CEPHALOPOD REMAINS IN THE STOMACHS OF EIGHT WEDDELL SEALS

By MALCOLM R. CLARKE* *and* NEIL MACLEOD*

ABSTRACT. Stomach contents of eight Weddell seals killed on Deception Island, South Shetland Islands, included unidentified fish, *Euphausia superba*, isopods, amphipods, pieces of blubber, bones, bits of algae, stones, parasitic worms and remains of cephalopods. The cephalopod remains included 349 lower beaks (mandibles), 383 upper beaks, eight 'crowns' of arms and nine buccal masses. The lower beaks, crowns and buccal masses were sorted into groups and identified as far as possible. Eight types of cephalopod of six families were identified. Three species each contributed almost a third of the total number of cephalopods in the diet; the squids *Moroteuthis knipovitchi* and *?Psychroteuthis glacialis* contributed 31.3 and 28.7%, respectively, and an octopod, probably *Pareledone*, contributed 33.6%. Estimates from beak size show that *Moroteuthis knipovitchi* contributed 48.5% and *?Pareledone* 21.9% of the weight of flesh represented by beaks in the samples. While squids predominated in March and April, octopods dominated the cephalopod fraction in July. Octopods were also collected from the stomachs of two Weddell seals caught at Halley Bay.

While Weddell seals (*Leptonychotes weddelli* Lesson, 1826) are known to eat a variety of animals (Bertram, 1940; King, 1964) no detailed study of the cephalopod part of their diet has been published. Cephalopod chitinous beaks (mandibles) are resistant to digestive juices. Recent studies on lower beaks of Antarctic cephalopods have made sorting possible and in some cases the beaks can be identified (Clarke, 1980).

The present work is part of a series of studies on cephalopods in the diet of predators throughout the world's oceans (reviewed in Clarke, 1980) including similar studies on other seals (Clarke and MacLeod, 1982: Clarke and Trillmich, 1980). This small collection from Weddell seals provides an interesting comparison with cephalopods from Antarctic sperm whales (Clarke, 1980) and albatrosses from South Georgia (Clarke and others, 1981; Clarke and Prince, 1981). The collection is also of particular interest since these seals obtained their food by diving beneath the ice where man cannot sample the larger fauna directly at present.

MATERIALS AND METHODS

All the stomach contents of eight Weddell seals killed in 1962 on Deception Island, South Shetland Islands (lat. 62° 57′ S, long. 60° 38′ W); were collected, preserved in formalin and returned to England for sorting. An octopod was preserved from the stomach of each of two more Weddell seals killed at Halley Bay (lat. 75° 31′ S, long. 26° 37′ W) on the eastern side of the Weddell Sea. After separating the various types of food etc. in the samples, the cephalopod upper beaks were counted and the lower beaks were sorted into groups and identified as far as possible (Clarke, 1980). Lower rostral lengths (LRL) of the squids and the crest lengths of the octopods were measured with vernier callipers to an accuracy of 0.005 cm. The weights of the squid represented by beaks were then estimated from the beak measurements by using published data relating the two (Clarke, 1980).

*Marine Biological Association of the United Kingdom, Citadel Hill, Plymouth.

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Seal Behaviour

Whalers Bay, where the present collection was made, is just inside the narrow entrance to the flooded crater of the active volcano that forms Deception Island. The Weddell seal does not migrate but remains close to land all the year round. It spends most of the winter months (when half of the samples were collected) in the water feeding under the ice. It goes to depths regularly exceeding 200 m and reaching 400 m (Kooyman, 1969, 1981), and keeps breathing holes in the ice open throughout the winter (Bertram, 1940; King, 1964).

Results

Table I summarizes the food and other objects collected from the eight stomachs. Seven of the eight stomachs contained fish remains, four of them large quantities. Six stomachs contained crustacea and of these, five had the krill *Euphausia superba*, one had isopods and two each had an amphipod. All the stomachs contained stones, the largest of which measured 1.9 × 1.4 × 1.3 cm. All the stomachs contained nematode parasitic worms, five containing many, one moderate numbers and two having only few. One contained pieces of one or possibly two tapeworms.

The cephalopod remains in the eight complete stomach samples comprised 366 lower beaks, 400 upper beaks, eight 'crowns' of arms and nine buccal masses (beaks of 'crowns' and buccal masses are included under beaks).

Table II shows the number of lower beaks of the seven cephalopod genera from the six stomach samples that contained lower beaks. The maximum number of lower beaks in one sample is 180 and the maximum number of species is seven.

All the beaks are barely affected by digestion and have a fresh appearance as if recently ingested. The 'fine gravel composed entirely of fragmented beaks' mentioned by Bertram (1940) was not present in these samples.

Table I. Contents of the stomachs of Weddell seals on Deception Island in 1962.

