Seabirds in the Greenland, Barents and Norwegian Seas, February–April 1982

R. G. B. BROWN

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The pelagic distributions of seabirds in the Greenland, Norwegian and western Barents Seas are poorly known, especially in winter. This paper describes quantitative observations made in the course of an oceanographic cruise between 60°–79°13′N and 15°W–18°30′E from 25 February to 4 April 1982. Seabirds were generally scarce: the principal species were *Fulmarus glacialis, Rissa tridactyla, Pagophila eburnea, Uria* spp. and *Alle alle*. Numbers were greatest in the south and east, where the sea surface temperatures were warmest. *Pagophila eburnea* and *Cepphus grylle* were most commonly seen near the edge of the pack-ice in the Greenland Sea. In the pack-ice zone *Fulmarus glacialis* and *Alle alle* were commonest where the sea surface was 40–60% covered with ice. These late-winter observations are compared with published accounts of summer distributions. Preliminary quantitative comparisons also suggest that the size of the population of *Uria* spp. wintering in the survey area, and especially in the western Barents Sea, is significantly larger than that which winters off Nova Scotia, eastern Canada; the reverse is true of *Alle alle*.

R. G. B. Brown, Canadian Wildlife Service, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia, Canada, B2Y 4A2.

Introduction

The Greenland, Norwegian, and Barents Seas form the northeast corner of the North Atlantic Ocean. Their northern boundary is at ca. 80°N, from northeast Greenland through northern Svalbard to Frans Josef Land, at the southern limit of permanent pack-ice – the boundary between the North Atlantic and Arctic Oceans. They are bounded on the west by Greenland, on the east by Novaya Zemlya, and on the south by Norway, Faeroe and the north coast of Iceland (Figs. 1–6).

This area supports a very large population of breeding seabirds; the distributions, and to a lesser extent the numbers, of these are fairly well known. There are between 1 and 5 million pairs of seabirds breeding in Svalbard, 1 million on Novaya Zemlya, 1.75 million along the coast between the Kola peninsula in northwest Russia and the Lofoten Islands in northwest Norway, and ca. 5 million in Faeroe and northern Iceland combined. There are also large, uncensused colonies in Frans Josef Land, Jan Mayen, and east and northeast Greenland. (Data from Bird & Bird 1935; Seligman & Willcox 1940; Salomonsen 1950, 1979a, 1981; Fisher 1952; Fisher & Lockley 1954; Løvenskiold 1964; Joensen 1966; Norderhaug *et al.* 1977; Brun 1979; Einarsson 1979; Petersen 1982.)

By contrast there is surprisingly little information about the birds' distributions at sea. Up to a point these can be inferred from analyses of the recoveries of birds ringed at colonies in Svalbard, Novaya Zemlya, northern Norway and the adjacent coasts of Russia; for example, Holgersen (1961), Bianki (1967), Norderhaug (1967), Salomonsen (1967, 1971, 1979b), and Tuck (1971). What is lacking, however, is *direct* observation of seabird distributions at sea in this area, comparable with that done off eastern Canada (e.g. Brown *et al.* 1975; Renaud *et al.* 1982). The published literature is sparse: Quennerstedt (1868), Belopol'skii (1933), Menzies (1965), Meltofte (1972), Gräfe (1973), Byrkjedal *et al.* (1976), Joiris (1976), Hansen (1978), Blomqvist & Elander (1981) and Meltofte *et al.* (1981), and the records in the more general reviews of Fisher (1952) and Løvenskiold (1964). Virtually all of these pelagic observations have been made during the summertime. Quennerstedt's (1868) summary of seabirds seen during a spring sealing voyage to the pack-ice east of Jan Mayen is the principal exception.

The present paper contributes observations which I made in this area on the Bedford Institute of Oceanography cruise 82-001 in early spring 1982. The CSS 'Hudson' left Reykjavik on 24 February, sailed north around Iceland to the Greenland Sea and reached 79°13′N, 01·16′E, the northernmost point of the cruise, on 12 March. We visited Tromsø on 23–25 March, passed Jan Mayen on 30 March, and arrived in Glasgow on 6 April. Most of our work was done in the deep waters between the east Greenland pack-ice, Jan

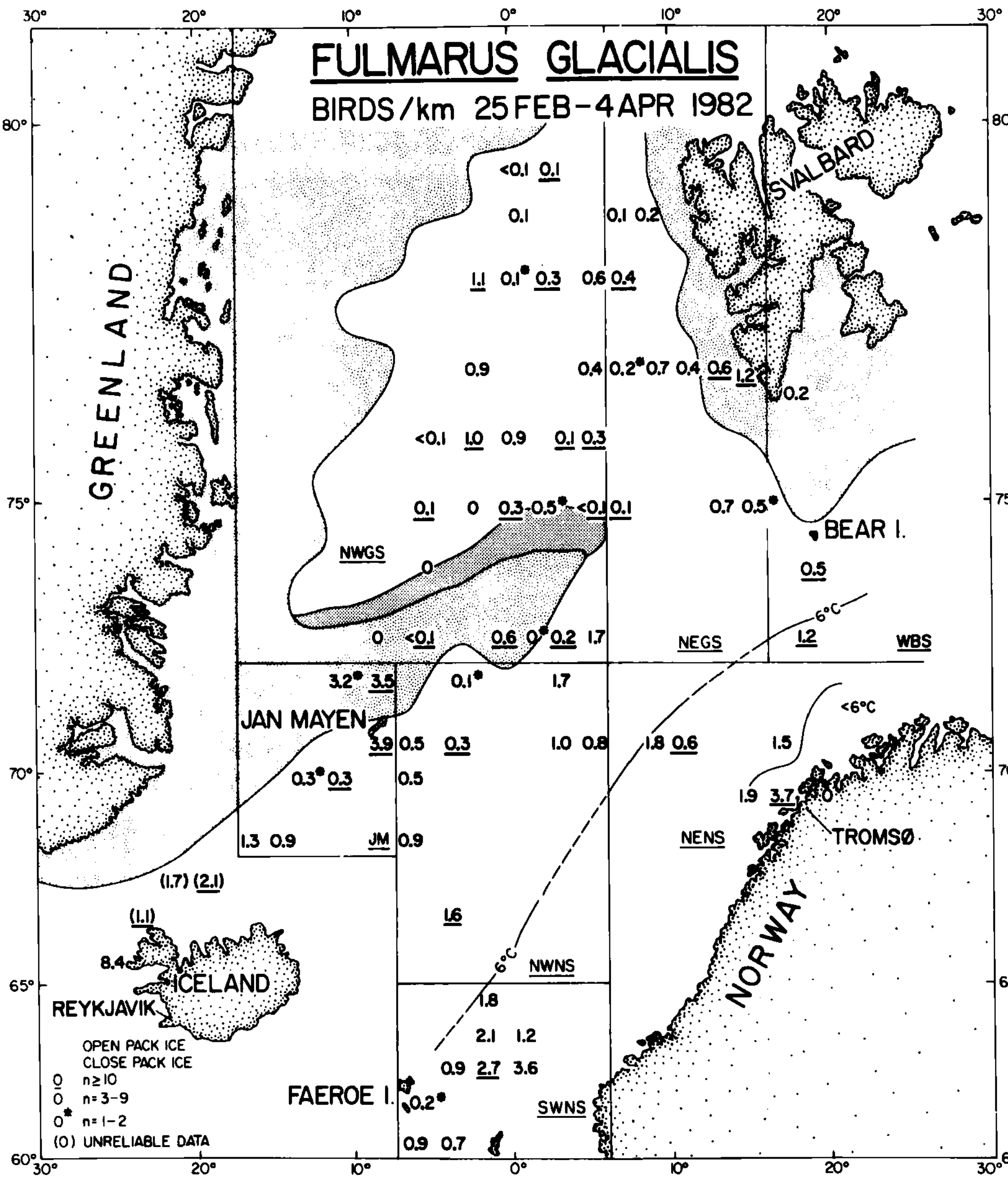

Fig. 1. Average numbers of Fulmars *Fulmarus glacialis* per kilometre in the Greenland, Norwegian and Western Barents Seas, 25 February–4 April 1982. Averages refer to 1°N × 2°W 'squares'; '*n*' indicates the number of 10-minute watches on which each was based. The 'unreliable' counts (in parentheses) were made during a period of strong gales, during which observation was difficult. The approximate position of the pack-ice is based on a map derived from satellite imagery and issued on 9 March 1982 by Deutsches Wetterdienst/Seewatter Amt, Deutsches Hydrographisches Institut, Hamburg. The pack-ice margin was east of the positions shown during the last half of March 1982. For further details, see the text.

