# SEASONAL AND COLONY DIFFERENCES IN THE FORAGING ECOLOGY OF NEW ZEALAND FUR SEALS (*Arctocephalus forsteri*)

**Alastair M. M. Baylis, BSc (Hons.)**

**Submitted in fulfilment of the requirements for the degree of**

**Doctor of Philosophy**

**University of Adelaide**

**Faculty of Science**

**School of Earth and Environmental Studies**

**April 2008**

**TABLE OF CONTENTS**

**LIST OF TABLES**

**CHAPTER 2. EFFECT OF SEASONAL CHANGES IN UPWELLING ACTIVITY ON THE FORAGING LOCATIONS OF A WIDE-RANGING CENTRAL PLACE FORAGER, THE NEW ZEALAND FUR SEAL**



**CHAPTER 3. COLONY-SPECIFIC FORAGING AREAS OF LACTATING NEW ZEALAND FUR SEALS**

**CHAPTER 4. FORAGING SITE FIDLEITY IN A WIDE-RANGING CENTRAL PLACE FORAGER, THE NEW ZEALAND FUR SEAL**

**CHAPTER 5. MILK FATTY ACIDS PREDICT THE FORAGING LOCATIONS OF A WIDE-RANGING CENTRAL PLACE FORAGER, THE NEW ZEALAND FUR SEAL: CONTINENTAL SHELF VS OCEANIC WATERS**

**LIST OF FIGURES**

**CHAPTER 1. GENERAL INTRODUCTION**



**CHAPTER 2. EFFECT OF SEASONAL CHANGES IN UPWELLING ACTIVITY ON THE FORAGING LOCATIONS OF A WIDE-RANGING CENTRAL PLACE FORAGER, THE NEW ZEALAND FUR SEAL**

**CHAPTER 3. COLONY-SPECIFIC FORAGING AREAS OF LACTATING NEW ZEALAND FUR SEALS**

**CHAPTER 5. MILK FATTY ACIDS PREDICT THE FORAGING LOCATIONS OF A WIDE-RANGING CENTRAL PLACE FORAGER, THE NEW ZEALAND FUR SEAL: CONTINENTAL SHELF VS OCEANIC WATERS**

**APPENDIX. ASSESSING THE USE OF MILK FATTY ACIDS TO INFER THE DIET OF THE AUSTRALIAN SEA LION (*Neophoca cinerea*): A PRELIMINARY INVESTIGATION FROM OLIVE ISLAND, SOUTH AUSTRALIA**

**ABSTRACT**

The New Zealand fur seal (*Arctocephalus forsteri*) is the most abundant fur seal species in the Australian-New Zealand region. Approximately 85 % of Australia's population of New Zealand fur seals reside in the state of South Australia. As a result of their abundance and size, it has been estimated that the New Zealand fur seal population in South Australia consumes the greatest biomass of resources of all marine mammal and seabird species. However, despite the importance of New Zealand fur seals as top predators, our understanding of their foraging ecology in South Australia is limited. In order to better understand the habitat utilized and the diet of New Zealand fur seals, this study explores the foraging ecology of lactating seals from four primary colonies in South Australia, which account for ~ 78 % of the Australian population. These colonies are Cape Gantheaume (36$^{o}$04'S, 137$^{o}$27'E) and Cape du Couedic (36$^{o}$03'S, 136$^{o}$42'E) on Kangaroo Island; North Neptune Island (35$^{o}$13'S, 136$^{o}$03'E) and Liguanea Island (34$^{o}$59'S, 135$^{o}$37'E).

I start this study by assessing the seasonal variation in foraging location and dive behaviour of lactating New Zealand fur seals from Cape Gantheaume. 18 seals were fitted with satellite transmitters and time depth recorders (TDRs). The presence of thermoclines (derived from TDRs), were used as a surrogate measure of upwelling activity in continental shelf habitats. During the austral autumn 80 % of lactating fur seals foraged on the continental shelf (114 ± 44 km from the colony), in a region associated with a seasonal coastal upwelling system, the Bonney upwelling. In contrast, during winter months seals predominantly foraged in oceanic waters (62 %), in a region associated with the Subtropical Front (460 ± 138 km from the colony). Results suggested that lactating New Zealand fur seals shift their foraging location

from continental shelf to oceanic habitats, in response to a seasonal decline in continental shelf productivity, attributed to the cessation of the Bonney upwelling in autumn.

