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

Vladimir Potelov[1], Kjell Tormod Nilssen[2], Vladislav Svetochev[1] and Tore Haug[2]

[1] *Polar Research Institute of Marine Fisheries and Oceanography (PINRO), 6 Knipovich Street, 183763, Murmansk, Russia*
[2] *Norwegian Institute of Fisheries and Aquaculture, N-9291 Tromsø, Norway*

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.

Potelov, V., Nilssen, K.T., Svetochev, V. and Haug, T. 2000. Feeding habits of harp (*Phoca groenlandica*) and hooded seals (*Cystophora cristata*) during late winter, spring and early summer in the Greenland Sea. *NAMMCO Sci. Publ.* 2:40-49.

Introduction

Three stocks of harp seals (*Phoca groenlandica*) (Fig. 1), and two stocks of hooded seals (*Cystophora cristata*), inhabit the North Atlantic Ocean. The Nortwest 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 one 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-

ern Iceland (Gray 1889, Nansen 1924, Pedersen 1930, Sivertsen 1941, Høst 1948, Rasmussen 1957,1960, Surkov 1960, Arsenjev *et al.* 1973, Kapel 1995, Hauksson and Bogason 1997).

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 moult 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 moult 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: Guðmundur Þórðarson

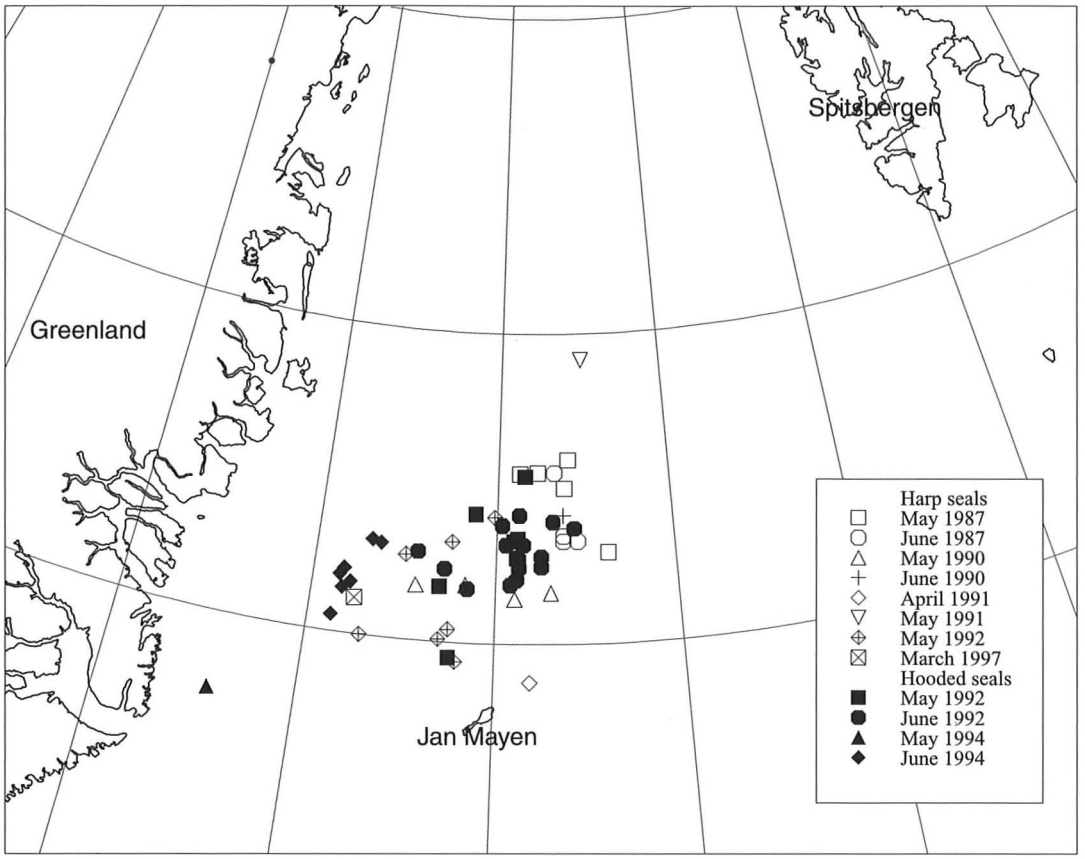

Fig. 2. *Sampling areas for harp and hooded seals in the Greenland Sea, 1987-1997.*

