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CEPHALOPODS REPRESENTED BY BEAKS IN THE STOMACH OF A SPERM WHALE STRANDED AT PAEKAKARIKI, NORTH ISLAND, NEW ZEALAND

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More than 3 000 cephalopod beaks taken from the stomach of a sperm whale stranded at Paekakariki, North Island, New Zealand, were identified to species and measured; estimates were made of the masses and standard lengths of the cephalopods represented. In all, 24 species of cephalopod in 13 families were represented. The most important species were *Histioteuthis atlantica* (contributing 78.56% of the number and 41.0% of the wet mass estimated from lower rostral lengths), *Moroteuthis ingens* (11.06% and 15.26%), *Taonius pavo* (3.69% and 2.32%), *Taningia danae* (1.50% and 8.56%), *Moroteuthis robsoni* (1.25% and 5.35%), *Architeuthis* sp. (0.12% and 23.74%) and *Kondakovia longimana* (0.31% and 1.28%). Other species each contributed less than 1%. A total of 10 lower beaks was from three Antarctic species and show that the whale had been in the Antarctic but probably had been in the New Zealand region for several days, at least, before stranding. The mean wet mass of individuals represented was 432 g, and they varied from 170 to 2 631 mm in standard length.

Commercially caught sperm whales *Physeter catodon* have been a source of information about the cephalopods in their diet in many parts of the world (Clarke 1980, 1986a, 1996), including New Zealand (Gaskin and Cawthorn 1967a, b) and the Tasman Sea (Clarke and MacLeod 1982). However, where there are no collections from commercial whaling, information must be gleaned from stranded whales. When cephalopod remains are present, the chitinous mandibles or "beaks" are usually in a condition where identification to the family, genus and often species is possible and, from the lower rostral lengths of the beaks, estimates can be made of the relative contribution to the diet by mass and by length of the various taxa (Clarke 1986b). This is not only of interest for dietary analysis but, because many of the cephalopods eaten by oceanic cetaceans are rarely caught in nets, it is also informative with respect to distribution (when small pieces of flesh are attached) and relative abundance of the various cephalopod taxa in the sea.

Gaskin and Cawthorn (1967a) examined a large collection of stomach contents collected from sperm whales caught commercially off Cook Strait, New Zealand. These included identifiable fish and cephalopod remains as well as beaks of cephalopods (Gaskin and Cawthorn 1967b). Although many lower beaks could be grouped into types, identification of few of these was possible at that time; now, many of the groups can be positively identified from the drawings given. Otherwise, samples collected by a Japanese whaler which traversed the Tasman Sea (Clarke and MacLeod 1982) constitute the only similar material examined from sperm whales off New Zealand. A sample of more than 3 000 beaks from a sperm whale which had stranded a year or two ago on a beach at Paekakariki, North Island (40°59´S, 174°57´E), was made available to the authors by Dr A. Van Holden of the New Zealand National Museum in Wellington. This sample, therefore, represents a useful addition to what is known of the cephalopod fauna of New Zealand and the diet of sperm whales in the region.

MATERIAL AND METHODS

The sample consisted of more than 3 000 beaks of cephalopods: 1 600 lower and about the same number of upper beaks. No flesh was present. The lower beaks were identified and their rostral lengths measured with vernier callipers by methods previously described (Clarke 1986a, b). Wet masses and dorsal mantle lengths were then calculated from the lower rostral lengths (Clarke 1986b). Mantle lengths were used to calculate standard lengths (the length from the tip of the mantle to the tip of the arms) of the cephalopods eaten, by applying ratios determined from measurement of published drawings (Nesis 1987). Minimum and maximum standard lengths are given, rather than the usually quoted mantle lengths, because they are closer to the target size presented to the sperm whale during predation.

