

# First independent feeding of harp seal (*Phoca groenlandica*) and hooded seal (*Cystophora cristata*) pups in the Greenland Sea

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## ABSTRACT

Data were collected from harp seal (*Phoca groenlandica*) and hooded seal (*Cystophora cristata*) pups belonging to the Greenland Sea (or "West Ice") stocks in 1995-1997. Pups of both species were observed to feed independently shortly after weaning, and their first food was almost exclusively crustaceans. *Parathemisto* sp., particularly *P. libellula*, dominated the diet of both the harp and the hooded seal pups, but the diet also contained sympagic amphipods of the genus *Gammarus*. Krill (*Thysanoessa* sp.) was of minor importance as food for seal pups in 1995, but occurred more frequently in the diet of both species in 1996 and 1997. Considerable niche overlap may suggest some interspecific competition between harp and hooded seal pups in the West Ice.

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## Introduction

Three stocks of harp seals (*Phoca groenlandica*) inhabit the North Atlantic Ocean (Sergeant 1991). One of the stocks is distributed in the Greenland and Norwegian Seas, breeding and moulting in the Greenland Sea pack-ice near Jan Mayen (the West Ice). The West Ice stock breeds on the fringe of the winter ice (usually snow covered floes of approximately 1 m thickness) seaward of the heavier multi-year ice along the East Greenland coast in an area where water depths range between 1000 and 3000 m. The main pupping period is in late March (Sergeant 1991, Øritsland and Øien 1995). Hooded seals (*Cystophora cristata*) also breed in the West Ice area, mainly in mid March (Rasmussen 1960, Øritsland 1964, Øritsland and Øien 1995). The duration of the lactation period for harp seals in the West Ice is probably 10-12 days (Sivertsen 1941, Rasmussen 1957, Sergeant 1991). The period is assumed to be considerably shorter for hooded seals, possibly within a range of 3-5 days, as observed for the species in the Northwest Atlantic (Bowen *et al.* 1985, Kovacs

and Lavigne 1992). Since both harp and hooded seals are present in the same areas of the West Ice through overlapping breeding seasons, pups of the two species commence independent feeding in a situation that might result in competition. Adult harp seals have a diet that differs from that of hooded seals in the West Ice (Potelov *et al.* this volume). It is, therefore, of interest to establish whether the same is true for the pups.

Although the feeding habits of both harp and hooded seal pups (Fig. 1 and 2) in the Northeast Atlantic are virtually unknown, it has been suggested that both may feed on crustaceans and fish (Nansen 1925, Sivertsen 1941, Høst 1948, Rasmussen 1957). Nevertheless, the limited knowledge on seal pup ecology has motivated thorough investigations of these questions in recent years. Based on field work performed in 1995-1997, this study attempts to assess when the weaned Greenland Sea harp and hooded seal pups start their first independent feeding, and

what prey items they choose. The possible existence of niche overlap between the two species is also evaluated.

## MATERIALS AND METHODS

### Sampling

The appropriate period for collection of seal pup data was assumed to be the first month after weaning, i.e. in April. This is the main sealing season in the West Ice, and the collection of pups could therefore be carried out from Norwegian sealing vessels during the commercial hunting seasons of 1995, 1996 and 1997. In 1995, commercial catches of pups were prohibited in the West Ice, and a special permit was obtained to take harp and hooded seal pups for scientific purposes. The permit stipulated that sampled pups must be weaned. Harp seal pups were therefore either in the process of shedding the white foetal coat ("ragged jackets", a stage which lasts 1-2 weeks) or completely moulted pups ("beaters", with a short spotted pelage) (see Sergeant 1991). The hooded seal pups shed their foetal hair in the uterus and are born with the shorthaired pelage that has given them the name "bluebacks" (Lavigne and Kovacs 1988), and samples from this species were obtained from weaned bluebacks. After the 1995 season, commercial catches of weaned pups were permitted and pup samples could therefore be obtained from commercial catches.

In 1995, sampling was carried out from two

Norwegian sealing vessels (*M/S Polarfangst* and *M/S Polarstar*) operating in the West Ice (Fig. 3) from 8 April to 12 May. During this period, stomachs and/or intestines were obtained from 236 bluebacks, 108 ragged jackets and 7 beaters. A temporal spacing of the samples was achieved by taking a certain number of specimens per week throughout the hunting season.

