

# A note on stomach contents of minke whales (*Balaenoptera acutorostrata*) in Icelandic waters

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## ABSTRACT

There is limited available information on food habits of minke whales (*Balaenoptera acutorostrata*) in coastal Iceland. Sixty-eight minke whales were examined for stomach contents; 51.5% contained fish only, 22.1% krill (Euphausiacea) only, 25.0% fish and krill together, and one animal (1.5%) had no food remains in the stomach. The fish species identified were capelin (*Mallotus villosus*), sandeel (*Ammodytidae*), cod (*Gadus morhua*) and herring (*Clupea harengus*). Two species of krill were identified; *Thysanoessa raschii* and *Meganyctiphanes norvegica*. Sandeel was the dominant prey species in the western and southwestern areas, while capelin and krill were more frequently found in animals sampled in North Iceland.

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## Introduction

The minke whale (*Balaenoptera acutorostrata*) is generally regarded as opportunistic in feeding habits. A large variety of food items have been found in the stomachs of minke whales caught in the North Atlantic (see review by Horwood 1990). While minke whales feed predominantly on krill in the Southern Hemisphere (Kawamura 1994), the species appears to be the most piscivorous of the Balaenopterids in the Northern Hemisphere. In Norwegian and adjacent waters, large temporal and spatial variations have been found in the diet of minke whales (Jonsgård 1951, 1982, Haug *et al.* 1995, 1996). In the North Western Atlantic capelin appears to be the most important prey species, although a variety of other species is also taken (Jonsgård 1982, Larsen and Kapel 1981, 1982, Neve this volume).

Minke whales near the coast of Iceland have been exploited since early this century (Sigurjónsson 1982) (Fig. 1). Although they are widely distributed in the coastal waters, particularly off the southwest, southeast and northeast coasts (see e.g. Gunnlaugsson *et al.* 1988, Sigurjónsson *et al.* 1989, Sigurjónsson *et al.* 1991, NAMMCO 1998), catches have been taken mainly in the sheltered northwest to northeast Icelandic waters (Sigurjónsson 1982). According to the most recent abundance estimate, around 56,000 minke whales inhabit the Icelandic continental shelf area during summer (NAMMCO 1998).

Systematic studies on the biology of minke whales off Iceland were initiated in the late 1970's. These studies were mainly focused on age and reproductive biology (Sigurjónsson

1980, MS 1988, Víkingsson and Sigurjónsson 1998). Although minke whales are by far the most important cetacean predator in Icelandic coastal waters (Sigurjónsson and Víkingsson 1997) information on their diet in the area is very limited.

## MATERIALS AND METHODS

This paper summarizes all available data on the diet of minke whales in Icelandic waters. Most of the material was collected in connection with the commercial minke whaling operations, while the remainder was derived from stranded or bycaught animals. As a part of a routine sampling program conducted by the Marine Research Institute (MRI), Reykjavík, minke whales were examined for stomach contents during the whaling seasons 1977 and 1978. The whales were usually landed at the nearest landing site to the catch position some 10 hours after being caught (Sigurjónsson 1982), or at the two fixed localities where special freezing and flensing facilities are located, i.e. one in West Iceland at Brjánslækur (see Fig. 2), and the other at Árskógssandur, North Iceland. In total, 56 whales were examined in the two seasons July 1977 and June-July 1978 (Table 1), 22 males and 34 females. In addition, one female from the 1984 season was sampled by a whaler. After the temporary stop in whaling operations, starting in 1986, minke whales have been sampled by MRI staff as a part of the Institute's efforts to monitor and sample stranded and bycaught cetaceans. Included in the present analysis are 11 minke whales (4 males, 6 females and one of unknown sex) that were bycaught in fishing gear or found dead on beaches during 1988-1997.