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RESULTS

In all, 24 species of cephalopod were represented by lower beaks (Table I). A total of 13 families that constituted 21 species and 99.31% of the beaks were probably eaten in temperate waters near New Zealand ("local species" Table I). Three species, *Kondakovia longimana* Filippova, 1972, *Moroteuthis knipovitchi* Filippova, 1972 and *Mesonychoteuthis hamiltoni* Robson, 1925 ("other species" in Table I), constituting 0.69% of the beaks, were eaten south of the Subtropical Convergence and probably south of the Antarctic Convergence (Clarke 1980, Clarke and MacLeod 1982).

The species that contributed most of the lower beaks were *Histioteuthis atlantica* (Hoyle, 1885) (78.56%), *Moroteuthis ingens* (Smith, 1881) (11.06%), *Taonius pavo* (Lesueur, 1821) (3.69%), *Taningia danae* Joubin, 1931 (1.50%) and *Moroteuthis robsoni* Adam, 1962 (1.25%). Each of the other species contributed fewer than 1%. Estimates from lower rostral lengths indicate that, by wet mass, *Histioteuthis atlantica* contributed 41.0%, *Architeuthis* sp., of which there were only two lower beaks, 23.74%, *Moroteuthis ingens* 15.26%, *Taningia danae* 8.56%, *Moroteuthis robsoni* 5.35%, *Taonius pavo* 2.32% and *Kondakovia longimana* 1.28%. The mean wet mass of the cephalopods represented by beaks was about 432 g, but if calculated separately, the local cephalopod species averaged 425 g and those of Antarctic origin 1 461 g.

Estimates, from the lower rostral lengths, of the minimum and maximum standard lengths of the prey species reveals that the sample included cephalopods with standard lengths of 169–2 631 mm. Only *Architeuthis* sp. and *Mesonychoteuthis hamiltoni* individuals exceeded standard lengths of 2 m, whereas *Moroteuthis robsoni*, *Taningia danae*, *Lepidoteuthis grimaldii* Joubin, 1895 exceeded and *Kondakovia longimana* and *Phasmatopsis cymoctypus* de Rochebrune, 1884 approached 1 m standard length. (For information on the issue of *Phasmatopsis cymoctypus* v. *Megalocranchia*, see Roeleveld 1998.)

DISCUSSION

The daily mass of squid consumed by a whale of 40 tons (about the smallest ever having the Antarctic species *Mesonychoteuthis* in its stomach) at a rate of 2% of its body mass per day (2–3.5% was proposed by Clarke 1977) would be 800 kg. As the 1 600 lower beaks collected are estimated to represent squid weighing 676 kg, they represent less than one day's food ration. Although it is uncertain whether the collection examined consisted of all the beaks in the stomach, it probably represented at least one-fifth of the total (an average of 1 300 and a maximum of 7 855 lower beaks were found by Clarke [1980] in a large collection of samples previously). Therefore, the presence of three Antarctic squid species indicates that the whale had travelled north, from south of the Subtropical Convergence (south of Cook Strait), probably within a few days prior to the stranding.

By far the commonest cephalopod was the squid *Histioteuthis atlantica* (78.56%), which also contributed 41% of the diet by mass. This again shows the dominance of the relatively small histioteuthids in the diet of sperm whales in temperate waters, a fact recorded elsewhere (Clarke 1996). The large *Architeuthis* sp. contributed only two lower beaks, but their lower rostral lengths indicate that the species probably is an important part of the diet when it occurs. *Taningia danae* is also sufficiently large to be important in the diet by mass. *Moroteuthis ingens* is numerous in the diet and contributed more than 15% by mass.

Five species represented here, *Taningia danae*, *Lepidoteuthis grimaldii*, *Ancistrocheirus lesueuri* (d'Orbigny, 1839), *Phasmatopsis cymoctypus* de Rochebrune, 1884 and *Taonius pavo* are found in sperm whale stomachs almost everywhere data are available except in polar regions (Clarke 1996).

