# Diet of fur seals *Arctocephalus forsteri* at Tonga Island, Abel Tasman National Park

Photo: Francesca Triossi

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# Diet of fur seals *Arctocephalus forsteri* at Tonga Island, Abel Tasman National Park

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# Executive Summary

The diet of the New Zealand fur seal *Arctocephalus forsteri* was examined at the Tonga Island (Abel Tasman National Park) rookery through analysis of scats and regurgitations from June – November 2007. The arrow squid *Notodarus sloanii*, anchovy *Engraulis australis*, pilchard *Sardinops neopilchardus*, and jack mackerel *Trachurus spp.* were the dominant prey species taken. Dietary composition did not vary markedly between winter and spring, when the colony was dominated by lactating females and their pups, and large territorial males, respectively. The dominance of certain prey species in the diet at different times probably reflects their local availability. Lanternfishes (Myctophidae), described as important fur seal prey in other locales, were absent. This is likely to be a function of the distance to the continental shelf edge from Tonga Island. Low numbers of some benthic coastal species were also taken. These may have been taken by pups learning to hunt in the immediate vicinity of the colony.

# 1. Introduction

New Zealand fur seal (*Arctocephalus forsteri*) populations were devastated by hunting during the 19$^{th}$ century (Richards 2003), and despite protection implemented in 1894 (Sorenson 1969) recovered only slowly until the 1970's, from which time the breeding range has gradually extended north (Dix 1993; Taylor et al. 1995). A breeding colony was established at Tonga Island, Abel Tasman National Park, around 1980, and by 1993 was producing over 100 pups year$^{-1}$ (Taylor et al. 1995).

The role of the New Zealand fur seal in coastal food web dynamics has not been assessed, despite several diet studies. These have been based on analysis of scats or regurgitates and have generally found the diet to be dominated by myctophids and pelagic schooling species such as anchovy, sardine, mackerel, hoki and barracouta (Street 1964, Tate 1981). However, Carey (1992) obtained evidence that diet composition may be strongly site-specific and reflect availability of prey. At Otago Peninsula, fur seals take large numbers of cephalopods – mostly the arrow squid *Notodarus sloanii* (Tate 1981, Fea et al. 1999). The studies of Fea et al. (1999) and Harcourt et al. (2002) also recorded morid cods (especially ahuru *Auchenoceros ahuru* and juvenile red cod *Pseudophycis bachus*) as common prey items: species that tend to be benthic or demersal in habitat. The latter work used time-depth recorders (TDRs) and satellite telemetry at Otago Peninsula to show that winter foraging was generally inshore during the winter, when more coastal species were taken.

The Tonga Island colony is the most distant breeding rookery from the edge of the New Zealand continental shelf, and it is therefore likely that the annual diet composition differs from other colonies. Here, we present results of a pilot diet study of fur seals at Tonga Island, to determine whether there is any evidence for more localised foraging than previously described.

# 2. Methods

Seal diet was characterised by prey remains in faecal and regurgitated material. Collecting trips were made to Tonga Island during low tide on 12 June 2007 and 11 July 2007 ("winter" samples), and 25 October 2007 and 21 November 2007 ("spring" samples). Searches were made of the mid-and upper-shore, which consists of large boulders and fragmented bedrock that seals use as haulout and breeding sites. All intact scats and regurgitated material found were individually bagged and labelled. Samples were frozen pending laboratory analysis.

In the laboratory scats and regurgitates were thawed, weighed, and then liquefied in warm water and detergent, before being passed through a 0.5 mm sieve. Bones, fish otoliths and cephalopod beaks were retained and identified to the lowest practicable taxonomic level.

# 3. Results

We collected 133 scats and 15 regurgitations over the 4 sampling days. The regurgitates were only found during the winter surveys, and were dominated by the arrow squid (Table 1). Fish remains were found in 9 of the 15 samples, although numbers were low (Table 1).

The size of the scats collected varied considerably, with a weight range of 3.2–415 g in winter, and 4.9–147 g in spring, probably reflecting whether deposited by adult seals or pups. All of the 133 scats contained fish remains (bones and/or scales). Of these, 76 contained identifiable remains (otoliths or cephalopod beaks). We recovered 286 otoliths from these samples, of which 20 otoliths could not be identified, due to breakage or erosion during digestion. Eleven fish species were identified from otoliths, numerically dominated by anchovy, pilchard, and jack mackerel. One octopus beak was found, and arrow squid comprised all remaining cephalopod remains (Table 2).

