The distribution and abundance of seabirds off southwestern Greenland in autumn and winter 1988-1989

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Ship-based surveys of seabirds were carried out off southwestern Greenland in the autumn of 1988 and winter of 1989. The results provide the first quantitative information on seabird distribution and numbers for single seasons and estimates for one particular area in winter. Some oceanographic habitat characteristics important for seabird distribution are described. In winter, high numbers of king eiders *Somateriaspectabilis*, Brünnich's guillemots *Urialomvia*, glaucous gulls *Larushyperboreus*, Iceland gulls *Larusglaucoides*, great black-backed gulls *Larusmarinus* and black guillemots *Cepphusgrylle* were found in offshore habitats with heavy ice cover. An estimated 280,000 king eiders, 170,000 Brünnich's guillemots, 2,500 glaucous gulls, 7,000 Iceland gulls, 9,500 great black-backed gulls and 25,000 black guillemots were found in winter in an area west of Nuuk.

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Introduction

Greenland has always relied heavily on marine resources. Through the last decades stock assessments and surveys of distribution of the most economically important species of fish, invertebrates and marine mammals have been important tools for resource management. Although heavily exploited, seabirds have not been included in routine monitoring programs, but the work of several scientists has led to the mapping of the breeding distribution of most colonial species in western Greenland, and to estimates of population size and change (Salomonsen 1950, 1979; Joensen & Preuss 1972; Boertmann 1979; Evans 1984; Kampp 1990; Evans & Kampp 1991; Boertmann 1994; Kampp et al. 1994).

Seabird breeding colonies are relatively easy to map and census, but determining the distribution of marine birds at sea is costly and much more labourous. Relatively few studies of the distribution of seabirds have been conducted near Greenland, particularly in fall and winter. With increasing human resource exploitation in marine areas, man-induced impacts on seabird populations have become evident. The first clear example of human interactions with seabirds from Greenland waters was the huge bycatch of seabirds, especially Brünnich's guillemots *Urialomvia*, in salmon drift nets set off West Greenland in the early 1970s (Tull et al. 1972; Christensen & Lear 1977). Pollution from oil exploration and transportation presents a more general risk to seabirds. As there is a clear need to minimize these risks, information on seabird distribution at sea is now in high demand, especially in the area off western Greenland where there is renewed interest in oil exploration.

The distribution of seabirds in Greenland waters outside the breeding season has been described in general terms by Salomonsen (1950). In recent years quantitative information been collated as part of a seabird mapping program for Eastern Canada with the rough mapping of seabird distribution in Greenland waters based on surveys from research vessels. The results of these surveys combined with efforts from various years were published as a seabird atlas by Brown et al. (1975) and subsequently updated by Brown (1986). The latter presents maps based on observations from the period 31 March 1969 to 31 December 1983. Other programs that mapped seabirds in the waters between Canada and Greenland were carried out by Canadian biologists from aircraft (McLaren 1982; McLaren & Renaud 1982; Renaud et al. 1982).

Evans & Waterston (1976) presented the results of counts of Brünnich's guillemots in August and

early September from passenger vessels in coastal waters of West Greenland. Boertmann (1979) mentioned scattered observations from Disko Bay southwards during the summers 1975 and 1976. Seabird distribution in autumn was indirectly studied by Christensen & Lear (1977) while researching bycatch in salmon drift nets. This paper presents the first available information on distribution and numbers of seabirds in southwestern Greenland waters through the autumn and winter.

Study area

The surveys were mainly conducted in waters less than 500 m deep along southwestern Greenland. The surface waters off the coast are dominated by cold water derived from the Polar Current, which transports water from the Polar Basin south along the East Greenland coast and around Cape Farewell to the west coast of Greenland (Buch 1990). Atlantic water is transported around Cape Farewell alongside the Polar Current. As these currents move north along the west coast of Greenland, they mix and gradually turn west towards Labrador and Baffin Island. Satellite images indicated that all transects fell within the Polar Current except for the westernmost transects off Sisimiut; the limit of the Polar Current is indicated in Fig. 1A.

Strong northerly winds along West Greenland may cause upwellings near the coast due to Ekman transport of surface water away from the coast (Buch 1990). Satellite images revealed that such upwellings occurred at least twice within the study area during the early autumn survey. The first event was in late August just south of Cape Thorwaldsen, and in early October upwellings were observed in the area between Nuuk and Maniitsoq as well as just south of Nuuk Fiord (Fig. 1A).

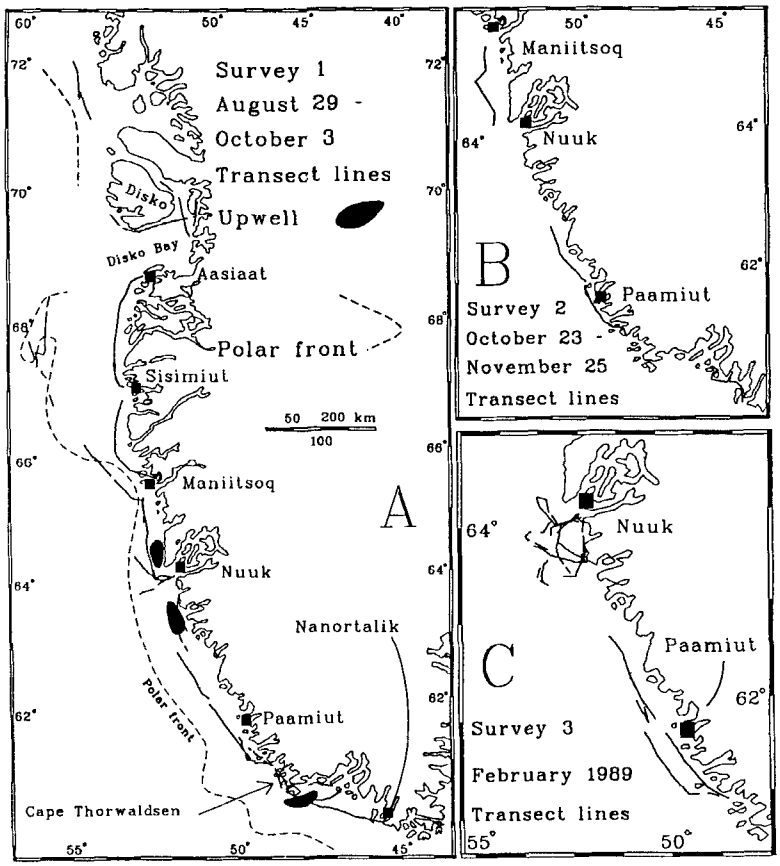

Fig. 1. Shipbased line transects off southwestern Greenland: (A) 29 August–3 October 1988; (B) 23 October–25 November 1988; (C) 14 February–15 March 1989.

Methods and material

Data were collected by the authors during three surveys. Survey 1 spanned the period 29 August – 3 October 1988, and covered the West Greenland coast between approximately 60°N and 72°N (Fig. 1A). This survey comprised 2,300 km transect lines, with a total of 736 10-minute sample periods. Survey 2 included observations performed between 23 October and 25 November 1988 along the coast from Maniitsoq and Nanortalik (550 km, 167 10-minute periods). A significant part of the survey took place in inshore waters (between islands and skerries) just north of Nanortalik (Fig. 1B). Survey 3 took place from 14 February to 5 March, when surveys were slowed by dense ice cover (1,100 km, 414 10-minute periods). Most of the time was spent in the northernmost navigable waters just west of Nuuk Fjord. An area of about 6,000 km^2 was covered with a high density of transect lines, allowing estimates of numbers of birds within that area (Fig. 2). Within this single area, a total of 230 10-minute bird counts were made, and 645 km transect lines were sailed which equals a coverage of 196 km^2 (3.4% of the total area). All observations were carried out from fisheries inspection vessels and passenger vessels. International observation standards were used which include a "snapshot technique" to allow for flux of birds in flight (Tasker et al. 1984; Webb & Durinck 1992). Bird observations were recorded in 10-minute periods and noted on field sheets for subsequent database storage. Each seabird observation was assigned one of three transect "bands": (1) from the ship to 150 m, (2) between 150 m and 300 m from the ship, or (3) further away than 300 m. Only observations within 300 m have been used to calculate relative densities (birds/km^2). Density was calculated as a 20-minute mean (two 10-minute periods) without compensation for changes in detectability over distance for different species (Skov et al. 1995). Within the 300 m transect, most birds were identified to species but some alcids and phalaropes could not be identified. Not including little auk *Alle alle*, Brünnich's guillemots made up 97% of all alcids identified to species (Table 1) and therefore unidentified large alcids have been treated as Brünnich's guillemots in further analyses. Likewise, red-necked phalaropes *Phalaropus lobatus* made up 98% of all phalaropes identified to species; observations of *Phalaropus* sp. have therefore been treated as *P. lobatus*.

