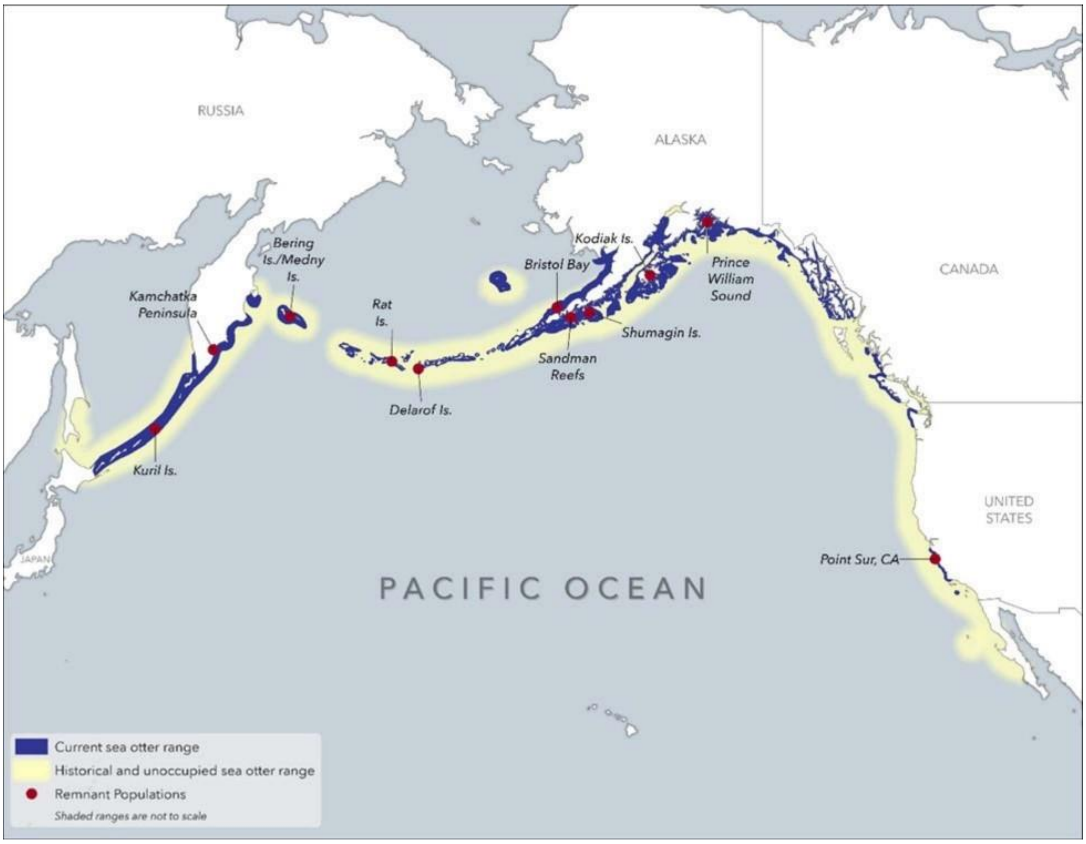

Figure 2. Historical and current sea otter range. (U.S. Fish and Wildlife Service, 2022)

The southern sea otter was thought to be extinct along the California coast until a tiny population numbering about 50 was discovered in 1914 at Point Sur, along the rugged Big Sur coast in California (Bryant, 1915). The most recent data indicate a central California population abundance of 2,962 per 2019 census (Hatfield et al., 2019). The overall 5-year trend for southern sea otters is flat at 0.12% increase per year. Additionally, per a survey in 2020, there is a small population of about 114 individuals at San Nicolas Island off the southern California coast, from translocations there in 1987-1990 (Yee et al., 2020). There have been sightings of southern sea otters off Baja, California which are believed to have dispersed from San Nicolas Island (Schramm et al., 2014).

The southern sea otter's historical range was from Oregon to Baja California, about 2500 km (1500 miles) (U.S. Fish and Wildlife Service, 2021). Its current range is a patchwork of small populations in Central California only, from Half Moon Bay north of Monterey to Point Conception near Santa Barbara, 370 km (200 mi) of California coast (Marine Mammal Commission, 2021). The current range is 13% of their historical range (U.S. Fish and Wildlife Service, 2015).

The status of the southern sea otter contrasts sharply with that of the northern sea otter both in range and abundance. The northern sea otter population exceeds 100,000 (Marine Mammal Commission, 2023) with an overall 15% growth rate. The population has nearly doubled since the early 2000s. Additionally, the northern sea otter occupies much of its historical range, in Alaska, British Colombia and Washington state (Marine Mammal Commission, 2021). Both northern and southern sea otters are protected from harvest in the United States by the Marine Mammal Protection Act. The only exception is traditional tribal usage in Alaska. In addition, southern sea otters and some northern sea otters are listed as threatened under the Endangered Species Act (U.S. Fish and Wildlife Service, 2022).

One concern about the northern sea otter is the Distinct Population Segment (DPS) of Southwest Alaska. This DPS was listed as threatened under the Endangered Species Act due to a 50% decline in population since the mid-1980s, caused by predation by killer whales (*Orcinus orca*) (Tinker et al., 2021a). It is estimated that one killer whale could predate over 1,800 sea otters annually to meet its energy requirements (Estes et al., 1998). One hypothesis to explain this is that overfishing caused seals and sea lions to vacate the area leaving killer whales to predate sea otters. Still, the current abundance of the Southwest Alaska DPS exceeds 50,000 otters (U.S. Fish and Wildlife Service, 2023).

Why haven't Southern Sea Otters in California expanded in Range and Abundance?

Sea otters in California face many threats. First, the current population is approaching carrying capacity in the center of its range due to food limitations (Larson et al., 2015; Tinker et al., 2016, 2019) which has many implications. Resource-limited carrying capacity in central California manifests as sea otters in poor body condition (Tinker et al., 2019). Otters in the area spend a high percentage of time foraging (40%) compared to areas like San Nicolas Island. San Nicolas Island has abundant prey resources, so otters there have much better body condition (Chen, 2017) and spend only 25% of their time foraging. Mortality for southern sea otter pups is about 50% (Estes et al., 2003). High pup mortality is consistent between southern and northern sea otter populations at carrying capacity. Certain populations of northern sea otters which are at carrying capacity also show high pup mortality (53%). This contrasts with a fast-growing northern sea otter population (not at carrying capacity) where pup mortality was 17% (Monson et al., 2000).