Sample No. *Date collected* *Sex*	*1* *4 Feb* *Male*	*2* *11 Feb* *Male*	*3* *22 Mar* *Female*	*4* *25 Mar* *Female*	*5* *12 Apr* *Male*	*6* *17 Jun* *Female*	*7* *28 Jul* *Male*	*8* *31 Jul* *Female*
Cephalopod								
crowns	—	—	—	—	—	3	4	1
buccal masses	—	—	6	—	1	—	2	—
beaks upper	1	—	190	37	21	—	81	53
beaks lower	—	—	174	45	22	—	54	54
Fish*	+++	+++	+++	—	+++	+++	++	+++
Euphausia superba	30	4	4	—	—	3	17	—
Isopods	—	—	—	—	—	18	—	—
Amphipods	—	—	—	—	—	—	1	1
Nematodes	+++	+	++	+	++++	+++	+++	+++
Cestodes	—	—	—	—	?2	—	—	—
Stones	+++	+++	+++	+++	+++	+++	+	+
Sand	+	—	—	—	—	—	+++	—
Kelp	—	—	—	—	—	+	+	+
Blubber	+	—	—	—	?+	—	—	—
Wood	+	—	—	—	—	—	—	—

* All material was of teleosts except sample 2 which was elasmobranchs.

Table II. The numbers of cephalopod lower beaks in the individual Weddell seal stomachs on Deception Island, 1962.

Family	Species	Sample No. 3	4	5	6	7	8
Onychoteuthidae	*Moroteuthis knipovitchi*	91	13	10	—	—	—
	Kondakovia longimana	—	2	—	—	—	—
Psychroteuthidae	*?Psychroteuthis glacialis*	83	19	1	1	1	—
Neoteuthidae	*Alluroteuthis* sp.	1	7	—	—	—	—
Brachioteuthidae	*Brachioteuthis* sp.	5	—	—	—	—	—
Gonatidae	*Gonatus antarcticus*	—	2	1	—	—	—
Octopodidae	*Eledoninae* sp. A	—	—	11	2	56	54
	Eledoninae sp. B	—	1	—	—	2	1
Unidentified		—	1	—	—	1	—
Totals		180	45	23	3	60	55

FAMILY ONYCHOTEUTHIDAE

Moroteuthis knipovitchi Filippova, 1972

One hundred and fourteen (31.1%) of the lower beaks belong to this species. Their LRLs have a peak at 0.60–0.65 cm and a range of 0.54–0.68 cm. This peak corresponds with a peak at 0.62–0.64 cm for examples found in sperm whale stomachs. The species is of great numerical importance in sperm whales of the Antarctic near the South Orkney and South Shetland Islands (Clarke, 1980). An estimate from the LRLs suggests that the mean weight of the squids eaten by Weddell seals is 551 g and they contribute 48.5% of the weight of flesh represented by beaks. The presence of five buccal masses of this species clearly shows that it lives in the waters near Deception Island and is under the ice in winter.

Kondakovia longimana Filippova, 1972

Two small beaks having LRLs of about 0.81 cm and no wings belong to this large species. The squids from which these beaks came probably weighed about 220 g each. The small size and absence of wings show that they were immature.

FAMILY PSYCHROTEUTHIDAE

?Psychroteuthis glacialis Thiele, 1921

One hundred and five (28.7%) of the beaks having a LRL peak at 0.45–0.60 cm and a range of 0.27–0.71 cm (Fig. 1), are thought to belong to this species by comparison with beaks from sperm whale stomachs (Clarke, 1980). In whales the peak occurs at 0.72–0.76 cm and the range is 0.64–0.84 cm (Clarke, 1980). Only 21 beaks could be measured because the jaw angle is easily damaged and often missing. An estimate from LRLs and data given in Clarke (1962, fig. 24, relationship 'X') suggests that the beaks came from squid averaging 288 g and that they contributed about 23.3% to the weight of flesh represented by beaks. The presence of one buccal mass and one crown of this species shows that it lives in the waters around Deception Island and, since nearly all were collected in March (although single beaks were collected in each of the months of April, June and July), is under the ice in winter.