Estimates of standard length vary from 170 to 2 631 mm. Some of the smallest of these may have been from the stomachs of the larger cephalopods eaten by the whale (Clarke *et al.* 1988). However, previous collections of complete cephalopods show that sperm whales eat many small cephalopods directly and that these include individuals with standard lengths from 200 mm upwards (Gaskin and Cawthorn 1967a, Clarke 1980). In the case of *Histioteuthis atlantica*, which in this sample had standard lengths of 211–426 mm and contributed 78.56% of the lower beaks, it would seem very unlikely that many of them were derived from the stomachs of other larger prey species, particularly as experience in examining the stomachs of squids, as well as those from sperm whale stomachs, rarely yields more than two or three beaks (Clarke 1980, Rodhouse and Nigmatullin 1996). These small prey species are probably taken from shoals, whereas the prey of standard length >1 m may be chased individually.

There have been few systematic works on the New Zealand cephalopod fauna. Since Dell (1952) summarized previous literature and listed the species of the region, the members of the Enoploteuthidae have been described by Riddell (1985), and several works on single genera have been published (e.g. Voss 1969 on *Histioteuthis*; Smith *et al.* 1987 on *Nototodarus*). Com-

Table I: Numbers and estimated sizes of cephalopods represented in the stomach of a sperm whale stranded in New Zealand

Taxon	Number	%	Wet mass (g)			Standard length (mm)	
			Total	%	Mean	Minimum	Maximum
Local species							
Architeuthidae							
Architeuthis sp.	2	0.12	163 905	23.74	81 953	2 477.8	2 631.2
Ommastrephidae							
Todarodes sp.	1	0.06	1 479	0.21	1 479	699.5	699.5
Onychoteuthidae							
Moroteuthis robsoni	20	1.25	36 939	5.35	1 847	705.5	1 060.8
M. ingens	177	11.06	105 335	15.26	595	430.2	772.2
Ancistrocheiridae							
Ancistrocheirus lesueuri	1	0.06	1 351	0.20	1 351	539.0	539.0
Octopoteuthidae							
Taningia danae	24	1.50	59 116	8.56	2 463	252.8	1 155.2
Lepidoteuthidae							
Lepidoteuthis grimaldii	2	0.12	1 266	0.18	633	702.0	1 148.0
Histioteuthidae							
Histioteuthis meleagroteuthis	1	0.06	62	0.01	62	169.6	169.6
H. ?heteropsis	2	0.12	958	0.14	479	454.4	489.6
H. atlantica	1 257	78.56	283 203	41.01	225	211.2	425.6
Mastigoteuthidae							
Mastigoteuthis sp.	7	0.44	1 763	0.26	252	363.3	453.6
Chiroteuthidae							
Chiroteuthis (2 species)	5	0.31	731	0.11	146	584.6	721.5
Joubiniteuthidae							
Joubiniteuthis portieri	1	0.06	23	0.00	23	194.0	194.0
Cranchiidae							
Galiteuthis armata	5	0.31	510	0.07	102	280.8	318.5
Teuthowenia megalops	8	0.50	455	0.07	228	397.8	423.8
T. pellucida	10	0.62	923	0.13	92	249.6	318.5
Taonius pavo	59	3.69	16 009	2.32	271	503.1	861.9
Phasmatopsis cymoctypus	5	0.31	1 475	0.21	295	473.2	950.6
Octopodidae	1	0.06	175	0.03	175	269.5	269.5
Vitreledonellidae							
?*Vitreledonella* sp.	1	0.06	200	0.03	200	450.0	450.0
Total local species	1 589	99.31	675 878	97.88	425.35		
Other species							
Onychoteuthidae							
Kondakovia longimana	5	0.31	8 840	1.28	1 768	788.5	922.2
Moroteuthis knipovitchi	1	0.06	365	0.05	365	471.5	471.5
Cranchiidae							
Mesonychoteuthis	4	0.25	5 407	0.78	1 352	555.2	2 416.0
Unidentified tip	1	0.06					
Total all species	1 600	100	690 490	100.00	431.56		

