NOTE FROM THE EDITOR

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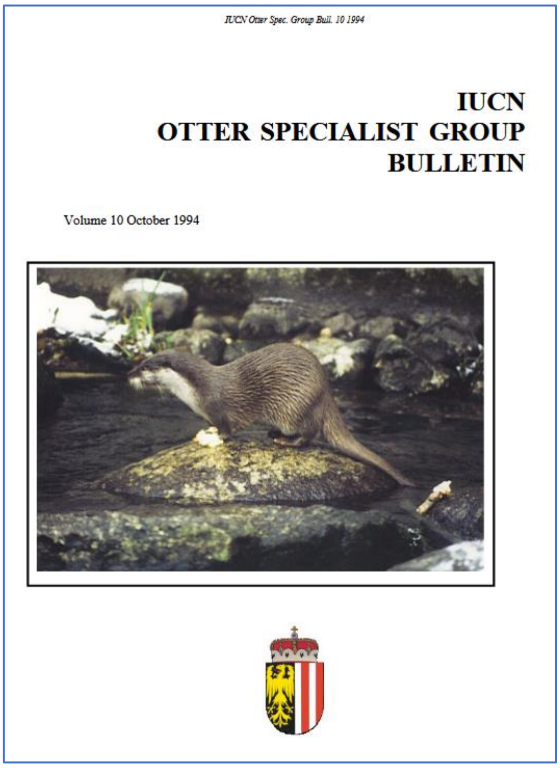
Dear Friends, Colleagues and Otter Enthusiasts!

We have closed issue 41/2 of this year and issue 42/3 goes now online. We are in October 2024, and it is a special month as 30 years ago the first issue of the IUCN OSG Bull. came out with me as editor. There is no reason to be nostalgic. We have all achieved something very nice with our journal over the years. I have lost track how many papers or pages we have published.



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It has been a lot of fun and at least for the near future I do not see any changes in my efforts to serve you all.

Lesley, for a large part you have heavily contributed to the development as I lost actually track since when we have the online only version and this would have not been possible without you. I do not know any of your magics so we all depend on you and your work.

R E P O R T

A SURVEY OF OTTERS IN THE KHOLONGCHU AND UPPER DRANGMECHU RIVERS, EASTERN BHUTAN

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Abstract: Otter species are declining across their distribution range in asia. Only scanty information is available about the presence of otters in Bhutan. This study documents the presence of three otter species, the smooth-coated otter (*Lutrogale perspicillata*), the small-clawed otter (*Aonyx cinereus*) and eurasian otter (*Lutra lutra*), in the landscape of Trashigang forest division in Eastern Bhutan. Multiple techniques were used to document otter presence, including camera trap survey, sign survey, direct sighting, reliable photographic evidence, found specimens, and public consultation. Habitat disturbances including sand mining and quarry, unregulated fishing and hydropower construction were identified as significant threats to otters in the study region. Further systematic otter surveys are needed in the region and other parts of the country to make an accurate population assessment, understand threats, and develop effective conservation strategies for the protection of otter species in Bhutan.

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INTRODUCTION

Thirteen species of otters exist globally, with five species in Asia (Basnet et al., 2020). The Smooth-coated otter *Lutrogale perspicillata*, the Small-clawed otter *Aonyx cinereus*, and the Eurasian otter *Lutra lutra* are the three extant species in the eastern Himalayas (Khatiwara and Bhutia, 2020; Borker et al., 2022). The Red List of the International Union for the Conservation of Nature (IUCN) classifies the first two species as Vulnerable (Duplaix and Savage, 2018), and the last as Near Threatened owing to sharp population declines across their range (Savage, 2022). The Smooth-coated otter and the Eurasian otter are listed in CITES Appendix I (Gupta et al., 2020).

Otters (Mustelidae) are semi-aquatic apex predators and keystone species in riverine ecosystems, and are recognized as ‘wetland ambassadors’ (Medhi et al., 2014). Prey mainly on fish but their diet may include reptiles, amphibians, snails, arthropods, aquatic invertebrates, crabs and occasionally birds (Gowtham et al., 2022; Naidu et al., 2022). There is little research on the distribution, ecology and conservation of otter species in Bhutan (De Silva, 2011).

Bhutan is part of the Eastern Himalayan Global Biodiversity Hotspot (Myers et al., 2000), and recognized as one of the 200 globally important eco-regions (Olson and Dinerstein, 2002). The country is abutted by India to the east (Arunachal Pradesh), south (Assam and West Bengal) and west (Sikkim), and China (Tibetan Autonomous Region) to the north. With over 38,394 sq.km, and undulating landscapes ranging in elevation from 65 to 7000 masl, the country has great biological significance. Commitment to conservation is strong in Bhutan, which harbours more than 200 mammal species (Wangchuk et al., 2004), with many globally threatened species. The Bhutan Forest and Nature Conservation Act 2023, and the 2023 Rules provision give robust legal protection status to otter species in the country.

There is little known about otter distribution in the country, and information about their conservation status is scanty. To our knowledge, only three studies in Bhutan have reliably reported the presence of otters (locally known as ‘chusham’). Chettri and Savage (2014) studied otter sign along the Punatshangchhu River in central Bhutan. Wangchuk et al. (2004) reported the presence of three species of otters. Gyeltshen and Dorji (2015) reported the occurrence of Eurasian otter and Small-clawed otter in Phrumshingla National Park (PNP).

In the neighbouring Indian state of Arunachal Pradesh, there are reports of all three otter species, Smooth-coated otter and Eurasian otter in Nyamjang Chu in western Tawang District (Medhi et al., 2014; Bhattacharya et al., 2019), and Small-clawed otter in Namdapha and Pakke Tiger Reserve in West Kameng District (Borker et al., 2022), reflecting otter populations with trans-boundary distributions with Bhutan (Medhi et al., 2014). Nyamjang Chu in Tawang District is one of the major headwaters of the Drangmechu River in eastern Bhutan. Moreover, 60.2 km of Trashigang Forest Division shares a northeastern boundary with Arunachal Pradesh (Tobgay et al., 2022). Two or three species of otter had been anecdotally reported to occur along the Drangmechu and Kholongchu Rivers inside Trashigang Forest Division in eastern Bhutan, but the identity of the species remain unconfirmed.

To address this knowledge gap, a rapid preliminary assessment was conducted in Trashigang Forest Division to document baseline information on otters in the region along the Kholongchu River and upper Drangmechu River and their tributaries.

STUDY AREA

The study focused on two river basins and their tributaries in Trashigang Forest Division, outside the protected areas of Trashigang and Trashiyangtse Districts, in eastern Bhutan. Trashigang Forest Division is endowed with rich biological diversity, including 273 species of birds (Norbu et al., 2021), 34 species of snakes (Koirala et al., 2021), 48 species of hawkmoths (Norbu et al., 2022), 25 mammal species (NCS, 2023) and 811 species of vascular plants (Tobgay et al., 2022).

It is also home to rich watershed resources, including freshwater rivers and streams, wetlands and lakes. The landscape forest types include broadleaved forest, mixed pine-cool broadleaved forest, pine forest, chir pine forest, mixed conifer forest, fir forest, alpine shrubs and meadows, and plantations. The area has a subtropical to temperate climate, with warm and wet summers from April to August, and cool and dry weather from September to March. It receives an average annual rainfall of 1000 to 2000 mm and an average annual temperature of 20.2 °C with wide seasonal variation (Koirala et al., 2021).

Potential fish species found in both the Kholongchu and Drangmechu basins which otters may prey upon include *Schizothorax richardsonii*, *Neolissochilus hexagonolepis*, *Pseudochinesis sulcata*, *Parachiloglanis bhutanensis*, *Garra gotyla*, *Creteuchiloglanis bumdelingensis* and *Schistura* sp., (Wangchuk et al., 2021). The endangered golden masher (*Tor putitora*) also inhabits the Drangmechu River.

The survey was conducted along the Kholongchu and Upper Drangmechu Rivers, main tributaries to the Manas River. Survey data collection was also extended along the Gamri River, a tributary to the Drangmechu River in Trashigang District, as well as along the Dongdichhu River and Tshergom stream in Trashiyangtse District (Fig. 1).