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

		NUMBER OF SEALS SAMPLED				
SPECIES	**YEAR**	**MARCH**	**APRIL**	**MAY**	**JUNE**	**TOTAL**
HARP SEALS	1987			125	205	330
	1990			137	15	152
	1991		153	286		439
	1992			79		79
	1997	54				54
TOTAL						**1054**
HOODED SEALS	1992			143	299	442
	1994			3	157	160
TOTAL						**602**

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.

	1987				1990				1991				1992		1997	
	May n=125		June n=205		May n=137		June n=15		April n=153		May n=286		May n=79		March n=54	
Prey item	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I
Empty	99.2	8.8	96.6	18.5	83.2	16.1	93.3	13.3	100	0	100	0	100	3.8	70.4	66.7
Molluska																
Cephalopoda																
Gonathus fabricius		0.8												5.1		
Crustacea																
Amphipoda																
Parathemisto libellula	82.4	3.4	77.1	15.3	82.5	6.7	86.7		100		100		89.9	20.4	25.9	
Gammarus wilkitzi														25.9	24.1	
Gammarus sp.														14.7	27.8	
Lysianassaidae sp.														1.8		
Eusirus sp.														5.6	3.7	
Eupausiacea																
Meganyctiphanes norvegica															1.8	
Thysanoessa sp.														17.7	1.8	14.8
Unid. Crust Remains				5.4												7.4
Pisces																
Gadidae																
Boreogadus saida		6.3		21.9						6.6		8		19		9.3

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 = numer of seals examined.

	Frequency (%)							
	1992				1994			
	May n=143		June n=299		May n=3		June n=157	
Prey item	**S**	**I**	**S**	**I**	**S**	**I**	**S**	**I**
Empty	100	0	96.7	3.3	100	0	100	0
Cephalopoda								
Gonatus fabricii		100	2.7	76.3		100		89.9
Crustacea								
Amphipoda								
Parathemisto sp.		7.7	0.7	6.4				1.9
Euphausiacea								
Thysanoessa sp.		1.4						
Unidentified crust. remains		7		1				10.2
Pisces								
Gadidae								
Boreogadus saida		30.8	1	81.6				68.2

prey was defined as the percentage of stomachs or intestines that contained one or more individuals of the prey species and (2) the relative contribution of each prey species to the total diet expressed in terms of calculated fresh wet weight.

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)

