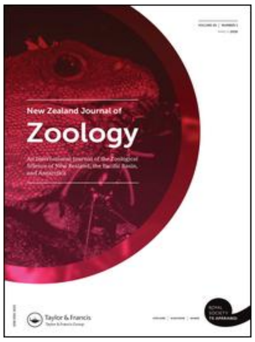

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First report on the stomach contents of long-finned pilot whales, *Globicephala melas*, stranded in New Zealand

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First report on the stomach contents of long-finned pilot whales, *Globicephala melas*, stranded in New Zealand

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Abstract Stomach contents of the long-finned pilot whale, *Globicephala melas*, are reported for the first time from New Zealand waters. Analyses based on two male and three female whales (2.5–5.3 m in length) that stranded on Farewell Spit, Golden Bay, South Island in December 2005 revealed a diet comprised exclusively of cephalopods (2–33 lower cephalopod beaks per stomach). Two genera of cephalopod from two orders; arrow squid, *Nototodarus* spp. (Teuthoidea: Ommastrephidae), and common octopus, *Pinnoctopus cordiformis* (Octopoda: Octopodidae) were represented. A further five pilot whale stomachs were examined and found to be empty.

Keywords Cephalopoda; diet; *Globicephala melas*; long-finned pilot whale; New Zealand; stranding

INTRODUCTION

Little is known about the ecology of many whales native to New Zealand waters, especially about their diets, due largely to the inherent difficulties of studying their foraging ecology. Most information on diet is gathered by examining the stomach contents of stranded animals.

Cetaceans strand frequently along New Zealand coasts; 92 separate stranding events involving some 562 individuals attributed to 17 species were recorded in 2005 alone (Childerhouse in press). The reasons that cetaceans strand is poorly known. Illness is often cited as a likely cause (Martin et al. 1987), but apparently healthy whales also strand in large groups, and more often than not they are oceanic Odontocetes (toothed whales) rather than inshore species or Mysticetes (baleen whales) (Martin et al. 1987).

Despite the unusually high frequency and numbers of oceanic cetaceans that strand in New Zealand waters (Brabyn 1991; Tuohy et al. 2001; Dalebout 2002), data on their diet are limited to recent studies of the pygmy sperm whale, *Kogia breviceps* (Beatson in press), and of the sperm whale, *Physeter macrocephalus* (Gomez-Villota 2006). Nothing was known of the regional diet of the long-finned pilot whale *Globicephala melas* prior to this study.

Globicephala melas is the most frequent mass-stranding cetacean species (Brabyn 1991; Childerhouse in press), and contributes by far the highest recorded number of individuals of any marine mammal species stranded in New Zealand (from April 2005 to March 2006, 475 individuals stranded, followed by 23 of both *Kogia breviceps* and *Delphinus delphis*). *G. melas* was involved in the largest single stranding event recorded in New Zealand, when c. 450 whales stranded together on Great Barrier Island in 1985 (Brabyn 1991). Mass-stranding events have been recorded at 21 sites around New Zealand, of which 15 have been multiple herd strandings (Brabyn 1991).

This paper presents the first report on the diet of long-finned pilot whales in New Zealand waters, based on material collected at Farewell Spit, Golden Bay, northernmost South Island. Golden Bay is a renowned hot spot for mass strandings of pilot whales —more than 20 such events have been recorded in this region since 1978 (The New Zealand Whale

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Stranding Database, held at the Museum of New Zealand Te Papa Tongarewa in Wellington). Such stranding events provide an unfortunate but unique opportunity to investigate the diet of these species and their role in marine ecosystems.

MATERIAL AND METHODS

From 20 to 22 December 2005, 124 long-finned pilot whales stranded at Port Puponga, Farewell Spit, Golden Bay (40°31′S, 172°43.52′E) (New Zealand Department of Conservation unpubl. data). At 10 a.m. on 20 December 2005 whales were reported to be in shallow water, and by 3 p.m. some were stranded; 99 were successfully refloated, but 25 died *in situ* or were euthanased (New Zealand Department of Conservation unpubl. data). One of the authors (MO) attended this stranding event on 22 December, recorded the length and sex and of all 25 euthanased or recently dead whales, and sampled the stomach contents of 10 of these whales. Unfortunately, the remaining 15 dead whales could not be sampled due to limitations on time and resources. The carcasses were classified as belonging to calves (not fully weaned), juveniles (nutritionally independent but sexually immature), or mature, based on body length from morphometric data given by Sergeant (1962), Kasuya et al. (1988), Bloch et al. (1993), Desportes & Mouritsen (1993), and Martin & Rothery (1993).

