

# Seabird distribution in the northern Barents Sea marginal ice-zone during late summer

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The abundance of five seabird species in ice-covered parts of the northern Barents Sea in late summer 1982 was analysed in relation to differences in sea-ice coverage. The dominant species was the Little Auk *Alle alle*. Differences between the seabird species in the use of the sea-ice habitat are partly explained by differences in their feeding ecology, and, for alcid species, by the need for open water for getting airborne. All species, except for the Fulmar *Fulmarus glacialis*, took as part of their diet organisms associated with the subsurface of the sea-ice. The Little Auk fed mainly on large copepods and pelagic amphipods, and was observed mainly in areas with low ice-cover where such zooplankters are abundant.

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The marginal ice-zones in arctic and antarctic waters are generally thought to be important to seabirds (Brown 1989). The pelagic distribution patterns of several species, e.g. the Ivory Gull *Pagophila eburnea* and Ross' Gull *Rhodostethia rosea* in the Northern Hemisphere (Mehlum 1989), and Snow Petrel *Pagodroma nivea*, Emperor Penguin *Aptenodytes forsteri*, and Adelie Penguin *Pygoscelis adeliae* in the Southern Hemisphere (Cline et al. 1969; Ainley et al. 1984), are limited by the extent of the sea-ice. Other species occur in high densities along ice-edges and in the marginal ice-zone (Irving et al. 1970; Divoky 1979; Renaud et al. 1982; Brown 1985; Fraser & Ainley 1986).

However, few studies have conclusively demonstrated that the occurrence of seabirds in sea-ice is a direct result of searching for prey, or of physical features (fronts, convergences, etc.) which may coincide with concentrations of prey (Fraser & Ainley 1986; Hunt this volume).

In summer, in the northern Barents Sea, the ice-edge and the marginal ice-zone retreat northwards (Vinje 1985). A high biological production is associated with the ice-zone during this retreat (Sakshaug & Skjoldal 1989), and provides food for the large number of seabirds (Mehlum 1989). Different seabird species in this area prey upon different food types according to their morphological limitations. Some are surface feeders, while others are pursuit divers which hunt their prey in the free water masses or at the under-

surface of the sea-ice. Sea-ice will naturally limit the access to the sea for foraging seabirds, especially for surface feeders. Because planktonic organisms are patchily distributed at scales of metres to hundred of metres (Haury et al. 1978), it is likely that the distribution of the different seabirds at sea and within the sea-ice zone will reflect the availability of suitable prey. In this paper I present seabird abundances in different concentrations of sea-ice east of Svalbard, and discuss the results in relation to the feeding ecology of the birds.

## Material and methods

The survey was made from R/V 'Lance' 22–25 August 1982 in the marginal ice-zone between Kong Karls Land and Frans Josef Land. I made 122 10-minute counts between 79° 17'N, 40° 24'E and 79° 00'N, 31° 14'E. Ice-cover was recorded and averaged over each 10-minute period on a scale from 0/8 (no ice) to 8/8 (100% ice-cover). Data from 1–2, 3–4, 5–6, and 7–8/8 were pooled in order to increase the sample size in each category. No 10-minute periods had 0/8 ice-cover. Seabird counts were made by recording all birds observed by the naked eye within 180 degrees in front of the vessel when moving at >5 knots (Mehlum 1989).

The survey occurred after the breeding season, so as not to bias the results by foraging distance

limitations of birds associated with breeding colonies.

Some seabirds were collected for stomach content analyses. The procedure and complete results were reported in Mehlum & Gjertz (1984).

## Results

The most commonly seen species was the Little Auk *Alle alle*, which accounted for 63.4% of the birds observed (Table 1); the Black Guillemot *Cephus grylle* was the second most numerous species. Only 17 Brünnich's Guillemots *Uria lomvia*, one of the most numerous species in the northern Barents Sea seabird community (Mehlum 1989), were seen. Twenty-one Ross'

Table 1. Total number of individuals observed among the seven most numerous seabird species between Kong Karls Land and Frans Josef Land, August 1982. Median ice-cover for the observations of each species is also presented.

