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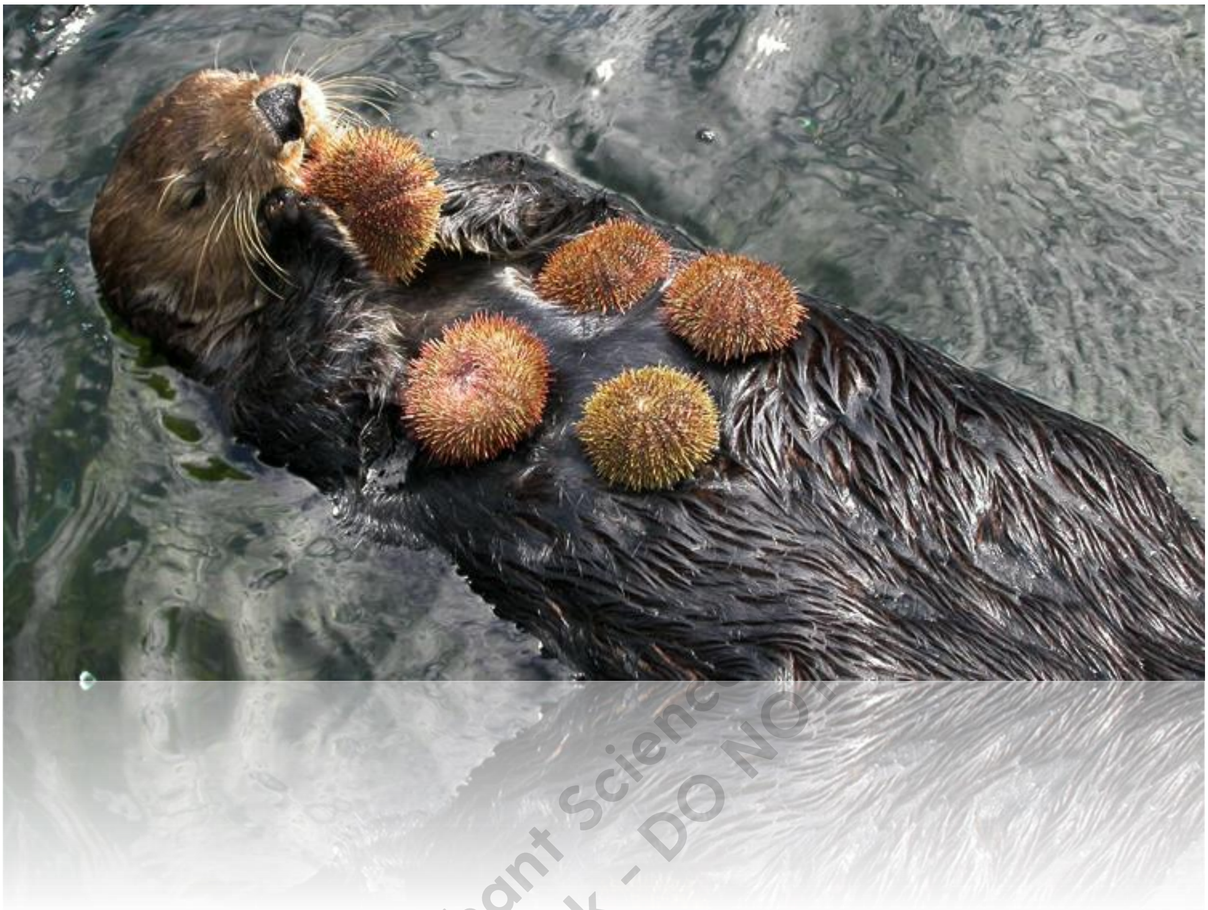

Fig. 1. Sea otter eating urchins. Courtesy of the Ecological Society of America.
https://www.esa.org/wp-content/uploads/2014/08/sea-otter-with-urchins.jpg

Recovery of the Southern Sea Otter (*Enhydra lutris nereis)* Under the Endangered Species Act

Science as a Human Endeavour Investigation – Keystone species

Sahithya Paramasivam | Journal of Keystone Marine Mammal Populations | 27/05/2020

Introduction

Keystone species are organisms that exert a disproportionate influence on their ecosystem by causing physical state changes in biotic or abiotic factors. Southern sea otters (*Enhydra lutris nereis*), also known as Californian otters, are a keystone species due to their role maintaining the health and stability of the near marine ecosystem such as kelp forests, embayment and estuaries. They are endemic to North Pacific Southern and amass in colonies along the central California coast from San Mateo to Santa Barbara. The estimated historical population of around 16,000 animals plummeted to around 50 post-exploitation for their rich and luxuriant fur that is the densest of any mammal (Defenders of wildlife Staff, 2018, & The Marine Mammal Centre, 2020). Consequently, they are been protected by State law since listed as a "Fully Protected Mammal" (Section 4700, Fish and Game Code) in 1913 and were listed as a threatened species under the Endangered Species Act in 1977.