Mayen and Svalbard; the extent of the ornithological coverage is shown in the species maps (Figs. 1–6).

The survey area is dominated by two circulation patterns (e.g. Norderhaug *et al.* 1977: Fig. 2). The East Greenland Current, the principal outflow from the Arctic Ocean, brings cold water and pack-ice southwest along the whole of the east coast of Greenland. On the east, by contrast, the relatively warm Norwegian Current, a continuation of the Gulf Stream/North Atlantic Drift system, flows northeast up the coast of Norway. Its influence in the northeast Atlantic, made apparent by the virtual absence of pack-ice, extends north to western Svalbard and east to Novaya Zemlya, and another branch of the Drift brings warm water to the south coast of Iceland.

For the purposes of this paper it is convenient to divide our survey area into eight Regions, based on this oceanographic zonation (Figs. 1–6; Table 1). The area north of 72°N is divided into the North-West Greenland Sea (NWGS: 16°W–6°E); North-East Greenland Sea (NEGS: 6°–16°E) and the Western Barents Sea (WBS: 16°–19°E). The regions south of 72°N are Jan Mayen (JM: 68°–72°N, 16°–6°W), the North-West Norwegian Sea (NWNS: 65°–72°N, 6°W–6°E); North-East Norwegian Sea (NENS: 68°–72°N, 6°–19°E) and South-West Norwegian Sea (SWNS: 60°–65°N, 6°W–6°E). A region off Northern Iceland (NI) has been added for the purposes of some of the discussions, but the weather was too stormy for reliable quantitative observations during our passage through it. Figs. 1–6 and Table 1 show the extent of pack-ice cover in the various Regions during our cruise. Table 1 also shows the average sea surface temperatures (measured by standard meteorological bucket); with the exception of WBS (n = 8), each average is based on over 20 samples.

Methods

Birds were counted by a modification of the technique described by Brown *et al.* (1975). The observer stood on the ship's bridge, eye height ca. 13.4 m above sea level (giving a horizon of ca. 13.5 km), and counted all birds seen in a 90° arc extending from the bows to one side of the ship. In the case of species which regularly follow ships, the only birds counted were those approaching the ship from ahead ('joiners'); birds which entered the 90° arc while they were circling or following the ship were ignored. No attempt was made to fix an outer limit to the census area. Tests with a range-finder (Heinemann 1981) on a subsequent cruise on the 'Hudson' suggest that on average I recorded large white birds like Fulmars *Fulmarus glacialis* and Kittiwakes *Rissa tridactyla* at distances of up to 400 m, but small, dark ones like Little Auks *Alle alle* only up to 200 m, though the latter were visible at greater distances under good conditions. Only counts made in good visibility are included in Table 1 and Figs. 1–6, for all Regions except North Iceland. All counts were made while the ship was moving, though the speeds were variable, especially when we were manoeuvring in pack-ice. The birds were therefore counted in 10-minute periods corrected for the ship's speed, and the results expressed as the number of birds/km.

Distributions

Fulmar Fulmarus glacialis – *(Fig. 1; Tables 1, 2)*

Fulmars were commonest in the Norwegian and Barents Seas, and close to their colony on Jan Mayen. In the Greenland Sea they usually occurred at the edge of the pack-ice, in the zone where 10–60% of the sea was covered by ice (Table 3). Quennerstedt (1868) found a similar association near Jan Mayen in spring, as did McLaren (1982) in Baffin Bay. Fulmars were also common off Northern Iceland, where they breed in large numbers (Fisher 1952; Petersen 1982).

The majority of the birds in the Norwegian Sea and off Jan Mayen were in the Light plumage morph ('LL' in Fisher's (1952) classification); the Dark morph (Fisher's classes 'L', 'D' and 'DD') predominated elsewhere. The percentages of 'LL' birds in the various Regions (based on counts of 'joining' birds only, see above) were: SWNS 96.0% (n = 177); NENS 92.4% (n = 185); NWNS 96.1% (n = 155); WBS 8.8% (n = 113); NEGS 10.6% (n = 142); JM 99.5% (n = 220); NWGS 26.1% (n = 203). 'LL' birds were commoner close to the Norwegian coast than Fisher (1952: Fig. 41a) shows for January–April, but the percentages elsewhere were very similar.

Gannet Sula bassana – *(Table 2)*

Single adult birds were seen in the South-West

Table 1. Seabird numbers in the Greenland and Norwegian Seas, February–April 1982. Regions are defined in Fig. 1: SWNS, NENS and NWNS are, respectively, the South-West, North-East and North-West sections of the Norwegian Sea; NEGS and NWGS are the North-East and North-West Greenland Sea; WBS is the Western Barents Sea and JM the area of Jan Mayen. W/n indicates the number of 10-minute watches in which the species was recorded, in relation to the total number of watches for the Region in question. Probabilities (p) are based on χ^2 two-tailed comparisons of W/n ratios. (+) and (−) indicate, respectively, where the result was greater or less than expectation; NS = no significant difference.

Region	SWNS	NENS	NWNS	WBS	NEGS	JM	NWGS	Total
Average sea surface °C	7.9	6.0	4.1	3.8	2.2	0.3	−0.3	
% watches with ice present	0	0	0	20.0	30.7	29.0	72.5	
Species:								
Fulmarus glacialis								
average birds/km	1.70	1.85	0.99	0.89	0.60	2.28	0.41	
(standard deviation)	(1.24)	(3.81)	(0.90)	(0.81)	(0.56)	(3.80)	(0.79)	
W/n	56/59	44/63	47/56	27/30	71/88	51/62	120/251	
χ^2	19.30	0.05	7.31	4.77	6.23	4.00	48.73	90.36
p	<0.001(+)	NS	<0.02(+)	<0.05(+)	<0.02(+)	<0.05(+)	<0.001(−)	<0.001
Rissa tridactyla								
average birds/km	0.82	0.48	0.23	0.92	0.15	0.06	0.01	
(standard deviation)	(1.38)	(1.40)	(0.52)	(1.59)	(0.43)	(0.14)	(0.10)	
W/n	39/59	26/63	21/56	21/30	22/88	11/62	7/251	
χ^2	17.70	10.10	5.46	34.46	0.03	1.38	62.48	131.61
p	<0.001(+)	<0.01(+)	<0.02(+)	<0.001(+)	NS	NS	<0.001(−)	<0.001
Pagophila eburnea								
average birds/km	0	0	0	0.04	0.04	0.31	0.12	
(standard deviation)	—	—	—	(0.13)	(0.14)	(1.02)	(0.39)	
W/n	0/59	0/63	0/56	3/30	9/88	9/62	33/251	
χ^2		13.86		1.53		17.92		33.31
p		<0.001(−)		NS		<0.001(+)		<0.001
Uria spp.								
average birds/km	0.07	0.10	0.07	0.44	0.19	0.32	0.02	
(standard deviation)	(3.30)	(0.35)	(0.18)	(1.01)	(0.79)	(0.80)	(0.10)	
W/n	5/59	10/63	10/56	17/30	15/88	19/62	12/251	
χ^2	1.47	0.42	0.71	17.02		14.39	23.31	57.32
p	NS	NS	NS	<0.00(+)		<0.001(+)	<0.001(−)	<0.001
Alle alle								
average birds/km	0.57	0.19	0.40	0.02	0.14	0.15	0.53	
(standard deviation)	(1.35)	(0.65)	(0.88)	(0.10)	(0.37)	(0.43)	(1.82)	
W/n	14/59	10/63	18/56	2/30	19/88	11/62	60/251	
χ^2	0.12	1.31	2.38	4.04	0.002	0.61	0.63	8.91
p	NS	NS	NS	<0.05(−)	NS	NS	NS	NS
Fratercula arctica								
average birds/km	0.01	2.05	0	0.08	0	0	0	
(standard deviation)	(0.07)	(6.25)	—	(0.22)	—	—	—	
W/n	2/59	20/63	0/56	5/30	0/88	0/62	0/251	
χ^2		26.47		0.01		14.44		40.92
		<0.001(+)		NS		<0.001(−)		<0.001

Note: Conditions were too stormy off northern Iceland for proper observation, though for completeness Figs. 1–6 include some data, mostly 'unreliable', for that Region. The average sea surface °C in the Region, north of 65°N, was 1.6°C; there was no pack-ice.

