Feeding habits of harp (Phoca groenlandica) and hooded seals (Cystophora cristata) during late winter, spring and early summer in the Greenland Sea

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ABSTRACT

Diet data were collected in the Greenland Sea pack ice (the West Ice) from March to June from harp seals (Phoca groenlandica) in 1987, 1990-1992 and 1997, and from hooded seals (Cystophora cristata) in 1992 and 1994, during Soviet/Russian commercial sealing and on Norwegian scientific expeditions. The majority of both harp and hooded seal stomachs were empty but intestinal contents were found in most of the seals. The harp seal diet was totally dominated by the amphipods Parathemisto sp. and Gammarus sp., but krill (Thysanoessa sp.) and polar cod (Boreogadus saida) were also eaten quite frequently. Hooded seals had been feeding mainly on the squid Gonatus fabricii, which was found most frequently in the intestines, but which also dominated in the few stomachs with contents. Polar cod also occurred quite frequently in the hooded seal diet, while crustaceans, such as amphipods and krill, occurred only sporadically.


Introduction

Three stocks of harp seals (Phoca groenlandica) (Fig. 1), and two stocks of hooded seals (Cystophora cristata), inhabit the North Atlantic Ocean. The Northwest Atlantic harp seal stock breeds off the coast of Labrador-Newfoundland and in the Gulf of St.Lawrence. In the Northeast Atlantic, one harp seal stock breeds in Greenland Sea pack-ice near Jan Mayen, and in the White Sea (Sergeant 1991). The Northwest Atlantic hooded seal stock breeds off Labrador-Newfoundland and in the Davis Strait, while the Northeast Atlantic stock breeds in the Greenland Sea near Jan Mayen (Sergeant 1974). The harp seal is the most abundant seal species in the North Atlantic, but the stocks of hooded seals are also large. All stocks of both species have been subject to exploitation and are managed separately. Their role as top predators is considered important in a management context, and a provisional attempt to estimate the consumption by harp seals off Newfoundland was made by Stenson et al. (1997). In the Barents Sea, harp seal consumption is included in multispecies modelling (Bogstad et al. 1997).

Recent harp and hooded seal studies in the Greenland Sea have mainly concentrated on stock size estimation and migration (Øien and Øritsland MS 1991,1995, Øritsland and Øien 1995, Folkow and Blix 1995, Folkow et al. 1996). Little attention has been paid to the feeding habits of the seals, and our knowledge about the ecological significance of the seal stocks in the Greenland Sea is poor. Only occasionally has the seal diet in these waters been studied, mostly in coastal areas of eastern Greenland and north-

In order to provide more data on the feeding habits of harp and hooded seals in the Greenland Sea, Norwegian studies of weaned pups of both species were initiated in 1995 (Haug et al. this volume). Soviet/Russian scientists have collected data on stomach and intestinal contents of harp and hooded seals during molt in the period 1987-1994, and stomach and intestinal contents of adult female harp seals were sampled during the breeding season in 1997 by Norwegian scientists in the Greenland Sea. This paper presents the results of these studies.

MATERIAL AND METHODS

Sampling
Subadults and adult seals of both species were sampled during molt on Soviet/Russian commercial sealing vessels in the pack-ice areas in the Greenland Sea (the West Ice). Adult harp seals were also sampled during a Norwegian research survey to the Jan Mayen area in the breeding season (Fig. 2). Samples of harp seals were collected in 1987 (4 May - 8 June), 1990 (20 May - 8 June), 1991 (22 April - 23 May), 1992 (8 - 24 May) and 1997 (24-29 March). Hooded seals were sampled in 1992 (14 May - 26 June) and 1994 (25 May - 26 June) (Table 1). All seals were shot on the ice and brought to the vessel, where stomachs and intestines (colon only) were immediately removed for analysis. A total of 1054 harp seals and 602 hooded seals were sampled.

Stomach and intestinal contents analyses
The stomachs and intestines were treated separately and were cut open on board the ship. The contents were removed and the wet weight of stomach contents was recorded. Contents from some of the stomachs and intestines were analysed on board the ship, while some were fixed in 4% formaldehyde solution and stored for later laboratory examination. In 1997, all stomachs and intestines with contents were frozen immediately for later laboratory analyses.

