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The diet of pygmy sperm whales, *Kogia breviceps*, stranded in New Zealand: implications for conservation

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Abstract The stomach contents of 27 pygmy sperm whales, *Kogia breviceps*, stranded on New Zealand beaches between 1991 and 2003 are reported. These individuals comprise 16 males, 10 females, and one for which no sex information is available. The diet was found to include fish and crustaceans, but is comprised primarily of cephalopods, with 0–526 lower beaks, representing an estimated maximum of *c*. 60 kg of cephalopod prey consumed by any one whale. Cephalopod prey is attributed to 23 species from 13 families, and is dominated by juvenile individuals of the families Histioteuthididae and Cranchiidae (adults of which usually occur at depths exceeding 400 m). Perceived threats to this whale, particularly those affecting distribution and abundance of prey species, are also discussed. These are the first data reporting the diet of this whale species in New Zealand waters. A comparison of the diet of *K. breviceps* is made with that of the sperm whale, *Physeter macrocephalus* from New Zealand waters, and with the diet of *Kogia* known elsewhere.

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Introduction

Cephalopods (octopus and squid) are significant in the marine food web, comprising a major portion of the diet of many apex predators such as marine mammals (cetaceans and pinnipeds), seabirds and large fish (both teleosts and elasmobranchs) (Clarke 1996a, b). Despite this, very little is known about what cephalopod species are consumed by predators in New Zealand waters, particularly marine mammals.

The diet of several toothed whale species found around New Zealand is predominantly squid (e.g. pygmy sperm whales [herein]; Risso's dolphin, *Grampus griseus*; long-finned pilot whale, *Globicephala melas*; sperm whales, *Physeter macrocephalus*; and the majority of beaked-whale species [family Ziphiidae]: MacLeod et al. 2003; Barros and Clarke 2002; Clarke 1996b; Gomez-Villota 2006). Worldwide, compared to fish-eating species, little is known about the diet of cephalopod-eating whales, due largely to the inherent difficulties of studying their feeding ecology. The most frequently used technique entails examination of stomach contents of dead animals (Barros and Clarke 2002). However, even though unusually high numbers of cephalopod-eating cetaceans strand in New Zealand waters (Tuohy et al. 2001; Brabyn 1991; Dalebout 2002), their diet has remained poorly known.

The pygmy sperm whale, *Kogia breviceps*, is widespread and thought to be common in all temperate, subtropical and tropical seas, although information of its biology is limited (Leatherwood et al. 1983; Baird et al. 1994). Sightings of *K. breviceps* are rarely reported and therefore most of our current knowledge of this whale has come from stranding events (Leatherwood et al. 1983; Vidal et al. 1987; Baird et al. 1994). Ross (1979) has reported length at birth to average about 1.2 m, sexual maturity to be attained at about 2.7–2.8 m for females and 2.7–3.0 m for males, and physical maturity reached at lengths of 3.0–3.3 m for both sexes. *Kogia breviceps* is considered an opportunistic feeder, with up to 77 different prey species identified from stomach contents from South African specimens (including 55 cephalopod taxa; Plön et al. 1999). Such previous analysis of stomach contents suggest that *K. breviceps* normally feeds in offshore waters at the same trophic level as the sperm whale, *Physeter macrocephalus* (Ross 1979; Nelson et al. 1991; Sekiguchi et al. 1992).

Kogia breviceps is the most frequently stranded cetacean species in New Zealand (364 individuals represented by 297 stranding events, based on records from 1873 to 2001), with the majority of pygmy sperm whale strandings being single, live events; few small group strandings have been reported (Brabyn 1991, Tuohy et al. 2001). More than half of these strandings have occurred in the Hawkes Bay region, on the southeast coast of the North Island (Brabyn 1991). Historically, twice as many female *K. breviceps* have stranded in New Zealand than males, and about half of these females have stranded in the Hawkes Bay region with a calf, perhaps indicating that *K. breviceps* may calve somewhere near Hawkes Bay (Brabyn 1991; Tuohy et al. 2001).

This contribution provides the first report of the composition of cephalopods in diet of the pygmy sperm whale, *K. breviceps*, in New Zealand waters, based on stomach content analysis of 27 individuals stranded on New Zealand beaches between 1991 and 2003. The habitat of *K. breviceps* off the New Zealand coastline is inferred from species recorded in the diet, and perceived threats to these whales with regard to the distribution and abundance of prey species are also discussed.