Second, the southern sea otter population is impacted by infectious diseases. For southern sea otters necropsied between 1998-2012, infectious disease was the most common cause of death (63%) (Miller et al., 2020). Infections included: acanthocephalans (parasitic worms), *Sarcocystis neurona* and *Toxoplasma gondii* (protozoans), arthropod and metazoan parasites, as well as bacterial, viral, and fungal infections. Additionally, an earlier study (Kreuder et al., 2003) found that parasitic disease was a major contributor to southern sea otter deaths in 38% of cases studied. Of note, 17% of those autopsied died from encephalitis caused by *T. gondii* carried by felids, and the parasite contributed to death in another 12%. Therefore, *T. gondii* is an important factor in southern sea otter morbidity and mortality (Shapiro et al., 2019). Unfortunately, a new, virulent strain of *T. gondii* was discovered recently in four deceased otters (Miller et al., 2023).

Third, southern sea otter females experience end lactation syndrome (ELS) causing emaciation and death, which is exacerbated in areas near carrying capacity. ELS is defined as moderate to severe emaciation, not attributable to a concurrent, independent disease, in females that die during late pup care or postweaning. Adult female sea otters are heavily burdened with the additional energy demands of pregnancy and lactation (Thometz et al., 2014). During lactation, energy demand increases by 96% over pre-pregnancy levels. Thus, females have high caloric challenge during pup care and thus female southern sea otters are extremely vulnerable to caloric deficiency (Chinn et al., 2016). Exhaustion of energy reserves results in ELS. For example, one study showed that for adult females that died during late pup care or postweaning, 83% of those had ELS as a primary or contributing cause of death (Miller et al., 2020). Population density is a risk factor for ELS. Therefore, maternal mortality, due to resource limitations which lead to ELS, has negative implications on the entire southern sea otter population (Estes et al., 2003).

Fourth, the population is impacted by harmful algae blooms (HABs). HABs occur when colonies of algae grow out of control and produce toxins. When an HAB occurs, domoic acid (DA), a toxin produced by diatoms in the genus *Pseudo-nitzschia*, bioaccumulates in shellfish (especially crab and clam) (Moriarty et al., 2021). When sea otters eat these shellfish species, they become susceptible to DA toxicosis, a neurological disease. Additionally, chronic DA exposure is linked to fatal cardiac disease in prime-aged southern sea otters. Although blooms are not fully understood, they appear to be linked to warmer climates and may be exacerbated by climate change (Moriarty et al., 2021). As bloom incidences increase with a warmer climate, it can be expected that southern sea otter mortality will also increase (Miller et al., 2020).

Most importantly though, the leading cause of death for southern sea otters is shark-bite trauma caused by white sharks (*Carcharodon carcharias*) (Hatfield et al., 2019). This phenomenon now accounts for greater than half of southern sea otter mortality. In California, shark-bite mortality has the greatest impact on population level recovery of any cause of death with over 1,800 carcasses collected in California's shores and waters in nearly 30 years (Tinker et al., 2016, 2021b). Shark attack is especially prevalent on the northern and southern ends of the sea otter range. Unfortunately, these are the only locations where this sea otter population can expand. Therefore, shark bite appears to be the main reason the southern sea otter range cannot expand without human intervention (Hatfield et al., 2019). The increase in shark attacks may be caused by an increase in white shark abundance due to more protection of sharks, but the data on this supposition is limited. Shark bites in winter and spring may correspond with sub-adult sharks transitioning from fish to blubber-rich marine mammals. (Tinker et al., 2016). Bite evidence indicates white sharks are the only species biting southern sea otters.

White sharks bite but do not predate sea otters. These appear to be exploratory bites. There is no evidence that white sharks are consuming sea otters, and no sea otters have been found in white shark stomach contents. White sharks overwhelmingly reject anything but their established prey (Moxley et al., 2019). Stranded otters with bite marks show no signs of being even partially consumed (Tinker et al., 2016). This is the first-known case of white shark bites being the leading cause of mortality for a non-prey species. With climate change, southern sea otter mortality in central California will likely increase due to warming waters intruding further north for longer periods of time, causing white sharks and sea otters to overlap in distribution (Tinker et al., 2016; Tanaka et al., 2021).

Sea otter range expansion occurs slowly (Lafferty and Tinker, 2014) typically beginning when males seek new territory (Lafferty and Tinker, 2014). Sea otters use kelp as cover, but kelp is lacking on the southern sea otter range edges (Nicholson et al., 2018). Therefore, adult male otters are the demographic being bitten most often by white sharks, especially at the edges of the range (Moxley et al., 2019). Range expansion continues when females follow males into new territories. However, kelp is used as nursery material and without kelp, females do not tend to follow (Nicholson et al., 2018). For these reasons, the southern sea otter range is not expected to expand naturally with the current conditions.

A combination of reduced population size, small range and threats from oil spills was the justification for listing southern sea otters as threatened under the Endangered Species Act (ESA) in 1977 (U.S. Fish and Wildlife Service, 2021). One stochastic event (e.g., oil spill) could devastate the entire southern sea otter population (U.S. Fish and Wildlife Service, 2012), thus, a major oil spill is the most serious possible threat to the southern sea otter population (Ralls et al., 1992). Establishing an additional population across a broader geographic range is the most important conservation action that could be taken to mitigate this risk (U.S. Fish and Wildlife Service, 2022).

The Exxon Valdez oil spill in southern Alaska in 1989 leaked more than 42 million liters (11 million gallons) of crude oil and killed nearly 3,000 sea otters immediately (Guterman, 2009). Studies show that an additional 900 otters died from long-term exposure to the oil in the decades since the spill. Residual oil can affect wildlife populations on much longer time scales than originally expected and can be as significant as the immediate effects (Monson et al., 2011). Oil in Prince William Sound, where the spill occurred, is expected to decay at a rate of 0-4% per year, and to persist for centuries (Guterman, 2009), and the oil spread more than 1990 km (1200 miles) (Peterson et al., 2003). For context, California receives over 750 million liters (200 million gallons) of crude oil a day by ship, so a large oil spill affecting sea otters is a possibility (Jessup et al., 2004). Specifically, oiling damages sea otter pelage so they cannot insulate against the chilly water. Oiled otters lose the ability to thermoregulate and quickly succumb to hypothermia. When the otter tries to groom itself to rid the fur of oil it ingests and inhales the oil. This results in pathological lung, liver, and kidney lesions, initiating a stress response leading to shock and death (Rudebusch et al., 2020).

