The role of long-term diet change in the decline of the New Zealand sea lion population

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ABSTRACT

The New Zealand sea lion (*Phocarctos hookeri*) is an endangered pinniped endemic to New Zealand (Wilkinson, Burges et al. 2003). Declared "nationally critical" under the NZ threat classification system and "vulnerable in decline" by IUCN, they have shown a 49% decline in pup production since 1995 (Chilvers, Wilkinson et al. 2010). I investigated the role of long-term changes in diet on the population ecology of NZ sea lions. I was interested in the role played by long-term changes in diet into the observed decline of the sea lion population. My study is set apart from others in that it spans 13 years of routine sampling, and represents one of the longest timelines of diet data for any pinniped species. I used scat and regurgitate samples from New Zealand sea lions that were collected at the Auckland Islands between the summer of 1995/1996 and 2012/2013. I identified 11 main prey types from hard parts including otoliths, beaks and other diagnostic bones. In scats these main prey types were opalfish (*Hemerocoetes spp.*), rattail (Macrouridae), red cod (*Pseudophycis bachus*), octopus (*Octopus sp.*) and arrow squid (Ommastrephidae), Ling (*Genypterus blacodes*), smallscaled cod (*Paranotothenia sp.*), hoki (*Macruronus novaezelandiae*), triplefin (*Tripterygiidae*), fur seal (*Arctocephalus forsteri*) and giant octopus (*Enteroctopus zealandicus*). Main prey types found in regurgitates were similar but there was a higher proportion of cephalopods than in scat samples. When assessing long-term trends in occurrence of main prey species I found that smaller prey types such as opalfish and *Octopus* sp. have been increasing in the diet over time, while larger species hoki and giant octopus have been decreasing. The ratio of fish:cephalopods in NZ sea lion diet has also been decreasing with time, possibly indicating an overall reduction in diet quality. I used catch per unit effort as a proxy for prey availability in the environment and compared this to frequency of occurrence (%FO) of main prey types over time. The best models for functional response by sea lions to increased prey availability were those that incorporated random variation among years, suggesting that abundance of prey species is not the only variable affecting intake of prey by NZ sea lions. Resource competition or habitat destruction imposed by fisheries could restrict intake by sea lions, or force prey shifts to species not commercially harvested. Lastly, I investigated age-related survival and breeding probability of NZ sea lions with reference to the amount of main prey species in the diet over time. Models were run to test the relationship between each prey type, and breeding and survival probabilities over time. Survival probability is best explained by the null model, indicating that survival is not significantly affected by the amount of any one prey type in the diet. Smallscaled cod and hoki have the best predictive capacity after the null; hoki was correlated with an increase in survival for all age groups, while smallscaled cod predicted an increase in survival for all age classes except individuals over 15 years. In contrast, breeding probability is better explained by the amount of hoki and ling in the diet than by the null model. Consequently, the estimated finite rate of increase (λ) of the sea lion population rises with increased hoki in the diet. λ

was estimated to be < 1 (population decline) under observed conditions (hoki found in 0-15% of scats depending on year), but λ was extrapolated to become >1 (population increase) if hoki were sufficiently abundant to be found in 35% of scats, a level that may have been reached historically (pre 1988). Similarly, λ was extrapolated to become > 1 if ling was found in > 30% of scats. The greater effect of prey types on breeding over survival makes biological sense when resources may be limiting population growth. Adult female NZ sea lions limited by prey availability may have enough food to survive but may choose not to invest in energetically expensive breeding. This would buffer the observed effect on survival since we would re-sight individuals that are alive but perhaps not in body condition to breed. If valuable prey stocks like ling and hoki continue to decline in the diet we could also see a significant impact on survival. Hoki has begun to recover but stock levels are still low in the Auckland Islands' region (MPI 2013).

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