Norwegian Sea at 62°08′N, 00°30′W (2 April), and at 60°46′N, 03°48′W and 60°19′N, 04°20′W (4 April).

Kittiwake Rissa tridactyla – *(Fig. 2; Tables 1, 2)*

Kittiwakes were commonest in the Norwegian and Barents Seas, and very scarce farther north.

By contrast, Quennerstedt (1868) found them abundant in open water near the pack-ice in the southern Norwegian Sea (ca. 72°N, 7°W–3°E) between 12 March and 31 May 1867. However, I was probably too early to see many Kittiwakes in 1982, since the birds do not return to breed on Jan Mayen and Svalbard until April (Bird & Bird 1935; Løvenskiold 1964).

The percentages of first winter juveniles among 'joining' birds were: SWNS 27.2% ($n = 33$); NENS 15.0% ($n = 20$); NWNS 16.7% ($n = 36$); WBS 3.4% ($n = 30$); NEGS 3.8% ($n = 27$); JM 0% ($n = 11$). The slightly higher proportion of juveniles in the south is consistent with the results of ringing (e.g. Salomonsen 1967), which show that juvenile Kittiwakes tend to winter farther south, and to return later in the spring, than adult birds.

Ivory Gull Pagophila eburnea – *(Fig. 3; Tables 1, 2)*

Ivory Gulls were seen only in the north of the survey area, mainly close to pack-ice in the Greenland Sea. Similarly, Quennerstedt (1868) only saw this species in the ice, never over open water. His account suggests that the birds were commoner than in 1982. This may be because his observations were made later in the spring (see above), and because many Ivory Gulls were attracted to his ship to scavenge the remains of dead seals.

A southward movement of Ivory Gulls along the east coast of Greenland has been recorded in winter (Blomqvist & Elander 1981), but I saw no evidence of any migration.

Black-headed Gull Larus ridibundus – *(Table 2)*
Herring Gull Larus argentatus – *(Table 2)*
Lesser Black-backed Gull Larus fuscus – *(Table 2)*
Greater Black-backed Gull Larus marinus – *(Table 2)*

A single adult Black-headed Gull in breeding plumage followed the ship at 60°41′N 03°38′W on 4 April.

Herring Gulls were seen only in the Malangen Fjord, off Tromsø (22, 25 March). Small numbers of Lesser Blackbacks followed the ship from 60°38′N, 01°03′W southward in the Norwegian Sea (4 April). There were single Greater Blackbacks at 73°23′N, 18°30′E (21 March), 70°02′N, 16°47′E (22 March), 70°48′N, 04°05′E and

Table 2. Sightings (S) of seabirds in February–April 1982 in the South-West, North-East and North-West Norwegian Sea (SWNS, NENS, NWNS), in the Western Barents Sea (WBS), off Jan Mayen (JM), in the North-East and North-West Greenland Sea (NEGS, NWGS), and off Northern Iceland (NI). For further details, see the text.

Region:	SWNS	NENS	NWNS	WBS	NEGS	JM	NWGS	NI
Species:								
Fulmarus glacialis	S	S	S	S	S	S	S	S
Sula bassana	S							
Rissa tridactyla	S	S	S	S	S	S	S	S
Pagophila eburnea				S	S	S	S	
Larus argentatus	*	S						
Larus fuscus		S						
Larus marinus	S	S	S	S		S		S
Larus hyperboreus		S	S	S	S	S	S	S
Larus ridibundus	S							
Alca torda	*	S						
Uria lomvia	**	**	S	S	S	S	S	**
Uria aalge	S	**	**	S	**	**	**	S
Alle alle	S	S	S	S	S	S	S	S
Cepphus grylle	S	S		S			S	S
Fratercula arctica	S	S		S				

* Recorded in April 1982 off northwest Scotland, just south of SWNS.

** Unidentified *Uria* spp. sighted. It is likely (Fig. 4, Table 2) that those in JM, NEGS and NWGS were *U. lomvia*, those in SWNS were *U. aalge*, and that both species were present elsewhere.

Note: Alca torda has also been recorded once from JM in February (Bird & Bird 1935), and *Rhodostethia rosea* once from NENS in January (Løvenskiold 1964).

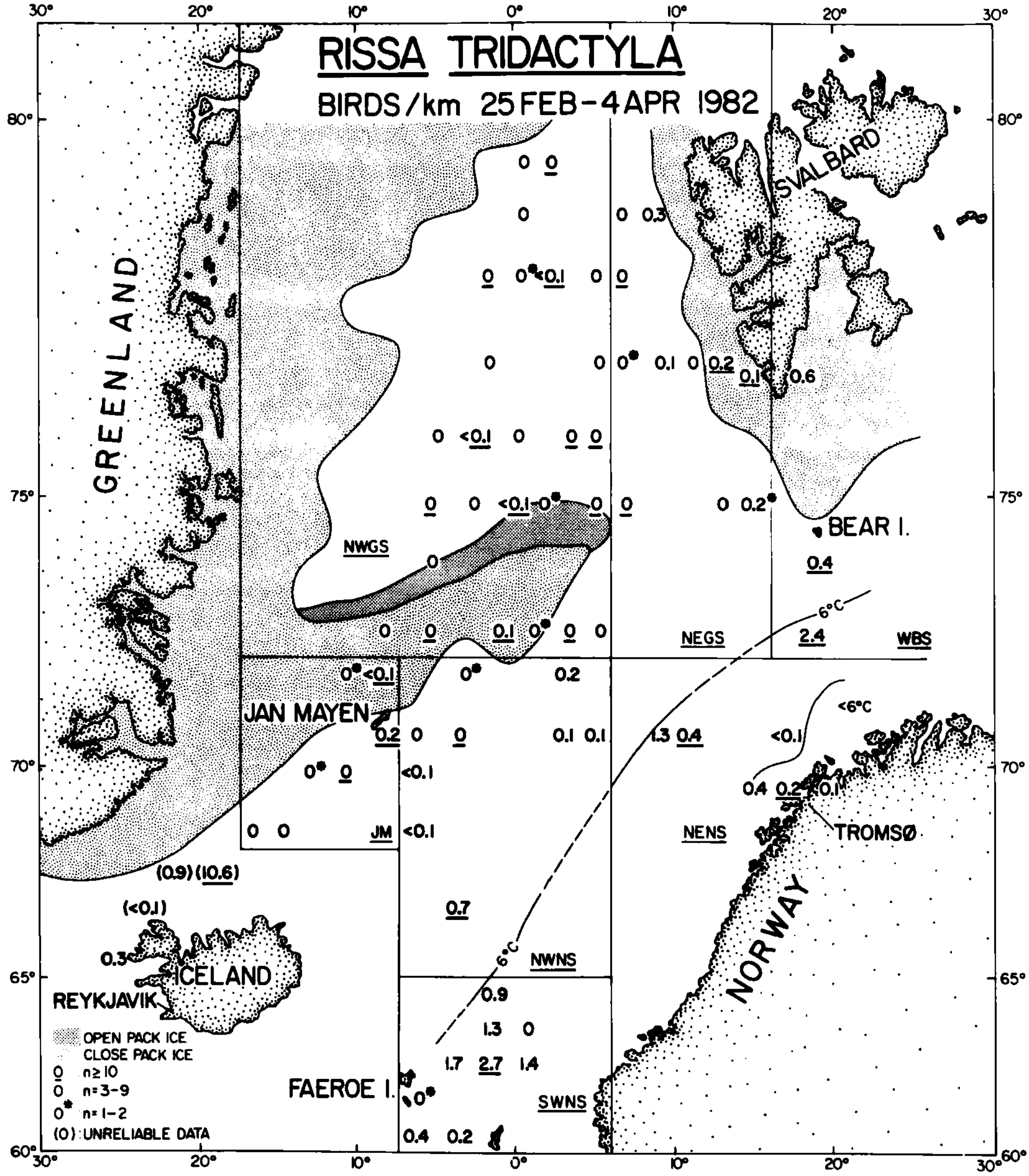

Fig. 2. Average numbers of Kittiwąkes *Rissa tridactyla* per kilometre in the Greenland, Norwegian and Western Barents Seas, 25 February–4 April 1982. For further details, see Fig. 1 and the text.