To create a redundant population and mitigate the threat of an oil spill, southern sea otters were translocated to San Nicolas Island in the 1980s. Carrying capacity for the area is estimated at 280 individuals (Rathbun et al., 2000) and abundance was estimated in 2020 at 114 (Yee et al., 2020) with a 22% annual growth rate. Based on this growth rate, the translocation at San Nicolas Island will ultimately have been successful in establishing a population of southern sea otters, even though more than 90% of the translocated otters dispersed and the project was deemed a failure. This outcome suggests that conservation efforts originally deemed a failure could be successful in the longer term. Unfortunately, the Exxon Valdez oil spill demonstrated that the sea otters at San Nicolas Island are not far enough away from the mainland to protect them from an oil spill and be a redundant population (Carswell et al., 2015), indicating that there is still a need for a redundant population of southern sea otters elsewhere.

Lastly, southern sea otters have among the lowest observed genetic diversity of any wild mammal population. This raises concerns over the population’s ability to avoid extinction when challenged by a changing environment or novel pathogens (Aguilar et al., 2008). This loss of genetic variation in the southern sea otter population likely was caused by the extreme bottleneck due to the fur trade (Larson et al., 2002, 2012). The current population of fewer than 3,000 has little genetic diversity because that population stems from the 50 that survived the fur trade.

For southern sea otter populations to expand, active reintroductions beyond the current range are likely necessary (Becker et al., 2020). Reintroduction serves many purposes. It could implement range expansion and promote population increases, provide population redundancy in the face of stochastic events, increase adaptive capacity in the context of climate change and novel pathogens and be a method to increase gene flow (Davis et al., 2019; Larson et al., 2021) if introduced near enough to another population, such as the northern sea otter population in Washington state or another introduced sea otter population.

SECTION TWO: OREGON AS A PLACE FOR REINTRODUCTION

The goal of reintroduction is to re-establish a viable population of the focal species within its historical range (IUCN, 2013). According to the recent feasibility assessment by the U.S. Fish and Wildlife Service (USFWS), their goals for sea otter reintroduction in Oregon specifically are three-fold: 1) restoring *E. lutris* to the largest gap in its historical range, 2) improving the conservation status of the southern sea otter and 3) restoring ecosystem function within the area of reintroduction (U.S. Fish and Wildlife Service, 2022). This feasibility assessment included northern California as well as Oregon.

Oregon may be a more appropriate locale for accomplishing the goals of reintroduction than other areas. Southern California has high human density, which leads to more disturbance, pollution, and depleted prey resources. (Lafferty and Tinker, 2014). Northern California's large estuary, San Francisco Bay, is another possibility. One study indicated that there are pockets of San Francisco Bay that could provide suitable habitat with a carrying capacity of 6,600 individuals (Hughes et al., 2019). However, some of those locations are in close proximity to high-risk areas of vessel traffic (fast ferries) or environmental contaminants (e.g., methylmercury or polychlorinated biphenyls) (Rudebusch et al., 2020). USFWS held stakeholder sessions in eight northern California coastal towns during the summer of 2023 to assess potential public support for otter reintroduction in those areas (Callahan, 2023).

Oregon is the only U.S. state where sea otters historically existed but are currently absent. There are several locations in Oregon that could support sea otters, especially in southern Oregon, since that is where the greatest density of canopy-forming kelp exists, specifically from Coos Bay south (Kone et al., 2021). Additionally, Oregon has numerous estuaries which could support high densities of sea otters, provide protection from white sharks and benefit from the positive indirect effects of sea otters on seagrass (U.S. Fish and Wildlife Service, 2022).

Oregon in the past served as a genetic "cline" or transition zone between northern and southern sea otter subspecies (Wellman, 2018). A genetic cline is a measurable gradient in a single characteristic (or biological trait) of a species across its geographical range. Sea otter remains have been found in Oregon, some with characteristics of northern sea otters and some with characteristics of southern sea otters. Oregon could serve as an area for northern and southern sea otter subspecies to mix genetically. Increased genetic diversity could give the sea otter species more adaptive potential (Larson et al., 2021) in the face of a changing environment and novel pathogens. Reintroduction could allow sea otters to "share" genetics, thereby improving gene flow. Southern sea otters, with their relatively small gene pool would gain more adaptive capacity from the more diverse northern sea otter genetics. In addition, southern sea otters, acclimated to warmer waters, may genetically benefit northern sea otters in adapting to climate change (vonHoldt et al., 2018, U.S. Fish and Wildlife Service, 2022).

What is more important, Oregon would benefit from a sea otter reintroduction. Oregon's kelp forests were adversely affected by increased sea surface temperatures (The Blob of 2014-2016) and sea star wasting disease. Those factors combined to create perfect conditions for an explosion in sea urchin abundance. In southern Oregon there has been a 10,000-fold increase in sea urchins (NOAA, 2023a). Warming water is hard on kelp which prefers cool waters. Sea stars predate sea urchins and with the disease decimating sea star populations, sea urchins were released from predation. Sea urchins then overgrazed kelp. One study showed that for some parts of Oregon kelp was reduced to 19% of its historical cover (Bell et al., 2023). Research is currently being done by NOAA to determine the status of kelp along the entire Oregon coast (NOAA, 2023a). Returning sea otters to the Oregon coast would reintroduce a predator of sea urchins and could increase the resilience of the kelp ecosystem.

Kelp ecosystems are important as they provide shelter, food, and nursery habitat for at least eighteen species of finfish. Kelp fuels a food web consisting of innumerable fish, shellfish, and sea birds (Bailey and Hatch, 2023). Grey whales seek safety from killer whales in kelp forests and eat the invertebrates and crustaceans found in nutrient rich kelp forests (NOAA, 2023b).

