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FISH PREY SPECIES OF THE NEW ZEALAND FUR SEAL *(ARCTOCEPHALUS FORSTERI,* LESSON)

Summary: The fish prey consumed by New Zealand fur seals *(Arctocephalus forsteri)* was investigated by analysis of faeces collected between February and August at sites on the east and west coasts of South Island, New Zealand. Twelve species were identified from otoliths recovered from faeces. Lanternfish *(Symbolophorus* sp. and *Lampanyctodes hectoris),* the most frequent fish prey, comprised 79% of all otoliths, followed by anchovy *(Engraulis australis)* at 12%, ahuru *(Auchenoceros punctatus)* with 3.9%, and hoki *(Macruronus novaezelandiae)* at 3.7%. Of these species only hoki is commercially important. Regional and seasonal differences in the proportions of species were evident, and the results are compared with those from previous studies.

Keywords: New Zealand fur seal; *Arctocephalus forsteri;* diet; commercial fisheries.

Introduction

Seals that live and forage in inshore waters are sometimes thought to be in conflict with commercial fishing interests because they are seen as potential competitors for the same stocks. Overlap in the fish species taken by seals and those caught by humans has been demonstrated in some areas (e.g., England: Pierce *et al.,* 1991; South Africa: King, 1983). In New Zealand, discussions of seal/fisheries competition have been hindered by the paucity of information on what seals eat and this study addresses that void.

The diet of seals is determined by examining either stomach contents, regurgitations, or faeces and each of these methods has its own advantages and biases. New Zealand fur seal diet was first investigated by Street (1964) who examined the stomach contents of seals .from Kaikoura, Banks Peninsula, Otago, The Nuggets (Southland), and Bench Island and identified the flesh of fish and cephlapods that had not been digested beyond recognition. He concluded that barracouta *(Thyrsites atun)* (38%), octopus (29%), and squid (24%) were the main prey taken. Tate (1981) investigated the diet of fur seals at Otago Peninsula by sampling faeces and regurgitations. With greater emphasis on regurgitations, Tate found arrow squid and octopus to be the main foods eaten; an unidentified fish, hoki, and barracouta were the most common fish species. At Macquarie Island, the southern limit of its range, *A. forsteri* was found to feed predominantly on fish and penguins (Green *et al.,* 1990).

Faecal analysis is favoured for studies of pinniped diet because scats are usually relatively abundant, easy to collect, and their collection is non-invasive (e.g., Treacy and Crawford, 1981; Murie and Lavigne, 1985; Prime and Hammond, 1987; Green *et al.,* 1990). But several limitations of this methodology have been identified. Faecal analysis does not provide a reliable assessment of the biomass or energy ingested (Dellinger and Trillmich, 1988) and some prey are under-represented (e.g., cephlapods) or not present at all in faeces (e.g., sea lice or animals with no hard parts) (de Silva and Neilson, 1985; Dellinger and Trillmich, 1988). However, faecal analysis is well suited to estimating the relative proportions of the prey species that do pass through the gut (Dellinger and Trillmich, 1988), and for which roughly equal digestion is assumed, e.g., fish versus fish, squid versus octopus, etc.

This study presents evidence of the fish species consumed by New Zealand fur seals and the relative importance of each species in the fish portion of the seals' diet. The results do not attempt to present the complete diet of fur seals in New Zealand.

Methods

Seal scats were collected from colonies at Cape Foulwind (41 45'S, 171 28'E) monthly from February to August 1991, at Kaikoura (42 25'S, 173 42'E) monthly from April to August, from Gillespie's Beach (43 24'S, 169 50'E) in February, plus April to July, and from Open Bay Islands (43 52'S, 168 53'E) in May.

Each scat/sample was collected and stored in a separate plastic bag until it was processed (less than 24 hours after collection). Scats were washed through a sieve of 1 mm mesh and all otoliths were removed, cleaned with water, and stored dry. A total of 286 samples was collected and 2558 otoliths recovered. Otoliths were identified (to species level in all but two cases) by comparison with a reference collection of

otoliths held by Dr C. Lalas. Fish size can be estimated from otoliths provided that otoliths which have not been exposed to digestion are available for comparison. Partial digestion of otoliths can result in very misleading estimates (Dellinger and Trillmich, 1988). Because no pristine otoliths are presently available, no size data are included here, though maximum sizes are given in Table 2.