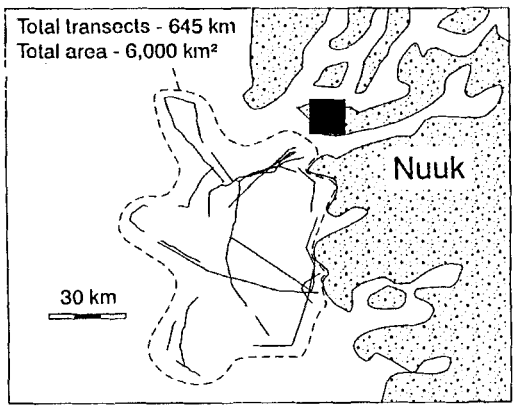

Fig. 2. Area southwest of Nuuk, Greenland with intensive sampling in February and March 1989.

Observations were only carried out in good or fair weather conditions, i.e. wind speed below 10 m/s and visibility greater than 500 m. Birds following trawlers or other ships were excluded from density calculations. Colour phases on fulmars *Fulmarus glacialis* were recorded according to Franeker & Wattel (1982).

Sea surface temperatures (°C) were recorded in a total of 513 10-minute periods from thermometers monitoring the temperature of the cooling water for engines of the fisheries inspection vessels. A Utilization Test was used to indicate whether the numbers of a given species found in a given range of temperature differed significantly (95% confidence limit chosen) from that expected from the distribution of effort (Haney & Solow 1992). In these 513 10-minute periods seven species of seabirds were considered numerous enough to allow this test (Fig. 16). Observation of ice cover in tenths (where 0/10 means no ice in sight and 10/10 is total ice cover) was sampled in 368 10-minute periods. Nine seabird species were considered numerous enough to allow a Utilization Test to determine if waters with certain ranges of ice cover supported some birds more than others (Fig. 17).

A total of about 4,000 km (2,200 nautical miles) of transects were sailed, yielding a total sample of 1,317 10-minute periods of observation. Most transects fell within 50 km of the coast, although some transects in September were as far as 200 km offshore (Fig. 1). Except for the surveys off Nuuk in February 1989 (Fig. 2), transect coverage was not dense enough to estimate population sizes of birds within the sampled areas.

Table 1. Bird species observed during three surveys off southwestern Greenland 1988/1989.

Species	Surveys 1[a]	2[b]	3[c]	Sum
Red-throated diver *Gavia stellata*	31			31
Great northern diver *Gavia immer*	2			2
Fulmar *Fulmarus glacialis*	7,661	403	1,792	9,856
Great shearwater *Puffinus gravis*	1,971			1,971
Great cormorant *Phalacrocorax carbo*	2	5	40	47
Canada goose *Branta canadensis*	42			42
Mallard *Anas platyrhynchos*	16			16
King eider *Somateria spectabilis*	62	22	7,482	7,566
Common eider *Somateria mollissima*	225	296	826	1,347
Eider sp. *Somateria* spp.	208	112	5,356	5,676
Harlequin duck *Histrionicus histrionicus*	1			1
Long-tailed duck *Clangula hyemalis*	20	135	384	539
Duck sp. *Anas* sp.	36	3	4	43
Red-breasted merganser *Mergus serrator*	17	1		18
White-tailed eagle *Haliaetus albicilla*	2			2
Gyrfalcon *Falco rusticolus*		3	4	7
Sanderling *Calidris alba*	11			11
Knot *Calidris canutus*	1			1
Dunlin *Calidris alpina*	19			19
Purple Sandpiper *Calidris maritima*	2	3	2	7
Sandpiper sp. *Calidris* spp.	25	2		27
Red-necked phalarope *Phalaropus lobatus*	224	1		225
Grey phalarope *Phalaropus fulicarius*	4			4
Phalarope sp. *Phalaropus* spp.	167			167
Great skua *Stercorarius skua*	9			9
Pomarine skua *Stercorarius pomarinus*	1			1
Arctic skua *Stercorarius parasiticus*	52			52
Kittiwake *Rissa tridactyla*	23,042	150	11	23,203
Ivory gull *Pagophila eburnea*		2		2
Sabines' gull *Larus sabini*	5			5
Herring gull *Larus argentatus*	1			1
Glaucous gull *Larus hyperboreus*	1,681	125	146	1,952
Iceland gull *Larus glaucoides*	68	63	285	416
Great black-backed gull *Larus marinus*	411	206	1,234	1,851
Gull sp. *Larus* spp.	3,255	52	746	4,053
Arctic tern *Sterna paradisaea*	197			197
Guillemot *Uria aalge*	13	2		15
Brünnich's guillemot *Uria lomvia*	3,324	11,875	15,264	30,463
Razorbill *Alca torda*	1			1
Black guillemot *Cepphus grylle*	77	418	427	922
Puffin *Fratercula arctica*	47	27		74
Little auk *Alle alle*	867	264	198	1,329
Alcid sp. *Uria* spp.	2,467	7	71,96	73,760
Raven *Corvus corax*	1		87	88

[a] 29 August–3 October 1988
[b] 23 October–2 November 1988
[c] 14 February–5 March 1989

Results

A total of 38 bird species were recorded on the three surveys (Table 1). Overall, the Brünnich's guillemot was the most abundant, although kittiwakes *Rissatridactyla* outnumbered all other birds on the early autumn survey. Relative abundance and distribution changed considerably between the three survey periods.

As the winter of 1988–89 was colder and more severe than usual in West Greenland, most fjords became ice covered and waters north of Nuuk

were almost completely ice covered by mid February. The survey carried out in February in some of the northernmost open waters revealed that there were huge concentrations of alcids and eider ducks (Figs. 5C, 6C, 13C and 14C) among the ice floes and near the ice edge. In late February 1989, an area of about 6,000 km^2 (Fig. 2) held an estimated 500,000 birds, mainly king eiders and Brünnich's guillemots.

Species account

Red-throated diver *Gavia stellata*

Red-throated divers were only observed during survey 1, during the period 29 August –11 September 1988.

Fulmar *Fulmarus glacialis*

The fulmar was the most widespread and the secondmost numerous bird seen during survey 1 (Table 1). Fulmars were observed in all areas except for fjords, waters close to the coast and parts of Disko Bay (Fig. 3). The highest densities were found on survey 1 ca. 25 km offshore south of Aasiaat and south of Paamiut. Fulmar densities tended to decrease with increasing distance from land. The average density of fulmars during survey 1 was 5.5 birds/km^2 (n = 780 10 min. periods). An average density of 8.0 birds/km^2 (n = 146) was calculated for the area just south of Paamiut and 6.6 birds/km^2 (n = 104) for the area between Nuuk and Manitsoq. The areas with fulmar concentrations coincided in space and time with observed upwelling areas. During survey 1 the area just south of Aasiaat had the highest average density of fulmars (12.6 birds/km^2 n = 100). In late September, only a few fulmars were

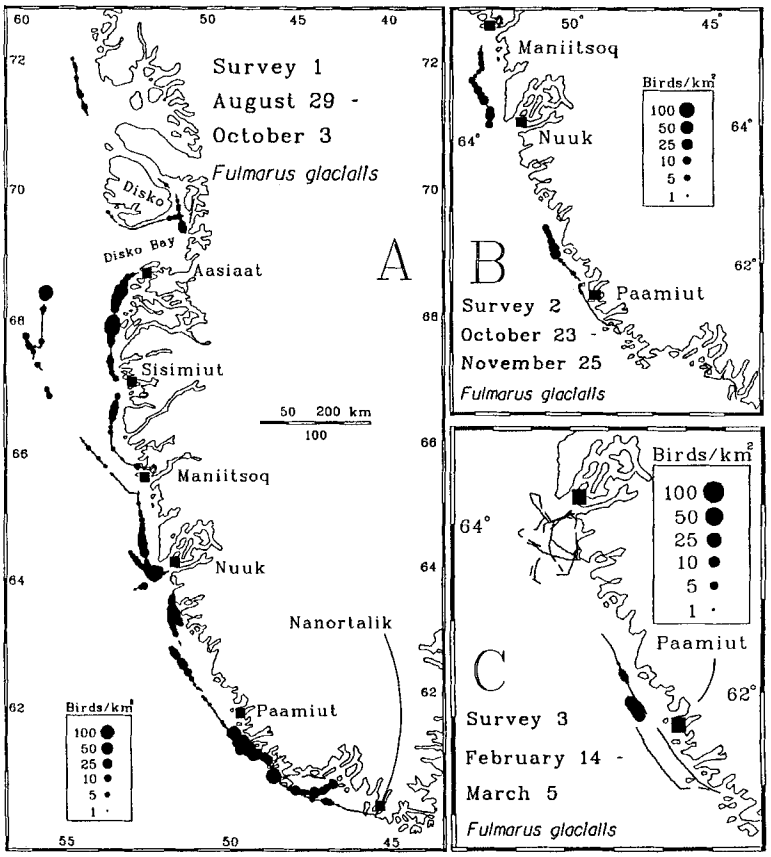

Fig. 3. Distribution of fulmar *Fulmarusglacialis* off southwestern Greenland.

observed north of Aasiaat. Fulmar numbers were low in areas characterised by low sea-surface temperatures, whereas numbers were high in the warmest water masses (Fig. 16). Concentrations of fulmars were often observed near long lines of drifting material, and this was the dominant species attending working fish trawlers. On survey 1, 13% of all fulmars were observed near trawlers.