SECTION THREE: CHALLENGES AND UNANSWERED QUESTIONS ABOUT A REINTRODUCTION TO OREGON

Several challenges and unanswered questions remain regarding a possible sea otter reintroduction to Oregon. For this paper's purposes, these issues fall into three broad categories: sea otter biology challenges, ecological threats, and economic and technical concerns. In terms of sea otter biology, what subspecies of sea otter should be used in the reintroduction? How can dispersal, a common cause of reintroduction failure, be mitigated? In terms of ecological challenges, would sharks, disease and harmful algae blooms threaten a newly reintroduced sea otter population and how can those threats be minimized? And finally, for economic and technical concerns, how will shellfisheries be impacted and what infrastructure is still needed to support a reintroduced sea otter population?

Sea Otter Biology: which Founder Source to use?

Of the many components of a possible reintroduction, selecting which type (or types) of sea otter to use as a founder source may be the most nuanced. There are four possible sea otter sources: northern sea otters from Washington State, northern sea otters from SE Alaska, southern sea otters from California or rehabilitated southern sea otters from California. Each option has its pros and cons.

Using northern sea otters from Washington state appears, at first glance, to be the logical choice. There is sufficient abundance (≈3000) (Hale et al., 2022) to supply a founder source without causing a decline to the population (Bodkin and Tinker, 2022). Logistics would be straightforward as the otters could be transported by road. However, while habitat in Washington may resemble that in Oregon, the sea otters in Washington occupy locations where sea surface conditions could make capture hazardous for both humans and otters. This situation would also make it challenging and more time consuming to attempt to capture otters of a specific demographic, like more juveniles or females.

The current abundance of northern sea otters in SE Alaska is approaching 30,000 (Tinker et al., 2019). Using a source there as a founder for Oregon would not negatively impact the SE Alaska population. Logistics would be more complex and costly, as the sea otters would be transported by air, but their locations in SE Alaska are more accessible and specific demographics of otters could more easily be acquired than in Washington state (Bodkin and Tinker, 2022). Additionally, the state of Alaska may support the removal of otters from SE Alaska since this action may assist management objectives such as supporting local areas with commercially important or subsistence shellfisheries. Lastly, the population in SE Alaska has the highest genetic diversity of any extant sea otter population. Sourcing otters from that area may best accomplish the goal of maximizing sea otter genetic diversity in Oregon (Larson et al., 2002, 2012).

From the standpoint of improving the conservation status of an organism, the use of southern sea otters from California would be the priority. As mentioned earlier, this population is listed under the Endangered Species Act as threatened. The southern sea otter population has flatlined at fewer than 3,000 (Hatfield et al., 2019), and southern sea otters are limited at the edges of their current range by shark attacks. Historically, when sea otters populated the Oregon coast, those in the southern half of the state genetically resembled California sea otters (Bodkin and Tinker, 2022). For the southern sea otter, translocation may be the only solution to increase abundance and expand range.

The center of the southern sea otter range has a high abundance of otters and would be the appropriate location for a founding source. In general, southern sea otters are at carrying capacity and so removing some should not have population level impacts (U.S. Fish and Wildlife Service, 2022). The number of otters removed should be fewer than 10% of the local population to sustain the larger population (Tinker, 2022).

The final possible founding source is surrogate-raised southern sea otters. If a female otter lacks resources, she may abandon the pup (Monson et al., 2000), or the mother and pup may separate due to severe storms, maternal inexperience, or death of the mother (Nicholson et al., 2023). In central California, when a stranded sea otter pup is found, it is brought to the Monterey Bay Aquarium. It is matched with a non-releasable female otter who then cares for the otter pup, teaching it social and foraging skills. Surrogate-reared otters have the same reproductive and survival rates as their wild cousins (Mayer et al., 2019). There have been few surrogate-reared pups, only 64 over the course of 20 years (Nicholson et al., 2023). However, their use would not affect the southern sea otter population since they are demographically removed from the wild population (Tinker, 2022).

Release of surrogate-reared juveniles into an estuarine environment has demonstrated a much lower level of dispersal, with most (more than 80%) settling within 10 km (6 mi) of the release area (Becker et al., 2020). How the surrogate-raised juveniles would respond to an area without otters is unknown since they have never been released into an area without an existing otter population. Additionally, surrogate-reared juvenile releases required the recapture of most animals (for behavior or health reasons) (Mayer et al., 2019). However, this process increased the probability of retention and population establishment near the release site (Becker et al., 2020). Lastly, the use of surrogate-raised otters comes at a greater cost to the taxpayers. The cost of reintroduction and all other required support over 10 years is approximately $338,000 per animal due to husbandry and surrogate-rearing costs (U.S. Fish and Wildlife Service, 2022), compared to $18,000-24,000 per animal if wild otters are translocated.

Sea Otter Biology: how to Mitigate Dispersal?

In the context of reintroduction, dispersal is when translocated wildlife does not remain at the new site. This phenomenon is a leading cause of failure in wildlife reintroductions (Berger-Tal et al., 2020). This is exacerbated by the tendency of translocated carnivores to return to their original home range (Linnell et al., 1997). Adult sea otters have strong fidelity to their home ranges (Larson et al., 2015). Social groups may stay in the same area for years or even decades. Without an extant population of sea otters, reintroduced wild otters will likely disperse, and losses could be as high as 90% (U.S. Fish and Wildlife Service, 2022).

In past relocations, sea otters typically did not remain where they were released. While some became established many kilometers from the release site (Bodkin and Tinker, 2022) many simply disappeared (Bailey and Tinker, 2023). This became apparent during past reintroductions in Southeast Alaska, British Colombia, Washington, California, and Oregon when sea otters were monitored, and large amounts of dispersal occurred from the reintroduction site (Rathbun et al., 2000, Carswell 2008). Some otters returned to their home ranges (Wild and Ames 1974) swimming as far as 318 km (200 miles) (Ralls et al., 1992). For example, this homing tendency was significant in adult southern sea otters relocated to San Nicolas Island off the coast of southern California (Carswell, 2008).

Strategies for mitigating dispersal include using juveniles in the reintroduced population and using a "soft release." Subadults or juveniles tend to have lower emigration rates from the release site (Jameson et al., 1982; Carswell, 2008). Younger animals are more likely to stay in the place of relocation, because they do not have the social network or home site fidelity that adults have developed (Mayer et al., 2019). However, a reintroduced population may not be able to consist entirely of juveniles. Adult females were key in establishing a population at San Nicolas Island due to their immediate reproductive potential (Carswell, 2008). So, using an adult female biased sex ratio may improve the reproductive potential of a reintroduced population (Bodkin and Tinker, 2022).