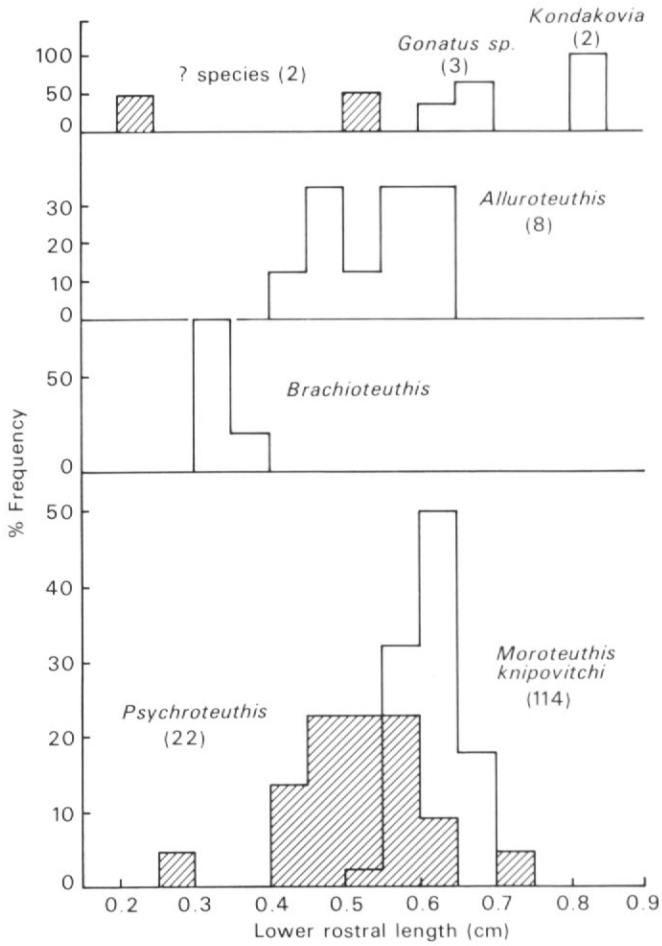

Fig. 1. Percentage frequency histograms of the lower rostral lengths of several species of squid from stomachs of Weddell seals from Deception Island.

FAMILY NEOTEUTHIDAE

Alluroteuthis sp.

Specimens of this type were formerly attributed to '*?Crystalloteuthis*' by Clarke (1980) but fresh material shows that these beaks belong to *Alluroteuthis*. Eight (2.2%) of the lower beaks belong to a species also found in sperm whales which has been identified as this genus. Their LRLs lie within the range 0.40–0.65 cm which is similar to the range covered by those from Antarctic sperm whales (Clarke, 1980). The species is small, averaging an estimated 72 g in weight, and contributed less than 1% to the weight of flesh represented by lower beaks in the seal stomachs. All were collected from two seals in March.

FAMILY BRACHIOTEUTHIDAE

Brachioteuthis sp.

Five (1.4%) of the lower beaks appear, from comparisons with a beak taken from a specimen caught by net, to be *Brachioteuthis picta*. Their LRLs of 0.33–0.35 cm

indicate that the beaks are from squids averaging 75 g and they contributed less than 1% to the weight of flesh represented by beaks. All the beaks have darkened wings and were all from one seal stomach.

FAMILY GONATIDAE

Gonatus antarcticus Lönnberg, 1898

Three (0.8%) of the lower beaks belong to this species. Their LRLs of 0.63, 0.65 and 0.67 cm are close to the peak of the species in Antarctic sperm whales, which is 0.64–0.66 cm, and are from squid estimated as weighing an average of 278 g; the species probably contributed less than 1% to the weight of flesh represented by beaks. The presence of one buccal mass shows that this species lives in the waters around Deception Island. Two beaks were from a seal killed in March and a buccal mass from a seal killed in April.

FAMILY OCTOPODIDAE

Eledoninae sp. A

One complete octopod, eight crowns, several buccal masses and 123 lower beaks belong to a species of this family. The almost intact octopod was collected from a seal at Halley Bay on 17 December 1962. Its arms measure on the right: I 12.5 cm, II 13.5 cm, III 14.0 cm, IV 13.0 cm, and on the left: I 13.5 cm, II 15.5 cm, III 16.0 cm and IV 14.5 cm. Webs between arms IV are about 3 cm deep, between arms III and IV 2.5 cm and are apparently absent between the other arms. The suckers are in a single row at the base and tip of the arm but contraction of the middle of the arm has drawn them into a double row. At the base of arm I the fourth sucker measures 0.7 cm.

A separate head and body, both presumed to belong to a second specimen, were collected from another seal killed at Halley Bay on 18 December 1962. This octopod has right arms measuring I 10.5 cm, II 10.5 cm, III 12.0 cm, IV 12.5 cm and left ones: I broken, II 11.5 cm, III 12.0 cm and IV 11.0 cm.

Both these octopods belong to a species of the sub-family Eledonellinae and have beaks similar to those under *Eledoninae* A in Tables II and III. It is not certain if all these beaks belong to a single species.

Table III. Cephalopod beaks from Weddell seals and estimates of the weight of flesh represented by beaks of each species.