Material and methods

Department of Conservation (DOC) officers present at every pygmy sperm whale stranding recorded length, sex and standard morphometric data. The stomachs of 27 of these euthanased or recently dead whales were collected between 1991 and 2003; the contents of which are herein reported. Information on stranding location, date, gender, body length, maturity status and condition upon stranding for each animal is provided in Fig. 1 and Table 1. Individuals have been classified as either sexually immature or mature, based on body length from morphometric data given by Ross (1979).

When stomach contents could not be sorted and fixed immediately the stomach was frozen whole and freighted to Aukland University of Technology (AUT), where they were defrosted, rinsed through a 1.0 mm sieve, and sorted. After sorting,

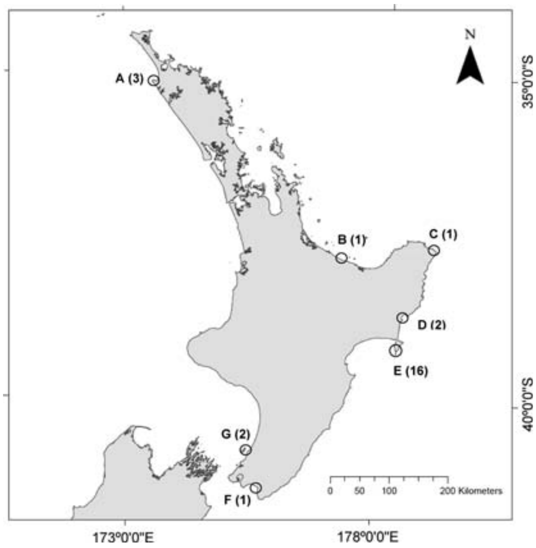

Fig. 1 Location map and numbers of *Kogia breviceps* strandings in New Zealand: A, Ahipara; B, Matata, Bay of Plenty; C, East Cape; D, Poverty Bay; E, Mahia Peninsula, Hawkes Bay; F, Palliser Bay; G, Kapiti Coast

Table 1 Locality, stranding and biological data for *Kogia breviceps*. Legend: M, male; F, female; 0, immature; 1, sexually mature; 2, live, not pregnant; 3, live, pregnant; 4, live, with calf/mother; 5 dead, not pregnant; 6 dead, pregnant; 7, all stomach contents; 8, sample of stomach contents; 9 stomach empty; ND, no data

Whale	Date	Location	Sex	Length (m)	Maturity	Condition	Sample
1	15-May-91	Black Reef, Hawkes Bay	F	1.86	0	4	ND
2	1998	ND	ND	ND	ND	ND	ND
3	9-Mar-00	Opoutama Beach, Hawkes Bay	M	1.73	0	4	7
4	9-Mar-00	Opoutama Beach, Hawkes Bay	F	2.92	1	2	7
5	21-Mar-00	Hawkes Bay	M	2.5	0	ND	ND
6	15-May-00	Mahia Beach, Hawkes Bay	F	1.88	0	4	7
7	15-May-00	Mahia Beach, Hawkes Bay	F	2.88	1	4	7
8	19-Jul-00	Paraparaumu, Kapiti Coast	M	2.99	1	2	7
9	3-Sep-00	Matata, Bay of Plenty	M	1.71	0	2	8
10	11-May-01	Mahia Beach, Hawkes Bay	M	1.74	0	2	7
11	10-Dec-01	Putungapama, East Cape	M	1.96	0	ND	7
12	20-May-01	Opoutama Beach, Hawkes Bay	M	2.92	1	2	8
13	28-May-01	Mahia Beach, Hawkes Bay	F	3.06	1	6	ND
14	11-Jun-01	Opoutama Beach, Hawkes Bay	M	1.93	0	5	7
15	11-Jul-01	Mahia Beach, Hawkes Bay	M	2.77	1	ND	7
16	14-Dec-01	Browns Beach, Poverty Bay	F	2.7	1	6	7
17	26-Mar-02	Mahia Beach, Hawkes Bay	M	3	1	2	7
18	24-Apr-02	Opoutama Beach, Hawkes Bay	M	1.63	0	ND	7
19	6-May-02	Mahia Beach, Hawkes Bay	F	2.9	1	4	9
20	13-May-02	Waikanae Beach, Kapiti Coast	F	1.87	0	ND	7
21	14-May-02	Te Kopi, Palliser Bay	M	2.6	0	2	7
22	8-May-02	Tauroa Point, Ahipara	M	2.84	1	5	7
23	26-Jun-02	Ahipara Bay, Ahipara	M	3.18	1	ND	7
24	6-May-02	Hukatere, Kaitaia	M	3.2	1	5	7
25	8-Jul-02	Napier, Hawkes Bay	M	2.09	0	2	7
26	25-Jan-03	Mahia Beach, Hawkes Bay	F	2.98	1	3	8
27	9-Mar-03	Poverty Bay	F	3.27	1	3	ND