70°57′N, 03°35′E (27 March), 70°27′N, 06°59′W (30 March) and 62°06′N, 01°30′W (3 April), and two birds off Iceland at 65°27′N, 24°33′W (25 February). All the Lesser and Greater Blackbacks were either adults or 3–4-year-old subadult birds.

Glaucous Gull Larus hyperboreus – *(Table 2)*

Seen fairly often in small numbers in the northern part of the survey area. The most southerly sightings in the west and east were, respectively, at 66°14′N, 02°04′W (1 April), and 69°45′N, 17°13′W (23 March). In contrast to the Lesser and Greater Blackbacks (see above), 21.0% ($n = 38$) of the Glaucous Gulls seen on this survey were first-winter juveniles.

Razorbill Alca torda – *(Table 2)*

The only confirmed sighting was an adult bird in breeding plumage off the Malangen Fjord, near Tromsø, on 23 March. However, others might have been overlooked among the more numerous Guillemots.

Brünnich's Guillemot Uria lomvia – *(Fig. 4; Tables 1, 2)*
Common Guillemot Uria aalge – *(Fig. 4; Tables 1, 2)*

It was difficult to separate these species at sea. The confirmed identifications (Fig. 4) showed, as one would expect from their breeding distributions (e.g. Tuck 1961; Norderhaug *et al.* 1977), that the Common Guillemot was the more southerly of the two.

Guillemots were present in small numbers in every Region. They were most abundant in the relatively shallow waters of the Barents Sea, but scarcest in the North-West Greenlands Sea (Table 1), where Quennerstedt (1868) also found them uncommon in the spring. The density in the Western Barents Sea is almost certainly an underestimate of the true figure; we passed the important colony at Bjørnøya at night and no counts were possible. Other observers on the 'Hudson' saw many small flocks at first light on 20 March at 73°00′N, 18°30′E, ca. 160 km south of Bjørnøya. Surface temperatures increased sharply by as much as 4°C at this point, as we passed into the zone of relatively warm water in the North-East Norwegian Sea (Table 1; see also Norderhaug *et al.* 1977), and it is possible that many birds were feeding at this oceanic front. The area is known to be important later in the year for baleen whales, feeding on euphausiid krill (e.g. Ingebrigtsen 1929). However, it is likely that the majority of Guillemots in the Barents Sea were well to the east of our cruise track, since the fishery for capelin *Mallotus villosus*, an important winter prey of these birds, was east of 30°E in the spring of 1982 (Barrett 1979 and pers. comm.).

Guillemots were also common close to their large colonies on Jan Mayen and Iceland (see Bird & Bird 1935; Seligman and Willcox 1940; Einarsson 1979). I saw very few birds off West Spitsbergen on 13 March, although Brünnich's Guillemots should have returned to breed by then (Løvenskiold 1964); however, we never came closer than 40 km to the land. The cruise was probably too late to observe the return migration of this species from West Greenland to Svalbard, demonstrated by ringing returns (Salomonsen 1967, 1971; Holgersen 1974, 1980).

Little Auk Alle alle – *(Fig. 5; Tables 1, 2)*

Little Auks were evenly distributed in small numbers throughout the survey area except in the South-West Norwegian Sea, where they were not seen in waters warmer than 7°C. There were very few birds close to the large colony on Jan Mayen, even though the species is said to occur in the vicinity of the Island all through the year (Bird & Bird 1935).

The migrations of the Little Auks which breed in Svalbard are quite well known, and the relative scarcity of the species in the North-West Greenland Sea is surprising. There have been many ringing recoveries in November–February from the west coast of Greenland (Norderhaug 1967; Salomonsen 1967, 1971, 1972; Holgersen 1969, 1980), and Salomonsen suggests that both coasts of Greenland make up the principal wintering area for Svalbard birds. Little Auks return to Svalbard in early April in most years (Løvenskiold 1964), and a recovery from North-East Iceland in early March (Holgersen 1969) suggests that their return migration from Greenland begins at least a month earlier. The timing and position of our survey therefore put me in a good position to observe it. At least a million birds make this migration (Norderhaug *et al.* 1977), yet Little Auks were no commoner in the Greenland Sea than they were anywhere else in the survey area. The inference is that the migration had not yet begun, and that the bulk of the population was no farther north than Iceland at this time.

Table 3 shows that the Little Auks which were seen in the Northwest Greenland Sea were commonest at the edge of the pack-ice, in the zone in which 40–60% of the water is covered by ice, but that they avoided areas where over 90% was covered. The species shows a similar preference in spring and summer in the eastern Canadian Arctic, at the ice-edge in Baffin Bay and Davis

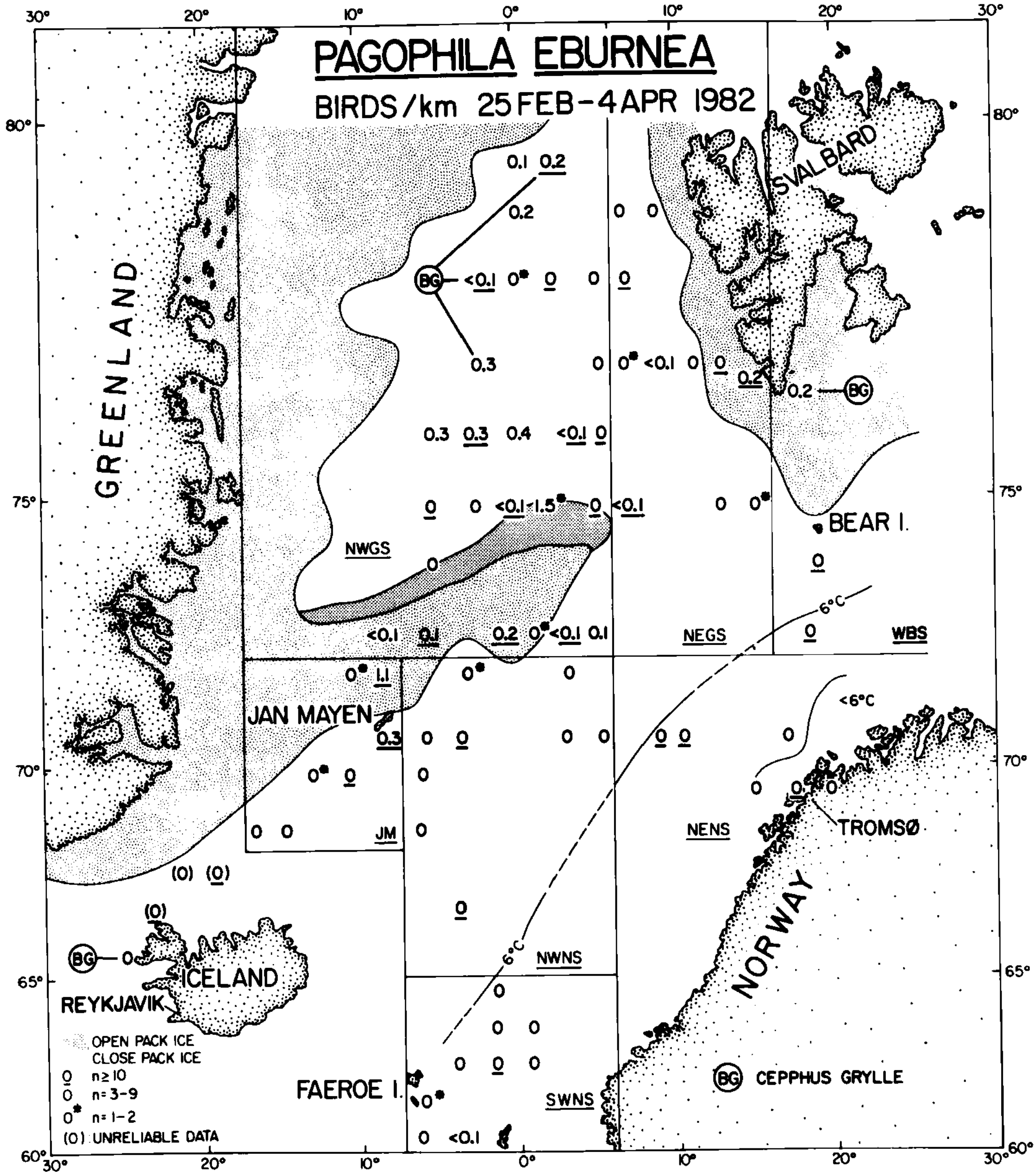

Fig. 3. Average numbers of Ivory Gulls *Pagophila eburnea* per kilometre in the Greenland, Norwegian and Western Barents Seas, 25 February–4 April 1982. 'BG' indicates 1°N × 2°W 'squares' in which Black Guillemots *Cepphus grylle* were also seen. For further details, see Fig. 1 and the text.