A "soft release" is when otters are held in net pens at the release site for a duration proportional to their travel distance (Murray, 2021). Tetzlaff et al., (2019) showed that "soft releases" of translocated mammals increased release site fidelity, reduced movement, and improved post-release survival rates. Some data suggested that holding sea otters in pens at the release site may increase their propensity to stay in the area instead of returning to the home range (Ralls et al., 1992). However, net pens have their complications. Male aggression may limit the number of males in each pen to one (Murray, 2021). Previous use of net pens where otters were separated by sex indicated that male aggression was rare and short-lived (approximately one minute in duration) (U.S. Fish and Wildlife Service, 1990). More importantly though, poor weather conditions caused the use of net pens in previous translocations to be a safety issue for the translocated otters. Otters were buffeted by waves and winds and not able to find protection. Consequently, the otters were released considerably sooner than planned (Carswell, 2008; Bailey and Tinker, 2023).

Ecological Challenges: will Shark Predation or Bite Trauma be a Threat to Reintroduced Sea Otters in Oregon?

As mentioned earlier, white shark bites are limiting sea otter range expansion in California, and seven of the last eight sea otter strandings in Oregon had evidence of shark bite trauma (U.S. Fish and Wildlife Service, 2022). However, the abundance and range of white sharks in Oregon is poorly documented (Murray, 2021), and it is also unknown if white sharks may expand their range into Oregon with climate change. Several variables could impact the extent to which sharks will pose a threat to reintroduced sea otters in Oregon, including water temperatures, kelp canopy cover, abundance and species of predatory sharks, and prey availability (Tinker et al., 2016; Nicholson et al., 2018; Moxley et al., 2019; Murray, 2021). Will the broadnose seven-gill shark (*Notorynchus cepedianus*), which is common in Oregon's estuaries (Williams et al., 2012), have an impact on reintroduced sea otters? The answer is currently unknown. Seven-gill sharks consume a broad range of prey including other sharks, teleost fish and marine mammals (Ebert, 1991; Lucifora et al., 2005). There have been no interactions with sea otters documented and there is currently a funded study by the Oregon Department of Fish and Wildlife to uncover the distribution and abundance of white and seven-gill sharks in Oregon (Oregon Department of Fish and Wildlife, 2023a).

Ecological Challenges: how will Domoic Acid affect Translocated Sea Otters in Oregon?

In a recent study, 20% of otters that died in California between 1998-2012 did so because of exposure to domoic acid (DA), a significant cause of death for sea otters there (Miller et al., 2020). Sea otters eat large amounts of invertebrates that bioaccumulate DA during algal blooms (Moriarty et al., 2021). Although blooms are largely still not understood, they are linked to warmer climates (climate change) so rising sea surface temperatures are expected to intensify harmful algae blooms (Trainer et al., 2020; Moriarty et al., 2021). Chronic, low-level exposure in sea otters causes cardiac disease in prime age adults. Therefore, DA intoxication could be a substantial threat to a reintroduced sea otter population in Oregon (Murray, 2021). Harmful algae blooms do occur off the coast of Oregon and are monitored along with domoic acid (Oregon Department of Fish and Wildlife, 2022), but the current monitoring system has limited applicability for detecting low-level exposure affecting otters, because it uses higher thresholds designed to protect the public. The potential for DA associated morbidity and mortality in Oregon to a reintroduced sea otter population is high and strategies for mitigation are unknown (Murray, 2021).

Ecological Challenges: how will Disease affect Translocated Sea Otters in Oregon?

With climate change, sea level rise is expected to inundate estuaries, reducing their capacity to filter out pollutants and pathogens (Shapiro et al., 2010). The combination of increased storms causing amplified runoff, along with reduced filtration, may facilitate more transmission of land-based pathogens, such as *Toxoplasma gondii*, into the marine environment (Miller et al., 2002; Conrad et al., 2005; Shapiro et al., 2010). Climate change may cause range shifts in hosts and pathogens, thereby exposing sea otters to novel pathogens (Harvell et al., 2002). Diseases, such as toxoplasmosis, can significantly affect sea otter populations in localized areas. An appreciable amount of freshwater run-off from coastal communities may flush a large pathogen load into the nearshore ecosystem, resulting in bioaccumulation in sea otter prey. While unlikely to impact an established community, this process could have a significant negative impact on a recently reintroduced one (Murray, 2021).

Economic and Technical Concerns: how will the Fisheries Industries be affected?

The Dungeness crab (*Metacarcinus magister*) industry grossed more than $90 million in Oregon last year, demonstrating its economic importance in the state (U.S. Fish and Wildlife Service, 2022; Surowidjojo, 2023). In a stakeholder survey, fishers expressed pride at the sustainable Dungeness crab fishery, and concern that the fishery might not remain sustainable if sea otters indiscriminately predate crabs of any size or sex during any time of the year.

The Dungeness crab industry in parts of Alaska where sea otters have been reintroduced has had negative impacts (Hoyt, 2015; Estes et al., 2022). In contrast, studies in California found no evidence of negative impact to Dungeness crab abundance there (Grimes et al.. 2020; Boustany et al.. 2021). Dungeness crab abundance was greater in areas within sea otter range than outside of it. In Oregon, the areas where most commercial crab fishing occurs do not overlap with the locations expected to support high densities of sea otters (Kone et al., 2021). Therefore, it is projected that the effects of sea otter recovery on the Dungeness crab industry in Oregon will more likely resemble that of California (little to no impact) as opposed to that in Alaska (moderate to substantial impact) (U.S. Fish and Wildlife Service, 2022).

The fishery most likely affected by sea otters is the red sea urchin (*Mesocentrotus franciscanus*) (Kone et al., 2021). The red sea urchin fishery is the most valuable dive fishery in Oregon and the third most valuable shellfishery in Oregon, distantly after Dungeness crab and pink shrimp, valued at over $700,000 in 2022 (Oregon Department of Fish and Wildlife, 2021, 2023b). In the southern part of the state, abundant red sea urchins are in areas predicted to support high densities of reintroduced sea otters. Dungeness crabs are different in that they are abundant throughout the state, including some areas that are predicted to support otters in high density and others that are not (Hodder et al., 2022).

In contrast to shellfish and sea urchin fisheries, finfish fisheries may likely benefit from the indirect effects of sea otter presence. This is because both kelp and sea grass systems provide important nurseries for a variety of commercial fishes (Markel and Shurin, 2015), and sea otter presence improves the productivity and stability of kelp and sea grass areas.