cephalopod beaks and other prey items were fixed in 10% formalin, and then stored in 70% ethanol. All prey items were identified to the lowest practicable taxon. Crustacean numbers were determined from carapace or telson counts (whichever was highest). Crustacean carapaces were also measured, where possible. Cephalopod lower beaks were identified with the aid of a comprehensive reference collection of beaks extracted from entire, identified squid and octopus occurring in New Zealand waters and from illustrations and keys presented in Clarke (1986) and O'Shea (1999). All stomach samples have been accessioned into the biological collections of AUT.

Size of cephalopod prey at ingestion was reconstructed by estimating mass from the lower rostral length (LRL) for squid and the lower hood length (LHL) for octopus, using regression equations from Clarke (1980, 1986); Wolff (1982) and Lu and Ickeringill (2002). Measurements were taken with calipers, or with a micrometer under a binocular microscope for very small beaks (±0.1 mm). The relative importance of prey items was ascertained by: (1) frequency of occurrence, (2) proportion of numerical abundance, (3) proportion of mass, and (4) index of relative importance. Frequency of occurrence (FO) is the proportion of stomachs that contained particular prey species, regardless of mass or abundance; proportion of numerical abundance (%Num) is the percentage of the total number of prey items recovered from all stomachs represented by a particular prey category; proportion of mass (%Mass) is the percentage of reconstructed mass of prey recovered from all stomachs represented by a particular prey category; and index of relative importance (IRI) (*sensu* Pinkas et al. 1971) combines the above three methods and is calculated in accordance with: IRI = FO × (%Num + %Mass).

Results

The individuals sampled comprised 16 males, 10 females (of which eight were pregnant or accompanied by a calf), and one for which no biological data is available. Although strandings have occurred throughout the year, the majority these whales (70%) have stranded between late summer and early autumn (9 March–28 May). All individuals have stranded on New Zealand's North Island, north of the Subtropical Convergence. Sixteen (59%) of the 27 whales herein reported stranded in the Hawkes Bay region, southeast North Island (Fig. 1) (Table 1).

Of the 27 *Kogia breviceps* stomachs examined, 24 contained prey remains while three were empty. Cephalopods, crustaceans and fish represented approximately 94%, 3% and 3% by number of recovered prey items respectively (Table 2). Cephalopod remains included beaks and eye lenses; crustacean remains comprised 47 exoskeltons of mysid, *Gnathophausia ingens*, and two unidentified amphipods. Carapace lengths of 32 measurable *Gnathophausia* ranged from 44–84 mm. Four largely intact *Gnathophausia* had a mean total length:carapace length ratio of 3.48. The estimated total length range of the *Gnathophausia* consumed is therefore 154–294 mm. Numerous fish eye lenses and two unidentified fish jaws were also recovered from *Kogia* stomachs (Table 2).

Cephalopod component of diet

A total of 1478 lower beaks were recovered from 24 stomachs, from which 23 species, attributable to 13 families and 3 orders of cephalopods were identified (Table 2). The total mass of cephalopod prey is an estimated *c*. 200 kg, with 0–526 lower beaks representing a maximum of *c*. 50 kg of cephalopods ingested by any one whale (Table 2).

With IRI's of 57.08 and 23.36, the histioteuthid squid, *Histioteuthis miranda* and *Histioteuthis* sp. 2, were the primary cephalopod prey, representing 31.52% and 24.29% by number and 59.09% and 12.80% by estimated mass of the total cephalopod prey ingested respectively (Table 2). The cranchiid squid, *Teuthowenia pellucida*, was the third most abundant cephalopod species recorded (IRI 15.56) and made up 18.71% by number and 7.67% by estimated mass of the cephalopod diet component (Table 2). *Nototodarus* sp. (IRI 3.61), *Taonius pavo* (IRI 1.87), and *Chiroteuthis* sp. 1 (IRI 1.30) were also significant components of the diet of this whale (Table 2). These six species represent 87% of the total lower beaks recovered, 90% of the total estimated cephalopod mass of *c*. 200kg, and have a combined IRI of 102.78.