Strait (Brown 1980a; Fig. 3, and unpublished observations; Renaud *et al.* 1982).

Black Guillemot Cepphus grylle – *(Fig. 3; Table 2)*

There was a single Black Guillemot close to the coast of Iceland on 25 February. All the other records were at or near the edge of dense pack-ice in the north of the Greenland Sea: a total of 25 birds in NWGS (9–12 March), and 3 in NEGS (16 March). The association between this species and the pack-ice is known elsewhere in the Arctic (e.g. Salomonsen 1967; Brown & Nettleship

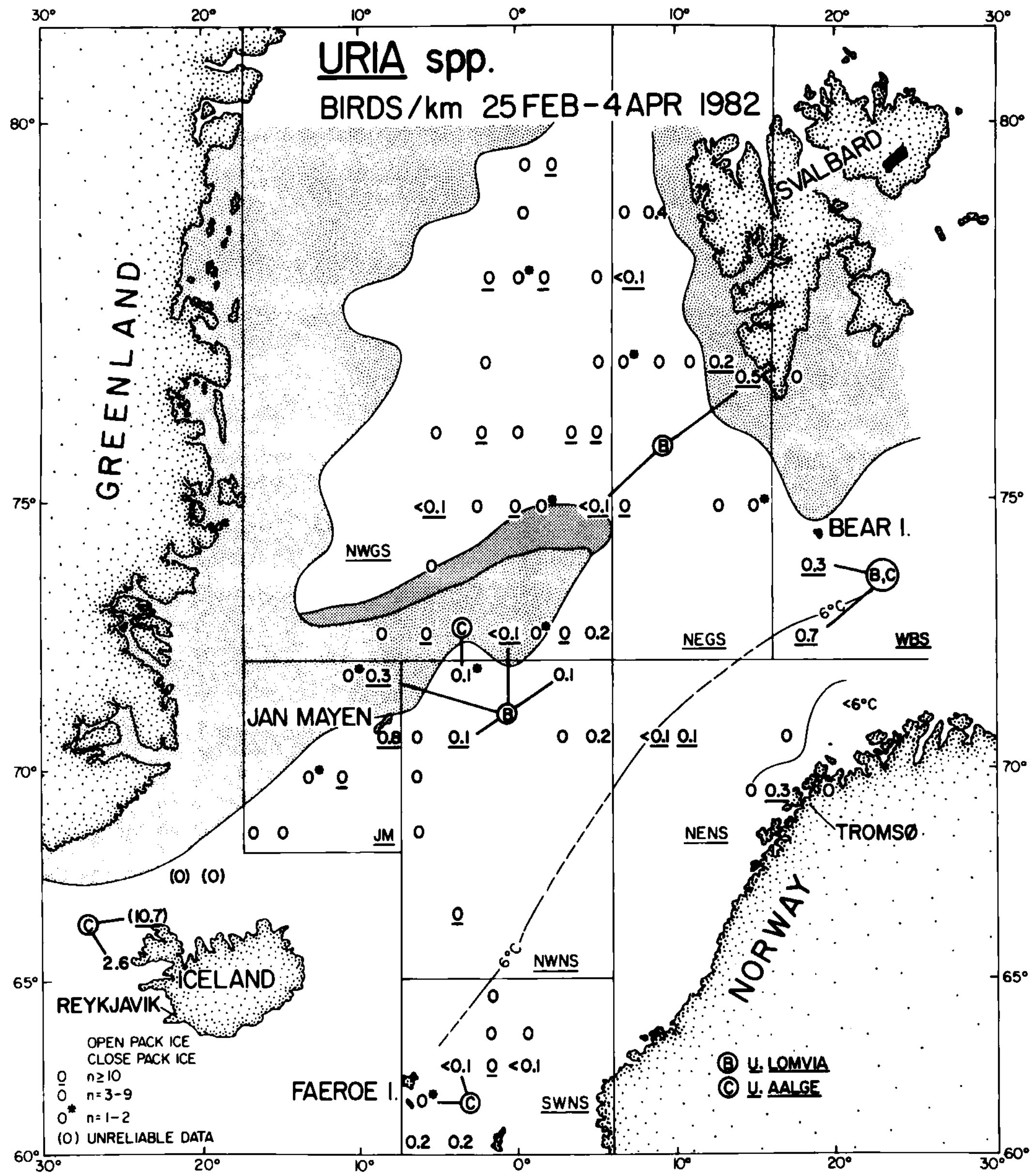

Fig. 4. Average numbers of Guillemots *Uria* spp. per kilometre in the Greenland, Norwegian and Western Barents Seas, 25 February–4 April 1982. 'B' and 'C' indicate, respectively, 1°N x 2°W 'squares' in which Brünnich's *U. lomvia* and Common Guillemots *U. aalge* were positively identified. For further details, see Fig. 1 and the text.

1981). In northern Baffin Bay in spring, for example, the birds occur along the edge of the dense pack, unlike the Little Auks which are found mainly in looser ice (McLaren 1982; Renaud *et al.* 1982).

The Icelandic bird was still in winter plumage, partly moulted; all but one of those in the Greenland Sea were already in complete, or almost complete summer plumage.

Puffin Fratercula arctica – *(Fig. 6; Tables 1, 2)*

Puffins were seen mainly in the Norwegian Sea, and in the Western Barents Sea up to ca. 200 km