Crustaceans were separated from cephalopods and fish and identified to the lowest possible taxon using a standard identification key (Enckell 1980). Fresh specimens of cephalopods and fish were identified by gross morphological characteristics. Otoliths and squid beaks were separated from the remainder of the stomach and intestinal contents (Treacy and Crawford 1981; Murie and Lavigne 1985) and identified to species when possible, using reference material (Clarke 1962; Härkönen 1986). The number of each fish species in the stomach contents of hooded seals collected in June 1992 was calculated by adding the number of fresh specimens and half the number of otoliths of the species (Nilssen et al. 1995a). The number of squids were obtained by adding the number of fresh specimens and the number of paired beaks. The contribution of each species to the diet in terms of wet weight in stomach contents was obtained by a combination of the wet weights of undigested specimens and, for fish, otolith length to fish weight relationships (Härkönen 1986). For squids, relationships between beak lengths and wet weights (Clarke 1962) were used. The contribution of crustaceans was calculated directly from the recorded weights. In the stomach contents of harp seals sampled in March 1997, a crude estimate of the numbers of crustaceans present was obtained by counting fresh animals and the carapaces of each species. Mean weights were obtained from fresh specimens (30 individuals of each species) recovered from the stomach contents, and these were used to calculate the total wet weight of each crustacean species in the diet. The diet data were presented in two ways: (1) the frequency of occurrence of a given

Fig. 1: An adult male harp seal.
Photo: Gudmundur Ólafsson
Fig. 2. Sampling areas for harp and hooded seals in the Greenland Sea, 1987-1997.

Table 1: Sampling of harp and hooded seals in the Greenland Sea (the West Ice) during 1987-1997.

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Minke whales, harp and hooded seals: Major predators in the North Atlantic ecosystem
Table 2. Frequencies of empty stomachs and intestines and of identified species of prey in all examined stomachs/intestines of harp seals sampled during Soviet/Russian commercial sealing in the Greenland Sea in May and June 1987 and 1990, April and May 1991 and May 1992, and during a Norwegian research survey in the Jan Mayen area in March 1997. S = stomachs and I = intestines, n = number of seals examined.

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Table 3: Frequencies of empty stomachs and intestines and of identified prey species in stomachs and intestines of hooded seals examined during Soviet/Russian commercial sealing in the Greenland Sea in May and June 1992 and 1994. S = stomachs and I = intestines, n = number of seals examined.

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RESULTS

Harp seals

The majority of harp seal stomachs were nearly or completely empty in all sampling periods, except in the breeding season (March 1997).
when 16 (29.6%) of 54 lactating females had stomach contents (Table 2). In this sample, the amphipods *Gammarus niloticus* and *Parathemisto libellula* dominated the stomach contents in terms of calculated biomass (Fig. 3). In the other sampling periods, the identifiable items recovered from the stomachs were also pelagic amphipods and krill (*Thysanoessa* sp.) (Table 2). Most of the intestines had contents in all sampling periods, ranging from 33.3% of the examined seals in March 1997 to 100% in April and May 1991. *Parathemisto* sp. dominated in all periods, with frequency of occurrence ranging from 77.1% in June 1987 to 100% in April and May 1991. Krill occurred in the intestinal contents in all sampling periods except in June 1990 and in April and May 1991, with frequency of occurrence ranging from 10.4% to 32.8%. Polar cod (*Boreogadus saida*) had been eaten in most of the sampling periods, and occurred in 4% to 21.9% of the intestines in May 1987 and 1990, respectively. The squid *Gonatus fabricii* occurred sporadically in May 1987 and 1992 (Table 2).

**Hooded seals**

All hooded seal stomachs were empty, except in June 1992 when 10 (3.3%) of 299 stomachs had contents (Table 3). The squid *G. fabricii* dominated the stomach contents and contributed 79.2% of the prey biomass (Fig. 4). The contributions of polar cod and *Parathemisto* sp. to the diet of the ten seals in terms of biomass were 15.7% and 5.1%, respectively. All intestines had contents in all sampling periods, except in June 1992 when 10 (3.3%) of 299 were empty (Table 3). *G. fabricii* occurred in 100% of the intestines in May 1992 and 1994, and in 76.3% and 89.8% in June 1992 and 1994, respectively. Polar cod also occurred quite frequently in May and June 1992 and in June 1994 when they were found in 30.8%, 81.6% and 68.2% of the examined intestines, respectively. Amphipods and krill were

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*Fig. 3.* Relative occurrence in terms of calculated bulk biomass of prey species in stomach contents of 16 adult breeding female harp seals sampled in the Greenland Sea in March 1997.
recovered sporadically in the intestinal contents in all periods, except in May 1994.

**DISCUSSION**

Studies based on mass transfer efficiency between mothers and pups and diving records of lactating females suggest that harp seal females have to consume some food during the lactation period (Lydersen and Kovacs 1993). Stomach contents were found in approximately 30% of the lactating harp seals in this study, confirming that females feed during the lactation period. The generally rapid digestion rate in seals (Murie 1987), and the fact that the seals were shot on the ice some time after feeding may explain the lack of prey remains in most of the examined stomachs of both harp and hooded seals. This was confirmed by the presence of contents in most of the intestines. Most of the seals were moulting, which is a period of reduced feeding intensity (Nansen 1924, Rasmussen 1960, Sergeant 1973,1991, Nilssen 1995, Nilssen et al. 1995b). Due to the rates of digestion, it is difficult to reconstruct the diet completely from intestinal contents, in particular when the prey includes crustaceans. Therefore, only frequencies of occurrence of prey species in the intestines have been presented, and no attempt has been made to calculate the mass or energy contribution of each prey species.