Fulmars were less abundant on survey 2, and none were observed south of Paamiut (Fig. 3B). Transects in the southernmost area, however, were performed in inshore waters between islands and skerries where fulmars are rarely found. North of Paamiut, the average density of fulmars was 4.1 birds/km^2 (n = 76).

On survey 3, fulmars were not seen in waters with any but the lightest ice cover (Fig. 17) and were only seen in and around an open water area between Paamiut and Nuuk, where high densities were recorded.

The proportion of birds recorded in primary moult decreased during September from 48% (n = 141) on 4 September to 24% (n = 169) on 16 September and to 19% (n = 291) on 27 September. Primary moult was not observed during surveys 2 and 3. The composition of colour phases in mid-September between Sisimiut and Cape Thorwaldsen was 60% LL, 6% L, 17% D and 17% DD (n = 660). The highest proportions of dark birds were found around Nuuk. During survey 2, the proportion of light phase birds (LL) was 92% (n = 167), and during winter 62% (n = 58).

Great shearwater *Puffinus gravis*

During survey 1, the great shearwater was the fourth most numerous species observed (Table 1). Nearly all the great shearwaters (97%) were seen in the last three days of August. The last individual was seen off Nuuk on 11 September. Shearwaters were roughly distributed in two large aggregations (Fig. 4); one just north of Nuuk had an average density of 2.6 birds/km^2, (n = 62) and one covering a large area around Cape Thorwaldsen had an average density of 6.3 birds/km^2 (n = 114). The northernmost observation of great shearwaters was made at 67°13'N on 10 September. Great shearwaters were not recorded in the coldest water masses and most were observed in areas within the middle or high ranges of temperature (Fig. 16). The upwelling areas south of Nuuk and Cape Thorwaldsen coincided with the two centers of great shearwater distribution. No great shearwaters were seen attending trawlers.

King eider *Somateria spectabilis*

The only flocks of king eiders recorded in September were in northern Disko Bay (Fig. 5A). Our survey of Disko Bay was not thorough and we did not record the large moulting flocks which gather there during summer and autumn (Salomonsen 1950). Birds were seen during survey 2 around Paamiut (Fig. 5B) in low densities (0.3 birds/km^2, n = 74).

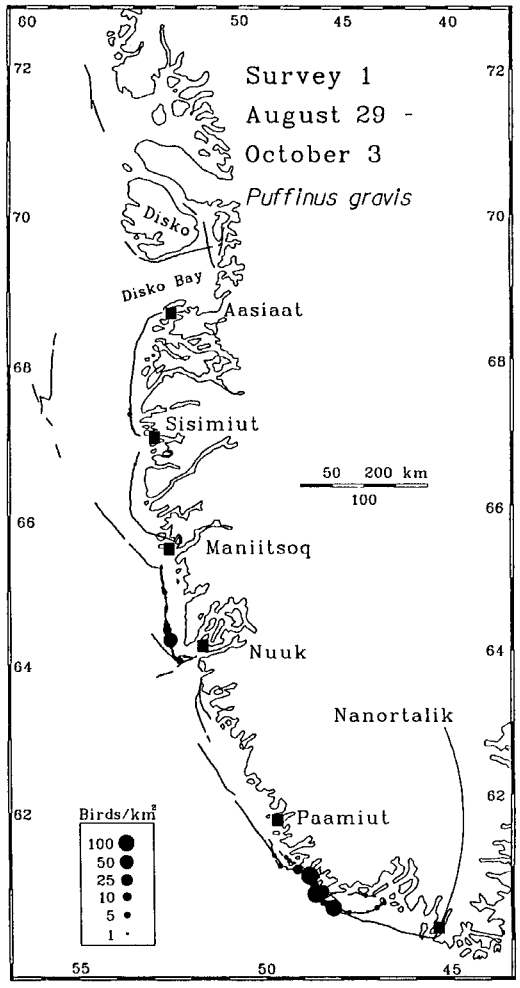

Fig. 4. Distribution of great shearwater *Puffinusgravis* off southwestern Greenland.

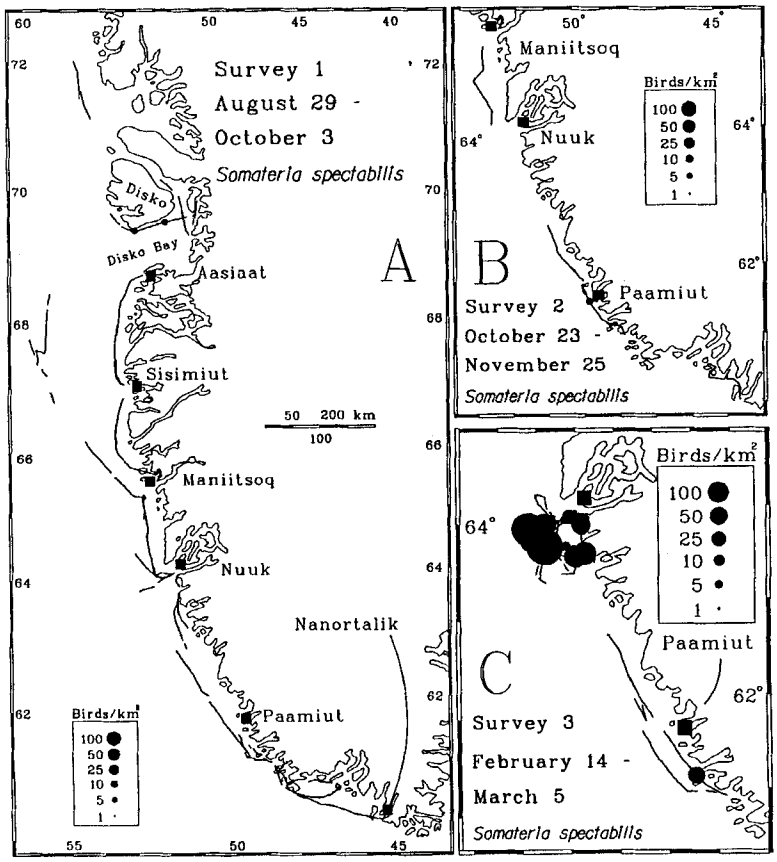

Fig. 5. Distribution of king eider *Somateriaspectabilis* off southwestern Greenland.

On survey 3, high densities of king eiders were observed west of Nuuk and in the almost ice free Nuuk Fjord. Large flocks of king eiders regularly gather in the ice free waters of Nuuk Fjord (local hunters pers. comm.). However, on our survey most birds resided in areas with heavy drift ice and scattered openings in the ice southwest of Nuuk Fjord. King eiders were significantly associated with high ice cover (Fig. 17). King eiders were not found throughout the 6,000 km^2 area west of Nuuk, but the average density of eiders was 54.3 birds/km^2 (n = 226), and the population within that area may be estimated to about 280,000 birds.

Common eider *Somateria mollissima*

Common eiders were the most frequently seen of the two eider species during both surveys 1 and 2, but were outnumbered by king eiders (85%) on survey 3. However, few were seen at any time and most were not identified to species. Most of the few birds observed on survey 1 were seen between Aasiaat and Sisimiut (Fig. 6A) and the density of common eiders calculated for this region was (0.9 birds/km^2, n = 98, Fig. 6A).

During survey 2, most eiders were recorded near the coast around Paamiut (Fig. 6B), and the density on this line was 2.2 birds/km^2 (n = 74). During survey 3 all eiders observed were concentrated among the ice in the archipelago west of Nuuk (Fig. 6C).

Common eiders were present in most icefree parts of Nuuk Fjord. Generally, common eiders were not associated with heavily ice-covered areas (Fig. 17). An average density of 7.6 birds/km^2 (n = 84) was found in a 1,500 km^2 area west of Nuuk, which leads to an estimate of ca. 12,000 common eiders occupying this area during survey 3.

