Feeding Habits of Northeast Atlantic Harp Seals (*Phoca groenlandica*) along the Summer Ice Edge of the Barents Sea

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Stomachs from 58 harp seals (*Phoca groenlandica*) from the northern part of the Barents Sea were collected between August 20 and September 5, 1987. Fifty-six of the stomachs contained identifiable remains. The amphipod *Parathemisto libellula* was the most common food item, found in 98% of the seal stomachs and constituting 57.9% of the total volume. Fish were the second most important prey group, with Arctic cod (*Boreogadus saida*) as the dominant species followed by Nybelin's sculpin (*Triglops nybelini*) and Greenland halibut (*Reinhardtius hippoglossoides*). Decapods, mainly *Pandalus borealis*, were also common as prey of harp seals. No sex- or age-related differences in choice of food were found. From knowledge of the depths at locations where seals were collected and the presence of fresh benthic fishes in the seal stomachs, it is assumed that harp seals could forage at depths below 300 m.

On a recueilli 58 estomacs de phoques du Groenland (*Phoca groenlandica*) capturés dans le secteur nord de la mer de Barents entre le 20 août et le 5 septembre 1987. De ceux-ci, 56 contenaient des restes identifiables. L'amphipode *Parathemisto libellula* était l'aliment le plus fréquemment consommé, étant retrouvé dans 98 % des estomacs et constituant 57,9 % du volume total. Le poisson venait au deuxième rang des proies les plus recherchées; le saïda franc *Boreogadus saida* était l'espèce la plus commune, puis venaient le faux-trigle aux grands yeux *Triglops nybelini* et le flétan du Groenland *Reinhardtius hippoglossoides*. Des décapodes, en particulier *Pandalus borealis*, étaient aussi une proie commune. On n'a pas relevé de différences liées au sexe et à l'âge en ce qui a trait au choix d'aliments. En se basant sur les profondeurs aux sites de capture des phoques et la présence de poissons benthiques frais dans les estomacs étudiés, on formule la conclusion que le phoque du Groenland peut plonger jusqu'à plus de 300 m à la recherche de nourriture.

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The harp seal (*Phoca groenlandica*) is an important species in the marine ecosystem in the Barents Sea. Its impact on the system is dependent on the size of the population and its food habits. No recent estimate of the population size exists. In 1978, the population was estimated as 800 000 seals with an annual increase of about 5% (Benjaminsen 1979). During the early 1980's, the population size was believed to exceed 1 million, but more recent studies indicate that it is probably declining (Ulltang and Øien 1988).

Markussen and Øritsland (1985) estimated that a population of 1 million harp seals in the Barents Sea needs 1.4–4.2 million tons of food every year depending on the type of prey consumed. However, knowledge of the feeding habits of Northeast Atlantic harp seals is scarce. Much of the available information is based on material collected during the breeding season or deals with the Northwest Atlantic stock (Sivertsen 1941; Myers 1959; Sergeant 1973; Bowen 1985; Kapel and Angantyr 1989; Finley et al. 1990). This paper reports on feeding habits of harp seals collected along the summer ice edge of the Barents Sea.

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Material and Methods

Stomachs of 58 harp seals were collected at the ice edge in the northern parts of the Barents Sea between Svalbard and the Franz Josef Land archipelagoes (79°15′–79°55′N, 27°35′–44°50′E) from August 20 to September 5, 1987. The seals were shot in the water and dissected immediately. The stomach contents were rinsed on a sieve with a mesh size of 1 mm and then frozen. Teeth and sex organs were sampled to enable grouping of the seals into adults and subadults. Cross-sections 0.2 mm thick were cut from the canines using a modification of the double-bladed cutting machine described by Khutzin (1967). Sections were mounted on glass microscope slides, and dentin growth layers were counted in transmitting light using a binocular dissecting microscope. All sections were read twice by two different readers, and no difference between readings concerning which of the adult or subadult group they belonged in was found. Presence of corpora lutea or albicantia in ovaries was the criterion for sexual maturity in females. Based on comparisons of relative size of testis, body size of the animal, and results from the age determination, males 6 yr or older were considered sexually mature and 5 yr and younger as subadults. Water depth at most of the hunting sites was recorded using an echo-sounder.