The supplementary samplings in 1996 and 1997 were designed primarily to study possible year-to-year variations in the pup diets, and included fewer animals taken over a more restricted time period than in 1995. In 1996, sampling was conducted from the *M/S Polarfangst*, and comprised stomachs and/or intestines from 49 bluebacks caught during the period 9 - 23 April, and 73 beaters caught during the period 19 - 23 April. The 1997 samples were taken from the *M/S Polarstar*, and included stomachs and/or intestines from 51 bluebacks caught on 17 and 18 April, and 50 beaters caught during the period 22 - 24 April.

Two scientists collected biological samples on each vessel. For each pup sampled, notes were made on species, date, time of the day, position, sex and stage of development. The stomach and large intestine of each pup were removed, and frozen for subsequent analysis in the laboratory.

### Biological collections and analyses

In the laboratory, the stomachs and intestines were thawed and then cut open. The stomach contents were removed and the intestinal contents were flushed out using fresh water. Crustaceans were separated from fish and identified to the lowest possible taxon according to Enckell (1980). A crude estimate of the number of crustaceans was obtained by counting carapaces. Otoliths were collected and identified to the lowest possible taxon using the keys developed by Härkönen (1986). The number of fish of each species was calculated by dividing the number of otoliths by two.

Indices commonly used in stomach analyses of top predators (Hyslop 1980, Pierce and Boyle 1991) were used to estimate the dietary contribution of different prey items:

1) the percentage of occurrence, defined as the percentage of stomachs or intestines that contained one or more individuals of a given dietary

**Fig. 1:**

*A harp seal pup, approximately 3-5 days old, with mother. Pups begin feeding after weaning is completed, 10-12 days after birth.*

*Photo: Guðmundur Þórðarson*





component;

2) the relative frequency of occurrence of a prey category, calculated as a numerical fraction of the total number of all prey categories (% numerical frequency).

Possible niche overlap between the two species was assessed using a multiplicative measure suggested by Pianka (1973):

$$o_{jk} = o_{kj} = \frac{\sum_{i=1}^n p_{ij} p_{ik}}{\sqrt{\sum_{i=1}^n p_{ij}^2 \sum_{i=1}^n p_{ik}^2}}$$

where  $p_{ij}$  and  $p_{ik}$  are the proportions of the  $i$ th resource used by the  $j$ th and  $k$ th species, respectively. The measure is symmetric and gives a single overlap value between 0 (no overlap) and 1 (complete overlap) for a niche overlap pair.

For calculations of the relative frequencies of occurrence of prey and of niche overlaps, the observed prey taxa were combined in five different categories: *Parathemisto* spp. (at least three species of this hyperiid amphipod genus), krill (mainly *Thysanoessa* spp., and to a very small extent *Meganyctiphanes norvegicus*), *Gammarus* sp. (mainly *G. wilkitzkii*), other crustaceans (*Eusirus* sp., Lyssianasida, unidentified crustaceans) and various items (fish, squid, other remains).

## RESULTS

### Harp seals

In 1995, stomachs and intestines of harp seal pups (ragged jackets as well as beaters) were examined in three sequential periods from 10 to 30 April. In 1996 and 1997, however, samples were generally collected over a more restricted period, and included only beaters. The stomachs were usually empty, but the incidence of empty intestines was low (0% to 15%). The percentage of occurrence of fourteen groups of prey is given in Table 1. Hyperiid amphipods of the genus *Parathemisto* occurred in 44% to 100% of the intestines, and *P. libellula* was particularly common. Amphipods belonging to the genus *Gammarus* sp., in particular the species *G. wilkitzkii*, were also encountered frequently in 1995 and 1996, but more rarely in 1997. The prey groups designated *Parathemisto* sp. and

*Gammarus* sp. most probably also include remains of *P. libellula* and *G. wilkitzkii*, which could not be identified to species. Some other amphipods also occurred occasionally in the intestines, including *Eusirus* sp. and representatives of the family Lysianassidae. Krill of genus *Thysanoessa* were rarely observed in the gastrointestinal system of harp seal pups in 1995, while in 1996 and 1997 they occurred much more frequently (56% to 73%). Contents from stomachs generally resembled those observed in the intestines.

