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

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Science
in
Conservation Biology

at Massey University, Manawatū, New Zealand.

Phoebe Stewart-Sinclair
2013

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).

ACKNOWLEDGEMENTS

Firstly, I would like to thank my main supervisor Dr Laureline Meynier for giving me the opportunity to do my Masters on the New Zealand sea lion and for her unfailing help whenever I needed it. Sharing an office with her was (almost) never a trial and I am so grateful for her help and support throughout this research. I cannot express my gratitude for her hours spent double-checking messy samples and identifying damaged hard parts I had given up as hopeless. Lastly, I will be forever grateful for her uncensored writing advice and prehistoric editing style, without which I fear this body of work, would follow no logical pattern.

I would also like to thank Prof Doug Armstrong, my co-supervisor, for his tireless patience for my endless questions; and long hours spent re-hashing minutiae in the mysterious realm of biostatistical modelling. Forever my biggest cheerleader and a good friend, I am always spurred on by his faith in me.

This project was sponsored by the Massey University Masterate Scholarship for which I am very grateful. Scat and regurgitate samples were collected with the help of many people over many years, usually associated with the Department of Conservation or Massey University, without whom I could not have done this research.

I would like to acknowledge (and thank) Dr Jim Roberts at NIWA for his contribution to my research using catch per unit effort as a proxy for prey availability. I also could not have done without our lengthy chats, numerous beers and his endless enthusiasm. I am grateful to Dr Simon Childerhouse for his contribution to my analysis of long term trends in diet, by providing comparable data to expand my timeframe. I wish to thank the lab staff on Level 6 of the Institute of Veterinary, Animal and Biomedical sciences (IVABS) for providing a supportive working environment, making space in the lab for me and politely not commenting on the smell. I would also like to acknowledge the contributions of Dr. Daryl MacKenzie for the tag-resight and breeding information he provided for my chapter on diet impacts on survival and breeding in NZ sea lions.

Thanks must also be given to my friends and family, who put up with me throughout the duration of this project, pretending to be interested in indecipherable graphs and providing timely comfort-foods when I was feeling frustrated. Big thanks to Stephen, Sarah, Jess, and Amie whom I could safely whinge to without feeling pathetic.

I wish to thank the charismatic and inspiring Sir David Attenborough, who brought the wonders of the world to the homes of millions, and showed me how beautiful, how miraculous and how

infinitely interesting the natural world can be. His childlike wonder and unbiased narrative will forever be the voice in my head.

I am grateful to my parents and grandparents, who instilled in me a respect for nature and a love of the sea. I dedicate this work to my Pa, who never could stand fishing shows, who taught me to think for myself and to always be gentle and kind. Also to my Nana Sinclair, who went swimming in the sea every day and taught me to pay attention to the natural world. Finally, to the New Zealand sea lion who I hope will continue on, for no good reason but for their own intrinsic value.

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