The frequent occurrence of krill and the dominance of amphipods in the intestinal contents of harp seals in the Greenland Sea is consistent with earlier observations from this area: Gray (1889) reported stomachs of adult harp seals in the Greenland Sea to contain *P. libellula* and krill, while Surkov (1960) reported *Parathemisto* sp. in harp seal stomachs and crustacean remains in faecal remains on the ice in the Jan Mayen area during spring and in July. *Parathemisto* sp. was also the dominant prey item of weaned harp seal
pups in the Greenland Sea in April 1995 (Haug et al., this volume). Polar cod occurred quite frequently in harp seal intestines in some of the samples in this study, which is consistent with previous observations made during spring and summer in coastal areas of eastern Greenland (Pedersen 1930).

Harp seals collected in the period February-May further to the south in coastal areas of northern Iceland had a diet consisting mainly of sandeels (Ammodites sp.), codfishes (Gadidae), capelin (Mallotus villosus), and various other fishes, and to a lesser extent crustaceans (including amphipods and krill) and various other invertebrates (Hauksson and Bogason 1997). This is rather different from the observed Greenland Sea diet which also differed from diets observed for harp seals during moult in the Barents and White Seas and in the Newfoundland area. The diet in the southeastern parts of the Barents Sea (the East Ice) during this period consisted mainly of capelin, codfishes and shrimp (Pandalus sp.), along with various other fish species. Capelin, sandeels, eelpouts (Zoarcidae) and crustaceans (mainly shrimp, but also Parathemisto sp.) dominated in the White Sea (Nilssen et al. 1995a). In the Gulf of St. Lawrence and in eastern Newfoundland (the Front), the harp seal diet during moult consisted mainly of capelin and shrimp (Sergeant 1991). The pelagic nature of the Greenland Sea diet, contrasting to the typically more demersal Barents Sea, White Sea, and Newfoundland diets, is probably due to the different habitats in these areas. The water depth in the sampling areas in the Greenland Sea ranges from 1000 to 2000 m. In the East Ice and the White Sea harp seals occur in waters with depths of less than 100 m during moult, while in the Gulf of St. Lawrence and east of Newfoundland, the depths of the harp seal molting areas are approximately 50–400 m. In other seasons, Parathemisto libellula, krill, polar cod, capelin, herring, Clupea harengus, and various other fishes have been found to be important harp seal food, both in the northern Barents Sea, along the coast of West Greenland and in northeastern Canadian waters (Chapskii 1961, Sergeant 1973, 1976, 1991, Lydersen et al. 1991, Nilssen 1995, Nilssen et al. 1995b).

Little information is available concerning the hooded seal diet in the Greenland Sea, although Nansen (1924) reported redfish (Sebastes sp.), codfishes, tusk (Brosme brosme), halibut (Hippoglossus hippolossus) and squid as components of the diet. Arseniev et al. (1973) reported that the hooded seal diet in the Greenland Sea mainly comprised squids and to a smaller degree fish, such as redfish, codfishes and others. As in the present analyses, most hooded seal stomachs examined by local hunters in southeastern Greenland were empty in July-August. In those with contents, redfish dominated, followed by Greenland halibut (Reinhardtius hippoglossoides) (Kapel 1982, 1995). The dominance of the squid G. fabricii and the frequent occurrence of polar cod in the hooded seal diet in this study compares to observations made in southeastern Greenland in early September, where analyses of stomach contents from mainly young hooded seals revealed that squid dominated the diet, followed by shrimp Pandalus sp., polar cod and redfish (Kapel 1995). In coastal waters of northern Iceland, hooded seals were observed to feed mainly on redfish, cod and various other fishes in April-October, but shrimps and the squid Todarodes sagittatus were also eaten (Hauksson and Bogason 1997). Parathemisto libellula dominated the hooded seal pup diet after weaning (April) in the Greenland Sea (Haug et al. this volume).

Recent satellite tracking data have shown that hooded seals perform long migrations between breeding and moult periods from the pack-ice areas in the Greenland Sea to the continental shelf edges around Faroe Islands and northern Ireland and to the Norwegian Sea (Folkow and Blix 1995; Folkow et al. 1996). After the moult, satellite-tagged West Ice hooded seals performed excursions which lasted for 3-7 weeks to such distant areas as the waters off the Faroe Islands, the Irminger Sea, north and northeast of Iceland, the Norwegian Sea and the continental shelf edge from Norway to Bear Island. Direct evidence of hooded seal feeding habits in those areas are still lacking, but Folkow and Blix (1995) suggested that blue whiting (Micromesistius poutassou) in Faroe Islands waters and redfish in the Irminger Sea might be potential prey for hooded seals in late autumn and winter. At Newfoundland, hooded seals have been observed to feed on Greenland halibut, polar cod, herring (Clupea harengus), capelin, redfish and various gadoids during winter and early spring (Ross 1993).
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