Stomach contents were sorted to the lowest possible taxonomic level. Total wet mass of the contents and volume

TABLE 1. Distribution of major groups of preys from stomachs of harp seals collected in northern Barents Sea during the autumn of 1987.

Prey group	Volume percent (*V*)	Occurrence (*O*)	Abundance factor (*A*)
Fish	28.0	0.70	19.6
Amphipods	57.9	0.98	56.7
Decapods	13.1	0.66	8.6
Cephalopods	1.0	0.29	0.29

percentages (*V*) of the major prey groups were recorded. A nontrace frequency of occurrence (*O*) was calculated for the main prey groups (Bigg and Perez 1985). Prey represented by trace occurrences only, such as beaks of squid and otoliths of fish, were excluded from these calculations and were only examined for qualitative purposes. To evaluate the relative importance of different prey, an abundance factor (*A*) was calculated as $A = V \times O$.

Results

Two stomachs were empty, and the mean wet mass of the remaining 56 stomach contents was 273 ± 253 g (SD) with a range of 0.1–1326 g.

Amphipods were the dominant prey group (Table 1) and consisted almost entirely of *Parathemisto libellula* (Table 2). Fishes constituted the second most important group. The largest fraction of the fish group, however, consisted of partly digested specimens which were not identified to species level. The identifiable fraction was dominated by Arctic cod (*Boreogadus saida*). Benthic fish like Greenland halibut (*Reinhardtius hippoglossoides*) and Nybelin's sculpin (*Triglops nybelini*) were also common. Some invertebrate species were found only as traces in single seal stomachs and were excluded in Table 2. They include the copepod *Pareuchaeta glacialis*, the isopod *Idotea granulosa*, and the bivalves *Astarte elliptica* and *Leda pernula*.

The harp seal sample consisted of 23 females and 35 males. The mean age of females was 7.2 ± 4.7 yr (SD) (range 1–16 yr) and of males was 8.1 ± 4.5 yr (range 1–15 yr). To test for age- and/or sex-related differences in diet, we grouped the stomach contents of adult males ($N = 23$), subadult males ($N = 12$), adult females ($N = 11$), and subadult females ($N = 12$), respectively (Fig. 1). No significant difference in diet was found between males and females ($\chi^2 = 0.190$, $p = 0.66$) or between adults and subadults ($\chi^2 = 0.365$, $p = 0.55$). The greatest difference was found between subadult females and adult females (Fig. 1), but was not significant ($\chi^2 = 2.318$, $p = 0.13$).

The mean depth recorded at locations where stomachs contained freshly eaten benthic fishes ($N = 12$) was 256 ± 61 m, with a maximum recorded depth of 340 m.

Discussion

The main potential bias in using volumetric assessment of feeding habits is the effect of progressive digestion. Food items which are digested more quickly or are eaten earlier than others will be underrepresented. Fish species found in stomachs containing a greater volume of prey are likely to be overrepresented, since digestion is less advanced and specimens more identifiable than in samples from small stomachs. Since our sample consists of many animals with small amounts of food in their stomachs, this may lead to a biased assessment of the fish composition of the diet. The main bias using the nontrace frequency of occurrence is that small specimens are given an exaggerated importance. When multiplying the volume per-

TABLE 2. Occurrence of prey species within each main prey group from stomachs of harp seals collected in the northern Barents Sea during the autumn of 1987.

Prey species	Volume percent (*V*)	Occurrence (*O*)	Abundance factor (*A*)
Fish			
Unidentified fish remains	63.7		
Boreogadus saida	20.4	0.36	7.3
Triglops nybelini	8.4	0.27	2.3
Reinhardtius hippoglossoides	6.1	0.18	1.1
Other fish including *Sebastes marinus, Hippoglossoides platessoides, Leptoclinus maculatus, Benthosema glaciale,* and *Liparis* sp.	1.4	0.12	0.2
Amphipods			
Parathemisto libellula	99.6	0.98	97.6
Gammarus spp.	0.2	0.07	0.01
Other amphipods	0.2	0.02	0.003
Decapods			
Pandalus borealis	95.0	0.66	62.7
Sabinea septemcarcinatus	2.0	0.13	0.26
Other decapods including *Lebbeus polaris* and *Pasiphaea tarda*	3.0	0.09	0.27
Cephalopods			
Gonatus fabricii	83.3	0.27	22.5
Octopods including *Bathypolipus arcticus* and *Elodone cirrhosa*	16.7	0.04	0.7