To study inter-colony differences in foraging locations, 21 New Zealand fur seals were satellite tracked from four colonies within close proximity (46 km – 200km apart). Seals initiated foraging trips on a colony-specific bearing (Cape Gantheaume 141 ± 33º, Cape du Couedic 186 ± 12º, North Neptune Island 200 ± 23º and Liguanea Island 234 ± 69º), and recorded little overlap between colony-specific foraging areas. The distribution of colony-specific foraging grounds appeared to be influenced by the proximity of colonies to predictable local upwelling features, as well as a distant oceanic frontal zone, the Subtropical Front.

Foraging site fidelity and route-choice was further assessed by comparing site fidelity between continental shelf and oceanic habitats. Data from 31 lactating females, satellite tracked over 107 consecutive foraging trips indicated that females foraging on the continental shelf recorded a significantly greater overlap in foraging area between consecutive foraging routes, when compared to females that foraged in oceanic waters (55.9 ± 20.4 % and 13.4 ± 7.6 %, respectively). Findings suggest that seals learn the direction of travel to a predictable foraging region, and initiate a foraging trip on that bearing. However, actual foraging routes are likely to be influenced by a number of factors including previous foraging trip experience and prey encounter rate, which is related to prey density and the spatial scale of the patch exploited.

The final chapter integrates scat analysis with milk fatty acid (FA) analysis to investigate dietary differences between continental shelf and oceanic waters. Milk FA composition was determined for 29 satellite-tracked fur seals, that were known to forage in either shelf or oceanic habitats. Based on FA compositions, I predicted the likelihood that milk samples collected at random ($n$ = 131) represented individual seals having foraged either on the continental shelf or in distant oceanic waters. FA analysis and satellite tracking results contrasted with scat analyses, from which only 6 % of scats by frequency of occurrence contained prey remains from oceanic waters. The results suggest that scats were biased toward females foraging on the continental shelf.

This study highlights the importance of two predictable ocean features utilised by New Zealand fur seals; (1) a nearby and seasonally predictable coastal upwelling system, the Bonney upwelling and; (2) a distant but permanent oceanic front, the Subtropical Front.

**Statement of originality and authority of access**

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

The author acknowledges that the copyright of published works contained within this thesis (as listed below) resides with the copyright holders of those works.

Signed

Alastair M. M. Baylis

April 2008

**The following peer-reviewed papers resulted from work completed during my candidature:**

Baylis, A.M.M., Page, B, McKenzie, J, McIntosh, R, Goldsworthy, S (2005). The ontogeny of diving in New Zealand fur seal pups. *Canadian Journal of Zoology* 83: 1149 – 1161.

Baylis, A.M.M., Page, B., Goldsworthy, S. (2008). Effect of seasonal changes in upwelling activity on the foraging locations of a wide-ranging central place forager, the New Zealand fur seal. *Canadian Journal of Zoology* 86: 774-789.

Baylis, A.M.M., Page, B., Goldsworthy, S. (2008). Colony-specific foraging areas of lactating New Zealand fur seals. *Marine Ecology Progress Series* 316: 379-390.

Baylis, A.M.M. and Nichols, P.D. (in press). Milk fatty acids predict the foraging locations of a wide-ranging central place forager, the New Zealand fur seal: continental shelf vs. oceanic waters. *Marine Ecology Progress Series*.

Baylis, A.M.M., Hamer, D.J., Nichols, P.D. (in press). Assessing the use of milk fatty acids to infer the diet of the Australian sea lion (Neophoca cinerea). *Wildlife Research*.

**Statement of the contribution of jointly authored papers**

I offered co-authorship to people who assisted me with this project. B. Page provided general supervision, advice on the analysis of satellite tracking data and commented on manuscript drafts. P. Nichols guided me through the extraction of fatty acids from fur seal milk, provided advice on the interpretation and analysis of results and commented on manuscript drafts. D. Hamer made available the Australian sea lion satellite-tracking data, provided the opportunity to collect sea lion milk, and commented on manuscript drafts. S. Goldsworthy was involved in the initial conception of the project and facilitated this research.