Stomach contents were dissected out, frozen and freighted to Auckland University of Technology. For analysis they were defrosted, rinsed through a 1.0 mm sieve, and sorted. Cephalopod remains were fixed in 10% formalin, then preserved in 70% ethanol. Cephalopod lower beaks were identified to the lowest possible taxon with the aid of Auckland University of Technology's comprehensive reference collection of beaks extracted from entire, identified squid and octopus collected in New Zealand waters. Small amounts of cephalopod flesh were also found but were too digested to assist identification. It is possible that these items were otherwise not represented by remains of hard parts.

The original size of the live prey at ingestion was estimated from the lower rostral length (LRL) for squid, and from the lower hood length (LHL) for octopus, using regression equations constructed by Clarke (1986) and Lu & Ickeringill (2002). Measurements were taken with calipers, or (for very small beaks) with a micrometer under a binocular microscope. The relative importance of prey items was quantified by: (1) frequency of occurrence (FO), defined as the proportion of five stomachs that contained a particular prey species, regardless of mass or abundance, (2) proportion of numerical abundance (%Num), the percentage of the total number of prey items recovered from all stomachs represented by a particular prey category, (3) proportion of reconstructed prey mass (%Mass), the percentage of reconstructed mass of prey recovered from all stomachs represented by a particular prey category, and (4) index of relative importance (IRI) (*sensu* Pinkas et al. 1971), which combines the above three methods and is calculated following the formula: $IRI = FO \times (\%Num + \%Mass)$.

Prey species composition was measured for all five whales as a group. Because of the small sample size, no detailed investigation of potential dietary differences between age, sex, or reproductive category was possible.

RESULTS

Information on gender, body length and maturity status for each of the 10 animals examined is provided in Table 1.

Five of the 10 stomachs contained identifiable prey remains, comprising 59 lower and 54 upper cephalopod beaks belonging to two genera of cephalopods; arrow squid *Nototodarus* spp. (Teuthoidea: Ommastrephidae) and octopus, *Pinnoctopus cordiformis* (Octopoda: Octopodidae) (Table 1). Low numbers of unidentified nematode parasites were found in five stomachs, three of which were otherwise empty (Table 1).

Nototodarus spp. accounted for 88.1% by number and 97.9% by reconstructed mass of the total cephalopod prey ingested (Table 1). The *Nototodarus* beaks recovered ranged from 1.7 to 5.6 mm in lower rostral length and from 97 to 253 mm in estimated mantle length. Both *N. gouldi* and *N. sloanii* are present off Farewell Spit, and they cannot reliably be distinguished on the basis of beak morphology.

The estimated total biomass of the prey found in the stomachs ranged from 1.1 kg in whale no. 1 to 17.3 kg in whale no. 6 (median 4.2 kg). Using the calculations of Sergeant (1962), which assume that an average sized pilot whale of c. 4 m length and 1000 kg weight requires a minimum of 11 kg of food to fill its stomach, estimates of stomach fullness for the five whales sampled herein range from 10 to 160% full (median 38%).

Table 1 Biological data and composition of cephalopods in the diet of 10 *Globicephala melas* stranded at Farewell Spit, New Zealand on 21 December 2005. Legend: M, male; F, female; C, calf; J, juvenile; A, adult; Y, stomach contained nematode parasites; N, stomach did not contain nematode parasites; FO, frequency of occurrence; IRI, index of relative importance.