It is also important to note here that the majority of the most abundant species of histioteuthid and cranchiid beaks recovered from *Kogia* stomach contents were remains of immature squid; as determined from LRL of wing darkening reported by Clarke (1986) (Fig. 2).

Discussion

All cephalopods in the diet of this whale species are represented by in situ captured squid and octopus in marine natural history collections from New Zealand waters. These cephalopods are almost exclusively oceanic, bioluminescent, of small to medium size, slow moving, and undergo diel vertical migrations. With the exception of two individuals of the benthic octopus, *Octopus kaharoa*, the general lack of extraneous debris (e.g. rocks, shell) and other benthic octopodids indicates that *Kogia* feeds almost exclusively on pelagic cephalopods. Approximately 78% of all cephalopod species in the diet of *Kogia breviceps* in New Zealand are known or are assumed to (based on female reproductive anatomy) release gelatinous, free-floating gelatinous egg masses (S. O'Shea, pers. comm.).

The mysid *Gnathophausia ingens* has been recorded from 210–3914 m depth although is most common between 600 and 1500 m (Paquegnat 1965). This species is also a diel vertical migrator but has not been found at the surface. In the eastern Pacific its upper limit is around 650 m during the day, while at night most occur between 274 and 650 m (Paquegnat 1965). All measurable specimens recorded herein were large adults (estimated total body length 154–294 mm), which

Table 2 Composition of taxa recorded in the diet of 27 *Kogia breviceps* stranded in New Zealand between 1991 and 2003

