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Andrew E. Derocher · Øystein Wiig · Magnus Andersen

Diet composition of polar bears in Svalbard and the western Barents Sea

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Abstract We estimated both the numerical and biomass composition of the prey of polar bears (*Ursus maritimus*) from 135 opportunistic observations of kills in Svalbard and the western Barents Sea collected from March to October 1984–2001. By number, the prey composition was dominated by ringed seals (*Phoca hispida*) (63%), followed by bearded seals (*Erignathus barbatus*) (13%), harp seals (*P. groenlandica*) (8%) and unknown species (16%). However, when known prey were converted to biomass, the composition was dominated by bearded seals (55%), followed by ringed seals (30%) and harp seals (15%). Results indicated that bearded seals are an important dietary item for polar bears in the western Barents Sea. We believe that different patterns of space use by different bears may result in geographic variation of diet within the same population.

Introduction

The most carnivorous of the Ursidae, polar bears (*Ursus maritimus*) are thought to prey largely on ringed seals (*Phoca hispida*) and, to a lesser extent, on bearded seals (*Erignathus barbatus*) (Stirling and Archibald 1977; Smith 1980; Gjertz and Lydersen 1986; Stirling and Øritsland 1995). However, the diet of polar bears is still poorly understood, with limited information about the relative energetic contribution of prey species and the seasonal composition of prey. An earlier study of polar bear diet in Svalbard also suggested that ringed and bearded seals were the main prey (Lønø 1970). Uncertainty in diet composition arises because polar bears also consume a variety of other species, including walrus (*Odobenus rosmarus*) (Calvert and Stirling 1990), white whales (*Delphinapterus leucas*) and narwhal (*Monodon monoceros*) (Lowry et al. 1987; Smith and Sjare 1990), harp seals (*P. groenlandica*) (Lønø 1970), seabirds (Stempniewicz 1993) and carrion (Christiansen 1981). However, most studies concur that seals are the main prey.

In this paper, we document polar bear predation on ringed, bearded and harp seals in Svalbard and the western Barents Sea from observations of seal kill sites. We also discuss the relative importance of these species in the diet of polar bears.

A.E. Derocher (✉) · M. Andersen
Norwegian Polar Institute,
9296, Tromsø, Norway
E-mail: derocher@npolar.no
Tel.: +47-77-750524
Fax: +47-77-750501

Ø. Wiig
Zoological Museum,
University of Oslo,
P.O. Box 1172 Blindern, 0318,
Oslo, Norway

Materials and methods

Sampling occurred from 1984 to 2001, from March to October, on an opportunistic basis. The total sampling area is approximately contained by the outermost locations of seal kills (Fig. 1). Polar bears in the sampling area represented all age, sex and reproductive classes in the population, and we believe the seal kills were representative of those taken by the population.

Seal kills on the sea ice are easy to identify due to the presence of blood, scavengers (glaucous gulls, *Larus hyperboreus*, ivory gulls, *Pagophila eburnea*, arctic fox, *Alopex lagopus*), or bears at the kill. We were able to exclude arctic fox predation based on presence or absence of tracks. Most ($n = 113$) seal kill sites were located while tracking polar bears by helicopter, during research on polar bear ecology. Observations collected during August (1999) were obtained during an aerial survey to estimate polar bear abundance. Some information on kills was collected from other researchers working in the area. We included 22 samples noted in earlier studies of seal predation to increase geographic coverage. We included 6 ringed seal kills from Gjertz and Lydersen (1986), 1 ringed seal kill from Lydersen and Gjertz (1986) and 15 ringed seal kills from Wiig et al. (1999).