Results

Fish remains were found in 89% of all scats collected and twelve different fish species were identified (Table 1). Otoliths from the lanternfish *Symbolophorus* (nomenclature in Table 1) were the most common type found, followed by those from anchovy, and another lanternfish *Lampanyctodes*. Ahuru (pink cod) and hoki were the only other species found more than incidentally. Small numbers of silverside, yellow-eyed mullet, pilchard, jack mackerel, *Scopelosaurus*. and another lanternfish, *Gymnoscopelus*. were also found. Scales from a rattail were found in two samples, and two sea lice and a paddle crab *(Ovalipes)* were recovered from the stomach of one dead seal found on a beach in Westland. Twenty-five squid beaks were also recovered from faecal samples, but because all were upper beaks, no identifications were possible.

When the data are considered without regard to quantity of fish taken, but simply whether or not a species was eaten, the results show that *Symbolophorus* was the species most often found in scats, followed by anchovy and then hoki (Table 2).

Table 1: *Fish otoliths recovered from New Zealand fur seal scats at four locations around the South Island. February to August 1991.*

Species	No. of otoliths	% of total
Clupeidae		
Sardinops neopilchardus		
Steindachner, 1879 (pilchard)	3	0.1
Engraulidae		
Engraulis australis (White, 1790) (anchovy)	307	12.0
Argentinidae		
Argentina elongata (Hunon, 1879) (silverside)	20	0.8
Scopelosauridae		
unidentified species	1	0.04
Myctophidae		
Lampanyctodes hectoris (Gunther, 1870)	236	9.2
Symbolophorus sp.	1786	69.9
Gymnoscopelus piabilis (Whitley, 1931) (lanternfishes)	2	0.08
Moridae		
Auchenoceros punctatus (Hutton, 1873) (ahuru)	99	3.9
Merlucciidae		
Macruronus novaezelandiae (Hector, 1871) (hoki)	96	3.8
Carangidae		
Trachurus declivis (Jenyns, 1841) (jack mackerel)	5	0.2
Mugilidae		
Aldrichella forsteri (Cuvier and Valenciennes, 1846) (yellow-eyed mullet)	1	0.04
Total	2556	

Table 2: *Maximum size offish and representation of fish species by scat samples*

Species	Average size of adult fish (cm)	No. of scats containing each species	% of total scat samples
Pilchard	10-20	1	0.35
Anchovy	8-12	47	16.3
Silverside	10-20	4	1.4
Scopelosaurid sp.	10-20	1	0.35
Lampanyctodes	5-7	17	5.9
Symbolophorus	5-10	52	18.0
Gymnoscopelus	5-10	2	0.7
Ahum	10	15	5.2
Hoki	60-100	37	12.8
Jack mackerel	30-40	5	1.7
Yellow-eyed mullet	20-30	1	0.35

The proportions of fish species varied between locations (Fig.1). *Symbolophorus* made up 93.7% of the otoliths recovered from Kaikoura, but only 33.4% of those from Open Bay Islands and 3.8 % at Cape Foulwind. No *Symbolophorus* were found at Gillespie's Beach. Anchovy *(Engraulis)* predominated at Cape Foulwind (73.6%) but was not present in the samples from any other site. *Lampanyctodes* was the principal fish eaten at Open Bay Islands (64.7%), while ahuru *(Auchenoceros)* dominated the diet at Gillespie's Beach (82%). However, because of the small sample sizes from Open Bay Islands and Gillespie's Beach, the data from these locations should be read with caution.

Seasonal variation was also evident at Cape Foulwind and Kaikoura, the only sites where samples were obtained frequently enough to warrant comparison (Fig. 2). At Cape Foulwind, anchovy *(Engraulis)* was not the major prey item until May, but it remained important throughout the winter. Conversely, the proportion of ahuru *(Auchenoceros)* in the diet decreased sharply after April. Silverside was present only in April and May but it was a substantial portion of the diet (35%) in April.

