



SKRIFTER NR. 191

Fridtjof Mehlum

Summer distribution of
seabirds in northern
Greenland and Barents Seas



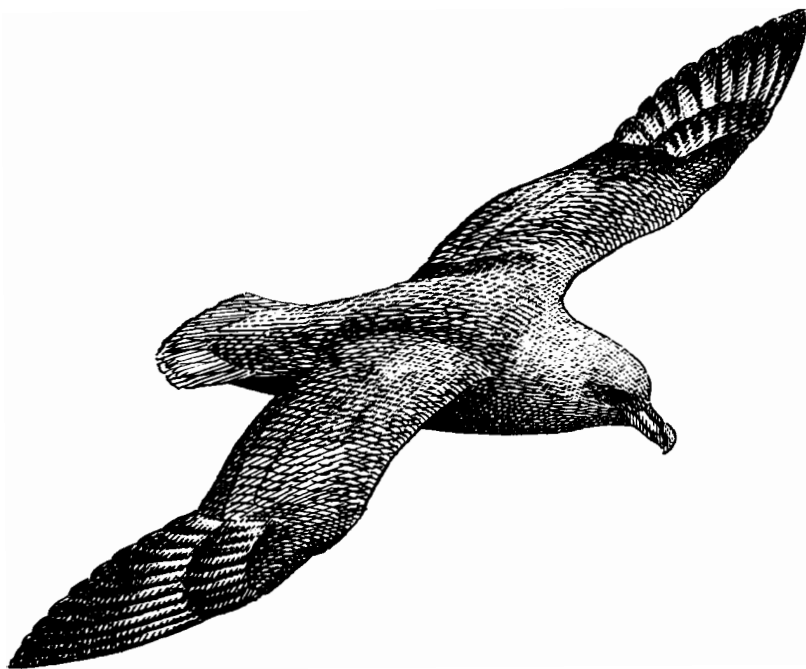
NORSK POLARINSTITUTT
OSLO 1989



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Cover page: Fulmar *Fulmarus glacialis*.
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Abstract

Line transects of seabirds were conducted in the seas around Svalbard during five summer seasons (1980–1984). The transects were made on board Norwegian, Swedish and West-German research vessels covering the area from Northeast Greenland in the west to Frans Josef Land in the east. The seabird observations were made along a total transect length of 26,700 km and are grouped into 10-minute watches. Because the transects had no fixed width, absolute densities of birds per area unit could not be obtained.

A computer programme was made to generate distribution and abundance maps for each seabird species. The abundance was given as mean number of birds recorded in each block (0.2 degrees north-south, 1 degree east-west) where registrations were made. The abundances were grouped into eight categories. A separate map was compiled showing the total observation time (effort) in each block. The total number of individuals of each seabird species was also computed.

Three species, the Little Auk *Alle alle*, the Fulmar *Fulmarus glacialis*, and the Kittiwake *Rissa tridactyla*, dominated in numbers during the transects and accounted for 86% of the total number of seabirds observed. Brünnich's Guillemot *Uria lomvia* accounted for another 9% of the birds. A total of 567,154 birds of 22 species was recorded. Distinct distribution patterns were obtained for each species. Distribution and abundance maps are presented for the 19 most numerous species.

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Introduction

The seas around the Svalbard archipelago are rich in biological resources. The large biomass of fish and pelagic invertebrates is exploited by seabird populations of many species. The Svalbard area and the whole Barents Sea area are inhabited by one of the largest and most important seabird communities in the northern hemisphere (Norderhaug et al. 1977; Croxall et al. 1984). The living resources of the seas around Svalbard are exposed to several threats. Extensive fisheries take place in these seas, especially in the Barents Sea. Management of fish stocks and offshore drilling activities will probably be of main importance for the fate of the marine ecosystems in these arctic areas. Seabirds are important elements in the marine ecosystems, but their functions in arctic ecosystems are not yet understood in full detail.

Researchers at Norsk Polarinstitutt have been working for several years on the mapping of the distribution and abundance of seabirds in the Svalbard area. Censuses of breeding colonies have been made all around the archipelago (Norderhaug et al. 1977; Jepsen & Mobæk 1983; Mehlum & Fjeld 1987). In 1980 we initiated a programme to map the pelagic distribution of seabirds in the seas around Svalbard. Before 1980 only a few ship-based censuses between the coast of Northern Norway and the southern point of Spitsbergen had been published (Voisin 1970; Byrkjedal et al. 1976; Hansen 1978). Brown (1984) conducted a comprehensive seabird census during the spring of 1982 in the Greenland, Norwegian and western Barents Seas, applying the same methods as used by the Canadian Wildlife Service in Canadian waters (Brown et al. 1975). In 1980 we cooperated with the Swedish 'Ymer'-80 expedition in mapping the pelagic distribution of seabirds (Edelstam 1981; Hjort et al. 1987). The 'Ymer' is an icebreaker able to cope with heavy multiyear ice. This cooperation gave the opportunity to obtain data from seas far to the north, which could not be reached by smaller research vessels. Similarly, in 1984 we cooperated with the Alfred Wegener Institut für Polarforschung, and were able to use the German icebreaker 'Polarstern' in heavy ice-covered waters in the northern parts of the Fram Strait.

The study of the pelagic distribution and abundance of seabirds in these areas has two main objectives. The first is to give a general description

of the occurrence of the different seabird species at different times of the year throughout these seas. The other is to try to explain the patterns of abundance of seabirds by the presence of other living organisms and different physical environmental factors. Additionally, the data will help to increase our knowledge of the biology and migration of arctic seabirds.

In the present paper the summer distribution of different seabird species from five consecutive years 1980–1984 is presented in the form of relative abundance maps. In this descriptive presentation no thorough analytical discussion of the distribution patterns has been made. These matters will be dealt with in future papers.

Material and methods

Cruises and areas covered

This report includes seabird observations collected during the summer season 1980–1984. The following cruises were conducted: 3 July–26 September 1980 with the Swedish icebreaker 'Ymer', 22 July–6 August 1980 with the Norwegian sealer 'Norvarg', 28 July–31 August 1981, 22 July–31 August 1982 and 19 July–1 September 1983 with the Norwegian Polar Research Institute research vessel 'Lance', 20 July–4 August 1984 with the West German ice-breaking research vessel 'Polarstern'. One to four observers participated on each cruise. All of the cruises were multidisciplinary, but fishing activities, which usually attract some seabird species, were never involved.

The total seabird observation time during these cruises was 2,006 hours, corresponding to a transect length of 26,700 km.

Surveys were made in the northern Greenland Sea and the Fram Strait, the northern and north-western Barents Sea as well as north of Svalbard into the Arctic Ocean. The actual areas covered by the cruises and the total observation effort (number of 10-minute watches in each geographical subunit, see below) are shown in Map 1. The range of the distribution maps is 20°W to 50°E and 74° to 83°N.

Recording methods

Seabirds at sea have been recorded in many different ways. Most counts have been done from ships, but in recent years aircraft have also been

used to some extent. Ships and aircraft both have their advantages and disadvantages. To be able to compare seabird census results from different parts of the world, obtained by many observers, it is important to have standardized recording methods. In recent years most observers have used 10-minute observation periods as recording unit (Brown et al. 1975; see Tasker et al. 1984 for review).

In our studies all seabirds seen from the moving ship were recorded. The transect width was unlimited, but in practice most birds were seen closer than 300 m from the ship, and in a sector 180° ahead of the moving ship. The observer was located outdoors on the deck above the steering house, and the watches were of 2–4 hours duration. During most cruises two or more observers were on board, and watch was usually kept around the clock as long as the ship was moving, except for periods with rough seas, fog, and from mid-August onwards during the dark hours. The observed birds were separated into different categories of age, behaviour, and sex (if possible). Data on weather, sea-ice and geographical positions were also included. Navigational data were obtained regularly from the ship's satellite navigation systems, usually every hour and whenever the ship's heading was changed. All data were recorded on a special form and later transferred to a computer file.

Distribution and abundance maps

A special FORTRAN computer programme (MAPPER) was developed for statistical treatment and for the drawing of abundance maps for each species. For the presentation of species abundance maps we have lumped the observations into a number of blocks with each entry corresponding to 0.2°N/S and 1°E/W. For each block the observation effort, i.e. the number of 10-minute watches, and the mean number of birds of different species seen per 10-minute period, was calculated. These values of relative abundance are represented by symbols on the distribution maps by eight categories (Fig. 1). A special projection was made in order to obtain the same size of all 0.2°N/S × 1°E/W degree blocks (squares). The abundance categories are in accordance with those used by Brown et al. (1975) in eastern Canadian waters. Circular symbols filled with black according to relative abundance were applied for easy visual perception of the

RELATIVE ABUNDANCE :

(MEAN NUMBER SEEN PER 10 MINUTES)

○ NONE	● 3.0 - 10.0
◐ 0.1 - 0.3	● 10.0 - 30.0
◑ 0.3 - 1.0	● 30.0 - 100.0
◒ 1.0 - 3.0	● MORE THAN 100.0

Fig. 1. The abundance of birds is indicated by the mean number of individuals observed per 10-minute watch within a unit block (0.2°N/S × 1°E/W). An open circle indicates no observations (see text).

abundance patterns. Longitudes west of Greenwich are indicated by negative values.

Some of the calculations involved need to be described. Between fixed geographical positions we calculated the positions for every 10-minute observation sub-interval. This was done by calculating 1) the distance between two neighbouring fixed positions, 2) the sum of all observation sub-intervals (in minutes) when the ship was moving between the two fixed positions, 3) the movement per minute of the ship, and by linear interpolation for determining the position of each 10-minute sub-interval.

The observation effort in each 0.2° × 1° block was then determined by first calculating the observation time in each block according to the previously calculated movement per minute between two fixed positions. Divided by 10, this gives the effort (number of 10-minute watches). A similar procedure was followed for calculating the abundance of observed birds in each block. For the purpose of this paper all age groups and behavioural categories are combined.