parison of these with the list of non-Antarctic species given here shows that species not listed for the New Zealand area but found in this sample of beaks are *Todarodes* sp., *Moroteuthis robsoni*, *Taningia danae*, *Lepidoteuthis grimaldii*, *Mastigoteuthis* sp., *Chiroteuthis* sp., *Joubiniteuthis portieri* (Joubin, 1912), *Galiteuthis armata* Joubin, 1895 and *Taonius pavo*. *Histioteuthis cookiana* Dell, 1951 was made a synonym of *H. atlantica* by Voss (1969). Voss noted records around New Zealand south of 35°S. She also noted one *H. meleagroteuthis* Chun, 1910 off North Island, although *H. heteropsis* (Berry, 1913) was more common.

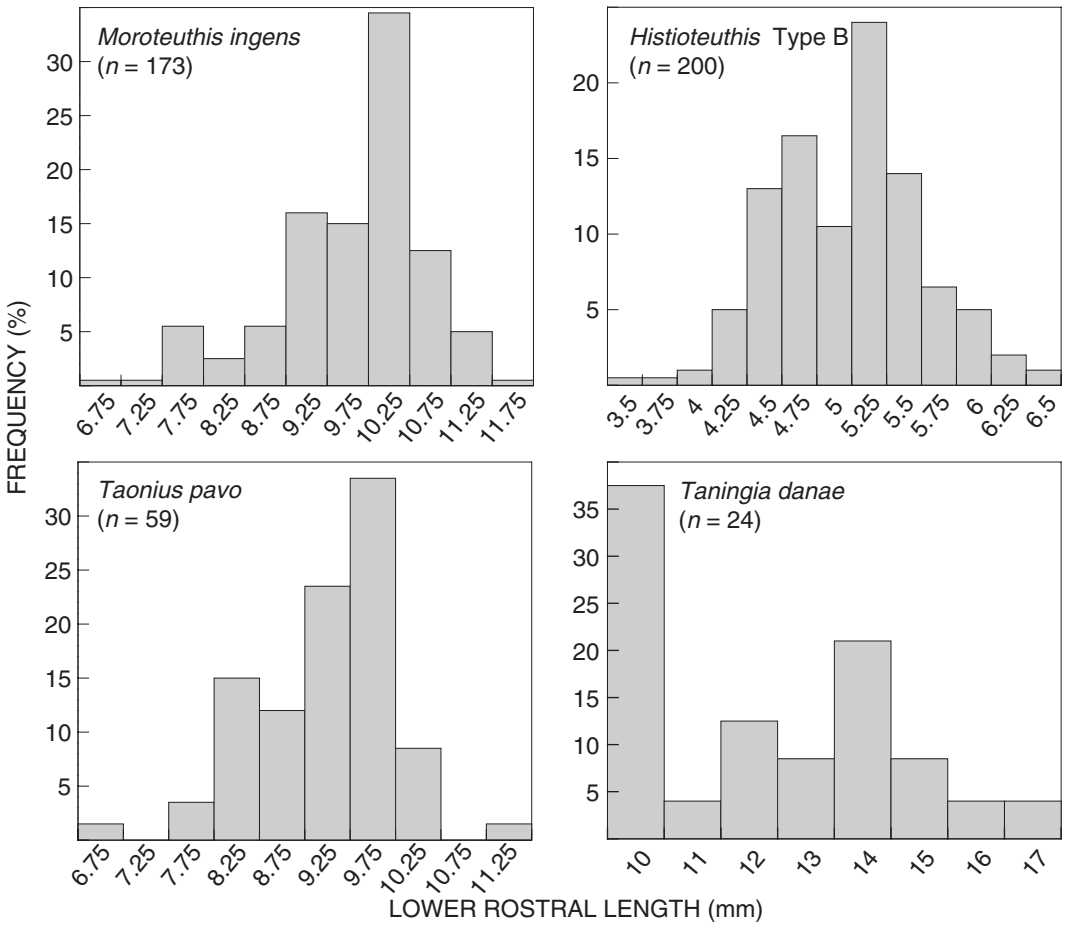

Fig. 1: Distributions of the lower rostral lengths of the four commonest species in the sample of lower beaks from a sperm whale stranded at Paekakariki, New Zealand