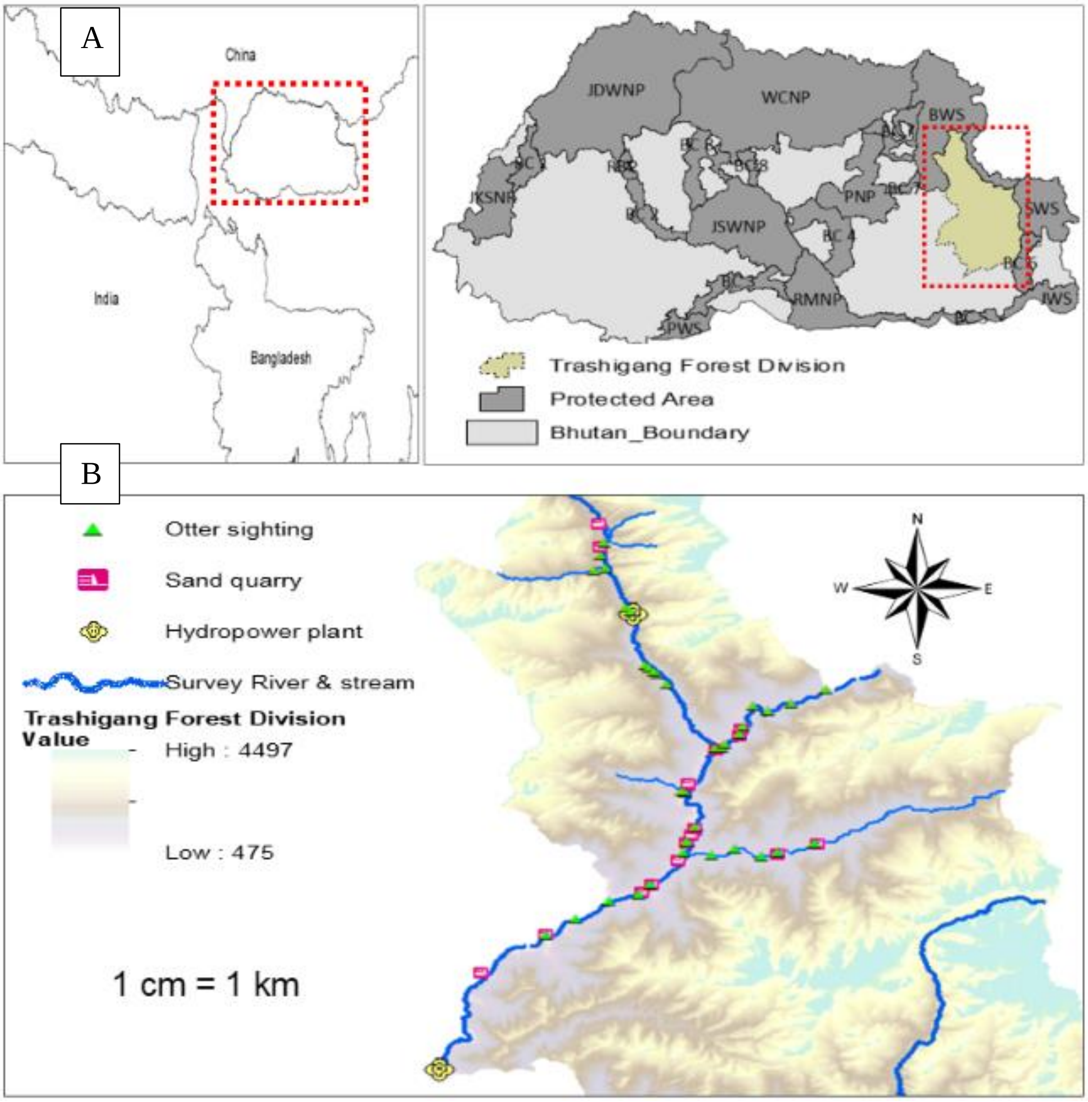

Figure 1. Map showing the location of a) Bhutan and Trashigang Forest Division and, (b) the study area rivers.

Data Collection

During an extensive fishing patrolling, incidental rapid biodiversity surveys, site inspection, environmental impact assessments and white-bellied heron (*Ardea insignis*) survey along upper Drangmechu River and Kholongchu River, opportunistic observation data was collected from 2018 to 2023, including a direct sighting and indirect signs of otters. Otter specific field surveys were also conducted on foot led by the first author across two rivers and tributaries (Fig. 2) to collect evidence of the presence of otters. The otter specific survey was undertaken during pre- and post-monsoon seasons. Survey team walked both sides of the banks of the rivers and their tributaries, and searched for otter presence/absence sign, all within an elevation range of 450 to 1850 masl.

Figure 2. The Kholongchu River, where the otter sign survey was conducted.

Otter presence indirect sign (scats, latrine sites, tracks, dens and grooming sites), direct sighting, locations and important habitat variables (river bankside condition, water current and depth, bank slope and gradient, escape cover distance, basking and grooming sites, presence of logs, sandy bank and surrounding vegetation type) were recorded. In addition, potential threats and disturbances signs were also recorded where considered potentially important for otters.

Two infrared camera-traps UWay^{TM} (Uway Outdoors, Norcross, Georgia, U.S.A.) were also installed opportunistically along the Kholongchu sub-basin in March, 2022, targeted to capture an image of otter. The camera traps were set to function 24 hours per day with five second time lapse between consecutive photographs, and three shots per trigger. No attractants, lure or bait was used. The geo-coordinates and elevation of both indirect and direct signs observed, and camera trap locations, were recorded using GPS-Garmin e-Trex® 30 (Garmin International Inc., Olathe, Kansas, U.S.A.) device set to WGS 84 datum.

To get an additional inputs and information about otters in the study area, we also consulted in local villagers, fishers and forestry personnel of the Trashigang Forest Division.

Identification of Sign and Otter Species

Otter scats were identified by the presence of fish bones, scales and a fishy odor. Latrines, displaying multiple scat, trails and tracks, were usually found at sandy areas and near large boulders near the water’s edge. Tracks were identified by a round impression of five toes and faint webbing marks on mud and sand along riverbank; only positively identified otter tracks were recorded. Melissa Savage (PhD), University of California, Los Angeles, USA was consulted for correct species identification.

RESULTS

Indirect Otter Signs

Otter scats, latrine sites, tracks or trail and dens were recorded along the Kholongchu and upper Drangmechu Rivers, and their tributaries such as Dongdichhu and Tshergom stream in Trashiyangtse District, and Gamri River in Trashigang District. A total of 99 indirect signs were recorded: scats= 61 with 26 fresh and 35 old to very old, tracks= 34, slide or grooming= 2 and den = 1.

The survey recorded otter tracks distinctly displayed on mud and sandy banks (Fig. 3). Otter slide and grooming sites were also recorded from the sandy bank of the

Kholongchu River, upper Drangmechu River and Gamri River. Cave, crevices and well-vegetated sandy banks were used for the otter den along kholongchu river bank in Betshateng Koncholing under Khamdang block, TrashiYangtse District. In the survey, fish (*Schizothorax richardsonii*) carcass remains (n= 1) with bite marks were recorded, with abdominal or the tail portions left discarded by the otters (Fig. 6b) likely because otters do not prefer the tail part of the fish, which lacks fleshy meat.

Figure 3. Eurasian Otter tracks on a sandy riverbank (© Lam Norbu).

Among the otter indirect sign recorded, scats and latrine sites were most often observed on the large flat stones and boulders at the edge or in the middle of the river where banks were flat and the water current slow, sluggish or static. Otters also used drift logs and sandy banks along the water edges for feeding and defecation. Otter scats were found of different sizes, from large and narrow, with fish and crustacean remains and a distinctively fishy odour (Fig. 4).

Figure 4. Otter scats containing fish bones and scales (© Lam Norbu).

Direct Sightings

Repeated sightings of groups of 2 to 5 otters were seen at multiple locations along the Drangmechu and Kholongchu Rivers, and their tributaries, including the Gamri River, Dongdhi chu and Tshergom stream. Photographic evidence of Smooth-coated otters (Fig. 5) was also recorded, during activities such as swimming, prey hunting and feeding, sun basking and grooming along these rivers and tributaries. A small-clawed otter with its prey (Fig. 6a) was opportunistically photographed from upper Kholongchu River in 2018 by forestry personnel of Bumdeling Wildlife Sanctuary, a record almost 10 km away from the town of Yangtse. In 2020, two small-clawed otter individuals were also spotted along the Kholongchu River below the town of Yangtse.

Figure 5. Smooth-coated otters hunting for prey in the upper Drangmechu River (left, © Tandin Jamtsho) and in the Kholongchu River (right, © Rinchen Choda).

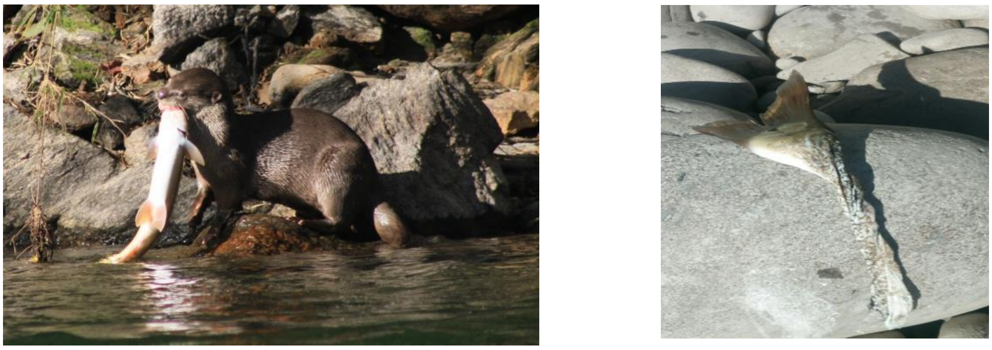

Figure 6. Asian small-clawed otter with its prey, *Schizothorax richardsonii*, on the Kholongchu River (left, © Tshering Choephel) and *Schizothorx richardsonii* remains left by otter at Gamri River bank (right, © Karma Jamtsho).

In November 2023, the forestry personnel of Radhi Forest Range rescued an injured adult Eurasian otter (Fig. 8a) from the Gamri River watershed, which was released and later found dead. Our survey team also recovered a Eurasian otter pelt in 2018 from a fisherman's house in the town of Doksum, Trashiyangtse (Fig. 7). During a detail investigation, it was learned that the otter pelt was recovered from bank of lower Kholongchu River, perhaps killed by the high flow of the monsoon river. One of the fishermen also reported that a juvenile otter was killed by cow herder and his dog at the Tshergom stream in Trashiyangtse. A similar incidence was also anecdotally reported from the town of Yangtse, a dead juvenile otter in Berzam chhu stream above Chorten Kora, suspected to be killed by the local feral dogs.