The dominant groups of prey by relative numerical frequency is illustrated by Fig. 4. *Parathemisto* sp., in all probability mostly *P. libellula*, was the dominant prey item in stomachs and intestines of both ragged jackets and beaters in all sampling years, contributing with 64% to 90%. The contribution of the genus *Gammarus* was notable in 1995 (5% to 25%), while krill contributed significantly in 1996 and 1997 (10% to 29%). Other food items were of minor importance.

### Hooded seals

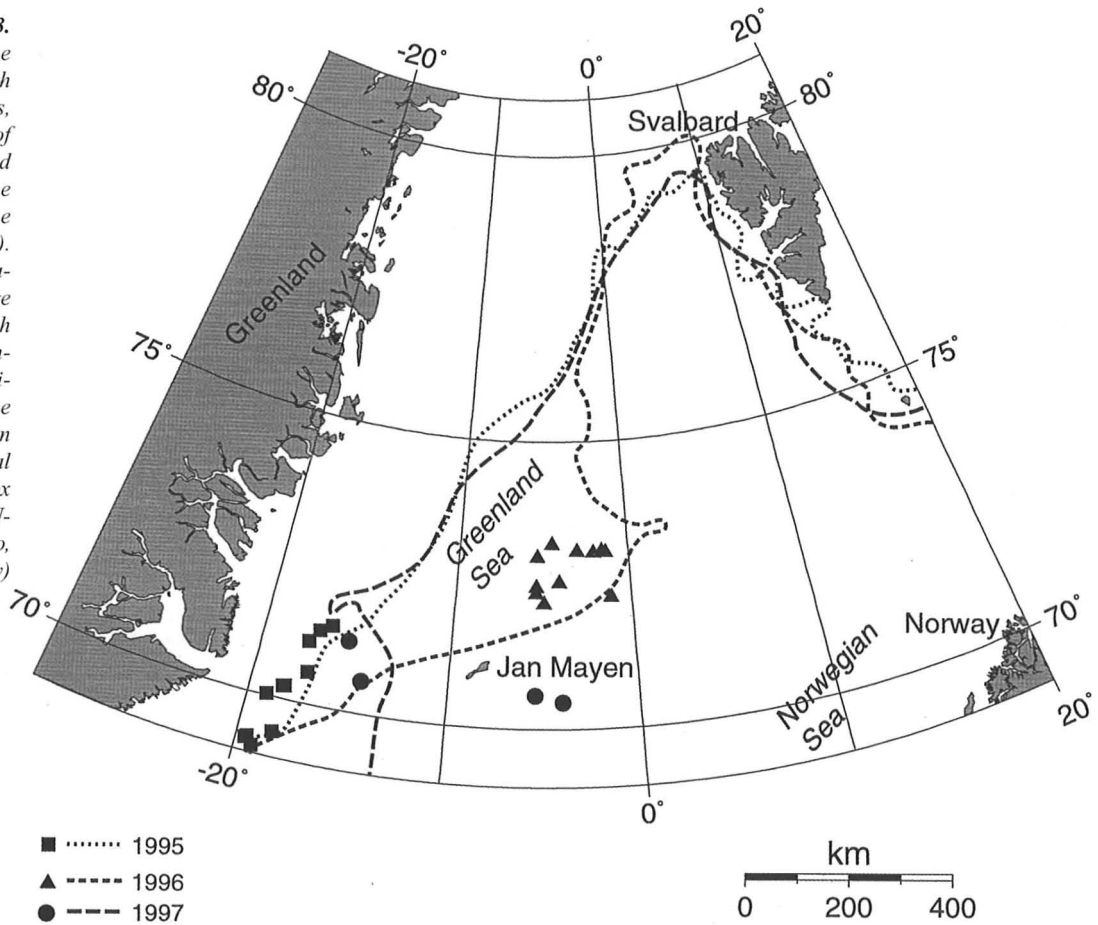
Bluebacks were examined in three sequential periods from 10 to 30 April in 1995, and in shorter periods of mid-April in 1996 and 1997 (Table 2). Most of the stomachs were empty (65% to 88%), while the frequency of empty intestines was much lower (0% to 38%). At least 20 different prey groups were identified. Crustaceans dominated the intestinal contents, but cephalopods and fish had also been con-