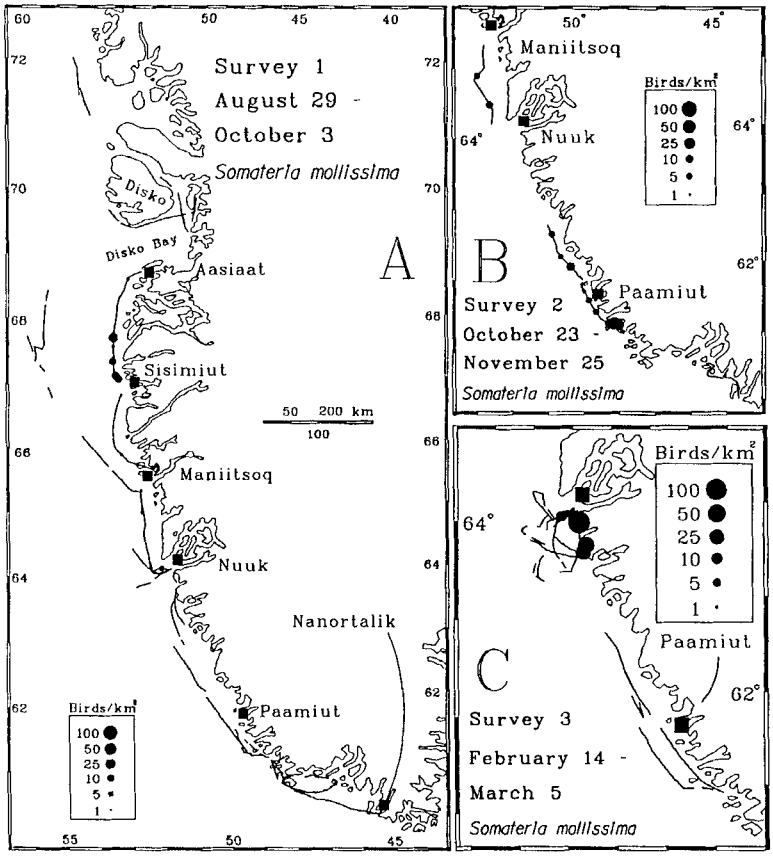

Fig. 6. Distribution of common eider *Somateria mollissima* off southwestern Greenland.

Long-tailed duck *Clangula hyemalis*

A few long-tailed ducks were seen in on survey 1, (Fig. 7A). On survey 2, long-tailed ducks were relatively common near Nanortalik (Fig. 7B). The long-tailed duck density in this area was 1.1 birds/km^2 (n = 66). Long-tailed ducks were concentrated in the icy waters near Nuuk in winter (Fig. 7C).

Gyrfalcon *Falco rusticolus*

No gyrfalcons were seen at sea during surveys 1 and 2. During winter gyrfalcons were seen up to 50 kilometres offshore in bird rich areas, and on some occasions the falcons were obviously hunting seabirds in areas with plenty of king eiders and Brünnich's guillemots. Five birds observed at close range were light grey or white.

Red-necked phalarope *Phalaropus lobatus*

This species was only recorded during survey 1, and the last birds were seen on 30 September 1988. The average density of phalaropes on survey 1 was 0.47 birds/km^2 (n = 780). Red-necked phalaropes were seen along most of the coast and densities generally decreased with increased distance from shore (Fig. 8). Most phalaropes were seen south of Nuuk, associated with concentrations of fulmars and guillemots. Many large baleen whales were also present in the area. The average density of phalaropes in that area was 4.2 birds/km^2 (n = 44). The phalaropes were found associated with waters with a temperature range between 0.5 and 1.5C (Fig. 16).

Grey phalarope *Phalaropus fulicarius*

Only four grey phalaropes were observed, all at

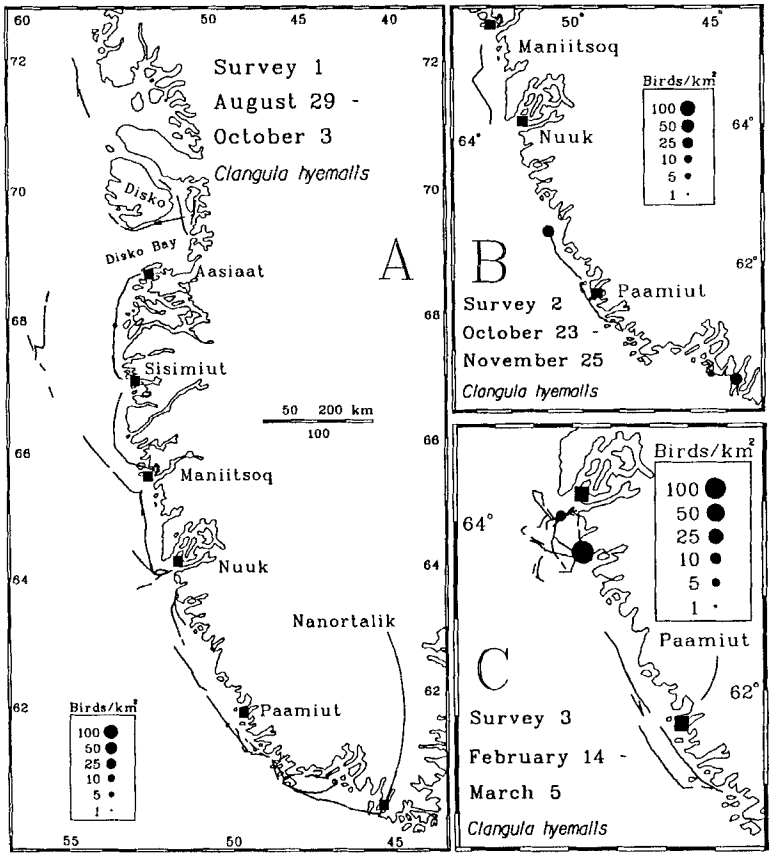

Fig. 7. Distribution of long-tailed duck *Clangulahyemalis* off southwestern Greenland.

least 50 km offshore; two birds were seen south of Paamiut on 31 August, one west of Nuuk on 15 September and the other northwest of Paamiut on 30 September.

Kittiwake *Rissa tridactyla*

Kittiwakes were the most numerous species observed during survey 1. They were present almost everywhere, although very few were recorded close to the coast, between islands and skerries, in the Disko Bay and in the area just north of Nanortalik (Fig. 9A). Numbers gradually declined during September, but a few still remained in late autumn and winter (Fig. 9B and C). In autumn, kittiwakes are known to occur regularly in flocks along the coast (Pihl 1976) or in offshore areas (Salomonsen 1979; Brown 1986). On survey 1, the distribution of the kittiwakes seemed to be associated with the warmer waters within the surveyed area (Fig. 16).

The average density for the total area covered in survey 1 was 7.9 birds/km^2 (n = 780). An average density of 11.5 birds/km^2 (n = 140) was calculated for the area around Cape Thorwaldsen, and 10.3 birds/km^2 (n = 170) for the area between Nuuk and Manitsoq. Between Sisimiut and Aasiaat an average density of 24.4 birds/km^2 (n = 104) was calculated.

During survey 2 the kittiwakes appeared to have a definite northerly distribution, although this pattern may be exaggerated by the inshore placement of the transects in the southern areas during this survey. The average density in the northern area was 3.5 birds/km^2 (n = 36).

Only 2.8% of all kittiwake observations on the surveys were associated with trawlers. Flocks, sometimes numbering hundreds of birds, were often seen resting on icebergs.

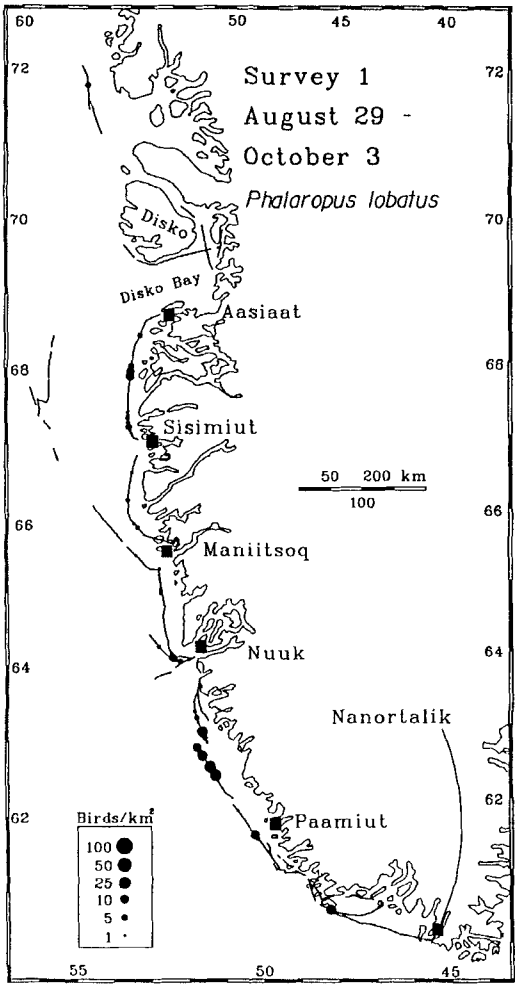

Fig. 8. Distribution of red-necked phalarope *Phalaropus lobatus* off southwestern Greenland.