Oceanography and sea-ice conditions

The oceanographic conditions in the Barents Sea are dominated by the southwesterly flow of cold arctic water from the Polar Basin, which meets a branch of the warmer North Atlantic Current flowing northeast along the Bjørnøya Channel to form a frontal system in the area southeast of

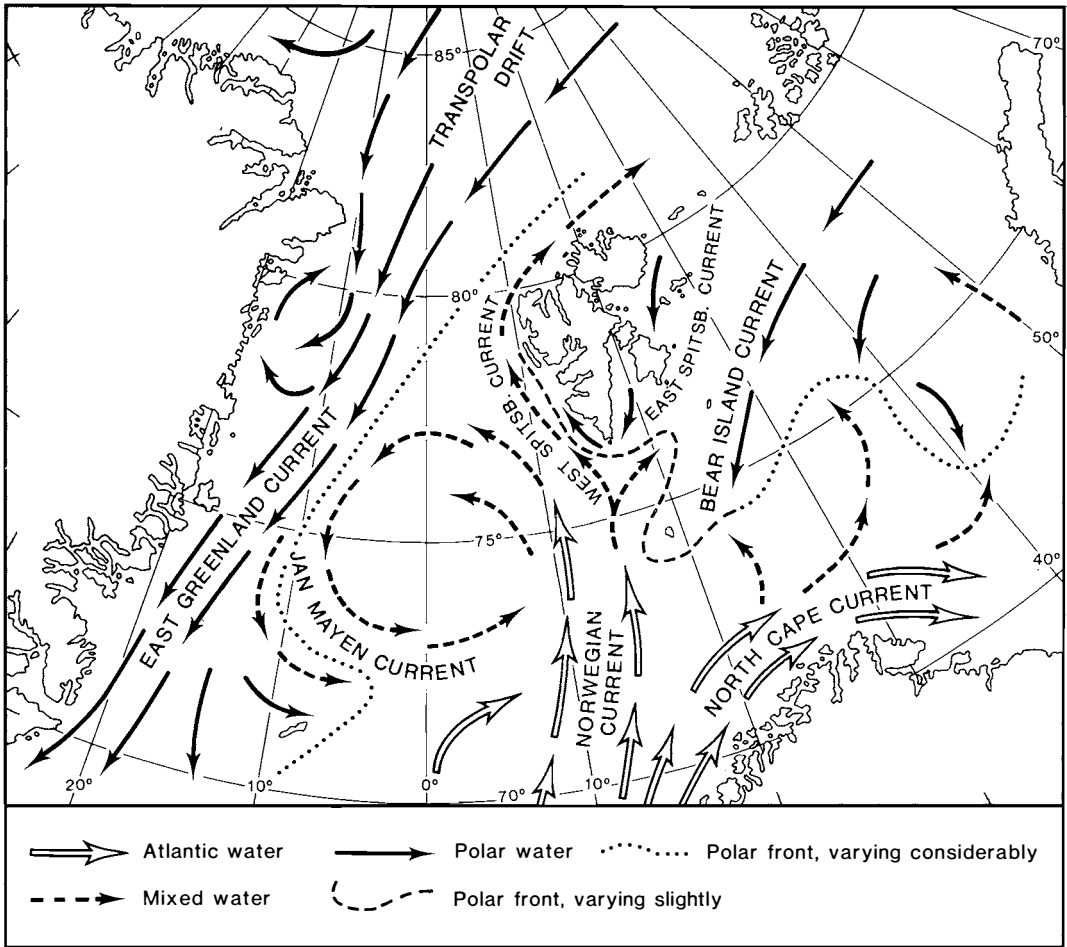


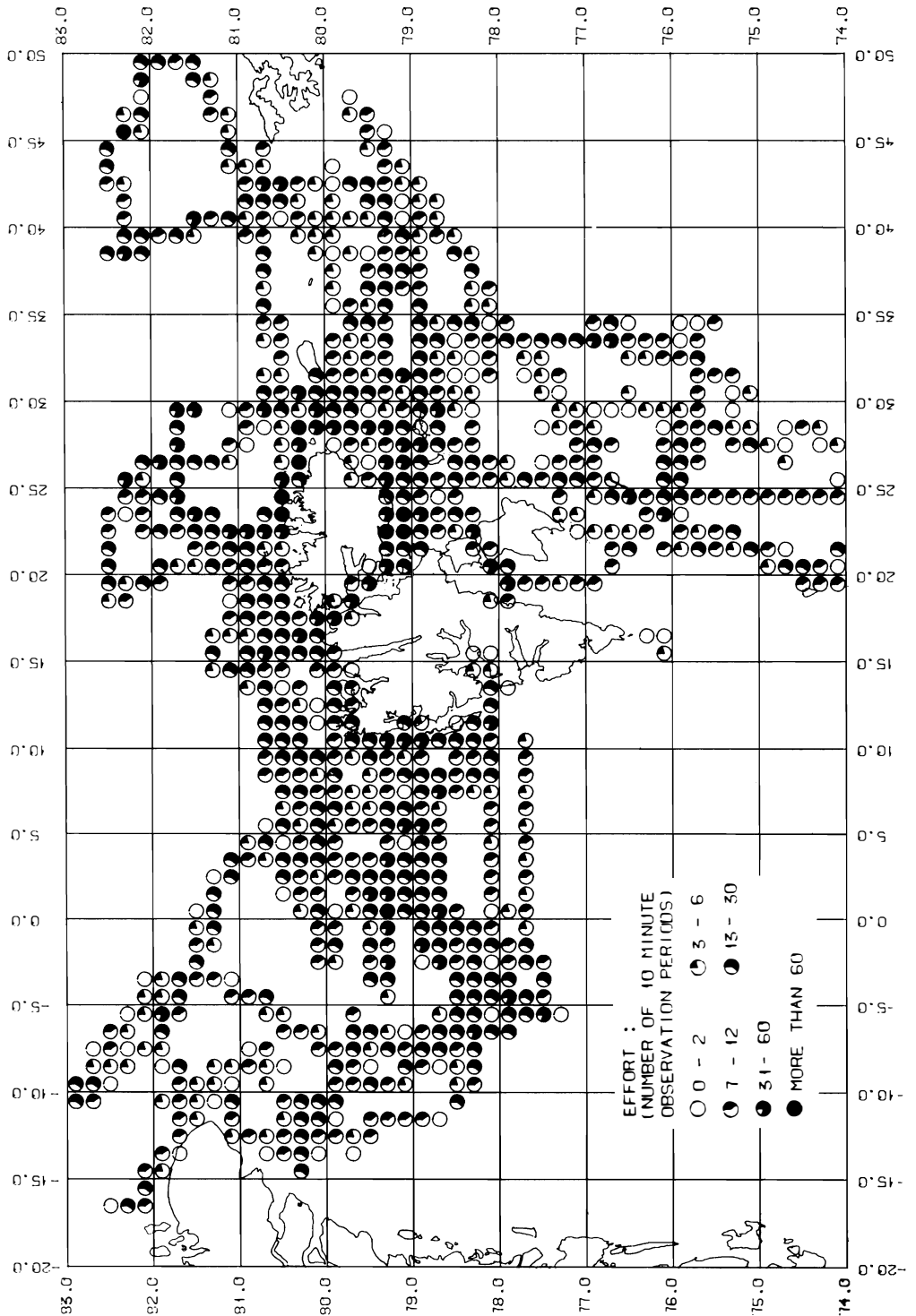
Fig. 2. Prevailing surface currents in the ocean areas around Svalbard. The 'polar fronts' indicated on the map suggest the approximate positions on the surface of the division between temperate, saline Atlantic water and cold, less saline water of polar origin.

Svalbard (Fig. 2). The Greenland Sea is characterized by the large outflow of cold arctic water from the East Greenland Current to the west, and the warmer West-Spitsbergen Current flowing northwards along the coast of Spitsbergen. The Barents Sea is a shallow sea (most parts are less than 300 m deep) and characterized by several banks like Storbanken, Sentralbanken (150–200 m) and Spitsbergenbanken (50–100 m). The Greenland Sea, however, except for a shelf (70 km wide on the Svalbard and 200–250 km wide on the Northeast-Greenland side) with depths between 100 m and 500 m is a deep sea area with depths of more than 3,000 m.

The northern parts of the study area are usually

covered by sea-ice. Most of the ice in the Barents Sea is formed locally, but there is also a variable influx of multiyear ice transported from the Arctic Ocean through the passage between Svalbard and Frans Josef Land. Winter ice may also be imported from the Kara Sea. Normally the ice in the Barents Sea melts during the summer, but in some years part of it survives and intermingles with the new ice formed during the following winter. Most of the sea-ice in the Greenland Sea is multiyear ice transported by the strong East Greenland Ice Drift Stream from the Arctic Ocean. However, large quantities of ice are formed locally during the cold season. Measurements indicate that 15–40% of a given area may