	Whale no.															
	1	2	3	4	5	6	7	8	9	10						
Sex	M	M	M	M	F	F	F	M	F	F						
Length (m)	4.9	5.7	2.0	5.1	2.5	3.2	3.2	5.3	4.2	3.8						
Maturity	A	A	C	A	C	J	J	A	A	J						
Stomach parasites	Y	Y	N	Y	N	N	N	N	Y	Y						
Species in diet											Total	FO	%Num	Mass (kg)	%Mass	IRI
Ommastrephidae																
Nototodarus spp.	1				2	33		6		10	52	1	88.1	30.6	97.9	186.0
Octopodidae																
Pinnoctopus cordiformis	4							2		1	7	0.6	11.9	0.6	2.1	8.4
Total upper cephalopod beaks	4	0	0	0	3	31	0	1	0	15	54					
Total lower cephalopod beaks	5	0	0	0	2	33	0	8	0	11	59					
Reconstructed biomass of prey (kg)	1.1	0	0	0	1.5	17.3	0	7.2	0	4.2	31.3					

DISCUSSION

The only taxa we recorded eaten by the five long-finned pilot whales we examined were fast-swimming, muscular squid of the genus *Nototodarus*, and benthic octopus *Pinnoctopus cordiformis*. The squid included numerous juveniles of a size consistent with those individuals frequently encountered in fine meshed trawls to depths ranging from 0 to 100 m.

The total bathymetric distributions of all ontogenetic stages of *Nototodarus* and *Pinnoctopus*, determined from fisheries data and from comprehensive museum collections from the New Zealand EEZ, extend to about 500 and 300 m, respectively (Mattlin et al. 1985; O'Shea 1999). A second species of octopus, *Octopus kaharoa*, is sympatric with *Pinnoctopus* towards the deeper end of the bathymetric range of *Pinnoctopus*, but no beaks of *Octopus kaharoa* were found in any of the five stomach samples. The presence of juvenile squid plus *Pinnoctopus*, combined with the absence of *O. kaharoa*, suggests that these long-finned pilot whales had been foraging both near the surface of the water column and on the seabed, most likely at depths shallower than 150 m.

Similar results have been reported from long-finned pilot whales sampled in other parts of the world. For example, stomach content analyses of *G. melas* from Canada (Sergeant 1962; Mercer 1975), North America (Gannon et al. 1997a,b), Britain (Martin et al. 1987), Faroe Islands (Clarke 1985; Desportes & Mouritsen 1988, 1993), the Mediterranean (Relini & Garibaldi 1992), South America (Clarke & Goodall 1994; dos Santos & Haimovici 2001), South Africa (Sekiguchi et al. 1992) and Tasmania (Gales et al. 1992), all found significant amounts of ommastrephid squid, and benthic octopus are also important prey items for *G. melas* around Tasmania (Gales et al. 1992).

Three dietary patterns have been proposed for the long-finned pilot whale (Gannon et al. 1997a): (1) a diverse diet (≥10 prey species) dominated by squids (Clarke 1985; Gales et al. 1992; Relini & Garibaldi 1992; Desportes & Mouritsen 1993; Clarke & Goodall 1994; Gannon et al. 1997a,b); (2) a restricted diet (≤3 species) dominated by squids (Sergeant 1962; Martin et al. 1987); and (3) a restricted diet (≤3 species) dominated by fishes (Mercer 1967; Waring et al. 1990; Overholtz & Waring 1991). Our data suggest that the New Zealand population, at least in the vicinity of Farewell Spit during

December 2005, fits the second pattern—one of low dietary diversity dominated by squid.

Species of *Nototodarus* are common throughout New Zealand waters (Roberts 1978); both *N. gouldi* and *N. sloanii* have been recorded in trawl surveys near Farewell Spit (Smith et al. 1987). Since the early 1970s a large, multi-national jig and trawl fleet has fished for arrow squid within New Zealand's 200-mile exclusive economic zone (EEZ) (Uozumi & Forch 1995). The total catch of arrow squid in the 2005 fishing season was c. 70 900 tonnes, caught entirely by trawl (Ministry of Fisheries 2006). *Nototodarus gouldi* releases large, free-floating gelatinous egg masses of 1.5–2 m diameter, and *N. sloanii* probably does the same. Trawl fisheries targetting spawning aggregations of arrow squid can easily damage or destroy these egg masses (O'Shea et al. 2004). Any serious impact on the earliest life stages of *Nototodarus* could retard the reproductive capacity of the squid population, and eventually reduce the availability of prey for cetaceans and pinnipeds in the area.

The limitations of dietary studies based on stomach content analysis of stranded cetaceans are well known and must be considered (see Pierce & Boyle 1991 for a review). Our results could be biased towards (1) near-shore prey, since they represent a snap-shot of the last meal(s) of the whales sampled (Clarke 1962); (2) harder to digest remains (like cephalopod beaks), since these are more likely to be represented in the sample than softer or more easily digested prey; and (3) sick whales, whose diet does not necessarily represent that of healthy whales.