Figure 7. Eurasian otter pelt recovered from fisherman’s house at Doksum, Trashiyangtse (© Lam Norbu).

Figure 8. (Left) Eurasian otter carcass from Gamri stream watershed, Radhi Range (© Phurpa Wangdi), and (Right) Eurasian otter from Trashigang (©Tandin Jamtsho).

Camera trap and Social Evidence

Remote camera traps were set in the field for 35 days but no images of otters were captured. However, multiple fresh otter tracks and scats were observed at the camera locations. Other wildlife fauna, viz. Leopard cat (*Prionailurus bengalensis*), Yellow-throated Marten (*Martes flavigula*), Arunachal macaque (*Macaca munzala*), Himalayan goral (*Nemorhaedus goral*), rodents and birds were repeatedly recorded from two camera trap locations.

Informal interviews and discussions were conducted with local communities, fishers, and forestry personnel of Trashigang Forest Division, and many thought that otter species were present; however, it is unclear whether these animals were correctly identified. Interviewed fishers reported frequent interections with otters while fishing along the rivers and tributaries. A few fishers mentioned that they had fishing nets damaged by otters and they had retaliated and killed otters often in the past.

Habitat Characteristics and Vegetation Types

Kholongchu sub-basin (Fig. 9b) runs primarily through a narrow valley, with a fast current and rapids; in some sections it passes through a gentle plain where river runs with a slow current. The banks of the river consists of a jumble of large boulders and stones, with sections of sandy banks scattered intermittantly. The riparian vegetation observed along the sub-basin and its tributaries are dominated by broadleaved forests, viz. *Cordia obliquum*, *Aphanamixis polystachya*, *Garcinia sopsopia*, *Altinga excelsa*, *Sloanea tomentosa*, *Trema* spp., *Daphniphylum himalayanse*, *Neolitsea* spp., *Acer oblongum*, *Schima wallichia*, *Schima khasiana*, *Symplocus* spp., *Alnus nepalensis*, *Cinnamomum* spp., *Lindera* spp., *Carpinus betulas*, and *Quercus griffithii*.

Figure 9. (Left) Drangmechu River, and (Right) Kholongchu River

Unlike the Kholongchu sub-basin, the upper Drangmechu basin (Fig. 9a) runs through a gentle gradient from fast to gentle and slow. The river basin banks consist of a jumble of boulders and stones with large sandy banks scattered intermittantly. The vegetation types observed along the upper Drangmechu River and its tribuatries are mostly dominated by xerophytes such as *Pinus roxburghii*, *Cycus* spp., *Cassia fistula*, *Acacia* spp., and, in some locations by broadleaved tree species such as *Dalbergia* spp., *Erythrina arborescens*, *Bombax ceiba*, *Diploknema butyracea*, and *Duabanga* spp.

Vegetation common to both the river basins include *Syzygium cuminii*, *Bischofia javanica*, *Radermachera sinica*, *Bauhinia* spp., *Mallotus phillipensis*, *Engelhardia spicata*, *Zizziphus* spp., *Clerodendrum glandulosum*, *Macaranga denticulata*, *Zanthoxylum* spp., *Ficus* spp., *Albizzia* spp., *Rhus* spp., *Phylanthus emblica*, and *Quercus gluaca*.

Disturbances and Threats to Otters

Potential disturbances and threats to otters were observed along both the river basin and their tributaries. Notable anthropogenic disturbances include sand dredging and other river material collection, illicit fishing, hydropower construction and unlawful dumping of non-degradable waste into rivers. One sand dredging site and numerous small collection points along the Kholongchu River stretch were observed. Similarly, more than eight commercial sand dredging sites and many small collection points were observed along the Drangmechu River (Fig. 10), as well as sand collection and stone quarry points along the Gamri River.

B

Figure 10. Sand dredging and quarry along the Drangmechu River.

Illegal fishing is also observed at 22 points along both river basin and their tributaries including illegal fishing sign and gear such as hooks, nets, and other signs, evidence of the severe competition and conflict that otters face from the fishing by humans (Fig. 11).

Figure 11. Foresters dismantling fishing gear unlawfully installed by fishers in Drangmechu and Kholongchu sub-basin.

Another major threat will be habitat fragmentation and degradation caused by the construction of the 600-megawatts Kholongchu hydroelectric power amenity. The project will construction a large dam on the Kholongchu River and a small diversion tunnel at its tributary, the Bramlangchu stream. Once the construction of dam and tunnel commences, a large portion of river and stream will be diverted into the tunnel, severely disrupting aquatic ecosystem dynamics (Khatiwara and Bhutia, 2020, Figure 12).

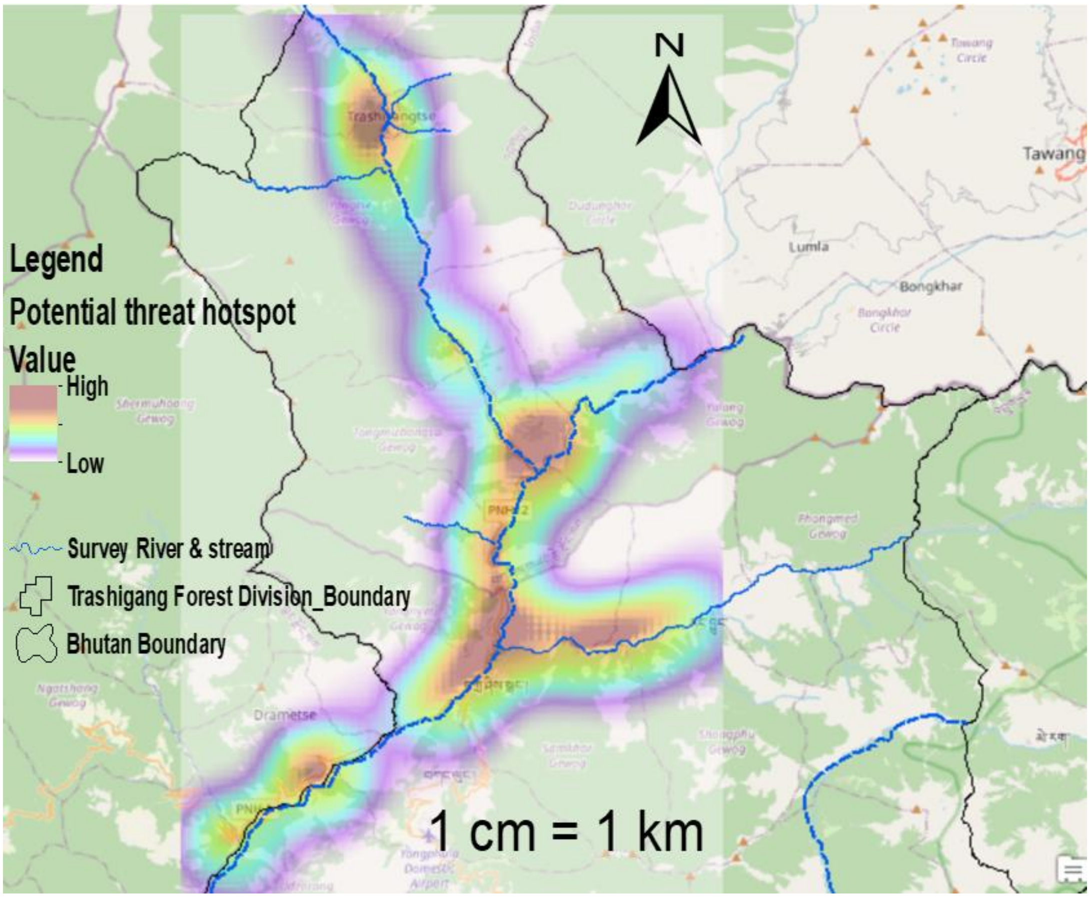

Figure 12. Potential hotspots of threats to otters in the study area.

DISCUSSION

This is the first preliminary survey effort on otters in the eastern Bhutan, despite the fact that the region, including the Kholongchu River and the upper Drangmechu River, and their tributaries inside Trashigang Forest Division landscape, have extensive suitable habitat for otters. This study reveals photographic evidence of presence of three otter species in the region, the Smooth-coated otter, Small-clawed otter and Eurasian otter. The survey found multiple otter sign such as tracks, scats, latrines and dens in sites with vegetation cover, along sandy river banks with large boulders, and with minimal human disturbances (Chettri and Savage, 2014). Based on the survey findings, all three otter species appear to inhabit the river systems, with some overlap their habitat use, thus suggesting likely coexistence or sympatric behaviour of these species. This survey did not study otter behaviour traits or prey base, nor otter abundance and population status. Therefore, further systematic studies are needed to confirm the abundance and population status of three otter species in the region.

CONCLUSION

Across South Asia and the Himalayan region, otter populations are dwindling and subject to intensifying pressure of expanding human population, fragmentation of wetland habitat, poaching, loss of adequate prey base, pollution, contamination of waterways, and construction of hydro power plants (Duplaix and Savage, 2018). Otters in eastern Bhutan and elsewhere in the country are significantly impacted by the construction of large hydroelectric plant facilities, as they are throughout the Himalayas (Foster-Turley et al., 1990; Chettri and Savage, 2014). However, no studies have yet been conducted on this issue, and the greatest threat to otter species in Bhutan is arguably the current and planned construction of multiple hydroelectric power facilities (Chettri and Savage, 2014). In addition, the impact on otter populations of human activities such as large-scale sand mining and quarrying, river bed material collections, dumping of waste and extensive fishing along the river basin deserve further investigation.