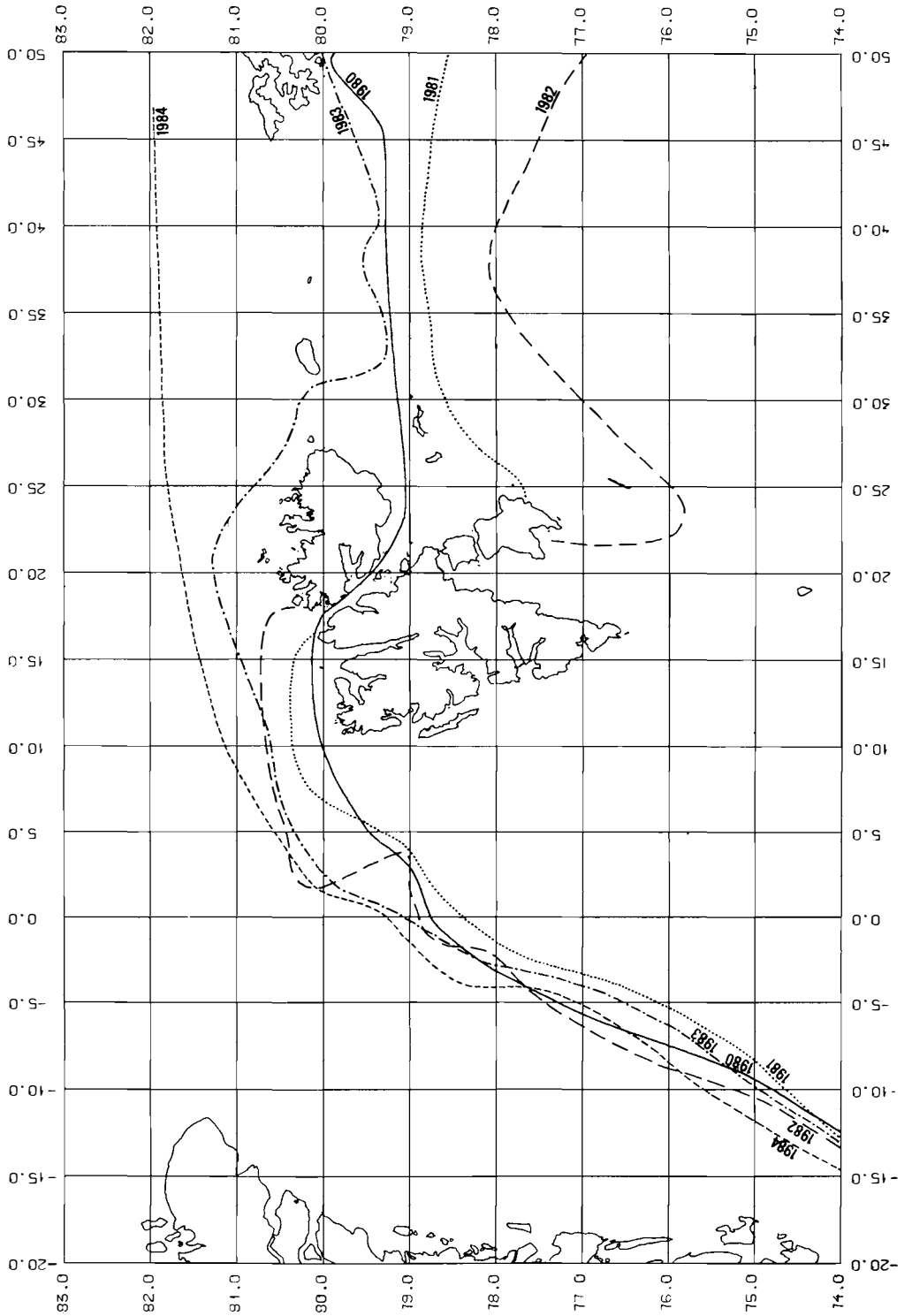
SUMMERS 1980 - 1984



Map 1. Total observation effort.

be covered by new ice (Vinje & Finnekåsa 1986). The southward extent of the sea-ice varies considerably both seasonally and interannually. Minimum ice coverage is normally observed in August. In Map 2 the August southern sea-ice limits for each of the five years 1980–1984 are presented. A detailed account of sea-ice conditions in this region is given by Vinje (1985) and Vinje & Finnekåsa (1986).

As can be seen from Map 2 the area influenced by the West-Spitsbergen Current was generally free of ice during the summer. In fact it is normally free of ice all year round because of the warm northbound currents (Vinje & Finnekåsa 1986). The ice-border in the Greenland Sea was also rather stable from year to year, while the southern ice-limit in the Barents Sea was much more variable between each of the five years.



Map 2. Southern sea-ice limits in August 1980 - 1984.

Results

A total of 22 species of seabirds, including two species of waterfowl (Common Eider *Somateria mollissima* and Long-tailed Duck *Clangula hyemalis*), was observed during the cruises. A total of 567,154 birds was recorded. The species are listed in Table 1, ranked according to their relative abundance. The Little Auk *Alle alle*, the Fulmar *Fulmarus glacialis*, and the Kittiwake *Rissa tridactyla* accounted for 86% of the total number of birds seen. A fourth species, Brünnich's Guillemot *Uria lomvia*, accounted for another 9%.

In the following section distribution maps are given for the 19 most abundant species. A survey of species diversity is presented in Map 23.

Table 1. Summary table of all seabirds seen during the cruises 1980–1984.

Species	Tot. no.	Mean no./km	Mean no./10-min
Little Auk <i>Alle alle</i>	184,364	6.9	15.3
Fulmar <i>Fulmarus glacialis</i>	163,534	6.1	13.6
Kittiwake <i>Rissa tridactyla</i>	138,486	5.2	11.5
Brünnich's Guillemot <i>Uria lomvia</i>	51,857	1.9	4.3
Ivory Gull <i>Pagophila eburnea</i>	14,500	0.5	1.2
Black Guillemot <i>Cepphus grylle</i>	4,088	0.2	0.3
Glaucous Gull <i>Larus hyperboreus</i>	3,877	0.1	0.3
Ross' Gull <i>Rhodostethia rosea</i>	1,949	<0.1	0.2
Pomarine Skua <i>Stercorarius pomarinus</i>	1,304	<0.1	0.1
Arctic Tern <i>Sterna paradisaea</i>	1,139	<0.1	<0.1
Puffin <i>Fratercula arctica</i>	866	<0.1	<0.1
Long-tailed Skua <i>Stercorarius longicaudus</i>	553	<0.1	<0.1
Common Eider <i>Somateria mollissima</i>	206	<0.1	<0.1
Arctic Skua <i>Stercorarius parasiticus</i>	172	<0.1	<0.1
Common Guillemot <i>Uria aalge</i>	171	<0.1	<0.1
Great Skua <i>Stercorarius skua</i>	26	<0.1	<0.1
Long-tailed Duck <i>Clangula hyemalis</i>	26	<0.1	<0.1
Sabine's Gull <i>Larus sabini</i>	16	<0.1	<0.1
Great Black-backed Gull <i>Larus marinus</i>	15	<0.1	<0.1
Storm Petrel <i>Hydrobatidae</i> indet.	3	<0.1	<0.1
Gannet <i>Sula bassana</i>	1	<0.1	<0.1
Manx Shearwater <i>Puffinus puffinus</i>	1	<0.1	<0.1

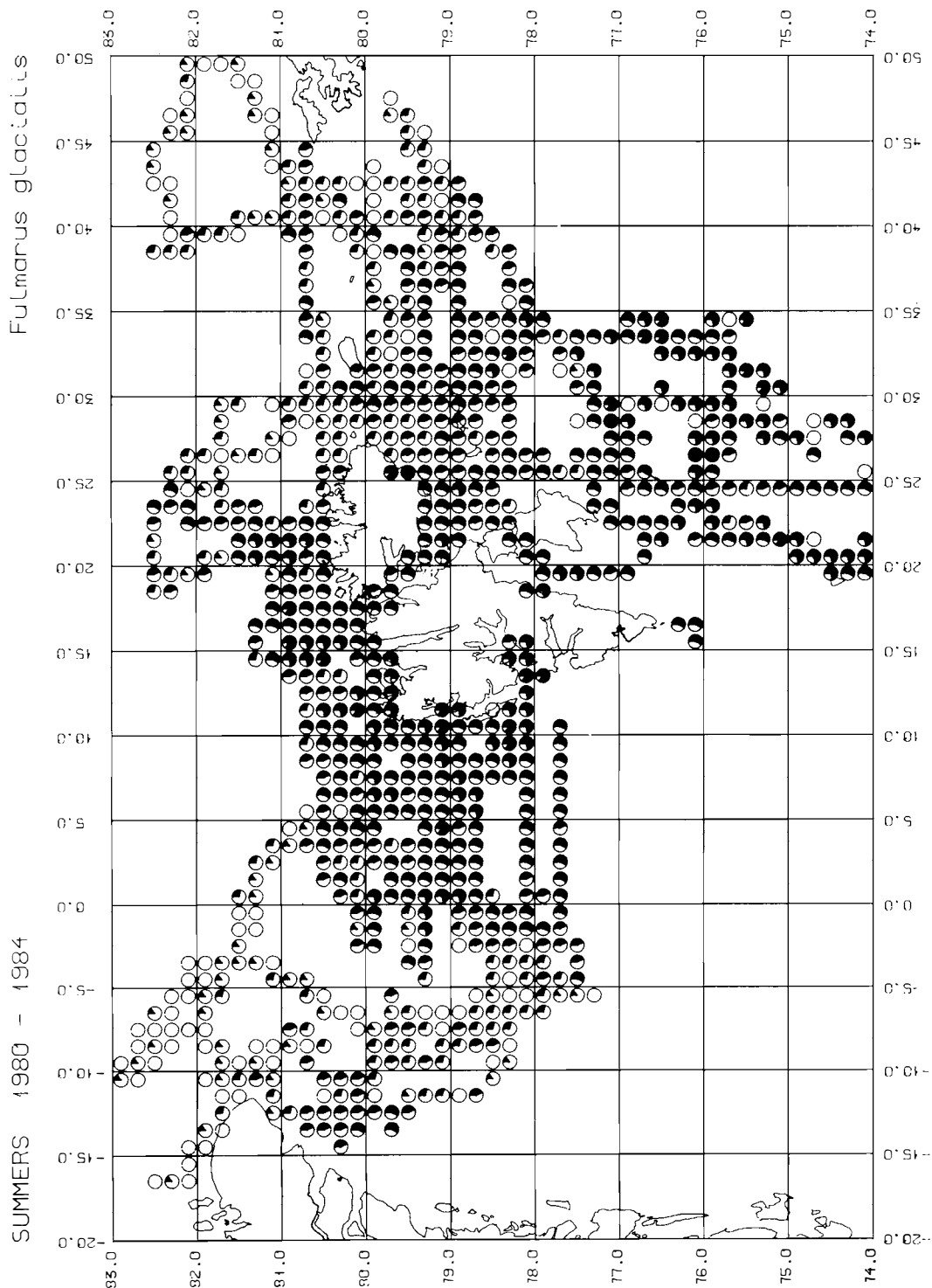
Fulmar *Fulmarus glacialis*

Breeding distribution. – The Fulmar is the only procellariiform species breeding within the area covered by the censuses. The breeding colonies are widespread over most of Svalbard, including Bjørnøya (Norderhaug et al. 1977). It also breeds in Frans Josef Land (Golovkin 1984), and some small colonies are known from Northeast Greenland (Pedersen 1942; Evans 1984). In Svalbard the Fulmar nests in bird cliffs along the coast as well as on inland nunataks (Løvenskiold 1964), and is seen near the colonies in early spring. Egg laying starts in the second half of May (Rahn et al. 1984), while hatching occurs in July.