Usually only the forestomach and the fundic chamber were examined, but sometimes the oesophagus and the mouth were also sampled. Samples were most often taken for later examination, labelled, fixed and stored in 4% formaldehyde solution. The amount of food was assessed visually as one of six categories (empty, very little, little, much, very much, full) and the prey species preliminarily identified. In some cases, the first author could positively identify the species and no sample was taken, but in most cases the samples were taken to the laboratory for close examination under magnification. Bones and otoliths were used to identify fish



**Fig. 1.**  
*A minke whale is hauled aboard a catching vessel. The short baleen plates and ventral grooves are characteristic of rorquals.*

remains when intact animals were not available.

As the stomach analysis from the period 1977-1984 consisted only of species identification, an evaluation of relative importance of different food species based on reconstructed weight is not possible. Therefore the relative contributions of prey items are expressed in terms of:

- a) The frequency of occurrence *i.e.* the proportion of the 67 examined non-empty whale stomachs in which a particular prey species was found.
- b) A rough weighted frequency index (WF) giving equal weight to each prey species (group) in stomachs containing more than one prey species. Thus, for each prey item WF was calculated as:

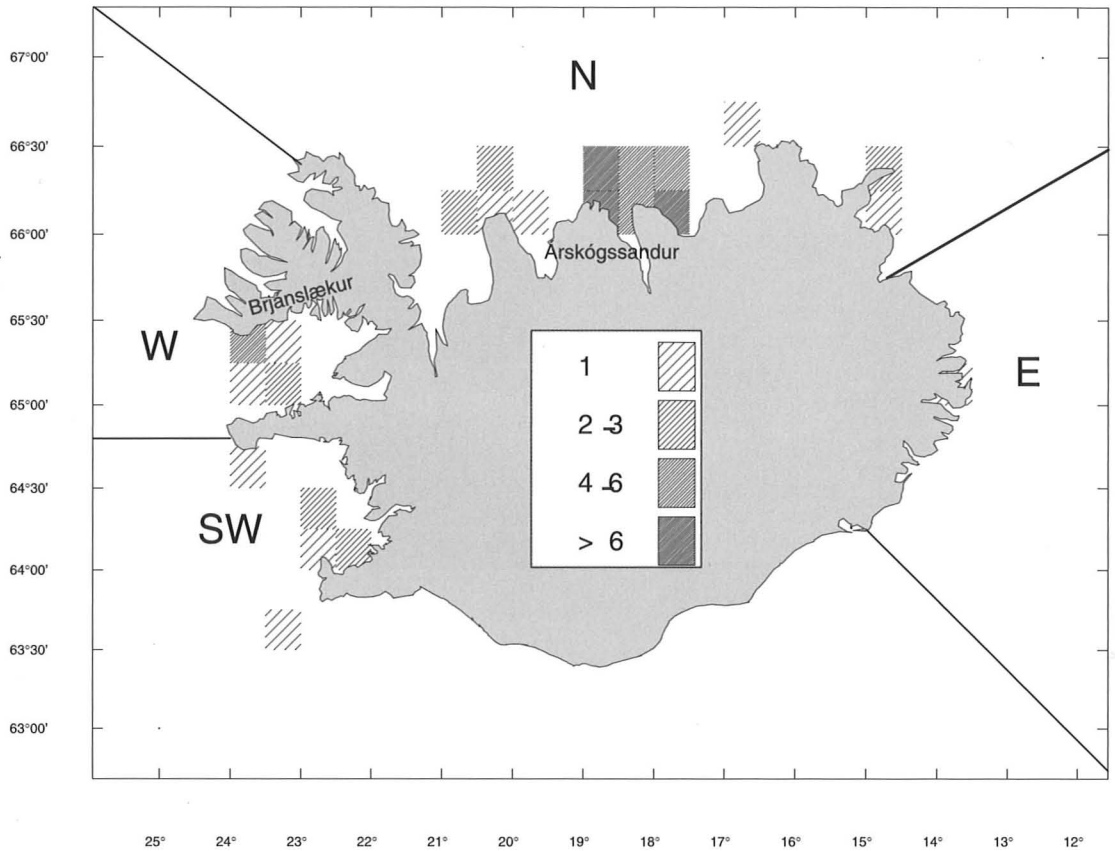
$$WF = \left( C_1 + \frac{1}{2}C_2 + \frac{1}{3}C_3 \right) \frac{100}{67}$$