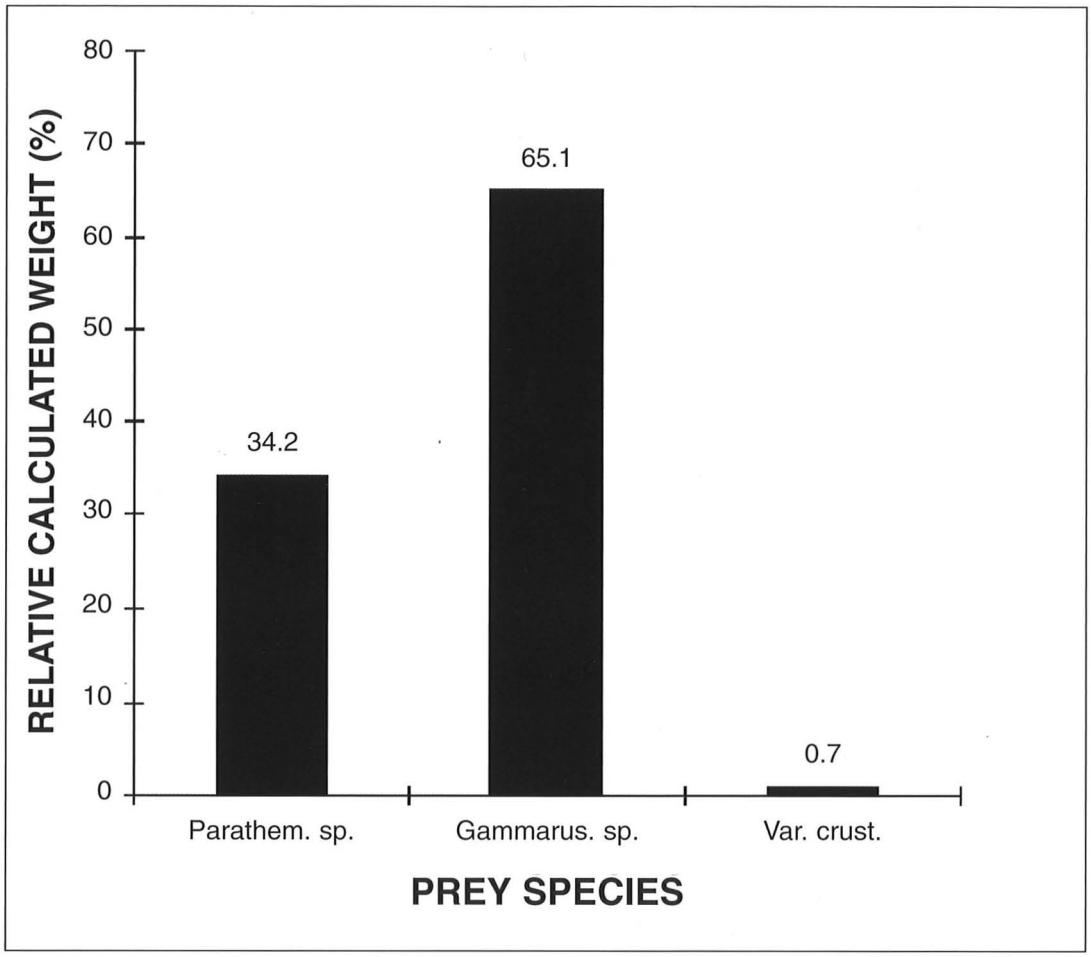

Fig. 3. *Relative occurrence in terms of calculated bulk biomass of prey species in stomach contents of 16 adult breeding female harp seals sampled in the Greenland Sea in March 1997.*

when 16 (29.6%) of 54 lactating females had stomach contents (Table 2). In this sample, the amphipods *Gammarus wilkitzki* 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