**Table 1. Identifiable prey remains from fur seal regurgitates (n = 15), Tonga Island, 2007.**

| Species | Common name | Number of items | % of total | Frequency of occurrence |
|---|---|---|---|---|
| Cephalopoda | | | | |
| *Notodarus sloanii* | arrow squid | 333 | 97.08 | 93.33 |
| Unidentified squid *sp.A*[1] | | 2 | 0.58 | 0.07 |
| Unidentified beaks | | 2 | 0.58 | 0.07 |
| Teleostei | | | | |
| *Sardinops neopilchardus* | pilchard | 2 | 0.58 | 0.13 |
| *Engraulis australis* | anchovy | 2 | 0.58 | 0.13 |
| *Pseudophycis bacchus* | red cod | 1 | 0.29 | 0.07 |
| Moridae *sp.B*[1] | | 1 | 0.29 | 0.07 |

[1]Identification to be confirmed

**Table 2. Identifiable prey remains from fur seal scats (n = 133), Tonga Island, 2007.**

| Species | Common name | Number of items | % of total | Frequency of occurrence |
|---|---|---|---|---|
| Cephalopoda | | | | |
| *Notodarus sloanii* | arrow squid | 81 | 21.89 | 0.16 |
| *Octopus maorum* | octopus | 1 | 0.27 | 0.01 |
| Unidentified beaks | | 2 | 0.54 | 0.02 |
| Teleostei | | | | |
| *Sardinops neopilchardus* | pilchard | 91 | 24.59 | 0.31 |
| *Sprattus sp.* | sprat | 9 | 2.43 | 0.04 |
| *Engraulis australis* | anchovy | 130 | 35.13 | 0.18 |
| *Argentina elongata* | silverside | 2 | 0.54 | 0.01 |
| Moridae *sp.A*[1] | | 1 | 0.27 | 0.01 |
| *Hyporhamphus ihi* | piper | 6 | 1.62 | 0.02 |
| *Trachurus sp.* | jack mackerel | 19 | 5.13 | 0.04 |
| *?Aldrichetta forsteri*[1] | grey mullet | 4 | 1.08 | 0.02 |
| *Notolabrus celidotus* | spotty | 1 | 0.27 | 0.01 |
| *Hemerocoetes monopterygius* | opalfish | 2 | 0.54 | 0.02 |
| *Arnoglossus scapha* | witch | 1 | 0.27 | 0.01 |
| Unidentified otoliths | | 20 | 5.40 | 0.10 |

[1]Identification to be confirmed

There was no relationship between scat weight and the quantity of identifiable prey items in the scat (Fig. 1), indicating either that there is no difference between pup and adult diet, or that scat weight is highly variable irrespective of animal size.

There was some seasonal variability between winter (June/July) and spring (October/November) scat samples (Fig. 2). Anchovy were absent from scats collected in June, whereas arrow squid was dominant. Squid were however absent from scat samples collected in July. Jack mackerel were present from June to October, but were absent in November.