where  $C_1$  is the number of stomachs containing only that particular prey,  $C_2$  is the number of stomachs containing the prey item together with one other prey type and  $C_3$  is the number of stomachs containing two other prey types. The total number of nonempty stomachs was 67.

## RESULTS AND DISCUSSION

In total 68 minke whales were examined for

**Fig. 2.**  
Catch positions and stranding sites of the minke whales examined in this study (number of animals sampled in different squares). The location of the two main freezing and flensing facilities for minke whales in Iceland is also shown.



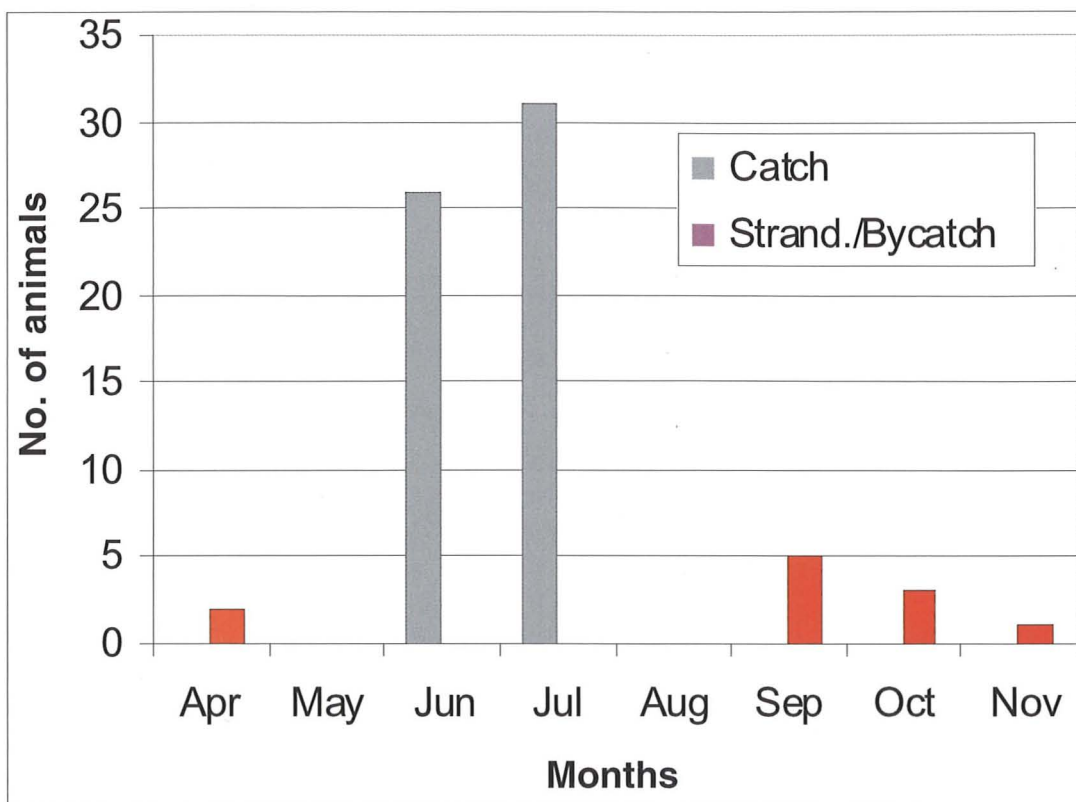
**Table 1.** Number of minke whale stomachs examined from the 1977, 1978 and 1984 catches off Iceland, and from beached and net entangled whales in 1988-1997.