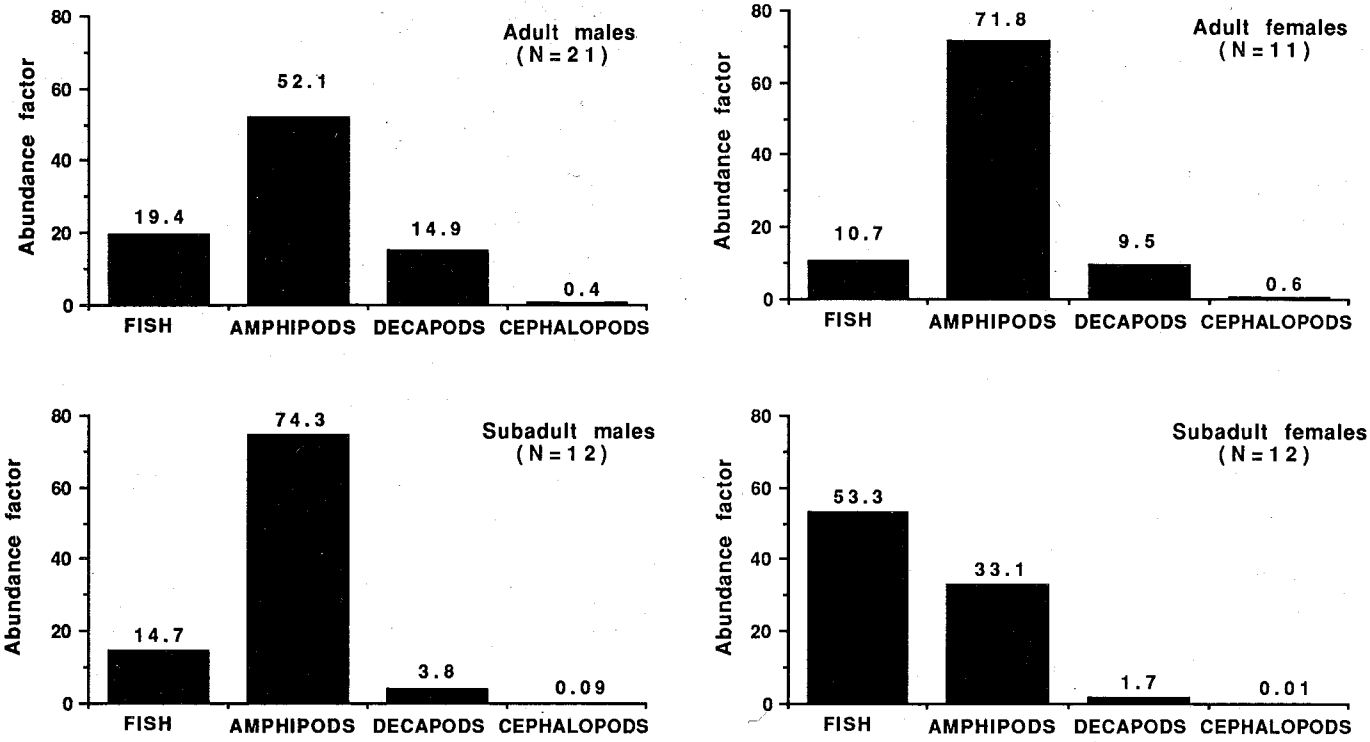

FIG. 1. Results from analysis of stomach contents of harp seals of different age and sex groups collected in the Barents Sea, August 1987.

centage with the frequency of occurrence, we moderate the effect one large prey organism in one single stomach would have on the total assessment.

Most information on harp seal diets is collected from their wintering grounds. On diet of the Northeast Atlantic population, Smirnov (1924) stated, without providing details, that pelagic crustaceans and Arctic cod followed by capelin (*Mallotus villosus*), herring (*Clupea harengus*), and pelagic molluscs were the most important food items. Sivertsen (1941) found that, after weaning, harp seal pups feed on pelagic crustaceans, especially the euphausids *Thysanoessa inermis* and *Thysanoessa raschii* and the amphipod *Anonyx nugax*. Yearlings had a different diet including capelin and shrimp species such as *Spirontocaris turgida* and *Crangon crangon*. Information on adult diet was based on two seals with contents in their stomachs which contained *T. raschii* and *C. crangon*.