Pelagic distribution. – The map shows that the species is abundant in most of the pelagic regions covered. It is the most uniformly distributed species involved in this study. The lowest abundance was registered in the ice-covered areas off Northeast Greenland and north of Frans Josef Land. However, it was one of the most abundant species in and around the Nordøstvandet polynya along the coast of Northeast Greenland (together with the Ivory Gull *Pagophila eburnea*).

The Fulmar is known to be attracted by ships and may follow them for hours. The observers were aware of this problem and tried to avoid repetitive counts of followers during the 10-minute counts.

Fulmars and other procellariiforms are known to have long foraging ranges. No exact data exist on the location of foraging areas for the Svalbard nesting birds. The Fulmar is a surface feeder and in these waters has a varied diet composed of squid, fish, pelagic crustaceans and polychaetes (Mehlum & Gjertz 1984; Gjertz et al. 1985).



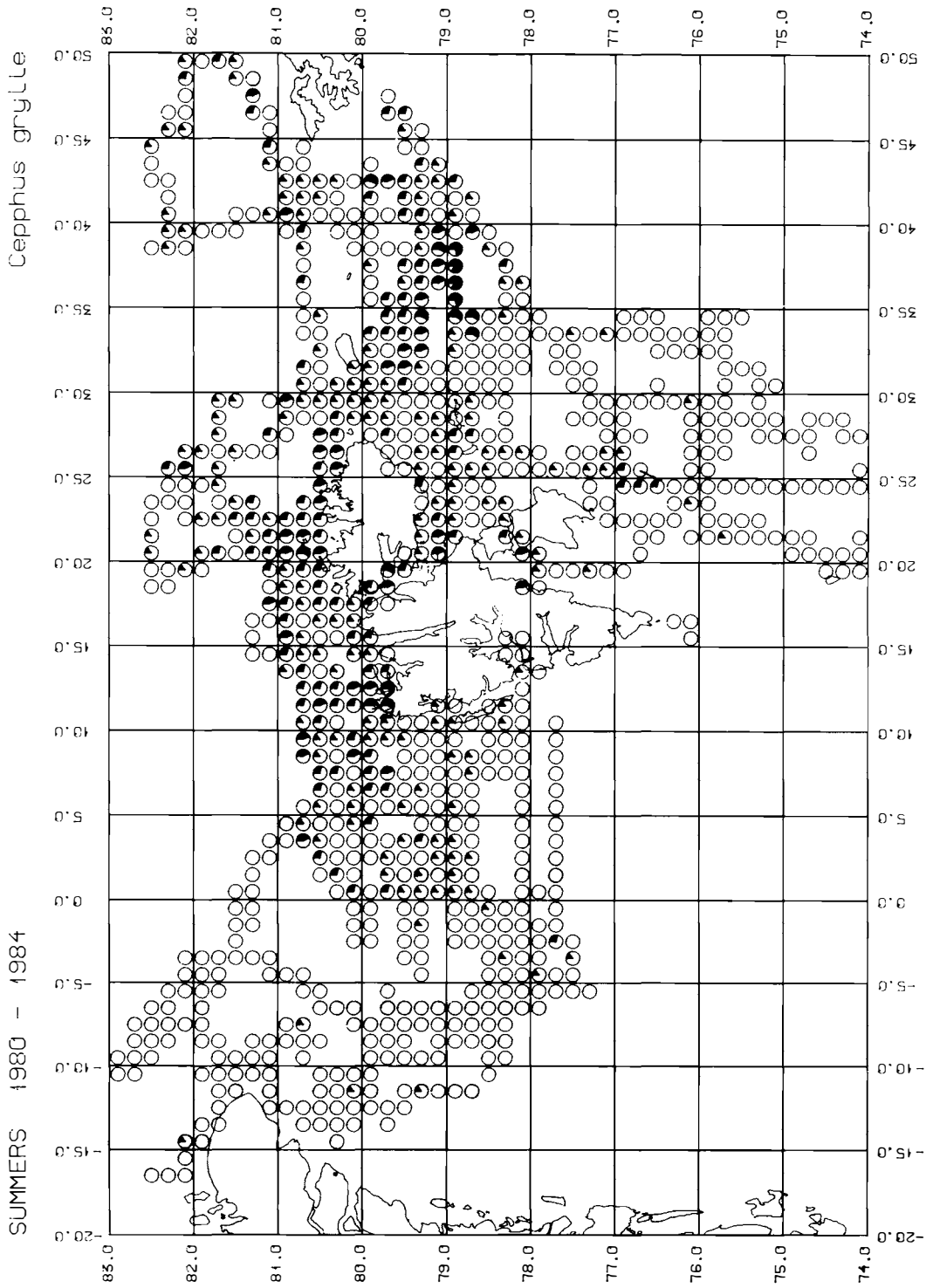
Black Guillemot *Cephus grylle*

Breeding distribution. – The Black Guillemot is a common breeder all along the coasts of Svalbard, usually in single pairs or in small colonies. It seems to be most abundant along the northern coasts. The species is also a common breeder in Frans Josef Land (Golovkin 1984) but is rather scarce in Northeast Greenland (Evans 1984). During the breeding season it is known to stay closer to the shores than the other auk species. It is also the only Atlantic alcid species with a clutch of two. This means that it must have ready access to an abundant food supply close to the breeding areas. During the breeding season the Black Guillemot, unlike other Atlantic alcids, mainly prey upon bottom-dwelling fishes and invertebrates in shallow waters (Cramp 1985). In Svalbard the eggs are normally laid in late June or early July, and the young appear on the water in late August (Løvenskiold 1964).

Pelagic distribution. – The distribution map shows that this species is mainly confined to ice-covered waters, and that it is fairly abundant not only in coastal waters but also far out at sea. The highest relative abundances were recorded east of Kong Karls Land, at 79°N. Most individuals observed pelagically are thought to be non-breeders and immatures. The majority of the individuals collected in the Barents Sea (Mehlum & Gjertz 1984; Gjertz et al. 1985) were moulting birds, indicating that the pack-ice zone, at least in the northern Barents Sea, is an important moulting area for the Black Guillemot.

The Black Guillemot is also known to inhabit the pack-ice zone in other geographical areas, and can be found in areas with open water in the Arctic all year round.

Food sample analyses have shown that the birds in the pack-ice prey mainly on arctic cod and different crustaceans associated with the subsurface of the sea-ice (Mehlum & Gjertz 1984; Gjertz et al. 1985).

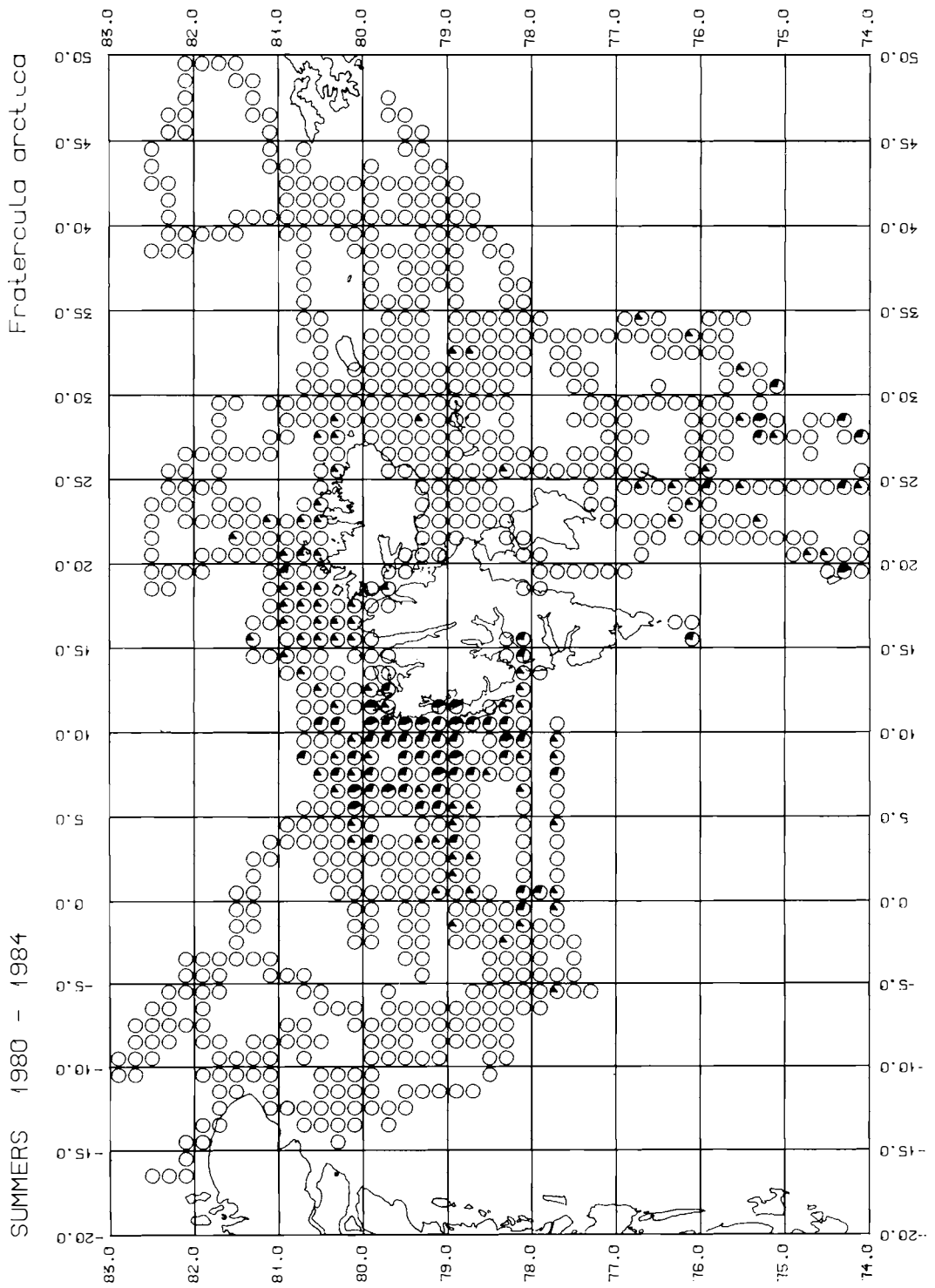


Map 4. Black Guillemot

Puffin *Fratercula arctica*

Breeding distribution. – Within the study area this species breeds mainly on the western and northern coasts of Svalbard and on Bjørnøya, while it is absent from Frans Josef Land and Northeast Greenland (Golovkin 1984; Evans 1984). Except for the Common Guillemot *Uria aalge* this is the least abundant auk species in the Svalbard area (excluding Bjørnøya), and no large breeding colonies like those known from regions farther south (like Røst of the Lofoten Islands, Northern Norway) are found. One reason for this may be the lack of suitable nesting places. In more temperate regions nest burrows are dug out in grassy slopes. The permafrost in high arctic areas prevents the Puffins from digging out nesting burrows, so they have to nest in appropriate crevices in cliffs and scree for nesting. Few details are known of the breeding biology of Svalbard Puffins.