**Fig. 2:** Hooded seal pups, or «bluebacks», are weaned in only 3-5 days, after which they begin to feed on their own

Photo: Guðmundur Þórðarson



**Fig. 3.** Map indicating the 1995-1997 catch positions (squares, triangles, dots) of harp and hooded seal pups in the Greenland Sea (the "West Ice"). Approximate location of the ice edge in mid April in each of the three sampling years is indicated (Source: The Norwegian Meteorological Institute, PO Box 43 Blindern, N-0313 Oslo, Norway)



sumed. *P. libellula* was the most frequent prey species, occurring in 10% to 25% of the stomachs and 46% to 87% of the intestines. In 1995 and 1996, *G. wilkitzkii* was also of some importance, occurring in 5% to 9% of the stomachs and 15% to 33% of the intestines. Co-occurrence of *Parathemisto* and *Gammarus* was observed in 20% of the 1995 and 1996 samples. In 1997, *Gammarus* was found in only 6% of the intestines and not at all in the stomachs. Krill of the genus *Thysanoessa* occurred quite frequently in blueback intestines in 1996 (31%), but more rarely in 1995 and 1997.

In terms of numerical frequency of occurrence (Fig. 5), *Parathemisto* sp., mainly *P. libellula*, dominated with a contribution of 82% to 95% to the blueback gastrointestinal contents in all sampling years. The contribution of krill was considerable in 1996 (14% in the intestines), while *Gammarus* sp. contributed with 4% in 1995 and 1996. Other food items seemed to be of minor

importance.

#### Niche overlap

A year-by-year pairwise comparison of dietary niche between the two seal species (stomach and intestine contents pooled) yielded niche overlap values of 0.999, 0.963 and 0.995 for 1995, 1996 and 1997, respectively

#### DISCUSSION

This study demonstrates that harp seal pups are able to find prey and feed independently immediately after weaning, and that hooded seal pups do so at least two weeks after weaning. In both species, most stomachs were empty, but food remains were found in the intestines of nearly all the harp seal pups, and a large fraction of the hooded seal pups. The significance of this early independent feeding as an energetic supplement is, however, not known. The large frequency of empty stomachs could be indicative of rapid digestion by the pups, but may also reflect a

