ALTERNATE FORAGING STRATEGIES AND POPULATION STRUCTURE OF ADULT FEMALE AUSTRALIAN SEA LIONS

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Declaration of originality

In presenting this thesis in fulfilment of the requirement for doctoral degree at the University of Adelaide, I affirm that this work is original and has not been submitted for a higher degree to any other university or institution and consent for this thesis to be made available to the University of Adelaide library, subject to the provisions of the Copyright Act 1968. The following summarises my contribution to the publications involving data analysis included in this thesis.

Signature: Date: 24/1/2012

Mr Andrew Lowther

Statement of contribution

Chapter 2: Detecting alternate foraging ecotypes in Australian sea lion (*Neophoca cinerea*) colonies using stable isotope analysis.

Lowther, A.D. and Goldsworthy, S.D. (2010). Detecting alternate foraging ecotypes in Australian sea lion (*Neophoca cinerea*) colonies using stable isotope analysis. *Marine Mammal Science* **27**(3): 567-586

Conception: 90%, Data Collection: 100%, Analysis: 100%, Writing: 95%

Chapter 3: Creatures of habit: foraging habitat fidelity of adult female Australian sea lions.

Lowther, A.D., Harcourt, R.G., Hamer, D. and Goldsworthy, S.D. (accepted). Creatures of habit: foraging habitat fidelity of adult female Australian sea lions. *Marine Ecology Progress Series*.

Conception: 100%, Data Collection: 90%, Analysis: 100%, Writing: 95%

Chapter 4: Population structure of adult female Australian sea lions is driven by fine scale foraging site fidelity.

Lowther, A.D., Harcourt, R.G., Goldsworthy, S.D. and Stow, A. (accepted). Population structure of adult female Australian sea lions is driven by fine scale foraging site fidelity. *Animal Behaviour* .

Conception: 90%, Data Collection: 90%, Analysis: 100%, Writing: 95%

Appendix I: Maternal strategies of the Australian sea lion Neophoca cinerea at Dangerous Reef, South Australia.

Lowther, A.D. and Goldsworthy, S.D. (2011). Maternal Strategies of the Australian sea lion at Dangerous Reef, South Australia. *Australian Journal of Zoology* **59**: 54-62.

Conception: 70%, Data Collection: 100%, Analysis: 100%, Writing: 80%

Co-authorship was offered to people who assisted me with this project. S. Goldsworthy was involved in the initial conception of this research and provided general supervision. R. Harcourt and A. Stow provided general supervision and commented of manuscript drafts. D. Hamer provided a subset of telemetry data for Chapter 3. By signing this declaration, all co-authors give their consent to allow each published or accepted paper to be included in this thesis.

Signature: Date: 16/11/11 A/Prof Simon Goldsworthy

Signature: Date: 16/11/11 Prof Robert Harcourt

Signature: Date: 16/11/11 Dr Adam Stow

Signature: Date: 16/11/11 Mr Derek Hamer

Dedication

To Brian, Jemma, Charlie, Jessica and Jimmy. My family who silently put up with my seven year journey of reinvention and gave me their unconditional support throughout. I am sorry for what this has done.

Acknowledgements

This body of work started out as a neatly conceptualised plan to be completed in 3,5 years. As Sun Tzu states in his book 'The Art of War', 'no plan ever survives first contact'. The unique and enigmatic animal I chose to study ensured not only the initial plan but also plans B, C and D fell by the wayside. As Australian sea lions all along the southern coastline of Australia battered my efforts to understand them, the support and guidance of several people kept me true to the cause. Although I will list a few here, there are doubtless many who I will fail to mention – my omissions are accidental and unintentional.

Firstly to my principal supervisor Associate Professor Simon Goldsworthy; you left me be when I needed to figure things out but you offered direction and 'out-of-the-box' ideas when I hit the wall. The support you offered in securing funding, establishing the list of contacts I needed to get through the mammoth amount of fieldwork required to complete this work and your positive and constructive criticism of manuscript drafts will be forever appreciated. To Professor Rob Harcourt; as well as the timely and insightful advice on manuscript drafts, your involvement in various aspects of fieldwork ranging from recapturing GPS transmitters to posing in photos on Western Australian roadsides will always be remembered. To Professor Stephen Donnellan and Dr Adam Stow; molecular ecology is as much an art-of-interpretation as it is a science, and your guidance and input on all things genetics were greatly appreciated.