Limited information from kills was available from most observations. Identification of species and age class of the kill was based on assessment from the air, ship or by examination of

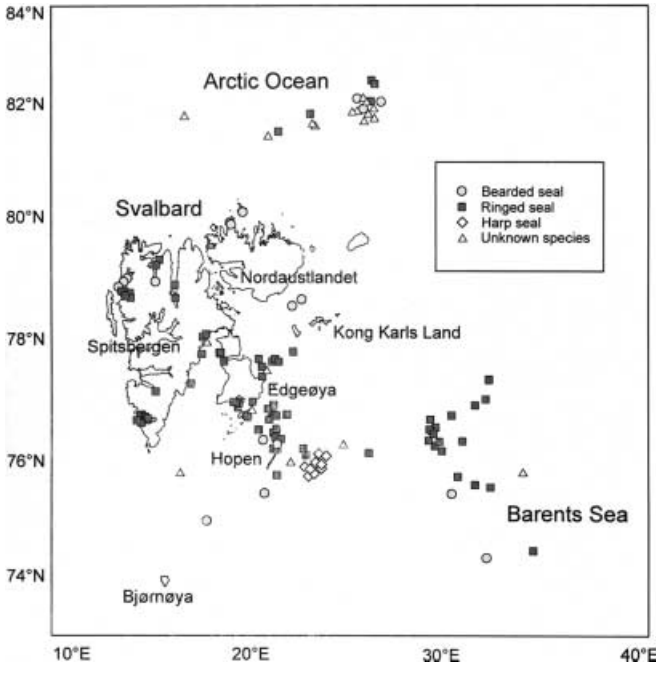

Fig. 1. Distribution of ringed seal, bearded seal, harp seal and unknown seal species killed by polar bears in Svalbard and the western Barents Sea in 1984–2001. The study area is approximately delineated by the outermost kill sites

remains. It was sometimes not possible to identify the prey species or age as only bone fragments or blood remained. During the spring pupping season, kills at digs in rough pressure-ridged ice with little blood in the area were classified as ringed seal pups. Adult bearded and harp seals were obvious from their size. Because teeth and claws were available from only a few samples (less than ten animals), ages from these were not determined.

We estimated prey biomass in the diet of polar bears using a mean mass as an approximation of the size for each seal species. We excluded all prey of unknown species and age class for biomass estimation. The mass of adult seals was obtained from growth curves using the mean asymptotic sizes of females and males. Adult mass of ringed seals was set at 57 kg (Lydersen and Gjertz 1987), 273 kg for bearded seals (Andersen et al. 1999) and 131 kg for harp seals (Innes et al. 1981). We pooled juvenile and adult seals and used adult size in calculations to treat the three species in a similar manner, but recognised that this may be a source of error. We averaged the birth and weaning masses to estimate pup body mass, from published studies. For ringed seals, we used 11 kg, based on a birth mass of 4.55 kg and a weaning mass of 18 kg (Lydersen et al. 1992). Similarly, we used 62 kg for bearded seal pups, which was based on a birth mass of 33 kg (Burns 1981) and a weaning mass of 92 kg (growth of 3.3 kg/day over 18 days) (Lydersen et al. 1994).

Results

Information was obtained on 135 seal kills (Table 1) with 120 (89%) collected in 1995–2001. Numerically, the majority of the kills were ringed seals (63%), followed by bearded seals (13%), harp seals (8%) and 16% of unknown species. The numerical kill composition of known species ($n = 114$) was 75% ringed seal, 16% bearded seal and 9% harp seal. Most (14/21) of the unknown prey species were from August, when sampling was conducted during an aerial survey and checking kills on the ground was not possible. Of the ringed seal kills, pups composed 72% (54/75) of those classified to age group. For bearded seals, 31% (5/16) were pups. The prey composition by biomass ($n = 98$) was estimated to be composed of 50% adult bearded seal, 20% adult ringed seal, 10% ringed seal pup, 15% harp seal and 5% bearded seal pup.

The seasonal distribution of predation was difficult to assess due to non-representative sampling through the months. However, ringed seal predation appeared to dominate in spring during the pupping season, and predation on bearded seals was more evenly distributed through the sampling period. Observation of harp seal predation was restricted to June. Twenty-four kills were observed during August, with eight in multiyear ice. While many of these kills were not identified to species, bearded seals were abundant in the area and two of four adult bearded seal kills in August were in multiyear ice. Insufficient data were available to determine the spatial patterns of the kills but it appeared that predation events occurred throughout the study area (Fig. 1).