The *Teuthowenia antarctica* Chun, 1910 and the *Megalocranchia pardus* Berry, 1916 listed by Dell are probably *Teuthowenia pellucida* (Voss 1985). *Phasmatopsis cymoctypus* beaks are similar to those found in sperm whale stomachs off South Africa (Clarke 1980). Gaskin and Cawthorn's (1967a) conclusions from the flesh they collected and subsequent work (Clarke and MacLeod 1976, Kawakami 1980, Clarke 1986a, Martin and Clarke 1986) show that fish were more common in the diet of sperm whales caught off Cook Strait than anywhere other than in the northern part of the North Pacific and off Iceland. The dominant squid represented in Gaskin and Cawthorn's (1967a) samples of flesh remains were *Moroteuthis*, whereas *Histioteuthis cookiana*, *Architeuthis* sp. and *Nototodarus sloanei* [sic] (possibly *N. gouldi*) were much scarcer. This difference from the present findings is probably because *Histioteuthis* flesh is digested more rapidly than the flesh of the firmer and larger *Moroteuthis*. Gaskin and Cawthorn found few ommastrephids, similar to the present sample. This is probably because sperm whales do not feed in shallow water where the commonest ommastrephid is *Nototodarus*; no other shallow-water species were in the current sample. The ommastrephid species in the present collection is probably *Todarodes* sp., on the grounds of its size and comparative rostral width.

In 1967, identification of squid beaks was in its infancy, so Gaskin and Cawthorn's (1967b) information from 2 118 lower beaks from two sperm whales was more limited than it would be today. They also failed to report the numbers of each species in their samples. From their descriptions, probable identifications are: Type Ai – *Histioteuthis* sp.; Types Aii, Aiii –

Moroteuthis ingens; Type Bi – *Pholidoteuthis boschmai* Adam, 1950 (although this species was not in the present sample it is frequently found in sperm whales, including one sampled at Hawaii – Clarke and Young 1998); Type Bii – as the authors stated, *Nototodarus sloanii* (although it could be *N. gouldi* and they were wrong in describing a "step"); Type Biii – not identifiable; Type C – *Histioteuthis atlantica* (= *H. cookiana*); Type D – *Lepidoteuthis grimaldii* (or possibly some of the 74 counted may be *Octopoteuthis* sp.); Type E – *Architeuthis* sp.; Type G – probably an octopodinid.

Imber (1973, 1976) and Imber and Russ (1975) recorded the beaks of many of the species and genera listed here in bird stomachs collected in New Zealand. They include all except *Todarodes* sp., *Joubiniteuthis portieri* and *Teuthowenia pellucida* (Chun, 1910). *Teuthowenia megalops* (Prosch, 1847) beaks are recorded here, because examples of those described as such by Clarke (1980) were found in addition to beaks of *T. pellucida*. It is the authors' opinion that these examples indicate another species in the area which is very similar to *T. megalops*.

Comparison of the lower rostral length distributions of the four species of which more than 24 lower beaks were collected (Fig. 1) with the distributions of the same species from sperm whales caught in the Tasman Sea (Clarke and MacLeod 1982) shows that the peaks are much the same for *Histioteuthis atlantica* and *Moroteuthis ingens* (= *Moroteuthis* A. Clarke 1980), but for *Taonius pavo* and *Taningia danae*, although distributions overlap, the peaks are not at the same lower rostral length. This may be a reflection of the smaller sample of those species in the present collection.

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