Pelagic distribution. – The pelagic distribution map reflects the limited distribution of breeding colonies in the area. Most of the transects were made within the breeding period of the Puffin. In Svalbard Puffin chicks normally leave the colonies in late August or in September (Løvenskiold 1964). Assuming that part of the pelagically observed birds were adults on feeding trips for their young, the results show that the travel distance between the nest and the feeding area may exceed 100 km off northwest Spitsbergen.



Map 5. Puffin

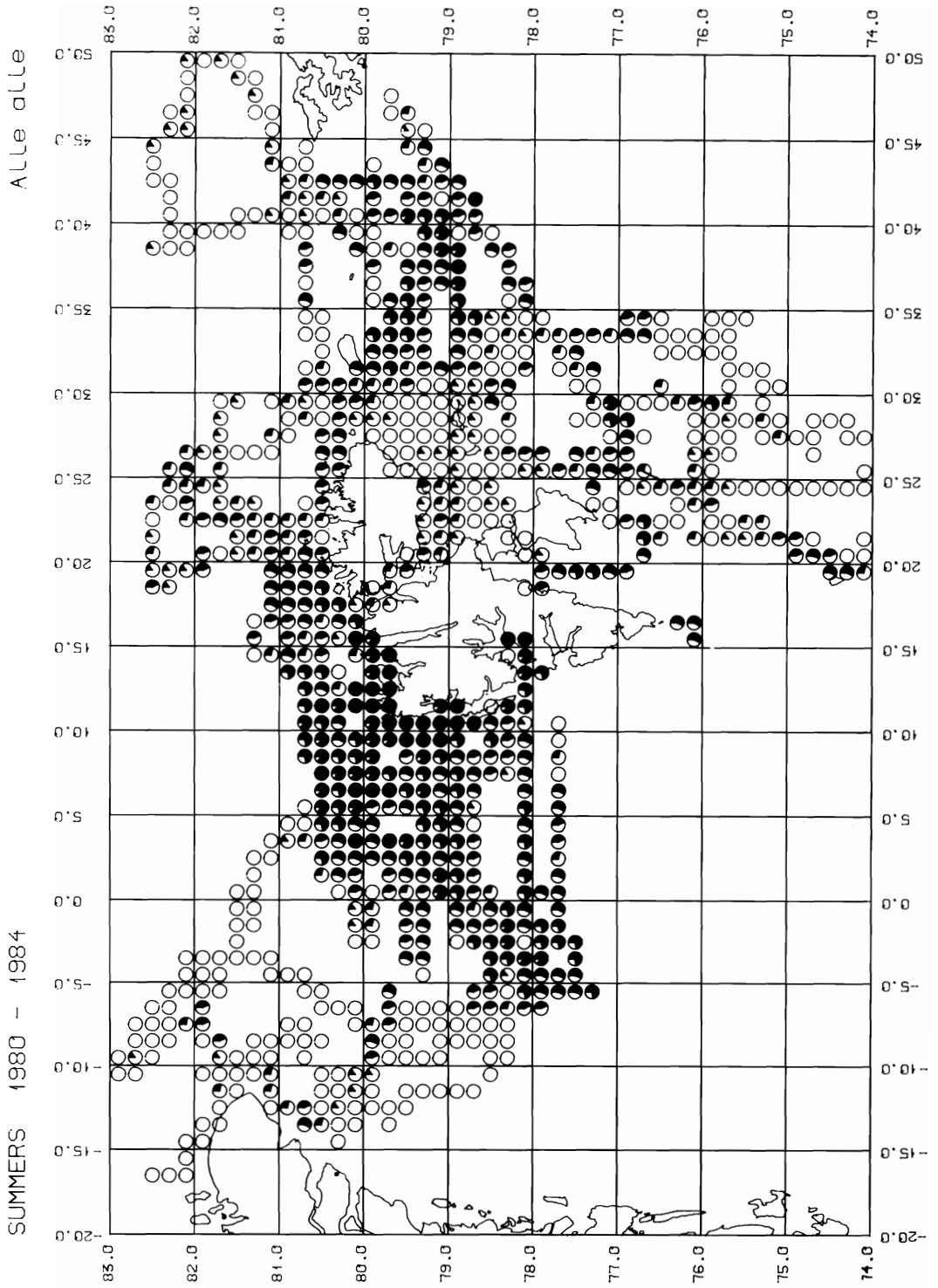
Little Auk *Alle alle*

Breeding distribution. – This typical high arctic species is known to breed in very large numbers in Svalbard, especially along the western coast of Spitsbergen (Løvenskiold 1964). It is also an abundant species in Frans Josef Land (Golovkin 1984), while no large colonies are known in Northeast Greenland north of Scoresby Sound (Evans 1984). In Svalbard the species is mainly associated with screes made up by ‘Hecla Hoek’ rocks. These types of rock are confined to the western parts of Svalbard. The Little Auk is less numerous in the eastern parts of the archipelago, but is abundant at Hopen, Bjørnøya and Tusenøyane. The latter area is a group of flat islands where the Little Auk nests among boulders. The breeding colonies are occupied later than the colonies of cliff nesting auk species, since the screes normally become snow-free later in the season. Egg-laying usually starts in late June or early July, while the young begin to leave the colonies in mid-August (Stempniewicz 1980).

Pelagic distribution. – As shown on the distribution map, the eastern parts of the Greenland Sea are of major importance for this species. There is an almost abrupt disappearance of the species as one moves to the northwestern parts of the Greenland Sea. Also important are the regions of the Barents Sea between Kong Karls Land in eastern Svalbard, and Frans Josef Land. It is unclear whether the pelagic concentrations of Little Auks in these eastern regions include birds belonging to the nesting populations in the territories of the Soviet Union (Frans Josef Land and Novaja Zemlja), or if they are Svalbard nesting birds. This problem can be investigated by biometrical studies. Most birds observed in this area are probably non-breeding immatures.

It is known from ringing recoveries that some Little Auks breeding on the western coast of Spitsbergen are wintering southwest of Greenland (Norderhaug 1967; Anker-Nilssen & Jensen 1981). The total wintering area of the Spitsbergen Little Auks is not known, but probably most of the birds winter along the ice-edge from southwest of Greenland to the central Greenland Sea. The observations by Brown (1984) of Little Auks along the ice-edge in the central Greenland Sea in March 1982 also support this. The winter quarters of eastern Svalbard birds are unknown.

Large nesting colonies of Little Auks are found in the Hornsund area, Spitsbergen. That part of the Greenland Sea which is off Hornsund, was not covered by the censuses. We assume that high abundances would also be recorded in these waters.