A fuller understanding of the distribution and status of otters in the study region and throughout Bhutan would enable informed conservation decisions. Lack of such information will hinder suitable conservation efforts and lead to further declines in their populations. Presence-absence data is crucial for framing a species conservation strategy. This study lays a foundation for future research on otter species in eastern Bhutan, to better understand their status, distribution, and threats and to plan for their long-term conservation in a highly biodiverse region of Bhutan.

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RESUMÉ: ENQUÊTE SUR LES LOUTRES DES RIVIÈRES DU KHOLONGCHU ET DU HAUT DANGMECHU, SITUÉES A L'EST DU BHOUTAN

Les différentes espèces de loutres sont en déclin dans leur aire de répartition en Asie. Il existe peu d'informations disponibles sur la présence des loutres au Bhoutan. Cette étude documente la présence de trois espèces de loutres à savoir la loutre à pelage lisse (*Lutrogale perspicillata*), la loutre cendrée (*Aonyx cinereus*) et la loutre eurasienne (*Lutra lutra*), dans le paysage de la division forestière de Trashigang, à l'est du Bhoutan. Plusieurs techniques ont été utilisées afin de documenter la présence des loutres, notamment des relevés à l'aide de pièges photographiques, des indices de présence, l'observation directe, des preuves photographiques fiables, des spécimens trouvés et la consultation publique. Les perturbations de l'habitat, notamment l'extraction de sable et les carrières, la pêche non réglementée et la construction de turbines, ont été identifiées comme des menaces importantes pour les loutres dans la région étudiée. D'autres enquêtes systématiques sur les loutres sont nécessaires dans la région et dans d'autres parties du pays pour réaliser une évaluation précise de la population, comprendre les menaces et développer des stratégies de conservation efficaces pour la protection des différentes espèces de loutres au Bhoutan.

RESUMEN: RELEVAMIENTO DE NUTRIAS EN LOS RÍOS KHOLONGCHU Y DRANGMECHU SUPERIOR, BHUTAN ORIENTAL

Las especies de nutrias están declinando en toda su área de distribución en Asia. Se dispone sólo de escasa información sobre la presencia de nutrias en Bhutan. Este estudio documento la presencia de tres especies de nutria, la Nutria Lisa ((*Lutrogale perspicillata*), la Nutria de Uñas Pequeñas (*Aonyx cinereus*) y la Nutria Eurasiática (*Lutra lutra*); en el paisaje de la División Forestal Trashigang, en Bhutan oriental. Se usaron múltiples técnicas para documentar la presencia de nutrias, incluyendo relevamiento con cámaras-trampa, relevamiento de signos, avistamiento directo, evidencia fotográfica confiable, hallazgo de especímenes, y consulta pública. Se identificaron como amenazas significativas a las nutrias en la región de estudio, los disturbios de hábitat incluyendo extracción de arena y canteras, pesca no regulada y construcción de represas hidroeléctricas. Se necesitan ulteriores relevamientos sistemáticos de nutrias en la región y en otras partes del país, para realizar una evaluación poblacional certera, comprender las amenazas, y desarrollar estrategias efectivas de conservación para la protección de las especies de nutrias en Bhutan.

བསྡུད་དོན་–འབྲུག་ཤར་ཕྱོགས་རྫོང་ཁག་ཁོ་ལོང་ཆུ་དང་གྲང་མེ་ཆུ་འགོའི་ནང་སྲམ་རིགས་ཀྱི་སྐོར་ལས་བརྟག་ཞིབ།

ཨེ་ཤི་ཡ་ལུང་ཕྱོགས་ནང་སྲམ་གི་རིགས་ཀྱི་ཁྱབ་ཚད་ཀྱི་ས་སྒོ་འདི་མར་ཉམས་འགྱོ་དོ་ཡོདཔ་ཨིན།དེ་མ་ཚད་འབྲུག་རྒྱལ་ཁབ་ནང་སྲམ་ཡོད་ལུགས་ཀྱི་བརྡ་དོན་འདི་ཉུང་སུ་ཅིག་ལས་མེདཔ་ཨིན།ད་སྔོ་གི་བརྟག་ཞིབ་འདི་གི་ཤར་ཕྱོགས་རྫོང་ཁག་བཀྲ་ཤིས་སྒང་མངའ་སྡེ་ནགས་ཚལ་ཡིག་ཚང་གི་ཁྱབ་འཁོར་གི་ས་གནས་ནང་ལུ་སྲམ་ཚུང་གི་རིགས་ ཨིས་མྱུད་ ཀོ་ཀྲེད་ ཨོ་ཀྲར་(*Lutrogale perspicillata*)་ ཨིས་མོལ་ ཀོ་ལོ་ཀྲ་ཨོ་ཀྲར་(*Aonyx cinereus*)་དང་ཡུ་རེ་ཤིན་ཨོ་ཀྲར་(*Lutra lutra*)་གསུམ་ཡོད་པའི་ཤེས་རྟོགས་འབྱུང་འདི་ཡིག་ཆ་བརྡ་སྤྲིག་འབདཔ་ཨིན།སྲམ་ཚུང་ཡོད་མེད་བརྟག་ཞིབ་ཀྱི་དོན་ལས་ཐབས་ཤེས་དང་རིག་རྩལ་མ་འདྲཝ་ལེ་ཤ་ལག་ལེན་འཐབ་པའི་ནང་གསེས་ལས་པར་ཆས་ཀྱི་འཕྲུལ་ཆས་བཙུགས་ཐོག་ལས་བརྟག་བཞིབ་སྲམ་ཚུང་ཡོད་པའི་རྟགས་མཚན་གྱི་བརྟག་ཞིབ་སྲམ་ཚུང་ངོ་མ་འབད་མཐོང་མི་པར་བཏབ་འདི་ཡོད་མི་ལས་དང་མི་སེར་ཚུ་དང་གཅིག་ཁར་གྲོས་བསྡུར་འབད་ཐོག་ལས་ཡིག་ཆ་འདི་བརྡ་སྤྲིག་འབད་འདི་ཡོདཔ་ཨིན།བརྟག་ཞིབ་འབད་བའི་ས་ཁོངས་ནང་བྱེམ་དང་རྡོ་བཏོན་མི་ཁྲིམས་བཀལ་ཐོག་ཉ་བཟུང་མི་དང་གློག་མེ་འཕྲུལ་ཁང་བཟོ་བསྐྲུན་གྱི་ལཱ་ཚུ་གི་སྲམ་ཚུང་ཁྱིམ་ས་ཁོངས་ཚུ་ལུ་གནོད་པ་རྒྱབ་མི་ལུ་བརྟེན་སྲམ་ཚུང་འདི་ལུ་གནོད་ཉེན་སྦོམ་ཡོད་པའི་ཤེས་རྟོགས་འབྱུང་ཡི།དེ་མ་ཚད་སྲམ་འདི་གི་གྲང་ཚད་ངེས་བདེན་ཐོབ་ནི་དོན་ལུ་གནོད་ཉེན་གྱི་སྐོར་ལས་ཤེས་ནི་གི་དོན་ལུ་དང་སྲམ་གྱི་རིགས་ཉམས་སྲུང་དང་སྲུང་སྐྱོབ་ཀྱི་འཆར་གཞི་བརྩམ་ནིའི་དོན་ལས་རྒྱལ་ཁབ་ནང་གི་ས་སྒོ་སོ་སོ་ནང་ལུ་ཡང་སྲམ་གྱི་སྐོར་ལས་བརྟག་བཞིབ་འབད་དགོཔ་ཁག་ཆེཝ་སྦེ་མངོན་གསལ་འབྱུང་ཡི།

फिर से शुरू करें: पूर्वी भूटान की खोलोंग्चू और ऊपरी ड्रांगमेचू नदियों में ऊदबिलावों का एक सर्वेक्षण

एशिया में अपने वितरण क्षेत्र में ऊदबिलाव प्रजातियाँ घट रही हैं। भूटान में ऊदबिलाव की मौजूदगी के बारे में बहुत कम जानकारी उपलब्ध है। यह अध्ययन पूर्वी भूटान में ट्रैशिगांग वन प्रभाग के परिदृश्य के अंदर तीन ऊदबिलाव प्रजातियों, चिकने-लेपित ऊदबिलाव, छोटे पंजे वाले ऊदबिलाव और यूरेशियन ऊदबिलाव की उपस्थिति का दस्तावेजीकरण करता है। ऊदबिलाव की उपस्थिति का दस्तावेजीकरण करने के लिए कई तकनीकों का उपयोग किया गया, जिसमें कैमरा ट्रैप सर्वेक्षण, संकेत सर्वेक्षण, प्रत्यक्ष दृष्टि, विश्वसनीय फोटोग्राफिक साक्ष्य, पाए गए नमूने और सार्वजनिक परामर्श शामिल हैं। अध्ययन क्षेत्र में रेत खनन और खदान, अनियमित मछली पकड़ने और जलविद्युत निर्माण सहित आवास संबंधी गड़बड़ी को ऊदबिलावों के लिए महत्वपूर्ण खतरे के रूप में पहचाना गया। सटीक जनसंख्या मूल्यांकन करने, खतरों को समझने और भूटान में ऊदबिलाव प्रजातियों की सुरक्षा के लिए प्रभावी संरक्षण रणनीति विकसित करने के लिए क्षेत्र और देश के अन्य हिस्सों में और अधिक व्यवस्थित ऊदबिलाव सर्वेक्षण की आवश्यकता है।