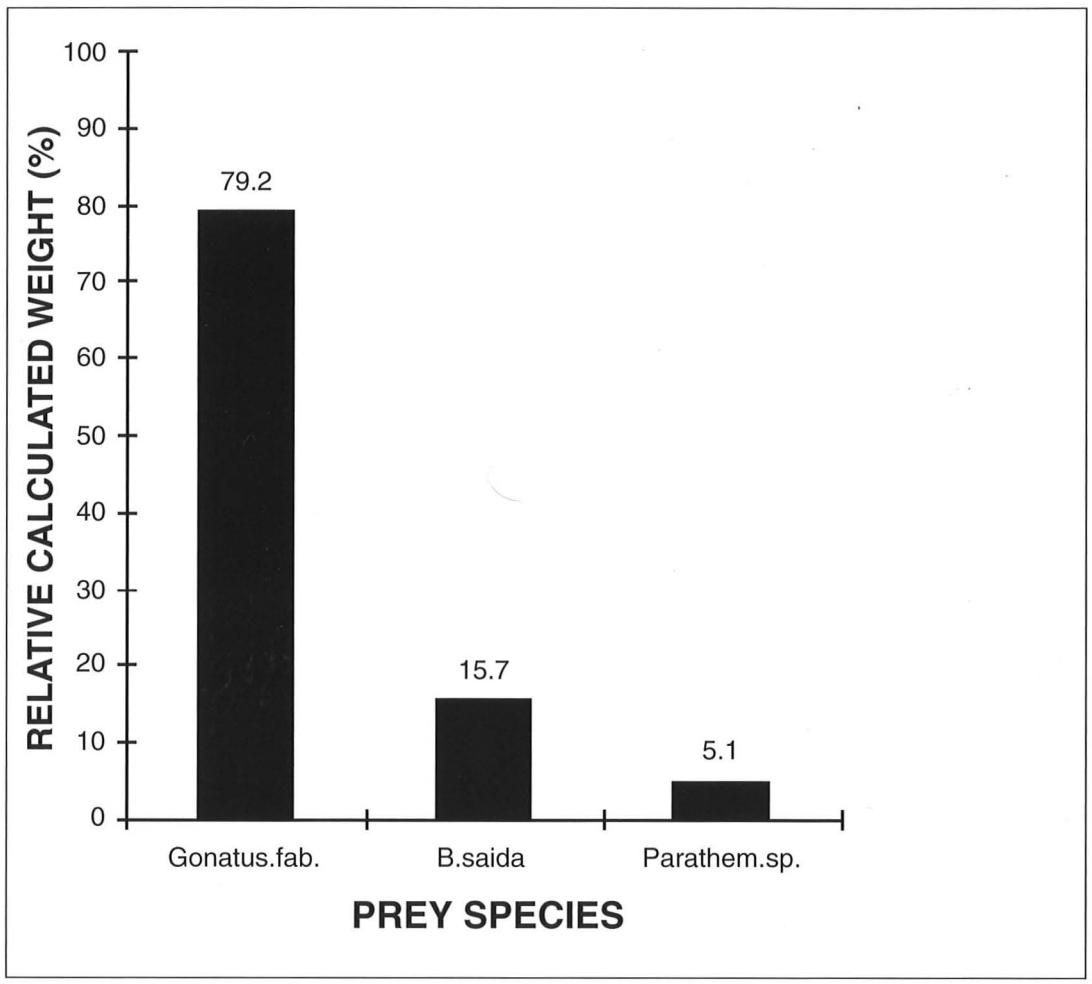

Fig. 4.
Relative occurrence in terms of calculated bulk biomass of prey species in stomach contents of 10 adult hooded seals caught in the Greenland Sea in June 1992.

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 (*Ammodytes* 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 moulting areas are approximately 50-400 m. In other seasons, *P. 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).

ACKNOWLEDGEMENTS

Thanks are due to the crews on board the vessels "Gremikha", "Teriberka", "Mezen", "Laplandia" and "Lance", and to the technicians S. Lukjanov, V. Mankov, Yu. Silinsky, V. Prischemikhin, O. Minibaeva, N. Stasenkova, O. Pilikin, L. Andreev and L. Lindblom for their help during the field work and analyses of biological samples. G. Víkingsson is acknowledged for technical assistance with the map. Thanks are due to R. Barret who commented on the manuscript and corrected the English.

REFERENCES

Arseniev, V.A., Zemskij, V.A., and Studenetskaya, I.S. 1973. *Morskie mlekopitayushchie. Pishevaja promyshlennost.* (Marine Mammals. Food Industry). 232 pp.

Bogstad, B., Hauge, K.H., and Ulltang, Ø. 1997. MULTSPEC - A multi-species model for fish and marine mammals in the Barents Sea. *J. Northw. Atl. Fish. Sci.* 22:317-341.

Chapskii, K.K. 1961 (1962). Nekotorye ekologicheskie obosnovaniya sezonnoi dinamiki areala belomorskoi populyatsii grenlandskogo tyulenya (Pagophoca groenlandica) (Some ecological factors determining seasonal changes in distribution of the White Sea harp seal population (*Pagophoca groenlandica*)). *Trudy Soveshchanii, Ikhtiol. Komissii Akad. Nauk SSSR* 12:150-163 (Transl. Ser. Fish. Res. Board. Can. 380:22pp.).

Clarke, M.R. 1962. The identification of cephalopod "beaks" and the relationship between beak size and total body weight. *Bull. Brit. Mus. (Nat. Hist.) Zool.* 8(10):419-480.