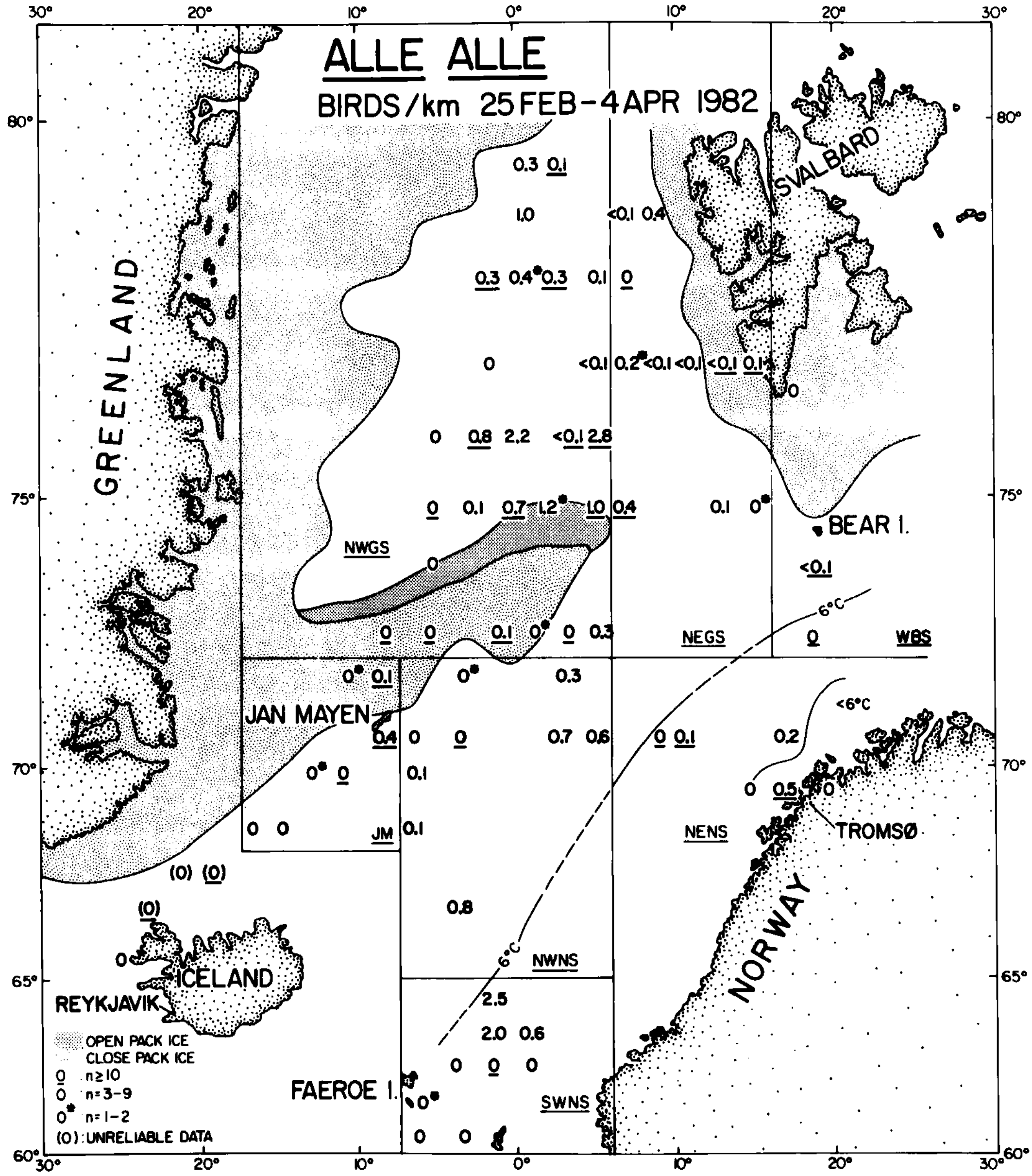

Fig. 5. Average numbers of Little Auks *Alle alle* per kilometre in the Greenland, Norwegian and Western Barents Seas, 25 February–4 April 1982. For further details, see Fig. 1 and the text.

north of the Norwegian coast, but were virtually absent elsewhere. They were commonest on 23 and 25 March on Sveinsgrunnen Bank, just west of the Malangen Fjord, ca. 69°45'N, 17°30'E. The directions of flight of these birds indicated that they came from the south, presumably from the colonies at Andøya or Bleik (Norderhaug *et al.* 1977; Brun 1979).

Other birds

A male and female Common Eider *Somateria mollissima* were seen close to the coast of Iceland on 25 February. Four Oystercatchers *Haematopus ostralegus* were seen east of the Faeroes on 2 April at ca. 64°25'N, 00°34'W, and another the next day at 62°06'N, 02°38'W. Two Redwings

Table 3. Distribution of *Fulmarus glacialis* and *Alle alle* in the North-West Greenland Sea in February–March 1982 in relation to the extent of pack-ice cover. The figures for each ice category indicate the numbers of 10-minute watches in which the birds were present or absent. For further information see Table 1.

NWGS Region: % ice cover:	0	10–30	40–60	70–80	90–100	Total
Fulmarus glacialis						
present	31	11	19	23	47	
absent	38	24	35	17	6	
χ^2	1.46	6.05	6.26	0.45	28.23	42.45
p	NS	<0.02(−)	<0.02(+)	NS	<0.001(−)	<0.001
Alle alle						
present	51	22	33	33	52	
absent	18	13	21	7	1	
χ^2	0.18	3.37	6.66	0.90	14.13	25.23
p	NS	NS	<0.01(+)	NS	<0.001(−)	<0.001

Turdus iliacus circled the ship at 64°21′N, 00°32′W on 2 April, and a bird was seen next day at 62°05′N, 01°58′W.

Analysis of distributions

Comparisons with distributions at other times of year

Table 2 summarizes the data presented in the last section, supplemented by information from the literature. For comparison, Table 4, compiled from the literature, summarizes distributions in the survey area for the period June–August. The summer communities of seabird species are two to three times larger than those found in the winter in most Regions, enlarged by migrants which either breed in the survey area, or are on their way to breed farther north. Few of the wintering species withdraw from the survey area in summer, though the Glaucous Gull, Little Auk and, possibly, Brünnich's Guillemot apparently leave the Norwegian Sea, the warmest part. One species, the Sooty Shearwater *Puffinus griseus*, is a 'winter' visitor from its breeding grounds in the Southern Hemisphere (Phillips 1963).

Table 4 is based on qualitative information only: breeding records, and casual observations at sea. It is difficult to make more precise, quantitative comparisons with Table 1, but Table 5 compares my data with those collected on two transects between northern Norway and southern Spitsbergen in the summer of 1973 (Byrkjedal *et al.* 1976). The comparisons must be made very cautiously because different years and, probably, different counting methods are involved. They do, however, suggest that Kittiwakes and Little Auks leave the North-East Norwegian Sea sometime after March; Kittiwakes and Fulmars start to move back there in September, just as Razorbills and Puffins are beginning to move away. Little Auks reach the Western Barents Sea – though not the North-East Norwegian Sea – in September, and there may also be an influx of Fulmars into the Western Barents Sea at that time. More data on seasonal changes in distribution are clearly needed.

Comparisons between the eastern and western Atlantic in winter

The southerly flow of the Labrador Current down the east coast of Canada ensures that the southern limit of Salomonsen's (1972) Low Arctic zone is at ca. 46°N in the western Atlantic, against ca. 71°N off northern Norway. The narrow band of temperate, ice-free water east and south of Nova Scotia, between 46°N and the northern edge of the Gulf Stream at ca. 40°–43°N, is therefore the approximate western equivalent of the Norwegian Sea. It is interesting to make some comparisons between winter seabird distributions in the two areas.

Table 6 shows that, in terms of the diversity of the species communities of seabirds, teleost fishes, squids and euphausiids, the South-West and North-East Norwegian Sea are the richest Regions in the present survey area, and very similar on all counts to those off eastern and