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Although I was immersed in Australian sea lions continuously for the best part of five years I never lost sight of their unique attributes and enigmatic characters. They are still the most attractive otariid out there, and they still have many secrets left to discover.

“Caveo !Hic Svnt Leones”

[“Caveo ! Hic sunt leones” is a Latin expression and literally means ‘Beware ! Here be lions’. It can be found written on uncharted territories of old maps and was used by the early geographers for unknown and unexplored territories they imagined as populated by savages, wild animals and other dangers. It was generally placed at the edges of their known world.]

ABSTRACT

Otariid seals pose several challenges in collecting behavioural data due because of the geographical decoupling of breeding habitat (terrestrial) and foraging grounds (aquatic). Additionally, life history traits such as breeding chronology and moult state constrain the temporal window over which data can be collected. Expensive telemetry devices coupled with logistical difficulties and the biology of animals often limits the ability to answer questions concerning the role of seasonal or life-history differences in foraging ecology. However, quantifying individual behavioural specialisations such as foraging behaviour that may impede gene flow is an essential prerequisite to understanding population structure.

Several unusual life history traits of the IUCN Red Listed (threatened) Australian sea lion *Neophoca cinerea* are interesting from an ecological, evolutionary and conservation standpoint. Australian sea lions are endemic to the southern and western coastline of Australia, distributed over approximately 70 breeding colonies with 86% of all breeding occurring in South Australia. Most notably, a unique 17.5month breeding chronology and asynchronous breeding between spatially-close colonies has been proposed to be an adaptive response to a low-quality foraging environment that has little or no seasonality. Contrary to this, recent studies suggest at least the South Australian range of the species is a region replete with mesoscale areas of seasonally rich productivity, further supported by the presence of large numbers of other top marine predators and the largest volume fishery in Australia. In the face of this contradiction, the ecological determinants of population structure clearly have yet to be identified. To address these key knowledge gaps, this study explored the population structure and foraging behaviour of adult female Australian

sea lions at seventeen of the largest breeding colonies across the South Australian range.

A novel screening technique which employed $\delta^{13}C$ and $\delta^{15}N$ present in the whiskers of wholly milk-dependent pups was developed and validated as a proxy for maternal values. Mother-to-pup fractionation was quantified, with a $\delta^{15}N$ enrichment of +1.92‰ (blood) and +1.27‰ (vibrissae). Subsequent large-scale sampling of >50% of all pups born on each colony suggested a degree of ecological partitioning over a spatial scale never previously described for otariids.

Isotope ratios of serially-subsampled vibrissae from 20 adult female Australian sea lions across seven breeding colonies revealed individual long-term temporal consistency in both foraging site (offshore vs inshore) and prey selection. Furthermore, dive and movement parameters did not differ between alternate foraging ecotypes, suggesting that the alternate foraging strategies of adult female Australian sea lions were temporally persistent and unrelated to phenotypic variation.

Finally, individual foraging specialisation and matrilineal pop ulation structure were integrated by obtaining isotope and mitochondrial DNA (mtDNA) samples from over 50% of all pups born at each of 17 breeding colonies in order to characterise foraging ecotype composition and matrilineal population structure. Alternate foraging ecotypes were present at almost every colony with no evidence to support particular mitochondrial lineages were restricted to specific foraging ecotypes. Spatial analysis of molecular data identified three putatitive clusters of colonies that share multiple haplotypes being interspersed with 9 singleton breeding sites, with genetic structure becoming more apparent at colonies closer to deep water. Colonies with little or no similarity in mtDNA haplotype composition were more likely to breed asynchronously

irrespective of the geographic distance between them. Contrary to expectations, the propensity for individual animals to forage offshore was unrelated to the proximity of breeding colonies to deep water.

This study adds considerable knowledge to our current understanding of Australian sea lion foraging behaviour and highlights the inappropriateness of making broad-scale inferences about foraging ecology or population structure in this species. Individual foraging specialisation may act as an ecological barrier to migration, with individuals only able to disperse to colonies within range of preferred fine-scale foraging habitat where they have appropriate hunting skills.