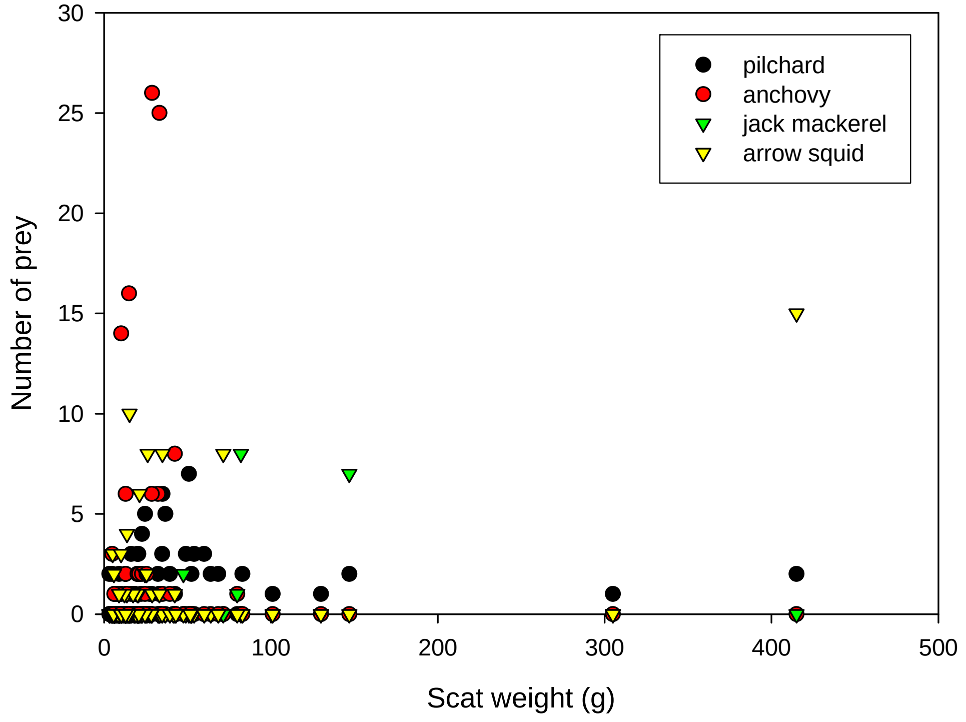


**Figure 1.** **Number of prey items plotted against scat weight for the four most common prey species.**

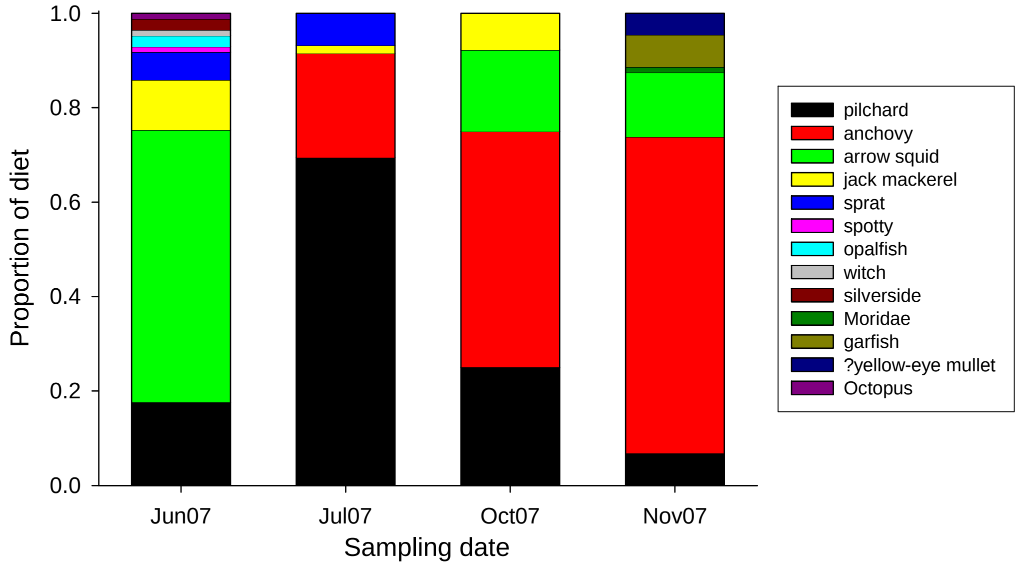


**Figure 2.** **Composition (relative proportion of number of prey items) of fur seal diet from scat analysis by sampling date.**

# 4. Discussion

This study found the diet of fur seals at the Tonga Island colony to be numerically dominated by schooling pelagic fishes and squid – based on identifiable remains, these were predominantly pilchard *Sardinops neopilchardus*, anchovy *Engraulis australis*, and arrow squid *Notodarus sloanii*. All scats collected contained fish bones and occasionally scales that were not identified during this project. Other species of fish and cephalopod were taken on rarer occasions. These results support the contention of Cary (1992) that fur seals tend to be fairly opportunistic, and their diet is likely to reflect the availability of prey. Despite forming a significant proportion of the diet at Otago Peninsula and other locations (Street 1964; Carey 1992; Fea et al. 1999), no lanternfishes (Myctophidae), barracouta (*Thyrsites atun*) or hoki (*Macruronus novaezelandiae*) were found in the diet of Tonga Island seals, and octopus were found only once. Colony composition during June and July was predominantly lactating females and their pups, whereas in October and November most of the seals found were males attempting to establish breeding territories. Lactating females do not travel on long foraging trips, as they must return to the colony to feed their pups (Harcourt et al. 2001) and males competing for breeding space are unlikely to be absent for extended periods. Given the lack of deeper water species in Tonga Island seal diets, it is likely that foraging trips of resident seals are limited to the Tasman and Golden Bay areas, and the shallow Cook Strait waters to the north. Fur seals elsewhere in New Zealand generally forage over the continental shelf and continental slope (Harcourt et al. 1995; Mattlin et al. 1998; Fea et al. 1999), and it is likely that seals from Tonga Island do the same when not constrained in range by breeding behaviour. A comparative study of seal diets from Tonga Island and colonies on the West Coast (e.g. Cape Foulwind, Wekakura Point and Farewell Spit) would determine the importance of geographical position to diet.

Seasonal variability in fur seal diet at Otago Peninsula has been described by Fea et al. (1999) and Harcourt et al. (2002). The greatest differences were found between summer/autumn and winter/spring. The current study collected samples only in winter and spring, so no comparison with summer diet could be made. It was expected *a priori* that there may have been detectable differences in diet between winter and spring, since the colony was composed almost exclusively of lactating females and pups in winter, and relatively low densities of large males and a few weaned pups in spring (authors' observations). No regurgitates were found in spring, but otherwise there were no clear distinctions, since the between-season variability was no greater than the between month (i.e. within-season) variability in diet composition. It is probable that the observed variation was due to local availability of prey, rather than colony composition. However, given the large observed variability between individual sampling days in the same season, a future study should: 1) collect samples over the entire calendar year, to determine if diet is correlated with seasonal variation in colony composition, 2) replicate sampling within months, to examine diet selectivity issues over shorter time-scales, and 3) also sample on consecutive days, to determine land-based fecal deposition relative to the number of seals present. Ad hoc collections, as ours were (weeks or months apart), will necessarily collect scats of varying age, thus reducing our ability to detect short-term variability in diet composition.