Species	Number	%	Median ice-cover
Little Auk <i>Alle alle</i>	4,360	63.4	3/8
Black Guillemot <i>Cephus grylle</i>	1,154	16.8	2/8
Kittiwake <i>Rissa tridactyla</i>	736	10.7	4/8
Fulmar <i>Fulmarus glacialis</i>	395	5.7	3/8
Ivory Gull <i>Pagophila eburnea</i>	196	2.8	4/8
Ross' Gull <i>Rhodostethia rosea</i>	21	0.3	4/8
Brünnich's Guillemot <i>Uria lomvia</i>	17	0.2	3/8

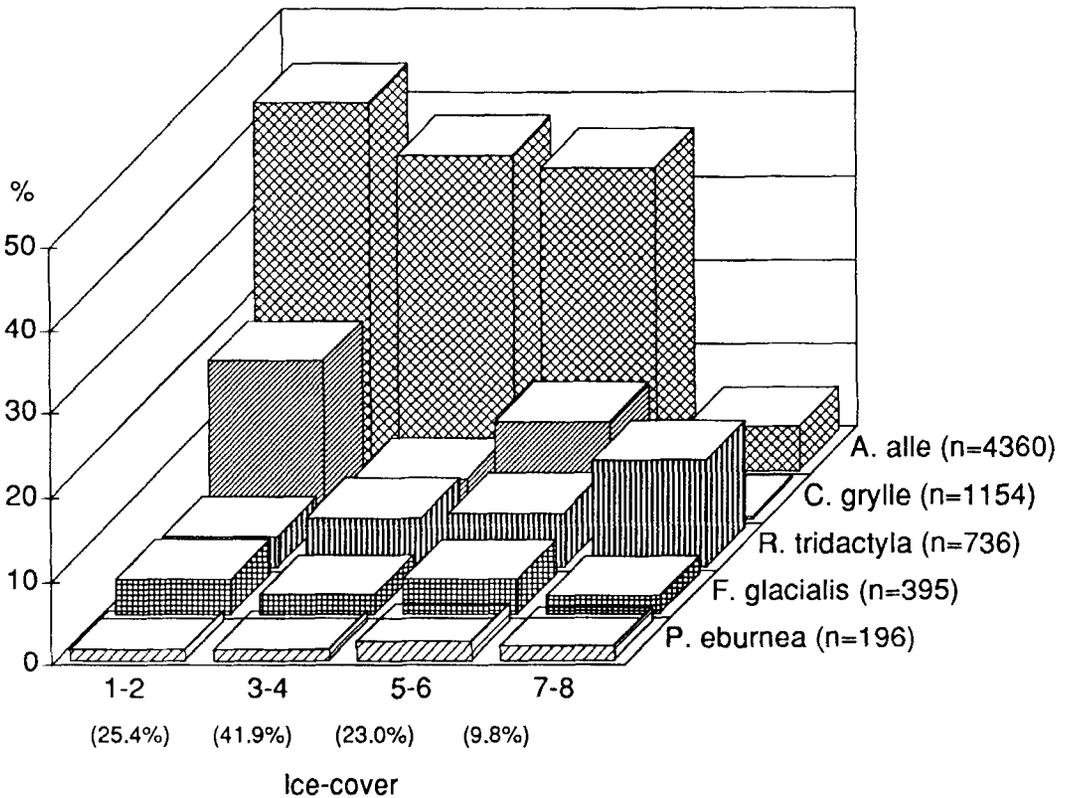


Fig. 1. Relative abundances of five seabird species in relation to ice-cover. The Y-axis represents the percentages of the 122 10-minute observation periods within which the species were present. The percentages of the total transect length in each ice-cover category are given in parentheses on the X-axis.