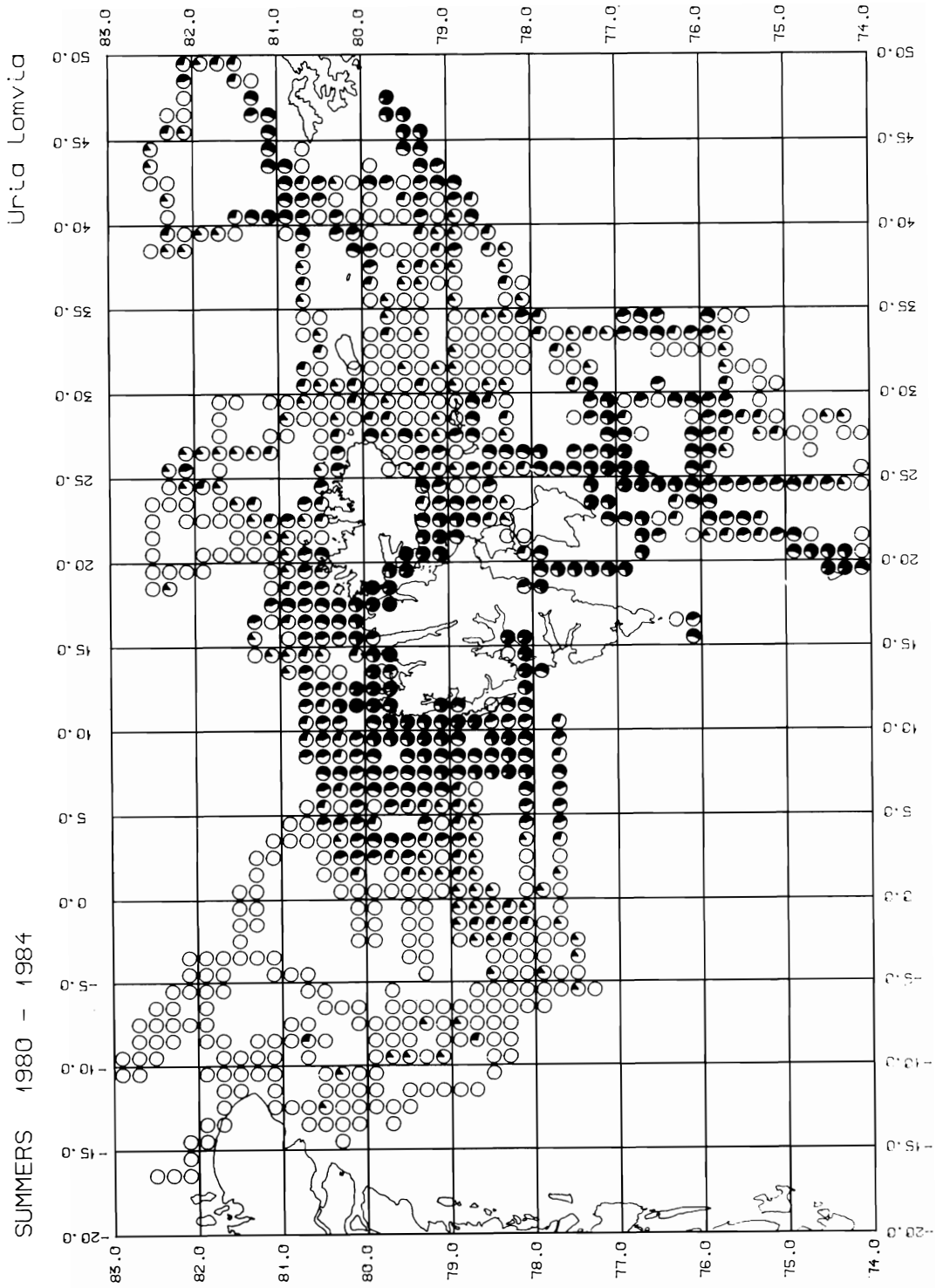
Map 6. Little Auk

Brünnich's Guillemot *Uria lomvia*

Breeding distribution. – This cliff-nesting auk is very numerous in the Svalbard area. The total population is probably in the order of one million pairs (Mehlum unpublished). The largest breeding colonies are concentrated on Bjørnøya, Hopen, in the Storfjorden and Hinlopenstretet areas, and on the western coast of Spitsbergen (Norderhaug et al. 1977). It is also very numerous on Novaja Zemlja (one million pairs) and less abundant in Frans Josef Land (100,000 pairs) (Golovkin 1984). It is typical of this species, as well as of the Common Guillemot *Uria aalge* and the Razorbill *Alca torda*, that the young leave their nesting ledges before they are able to fly. The chick is accompanied by a parent when it starts its swimming migration from its breeding place to the open sea towards the winter quarters. Comprehensive ringing has demonstrated that the waters southwest of Greenland are an important wintering area for Brünnich's Guillemots breeding in Western Spitsbergen (Norderhaug et al. 1977). Nothing is known about the winter quarters of Brünnich's Guillemots breeding in other parts of Svalbard. The species arrives in the early spring at the breeding ledges (in Hornsund 1985 on 3 April, C. Lydersen & I. Gjertz pers. comm.). The main egg-laying period is in June (Rahn et al. 1984), and the chicks depart from the colonies in the first half of August.

Pelagic distribution. – The pelagic distribution map reflects the breeding distribution around both Svalbard and Frans Josef Land. The species is observed further to the west in the Greenland Sea than the Puffin *Fratercula arctica*, which may indicate a longer foraging radius during breeding. But many of these birds could also be non-breeders, or birds which have started their SW migration early.

The species was found both in open and ice-covered waters. Studies on feeding ecology (Mehlum & Gjertz 1984; Gjertz et al. 1985; Lydersen et al. 1985; Mehlum unpublished) have shown that in the Svalbard area it feeds mainly on the pelagic amphipod *Parathemisto libellula* and arctic cod *Boreogadus saida*.

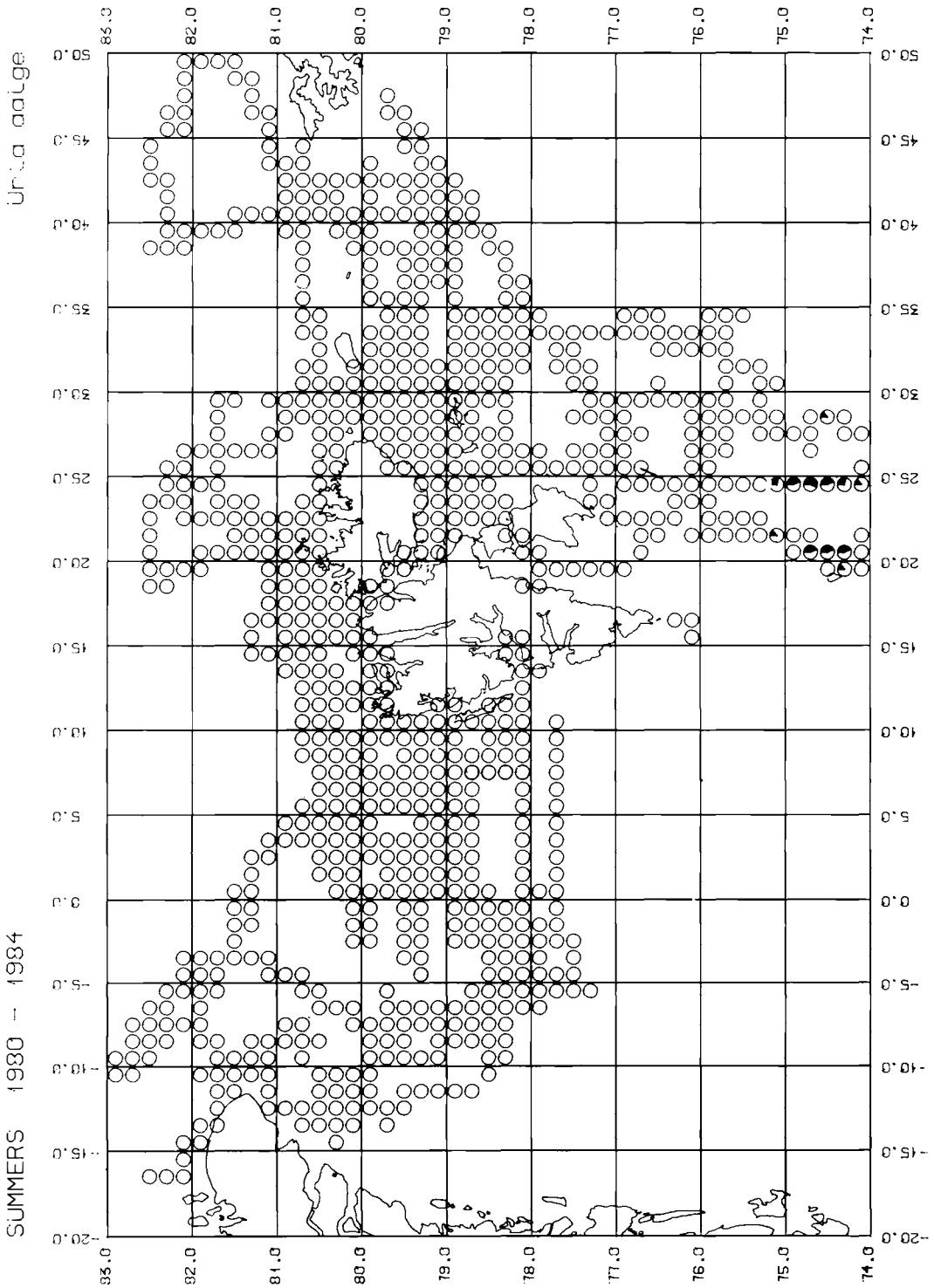


Map 7. Brünnich's Guillemot

Common Guillemot *Uria aalge*

Breeding distribution. – This species breeds in large numbers on Bjørnøya (Franeker & Luttick 1981), but only about two hundred pairs are documented as breeders farther north in Svalbard (Norderhaug 1974; Kempf & Sittler 1988). The largest known colony in Svalbard except for Bjørnøya is the one at Fuglehuken, the northernmost point of the large island Prins Karls Forland off the west coast of Spitsbergen. Scattered pairs have been observed elsewhere on the western coast of Spitsbergen. It may also breed at Hopen, but this still has to be documented. The Common Guillemot is not reported breeding in Frans Josef Land (Golovkin 1984) or in Northeast Greenland (Evans 1984).

Pelagic distribution. – As seen on the distribution map, the Common Guillemot is only documented to have been seen in areas close to Bjørnøya. The Common Guillemot overlaps in breeding distribution with the more northerly distributed Brünnich's Guillemot *Uria lomvia*. Because these two species are difficult to distinguish at sea, some Common Guillemots may have been overlooked and incorrectly identified as the more abundant Brünnich's Guillemot. The existing data indicate that most Common Guillemots forage in the areas to the south of 75°N during late summer. In contrast, the Brünnich's Guillemot was observed in abundance in the area between Bjørnøya, Hopen and Storfjorden (Map 7).