Stakeholders from conservation interests, recreation and tourism underlined the fact that ocean resources are a public trust and that everyone should benefit. Fishers who privately gain from the ocean should be regulated so that their actions are sustainable (U.S. Fish and Wildlife Service, 2022). Some stakeholders suggested that the shellfish fisheries have been artificially inflated in the absence of sea otters and with the return of the sea otter the system will return to a lower level more appropriate for the ecosystem.

One study in British Columbia showed that economic gains in ecotourism due to sea otters outweighed losses to invertebrate fisheries by a factor of six (Gregr et al., 2020). People are willing to pay for the chance to view sea otters. The desire to observe sea otters is second only to the desire to see whales, the number one factor for tourists choosing a wildlife tour (Martone et al., 2020). Additionally, tourism in southern Oregon could benefit from a sea otter reintroduction. South Oregon coastal cities are estimated to gain more than $35 million annually after the establishment of a viable sea otter population (Runyan Associates, 2023). Oregon’s nearshore and coastal communities could benefit in expected and unexpected ways from a return of this keystone species.

Regardless, in order to minimize conflict and increase the probability of successful translocations, future research should include assessment of socioeconomic costs and mitigation of shellfisheries concerns (Davis et al., 2019). Some questions that remain to be answered include: to what degree will the fishers be impacted? How will the impacts be offset? The U.S. Fish and Wildlife Service (2022) conducted a small, preliminary stakeholder survey, and found that the most common concern among stakeholders was the need for a long-term management plan in place before sea otters are reintroduced.

Economic and Technical Concerns: what Infrastructure is needed to support a Population of Reintroduced Sea Otters?

The necessary infrastructure for support of a reintroduced sea otter population includes stranding response, veterinary care, monitoring, housing (if being recaptured), oil-response program and possible surrogacy training (depending on source population) (Becker et al., 2020; Murray, 2021). For example, in California, the stranding response (answer to a call about a dead sea otter or live sea otter in distress) documents mortality, determines cause of death, improves care for oiled sea otters and initiates possible rehabilitation (California Department of Fish and Wildlife, 2023a). A network of many organizations responds to strandings depending on if the otter is still alive. California Department of Fish and Wildlife (CDFW), Monterey Bay Aquarium (MBA) and The Marine Mammal Center (TMMC) respond to live strandings. Rehabilitation is done by MBA and TMMC, both of which have veterinarians on site. CDFW and TMMC respond to dead stranded sea otters. When responding to a dead stranded otter, a detailed examination and necropsy is done.

By contrast, in Oregon stranding response is coordinated through the Oregon Marine Mammal Stranding Network (OMMSN). OMMSN is an informal alliance of experts from Oregon universities. Response calls are directed by the National Marine Fisheries Service in Seattle, WA, which is part of the National Oceanic and Atmospheric Administration (NOAA). The Northwest Marine Mammal Stranding Network is made up of several agencies, including Oregon State University's Marine Mammal Institute. Response to the stranded animal depends on the type of animal. They do not provide rehabilitation (Oregon State University, 2012). The only rehabilitation facility in Oregon is the Oregon Coast Aquarium in Newport, OR. They are in the fundraising phase of creating a large rehabilitation center (Oregon Coast Aquarium, 2023).

This raises several questions. Is there a large enough human population near the proposed release sites to notice stranded sea otters? Is there strong enough public awareness and support for individuals to call the requisite organization if sea otters are stranded? Who would respond to the calls? Where would stranded sea otters be taken for necropsy or rehabilitation?

Veterinary care, rehabilitation, monitoring and possibly surrogacy training would all need to be instituted in Oregon. For example, in California, sea otters have been monitored since 1982 in standardized, coordinated annual monitoring surveys which occur throughout the range of the southern sea otter. The count is done by the U.S. Geological Survey, CDFW and the MBA (California Department of Fish and Wildlife, 2023b). A combination of nearshore land observations and aerial survey by fixed wing aircraft are employed. Who will do the requisite monitoring in Oregon?

Finally, in terms of oiled wildlife response, the Oiled Wildlife Care Network in California is made up of more than 40 organizations (University of California, Davis, 2018). The cooperative maintains fully equipped facilities and equipment caches, conducts trainings and drills of staff and volunteers. The Network coordinates responses through an incident command system and has access to 12 wildlife rehabilitation facilities. The collaborative also does research on collecting and caring for wildlife and disseminates information on oil response.

Oil spills do happen off the coast of Oregon. A cargo ship ran aground off Coos Bay in 1999. More than 260,000 liters (70,000 gallons) of oil leaked onto nearby beaches (Williams, 2020). There is no oil response program for marine mammals in Oregon. If sea otters are translocated there, Oregon will need an oil response program. The Department of Environmental Quality has an emergency response program; however, the focus is on quick response and protecting human health while minimizing impact to the environment (Department of Environmental Quality, n.d.). The organization International Bird Rescue has responded to oil spills in Oregon, but a coordinated oiled wildlife response program would need to be established in Oregon.

Economic and Technical Concerns: Did We learn Enough from the Previous Oregon Reintroduction to make this one a Success?

In 1970-71, ninety-three sea otters were translocated from Amchitka Island, Alaska to Cape Arago and Port Orford in southern Oregon. For at least 10 years, some sea otters stayed in southern Oregon (with a high count of 23) and produced pups (at least 17). However, in 1981 the last known sighting of these otters occurred and one of the otters was found dead with trauma caused by shark attack (Jameson et al., 1982). All three releases were affected by storms, so that otters being kept in net pens were no longer safe and were released into areas where they were not originally planned (Bailey and Tinker, 2023). None of the otters were tagged (the technology did not exist yet) and post-release monitoring did not start until the year following the release. Due to the large scale of where otters dispersed (over 160 km or 100 mi) it was difficult to monitor the sea otters.

Strong sea otter homing tendencies and thus emigration is believed to be the most probable cause for the failure of the Oregon reintroduction (Jameson et al., 1982). The population became so small (for unknown reasons) that stochasticity (an unexpected negative event) likely played a role. For example, the stochastic event could have been due to demographic reasons (male-biased population that did not favor positive birth rates) or environmental impact (e.g., storms) (Bailey and Tinker, 2023). Ultimately, it is unknown why the population in Oregon did not persist. To understand any future reintroduction endeavors more fully, post-release monitoring and carcass recovery and analysis need to be included (Murray, 2021).