Studies of fur seal diets that rely mainly on scats tend to be biased toward fish species while analysis of regurgitates tend to overestimate the proportion of cephalopods (e.g. Dellinger & Trillmich 1988; Carey 1992; Lalas 1997). This is consistent with the present study for which the bulk of the regurgitates consisted of cephalopod beaks and pens. Despite known biases in both these methods (Carey 1992; Gales & Cheal 1992; Fea & Harcourt 1997; Bowen 2000), they provide a non-invasive means of semi-quantitative evaluation of diet composition. Scats collected from rookeries or haulouts on a single day probably represent only a very small fraction of the total faecal production of a colony. Gut throughput rates of fur seals have been measured at up to 9 days (Fea & Harcourt 1997) but evacuation rates may vary according to activity levels (Casper et al. 2006). It is likely that a significant percentage of seal defecation occurs at sea, especially on longer foraging trips.

We did not obtain any correlation between scat weight and the number of identifiable prey items found within the scat. This may be because large scats resulted from feeding bouts upon cephalopods, after which the seal would regurgitate any identifiable hard parts, leaving only digested organic material in the scat. This issue may be tested using recently developed stable isotope or DNA techniques for prey identification (Casper refs). Alternatively, the weights of scats that were collected did not represent the original scat weight due to drying in the sun, breaking up of the scat due to movements of the seals, or dissolution of the scat after rain events. To our knowledge, none of these sources of bias have been previously examined.

The presence of opalfish, morid cods, spotty, and flatfish in Tonga Island scats constitutes limited evidence for benthic foraging on locally occurring shallow water fishes on and around reefs. It is possible that at least some of these species were taken by seal pups in their first year gaining hunting experience. New Zealand fur seal pups may commence active foraging as early as 5-6 months of age, which is 4-5 months prior to weaning (Bayliss et al. 2005). Initial foraging bouts are depth limited in pups, and more than 90% of dives are to less than 10 m (Bayliss et al. 2005). No research to our knowledge has examined the local effects of seal colonies on local assemblages of reef-associated fishes via predation, or on benthic assemblages as an indirect result of such predation and/or locally elevated nutrient input from excretion. Even if reef fishes are not preferred prey, it is possible that sustained low-intensity predation by seals may, over time, alter assemblage composition or local fish densities.

Studies of the diet of marine predators are critical for understanding ecosystem food web dynamics, and for detecting changes in ecosystem function brought about by human impacts or climate change. Such studies in New Zealand are hindered by a lack of generally available resource material from which to identify animal remains. Specifically, detailed atlases of cephalopod beaks (e.g. Lu & Ickeringill 2002), fish otoliths (incorporating morphometrics and relationships with fish size, e.g. Smale et al. 1995) and fish bones (e.g. Leach 2006) are needed to support detailed study. Such New Zealand material as exists has been collected on an *ad hoc* basis for specific studies and is not publically available.

## 5. Acknowledgements

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## 7. Appendix 1 – Photographs of representative prey material

*Trachurus sp.* - jack mackerel

*Engraulis australis* – anchovy

*Trachurus sp.* - jack mackerel

*Notolabrus celidotus* – spotty (broken)

*Hemerocoetes monopterygius* - opalfish

*Sprattus sp.* – sprat

*Sardinops neopilchardus* – pilchard

*Argentina elongata* – silverside

Moridae *sp. A* – unidentified morid

Fish bones

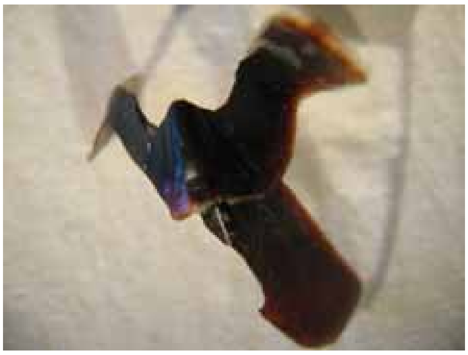
Moridae *sp. B* – unidentified morid

*Notodarus sloanii* – arrow squid

*Pseudophycis bacchus* – red cod

*Octopus sp.* upper beak

*Arnoglossus scapha* – witch



*Octopus sp.* lower beak (damaged: right lateral wall missing)