Map 8. Common Guillemot

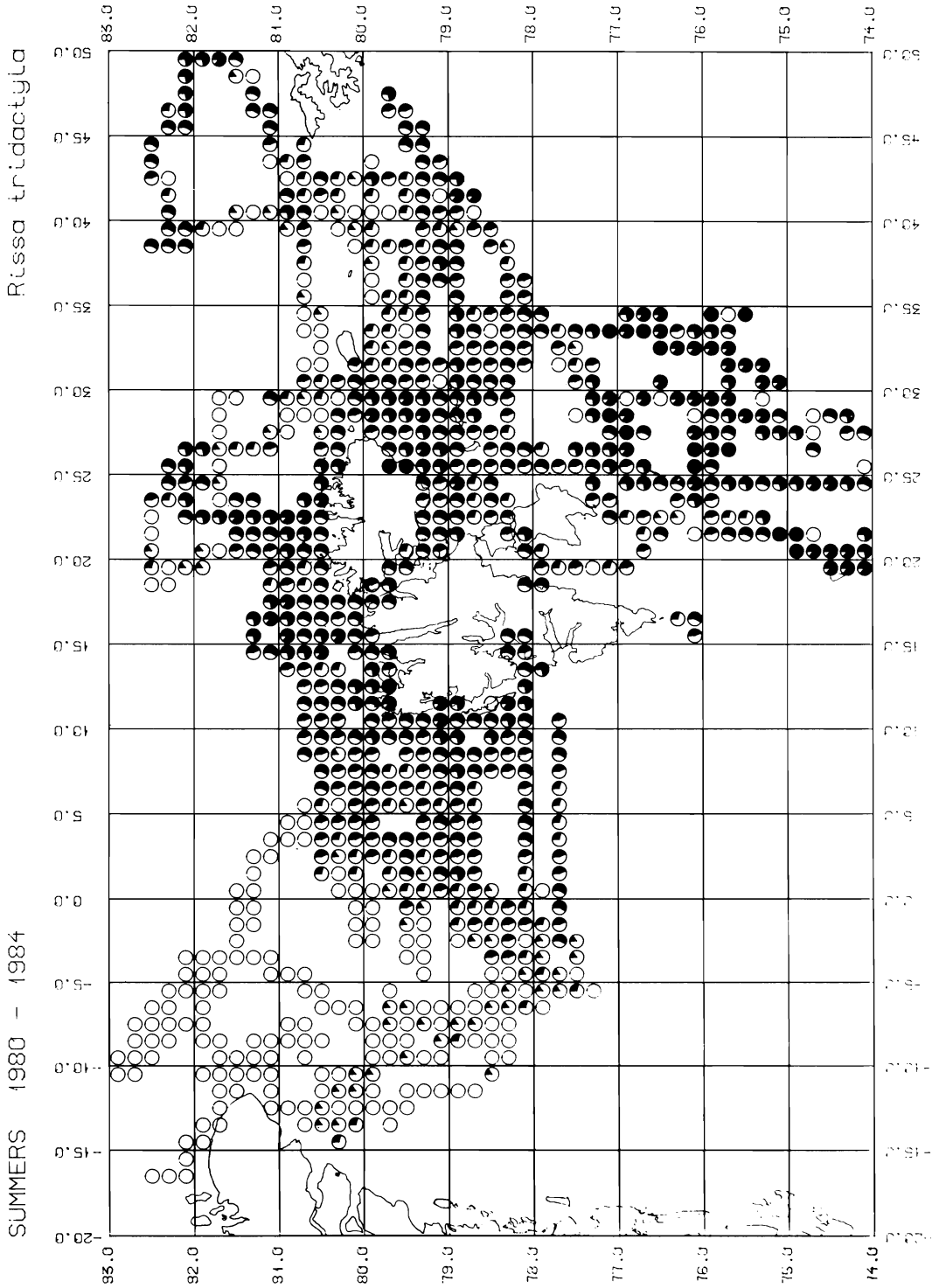
Kittiwake *Rissa tridactyla*

Breeding distribution. – The Kittiwake belongs to the group of the most abundant breeding seabird species in the area covered. Breeding colonies are distributed on cliffs all along the coasts of the Svalbard archipelago. It is also common in Frans Josef Land (Golovkin 1984) but very scarce or absent in Northeast Greenland north of Scoresbysund (Hjort et al. 1983; Evans 1984). In Svalbard the Kittiwakes occupy their nesting cliffs in April, and egg-laying usually starts in early June. One or two eggs are laid in each clutch, and the young leave the nests in August. Immature birds are often seen foraging in the fiords and other coastal areas during summer (Mehlum unpublished).

Pelagic distribution. – The general pattern obtained by the surveys is a wide distribution and high relative abundance over most of the study area. However, a distinctly reduced abundance was observed in the northwest Greenland Sea, comparable to the distribution pattern of the Little Auk *Alle alle* and Brünnich's Guillemot *Uria lomvia*. Kittiwakes are attracted to ships, and this has to be considered when comparing the relative abundance maps with maps of other species which are not attracted. Their abundance may have been somewhat overestimated. Additionally, some of the birds following the ship for several 10-minute periods may have been recorded several times.

The chicks of the Kittiwake usually stay in their nests until mid-August (Løvenskiold 1964). Time-budgets at Kongsfjorden, Spitsbergen (Mehlum unpublished; Gabrielsen & Mehlum 1989) and at Hopen (Gabrielsen et al. 1987) show that the adults may have very long shifts of attending the nest. The normal pattern was 12–24 hours between each time the parents changed guarding the chicks at the nest. The birds can fly considerable distances during that many hours. The high abundance recorded in the central part of the Greenland Sea may suggest that feeding ranges can be more than 200 km for individuals nesting on the western coast of Spitsbergen. However, these birds could also be non-breeders.

The Kittiwake was found both in open waters and in ice-covered areas, except in most of the northwestern part of the Greenland Sea. Stomach analyses (Mehlum & Gjertz 1984; Gjertz et al. 1985) and direct observations show that Kittiwakes mainly eat arctic cod *Boreogadus saida* in the ice-covered waters, but that they also prey on various crustaceans (mainly amphipods). Farther south, e.g. around Hopen, they mainly depend on capelin *Mallotus villosus* in the summer (Gabrielsen et al. 1987).



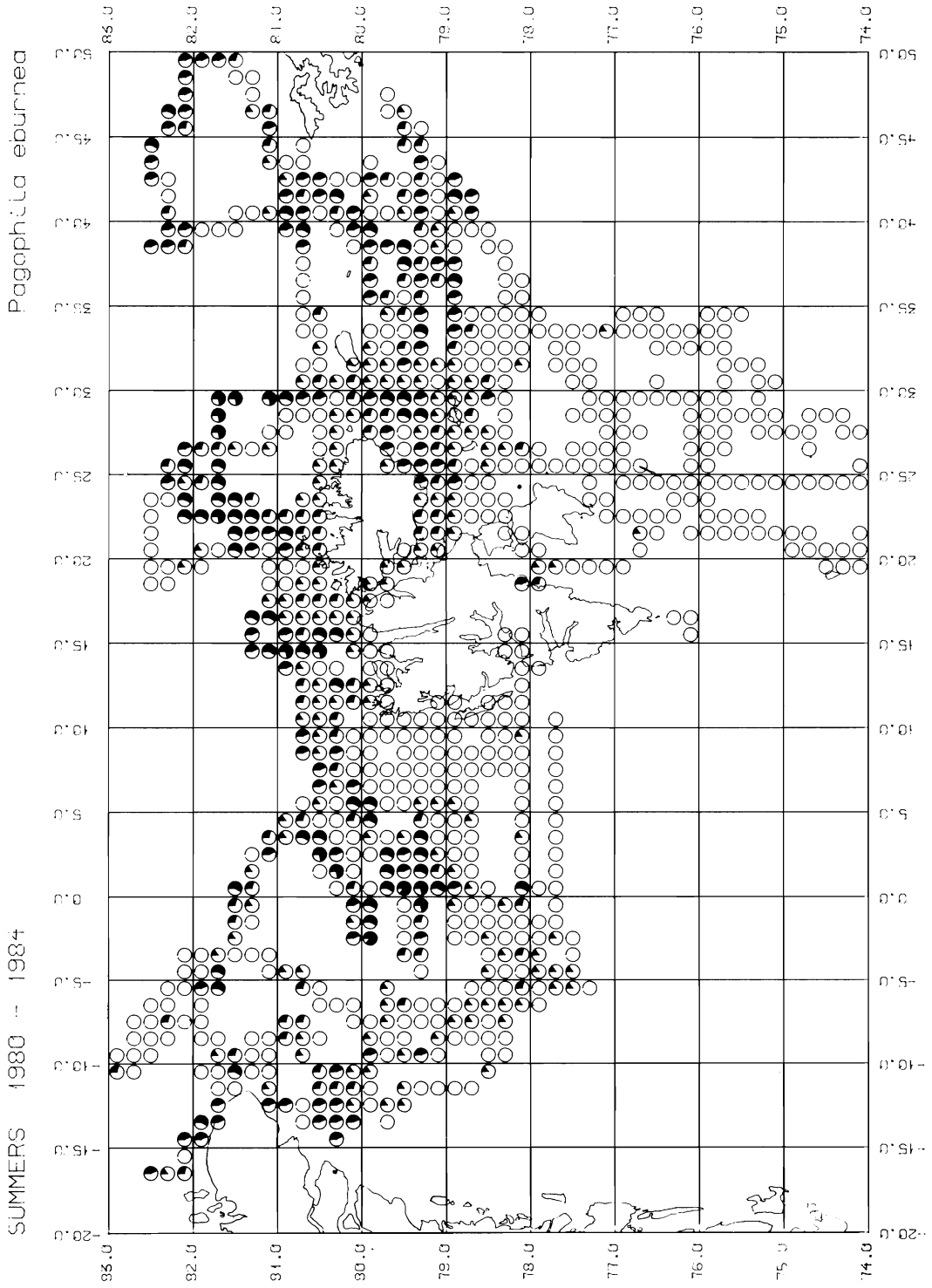
Map 9. Kittiwake

Ivory Gull *Pagophila eburnea*

Breeding distribution. – This gull is generally confined to High Arctic breeding places. In Svalbard it is known to breed in scattered colonies at some nunataks on Spitsbergen, but most of the known breeding colonies are in the easternmost part of the archipelago. In this area, where the characteristic pointed nunataks of Spitsbergen are missing, the Ivory Gull breeds in small numbers on bird cliffs or, occasionally, on flat ground. The species is fairly abundant as a breeding bird in Frans Josef Land (P. S. Tomkowich pers. comm.) and it probably breeds in small numbers in most of High Arctic Greenland (Evans 1984). Very little is known about the breeding schedule of this species in Svalbard (Løvenskiold 1964).

Pelagic distribution. – The pelagic distribution map shows clearly the Ivory Gull's close association with sea-ice. Its main distribution is north of 79°N. The map also shows the high relative abundance of the species, even if the calculated values may be influenced by its habit of being attracted to ships. The Ivory Gull is the bird which is recorded in highest abundance in waters off NE Greenland, on the coast of which several breeding colonies are known (Håkansson et al. 1981; Hjort et al. 1983).