Area	Caught whales			Beached whales	Net Entangled whales	Total
	1977	1978	1984	1990-95	1988-97	
N-Iceland	8	41	1	0	0	50
W-Iceland	0	7	0	0	2	9
SW-Iceland	0	0	0	2	5	7
E-Iceland	0	0	0	1	0	1
Unknown	0	0	0	0	1	1
All areas	8	48	1	3	8	68

stomach contents. While some animals were caught/found in most parts of Icelandic coastal waters, the majority of the present sample (73.5%) was derived from the area north of Iceland, mostly from the 1978 season (Fig. 3 and Table 1). The material sampled in connection with the whaling operation was obtained during summer (12 June - 26 July), while stranded animals were sampled in the period 12 September -

24 April (Fig. 3). There was also a geographic difference between the caught vs stranded minke whales. Fifty out of the 57 harvested animals were caught off northern Iceland while 9 out of 10 stranded/bycaught animals originated from the waters southwest and west of Iceland.

Table 2 presents stomach contents by the major prey groups. Minke whales with only one type of



**Fig. 3.** Seasonal distribution of the minke whale samples obtained from catches and strandings/bycatches.

**Table 2.** Number of minke whale stomachs examined, grouped by food categories (one type fish only, krill only, fish and krill together, different fish species together, and empty).

Area	Fish	Krill	Fish/Krill	Fish/Fish	Empty	Total
N-Iceland	17	14	15	3	1	50
W-Iceland	6	1	2	0	0	9
SW-Iceland	6	0	0	1	0	7
E-Iceland	1	0	0	0	0	1
Unknown	1	0	0	0	0	1
All areas	31	15	17	4	1	68

fish remains in the stomach comprised 45.6% of all stomachs examined, stomachs with krill remains only 22.1%, stomachs with mixed fish and krill remains 25.0%, stomachs with two species of fish 5.9%, and one animal had an empty stomach (1.5%). Off the north coast, the three first categories had much the same frequency, while 3 animals had two types of fish in the stomach, and one stomach was empty. Off the west and southwest coasts, fish only was found in 13 out of 16 stomachs, while fish and krill remains were found in one. Based on this

small sample, a significantly larger proportion of the diet consisted of crustaceans in the northern areas than in the western and southwestern areas, where fish was the dominant food ( $\chi^2 = 8.0012$ ;  $df = 2$ ;  $P = 0.02$ ). This geographical difference is, however difficult to interpret because of the difference in sampling period (Table 1), sampling season (Fig. 3) and sampling methods (catch vs. stranding).

The food composition is further detailed in Tables 3 and 4. Only 4 species of fish could be

**Table 3.** Food items in each of the categories of stomach contents in minke whale examined in Iceland.

Food category	No. Whales	Food Items
One type fish	18	Ammodytidae
	1	<i>Ammodytes marinus</i>
	10	<i>Mallotus villosus</i>
	1	Small unidentified fish
	1	Large unidentified bony fish
<b>Category total</b>	<b>31</b>	
Crustaceans only	6	Euphausiacea
	3	Digested Crustacea
	5	<i>Thysanoessa raschii</i>
	1	<i>Megantctiphanes norvegica</i>
<b>Category total</b>	<b>15</b>	
Fish and krill	1	<i>M. villosus</i> /Euphausiacea
	3	<i>M. villosus</i> / <i>T. raschii</i>
	1	<i>M. villosus</i> -Ammodytidae/ <i>T. raschii</i>
	4	<i>M. villosus</i> / <i>M. norvegica</i>
	1	Ammodytidae/ <i>T. raschii</i>
	1	Ammodytidae/digested Crustacea
	3	Small unidentified fish/Euphausiacea
	1	Gadiformes/Euphausiacea
	1	Large unidentified fish/Euphausiacea
	1	Large unidentified fish/ <i>T. raschii</i>
<b>Category total</b>	<b>17</b>	
Fish/Fish	2	<i>M. villosus</i> /Ammodytidae
	1	<i>Clupea harengus</i> /Ammodytidae
	1	<i>Gadus morhua</i> /Large unidentified fish
<b>Category total</b>	<b>4</b>	
Empty	1	
<b>Total</b>	<b>68</b>	