REPORT

PHOTOGRAPHIC EVIDENCE OF INCIDENTAL SIGHTINGS OF THE VULNERABLE ASIAN SMALL-CLAWED OTTER (*Aonyx cinereus* ILLIGER, 1815) IN THE MIXED FOREST OF DARJEELING AND KALIMPONG DISTRICT AS PART OF CENTRAL HIMALAYA

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Abstract: Direct incidental sightings and confirmed identification of *A. cinereus* was recorded for the first time with documented photographic evidence in the study areas. This new report of *A. cinereus* from subtropical humid type mixed forest (1294m a.s.l.) in District Darjeeling and from semi-temperate type forest (Elevation: 1924.35m a.s.l.) of District Kalimpong, in state West Bengal, India as a part of Bio-geographic Province 2C, Central Himalaya demonstrates that the distribution and ranging patterns of such vulnerable species is still patchy in India. The present study aims to fill up an immense knowledge gap on the distributional range of Asian small-clawed otter in human dominated vulnerable landscapes from the Central Himalaya.

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Keywords: *Aonyx cinereus*, photographic evidence, temperate forest, Central Himalaya

INTRODUCTION

The ecosystem services offered by the mammals should inspire not only ecologists and conservationists of biodiversity but also to anyone concerned with sustainability of the biosphere. Mammals are considered to play an indispensable role in ecosystems functioning such as grazing, predation, and seed dispersal, and provide important benefits to humans in terms of food, recreation, and income, yet in spite of their unquestionable significance our understanding of them is still surprisingly sparse (Reeder et al., 2007; Schipper et al., 2008).

It is indeed a sad reflection on the researchers from this part of the world, that when many countries are preparing the Red-Data listings of threatened species from the perspective of conservation of nature and natural resources, being an integral part of biodiversity hotspot, most part of Bio-geographic Province 2C, Central Himalaya, still remain biologically unexplored.

The Asian small-clawed otter (*Aonyx cinereus* Illiger, 1815) is one of three species of river otters found in India while the others which are well documented from different regions of India include the Eurasian Otter (*Lutra lutra* Linnaeus, 1758) and the Smooth-coated Otter (*Lutra perspicillata* I. Geoffroy Saint-Hilaire, 1826), (Savage, 2022). Asian small-clawed otter (*Aonyx cinereus*) is a small semi-aquatic animal belonging to the mammalian order Carnivora and family Mustelidae (Hussain et al., 2011). They have distinctive hand-like front paws with reduced claws, well adapted for catching and handling small prey and a tapering tail which aids in propulsion for catching small vertebrate and invertebrate prey in shallow and murky water (Larivière, 2003; Hussain et al., 2011). The Asian small-clawed otter is reported to be the smallest otter among the 13 extant species of otters in the world (Harris, 1968; Foster-Turley and Santiapillai, 1990) rarely weighing more than 5 kg (Hussain et al., 2011). This species is a top carnivore and therefore plays an important role in the balance and processes of ecosystems. Thus, any disturbances in the distribution of the wild population of otters could significantly influence the overall spatiotemporal dynamics of river systems, and thereby impacting the beneficial ecosystem services that they provide (Gupta et al., 2016, 2020).

In the recent past this species is reported to be at risk of becoming regionally extinct in some areas, due to rapid population decline and loss of genetic variation, caused mainly by rampant habitat destruction, water pollution, depletion in prey species and direct exploitation by humans (Wright et al., 2015; Cuculescu-Santana et al., 2021). The species has been listed on CITES Appendix I since 2019 and the Red List of the International Union for the Conservation of Nature (IUCN) classifies the Small-clawed otter species as Vulnerable under criterion A2cde+3cde (Duplaix and Savage, 2018; Wright et al., 2021; Cuculescu-Santana et al., 2021) on the basis of its small and rapidly declining population. It is also estimated that the global population of the Asian Small-clawed otter has declined by >30% over the past 30 years (Pacifici et al., 2013).

The Asian small-clawed otter has a large distributional range. In the wild it is found extending from major river basins of Nepal to India in South Asia through Bangladesh, Myanmar, Thailand, and Indonesia in Southeast Asia to Philippines and Taiwan in the east and Southern China in the north (Hussain et al., 2011; Shrestha et al., 2021). It is reported to be found in diverse habitats, including coastal and freshwater wetlands, and rivers and lakes in forested areas (Wright et al., 2015; Cuculescu-Santana et al., 2017; Shrestha et al., 2021).

In India, the species of *Aonyx* is reported to occur in North India from the Himalayan foothills of Himachal Pradesh, West Bengal, Assam hill ranges as well as in South India, in the higher ranges of the hills in Coorg (Karnataka), Ashambu, Nilgiris and Palani hills (Tamil Nadu) and some places in Kerala (Pocock, 1941; Prater, 1948; Hussain, 1999). In recent years, its occurrence has been confirmed from the state of Odisha (Mohapatra et al., 2014; Mishra and Mohan, 2018), Sikkim (Khatiwara and Bhutia, 2020) and Chhattisgarh (Naidu et al., 2022) in India.

It has been observed that there is a gradual decline of otter populations in the wild across their range in Asia particularly related to the intensification of hunting and poaching (Aiyadurai et al., 2010; Datta et al., 2008; Gomez and Shepherd, 2019), which has led to infrequent sighting and even if spotted the observer are experiencing extremely small population. Amongst the other the threat posed by poaching is reported to be a significant one in many parts of India, and across Southeast Asia, and demands constant monitoring (Wright et al., 2015). The decline is projected to increase in the foreseeable future as a result of direct exploitation and emerging threats in different country related to the illegal trade in otters as pets in Asia which has become a major area of concern, with Indonesia, Japan and Thailand standing out as key players in this trade (Aadrean, 2013; Shepherd and Tansom, 2013; Gomez et al., 2016; Gomez and Bouhuys, 2018; Kitade and Naruse, 2018; Siriwat and Nijman, 2018; Gomez and Shepherd, 2019).

In the Indian context, illegal hunting of the species mostly for their pelts is prevalent in Northeastern part of India, where otters continue to be poached in Arunachal Pradesh and transported to Assam for sale at extremely high prices in the black market (Datta et al., 2008; Aiyadurai et al., 2010). Greater demands of pelts for trade in the colder regions of Northeast India, Tibet, and China are likely to lead to increased intensity of poaching and thus decreased conservation in its wild settings (Menzies and Rao, 2021). Thus, the Asian small-clawed otter once commonly found in numerous streams and wetlands of South and Southeast Asia is now restricted only to be found in a few protected areas (Hussain et al., 2011). In the present report, we explored the new distributional range of Asian Small-clawed otters from temperate forest of Kalimpong District, India and assessed the community-based perception on its conservation and future threats through informal conversations.

STUDY AREA

The present study of opportunistic sighting of small-clawed otter (Fig. 2) was documented from Khoppi Village (Elevation: 1924.35m a.s.l., Kalimpong District, West Bengal, India; Fig. 1), which is a forest fringe village situated in close proximity of Neora Valley National Park (NVNP). Established in 1881, NVNP is one of the oldest reserve forests in India and it covers a total area of 159.78km^2 in 2017, falling under Bio-geographic Province 2C, the Central Himalayas, as classified by Wildlife Institute of India (Mallick, 2010). NVNP as an integral part of the ecological trijunction with Sikkim and Bhutan is considered to be an ecologically important area with wide range of altitudinal variations with intact primary forest that has been short-listed in world heritage sites due to its rich Himalayan Biodiversity (Roy et al., 2012).

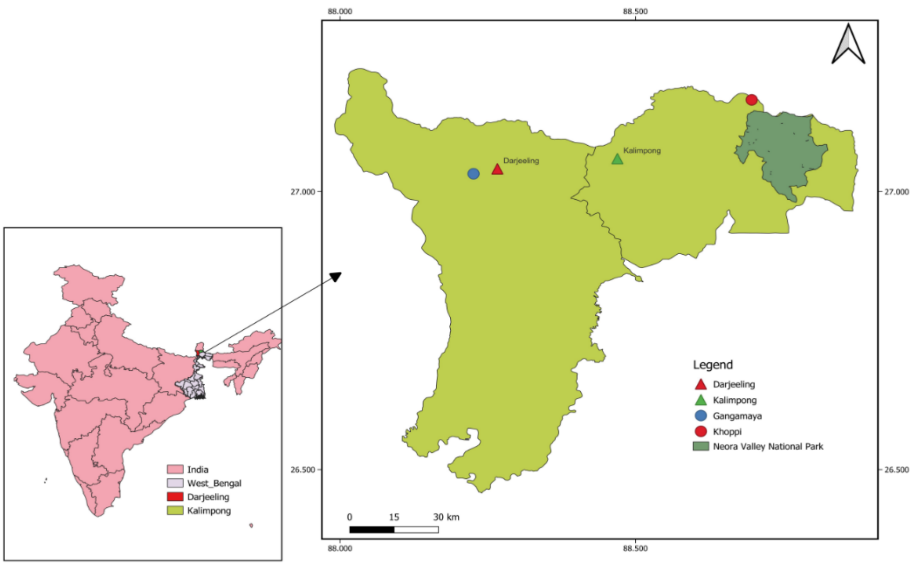

Figure 1. Map of study area and location of incidental otter sightings (Gangamaya and Khoppi).

