Cumulative impacts on sea otters

Globally, marine mammals have been under threat from a variety of pressures including hunting, pollution, and competition for habitat and prey. Consequently, many of these mammals, including sea otters (similarly sei whales, right whales) have been reduced to small and remnant populations. Small populations behave differently than larger populations, making them extremely vulnerable to extinction.[1] There are three main reasons for this:

First is the role of "chance variability." This occurs when there is a random drop in birth rate, an increase in death rate, or repeated offspring of the same sex in a generation, all of which can lead to extinction.

Secondly, when small populations experience random events such as food shortages, disease, pollutants, or toxic spills, the loss of individuals, (especially breeding females), can have severe consequences. This is an important concept that underscores the importance of numbers to maintain the resilience and adaptive abilities of populations that are faced with disturbances.

Thirdly, small populations are vulnerable owing to reduced genetic variation. By their very nature, small populations are a narrow subset of individuals from what was once a much larger population. As small populations breed, the role of chance error in genetic make up becomes much higher. For populations to adapt and evolve with changing conditions genetic variability must be present. Hence, reducing genetic variation results in decreased survival (i.e. increased mortality). Increased mortality leads to further reduction in genetic variation resulting in a negative feedback loop known as an "extinction vortex." Loss of genetic diversity through random genetic drift is the most commonly invoked evolutionary concern in conservation biology.

Cumulative impacts of climate change and the Northern Gateway project on can also manifest

[1] Raincoast Conservation Foundation. 2010. What's at Stake? The cost of oil on British Columbia's priceless coast. Raincoast Conservation Foundation. Sidney, British Columbia. Ver 02-10, pp 1-64.

through many trophic levels because of sea otters' complex role in ecosystem function. Potential effects of climate change on sea otter range are uncertain, but climate change can result in indirect effects to marine mammals such as changes in prey availability affecting distribution, abundance and migration patterns, community structure, and susceptibility to disease and contaminants (Learmonth et al. 2006[2]).

Research on hydrocarbons and sea otters in British Columbia has shown that partitioning of hydrocarbons between sediments and adjacent benthic food webs provides an important exposure route for sea otters, which consume approximately 25% of their body weight daily in benthic invertebrates. Thus, sea otters are vulnerable to hydrocarbon contamination even in the absence of a catastrophic oil spill. [3]

One significant change, likely attributable to climate disruption, is increased predation on sea otters by killer whales. This might reflect a rearrangement or modification of long-standing trophic relationships. The relationship of sea otters to North Pacific kelp forests through predation on sea urchins, that are in turn predacious on kelp forests[4] is well known. Researchers have also demonstrated how killer whale predation on sea otters link oceanic and near shore ecosystems.[5] Estes et al. (1998) show that after nearly a century of recovery from overhunting, sea otter populations are in rapid decline over large areas of western Alaska. They identify increased killer whale predation as the likely cause of these declines. Amplified predation resulted in increased sea urchin density and consequent deforestation of kelp beds in the nearshore community - a confirmation that the otter's keystone role had been reduced or eliminated. Estes et al. (1998) also suggest that these interactions were initiated by anthropogenic changes in the offshore oceanic ecosystem.

Similarly, as kelp forests are known to be important components of coastal ecosystems (Dayton

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[2] Learmonth, J.A., MacLeod, C.D., Santos, M.B., Pierce, G.J., Crick, H.Q.P and R.A. Robinson. Potential effects of climate change on marine mammals. *Oceanography and Marine Biology: An Annual Review, Volume 44, 2006, pages 431-464.*

[3] Kate A. Harris, Mark B. Yunker, Neil Dangerfield, Peter S. Ross, Sediment-associated aliphatic and aromatic hydrocarbons in coastal British Columbia, Canada: Concentrations, composition, and associated risks to protected sea otters, *Environmental Pollution, Volume 159, Issue 10, October 2011, Pages 2665-2674.*

[4]Jackson, J.B.C. and 18 others. Historical overfishing and the recent collapse of coastal ecosystems. *Science Volume 293, July 2001, Pages 629-638.*

[5]J. A. Estes, M. T. Tinker, T. M. Williams and D. F. Doak, Killer Whale Predation on Sea Otters Linking Oceanic and Nearshore Ecosystems, *Science, 16 October 1998, Volume. 282 no. 5388 pp. 473-476* .

1985[6]), direct responses of kelp to multiple global changes could alter the integrity of future coastal marine systems. Swanson and Fox[7] identify that whilst CO_2 and ultra violet light significantly influence kelp growth, the effects of climate change are likely to be kelp species specific. Changes in distribution and productivity of kelp beds will in turn influence otters.

[6] Dayton, P.K. Ecology of kelp communities, *Annual Review of Ecology and Systematics, Volume 16, 1985, Pages 215-245.*
[7] Andrew K. Swanson, Caroline H. Fox, Altered kelp (Laminariales) phlorotannins and growth under elevated carbon dioxide and ultraviolet-B treatments can influence associated intertidal food webs, *Global Change Biology, 2007, 13, Pages 1696–1709.*