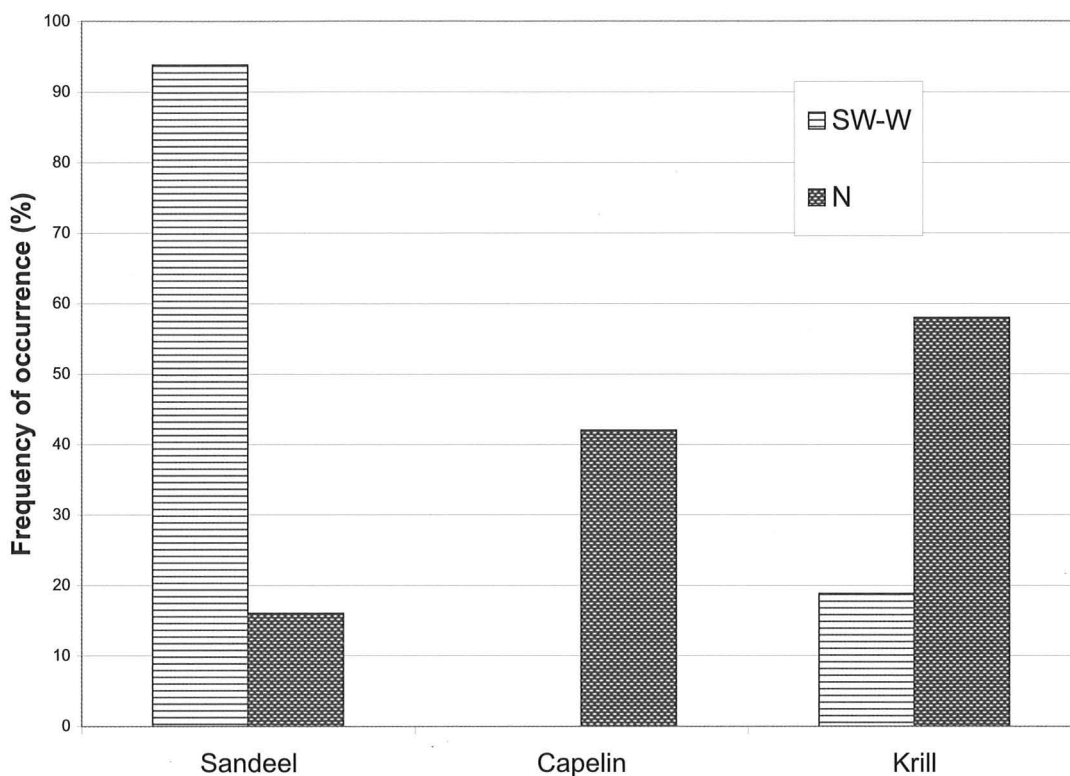
identified; capelin (*Mallotus villosus*), sandeel (*Ammodytes marinus*), cod (*Gadus morhua*) and herring (*Clupea harengus*), while other fish remains were classified at higher taxonomic levels ranging from sandeels (Ammodytidae) to large/small unidentified fish. Two species of crustaceans were identified in the food remains; *Thysanoessa raschii* and *Meganyctiphanes norvegica*. In half of the stomachs containing crustaceans, species identification could not be made (Table 3).

The euphausiid *T. raschii* was found in 11 stom-

achs and *M. norvegica* occurred in 5. In Icelandic waters the former species is usually confined to fjord and bay areas while the latter is more oceanic in distribution (Astthorsson and Gislason 1990). To our knowledge, *M. norvegica* has only once before been reported as a prey item of minke whales (Nordøy and Blix 1992), but it is predominant in the diet of fin whales (*Balaenoptera physalus*) off Iceland (Rørvik *et al.* 1976, Vikingsson 1997). No temporal or spatial differences in occurrence were apparent between minke whales containing the two euphausiid species.