Enckell, P.H. 1990. *Fältfauna / Kräftdjur.* (Field-fauna/ Crustaceans). Bokforlaget Sigmun i Lund. 685 pp.

Folkow, L. 1994. Satelitt-overvåkning av selens vandringer og adferd. (Satellite-monitoring of seal migrations and behaviour). *Ottar* 201:34-37.

Folkow, L., and Blix, A.S. 1995. Distribution and diving behavior of hooded seals. In: Blix, A.S., Walløe, L. and Ulltang, Ø. (eds) *Whales, seals, fish and man.* Elsevier Science B.V., Amsterdam, 193-202.

Folkow, L., Mårtensson, P.-E., and Blix, A.S. 1996. Annual distribution of hooded seals (*Cystophora cristata*) in the Greenland and Norwegian Seas. *Polar Biol.*, 16:179-189.

Gray, R.W. 1889. Notes on a voyage to the Greenland Sea in 1888. *Zoologist,* 3(13):1-9; 41-51; 95-104.

Härkönen, T. 1986. *Guide to the otoliths of the bony fishes of the northeast Atlantic.* Danbiu ApS, Hellerup, Danmark.256 p.

Haug, T., Nilssen, K.T., and Lindblom, L. (This volume) First independent feeding of harp seal (*Phoca groenlandica*) and hooded seal (*Cystophora cristata*) pups in the Greenland Sea.

Hauksson, E., and Bogason, V. 1997. Comparative feeding of grey (*Halichoerus grypus*) and common seals (*Phoca vitulina*) in coastal waters of Iceland, with a note on the diet of hooded (*Cystophora cristata*) and harp seals (*Phoca groenlandica*). *J. Northw. Atl. Fish. Sci.* 22:125-135.

Høst, P. 1948. Undersøkelser over klappmyss. (Hooded seal investigations). Foredrag Selfangstmøtet, Oslo, 25. Oktober 1948. 15 p.

Kapel, F.O. 1982. Studies on the hooded seal, *Cystophora cristata*, in Greenland, 1970-80. *NAFO Sci. Coun. Studies* 3:67-75.

Kapel, F.O. 1995. Feeding ecology of harp and hooded seals in the Davis Strait-Baffin Bay region. In: Blix, A.S., Walløe, L. and Ulltang, Ø. (eds) *Whales, seals, fish and man.* Elsevier Science B.V., Amsterdam, 193-202.

Lydersen, C., Angantyr, L.A., Wiig, Ø., and Øritsland, T. 1991. Feeding habits of northeast Atlantic harp seals *Phoca groenlandica* along the summer ice edge of the Barents Sea. *Can. J. Fish. Aquat. Sci.* 48:2180-2183.

Lydersen, C., and Kovacs, K.M. 1993. Diving behaviour of lactating harp seal, *Phoca groenlandica,* females from the Gulf of St Lawrence, Canada. *Anim. Behav.* 46:1213-1221.

Murie, D.J. 1987. Experimental approaches to stomach content analyses of piscivorous marine mammals. In: A.C. Huntley, D.P. Costa, G.A.J. Worthy, and M.A. Castellini (eds); *Approaches to marine mammal energetics*. Society for Marine Mammalogy Spec. Publ. 1. Lawrence, KS, U.S.A., 147-163.

Murie, D.J. and Lavigne, D.M. 1985. Digestion and retention of Atlantic herring otoliths in the stomachs of grey seals. In: Beddington, J.R., Beverton R.J.H., and Lavigne D.M. (eds); *Marine mammals and Fisheries*. George Allen and Unwin, London, 292-299.

Nansen, F. 1924. *Blant sel og bjørn. Min første ishavsferd.* Jacob Dybwads Forlag. Kristiania. 285 p. [1925. Hunting and adventure in the Arctic. J.M. Dent and Sons Ltd. London. 462 pp.]

Nilssen, K.T. 1995. Seasonal distribution, condition and feeding habits of Barents Sea harp seals (*Phoca groenlandica*). In: Blix, A.S., Walløe, L. and Ulltang, Ø. (eds) *Whales, seals, fish and man.* Elsevier Science B.V., Amsterdam, 241-254.