Figure 2. Photograph of Asian Small-Clawed Otter in Khoppi Village (Elevation: 1924.35m a.s.l.).

The second sighting (Fig. 3) was observed in Gangamaya as part of Darjeeling Hills at an elevation of 1294m a.s.l. (Fig. 1). Lying in the lower reaches of the foothills of the Darjeeling Hills, the study area Gangamaya experiences a humid subtropical type of climate. The summers are mostly hot and winters are cooler associated with the altitudes. In addition, the formation of mountains on all side may have profound effects on the humidity and the study area experience humidity from April to September with heavy rainfall during the monsoon. In the present study, an attempt was made to enlist the otter species in fringe village Khoppi in NVNP and in Gangamaya through direct accidental sightings during field trips especially conducted for bird watching.

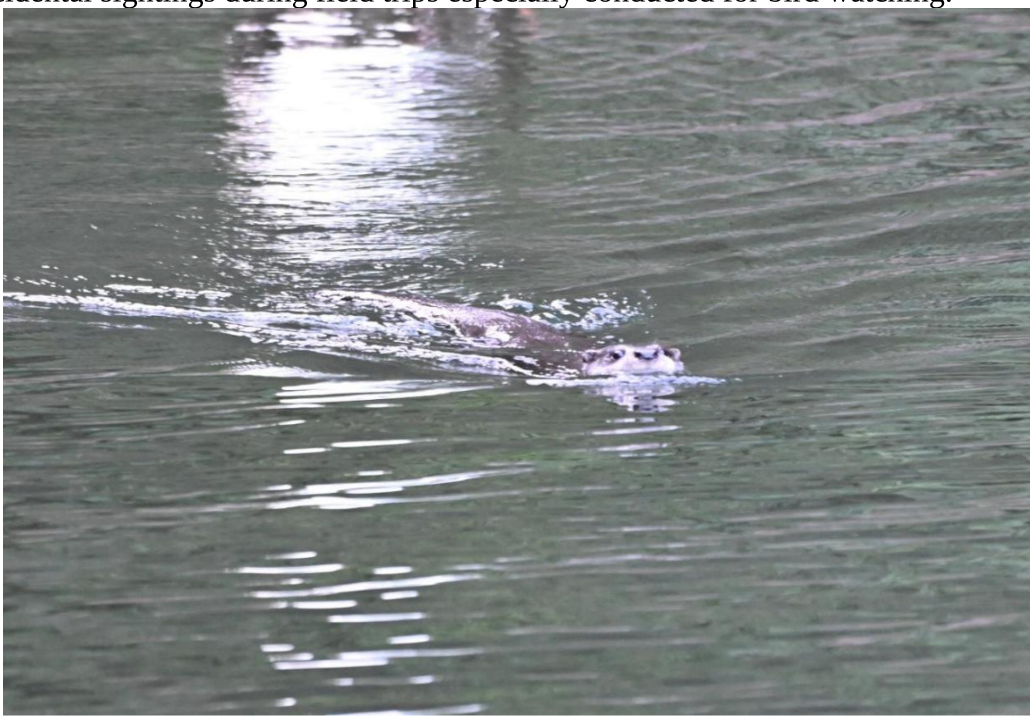

Figure 3. Photograph of Asian Small-Clawed otter found in Gangamaya (Elevation: 1294m a.s.l.).

RESULTS AND DISCUSSION

A Digital Camera (NIKON Z50 with a 270mm lens) was used for otter observation and photography and the Global Positioning System (GPS), was used for recording plot locations and measurement of plot distance. No population census was conducted across its home range in this study. However, the estimated population is found to be best placed in the band of 5 – 8 mature individuals as per informal conversations with the local people living near the river and adjoining lake. In Central Himalaya, Otter is locally known as "Paniko Oont", which is a Nepali word concoction that literally translates to water camel.

A single animal was observed opportunistically on the morning of 15th October 2022, on the surface at the roadside at Fringe Village Khoppi in the Kalimpong district. In compliance with the managing policy of IUCN relevant guidelines, we have chosen not to disclose the precise GPS location of this Vulnerable species in this publication to avoid potential risks, such as attracting poachers and endangering local species which is frequently occurring in Northeastern part of India, and that is leading to many biological species to extinction. Direct observation of Asian small-clawed otter was made from the road mainly used by resident of Fringe Village Khoppi for their day-to-day purpose. Adjacent to the road the habitat was generally marshy, but at other times of the year a stream flows here, and within walking distance, there is also a lake preserved by local communities. The main habitat here is the temperate forest dominated by the vegetation of the species of the genera *Castonoposis*, *Quercus* and *Engelhardtia* etc., with nearby low-intensity agricultural land and villages. The identification of the live encountered animal was solely based on its external morphology as captured through incidental sightings. Interestingly, the close-up zoom in photographs on computer screen revealed that this individual is an *Aonyx cinereus*, because it has a brownish dorsal body colour, distinctive webbed feet, with the third and fourth digits markedly longer than second and fifth on each foot (Hussain et al., 2011).

Preliminary information collected from this area suggested that local people do not pay any particular attention to this, however, some of the local people from the fringe Village Khoppi within the middle of NVNP were more or less aware of the occurrence of this ecologically important animal. In addition, there is no clue as such of any illegal poaching as indicated by respondents through informal conversation, however, they do strongly agree and support the conservational need of this animal in their respective locality. The highlight of the present documentation as accrued by speaking to local community respondents indicates that the local people can be persuaded by some initiatives from the educational or any other conservational institutions for preservation and management strategies of this animal in their natural habitat.

As species like *A. cinereus*, are rare; they deserve earliest attention for their conservation in the study areas through proper planning. The management and conservation strategies are important in the present context of the fringe village Khoppi as "habitat loss is regarded as one of the greatest threats for biodiversity loss" (Wilcove et al, 1998). In the study area, some of the factors may play an important role in the overall management of *A. cinereus* with the continuous pressure of high settlement density with increasing agricultural and pastoralist practices as the study area is dominated by people who are mostly agriculturists, and the documented sites lies close proximity to NVNP. It is well known, in such human dominated spaces domestication of carnivore species like *Canis familiaris* (dogs) and *Felis catus* (cats) for safeguarding their resources is perhaps quite natural (Driscoll et al., 2009). What is not known to local people, that as reported by the previous workers that domestic dogs are apparently the most abundant carnivore globally and is perceived as a severe threat and vulnerable to the local wildlife (Daniels and Bekoff, 1989a; 1989b) and this may significantly contribute to the loss of species.

The Himalayas are essentially a mountainous range in Asia, with 24% coverage of terrestrial land surface and home to about 20% of the global population, mountain ecosystems are one of the unique in nature (FAO 2015; Xu et al., 2019; Sharma and Chhetri, 2021). The mountains possess a diversity of microclimatic conditions that generates a variety of vegetation and ecological conditions which are of global significance owing to the extreme variations in mountainous biophysical system such as elevation, slope and aspects (Antonelli et al., 2018; Huang et al., 2019; Sharma and Chhetri, 2021). Climate change that we are now perceiving is believed to be one of the biggest environmental challenges of the twenty first century with a detrimental consequence to mountain ecosystem (Chettri et al., 2018; Roy et al., 2024)). Mountains are typically exposed to multiple hazards, and it represents an important area for detecting climate change and assessing climate change impacts (Nogues-Bravo et al., 2008; Kohler et al., 2010). Threats to biodiversity are numerous but the prevailing climate change trend in the Himalayas including the Central Himalaya are bringing alarming signal of biodiversity loss leading to vulnerability and negatively affecting the biodiversity of the region (Chettri et al., 2018).

At the present time, knowledge of changing climate from the Central Himalaya is scanty and scattered. The smooth-coated otter (*Lutrogale perspicillata*); the Asian small-clawed otter (*Aonyx cinereus*) (Duplaix and Savage, 2018); and the Eurasian otter (*Lutra lutra*) (Jamwal et al., 2016), which are also found in the Himalayan region have been species modelled to determine the global vulnerability index and to evaluate the effects of global climate change on the future distribution of the Eurasian otter particularly in Europe (Cianfrani et al., 2011; 2018). However, in the context of the Himalayan region it has been in recent past predicted through the technique of Climate Change Vulnerability Assessment (CCVA), future climate and land use alterations will exert an overall detrimental effect on the geographical range of three otter species in the Himalaya, contributing to increased vulnerability index (Jamwal et al., 2022). It has already been noted through modelling species response to climate change, that all three species in the Himalaya with respect to both climate and land use future alterations might be causing these species to undergo moderate to severe shrinking and shift in their distribution under 2050 global change scenarios (Jamwal et al., 2022). *A. cinereus* has been reported to have environmental preferences, where forest habitats being the prime and any fluctuation in temperature and land use modifications are predicted to exert the most vulnerable effects on *A. cinereus* (Jamwal et al., 2022). In the present context, mountain geological formations in the Central Himalaya are fragile and ecosystems are depleting fast because of critical drivers of climate change and biodiversity loss. The ecosystem in the Central Himalaya is slowly losing its resilience due to homogenization and fragmentation of landscapes. Therefore, impending threat posed by changing climate to the distribution of *A. cinereus* is well perceived in Central Himalaya and are in concordance to the predictions made by Climate Change Vulnerability Assessment on three otter species occurring in the Himalayan region (Jamwal et al., 2022).