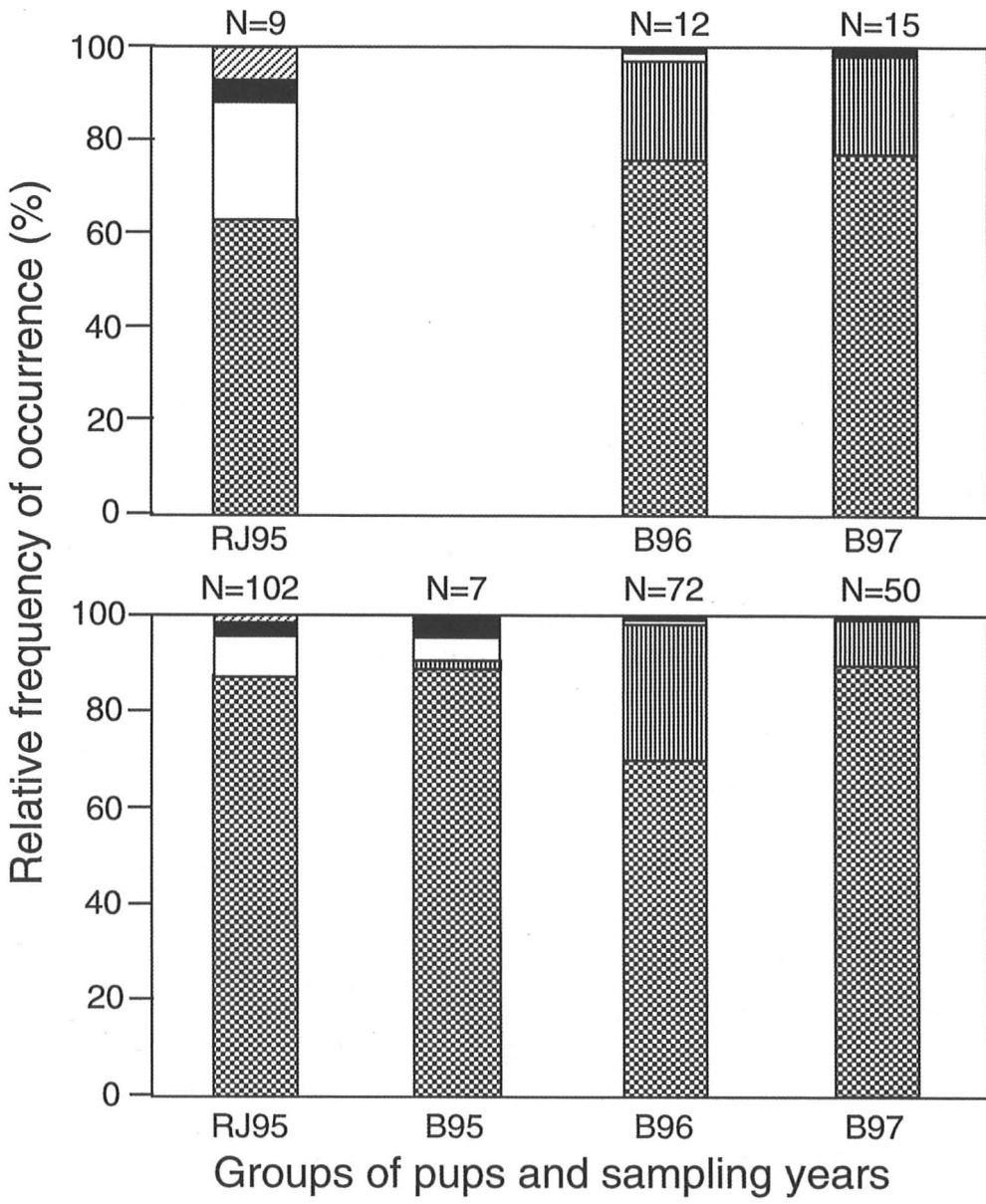


Fig. 4. Relative numerical frequency of occurrence of prey species in stomachs (above) and intestines (below) of West Ice harp seal pups (ragged jackets: RJ; beaters: B) in April in 1995, 1996 and 1997. N = number of stomachs/intestines examined.

- Various
- Thyssanoessa* sp.
- Other crustaceans
- Parathemisto* sp.
- Gammarus* sp.

**Table 1:** Frequencies of empty stomachs and intestines, and percentage occurrence of prey items in stomachs and/or intestines of West Ice harp seal pups (RJ = ragged jackets, B = beaters) captured in 1995 during the periods 10-16 April, 17-23 April and 24-30 April, respectively, in 1996 during the period 19-23 April, and in 1997 during the period 22-24 April. N = number of stomachs and/or intestines examined. "Others" includes remains such as hair and algae.

	1995					1996		1997	
	10-16 Apr.		17-23 Apr.		24-30 Apr.	19-23 Apr.		22-24 Apr.	
	RJ		RJ		B	B		B	
	stom.	intestines	intestines		intestines	stom.	intestines	stom. intestines	
N	73	73	26	6	9	73	73	50	50
Empty	87.7	2.7	15.4	0	0	83.6	1.4	70.0	0
Crustaceans									
Copepoda									
Copepoda indet.	0	0	11.5	16.7	11.1	1.4	6.8	8.0	4.0
Amphipoda									
<i>Parathemisto libellula</i>	5.5	52.1	57.7	100	55.6	15.1	94.5	28.0	96.0
<i>Parathemisto</i> sp.	4.1	47.9	57.7	100	44.4	12.3	89.0	22.0	98.0
<i>Gammarus wilkitzii</i>	5.5	43.8	38.5	66.7	44.4	2.7	20.5	2.0	2.0
<i>Gammarus</i> sp.	2.7	26.0	26.9	33.3	33.3	2.7	13.7	2.0	12.0
<i>Eusirus</i> sp.	0	6.8	11.5	16.7	11.1	0	0	2.0	4.0
Lysianassidae indet.	1.4	27.4	26.9	50.0	33.3	1.4	1.4	0	4.0
Amphipoda indet.	1.4	8.2	7.7	16.7	0	0	0	0	0
Euphausiacea									
<i>Thyssanoessa inermis</i>	0	0	0	0	0	0	0	8.0	2.0
<i>Thyssanoessa</i> sp.	0	0	7.7	16.7	0	12.3	72.6	22.0	56.0
Unidentified crustacea	0	0	11.5	0	0	0	1.4	0	0
Pisces									
<i>Boreogadus saida</i>	0	0	0	0	0	0	4.1	0	0
Others	1.4	2.7	3.8	0	11.1	0	4.1	0	0
Undetermined remains	1.4	32.9	11.5	0	22.2	1.4	0	0	0