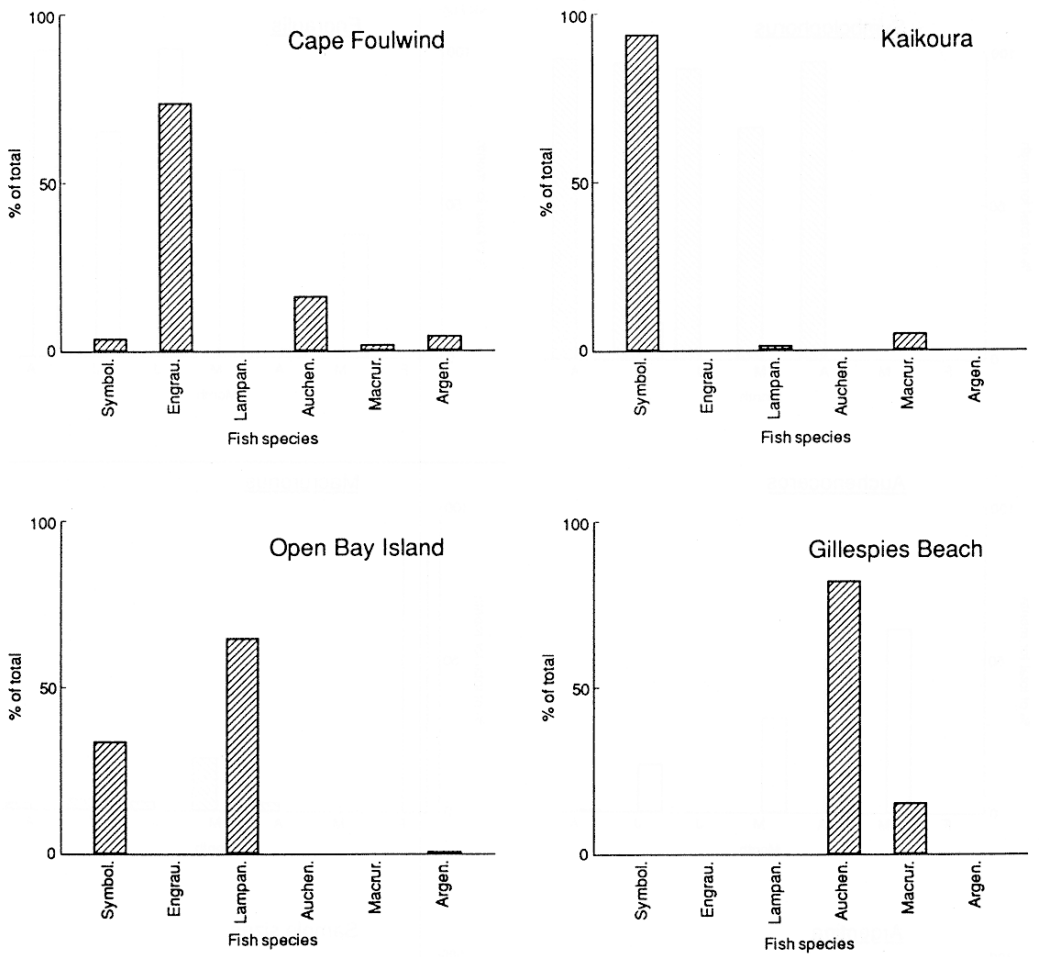

Figure 1: *Proportions of each fish species at each site. Only the six most numerous species (> 1% for at least one location) are shown. Sample sizes: Kaikoura - 1770 otoliths recovered from 128 samples; Cape Foulwind - 417 otoliths from 129 samples; Open Bay Island* - 332 *otoliths from 16 samples; Gillespie's Beach* - 39 *otoliths from 13 samples.* Symbol = *Symbolophorus,* Engrau = *Engraulis,* Lampan = *Lampanyctodes,* Auchen = *Auchenocerus,* Macrur = *Macruronus,* Argen = *Argentina.*

At Kaikoura, *Symbolophorus* was the main fish prey throughout the sampling period (over 90% in every month except May). Hoki comprised 2.1- 3.7% except in May, when 17.1 % of otoliths recovered at Kaikoura were from hoki.

Most samples (258, 90%) contained only one type of otolith. Twenty-six samples (9%) contained two species, and only two samples (0.6%) had three species in them. There were 102 samples which contained lanternfish or hoki, but in only 6 of these were otoliths of both species present.

Discussion

The results show that the major fish prey of fur seals in New Zealand are lantemfish and anchovy. Lanternfish are mesopelagic, common around New Zealand, and are usually found off the continental shelf (Robertson, Roberts and Wilson, 1978). Anchovy are found in shallow water coastal areas, particularly around North Island and the northwest coast of South Island (Paul, 1986). Hence, Cape Foulwind was the only site sampled in this study which overlapped with the range of