Per through collaboration within the local community, governmental bodies and international groups based on ecological and environmental considerations, the *Recovery Plan for the Southern Sea Otter (Enhydra lutris nereis)* was established by the U.S. Fish and Wildlife Service in 1982.With the solution for the development of the plan to recover the population of southern sea otters, SHE Application factors such as knowledge and discoveries influence or limit the directions taken in the recovery to save this species.

Significance of Otters

Southern sea otters have high energetic requirements consuming 25 percent of their body mass per day due to their little subcutaneous fat without a layer of blubber for energy storage and thermo-insulation (U.S Fish & Wildlife Service Staff, 2003). Hence, they rely on their dense water-resistant fur for insulation and maintain a high metabolic rate in compensation for their lack of blubber. Their diet includes numerous invertebrates such as mussels, crabs, snails, sea urchins, abalone, sea stars and other 40 benthic marine species (Konar, 2000). In particular, sea urchins are a preferred prey of sea otters and its predation largely reduces herbivory and the densities of sea urchins. Due to their consumption of large quantities of marine invertebrates that graze kelp forests, sea otters are keystone species that have a significant impact on marine ecosystems and play a vital role in the kelp forest food web as exhibited by Figure 2.

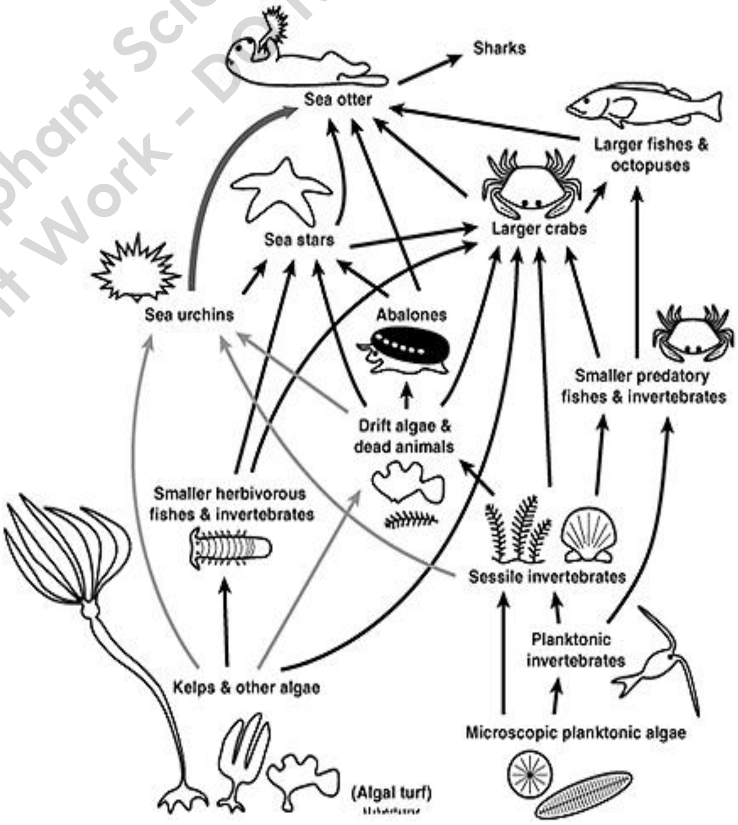

Fig. 2. The kelp forest food web illustrating the role sea otters play in their food web and food-web complexity in their presence. Source: Healing Earth

Kelp forests provide numerous ecological benefits, including habitat for a variety of invertebrates, fish species, marine mammals and birds, prevent coastal erosion, and sequestrate carbon. A study reveals that it is having a measurable impact on climate change as kelp forests can absorb up to 12 times more atmospheric carbon dioxide when otters are present (Wilmers & Estes, 2012). Otters play a positive role in healthy kelp forests to maintaining the ecological balance in climate-driven changes.

Hypothetical Extinction

If sea otters were to become extinct, the trophic cascade relationship between the secondary consumer (southern sea otter), herbivore (urchin), and plant (kelp) would cease. The loss of sea otters will result in co-occurring loss of kelp as grazing invertebrates will overexploit the ecological niche and consequently destroy the kelp forest habitat to the detriment of other species in the ecosystem. This includes primary consumers that obtain nutrients by eating kelp comprising invertebrates (i.e. prawns, snails, anemones, crabs, sea stars & anemones) and many fish species and higher-order consumers (i.e. seals, sea lions, whales & sharks) that eat the primary consumers. As autotrophs, kelp absorb carbon dioxide from the atmosphere through photosynthesis to transform it to energy for their growth. Therefore, losing kelp results in the loss of an important carbon sequestrator and habitat for marine organisms. As kelp can maximise the survival of future change of the marine ecosystem by hosting many different plants and animals with abundant genetic diversity, there will be lost mitigation of climate change.