Glaucous gull *Larus hyperboreus*

During survey 1, the glaucous gull was the most widespread large gull. An average of 0.14 birds/km^2 (n = 780) was calculated for the entire survey. Although the majority of glaucous gulls were seen near the coast, many birds ventured far offshore, and some were observed as far as 180 km offshore (Fig. 10A). On survey 2, glaucous gulls were seen in all areas surveyed (Fig. 10B), but most abundantly in the area around Nanortalik (1.3 birds/km^2, n = 66).

In winter an average density of 0.4 birds/km^2 (n = 234) was found in an area of 6,000 km^2, giving an estimate of about 2,500 glaucous gulls west of Nuuk. Most birds were observed in areas with moderate ice cover and this association was statistically significant (Fig. 17). About 9% of all observations were associated with trawlers.

Iceland gull *Larus glaucoides*

The distribution of Iceland gulls was strictly coastal in autumn (Fig. 11A), and the highest densities were recorded on the transects close to the shore north of Nanortalik on survey 2 (Fig. 11B). The average density for Iceland gulls on survey 1 was calculated to 0.08 birds/km^2 (n = 780). On survey 2 the Iceland gulls were most abundant around Nanortalik (0.8 birds/km^2, n = 66, Fig. 11B). In winter the distribution of Iceland gulls shifted seaward (Fig. 11C). The gulls were most numerous in areas with moderate ice cover (Fig. 17) west of Nuuk Fjord and off Paamiut. In the area west of Nuuk an average density of 1.2 birds/km^2 (n = 296) was calculated for an area of 6,000 km^2, giving an estimated population of about 7,000 Iceland gulls. Only a few Iceland gulls were observed near fishing trawlers; in the autumn surveys no birds were associated with trawlers, and in winter only 5% of the observations were seen near operating vessels. No birds of the subspecies *L.g. kumlieni* were observed on the surveys.

Great black-backed gull *Larus marinus*

During surveys 1 and 2, great black-backed gulls were only seen close to the coast (Fig. 12A and B). In survey 1, the average density of great black-backed gulls was 0.28 birds/km^2 (n = 780). Only 6% of all observations were associated with trawlers. On survey 2, the great black-backed gulls were most abundant around Nanortalik (1.5 birds/km^2, n = 66, Fig. 12B).

In winter, great black-backed gulls were virtually omnipresent, and high concentrations were present west of Nuuk Fjord (Fig. 12C), in the same general area as the concentrations of king eiders, Brünnich's guillemots and black guillemots. Most birds were found in areas with moderate or high ice cover and they seemed to avoid areas with lesser ice cover (Fig. 17). In winter, only 1.4% of all observations were associated with trawlers. In an area of 6,000 km^2 west of Nuuk, an average of 1.6 birds/km^2 (n = 298) was

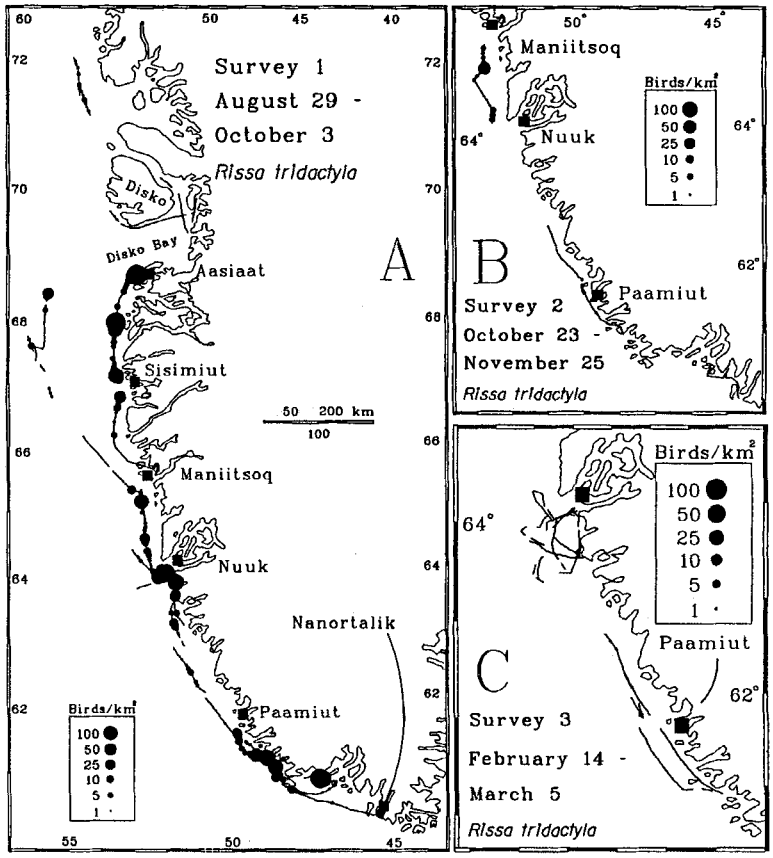

Fig. 9. Distribution of kittiwake *Rissatridactyla* off southwestern Greenland.

found, giving an estimate of about 9,500 great black-backed gulls.

Arctic tern *Sterna paradisaea*

Terns were only recorded during the survey 1, and the last bird was seen on 10 September.

Brünnich's guillemot *Uria lomvia*

Both guillemot species were recorded on the surveys, although the guillemot *Uria aalge* is not common in Greenland waters, and only 15 birds were identified. Brünnich's guillemots were present on most transects during all three surveys (Fig. 13), being the most numerous bird in most areas, although only small numbers were observed between Sisimiut and Aasiaat and far from land off Sisimiut (Fig. 13A). In survey 1, the highest densities were generally found at distances of 10 to 75 kilometres offshore. The average density of guillemots was 5.4 birds/km^2 (n = 780), and in the high density area south of Nuuk, the average density was 30.1 birds/km^2 (n = 70). On the transects between Nuuk and Sisimiut the average density was 7.6 birds/km^2 (n = 226). During survey 1, most birds were recorded in waters with surface temperatures in the lower range, a picture which strikingly resembles that of the red-necked phalarope (Fig. 16).

In late autumn and winter the guillemots were found close to the coast (Figs. 13B and C). In survey 2, very high densities of guillemots were found along the coast and, locally, in the archipelago northwest of Nanortalik (Fig. 13b). The average density of guillemots was 49.9 birds/km^2 (n = 166) and the highest densities were found on the line between Nuuk and Cape Thorwaldsen (82.5 birds/km^2, n = 74).

The Brünnich's guillemot was the most common and widespread species seen on the winter survey and huge numbers of guillemots had

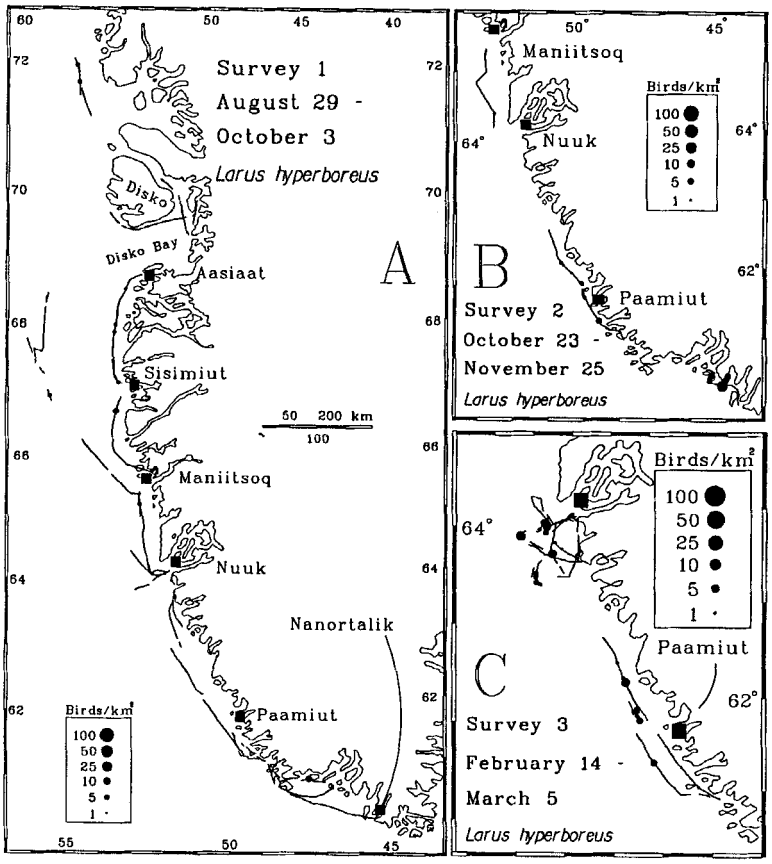

Fig. 10. Distribution of glaucous gull *Larushyperboreus* off southwestern Greenland.

gathered in the waters west of Nuuk. The guillemots sometimes formed very large and dense flocks; two flocks of 33,000 and 27,000 birds were counted, but the transects did not cut into these flocks. The average density of Brünnich's guillemots was 28.1 birds/km^2 (n = 288) in an area of 6,000 km^2, in and around the Nuuk Fjord, giving a total estimate of about 170,000 guillemots. In the southern part of the winter survey, an average density of 7.8 birds/km^2 was found. In winter, about 30% of all guillemots were seen in small open areas within heavy drift ice, but most were found in areas with less ice cover (Fig. 17).