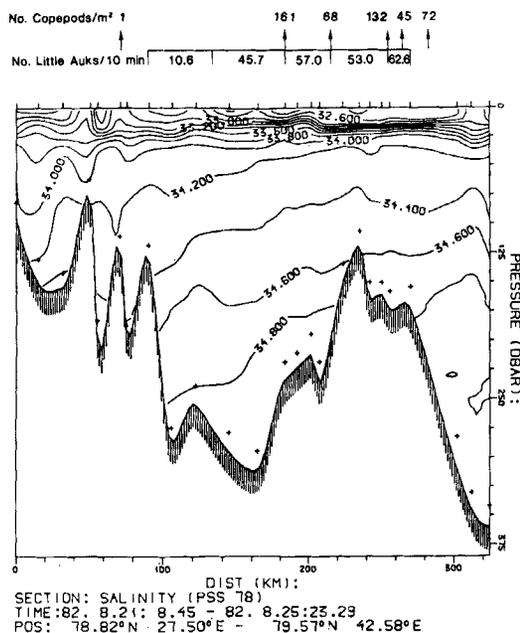


Fig. 2. Salinity profile for the section investigated. Mean numbers of Little Auks *Alle alle* observed per 10-min observation period and density per m<sup>2</sup> of copepods below the sea-ice are also given. (Salinity profile, after T. Gammelsrød unpublished; copepods, after Gulliksen 1984.)

Gulls were seen. This species was recorded in 9 of the 122 10-minute periods.

Both the Little Auk and the Black Guillemot were less frequent in dense ice cover (7/8–8/8) than in areas with more open water ( $X^2 = 348.2$ ,  $df = 1$ ,  $p < 0.001$  and  $X^2 = 117.8$ ,  $df = 1$ ,  $p < 0.001$ , respectively) (Fig. 1). The Fulmar *Fulmarus glacialis* and the Ivory Gull were more evenly distributed over the four groups of ice coverage. In contrast, Kittiwakes *Rissa tridactyla*

occurred more frequently in areas with dense ice-cover (7/8–8/8) ( $X^2 = 96.0$ ,  $df = 1$ ,  $p < 0.001$ ). Ross' Gulls were seen in ice-cover from 3/8 to 7/8, and 57% of the observations were made in 3/8–4/8. The sample size is too small to determine preferences of ice coverage.

In Fig. 2, the abundance of Little Auks along the transect is compared to the salinity profile (Gammelsrød unpublished) and the density of calanoid copepods sampled below the sea-ice subsurface (Gulliksen 1984). In the eastern part of the section, there was a strong salinity and temperature stratification above 20–25 m, with low salinities and temperatures near the surface. All the under-ice zooplankton stations within the eastern part of the section contained high numbers of calanoid copepods, while one station to the west had few (Gulliksen 1984). The data presented in Fig. 2 indicate that areas with abundance of zooplankton associated with the strong stratification in the upper layer of the sea are attractive feeding areas for Little Auks.

A separate analysis of the stomach contents of birds shot during the cruise (summarized in Table 2) showed that the marginal ice-zone was used extensively as a feeding area (Mehlum & Gjertz 1984). Most individuals contained newly ingested prey.

Sympagic fauna (i.e. animals associated with the undersurface of the sea-ice) were major prey of Black Guillemots, Kittiwakes and Ivory Gulls (Table 2). However, Little Auks and Fulmars mainly preyed upon pelagic organisms. Sympagic organisms, mainly gammarid amphipods and polar cod *Boreogadus saida*, were found in stomachs of all the seabird species investigated, except for the Fulmar. Only four Fulmar stomachs were examined, and they contained remnants of

Table 2. Stomach content of seabirds collected in the marginal ice-zone between Kong Karls Land and Frans Josef Land, August 1982. Sample sizes in parentheses (data from Mehlum & Gjertz 1984).

