

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

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

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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°04'S, 137°27'E) and Cape du Couedic (36°03'S, 136°42'E) on Kangaroo Island; North Neptune Island (35°13'S, 136°03'E) and Liguanea Island (34°59'S, 135°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 $141 \pm 33^\circ$, Cape du Couedic $186 \pm 12^\circ$, North Neptune Island $200 \pm 23^\circ$ and Liguanea Island $234 \pm 69^\circ$), 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 ($55.9 \pm 20.4\%$ and $13.4 \pm 7.6\%$, 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.

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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.

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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.

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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