Razorbill *Alca torda*

Although the razorbill breeds in small numbers along the coast north of Cape Thorwaldsen (GM & OC 1993), only one bird was identified on the surveys. This species has probably been overlooked among all the guillemots due to problems in identifying the alcids, especially the juveniles, at a distance. The species do occur in West Greenland in winter. We observed one juvenile during a trip with local hunters in the archipelago west off Nuuk in February 1989.

Black guillemot *Cepphus grylle*

Black guillemots were almost exclusively seen close to land during surveys 1 and 2 (Fig. 14A and B). During survey 2, the majority of black guillemots were recorded inshore northwest of Nanortalik where the density was 5.1 birds/km^2 (n = 66) near a large breeding colony (GM & OC 1993). During survey 3, many birds were seen offshore, and particularly large numbers were concentrated west of Nuuk in the same general

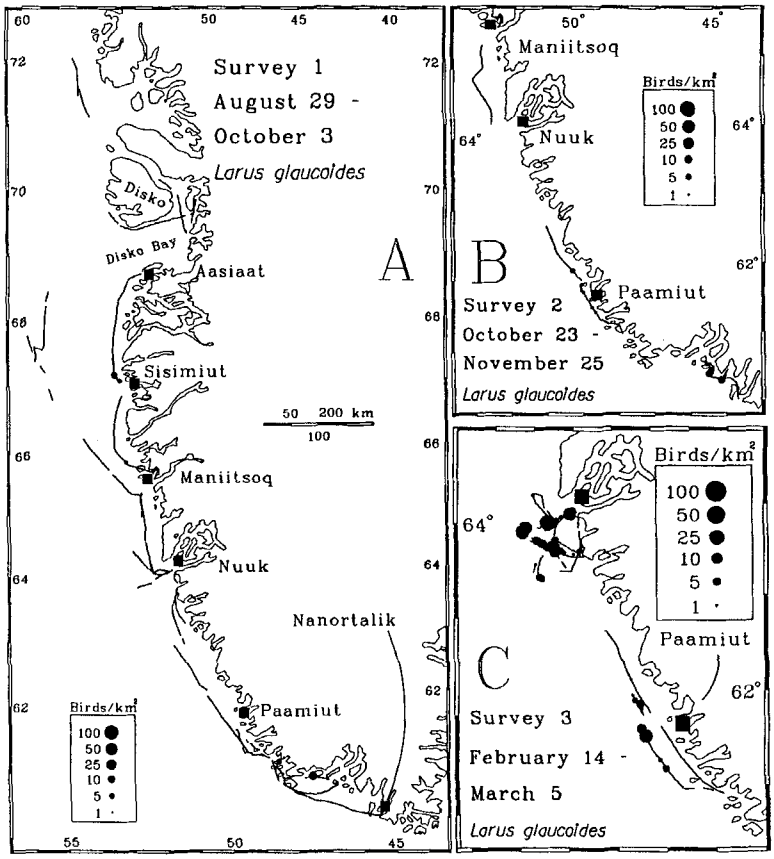

Fig. 11. Distribution of Iceland gull *Larusglaucoides* off southwestern Greenland.

area as guillemots and eiders (Fig 14C). The average density of black guillemots in a 6,000 km^2 area west of Nuuk was 3.9 birds/km^2 (n = 290), and the population within that area can be estimated to about 25,000 birds. Most black guillemots were found in areas with heavy ice cover (Fig. 17).

Puffin *Fratercula arctica*

Very few puffins were seen. A total of 42 observations comprising 47 birds were made during survey 1, most birds being seen in the southern part of the area covered, especially in the area between Paamiut and Nanortalik. The average density of puffins in survey 1 was 0.06 birds/km^2 (n = 780), but south of Cape Thorwaldsen the density was 0.5 birds/km^2 (n = 56). On survey 2 puffins were not seen on the southern transect close to the coast. The density calculated for the northernmost line was 0.3 birds/km^2 (n = 36) and for the area off Paamiut, 0.2 birds/km^2 (n = 74). No puffins were noted on the winter survey.

Little auk *Alle alle*

Little auks were recorded during all three surveys. On survey 1 the highest densities (5.6 birds/km^2, n = 94) were found far offshore between Sisimiut and Aasiaat, whereas no birds were recorded on the transect close to the coast on the same latitudes (Fig. 15A). The density south of Cape Thorwaldsen was 1.3 birds/km^2 (n = 48) and the average density of little auks was 0.9 birds/km^2 (n = 780). The little auks generally were not found in waters with surface temperatures in the higher range (Fig. 16). On survey 2 they were most numerous around Paamiut, and none were

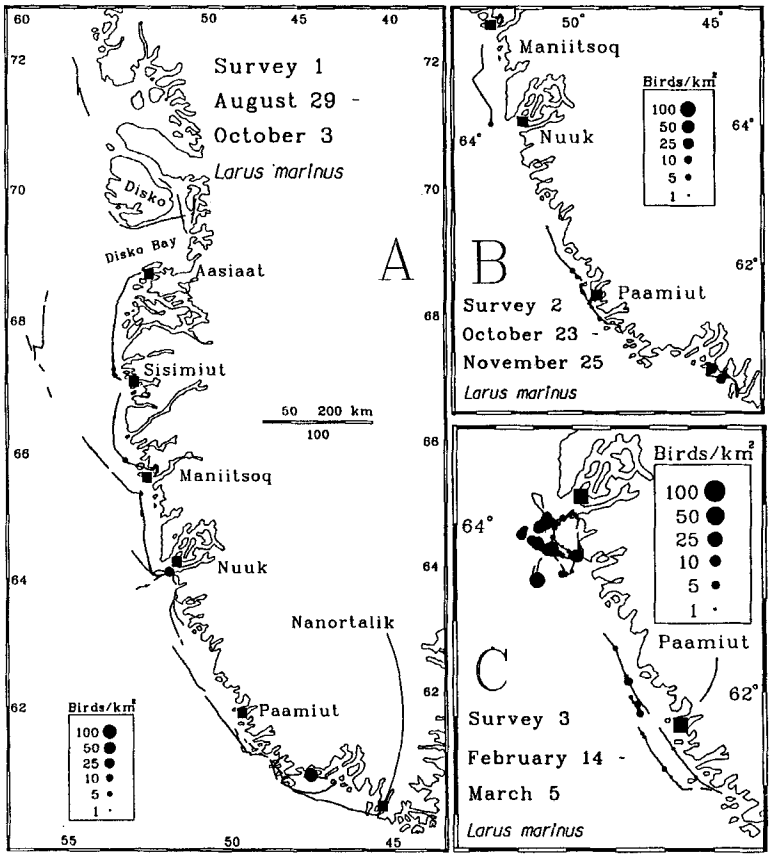

Fig. 12. Distribution of great black-backed gull *Larusmarinus* off southwestern Greenland.

recorded between islands and skerries (Fig. 15B). On survey 2 the distribution of little auks resembled that of the puffin. The density calculated for the northern line on survey 2 was 1.3 birds/km^2 (n = 36) and for the area off Paamiut 2.7 birds/km^2 (n = 74). During the winter survey, little auks were generally scattered in low densities (1.2 birds/km^2, n = 252) in an area of 6,000 km^2 west of Nuuk Fiord, giving an estimated 6,000 little auks for that area (Fig. 15C). The densities recorded further south were very low. Few little auks were found in areas with heavy ice cover (Fig. 17).

Discussion

The results of the surveys in 1988–89 confirm most existing knowledge on the general distribution and phenology of seabirds along the coast of southwestern Greenland in the autumn and winter seasons (Salomonsen 1950, 1979; Brown 1986). In addition this study quantifies information on bird numbers and distribution patterns and describes some oceanographic habitat characteristics important for seabird distribution. The survey lines were few and scattered and only a rough picture of seabird distribution as well as indications of densities could be produced.