	Whale #																																
	1991	1998	2000							2001							2002									2003							
SPECIES	1	2	3*	4*	5	6*	7*	8*	9	10*	12	13	14	15*	11*	16*	17*	18*	19*	24*	22*	20*	21*	23*	25*	26	27	Total Num	FO	% Num	Mass (kg)	% Mass	IRI
Cephalopod Component																																	
Histioteuthidae																												**904**	**0.81**	**57.32**	**148.04**	**73.12**	**106.29**
Histioteuthis miranda		1		70	55	1	6	113			3	76			1	19	47				3		3	57	10	27	5	497	0.63	31.52	119.63	59.09	57.08
Histioteuthis macrohista				18						1																3	2	24	0.15	1.52	2.50	1.24	0.41
Histioteuthis sp. 2			4		54	7	20	147				27	1			2	3	1			23	2	11	45	19	17		383	0.63	24.29	25.91	12.80	23.36
Cranchiidae																												**351**	**0.67**	**22.26**	**19.89**	**9.83**	**21.39**
Megalocranchia sp.																								1				1	0.04	0.06	0.63	0.31	0.01
Taonius pavo	1			5	1	4	1	11		3		3					3	1				1		13		1		48	0.44	3.04	2.46	1.21	1.87
Teuthowenia pellucida				11	2	9	15	214		1		10	1			2	4				1	1	6	2	2	14		295	0.59	18.71	15.52	7.67	15.56
Galiteuthis armata				3	1							1					1							1				7	0.19	0.44	1.29	0.64	0.21
Chiroteuthidae																												**74**	**0.52**	**4.69**	**4.19**	**2.07**	**3.51**
Chiroteuthis sp. 1						8	3	20								1	1	2					1	3	2			41	0.33	2.60	2.70	1.33	1.30
Chiroteuthis sp. 2								6				1												13		1		21	0.15	1.33	1.09	0.54	0.28
Chiroteuthis sp. 4	1			2			1	2									1				1			3		1		12	0.30	0.76	0.40	0.20	0.29
Enoploteuthidae																												**38**	**0.19**	**2.41**	**0.12**	**0.06**	**0.46**
Abraliopsis gilchristi			8																	1	19			7	3			38	0.19	2.41	0.12	0.06	0.47
Brachioteuthidae																												**29**	**0.37**	**1.84**	**0.29**	**0.14**	**0.73**
Brachioteuthis picta				2	5	2	5	3				1											3	1	6	1		29	0.37	1.84	0.29	0.14	0.73
Ommastrephidae																												**25**	**0.41**	**1.59**	**14.60**	**7.21**	**3.58**
Nototodarus spp.		1	1		7		2	1							1						3	1		4	1	3		25	0.41	1.59	14.60	7.21	3.61
Sepiolidae																												**17**	**0.15**	**1.08**	**0.02**	**0.01**	**0.16**
Heteroteuthis sirventyi						3																		1				4	0.07	0.25	0.01	0.00	0.02
Iridoteuthis maoria	12		1																									13	0.07	0.82	0.02	0.01	0.06
Octopoteuthidae																												**16**	**0.33**	**1.01**	**5.28**	**2.61**	**1.21**
Octopoteuthis megaptera					1		1	4				2					2							2		1	1	14	0.30	0.89	3.08	1.52	0.72
Taningia danae				1								1																2	0.07	0.13	2.20	1.08	0.09
Gonatidae																												**11**	**0.19**	**0.70**	**0.51**	**0.25**	**0.18**
Gonatus antarcticus				1	3												4							3				11	0.19	0.70	0.51	0.25	0.18
Onycoteuthidae																												**7**	**0.11**	**0.44**	**4.01**	**1.98**	**0.27**
Moroteuthis ingens					1			5									1											7	0.11	0.44	4.01	1.98	0.27
Ancistrocheiridae																												**2**	**0.07**	**0.13**	**1.02**	**0.50**	**0.05**
Ancistrocheirus lesueuri				1								1																2	0.07	0.13	1.02	0.50	0.04
Pholidoteuthidae																												**1**	**0.04**	**0.06**	**4.46**	**2.21**	**0.08**
Pholidoteuthis massyae																								1				1	0.04	0.06	4.46	2.21	0.08
Octopodidae																												**3**	**0.07**	**0.19**	**0.02**	**0.01**	**0.01**
Octopus kaharoa			2																									2	0.04	0.13	0.02	0.01	0.00
Pinnoctopus cordiformis																									1			1	0.04	0.06	0.00	0.00	0.00
Total Lowers	**14**	**2**	**16**	**114**	**130**	**34**	**54**	**526**	**0**	**5**	**3**	**123**	**2**	**0**	**2**	**24**	**67**	**4**	**0**	**1**	**50**	**5**	**24**	**157**	**44**	**69**	**8**	**1478**		**93.72**	**202.45**		
Total Uppers	20	8	29	98	125	42	46	484	0	7	10	106	2	0	6	15	0	4	0	1	52	8	17	132	32	61	6	1311					
Mass (kg)	**0.03**	**0.32**	**0.28**	**22.08**	**22.09**	**1.15**	**5**	**50.7**	**0**	**0.16**	**0.7**	**27.54**	**0.13**	**0**	**2.09**	**5.4**	**15.63**	**0.19**	**0**	**0.01**	**6.37**	**0.16**	**2.05**	**25.01**	**3.7**	**10.32**	**1.31**	**202.42**					
Non-cephalopod component																																	
Gnathophausia ingens				12	1		5	1				16								1		1	1	1		6	2	**47**	0.41	**3.18**			
Amphipoda													2															**2**	0.04	**0.14**			
Fish eye lens (pairs)			3		1	6						2	6							1		5	1			23		**48**	0.33	**3.25**			
Unidentified fish jaws																											2	**2**	0.04	**0.14**			
COMBINED TOTAL	**14**	**2**	**19**	**126**	**132**	**40**	**59**	**527**	**0**	**5**	**3**	**141**	**10**	**0**	**2**	**24**	**67**	**4**	**0**	**3**	**50**	**11**	**26**	**158**	**44**	**98**	**12**	**1577**					

* Entire stomach contents examined; FO, frequency of occurrence; IRI, index of relative importance