We acknowledge these constraints, but consider that the inherent difficulties in studying the feeding ecology of oceanic cetaceans, and the lack of knowledge of the biology of pilot whales in New Zealand, justifies reporting the stomach contents of stranded individuals when opportunity offers.

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REFERENCES

Beatson E in press. The diet of pygmy sperm whales, *Kogia breviceps*, stranded in New Zealand: implications for conservation. Reviews in Fish Biology and Fisheries.

Bloch D, Lockyer C, Zachariassen M 1993. Age and growth parameters of the long-finned pilot whale off the Faroe Islands. In: Donovan GP, Lockyer C, Martin AR ed. Biology of Northern Hemisphere pilot whales. Cambridge, UK, International Whaling Commission. Pp. 163–208.

Brabyn MW 1991. An analysis of the New Zealand whale stranding record. Department of Conservation Science & Research Series 29: 47 p.

Childerhouse S in press. Cetacean research in New Zealand 2005/06. Department of Conservation Science Internal Series.

Clarke MR 1962. The identification of cephalopod 'beaks' and the relationship between beak size and total body weight. Bulletin of the British Museum (Natural History), Zoological Series 8(10): 419–480.

Clarke MR 1985. Cephalopods in the diet of cetaceans and seals. Rapport Commission Internationale Mer Mediterranee 29: 211–219.

Clarke MR ed. 1986. A handbook for the identification of cephalopod beaks. Oxford, Clarendon Press. 273 p.

Clarke MR, Goodall N 1994. Cephalopods in the diets of three odontocete cetacean species stranded at Tierra del Fuego, *Globicephala meleana* (Traill, 1809), *Hyperodon planifrons* (Flower, 1882) and *Cephalorhynchus commersonii* (Lacepede, 1804). Antarctic Science 6(2): 149–154.

Dalebout ML 2002. Species identity, genetic diversity and molecular systematic relationships among the Ziphiidae (beaked whales). Unpublished PhD thesis, School of Biological Sciences, University of Auckland, Auckland, New Zealand. 385 p.

Desportes G, Mouritsen R 1988. Diet of the pilot whale, *Globicephala melas*, around the Faroe Islands. International Council for the Exploration of the Sea C.M. 1988/N:12. 15 p.

Desportes G, Mouritsen R 1993. Preliminary results on the diet of long-finned pilot whales off the Faroe Islands. Reports of the International Whaling Commission Special Issue 14: 305–324.

dos Santos RA, Haimovici M 2001. Cephalopods in the diet of marine mammals stranded or incidentally caught along southeastern and southern Brazil (21–34°S). Fisheries Research 52: 99–112.

Gales R, Pemberton D, Clarke MR 1992. Stomach contents of long-finned pilot whales (*Globicephala melas*) and bottlenose dolphins (*Tursiops truncatus*) in Tasmania. Marine Mammal Science 8(4): 405–413.

Gannon DP, Read AJ, Craddock JE, Fristrup KM, Nicolas JR 1997a. Feeding ecology of long-finned pilot whales *Globicephala melas* in the western North Atlantic. Marine Ecology Progress Series 148: 1–10.

Gannon DP, Read AJ, Craddock JE, Mead JG 1997b. Stomach contents of long-finned pilot whales (*Globicephala melas*) stranded on the US mid-Atlantic coast. Marine Mammal Science 13(3): 405–418.

Gomez-Villota F 2006. Sperm whale diet in New Zealand. Unpublished MAppSc thesis. Division of Applied Sciences, Auckland University of Technology, Auckland, New Zealand. 221 p.

Innes S, Lavigne DM, Earle WM, Kovacs KM 1987. Feeding rates of seals and whales. The Journal of Animal Ecology 56(1): 115–130.

Kasuya T, Sergeant DE, Tanaka K 1988. Re-examination of life history parameters of long-finned pilot whales in the Newfoundland waters. Scientific Reports of the Whales Research Institute 39: 103–119.

Lu CC, Ickeringill R 2002. Cephalopod beak identification and biomass estimation techniques: tools for dietary studies of southern Australian finfishes. Museum Victoria Science Reports 6: 1–65.