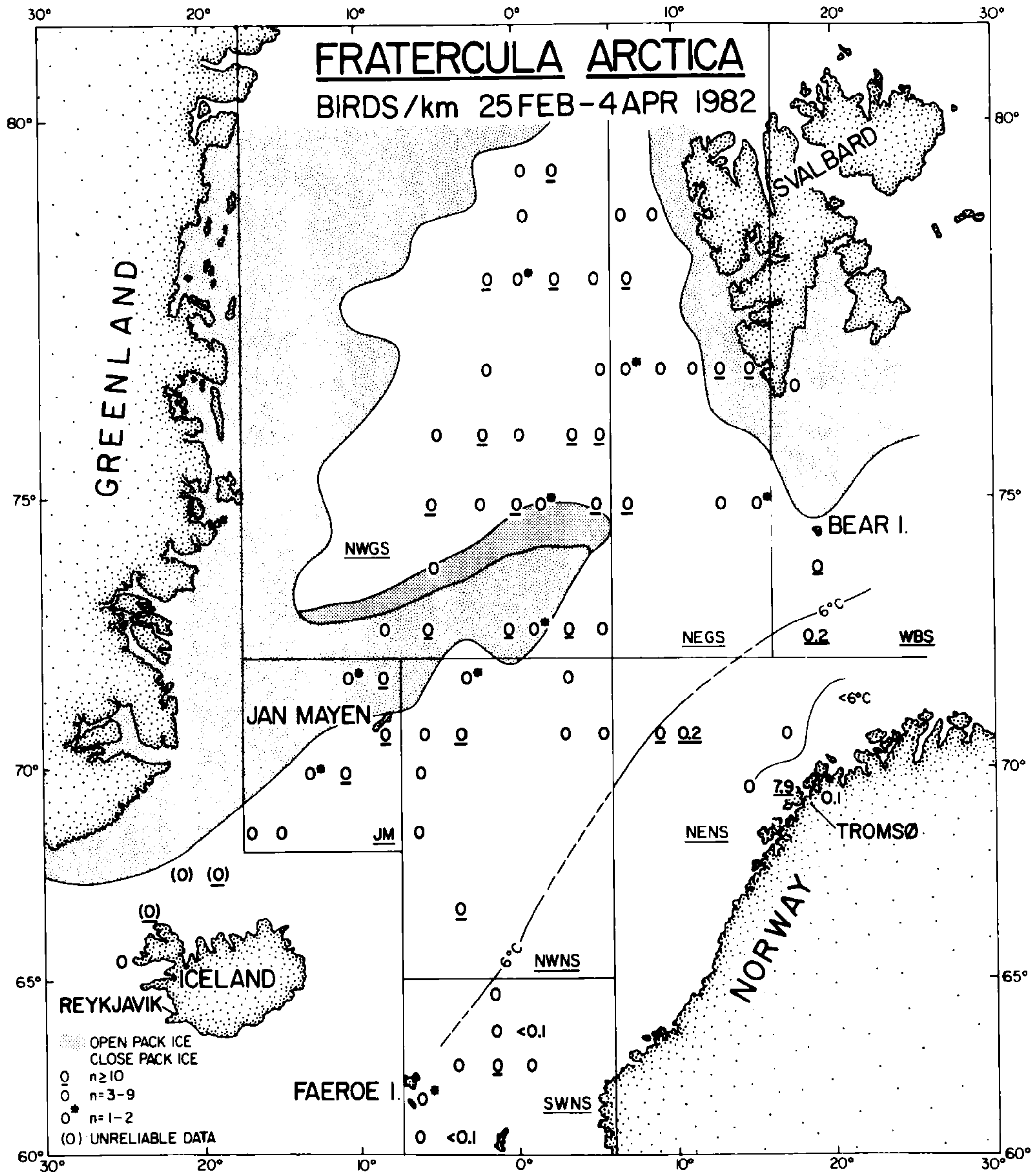

Fig. 6. Average numbers of Puffins *Fratercula arctica* per kilometre in the Greenland, Norwegian and Western Barents Seas, 25 February – 4 April 1982. For further details, see Fig. 1 and the text.

southern Nova Scotia. The seabird communities are also broadly similar in their composition as well. Seven species occur in both areas in winter and 16 in summer, though the number of breeding species is greater in the eastern Atlantic.

Table 7 compares the data for Brünnich's/Common Guillemots and Little Auks presented in Table 1 with observations which I made on two winter cruises to the Scotian Shelf (R. G. B. Brown, unpublished). Again, comparisons between different areas in different years must, of course, be made very cautiously, but they suggest that Guillemot densities on the Scotian Shelf were very similar to those in most of the present survey area. However, they were significantly lower than the Guillemot densities

Table 4. Occurrence of seabirds in summer (June–August) in the South-West, North-East and North-West Norwegian Sea (SWNS, NENS, NWNS), Western Barents Sea (WBS), off Jan Mayen (JM, in the North-East and North-West Greenland Sea (NEGS, NWGS) and in Northern Iceland (NI). B: species breeds in the Region; S: species has been sighted in the Region. For further details see the text.

Region:	SWNS	NENS	NWNS	WBS	NEGS	JM	NWGS	NI
Species:								
Fulmarus glacialis	BS	BS	S	BS	BS	BS	BS	BS
Puffinus griseus	S			S				
Puffinus puffinus	BS							S
Hydrobates pelagicus	BS							
Oceanodroma leucorhoa	B							
Sula bassana	BS	BS	S	S		S		BS
Phalacrocorax carbo	B	B						B
Phalacrocorax aristotelis	B	BS						
Phalaropus fulicarius				B	B		B	B
Lobipes lobatus					B			B
Catharacta skua	BS	S	S	S	S	S		S
Stercorarius pomarinus		S	S	S	S	S	S	
Stercorarius pomarinus	BS	BS		BS	BS	B	B	BS
Stercorarius longicaudus		B	S	S	BS	BS	B	
Rissa tridactyla	BS	BS	S	BS	BS	BS	BS	BS
Pagophila eburnea				B	BS	S	BS	
Rhodostethia rosea					*BS		S	
Xema sabini				S	*BS	S	B	
Larus argentatus	BS	BS		S		S		S
Larus fuscus	BS	BS		S	S			
Larus marinus	BS	BS		*B	*B	S		BS
Larus hyperboreus				BS	BS	BS	BS	BS
Larus canus	BS	B		S				
Larus ridibundus	BS	S						S
Sterna hirundo	B	B						
Sterna paradisaea	BS	BS		BS	BS	S	BS	BS
Alca torda	BS	BS		*B	*B			BS
Uria lomvia		*BS		BS	BS	BS	S	BS
Uria aalge	BS	BS		BS				BS
Alle alle				BS	BS	BS	S	*B
Cepphus grylle	BS	BS		BS	BS	B	BS	BS
Fratercula arctica	BS	BS		BS	BS	BS	S	BS

* Breeding population very small.

In addition *Larus glaucoides* has been reported breeding on Jan Mayen, but this is probably a confusion with *L. hyperboreus* (Bird & Bird 1935). *Sterna sandvicensis* has been seen on one occasion in summer on Jan Mayen (Bird & Bird 1935).

Sources: Bird & Bird (1935), Brun (1979), Byrkjedal *et al.* (1976), Cramp *et al.* (1974), Duffey & Sergeant (1950), Einarsson (1979), Fisher (1952), Fisher & Lockley (1954), Hansen (1978), Joensen (1966), Joiris (1976), Løvenskiold (1964), Marshall (1952), Meltofte (1972), Meltofte *et al.* (1981), Musters (1930), Norderhaug *et al.* (1977), Salomonsen (1950, 1981), Seligman & Willcox (1940).

in the Western Barents Sea which, for the reasons already discussed, were themselves undoubtedly underestimated. This difference almost certainly reflects differences in the availability of prey, especially capelin. These fish are taken extensively by wintering Guillemots on both sides of the Atlantic (Tuck 1961; Barrett 1979) but, while capelin are abundant in the Barents Sea they are very rare off southern Nova Scotia (Leim & Scott 1966; Jangaard 1974).

However, the principal wintering area for Guillemots off eastern Canada is farther northeast, off eastern Newfoundland and on the Grand Banks (Brown *et al.* 1975; Gaston 1980). The data from these areas are insufficiently standardized for a comparison of this kind, although one may base some speculations on the sizes of the breeding populations in the northwest and northeast Atlantic. Gaston (1980) estimates that *ca* 4 million Brünnich's Guillemots from colonies in West Greenland and the eastern Canadian Arctic winter in Newfoundland waters. An unknown but

Table 5. Seasonal changes in the densities of seabirds (birds/km) in the North East Norwegian Sea (NENS) and Western Barents Sea (WBS). Pelagic observations from the vicinity of Bjørnøya (Bear Island: BI) are presented separately from those from the rest of WBS. Data for March 1982 are from this paper. Data from July and September 1973 have been calculated from Byrkjedal *et al.* (1976).

Region:	NENS			WBS			BI
	March 1982	July 1973	Sept. 1973	March 1982	July 1973	Sept. 1973	July 1973
Species:							
Fulmarus glacialis	1.85	1.67	3.53	0.89	1.61	4.44*	2.38
Rissa tridactyla	0.48	0.03	0.32	0.92	1.46	1.60	9.16
Alca torda	0	0.27**	0.01	0	0.01	0	0
Uria spp.	0.19	0.06	0.14	0.44***	1.19	1.33	50.07
Alle alle	0.19	0	0	0.02	0.09	0.80	0.11
Fratercula arctica	2.05**	4.97**	0.21**	0.08	0.03	0.10	0

* Excludes large numbers of birds associated with fishing trawlers.
** Most birds seen close to the colony on Andøya (March, Sept.) or Fugløy (July).
*** Almost certainly an underestimate: see the text.
Survey dates: 15, 21 March 1982 (WBS), 22–26 March (NENS). 19 July, 5 Sept. 1973 (NENS); 20 July, 4 Sept. (WBS).

probably large proportion of the ca. 1 million Common Guillemots and their young from colonies in Newfoundland, Labrador and the Gulf of St. Lawrence must be added to this total (Tuck 1961). The populations of the two species breeding in the Barents Sea total ca. 5 million birds, plus a large but unknown number in Frans Josef Land. However, ringing recoveries suggest that most of the Brünnich's Guillemots from Svalbard and some from Novaya Zemlya (where the breeding populations each number ca. 2 million birds: Norderhaug *et al.* 1977) do not winter in the Barents Sea but migrate to West Greenland instead (e.g. Salomonsen 1967, 1971). It is therefore likely that the Brünnich's/Common Guillemot populations wintering off Newfoundland and in the Barents Sea are similar in magnitude; that off West Greenland is probably smaller than either.