Alastair Baylis

## ACKNOWLEDGEMENTS

Producing this body of work in 3.5 years has been exhausting and many people have contributed along the way. It is neither appropriate nor fair to adequately convey my thanks to the people involved in these few paragraphs, but it is necessary to formally acknowledge the contribution of the following:

My supervisors, Drs Brad Page, David Paton, Peter Nichols and Simon Goldsworthy. Brad Page provided general supervision, time in discussion and sound advice, for which I extend my sincerest thanks. David Paton looked out for me with all things uni related, provided much advice and support and made time for last minute drafts. Dave also oversaw the changes to my thesis. His continued help, patience, advice and immense support back in Adelaide allowed me to fulfil the requirements of final submission – not a straightforward task when you are in another country. My time at CSIRO Hobart under the supervision of Peter Nichols was one of the outstanding experiences of my PhD. I thank Peter for welcoming me into his lab, his unrivalled enthusiasm and excitement, support, patience, words of encouragement and always having time. I extend my thanks to Simon Goldsworthy who was involved in the initial conception of the project, facilitated this research and provided comments to manuscript drafts. I am indebted to Tim Ward for securing Fisheries Research and Development Council (FRDC) funding that made this work possible. Tim Ward also provided timely advice, support and invaluable comments and also fast tracked an initial stipend through SARDI. Peter Shaughnessy - 40 years of seal research and 20 years of South Australian seal research, he is a legend and a gentleman. Thanks to Peter for his advice and sharing stories of South Africa, Alaska, Antarctica and places in between. A special thanks to Jane McKenzie for a summer working on fur seals all those years ago. To the many, many genuinely good people at SARDI, in particular Cam Dixon, Shane Roberts, Graham Hooper, Tim Ward and Dave Currie who enriched my time at SARDI through diverse work opportunities. They kept food on the table and the salt in my blood. Thanks also to Lee Warneke and to Darian Wilcoxs for their support and for making my time at SARDI so comfortable and enjoyable. You are all standouts and I am indebted.

Thanks to the staff of the Department of Environment and Heritage (DEH) KI: Bill Haddrill, Dave Heard, Derek Snowball, Anthony Maguire and Collin Groves, who welcomed me onto KI and provided much help and support and always had time for a yarn. Fieldwork would have not have been possible without the tremendous help of Candy Irriarte, Nat Bool, Dan Iliot, Dave Lierch, Carel Pleuis, Min Stuart-Smith, Peter Dodd, Andy Lowther, Ian Jupp, Ben and Bec Abbott, Luke and Cath Einoder and many others. It was a pleasure to spend time on those very special islands with an equally special mob, which rose to any and every challenge. Thanks for being such a dedicated and enthusiastic crew. Also to the seals, with only a fistful of trackers the fieldwork would have not been successful without their unwitting cooperation. It was a pleasure to work on such forgiving and easy going critters, and I feel privileged to have learnt a little more about these dynamic animals. The Adelaide University field equipment store was an integral part of field work. David Ladd always ensured generators were serviced, cars in order and other equipment up to scratch. He also generously allowed for extended loans.

Many colleagues gave their time to help me improve manuscript drafts. Kym Collins, Bec McIntosh, Mel Lancaster, Derek Hamer, Peter Shaughnessy, Tim Ward, Luke Einoder, Kris Peters, Rick and Min Stuart-Smith and Pat Lewis. I sincerely appreciate your willingness to read drafts and the time and effort in providing thoughtful comments and suggestions.

While this study was not possible without the above and their contribution of time, effort and ideas, there are a few people to whom I am particularly indebted. These are mates that kept me on track, focused and enthused and above all, kept this real: Didier Barreau, Luke and Cath Einoder, Derek Hamer, Kristian Peters. Unquestioning support, encouragement, always having time for a yarn and a beer and always there to bounce ideas. Thanks for the tireless reading of drafts, keeping me fed, the strong coffees, cottage cook ups, late nights, crazy horses, sharing SARDIs most distinguished office and the times away from the desk. An exceptional group of people. In Tassie: Rick and Min Stuart-Smith, Pat Lewis and Richard Cook – for equally unquestioning support and a few months of putting me up in Hobart and making sure I got a dose of highland trout. To my brother Alex, blisters Phil, Eri and Treen and wee sweet nephews, Nazir and Zavier, more love than can fit on the page.

Finally, the immense support received through the organisations involved made this research possible: SARDI Aquatic Sciences, Adelaide University, CSIRO Marine Hobart and DEH, SA. The Australian Postgraduate Award scheme provided a stipend and several funding bodies provided the freedom to explore the ideas presented by generously funding this research.

FRDC funding
Holsworth Wildlife Fund
Wildlife Conservation Fund
Project AWARE
Sea Link Travel Group
Sea World Research and Rescue Foundation
Nature Foundation South Australia
MA Ingram Trust
Rossi Boots Australia

*“There are known knowns. There are known unknowns. But there are also unknown unknowns. These are things we don't know we don't know.” D. Rumsfeld*