Martin AR, Rothery P 1993. Reproductive parameters of female long-finned pilot whales (*Globicephala melas*) around the Faroe Islands. Reports of the International Whaling Commission 14: 263–304.

Martin AR, Reynolds P, Richardson MG 1987. Aspects of the biology of pilot whales (*Globicephala melaena*) in recent mass strandings on the British coast. Journal of Zoology, London 211: 11–23.

Mattlin RH, Scheibling RE, Forch EC 1985. Distribution, abundance and size structure of arrow squid (*Nototodarus* sp.) off New Zealand. NAFO Science Council Studies 9: 39–45.

Mercer MC 1967. Wintering of pilot whales, *Globicephala melaena*, in Newfoundland inshore waters. Journal of the Fisheries Research Board of Canada 24(11): 2481–2484.

Mercer MC 1975. Modified Leslie-DeLury population models of the long-finned pilot whale (*Globicephala melaena*) and annual production of the short-finned squid (*Illex illecebrosus*) based upon their interaction at Newfoundland. Journal of the Fisheries Research Board of Canada 32: 1145–1154.

Ministry of Fisheries 2006. The state of our fisheries. Annual Summary 2006. Wellington, Ministry of Fisheries. 44 p.

O'Shea S 1999. The marine fauna of New Zealand: Octopoda (Mollusca: Cephalopoda). NIWA Biodiversity Memoir 112: 280 p.

O'Shea S, Bolstad K, Ritchie P 2004. First records of egg masses of *Nototodarus gouldi* McCoy, 1988 (Mollusca: Cephalopoda: Ommastrephidae), with comments on egg-mass susceptibility to damage by fisheries trawl. New Zealand Journal of Zoology 31: 161–166.

Overholtz WJ, Waring GT 1991. Diet composition of pilot whales *Globicephala* sp. and common dolphins *Delphinus delphis* in the Mid-Atlantic Bight during spring 1989. Fishery Bulletin 89: 723–728.

Pierce GJ, Boyle PR 1991. A review of methods for diet analysis in piscivorous marine mammals. Oceanography and Marine Biology 29: 409–486.

Pinkas L, Oliphant MS, Iverson ILK 1971. Food habits of the albacore, bluefin tuna, and bonito in California waters. California Department of Fish and Game, Fish Bulletin 152: 1–105.

Relini LO, Garibaldi F 1992. Feeding of the pilot whale, *Globicephala melas*, in the Ligurian Sea: a preliminary note. Sixth Annual Conference of the European Cetacean Society, San Remo, Italy. Pp. 142–145.

Roberts PE 1978. New Zealand squid resources. Pelagic Fisheries Conference, New Zealand Fisheries Research Division Occasional Publication 15. 102 p.

Sekiguchi K, Klages NTW, Best PB 1992. Comparative analysis of the diets of smaller odontocete cetaceans along the coast of southern Africa. South African Journal of Marine Science 12: 843–861.

Sergeant DE 1962. The biology of the pilot or pothead whale *Globicephala meleana* (Traill) in Newfoundland waters. Bulletin of the Fisheries Research Board of Canada 132. 84 p.

Smith PJ, Mattlin RH, Roeleveld MA, Okutani T 1987. Arrow squids of the genus *Nototodarus* in New Zealand waters: systematics, biology, and fisheries. New Zealand Journal of Marine and Freshwater Research 21: 315–326.

Tuohy M, Stratton M, Duignan P, Jones G, Davies A, Smith MH, Quirk J, Van Helden A, Plön S, Baker CS 2001. Pygmy sperm whale (*Kogia breviceps*) strandings in New Zealand: distribution patterns based on age, sex, and reproductive status. 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada. 28 November–3 December 2001. P. 219.

Uozumi Y, Forch E 1995. Distribution of juvenile arrow squids *Nototodarus gouldi* and *N. sloanii* (Cephalopoda: Oegopsida) in New Zealand Waters. Fisheries Science 61(4): 566–573.

Waring GT, Gerrior P, Payne PM, Parry BL, Nicolas JR 1990. Incidental take of marine mammals in foreign fishery activities off the northeast United States, 1977–88. Fishery Bulletin 88(2): 347–360.