Unlike the Guillemots, Little Auks were significantly more abundant on the Scotian Shelf than in any of the Regions covered by the present survey (Table 7). They are also extremely common in winter on the Grand Banks (Brown *et al.* 1975; Brown 1980b: Fig. 1). These figures, along with ringing returns, strongly suggest that the majority of the world's Little Auks winter in the western, not the eastern Atlantic. The largest

Table 6. The numbers of seabirds, of native, marine teleost fishes, and of oceanic squids and euphausiids in regions of the Greenland, Norwegian and Western Barents Seas.

Region:	Number of species:							
	SWNS	NENS	NWNS*	WBS	NEGS	JM*	NWGS	NI
Group:								
Seabirds (winter)	10	11	7	10	6	7	7	7
(summer)	21	20	5	22	19	16	14	20
Teleosts	158	136	10	54	43	20	25	71
Squids	11	4	1	2	2	2	1	3
Euphausiids	13	6	5	4	4	3	4	7

* Relatively low numbers of species in NWNS and JM at least partly reflect lack of sampling there.
Sources: Seabirds: Tables 2, 4. Teleosts: Hognestad & Vader 1979; Muus 1981; Wheeler 1969. Squids: Clarke 1966. Euphausiids: Mauchline & Fisher 1969, supplemented by Mauchline 1980.
Comparative Note (see Table 7 and Discussion): In the region of southern Nova Scotia, Canada, south of ca. 45°N, there are approximately 169 species of teleosts, 10 oceanic squids and 16 euphausiids (Leim & Scott 1966; Clarke 1966; Mauchline & Fisher 1969, supplemented by Mauchline 1980).

Table 7. Numbers of wintering *Uria* spp. and *Alle alle* off eastern Canada, compared to the Norwegian and Greenland Seas. Eastern Scotian Shelf (ESS): shelf east of Nova Scotia between 42°40′–44°20′N (sampled 26–27 January 1976); Southern Scotian Shelf (SSS): seas south of Nova Scotia between 41°40′–44°30′N (sampled 19–27 February 1980). χ^2 and probabilities refer to differences between the W/n ratios for Nova Scotia and those for the Norwegian and Greenland Seas given in Table 1; (+), (−) indicate, respectively, where the Nova Scotia data were significantly greater or less. For further information see Table 1.

Species:		*Uria* spp.		*Alle alle*	
Region:		ESS	SSS	ESS	SSS
	average birds/km	0.151	0.108	2.767	1.893
	(sd)	(0.432)	(0.296)	(4.396)	(6.516)
	W/n	5/34	52/249	25/34	110/249
SWNS	χ^2	—	4.08	19.97	7.46
	p	NS*	<0.05(+)	<0.001(+)	<0.01(+)
NENS	χ^2	—	2.53	29.37	15.84
	p	NS*	NS	<0.001(+)	<0.001(+)
NWNS	χ^2	0.01	0.01	14.15	4.18
	p	NS	S	<0.001(+)	<0.05(+)
WBS	χ^2	10.65	16.54	26.53	14.15
	p	<0.01(−)	<0.001(−)	<0.001(+)	<0.001(+)
NEGS	χ^2	0.003	0.38	26.31	19.40
	p	NS	NS	<0.001(+)	<0.001(+)
JM	χ^2	2.18	2.16	26.83	24.11
	p	NS	NS	<0.001(+)	<0.001(+)
NWGS	χ^2	—	0.38	32.90	22.00
	p	NS*	NS	<0.001(+)	<0.001(+)

* Probabilities calculated by the Exact χ^2 method.

Notes: Nova Scotian data collected from CSS BAFFIN (ESS; observer's horizon ca. 12.4 km) and CCGS LADY HAMMOND (SSS; horizon ca. 10.1 km) by R. G. B. Brown (unpublished), using the techniques described in the Methods section.

breeding concentration of the species (ca. 14–30 million birds: Freuchen & Salomonsen 1958; Renaud *et al.* 1982) is in North-West Greenland, and the ringing recoveries suggest that all of this population winters off Newfoundland (Salomonsen 1967, 1979b). The Little Auk population breeding in the eastern Atlantic has been estimated at ca. 35 million birds (Freuchen & Salomonsen 1958), though this is almost certainly an overestimate (see Norderhaug *et al.* 1977). The ringing recoveries suggest that at least the Svalbard section of this population leaves the eastern Atlantic altogether and winter off West Greenland instead (Norderhaug 1967; Salomonsen 1967, 1971, 1979b).

Conclusions

The main value of a preliminary survey of this kind is to draw attention to the requirements for future research. There is an obvious need for many more quantitative surveys of the pelagic distributions of seabirds in the Greenland, Barents and Norwegian Seas, both in summer and winter. Several oceanographic cruises are planned for the Greenland Sea and farther north in the near future, and these should provide many opportunities for ornithologists to collect more information, and also to correlate their observations with the oceanographic data. On a broad scale, the objective is to assess seabird distributions in the North-East Atlantic Ocean throughout the year. As a background to this, we need much more information on the numbers of breeding seabirds, especially in East Greenland, Jan Mayen and Frans Josef Land. On a finer scale, we need to know more about the extent to which seabirds exploit local phenomena, such as swarms of zooplankton (e.g. Zelickman & Golovkin

1972), upwelling at glacier faces (e.g. Hartley & Fisher 1936), oceanic fronts (e.g. Belopol'skii 1933), and ice-edges and polynyas (e.g. Brown & Nettleship 1981; Bradstreet & Cross 1982).

It is clearly important to take as broad a geographical view as possible. Ringing recoveries have shown that seabirds from colonies in the Barents Sea may winter as far away as West Greenland and the Grand Banks of Newfoundland (e.g. Norderhaug 1967; Salomonsen 1971; Tuck 1971). We must therefore think of the North Atlantic as a single ecosystem as far as many of the more specialized marine birds are concerned. This paper has attempted some preliminary comparisons between the Guillemot and Little Auk populations wintering in the eastern and western Atlantic.

It would be intersting to go a step further and compare and contrast the seabird communities in the North Atlantic with those in the North Pacific, or around Antarctica. The diversity of seabird species in the Antarctic in winter, for example, is not unlike that described in this paper (Tables 2 and 5). Approximately ten species occur between the Antarctic Convergence and the ice-edge in the South Pacific, but only six in the ice-edge zone itself (Szijj 1967); ca. 19 on the Patagonian Shelf, but only ca. nine off South Georgia (Tickell & Woods 1972; Jehl 1974; Rumboll & Jehl 1977). However, there are some interesting differences. The prevalence of large species such as albatrosses and penguins in the Antarctic and Subantarctic probably means that the overall biomass of the Antarctic community is much greater than that of the Arctic. The Antarctic seabird community includes five small- to medium-sized species of fulmarine petrels, while the Arctic supports only one (Watson 1975). There is, on the other hand, no small planktivorous, diving seabird equivalent to the Little Auk in the Antarctic proper, though the convergent diving-petrels *Pelecanoides* spp. occur in the Sub-Antarctic. These contrasts must reflect differences in the quality or quantity of the food available in the two polar regions: the notothenid fishes and the greater variety and biomass of euphausiids in the Antarctic, for example, in contrast to the capelin and polar cod *Boreogadus saida* of the Arctic (e.g. Leim & Scott 1966; Andriashev 1968; Mauchline & Fisher 1969; Jangaard 1974). An investigation of the reasons for such differences and similarities would tell us a great deal about the pelagic ecology of both communities of seabirds, and also about the structure of seabird communities in general. It is to be hoped that ornithologists will make use of the bipolar oceanographic cruises which are now being planned by several countries, to answer some of these questions.

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