moderate feeding intensity during this period. Examination of stomach and intestinal contents revealed that the first food of both harp and hooded seal pups was almost exclusively restricted to crustaceans. The post-weaning diet of the harp seal pups was particularly characterized by amphipods of the genus *Parathemisto*. In 1995, krill appeared to be rather unimportant, while amphipods of the genus *Gammarus*, in particular *G. wilkitzii*, contributed significantly to the diet. The situation was different in 1996 and 1997 when krill occurred much more frequently and *Gammarus* sp. more rarely. These changes in diet may reflect annual variation in the relative abundance of prey organisms in the Greenland Sea. Certainly, the differences in sampling sites due to variations in ice configurations between the years in question (Fig. 3) may have been a contributory factor. Unfortunately, there is no information available on prey abundance in the West Ice area.

Previous information about the feeding habits of

ragged jackets and beaters from the West Ice is very scarce, although Rasmussen (1957) observed beaters returning from dives with polar cod in their mouths in April. Only a few individuals of polar cod were recorded in the diet of harp seal pups in our study. Adult West Ice harp seals are known to feed mainly on *Parathemisto* sp. both during spring and early summer (April-June) (Potelov *et al.* this volume). The importance of crustaceans, *P. libellula* in particular, in the diet is also reported for the Barents and White Sea stock of harp seals. Weaned pups from this stock start their first independent feeding in the southeastern Barents Sea, and have been observed to have an early post-weaning diet dominated by krill, but with considerable amounts also of *Parathemisto* sp. (Haug *et al.* 1996). *Parathemisto* sp. and krill are important for pups and for older seals as well in the Barents Sea in late summer and early autumn (July-September), while in October there is a shift in the diet from crustaceans to fish (Nilssen *et al.* 1995, 1998, Lindström *et al.* 1998). Harp seals