Economic and Technical Concerns: is there Enough Funding?

Lack of funding constitutes a leading reason for wildlife reintroduction failures (Berger-Tal et al., 2020). Species reintroductions are known for being inherently complex, lengthy, and expensive. In contrast, resources to implement the reintroduction are limited. USFWS estimates that reintroduction would cost taxpayers $26-43 million over a 13-year period. This would include pre-reintroduction habitat evaluation (3 years), acquisition and release of sea otters (releases of wild sea otters over 5 years or surrogate reared otters over 10 years), habitat and population monitoring (10 years) and postmortem and oil spill response programs (U.S. Fish and Wildlife Service, 2022). Whether there is enough funding remains to be seen.

SECTION FOUR: NEXT STEPS

The USFWS proposed six next steps. The first step would be to “identify and apply site selection criteria” (U.S. Fish and Wildlife Service, 2022). Kone et al. (2021) and Hodder et al. (2022) proposed areas of greatest habitat suitability. In general, canopy-forming kelp is more prevalent and more likely to form quality habitat in the southern third of the coast (from Coos Bay south) than in the northern coast (Hodder et al., 2022). For such kelp forest habitat, the locations most applicable are Depoe Bay/Yaquina Head in central Oregon; Blanco Reef, Orford Reef, and Redfish Rocks (all near Port Orford) in southern Oregon; and Simpson Reef (near Cape Arago) in southern Oregon. For estuaries, the possible areas are Tillamook Bay in northern Oregon, Yaquina Bay in central Oregon and Coos Bay in southern Oregon (U.S. Fish and Wildlife Service, 2022). Water quality monitoring of these areas indicates some anthropogenic impact but no more than that seen in California (Hodder et al., 2022).

The second step would be to "identify and select a range of most likely reintroduction scenarios" (founder animals, numbers, gender, age, etc.) (U.S. Fish and Wildlife Service, 2022). One possible scenario would be to develop pilot studies or small-scale experimental reintroductions to assess the viability of using surrogate-reared southern sea otters or small numbers of wild captured sea otters in estuaries as a source for the establishment of new populations (Tinker, 2022). Examples of species that have been reestablished using a small experimental population includes whooping cranes (*Grus americana*), black-footed ferrets (*Mustela nigripes*) and California condors (*Gymnogyps californianus*) (U.S. Fish and Wildlife Service, 2022). In terms of regulatory process, additional rulemaking to establish the reintroduced population as an experimental population under section 10(j) of the Endangered Species Act would be advisable if a listed population of sea otters is used as the founding source, such as southern sea otters or the DPS of northern sea otters in Southwest Alaska (U.S. Fish and Wildlife Service, 2022).

Another strategy would be to use multiple release sites. Oregon has a linear coastline, and linear coastlines tend to have slow sea otter population growth. Multiple introduction sites would address this issue and mitigate in case the population at one release site failed to persist (U.S. Fish and Wildlife Service, 2022). Sea otters reintroduced to multiple sites would provide "increased representation" (the ability to adapt to environmental conditions over time) and "redundancy" (ability to withstand catastrophic events) (Smith et al., 2018). A possible scenario that includes multiple release sites and would restore genetic connectivity is to release southern sea otters into central or southern Oregon, mixing with northern sea otters that either disperse from Washington or are introduced to northern (or central) Oregon (U.S. Fish and Wildlife Service, 2022). One possible release scenario modeled is the release of 50 otters at the outer-coast site near Port Orford and 25 additional otters released in Coos Bay with the subsequent release of three juveniles per year for 10 years (Bodkin and Tinker, 2022). Since otters are social creatures, their distribution would likely stay in patchy concentrations in high-quality habitat (Tinker, 2015). Ultimately, if reintroduction were a success, it would likely not result in thousands of sea otters along the Oregon coast, but rather, a few hundred over the coming decades (Tinker, 2022).

The third step would be to evaluate prey availability, since there is a lack of data on sea otter invertebrate prey in Oregon that is not commercially important (Hodder et al., 2022). Also involved in this step would be to evaluate mortality risk and other biological and ecological criteria for sustaining a healthy sea otter population at potential reintroduction sites (U.S. Fish and Wildlife Service, 2022).

The final three steps are about the social, economic, and infrastructure components of reintroduction. Step four would be to comprehensively evaluate the probable socio-economic impacts of sea otter reintroduction at specific reintroduction sites, including positive and negative impacts and monetary and non-monetary values (U.S. Fish and Wildlife Service, 2022). Step five is to explore possible regulatory flexibilities or changes, or other ways to mitigate potential negative socioeconomic impacts associated with reintroduction. The final step is to identify resources to support reintroduction and long-term post-release monitoring and management.

SECTION FIVE: Conclusion

Many questions and challenges remain regarding a possible reintroduction of sea otters to the Oregon coast. Answers to some of these questions may surface before the reintroduction, but other answers may not be known until years after.

In terms of sea otter biology, one question revolves around the issue of founder source. If northern sea otters were used from SE Alaska, then that resident population would not be negatively impacted since there are so many. In fact, use of those otters may be an assistance to the Alaskan government in managing commercially important or subsistence shellfisheries. However, because conservation of the southern sea otter is a priority, then either wild southern sea otters or surrogate-reared juveniles should be used. There are local limits to the numbers of southern sea otters that can be used to avoid negatively affecting the source population.

Strong home site fidelity and social bonds imply that translocated otters will disperse from the release site at rates as high as 90%. A case in point is the previous reintroduction to Oregon which failed. And while the definitive reason for failure is unknown, dispersal likely played a significant role. Strategies for mitigating dispersal include using juveniles in the reintroduced population and using a “soft release.” Ultimately the use of a small-scale iterative process called “adaptive management” would allow scientists to modify the process and potentially improve outcomes with every successive step (Wilson et al., 2020).

For ecological challenges, white shark and seven-gill shark distribution and abundance lead the list of concerns, and this is currently being researched. A possible mitigation measure is to release reintroduced otters into estuaries which may provide protection from sharks (and storms). More research is needed to determine low-risk areas for release in relation to disease and domoic acid exposure.