General seabird densities were much greater close to land and over shallow areas than over the deeper parts of the study area. In some cases, seabird concentrations seemed to be related to oceanographic features such as areas with upwellings or convergent fronts, the latter phenomena evidenced by lines of drifting matter. The fulmar was one of the most widespread and common seabirds seen along southwestern Greenland. Although the data do not warrant a population estimate, we believe that in autumn there were

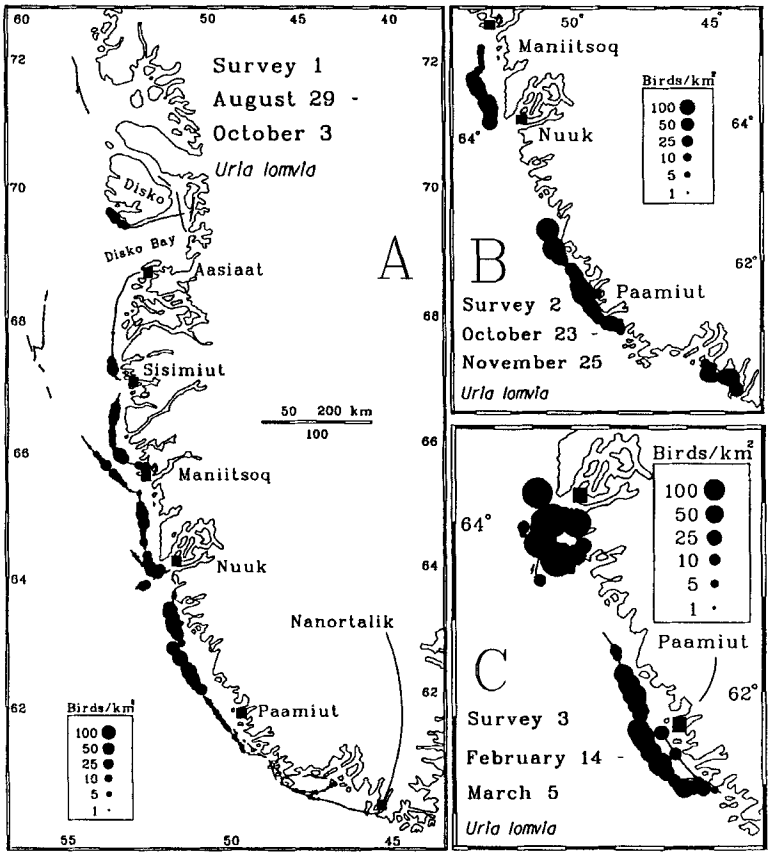

Fig. 13. Distribution of Brünnich's guillemot *Urialomvia* off southwestern Greenland.

at least one million fulmars in the area. The fact that only small numbers of fulmars were observed near fishing vessels indicates that fishing activities played only a minor role for the distribution of fulmars at this time of year, as found by Brown (1970). The fact that fulmars were mainly found in the warmer waters found during survey 1 probably explains the virtual absence of fulmars from the Disko Bay area where sea surface temperatures were very low. The highest proportions of dark phase birds were found around Nuuk as also noted by Salomonsen (1965) and Boertmann (1979). Presumably these birds originated from the huge breeding colonies at Baffin Island as is also suggested by Brown et al. (1975).

The numbers of great shearwaters off West Greenland seems to fluctuate from year to year; although they were numerous in the autumn of 1988, they were not observed on transect lines south of Cape Thorwaldsen in the summer 1990 (Glahder 1993), and they were almost absent from West Greenland waters in early autumn 1992 (Greenland Environmental Research Institute unpubl. data). A study of seabird distribution in the North Atlantic suggests that the great shearwaters concentrate in the waters of the Irminger Basin southeast of Greenland (Skov et al. 1994). Glahder (1993) showed that high densities of great shearwaters were present off southeastern Greenland in August 1990. In the present study great shearwaters were found in waters within the upper range of surface temperatures measured. It has been suggested that the movements of great shearwaters around the Atlantic Ocean follow seasonal peaks in local food sources (Brown et al. 1981).

The three large gulls showed roughly similar distribution patterns. The great black-backed gull was the most numerous staying near the coast in autumn as observed by Salomonsen (1950). All

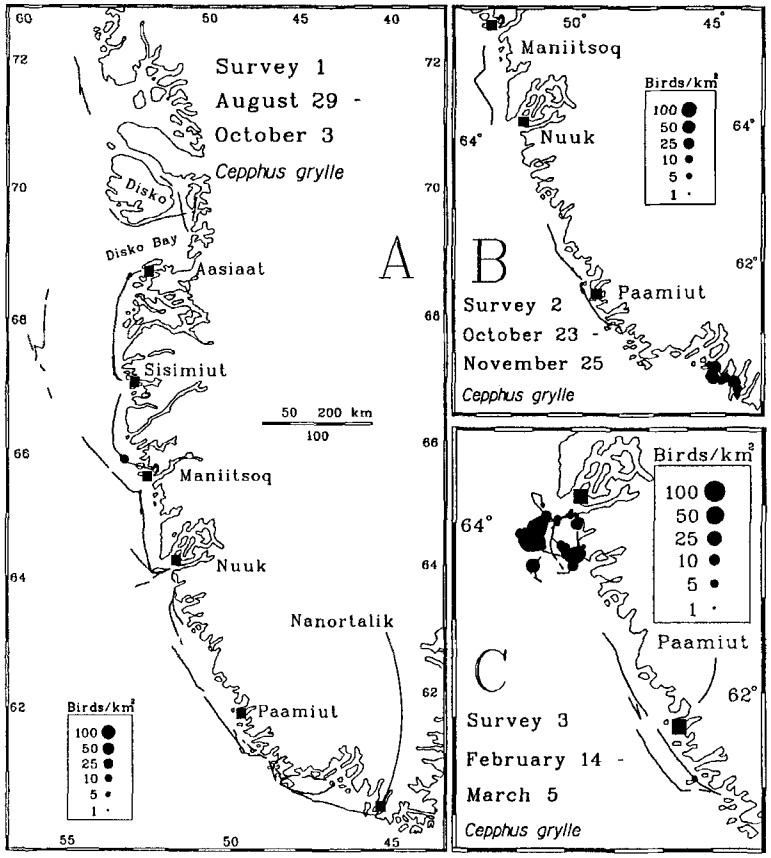

Fig. 14. Distribution of black guillemot *Cepphusgrylle* off southwestern Greenland.

three gull species showed higher densities close to the coast. The Iceland gull was the least numerous and the species distributed closest to the coast. All three species were apparently more abundant offshore during winter.

Brünnich's guillemots were the most numerous birds in this study, especially at some distance from the coast. Information from seabird bycatch in salmon drift-nets in the 1970s suggests a similar distribution of guillemots in September, when the largest catch numbers (per unit effort) were recorded in relatively shallow areas a good distance from the coast (Christensen & Lear 1977). However, in late summer and autumn, guillemots can be found in small numbers everywhere in the Davis Strait (Brown 1986). Although our surveys cannot determine an accurate population estimate, the numbers in autumn were probably between half and three-quarters of a million birds off southwestern Greenland. The Brünnichs guillemot's affinity to the shallow offshore areas in early autumn may be the main reason that net-entanglement in drift-nets is no longer a major mortality factor. Currently, most nets are set in the fjords, and September is the main fishing period (Falk & Durinck 1991). But when the guillemots enter the fjords in late autumn the birds are exposed to hunting pressures (Falk & Durinck 1992).

Early in the autumn some little auks probably move down towards the central coast of southwestern Greenland from the huge colonies in northwest Greenland. Most birds recorded in the northern part of the surveyed area in survey 1 probably derived from these colonies. The largest concentrations of little auks recorded in September were found along the edge of the Polar Front west of Sisimut (Figs. 1A and 15A), implying that little auks may be found in greater numbers west of the study area. This pattern is