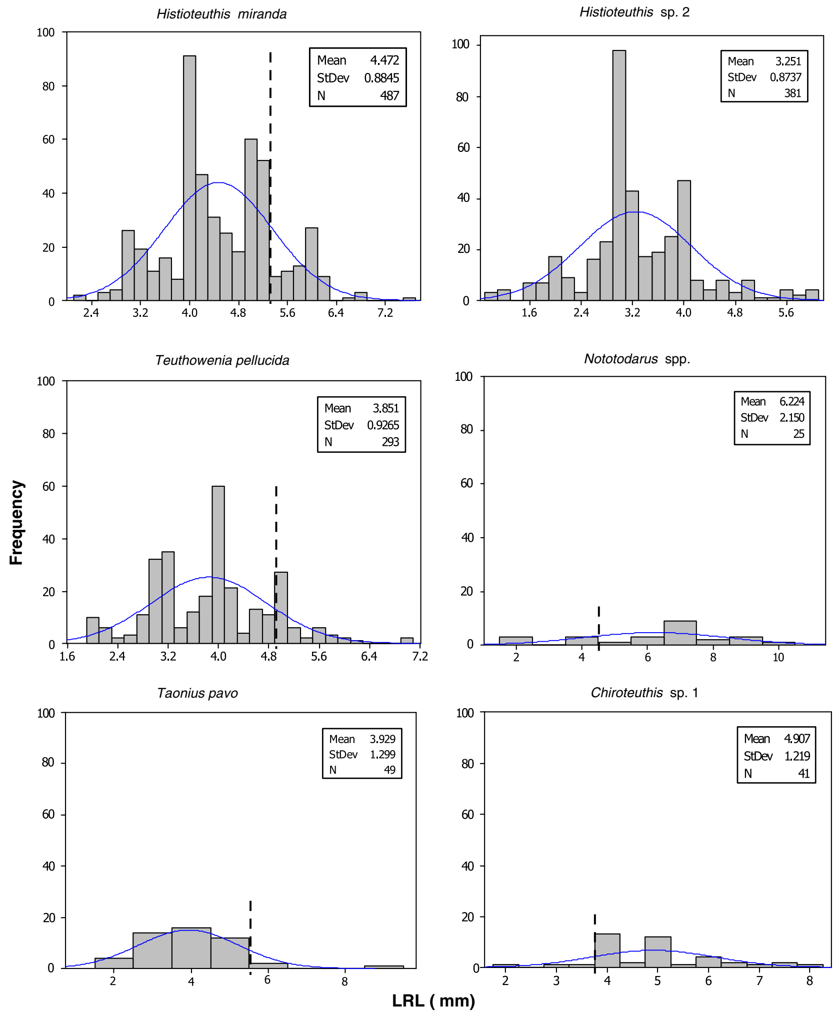

Fig. 2 Lower rostral length (LRL) distribution for major cephalopod components of *Kogia breviceps* diet; *Histioteuthis miranda*, *Histioteuthis* sp. 2, *Teuthowenia pellucida*, *Nototodarus* spp., *Taonius pavo*, and *Chiroteuthis* sp. 1. Dotted line indicates approximate LRL wings darken, where known, from Clarke (1986)

occur deeper than juveniles, with individuals of body length greater than 80 mm rarely recorded above 500 m (Paquegnat 1965).

The bathymetric distribution of ontogenetic stages of the most critical species in the diet of *K. breviceps* determined from examination of comprehensive museum collections from the New Zealand EEZ, identifies the depth to which this species feeds as a juvenile to at least 500 m and as an adult from 650–1100 m. The incidence of numerous juvenile histioteuthids and a diverse array of juveniles of taxa other than species of histioteuthid, cranchiid, or chiroteuthid squid of a size consistent with those individuals frequently encountered in fine meshed trawls to depths ranging from 0–100 m, might indicate that this whale species also browses at considerably shallower depths. As the majority of species recorded from the diet are vertical migrators, *K. breviceps* may feed primarily at night when these are closest to the surface. Alternatively they may adjust their dive to follow the diel movements of prey.

With the exception of lycoteuthid squid, the composition of cephalopods in the diet of pygmy sperm whales in New Zealand is very similar to that recorded for this whale in other parts of the world. For example, dietary studies on *K. breviceps* from South Africa (Ross 1979, 1984; Klages et al. 1989; Sekiguchi et al. 1992; Plön et al. 1999), North America (Eliason and Houck 1986; Candela 1987), the Azores (Martins et al. 1985), Brazil (Secchi 1994; dos Santos and Haimovici

2001, 2002), New Caledonia (Garrigue et al. 2000) and Taiwan (Wang et al. 2002) all report pygmy sperm whales to feed on mesopelgic squid, (particularly species of the families Histioteuthidae, Cranchiidae, Enoploteuthidae, Octopoteuthidae, Chiroteuthidae and Onychoteuthidae) and crustaceans (predominantly *Gnathophausia ingens*). Lycoteuthid squid also have been identified as important prey for pygmy sperm whales in South Africa and Brazil (Ross 1979, 1984; Klages et al. 1989; Sekiguchi et al. 1992; Plön et al. 1999; Secchi 1994, dos Santos and Haimovici 2001, 2002), although are absent from the diet of these whales in New Zealand, likely reflecting the tropical/subtropical distribution of these squid in New Zealand waters (Imber 1975).