In the wider context of otter conservation, it is also important to note that climate change in the mountains may bring about vulnerable effects on the overall carrying capacity. Global climate change can exert its strong effects on otter's, reproductive patterns, change on distribution including prey base, increased incidence of emerging and reemerging infectious diseases and eventually it may lead to genetic alteration that may increase or decrease the overall fitness. Within the purview of future study, it would be desirable to carry out vulnerability assessments that are critical in mountain ecosystems, which are one of the most sensitive ecosystems to global climate change (Beniston, 2003).

Arguably, the Central Himalayan region could be one of the critical otter conservation strongholds for conservation biologists and policy-makers at large to manage this vulnerable species in human modified landscapes. At the present time, faced with obvious multifaceted difficulties with respect to scarcity of *in situ* baseline data in Darjeeling and Kalimpong Districts, population assessments and determination of potential threats of this vulnerable indicator species in several prime otter habitats periodically can be prerequisite. In addition to traditional field survey, eDNA-based approaches such as eDNA metabarcoding analysis are also being used for better species resolution in assessing freshwater otter biodiversity in the fragile and challenging Trans-Himalayan ecosystem (Jamwal et al., 2023). Thus, new molecular approaches could be applied in future studies to delineate the taxa from Central Himalaya. Further, in order to ensure the conservation of otter, it would be desirable to study the resident flora and fauna contained therein which constitute the essential and fundamental components of the prey base for a top carnivore.

The otter is considered to be a keystone aquatic predator and indicator species of healthy fresh water ecosystems (Kruuk, 2006; Ruiz-Olmo et al., 1998; Jamwal et al., 2022). Research should aim to minimise anthropogenic disturbances in the proximity of its habitat as otters are highly vulnerable species, sensitive to habitat loss and water pollution (Kruuk, 2006; Ruiz-Olmo et al., 1998). Rapid habitat fragmentation, contamination of water and illegal trade are responsible for the recent decline in otter populations throughout Asia and the Himalayan region (de Silva, 2011; Duplaix and Savage, 2018; Loy et al., 2021; Loy et al., 2022; Jamwal et al., 2022). Further, emphasis should be laid on otter movements through GPS collaring otter or by using camera trapping study. Prime otter habitat which includes both the terrestrial, lakes and riverine forest habitats must be protected as core zone and critical conservation areas to restrict human landscape modifications. One of the key risk factors that may impact the survival of otter in riverine forest system depends on an appropriate quality of water and the prey base present therein. In general, species of otter are characteristics for carrying out movement and predation on free-flowing freshwater rivers. Further, it is also equally important to mention here, that an indiscriminate illegal fishing activities including electrofishing and poison fishing will negatively affect the abundance of this species inevitably. These destructive and hazardous practices will not only lead to decrease in food sources in riverine system but it will also significantly decrease the already extremely small population of otter. In a different context, we have registered a few events of electrofishing and poison fishing in the temperate riverine systems of Central Himalaya. In case of poison fishing, piscicidal plant extracts and salts of heavy metals especially copper sulphate, silver nitrate, mercuric sulphate, bleaching powder, DDT and parathion are used by the local people and addition of these concentrated substances in the water is detrimental to all aquatic life forms including otter. Many of these chemicals are cheap and effective that are easily available in the market, but the local people are completely unaware of the catastrophic health risks these chemical contaminants pose. Hence, it should be noted that these detrimental practices of fishing by the local people in the backdrop of insufficient scientific knowledge on the appropriate dosages of these hazardous chemicals which are vulnerable to environmental change, consequently this cannot be rule out in the present perspective of otter conservation. In addition, research on toxicological experiments is required to investigate the synergistic and long-term effects of chemical contaminants on successive life stages and sexual development of otter to highlight those areas where these contaminants are most likely to exceed the level that this indicator species may withstand. Thus, breeding and non-breeding habitats with seasonal variations must be identified if the conservation of otter species is to be made effective. Analysis on carnivore intraguild relations should be a top priority especially for management and conservation actions chiefly in these areas to help us predict whether there is a conclusive habitat overlap between otter and on other large carnivores which is fundamental to their ecology and conservation as the otter range continues to expand.

Although our knowledge of the of otter poaching in the Central Himalaya for economic reasons or meat consumption is poorly represented and far from complete, we know there is an existing active trade in otter pelts and as a pet in many parts of India, and across Southeast Asia (Wright et al., 2015). Illegal trading of otter pelts from Central Himalaya is however unstudied at the present time, unthinking of such possibilities in the prevalence of illegal market for otter especially in the Northeastern part of India is also of concern. Such practices even at a small level may bring unforeseen impacts on the overexploited Asian Small-Clawed otter**.** One of the most prompt fundamental solutions is patrolling with field researchers that needs to be strengthened and upscaled to reduce dangers of otter hunting and poaching for economic reasons. Patrolling can also curb other illegal activities taking place in otter habitats and more refined measures can be adopted later, as we gather more and more information on understanding of the species. As study revealed that most of the local people living in proximity to Central Himalaya belong to low economic strata and are mostly agro-pastoralists in livelihood occupation. Thus, mountain ecosystem plays an important extrinsic and intrinsic role in generating a diverse range of livelihood activities for any one household. Therefore, community awareness shares an integral and indispensable relationship to any successful conservation program. In this context, there is an urgent need to educate people through effective community-based conservation policies such as frequent sensitization workshops about the biology and ecology of otter especially in areas where anthropogenic habitat disturbances, such as construction projects like hydel power dam, broad roadways constructions are rising thereby leading to indiscriminate fragmentation of contiguous forest tract. In the context of environmental degradation with respect to deforestation, land sliding, and large-scale downstream flooding, coupled with inappropriate mega man-made environmental collapse due to rampant construction of heavy power hydel dam and railway tunnels are ravaging the delicate equilibrium in the fragile Bio-geographic Province 2C, Central Himalaya. To lose such a valuable bioresource in terms of flora and fauna from the Himalayas, conservationists, biologists, and indigenous people have expressed growing apprehension about the rapid degradation in the Himalayan environment. A clear indication of such perception has been noticed and experienced during the recent flash flood catastrophe that has drastically resulted in the loss of flora, fauna and aquatic life equally in the mountain part of Sikkim and West Bengal, India.

Other studies have identified that human interference in wildlife natural habitats through anthropogenic change has led to competition for shared resources, resulting in heterogenous conflict as these factors are believed to hinder the dispersal ability of wildlife in their home ranges especially in forest fringes (Karanth and Kudalkar 2017; Sharma et al., 2022). Concurrently, through participatory biodiversity conservation programmes, awareness on the importance of otter conservation, existing legal framework on Wild Life Protection Act, fines and penalties on wildlife poaching, and trading of wildlife species mainly otter in India should be augmented. These are some of the reasons why it is important to convince local communities through any means, especially regarding the management of environmental resources to protect the vulnerable species *A. cinereus.* Despite the urgency to mitigate the impending threat, baseline information on ecology of *A. cinereus* particularly in Central Himalaya is seriously wanting. In order to ascertain these dynamics, it is extremely important at this point to carry out further scientific research and conservation action particularly in man altered landscape in Central Himalaya for continued positive outcomes.

CONCLUSIONS

In view of the incidental sighting of the spontaneous animal, the present study contributes important information to the understanding of *A. cinereus* distribution and status in forest of Kalimpong and Darjeeling District, India. A bird's eye view of the literature using various digital search engine with key words otter and library resources reveals that no existing literature information is available on distributional pattern of this species from this part of India. This study presents the documentation of the first evidence of *A. cinereus* from the forest fringe village Khoppi situated in close proximity of Neora Valley National Park and in Gangamaya in Darjeeling hills. While an assessment of population distribution of small-clawed otter in the study sites was beyond the scope of this study. However, due to high diversity of trees species and animals at all taxonomic levels, the NVNP and Darjeeling hills would provide an ideal location to carry out further research on otters. In general, for the plan conservation measures the present study demands further exhaustive reassessment and management recommendation urgently to advance our understanding with respect to the biodiversity of the species, overall niche characteristics and water quality assessment to ensure the water in the lake and riverine systems are not polluted.

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RÉSUMÉ : PREUVES PHOTOGRAPHIQUES D'OBSERVATIONS FORTUITES DE LA LOUTRE CENDRÉE (*AONYX CINEREUS* ILLIGER, 1815), ESPÈCE VULNÉRABLE, DANS LA FORÊT MIXTE DE DARJEELING ET DU DISTRICT DE KALIMPONG SITUÉ DANS L'HIMALAYA CENTRAL

Des observations directes fortuites et une identification confirmée de la loutre cendrée (*A. cinereus*) ont été enregistrées pour la première fois avec des preuves photographiques documentées dans les zones d'étude. Ce nouveau rapport d'*A. cinereus* concerne une forêt mixte de type subtropical humide (altitude : 1.294 m au-dessus du niveau de la mer) dans le district de Darjeeling et une forêt de type semi-tempéré (altitude : 1.924,35 m au-dessus du niveau de la mer) du district de Kalimpong, dans l'État du Bengale occidental au niveau de la province Bio-géographique 2C de l'Himalaya central en Inde. Ce rapport démontre que la répartition et les schémas de distribution de ces espèces vulnérables sont encore variables en Inde. La présente étude vise à combler un immense manque de connaissances concernant l'aire de répartition de la loutre cendrée dans les paysages vulnérables de l'Himalaya central dominés par l'homme.