Discussion

Estimating the diet of any free-ranging animal is a difficult undertaking and prone to inaccuracies. Given the inaccessibility of polar bear habitat, it is extremely problematic to obtain an overview of their diet, particularly in remote areas, during summer when the ice is melting, and during the winter dark period. The methods used in our study were opportunistic and classification into age classes was approximate. Using a mean pup mass and asymptotic mass for adults may result in biases of estimating intake if, for example, bearded seals

Table 1. Number of seal kills found opportunistically in Svalbard and the western Barents Sea from 1984 to 2001 and attributed to polar bear predation, in relation to month

Month	Ringed seals			Bearded seals			Harp seals		Unknown
	Ad/Juv	Pup	Unk	Ad/Juv	Pup	Unk	Ad/Juv	Unk	
March	1	2	–	–	–	–	–	–	–
April	9	35	6	3	1	–	–	–	4
May	7	17	1	2	4	1	–	–	2
June	–	–	–	2	–	–	7	4	–
August	3	–	3	4	–	–	–	–	14
October	1	–	–	–	–	1	–	–	1
Total	21	54	10	11	5	2	7	4	21

killed were well below the asymptote. However, we feel that the methods used are a reasonable representation and any method would result in some level of bias. We could not assess possible sampling bias of the different prey. For example, it is possible that a fresh kill of a large bearded seal may be more easily detected than a smaller ringed seal killed some days earlier. Therefore, interpretation of our data must proceed with caution.

Marine-mammal resources available to polar bears in the study area are poorly understood and quantitative estimates are unavailable for most potential prey. Bearded seals are widely distributed throughout Svalbard and the western Barents Sea (Benjaminsen 1973), and their distribution overlaps substantially with that of polar bears. Bearded seals are largely benthic feeders and can dive to depths up to 400 m (Burns 1981; Gjertz et al. 2000), so that most of the Barents Sea, which is less than 300 m deep, may provide feeding habitat. The abundance of bearded seals is uncertain but may number in the 300,000 range in the North Atlantic (Burns 1981).

The ringed seal population size in the Svalbard area is unknown but the global population likely numbers in the millions (Reeves 1998). In Svalbard and the western Barents Sea, there is ringed seal reproduction in both land-fast ice (Smith and Lydersen 1991) and drifting pack-ice (Wiig et al. 1999). During studies of ringed seal breeding habitat in Svalbard, a discrepancy was noted in the production of ringed seals and the number of ringed seals required to support the polar bear population in the area (Smith and Lydersen 1991). Smith and Lydersen (1991) suggested that pack-ice production of ringed seals may be an important contribution to the population. Our results further confirm the findings of Wiig et al. (1999) that ringed seals breed in the drifting pack ice of the Barents Sea, particularly northwest of Hopen Island. Ringed seals are available to all bears in the study population.

The Barents Sea harp seal population is approximately 2.2 million animals (Nilssen et al. 2000) and represents a potentially abundant food source for polar bears. However, harp seals do not reach polar bear habitat until April/May and then increase in abundance along the drift-ice edge until October, when they return south (Haug et al. 1994; Nordøy et al. 1998). Harp seals are available to polar bears particularly in early summer, when both species select open ice (10–60% cover) (Haug et al. 1994). However, some harp seals are pelagic and this portion of the population is unavailable to polar bears (Nordøy et al. 1998). Further research is needed to quantify the importance of harp seals to this polar bear population.

The only previous study of polar bear diet in the study area comes from bears harvested throughout the year near Svalbard; 52 ringed seals, 10 bearded seals and 6 harp seals were found in stomachs (Lønø 1970). Harp seals were only found during June/August and most bearded seals (9/10) were found in the same period. The prey composition from this study was 76% ringed seal, 15% bearded seal and 9% harp seal, and was very similar to the composition of the 114 samples of known species in our study. Numerically, similar to earlier studies, ringed seals are the dominant prey of polar bears. However, on a biomass basis, the results from Lønø (1970), together with ours, suggest that the diet of polar bears in Svalbard and the western Barents Sea has a significant contribution from bearded seals. However, in the eastern Barents Sea, a Russian study reported 68% ringed seal, 22% walrus and miscellaneous other items for the diet of polar bears (Parovshchikov 1964) and may reflect further geographic variation in the same population. Studies of fatty-acid profiles of polar bears suggest that geographic variation in diet may be large (Iverson et al. 1999).