Economic and technical concerns also affect sea otter release. The red sea urchin shellfishery will very likely be negatively impacted by an otter reintroduction in Oregon. The extent of this impact remains to be seen, as does the need for mitigating measures. Some fisheries may benefit, however, from the keystone effects of sea otters, and there is a potential for economic benefits from ecotourism.

Funding issues plague reintroduction attempts. Species reintroductions are known for being inherently complex, lengthy, and expensive. In contrast, resources to implement the reintroduction are limited. Whether this reintroduction has sufficient funding is yet to be determined.

Support infrastructure will be important for a successful reintroduction of sea otters. The necessary infrastructure for support of a reintroduced sea otter population includes stranding response, veterinary care, monitoring, housing (if recaptured), oil-response program and possible surrogacy training (depending on source population). This raises several questions. Who will monitor the reintroduced population? Is there a large enough human population near the proposed release sites to notice stranded sea otters? Is there strong enough public awareness and support for individuals to call the requisite organization if sea otters are stranded? Who would respond to the calls? Where would stranded sea otters be taken for necropsy or rehabilitation? All this still needs to be coordinated. Support of a reintroduced sea otter population would require involvement from many institutions and the public at large.

It is likely that the answers to these questions (and others not yet even considered) may not be answered before a reintroduction. However, that does not mean that a reintroduction should not be attempted. Over one-third of today’s sea otter population is due to reintroductions, processes that did not have all the answers. In the 1960’s Karl Kenyon translocated several hundred sea otters to SE Alaska, which now has an abundance of over 30,000 otters. In the words of Karl Kenyon, "These questions can be answered only by continued experimentation" (Kenyon, 1969).

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RÉSUMÉ : RÉINTRODUCTION DE LA LOUTRE DE MER (*ENHYDRA LUTRIS*) SUR LA CÔTE DE L'ORÉGON AUX ÉTATS-UNIS: DÉFIS ET QUESTIONS SANS RÉPONSE

Les loutres de mer (*Enhydra lutris*), répertoriées comme en voie de disparition par l'UICN, sont une espèce clé de voûte. Elles sont absentes de la côte américaine de l'Orégon depuis plus de 100 ans. La communauté de conservation de l'ouest de l'Amérique du Nord étudie la possibilité de réintroduire les loutres de mer dans cette vaste partie de leur aire de répartition historique. Le US Fish and Wildlife Service et l'organisation sans but lucratif Elakha Alliance ont réalisé des études de faisabilité et déterminé que la réintroduction est possible. De nombreux défis et interrogations demeurent. La question de savoir quelle souche initiale utiliser, du nord ou du sud, sauvage ou élevée par substitution, reste sans réponse. Un processus adaptatif lors de la réintroduction devrait permettre aux scientifiques d'optimiser la souche initiale. La dispersion des loutres réintroduites est souvent préjudiciable aux tentatives de translocation. La dispersion peut être atténuée par la libération de juvéniles qui n'ont pas développé une grande fidélité à leur domaine vital. Les évaluations des risques écologiques tels que les morsures de requins ou la prédation (en cours de recherche), ainsi que l'exposition aux maladies et à l'acide domoïque (évaluées une fois qu'un site de réintroduction est déterminé) sont des aspects importants de la planification. Des préoccupations économiques et techniques demeurent. La pêche à l'oursin rouge devrait être affectée négativement par la réintroduction de la loutre de mer. D'autres problèmes doivent encore être résolus, notamment le financement et les infrastructures de soutien, la surveillance, la problématique des échouages, les soins vétérinaires, les risques liés aux hydrocarbures et un éventuel programme de maternité de substitution. Il n'est pas possible de répondre à toutes ces questions avant qu'une réintroduction n'ait eu lieu. Les réintroductions précédentes en Amérique du Nord représentent plus de 30 % de la population mondiale de loutres de mer. Ces réintroductions de loutres de mer ont été réalisées à l'aide d'informations bien moindres que celles dont nous disposons aujourd'hui, illustrant le fait que le succès est possible même si des questions restent sans réponse.

RESUMEN: RE-INTRODUCCIÓN DE LA NUTRIA MARINA (*ENHYDRA LUTRIS*) EN LA COSTA DE OREGON, ESTADOS UNIDOS: DESAFÍOS Y PREGUNTAS AÚN NO RESPONDIDAS

Las nutrias marinas (*Enhydra lutris*), listadas como En Peligro de Extinción por la UICN, son una importante especie clave. Han estado ausentes de la costa de Oregon (Estados Unidos) por más de 100 años. La comunidad de conservación del oeste de Norteamérica está explorando la posibilidad de reintroducir nutrias marinas en ésta gran sección de su distribución histórica. El Servicio de Pesca y Fauna de Estados Unidos y la organización sin fines de lucro Elakha Alliance completaron evaluaciones de factibilidad y determinaron que la re-introducción es factible. Persisten muchos desafíos y preguntas. La pregunta de qué fuente fundadora utilizar, septentrional o meridional, silvestre o criada por padres surrogantes, debe aún ser respondida. Un proceso adaptativo durante la re-introducción permite a los científicos optimizar la fuente fundadora. La dispersión de las nutrias re-introducidas es a menudo detrimental para los intentos de translocación. La dispersión puede ser mitigada liberando juveniles

que no hayan desarrollado una fuerte fidelidad al home range. Las evaluaciones ecológicas del riesgo, tales como la mordedura o la predación por tiburones (se está investigando) y la exposición a enfermedades y a ácido domoico (que se evalúan una vez que se determina un sitio de re-introducción) son importantes aspectos de la planificación. Persisten preocupaciones económicas y técnicas. Es de esperar que las pesquerías de erizo rojo sean impactadas negativamente por la re-introducción de nutria marina. Otras preocupaciones que aún resta resolver comprenden el financiamiento y la infraestructura de soporte, incluyendo el monitoreo, la respuesta a varamientos, el cuidado veterinario, la respuesta a derrames de petróleo, y un posible programa de surrogancia. No todas las preguntas pueden ser respondidas antes de que ocurra una re-introducción. Las re-introducciones previas en Norteamérica dan cuenta de más del 30% de la población global de nutria marina. Estas re-introducciones fueron llevadas a cabo con considerablemente menos información sobre la nutria marina que la que se tiene hoy, lo que ilustra que el éxito es posible aún con preguntas no respondidas.