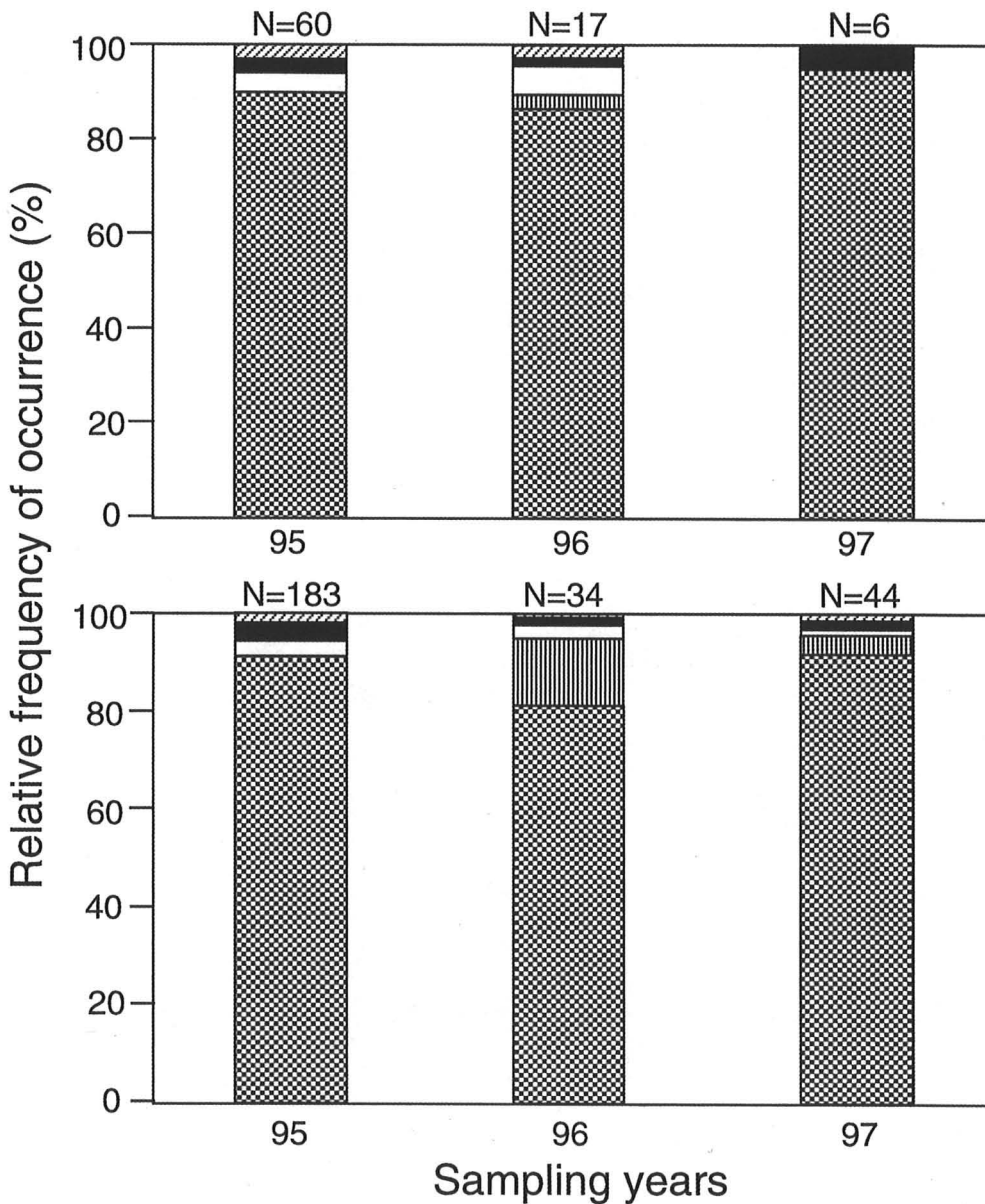


Fig. 5. Relative numerical frequency of occurrence of prey species in stomachs (above) and intestines (below) of West Ice hooded seal pups (bluebacks) in April 1995, 1996 and 1997. N = number of stomachs/intestines examined.

- Various
- Thyssanoessa sp.
- Other crustaceans
- Parathemisto sp.
- Gammarus sp.

**Table 2:** Frequencies of empty stomachs and intestines, and percentage occurrence of prey items in stomachs and/or intestines of West Ice hooded seal pups (bluebacks) captured in 1995 during the periods 3-9 April, 10-16 April, 17-23 April and 24-30 April, respectively, in 1996 during the period 9-23 April, and in 1997 during the period 17 - 18 April. N = number of stomachs/intestines examined. "Others" includes remains such as hair and algae.

	1995						1996		1997	
	10-16 Apr.		17-23 Apr.		24-30 Apr.		19-23. Apr.		22-24 Apr.	
	stom.	intest.	stom.	intest.	stom.	intest.	stom.	intest.	stom.	intest.
N	39		181		15		49		51	50
Empty	87.2	38.5	70.9	19.6	80.0	0	65.3	30.6	88.2	12.0
Crustaceans										
Copepoda										
Copepoda indet.	0	2.5	0	0.6	0	0	0	0	2.0	4.0
Amphiphoda										
<i>Parathemisto libellula</i>	10.3	46.2	25.7	67.0	20.0	86.7	28.6	53.0	9.8	76.0
<i>Parathemisto abyssorum</i>	0	0	0	0	0	0	0	0	0	2.0
<i>Parathemisto</i> sp.	2.6	25.6	10.1	33.0	6.7	66.7	12.2	26.5	3.9	40.0
<i>Gammarus wilkitzii</i>	5.1	15.4	8.9	16.8	6.7	33.3	14.3	18.4	0	6.0
<i>Gammarus</i> sp.	0	5.1	1.7	3.4	0	13.3	6.1	4.1	0	4.0
<i>Eusirus</i> sp.	2.6	0	4.5	14.0	0	26.7	0	0	2.0	2.0
Lysianassidae indet.	0	2.6	0.6	2.8	0	0	2.0	0	0	0
Amphiphoda indet.	0	0	0	0.6	0	6.7	0	4.1	0	0
Euphausiacea										
<i>Thysanoessa inermis</i>	0	0	0	0	0	0	0	0	0	12.0
<i>Thysanoessa</i> sp.	0	0	0	0.6	0	6.7	16.3	30.6	0	6.0
<i>Meganycitiphanes norvegica</i>	0	0	0	0	0	0	0	0	0	2.0
Decapoda										
Decapoda indet.	0	0	2.2	6.7	0	13.3	2.0	4.1	0	0
Unidentified crustacea	0	2.6	1.7	6.1	0	6.7	0	2.0	3.9	8.0
Cephalopods										
<i>Gonathus fabricii</i>	0	0	1.7	2.8	6.7	13.3	2.0	4.1	0	2.0
Pisces										
<i>Boreogadus saida</i>	0	2.6	1.7	6.1	0	6.7	8.2	18.4	0	4.0
Gadoidea indet.	0	0	0	0.6	0	6.7	0	2.0	0	0
Unidentified fish	0	0	0	0.6	0	0	0	0	0	0
Others	1.9	2.6	16.2	2.2	13.3	6.7	26.5	10.2	0	12.0
Undetermined remains	0	5.1	0	5.0	0	0	0	8.2	0	0