				Estimated weights of flesh		
Family	*Species*	*No.*	*%*	*Mean (g)*	*Total (kg)*	*Total (%)*
Onychoteuthidae	*Moroteuthis knipovitchi*	114	31.0	551	62.8	48.5
	Kondakovia longimana	2	0.5	219	0.4	0.3
Psychroteuthidae	*Psychroteuthis glacialis*	105	28.7	288	30.2	23.3
Neoteuthidae	*Alluroteuthis* sp.	8	2.2	72	0.6	0.5
Brachioteuthidae	*Brachioteuthis picta*	5	1.4	75	0.4	0.3
Gonatidae	*Gonatus antarcticus*	3	0.8	278	0.8	0.6
Octopodidae	*Eledoninae* sp. A	123	33.6	230	28.3	21.9
	Eledoninae sp. B	4	1.1	1 390	5.6	4.3
Unidentified		2	0.6	136	0.3	0.2
Totals		366	100.0	354	129.4	99.9

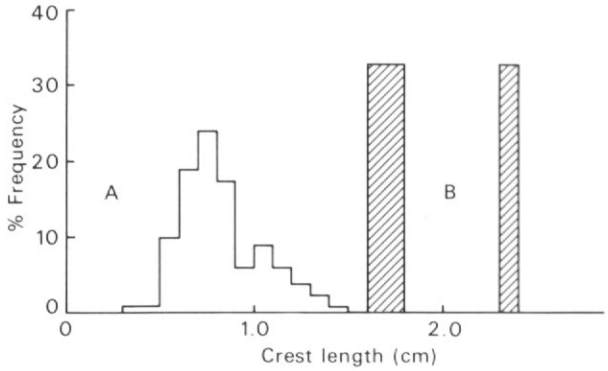

Fig. 2. Percentage frequency histograms of crest lengths of beaks of octopods from stomachs of Weddell seals from Deception Island. A = *Eledoninae* sp. A, B = *Eledoninae* sp. B.

This group contributes 33.6% of the lower beaks. The crest lengths have a peak at 0.75–0.80 cm and a large range of 0.38–1.55 cm (Fig. 2). there is a suggestion of a second peak at a crest length of 1.0–1.1 cm. It is estimated that the octopods from which the beaks came averaged about 230 g in weight and the species contributed 21.9% of the flesh represented by beaks in the stomachs. A beak with a crest length of 0.38 cm has wings which are not darkened. Three crowns, apparently of this group, were collected from a Weddell seal killed at McMurdo Sound in 1963 (Dearborn, 1965).

Eledoninae sp. B

Four (1.1%) of the beaks belong to a second species of octopod, also of the *Eledoninae* and possibly of the genus *Pareledone*. These were from larger animals than the other octopod species averaging about 1390 g and are estimated to have contributed 4.3% to the flesh represented by beaks. A buccal mass shows that this species lives in waters around Deception Island.

UNIDENTIFIED

Two squid lower beaks with LRLs of 0.50 and 0.21 cm could not be identified.

DISCUSSION

The flesh attached to beaks of *Moroteuthis knipovitchi, Gonatus antarcticus, ?Psychroteuthis glacialis* and both octopod species shows that these were all caught by the seals near Deception Island and were living under the ice.

From these very limited data it would appear that in March the cephalopod diet of the seals is almost entirely squid but by April it also includes octopods. By July the seals are catching very few squid, and their cephalopod diet consists almost entirely of octopods (Table II).

All the squids identified, except *Brachioteuthis*, are also eaten by sperm whales but the seals have no *Mesonychoteuthis hamiltoni* in their stomachs which are very important in the sperm whales' Antarctic diet (Clarke, 1977, 1980). Possibly, *M. hamiltoni* generally live too deep for the seals to catch them.

While all the squid species present in Weddell seals except *?Psychroteuthis* and *Brachioteuthis*, are also present in wandering albatrosses sampled at roughly the same time of year (Clarke and others, 1981; Imber and Russ, 1975, recorded one *?Psychroteuthis* beak) the octopod species are not present and the squid species are in very different proportions.

The commonest squids in the seals, *Moroteuthis knipovitchi*, contribute only 0.5% of the cephalopods in the wandering albatrosses' diet. Similarly, the commonest cephalopod in the wandering albatross, *Kondakovia*, contributes only 0.5% to cephalopods in the seals. The albatross samples have far more squid species. Possible factors contributing to the difference between the cephalopod diets of the seals and the albatrosses are the much greater foraging range of the albatross and the ice cover in winter which prevents the birds from feeding at such high latitudes as the seals.

Grey-headed and black-browed albatrosses also differ from Weddell seals in their cephalopod diet (Clarke and Prince, 1981). These birds do not eat *Moroteuthis knipovitchi*, *?Psychroteuthis glacialis* or *Brachioteuthis* and the two commonest cephalopods in their diet, *Todarodes sagittatus* and *Mesonychoteuthis* sp. A, are not among the Weddell seal stomach contents. It is probable that the range of *Todarodes* does not extend into the high latitude of the South Shetland Islands and this may also be true of *Mesonychoteuthis* sp. A. However, in addition to being at a latitude different from the seals, and having a different foraging range, these albatrosses were sampled in the summer.

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