For the Northwest Atlantic population, Myers (1959) found fish remains, with herring as the dominant species, in a sample of 185 harp seals from Canadian waters. Sergeant (1973) stated that pelagic fishes, especially capelin, plus pelagic and benthic crustaceans were the most important prey. He collected a small sample from harp seals summering in the cold waters between northwest Greenland and the Canadian Arctic archipelago, and these seals were mainly eating Arctic cod and various crustaceans including *P. libellula*. Bowen (1985) reviewed available data on feeding of the Northwest Atlantic harp seal population and concluded that they fed mainly on pelagic fishes dominated by capelin and Arctic cod and on a variety of invertebrates, particularly euphausids and shrimps. Kapel and Angantyr (1989) studied stomachs from 661 harp seals collected at different locations along the west coast of Greenland during 1985–88. They found capelin to be the dominant prey in spring and summer in southwest and central-west Greenland. In the north and northwest of Greenland, however, Arctic cod and polar cod (*Arctogadus glacialis*) and crustaceans, including *P. libellula*, dominated. Finley et al. (1990) found that the main prey of summering harp seals in the Canadian high Arctic was Arctic cod, with polar cod as the second most important prey group. Invertebrates were of minor importance in their sample of 157 seal stomachs but were dominated by *Parathemisto* spp. and *Mysis* spp.

The results of the present study are in general agreement with studies of harp seals feeding in other Arctic areas (Sergeant 1973; Kapel and Angantyr 1989; Finley et al. 1990). Comparing results from investigations of stomach contents from different marine mammals which, at least partly, forage pelagically in association with the ice edge both in the European and the American Arctic, it appears that pelagic crustaceans including *P. libellula* and Arctic cod are the most significant prey (Lowry et al. 1980; Bradstreet and Cross 1982; Finley and Gibb 1982; Bradstreet et al. 1986; Gjertz and Lydersen 1986; Smith 1987; Kapel and Angantyr 1989; Lydersen et al. 1989). The sample of Finley et al. (1990) was totally dominated by Arctic cod. Their sample was collected in coastal waters, while our sample was collected in a more pelagic situation. Since *P. libellula* is a pelagic amphipod, this may explain this difference in the diet.

During summer, large herds of harp seals are normally observed in open waters between the coast of Finmark (northern Norway) and the Svalbard – Franz Josef Land archipelagoes. Considerable effort was expended to locate some of these herds, including assistance from the large fleet of fishing vessels in the area. However, no herds of harp seals were found. In general, the only area where seals were observed was along the ice edge, and sampling was therefore concentrated in this area. One explanation for the scarcity of seals in open water could be the collapse in the stock of capelin in the Barents Sea in 1987 (Anonymous 1990). It is assumed that capelin has been the

principal food source for harp seals summering in this area (Wiig 1988) and that the collapse induced the seals to search for food in other areas. One harp seal was shot in the southern Barents Sea but was excluded from our analysis, since it had been collected remotely from the rest of the sample. This seal, however, had eaten capelin.

Sergeant (1973) suggested diving abilities of harp seals down to 250 m based on the occurrence of fresh benthic fishes in the stomachs of seals collected in areas of known depths. We collected harp seals containing fresh benthic fishes in areas where depth exceeded 300 m. *Reinhardtius hippoglossoides* was one of the species considered benthic. This species has, however, been found to have a bathypelagic mode of life (Chumakov 1969), feeding in the water column (Haug and Gulliksen 1982), and might therefore seem unreliable as an indicator of foraging depths of harp seals. Most of the *R. hippoglossoides* in the Svalbard area are, however, caught at depths below 200 m (Godø and Haug 1987), and Chumakov (1969) stated that *R. hippoglossoides* are on the bottom during daytime, when most seals were collected for this study. The results therefore indicate that the harp seal may feed at depths of 300 m.

In conclusion, amphipods, mainly *P. libellula*, were found to be the most significant food item of harp seals feeding along the ice edge in the northern parts of the Barents Sea. Fish were found to be the second most important prey, with Arctic cod as the dominant species followed by *T. nybelini* and *R. hippoglossoides*. No significant sex- or age-related difference in choice of prey was found.

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