Polar bears in Svalbard and the western Barents Sea area are part of a common population that extends as far east as Franz Josef Land (Mauritzen et al. 2002). Polar bears living in the study area have two different space use patterns: one group lives near shore and has small annual ranges whereas the other lives offshore and has larger ranges (Mauritzen et al. 2001). Annual range size of adult females ranged from 185 to 373,539 km^2 and dietary differences were postulated to explain the different space use patterns (Mauritzen et al. 2001). In particular, Mauritzen et al. (2001) suggested that near-shore bears relied more on the land-fast ice and preyed largely on ringed seals during spring while pelagic bears preyed more on bearded and harp seals over a longer period. Our results support this hypothesis given that most of the kills observed in June and August were in multiyear pack-ice where the pelagic bears tend to summer.

Sampling of polar bear kills is not easily accomplished and most other studies have been conducted over a relatively brief period during the spring when ringed seals pup (Stirling and Archibald 1977; Smith 1980). Further, these studies have been restricted to the Canadian Archipelago where stable ice creates good ringed seal breeding habitat (Hammill and Smith 1989, 1991; Furgal et al. 1996). The results from our study suggest that polar bears in the Barents Sea, which summer in the multiyear ice, may feed on seals all year.

Polar bears are opportunistic and other prey species are available to them in the study area. Hooded seals (*Cystophora cristata*) range northward to the ice edge in summer and overlap with polar bears (Gjertz 1991). We found no instances of walrus predation but, as the walrus population in Svalbard recovers from overharvest (Gjertz and Wiig 1995), it is possible that walrus predation may increase. In addition, harbour seals (*Phoca vitulina*) are found in the Svalbard Archipelago (Gjertz et al. 2001) and, during the ice-free period in August 2001, we observed polar bears attempting aquatic stalks of hauled-out harbour seals in Van Keulen Fjord on the west coast of Svalbard. We did not observe successful predation but did observe several polar bear tracks in the bottom sediments near shore and saw two bears swimming toward hauled-out seals.

Polar bears are also opportunistic scavengers. In summer 2001, polar bears were observed feeding on both a white whale carcass and a sperm whale (*Physeter macrocephalus*) carcass in northern Svalbard (J.O. Scheie, personal communication). In these 2 observations, up to 14 and 17 bears, respectively, were observed on the carcasses, suggesting that scavenging is important for many individuals. Further, observations of predation and scavenging of reindeer (*Rangifer tarandus platyrhynchus*) (Derocher et al. 2000) attest to the diversity of diet.

Prey composition is an important element for understanding the ecotoxicology of polar bears. In Svalbard, there was speculation that harp seals were responsible for the high levels of polychlorinated biphenyls in polar bears (Kleivane et al. 2000; Gabrielsen and Henriksen 2001). However, our results make it clear that more detailed study of polar bear diet is required to understand trophic transfer of pollutants. In particular, mother-offspring transfer of pollutants can result in nursing young having higher pollution loads than the mother (Tanabe and Tatsukawa 1991; Polischuk et al. 1995; Beckmen et al. 1999). Given the large number of ringed and bearded seal pups consumed by polar bears, it is important that the pollution load of seal pups be studied. However, careful quantification of the season-, sex- and age-specific diet of polar bears is required before trophic-level transfer of pollution can be understood. Similarly, if climate change alters the distribution and abundance of prey (Stirling and Derocher 1993), better documentation of current predation patterns is essential for understanding the effects of climate change on polar bears.

In summary, similar to other areas, the diet of polar bears in Svalbard and the western Barents Sea is dominated by ringed seals on a numerical basis, but bearded seals make a significant contribution to the diet when biomass is considered. Harp seals likely play an important, but lesser, role in the diet of bears living in more pelagic habitats, but only during the summer months.

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