**Table 4.** Frequency of occurrence, and weighted frequency of prey groups in minke whale stomachs from Icelandic waters (further explanations in text).

	Frequency of occurrence (%)	Weighted frequency (%)
Capelin	31.3	22.9
Ammodytidae	37.3	32.6
Herring	1.5	0.7
Cod	1.5	0.7
Large teleost fish	7.5	4.5
Krill	47.8	34.8
Small unidentified fish	6.0	3.7



**Fig. 4.** Frequency of occurrence in the examined stomachs of the three main food types in the northern (N) and western and southwestern (SW-W) areas (see Fig. 2).

Table 4 shows the frequency of occurrence of the different food species found in the 67 non-empty stomachs, and gives a rough weighted frequency index (WF). If these indices reflect the relative importance of different prey groups, nearly two thirds of the diet consists of fish, while around one third is krill.

The data are in agreement with other studies showing opportunistic, and predominantly piscivorous feeding habits of minke whales in the North Atlantic, as has been demonstrated off Norway and in the Barents Sea (Christensen 1974, Jonsgård 1982, Haug *et al.* 1995, 1996),

off East and West Greenland (Christensen 1974, Jonsgård 1982, Larsen and Kapel 1981, 1982, Neve this volume) and off the eastern coast of Canada (Mitchell 1974, 1975, NAMMCO 1998). Among the fish prey in this sample, sandeel and capelin stand out as predominant species (Table 4). Sandeel was found in 25 stomachs, but distinction between the three Icelandic species of sandeel could be made only in one sample, where the species was identified as *A. marinus*. Sandeel was by far the dominant prey in the western and southwestern areas, while capelin and krill were more frequently found in animals sampled in North Iceland (Fig. 4). The

absence of capelin from stomachs sampled in the western and southwestern areas was to be expected, as the sampling period did not overlap with the migration time of capelin in that area (Vilhjálmsson 1994). Large temporal and spatial variations in diet, apparently related to capelin migration, have been demonstrated for another cetacean species in Icelandic waters, the harbour porpoise (*Phocoena phocoena*) (Vikingsson and Sigurjónsson 1996). One minke whale stomach was almost full of cod (*G. morhua*) and another contained cod or cod-like species (Gadiformes) together with Euphausiids.

Capelin also seems to be among the most important prey species off Greenland (Christensen 1974, Jonsgård 1982) and Canada (NAMMCO 1998), whereas in Norway, herring is the dominant fish prey (Haug *et al.* 1995, 1996). Herring was found in only one stomach in the present study, although this may be an artifact resulting from the lack of overlap of sampling areas/time with herring distribution.

Evidently, fish constitutes a major part of the food of minke whales in Icelandic waters. Fish or fish remains were found in 76% of the examined stomachs, while the corresponding frequency for krill was 47%. However, because of the limitations of the sample, both with regard to total sample size, and sampling distribution in time and space, it is difficult to assess the rela-

tive importance of different prey species with any confidence. As Kasamatsu and Tanaka (1992) demonstrate for North Pacific minke whales, major changes in the food habits of minke whales can take place in a few years time, which they were able to associate with drastic changes in the abundance of the pelagic fish stocks that were important prey species.

Our knowledge of the feeding habits of minke whales in Icelandic waters is very limited. Further research in this field is of particular importance in light of the large numbers of minke whales in the area, which have been estimated to consume around 2 million tonnes annually (Sigurjónsson and Vikingsson 1997). Depending, among other things, on the composition of the diet, this consumption may significantly influence the yield of commercially important fish stocks in Iceland (Stefánsson *et al.* 1997).

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