The pygmy sperm whale does not appear to venture as far off-shore or as far south as the sperm whale (Gomez-Villota 2006), as all beaks identified from stomach contents can be attributed to locally occuring squid and octopus species. Moreover, a predominance of mesopelagic squid in the diet of *K. breviceps*, as opposed to the importance of benthopelagic species recorded in the diet of *P. macrocephalus*, in New Zealand waters (Gomez-Villota 2006), indicates that *K. breviceps* may be feeding much higher in the water column than *P. macrocephalus*. This would be consistent with the ability of larger whales to dive deeper for longer periods of time, with the body size of diving cetaceans being positively correlated with maximum depth and dive time (Clarke 1980). An explanation for the overlap of squid such as *Histioteuthis miranda, H. macrohista, Taningia danae, Taonius* sp., *Galiteuthis* sp., *Ancistrocheirus* sp., and *Chiroteuthis* sp. 1 and 2, found in the diets of both the pygmy sperm and sperm whales in New Zealand waters may be a product of the pronounced ontogenetic shifts in bathymetric distribution of squid prey. Juveniles of these species occur near the sea surface, where it appears they are preyed on by *K. breviceps*, while the adults live much deeper, although within the reach of the deeper diving *P. macrocephalus* (Lu and Clarke 1975; Voss 1985; Hunt and Seibel 2000).

The limitations of dietary studies based on stomach content analysis of stranded cetaceans must be considered. Our results could be biased towards near-shore prey (Clarke 1962), prey that is not usually an important component of the diet, or prey items that take a considerable amount of time to digest or purge from the alimentary system. Nevertheless, in a direct comparison of stomach contents of cetaceans collected at sea with those from strandings, Ross (1979) concluded that stranded whale stomach content analysis did provide representative dietary information. Accordingly, monitoring of stomach content composition in stranded cetaceans is a potentially valuable tool to assess environmental health from a whale's perspective.

Worthy of note is that the stomach of one immature male (whale #3) contained beaks of the benthic octopus, attributed to *Octopus kaharoa*, a species usually found at depths of 200–400 m off the Hawkes Bay coastline. This species is recognised in the New Zealand Department of Conservation Threat Classification System lists as being in serious decline (Hitchmough [comp.] 2002). Benthic invertebrates in the adjacent Bay of Plenty at comparable depth horizons are intensively trawled for scampi, and have been considerably impacted by bottom trawling (Cryer et al. 2002). An intensive fishery for scampi also occurs off Hawkes Bay. Should the Hawkes Bay region prove to be a nursery ground for *Kogia*, with the young calves feeding between 200 and 400 m depth, and in close proximity to the sea bed, there is potential for this fishery to impact the feeding grounds of this whale.

Some 127 cephalopod taxa are now recognised from New Zealand waters (O'Shea unpublished). Despite this diversity there is a dearth of biological information on any species, although some, described as recently as 1999, already appear to be threatened as a consequence of fishing activity (based on declining abundance in fisheries by-catch) (Hitchmough [comp.] 2002). Given the importance of cephalopods in the diet of teuthophagus cetaceans (and pinnipeds), and the damage that fisheries trawls are known to cause to the gelatinous egg masses of many pelagic cephalopod prey species (O'Shea et al. 2004), the threat that trawling poses to top predators such as marine mammals is very real.

With the apparent decrease in both abundance and diversity of large-bodied cephalopod species in our waters (Hitchmough [comp.] 2002), and the localised depletion of many deep-sea fisheries resources, it is likely that the diet of toothed whales, particularly sperm and pygmy sperm whales, has changed already, and worse still, has been forced to change as a direct consequence of deep-sea trawling. Any such change is likely to be manifested in the diet of cephalopod-eating whales. Continued monitoring of squid diversity and size-class structure in toothed whale diet is therefore a potentially valuable tool to assess environmental health from a whale's perspective. If unregulated, the long-term repercussions of trawling to teuthophagus cetaceans and pinnipeds could be devastating.

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