Fig. 3. 'No sea otters. No kelp forests.' Source: seaotters.com

Application of Human Knowledge & Discoveries

The U.S. Fish and Wildlife Service has applied scientific knowledge and discoveries to establish the *Recovery Plan for the Southern Sea Otter (Enhydra lutris nereis)* in 1982. The hunting of southern sea otters for pelts in international trade and to reduce competition for commercial fisheries generated economic activity in coastal communities in the U.S. In consideration, the ecological consequence of nearly eradicating southern sea otters was of the disruption of a critical trophic cascade between high sea otter numbers, low sea urchin populations and in turn healthy kelp forests.

On comprehension of the adverse environmental impacts, policies were introduced and Federal law banned hunting and the sale of raw pelts. Henceforth, the endangered species were saved from the brink of eradication as a result of the international ban on sea otter hunting. In clear recognition of the adverse human impacts, the primary objective for the recovery plan was to *"manage human activities that jeopardise the existence"* of southern sea otters through two primary goals (U.S Fish & Wildlife Service Staff, 1982). The first was to increase the range of sea otters through translocation and to decrease the risk of a single oil spill curbing recovery. The second goal focuses on habitat maintenance by decreasing the likelihood of a major oil spill within the sea otter's range. The environmental considerations of sea otters playing a role in maintaining global environmental health were realised for a balanced near marine ecosystem and as kelp sequesters atmospheric carbon dioxide from photosynthesis to help tackle climate crisis.

On discovery that oil kills sea otters by toxicological ingestion and drastically reducing thermal insulation, populations were translocated to San Nicholas Island for the threat of oil spills where the population had been depleted (U.S Fish & Wildlife Service Staff, 1982). The translocated populations in Nicholas Island, as circled on Figure 3 to the right, could expand in many directions simultaneously which allows higher population growth rates in comparison to that of the Californian population which could only expand north or south. The impact of the Application factors of knowledge, discoveries and solutions is that the population numbers increased from 50 to 3,035 as of 2018 (U.S. Geological California sea otter census results, 2018).

Fig. 4. The range of southern sea otter population. Circle shows San Nicholas Island. Source: seaotters.com

Solutions

The potential solutions for reducing the impact of human activities on southern sea otters include interbreeding experimentation, reducing climate change and further translocation efforts to San Francisco Bay through the SHE application of knowledge.

As otters experienced a significant loss of genetic diversity due to the reduction in population numbers following their exploitation for fur trade, it has been found that there has been a loss of at least 62% of the alleles and 43% of the expected heterozygosity in extant southern sea otters (Larson, Jameson et al., 2002). Due to the population 'bottleneck', they are more prone to harmful genetic mutations which affects their ability to withstand diseases, reproduce and survive changing environmental conditions. The population is left vulnerable as genetic diversity does not recover as rapidly as the population numbers increasing the likelihood of extinction. As a technology-based SHE solution, if genome sequencing is incorporated to the conservation efforts of the recovery plan, it can be used to identify populations with a higher vulnerability to disease due to past small population sizes and determine if they would be benefitted by introducing to sub-species such as the northern sea otters with different genetic profiles that currently do not breed. On conducting advanced research, the southern sea otters could be interbred with northern sea otters to increase genetic diversity and population numbers. This requires scientific and technological experimentation with cells and genome sequencing with potential disadvantages such as introducing new diseases and whether fertile and healthy offspring is produced (post-zygotic isolation mechanism).

Addressing climate change will reduce the ecological pressure of habitat destruction, ocean acidification and possibly reduce shark venturing into the sea otters' range toward cooler areas and lessen shark bite mortality. Due to climate change and warming waters, shifts in the ocean current patterns might be changing the distribution of marine ecosystem food chains and therefore induce changes in shark distribution patterns into nearshore waters utilised by both sea otters and their prey of pinnipeds (Tinker et al., 2016). Shark bite mortality has caused a 2.2 percent decline in the sea otter population in the mainland in 2018 as can be seen on the graph below and bites are estimated to be about 50 percent for all stranded sea otters (U.S. Geological California sea otter census results, 2018). Some solutions to lessen greenhouse gas emissions include to use more renewable energy, lessen food and meat waste, choose active transport and energy-efficient options.