RESUMEN: EVIDENCIA FOTOGRÁFICA DE AVISTAJES INCIDENTALES DE LA VULNERABLE NUTRIA DE UÑAS PEQUEÑAS ASIÁTICA (*Aonyx cinereus* Illiger, 1815) EN EL BOSQUE MIXTO DE LOS DISTRITOS DARJEELING Y KALIMPONG, HIMALAYAS CENTRALES

Se registraron avistajes directos incidentales con identificación confirmada, con evidencia fotográfica documentada de *A. cinereus*, por primera vez en las áreas de estudio. Este nuevo reporte de *A. cinereus* en el bosque mixto subtropical húmedo (Elevación: 1294 m s.n.m.) en el Distrito de Darjeeling y en el bosque semi-templado (Elevación: 1924.35 m s.n.m.) en el Distrito Kalimpong, estado de Bengala Occidental, India, como parte de la Provincia Biogeográfica 2C, Himalayas Centrales, demuestra que la distribución y los patrones de ocupación de ésta especie vulnerable son aún irregulares en India. Este estudio está dirigido a completar un hueco inmenso de información sobre el área de distribución de la nutria de Uñas Pequeñas Asiática en los paisajes vulnerables dominados por el ser humano, en los Himalayas Centrales.

सारांश : दार्जिलिङ र कालिम्पोङ पार्तिमपोङ पार्तिमपाङ जिल्लाको मिश्रित जंगलमा कमजोर एसियाली सानो-क्लेड ओटर ***A. CINEREUS*** (एनिक्स सिनेरियस इलिगर, १८१५) को आकस्मिक दृश्यहरूको फोटोग्राफिक प्रमाण

प्रत्यक्ष आकस्मिक दृश्यहरू, र *A. cinereus* (एनिक्स सिनेरियस इलिगर, १८१५) को पुष्टि गरिएको पहिचान पहिलो पटक अध्ययन क्षेत्रहरूमा दस्तावेज फोटोग्राफिक प्रमाणहरूको साथ रेकर्ड गरिएको थियो। दार्जिलिङ जिल्लाको उपोष्णकटिबंधीय आर्द्र प्रकारको मिश्रित वन (1294m a.s.l) र जिल्ला कालिम्पोङ जिल्लाको अर्ध-शीतोष्ण प्रकारको वन (उचाई: 1924.35m a.s.l) बाट

A. cinereus को यो नयाँ प्रतिवेदन, भारतको पश्चिम बंगाल राज्यको जैविक भागको रूपमा। भौगोलिक प्रान्त 2C, मध्य हिमालयले देखाउँछ कि त्यस्ता कमजोर प्रजातिहरूको वितरण र विस्तृत ढाँचा भारतमा अझै पनी छ। हालको अध्ययनले मध्य हिमालयबाट मानव प्रभुत्व भएका कमजोर परिदृश्यहरूमा एसियाली सानो-पंजाको ओटरको वितरण दायरामा ज्ञानको ठूलो अन्तरलाई भर्ने लक्ष्य राखेको छ।

ARTICLE

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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Key Words: distribution range, wildlife conservation, North America, translocation, keystone species, kelp forest

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?

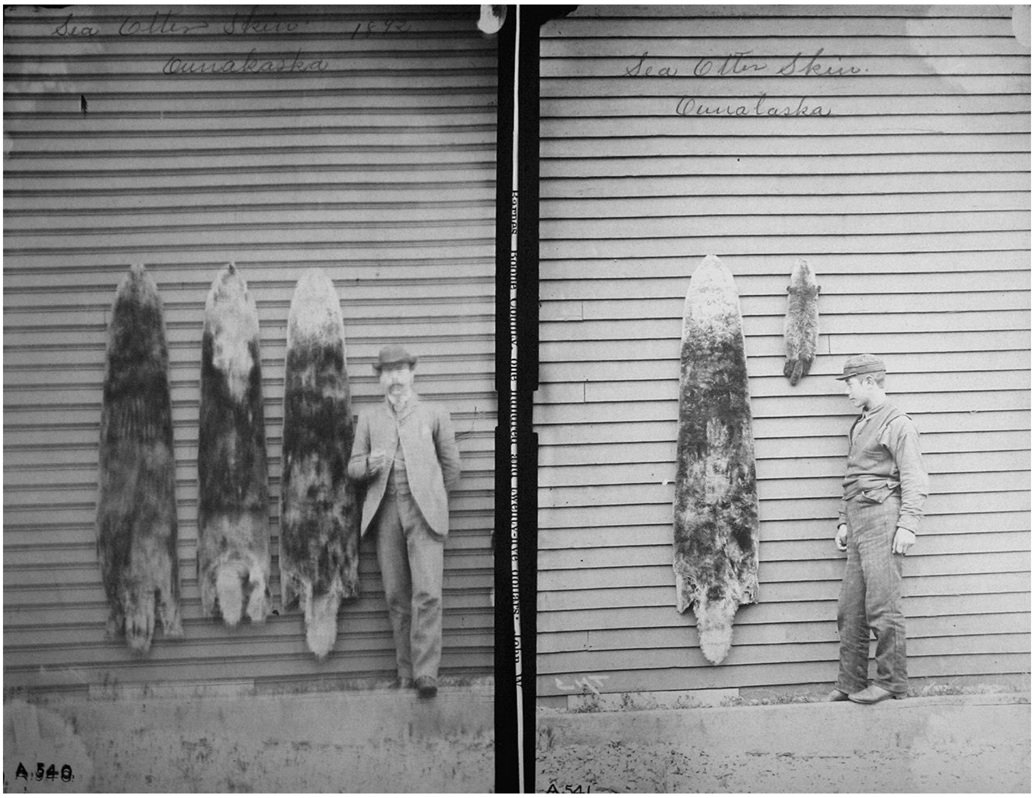

Figure 1. The skins of sea otters circa 1892. (Source: public domain.)

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).

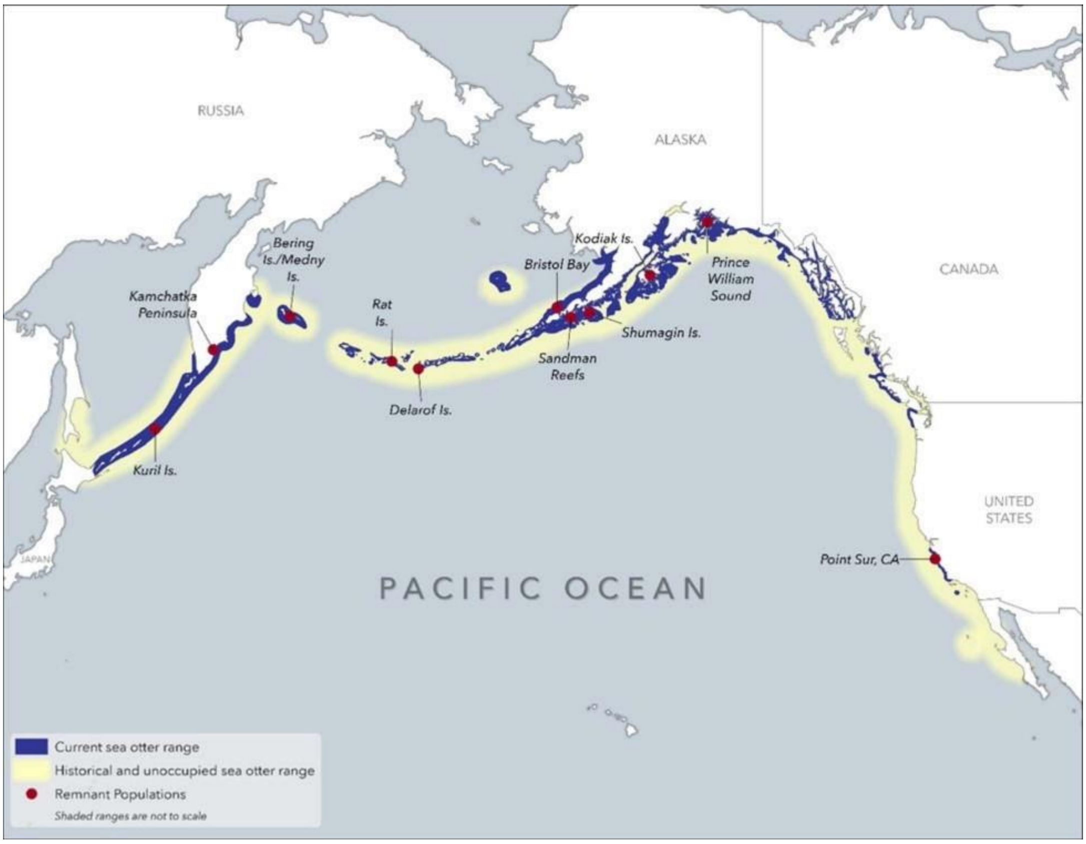

Figure 2. Historical and current sea otter range. (U.S. Fish and Wildlife Service, 2022)

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.