have been reported to consume amphipods, in particular *P. libellula*, in considerable amounts also in the Arctic areas of Greenland and Canada (Sergeant 1973, Davis *et al.* 1980, Finley *et al.* 1990, Kapel 1995).

The initial blueback diet appeared to be very similar to that observed for the harp seal pups: a dominance of *Parathemisto* (almost exclusively *P. libellula*), with some contribution from *Gammarus* sp. (mainly *G. wilkitzii*). Krill appeared in the 1996 and 1997 blueback diet, while it was absent in 1995, a situation similar to that observed for the harp seal pups. There is some evidence that the abundance of non-crustacean prey items such as polar cod and the cephalopod *Gonatus fabricii* may increase

towards the end of April. The occurrence of crustaceans in the diet of the youngest bluebacks and an increasing amount of fish and cephalopods in the diet of the older ones was observed in the West Ice in 1932 and 1937 by Høst (1948). Both polar cod and in particular *G. fabricii* are known to be important food items for adult hooded seals in the West Ice (Potelov *et al.* 2000), although cephalopods and crustaceans were predominant food items for young-of-the-year hooded seals in Southeast Greenland in early September 1991 (Kapel 1995). In other areas, hooded seals are known to be mainly piscivorous (Ross 1993, Kapel 1995).

In the Northwest Atlantic, *P. libellula* has been shown to be a dominant species in cold water



plankton communities in the upper 50 m of the water column (Percy 1993). The dominance of *Parathemisto* sp. in the diets of both harp and hooded seal pups in the West Ice confirms previous suggestions that these amphipods are important links in the food chain between herbivorous zooplankton and marine fish, birds and mammals in most Arctic waters (Dunbar 1942, 1946, 1957, Sergeant 1973, Davis *et al.* 1980, Bradstreet and Cross 1982, Lønne and Gulliksen 1989, Aijad and Gjørseter MS 1990, Mehlum and Gabrielsen 1993). In the Barents Sea, krill species of the genus *Thysanoessa* are also known to be important links between herbivorous zooplankton and fish, sea birds and mammals (Sakshaug *et al.* 1992), and the present investigation seems to indicate that krill may, at least occasionally, be of some importance as food for seal pups in the Greenland Sea as well.

*G. wilkitzkii* is an autochthonous sympagic amphipod of Arctic areas (Gulliksen and Lønne 1991), and its occurrence in the diet of West Ice harp and hooded seal pups suggests that the pups may perform their first feeding excursions at the ice-water interface. *G. wilkitzkii* is most abundant in the perennial sea ice zone areas (Gulliksen and Lønne 1991), and this may explain why the species was present in the diets of the seal pups in the multi year sea ice areas of the West Ice, while it is known to be absent from the diets of harp seal pups in the seasonal sea ice areas of the southeastern Barents Sea (Haug *et al.* 1996). Given its high degree of co-occurrence with *G. wilkitzkii* in the seal stomachs and/or intestines, and its frequent occurrence close to the surface of sea ice, *P. libellula* may

also have been taken by the seal pups as they foraged near the undersurface of the ice floes. However, *P. libellula* is classified as belonging to the planktonic fauna, due both to its lack of physical association with sea ice and to its frequent pelagic occurrence in ice-free cold water areas (Gulliksen and Lønne 1991, Lønne and Gulliksen 1991). This prey may therefore have been consumed by seals foraging in open waters and/or at greater depths.

The general impression of similarity, gained from both the frequency of occurrence (Tables 1 and 2) and relative frequency of occurrence (Figs 2 and 3) of prey items between the two seal species, was confirmed by the niche overlap values, which were very close to unity in all years of investigation. The high degree of overlap along the niche dimensions describing the diet indicates that the behaviour of harp and hooded seal pups during their first independent feeding in the West Ice must be quite similar. Given their coinciding geographical and temporal appearance in the area, some interspecific competition between the two species may be inferred.

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