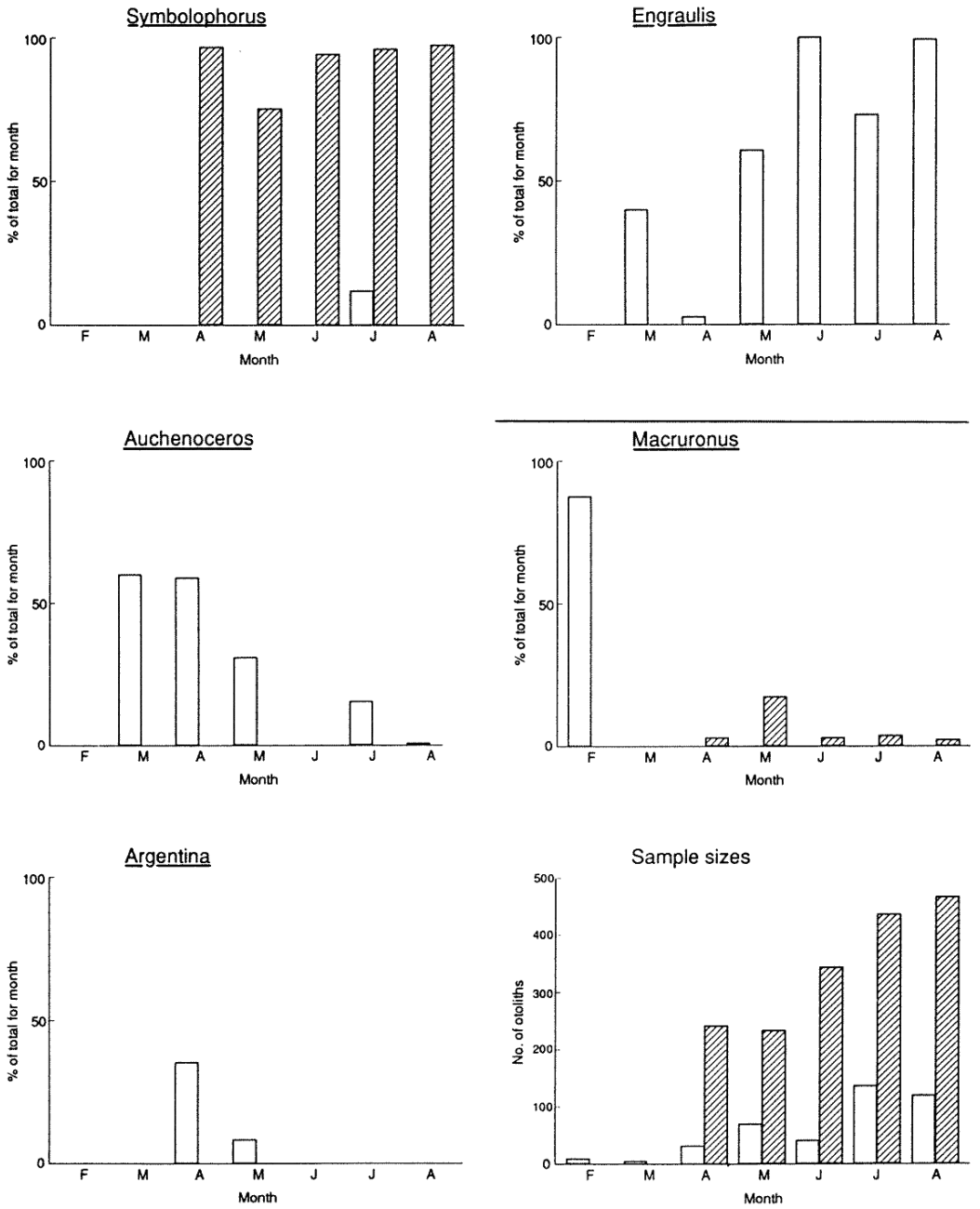

Figure 2: *Proportions of each fish species for each month at Cape Foulwind and Kaikoura. N.B. sampling at Kaikoura did not begin until April. Only those species comprising more than 2% of the total for either location are shown. Open bars = Cape Foulwind, hatched bars = Kaikoura.*

anchovy. Both anchovy and lanternfish are often found in large schools (Paul, 1986). Also, it is likely that these fish comprise a larger part of the diet than was indicated by otolith recovery because experimental studies (Dellinger and Trillmich, 1988) have shown that the number of small fish is under-represented in faeces.

When small fish show up in a seal's diet, there is the risk that the seal did not consume them directly, but rather ate a larger fish that already had the small fish in its gut. Hoki are known to be major consumers of lanternfish (Ayling and Cox, 1982) so data were checked to see if seals were ingesting lanternfish as a by-product of their hoki consumption. This was not the case. In only six samples were hoki and lanternfish found together, compared to 62 samples where lanternfish were present and hoki were absent.