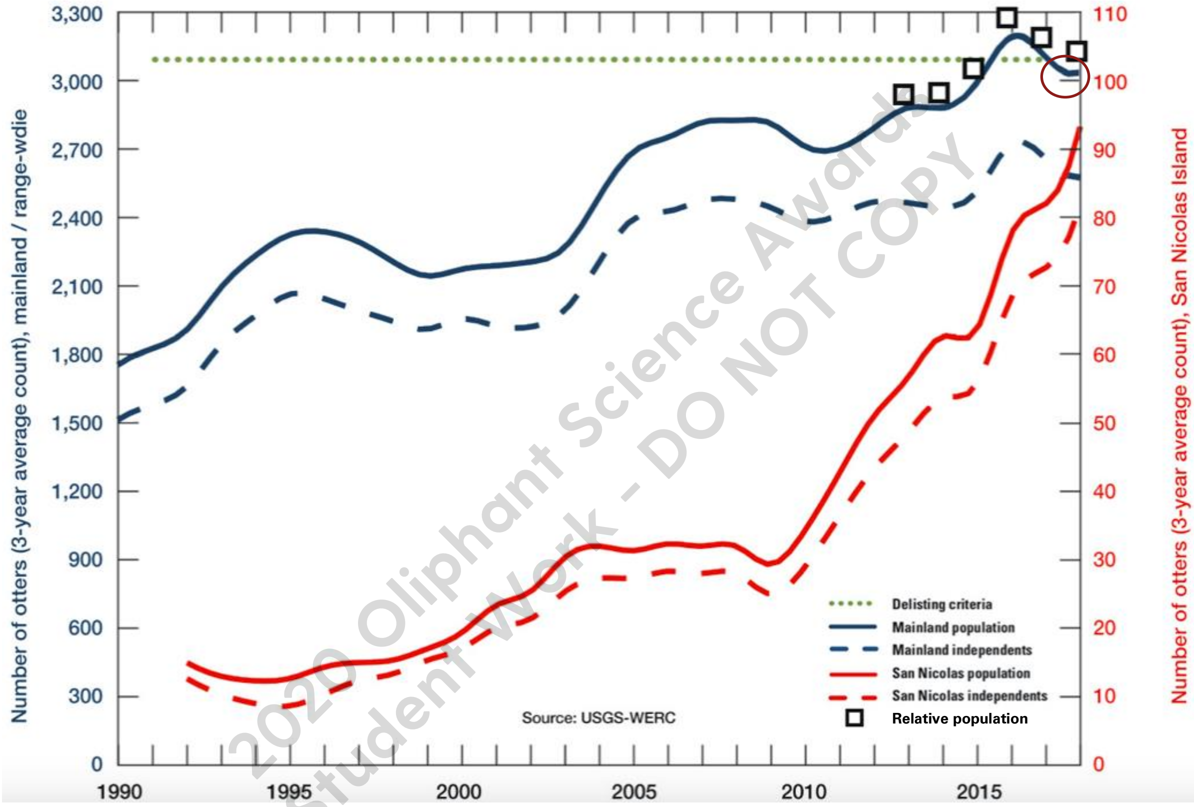

Fig. 5. Trends in abundance of sea otters. In 2018, a decline of 2.2% in population to 3,035 could be resulted from increase in shark bites as a result of climate change. Source: U.S. Geological California sea otter census results, 2018

As fragmented habitats limit natural dispersion, the captive breeding program can re-establish residency to estuaries in San Francisco Bay that was once a historical range which the current recovery plan does not include as target habitats. The is due to the presence of great white shark gauntlets which otters cannot travel past.). As a SHE solution of knowledge application, if they were established inside San Francisco Bay, a study estimated that it could more than triple its population from 3000 to nearly 10,000 through modelling growth using existing studies (Gullixson, 2019). Expanding the range upward is beneficial for food source as the population increases. As can be seen on the graph in Figure 5, there is an upward trend in the population at Nicholas Island which has fewer sharks in comparison to the mainland. If expanding otter territory into estuaries where sharks don't swim, the loss to the population could be prevented. This is the most effective solution as there would be less competition for food sources, it was a historical range, shark bite mortality will decrease and the population size will increase simultaneously.

Justification

While looking at the SHE understanding of Development, Application and Influence under the subsections of knowledge, discoveries and solutions, I have investigated how they significantly impacted the development of the Recovery Plan and influenced the significant growth in the population of southern sea otters. In 1914, the fur trade deleted southern sea otter counts to only 50 remnant examples. Solutions were established using knowledge and discoveries through translocative breeding programs, criminalising the harvesting of sea otter fur and restoring habitat. The impact of human activities on these species could be reduced through interbreeding experimentation, reducing climate change and further translocations. As it has not been done in the Recovery Plan, translocation efforts can be made to occupy the estuaries in San Francisco Bay to allow pre-exploitation recovery and regain historic population numbers.

Word count (excluding captions, in-text references, and headings): 1,519

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