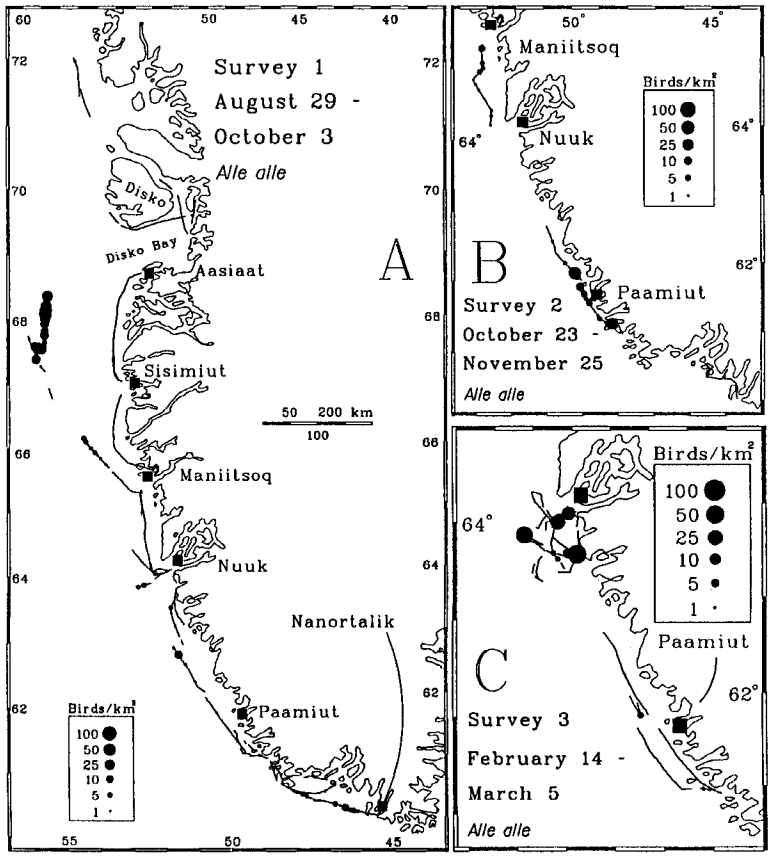

Fig. 15. Distribution of little auk *Alle alle* off southwestern Greenland.

as also suggested by net-entanglement data from 1970s (Christensen & Lear 1977), and from surveys in the Davis Strait (Brown 1986). Although little auks from Svalbard are known to winter off West Greenland (17 ring recoveries, GM & OC 1993), and we find it surprising how few birds were recorded in the late autumn and winter surveys.

In the winter of 1988–89, in the northernmost areas with some open water (Nuuk Fjord and the coastal area west of Nuuk), huge numbers of king eiders (ca. 280,000), Brünnich's guillemots (ca. 170,000) and black guillemots (ca. 25,000) were concentrated in an area of about 6,000 km^2. If this is a recurring phenomenon, the area must be regarded as an important wintering area for seabirds. The area west of Nuuk is a traditional hunting area for the local inhabitants and a well-known feeding area for guillemots and eider ducks (Anon 1976; Falk & Durinck 1993).

Winter ice cover provided opportunities for land birds to forage at sea. For predators, ice was a convenient perch for hunting and eating prey, and on several occasions gyrfalcons were seen hunting seabirds in icy areas far from land. Furthermore, great black-backed gulls and ravens *Corvus corax* seemed attracted to the dense ice cover. This could be because offal was often left on the ice from trawlers operating in winter in areas with dense ice cover, thereby providing easily accessible forage to scavenging gulls and ravens. In addition, as one of the most abundant marine scavengers, the fulmar, appeared to avoid dense ice cover, the ravens and gulls had little competition in the icy waters.

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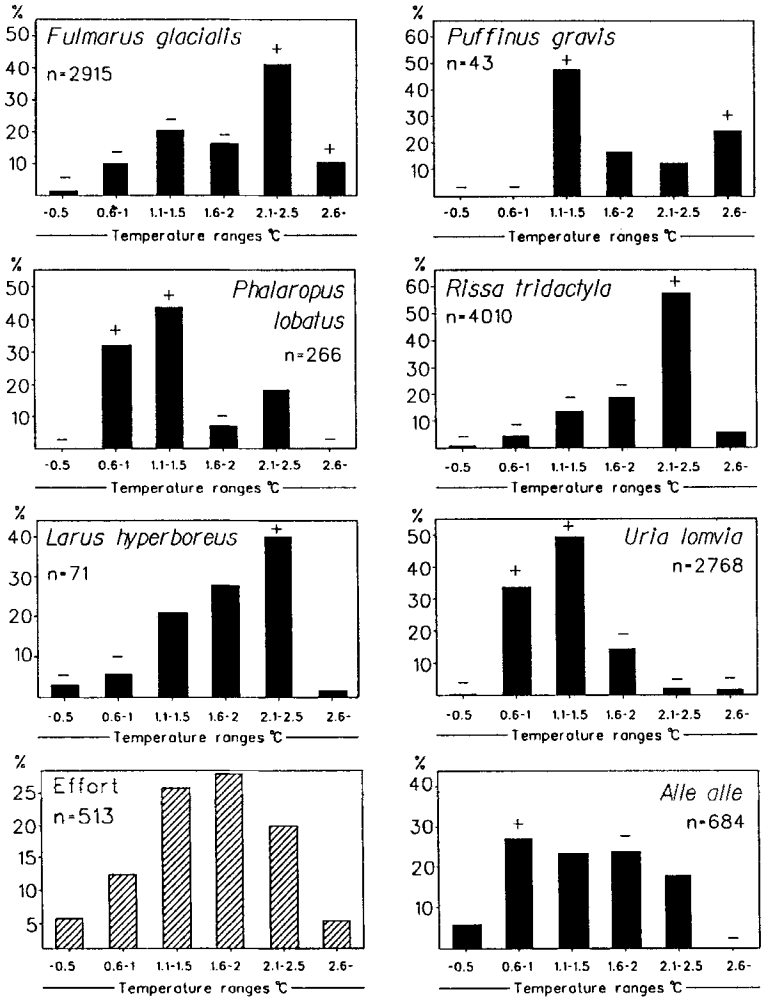

Fig. 16. Proportional distribution of seabirds observed within specific ranges of sea surface temperature off southwestern Greenland September 1988. Positively significant association (95%) for range indicated by "+" while "–" indicates negative significance. Blank indicates "not significant".

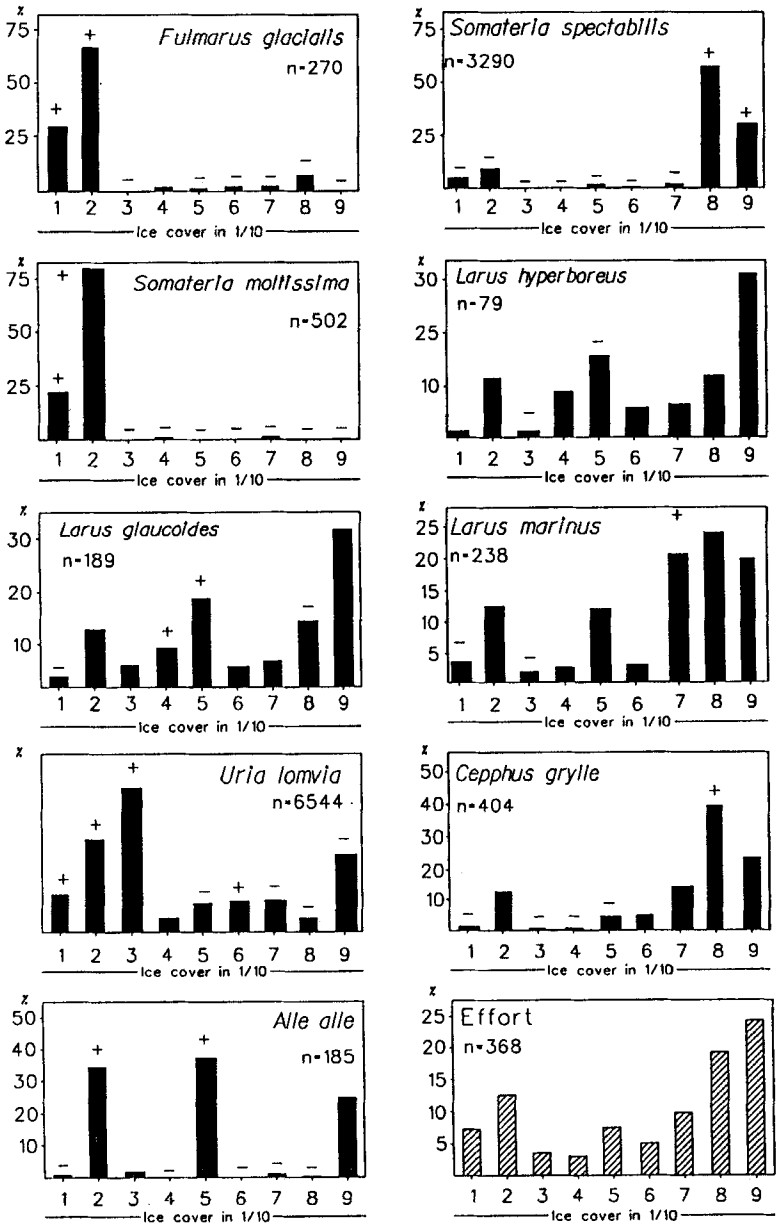

Fig. 17. Proportional distribution of seabirds observed within specific ranges of ice cover (1/10 to 9/10) off southwestern Greenland February 1989. Positively significant association (95%) for range indicated by "+" while "–" indicates negative significance. Blank indicates "not significant".

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