Significantly, the major fish prey of fur seals in New Zealand were species which are not presently of commercial concern. Jack mackerel (5 otoliths recovered) and yellow-eyed mullet (1 otolith) are of commercial value but they seem to be of little importance to seals. Hoki (96 otoliths, 3.8% of the total) is the only commercial fish species that appears to be targeted by seals.

Although hoki remains were found in 12.8% of the scats collected, they only accounted for 3.8% of the otoliths recovered. This discrepancy is not surprising, since hoki are about ten times larger than lanternfish and anchovy, and so a seal feeding on hoki would likely require fewer individuals for a full meal.

The proportion of hoki in the diet varied slightly between sites. Hoki was most common in samples from Kaikoura, where it comprised 4.7% of the diet over the whole study period, and up to 17.1 % during May. In all other months it never exceeded 4% there. At Cape Foulwind hoki only comprised 1.7% of the fish diet between February and August. Indeed, hoki was only present in February when seven of the otoliths recovered (from a total of eight) were from this species. Similarly, at Gillespie's Beach, 15.4% of the diet was made up of hoki but again small sample size probably exaggerates the importance of this species. Only 13 scats were obtained from Gillespie's Beach and of these, only four contained otoliths of any kind.

The differences in fish prey between sites is likely to be a reflection of fish distribution. Kaikoura is much closer to the Continental Slope than the other sites and the diet of seals there is dominated by mesopelagic species. The availability of lanternfish at Kaikoura also makes this species an important part of the diet of dusky dolphins *(Lagenorhynchus obscurus)* there (Cipriano, 1985). At Cape Foulwind, where the shelf is broader, a shallow water coastal species predominates. Green *et al*. (1990) found significant differences in diet between seals at opposite ends of Macquarie Island - less than 35 km apart.

Overall, there do not appear to be many seasonal fluctuations in diet composition, but obviously where they do exist they must be driven by differences in the abundance and availability of prey items. Samples from Cape Foulwind showed a decrease in the importance of ahuru as winter progressed, accompanied by an increase in the consumption of anchovy. Larger sample sizes and a year-round sampling programme may discover more seasonal differences.

The results of this study are not readily comparable with Street's (1964) work because of the differences in methodology. For identification of prey, the earlier study relied on soft tissue taken from the stomach of the seal. Prey which had been in the gut longer or which were more readily digested, would therefore be under-represented. Street did not identify any lanternfish in the 70 seals he examined, but a small fish eaten over the Continental Slope (i.e., not close to shore) would likely be unrecognisable when the seal returned to land.

Street did find hoki in the stomachs of three seals and jack mackerel in two, but these were the only species also found in this present study. Barracouta was the main fish species found in Street's study; it was present in 20 seals. The complete lack of barracouta in the samples from the present study is therefore puzzling. Given the distinctive otolith of this species and its enamelled teeth (which tend to resist digestion) one would expect faecal analysis to detect if a seal had been eating barracouta (but see below). One possible explanation for the absence of barracouta from this study is that this fish is most commonly eaten in summer, i.e., outside of the study period. Three quarters (22 of 29) of the barracouta recovered by Street were found between September and January - months not sampled during the present study. The one study that covered a full 12 month period (at Macquarie Island) found minor seasonal differences in the diet of *A. forsteri* there (Deidre Johnson, *pers. comm.)*. Her study also shows some changes in the proportion of some prey types compared with work there in an earlier summer (Green *et al.,* 1990).

Tate (1981) investigated the diet of fur seals in Otago from February to July by analysing remains in vomitus and faeces. These methods make comparison with the present study more valid and some overlap was found. Tate reported an unidentified otolith and hoki to be the most common fish remains. The unidentified otolith appears to be *Symbolophorus* (see Fig. 4, p. 15, Tate, 1981). The only other otoliths found frequently were ahuru, but small numbers of red cod *(Physiculus bachus),* jack mackerel, and yellow-eyed mullet were also recorded. Tate did not record finding any barracouta otoliths in regurgitations or faeces. However, he did find the vertebrae of barracouta in 18 (5%) of the regurgitation samples. Hence, it appears that at least in low numbers, the presence of this species may be difficult to detect.

The discrepancies between the three studies of fur

seal diet in New Zealand highlight the limitations of different methods. Because this present study used only faecal analysis, it is confined to the fish portion of the diet. Faecal analysis, while it does not provide a comprehensive list of what a seal eats, does accurately assess the relative importance of those food items which do pass through the gut with assumed equal digestibility. The findings demonstrate that fur seals in New Zealand are not competing with commercial fishermen for the same fish stocks.

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