	<i>Nereis</i>	<i>Calanus</i>	Gammaridae	<i>Parathemisto</i>	<i>B. saida</i>	Others
<i>F. glacialis</i> (4)	xx			xx		xx*
<i>A. alle</i> (19)		xx	x	xx		
<i>C. grylle</i> (7)		x	x		xx	x**
<i>R. tridactyla</i> (7)					xxx	xx***
<i>P. eburnea</i> (6)			x		xx	x****

x = 10–40%, xx = 40–70%, xxx = >70% frequency of occurrence in stomachs investigated.

\* Cephalopods

\*\* *Lycodes*

\*\*\* *Lycodes*, Cottidae

\*\*\*\* Mammalian blubber

pelagic prey, i.e. polychaetes (*Nereis* sp.), cephalopods (*Gonatus* sp.), and the pelagic amphipod *Parathemisto libellula*. The main diet of Little Auks was copepods *Calanus* sp. and *Parathemisto*. In the northern Barents Sea the fauna of sympagic animals is well developed, reaching a mean biomass of 9.6 g per m<sup>2</sup> sub-surface of sea-ice, with higher values in multi-year ice than in first year ice (Gulliksen 1984; Gulliksen & Lønne 1989).

## Discussion

In late August 1982, there were large numbers of Little Auks in the marginal ice-zone in the area between the eastern parts of Svalbard (Kong Karls Land) and Frans Josef Land. According to the distribution maps presented by Mehlum (1989), this is probably a regular phenomenon. The area is also important for other seabird species, but they are less common than the Little Auk. Species such as the Ivory Gull, Ross' Gull and Black Guillemot are often associated with areas with sea-ice in the northern Barents Sea during late summer, while others such as the Fulmar and the Kittiwake are distributed both in ice-covered and open waters farther south at this time of the year (Mehlum 1989). A high proportion of the Little Auks and Black Guillemots are immature and moulting individuals (Mehlum 1989).

The less frequent occurrence of Little Auks and Black Guillemots in very dense sea-ice (7/8–8/8) may partly be due to their need for sufficient open water between the ice-floes to take off into the air. Gulls, on the other hand, which can take off vertically, are associated with dense ice where they search for prey which may be exposed when ice-floes grind together in the moving pack-ice or when they turn upside down.

The polar cod was a major prey of Kittiwakes, Ivory Gulls and Black Guillemots. The youngest year-groups of polar cod are known to associate with sea-ice, the typical habitats being between sandwiched ice-floes or in melting holes and crevices in the ice (Lønne & Gulliksen 1989).

In contrast, the Little Auk does not seem to be dependent on the sympagic fauna, but feeds mainly on copepods and young specimens of the amphipod *Parathemisto libellula* living in the water column. Bradstreet (1982) also reported that little Auks selected the oldest age-stages of

the largest potential prey in his study area in the Canadian Arctic. Similar information is reported from Novaya Zemlya (Zelickman & Golovkin 1972).

The strong stratification in temperature and salinity observed above 20–25 m depth along the ice-edge was caused by melting of sea-ice, forming a relatively stable and nutrient rich body of water in which primary production is high (Sakshaug & Skjoldal 1989). The algal populations are grazed upon by the growing stages of zooplankton, in these waters dominated by *Calanus glacialis*. According to Sakshaug & Skjoldal's (1989) model of the abundance of *Calanus glacialis* along the ice-edge in the northern Barents Sea, the largest (oldest) age-stages should be found in the outer part of the ice-zone, grazing on the phytoplankton bloom. It was in these areas with low ice-cover that we also found the highest density of Little Auks.

In other geographical areas, large concentrations of the Little Auk have been reported in association with sea-ice, continental slopes and at different oceanic 'fronts' (Bradstreet & Brown 1985), where they feed upon the prey that tend to accumulate there in high densities (Pingree et al. 1974; Bradstreet 1980, 1982; Brown 1980; Bradstreet et al. 1981). Bradstreet & Brown (1985) showed how densities of Little Auks and zooplankton above 20 m increase towards the outer edge of the Southern Scotian Shelf, while Zelickman & Golovkin (1982) reported that 75% of the Little Auks off Novaya Zemlya were foraging in areas with dense swarms of crustaceans.

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