Nilssen, K.T., Haug, T., Potelov, V., Stasenkov, V.A., and Timoshenko, Y.K. 1995. Food habits of harp seals (*Phoca groenlandica*) during lactation and moult in March-May in the southern Barents Sea and White Sea. *ICES J. mar. Sci.* 52:33-41.

Nilssen, K.T., Haug, T., Potelov, V., and Timoshenko, Y.K. 1995. Feeding habits of harp seals (*Phoca groenlandica*) during early summer and autumn in the northern Barents Sea. *Polar Biol.* 15:485-493.

Øien, N., and Øritsland, T. (MS) 1991. Recaptures of harp seals (*Phoca groenlandica*) tagged as pups in the Greenland Sea; pup production and dispersion patterns. Working paper to the joint ICES/NAFO Working group on harp and hooded seals, WP SEA-33, Copenhagen, October 1991.21 p. Cited with permission.

Øien, N., and Øritsland, T. 1995. Use of mark-recapture experiments to monitor seal populations subject to catching. In: Blix, A.S., Walløe, L. and Ulltang, Ø. (eds) *Whales, seals, fish and man.* Elsevier Science B.V., Amsterdam, 35-45.

Øritsland, T., and Øien, N. 1995. Aerial surveys of harp and hooded seal pups in the Greenland Sea pack-ice. In: Blix, A.S., Walløe, L. and Ulltang, Ø. (eds) *Whales, seals, fish and man.* Elsevier

Science B.V., Amsterdam, 77-87.

Pedersen, A. 1930. Fortgesetzte Beitrage zur Kenntnis der Saugetiere und Vogelfauna der ostkuste Grönlands. (Contributions to the knowledge of the mammal and bird fauna at the eastern coast of Greenland). *Medd. Grönl.* 77(5):344-506.

Rasmussen, B. 1960. Om klappmyssbestanden i det nordlige Atlanterhav. (About the hooded seal stock in the North Atlantic). *Fisken Hav.* 1960 (1):1-23.

Ross, S-A.1993. *Food and feeding of the hooded seal (Cystophora cristata) in Newfoundland.* M. Sc. Thesis, Memorial University of Newfoundland.163 p.

Sergeant, D.E. 1973. Feeding, growth and productivity of northwest Atlantic harp seals (*Pagophilus groenlandicus*). *J. Fish. Res. Board. Can.*30:17-29.

Sergeant, D.E. 1974. A rediscovered whelping population of hooded seals *Cystophora cristata* Erxleben and its possible relationship to other populations. *Polarforsch.* 44:1-7.

Sergeant, D.E. 1976. Studies on harp seals of the western North Atlantic population in 1976. *ICNAF Res. Doc.* 76/X/124 (revised), Ser. No. 4010:32 p.

Sergeant, D.E. 1991. Harp seals, man and ice. *Can. Spec. Publ. Fish. Aquat. Sci.* 114:153 p.

Sivertsen, E. 1941. On the biology of the harp seal *Phoca groenlandica* Erx. Investigations carried out in the White Sea 1925-1937. *Hvalrådets Skr.* 26:166 p.

Stenson, G.B., Hammill, M.O., and Lawson, J.W. 1997. Predation by harp seals in Atlantic Canada: Preliminary consumption estimates for Arctic cod, capelin and Atlantic cod. *J. Northw. Atl. Fish. Sci.*, 22:137-134.

Surkov, S.S. 1960. Dannye po biologii i promyslu YanMaienskogo lysuna i kohkhlacha v Zapadnykh L'dyakh (Data on the biology and hunting of the Jan Mayen harp and hooded seals in the West Ice.) *Trudy PINRO, Murmansk* 12:88-106. (Transl. 538, U.S. Naval Oceanographic Office, Washington, D.C. 20390, 1972, 30 p.).

Treacy, S.D. and Crawford, T.W. 1981. Retrieval of otoliths and statoliths from gastrointestinal contents and scats of marine mammals. *J. Wildl. Manage.* 45:990-993.