The extreme northern pelagic distribution may be determined by the species' feeding habits. Our studies (Mehlum & Gjertz 1984; Gjertz et al. 1985) confirm earlier studies of the species' varied diet. It feeds on arctic cod and different crustaceans associated with the sub-surface of the sea-ice. Their food is caught either by plunging into the water or pecking food items from the ice surface. Another important food source is the remains of seal carcasses and blubber left by polar bears.



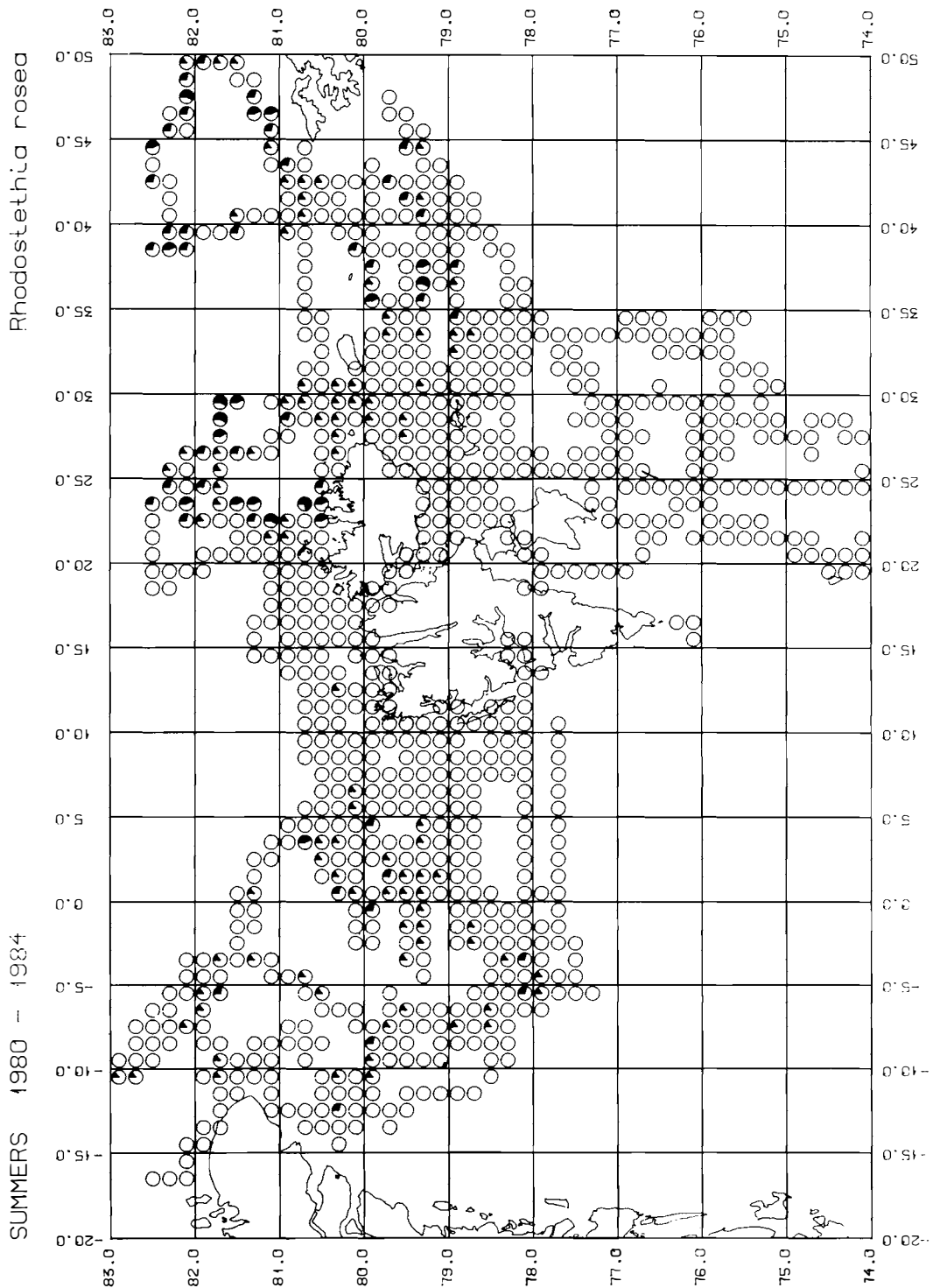
Map 10. Ivory Gull

Ross' Gull *Rhodostethia rosea*

Breeding distribution. – Outside the breeding areas very little is known about Ross' Gull. The main breeding groups are located in the tundra and swampy northern taiga lowlands between the Jana and Kolyma rivers in Eastern Siberia (Andreev & Kondratev 1981). Isolated nesting areas have also been found in Tajmyr (Pavlov & Dorogov 1978) and in the Caun Lowland (Andreev & Kondratev 1981). Single breeding records are reported from Svalbard (Løvenskiold 1964), Northern Greenland (Kampp & Kristensen 1980; Hjort 1980) and arctic Canada (MacDonald 1978; Chartier & Cooke 1980).

Pelagic distribution. – Several old records of Ross' Gulls exist from ice-covered areas north of Svalbard and Frans Josef Land. Ross (Parry 1828), Nansen (Collett & Nansen 1900), and Andrée (Lönnerberg 1931) observed several individuals during the summer months July and August. The importance of these areas to Ross' Gull was confirmed by ornithologists on the 'Ymer'-expedition in 1980 (Meltøfte et al. 1981).

Additional observations of Ross' Gulls have been made on cruises conducted since the 'Ymer'-expedition, but the distribution pattern is similar to that reported by Meltøfte et al. (1981). The data obtained during the 'Ymer'-expedition are included in the distribution map presented here. Ross' Gull was encountered in the ice-covered areas north of Nordaustlandet, Svalbard, south of Victoria Island and north of Frans Josef Land. West of Svalbard the species was widely distributed in the central and northwestern parts of the Greenland Sea, even if the relative abundance in each block was low. In most squares in the Greenland Sea area the species was recorded in abundance category 0.1–0.3 individuals per 10-minute period, while higher abundances were recorded north and east of Svalbard. Ross' Gull, like the Ivory Gull, was restricted to ice-filled waters in the northern part of the study area.

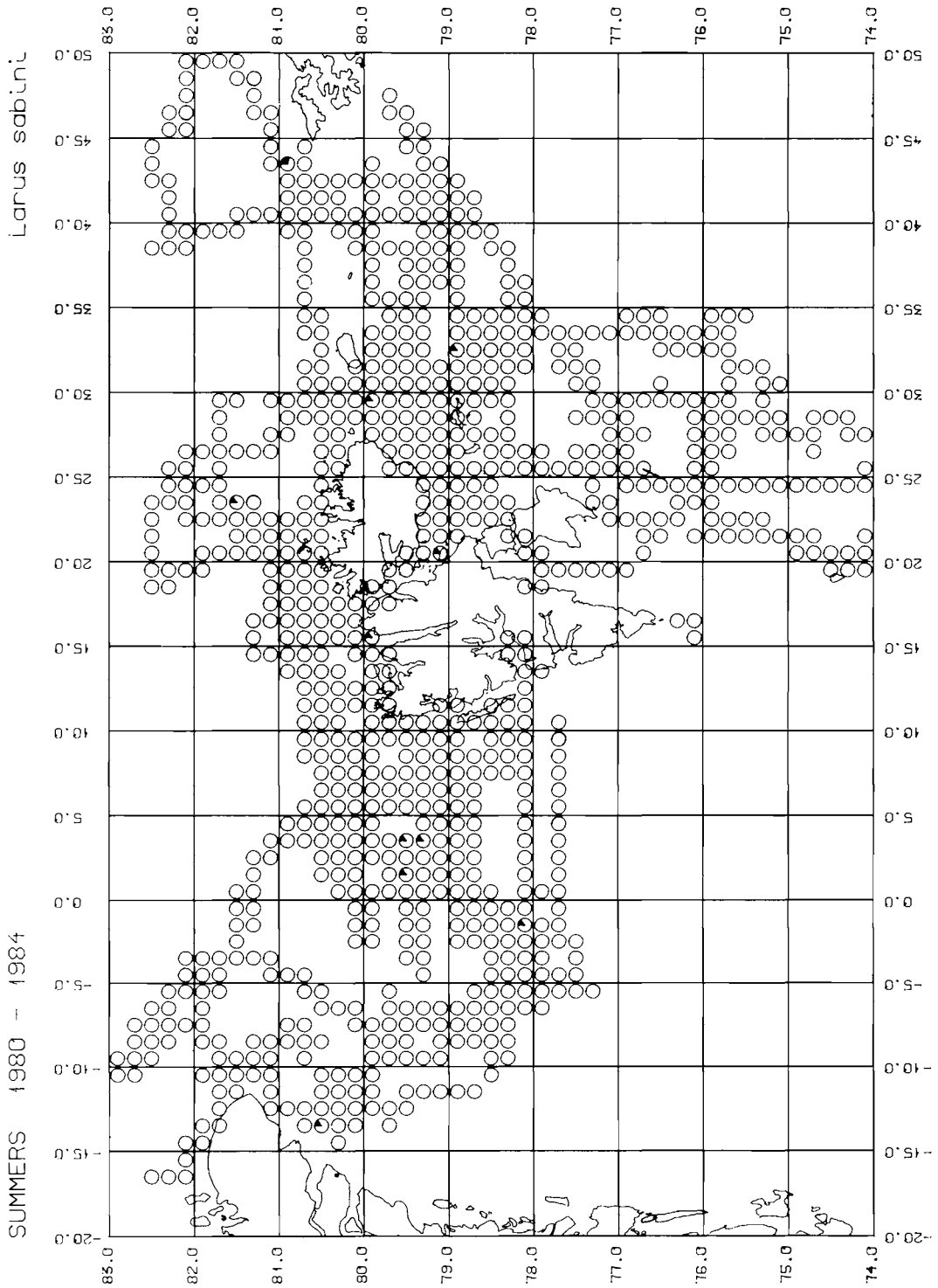


Map 11. Ross' Gull

Sabine's Gull *Larus sabini*

Breeding distribution. – Sabine's Gull is mainly a Low Arctic species and has an almost circumpolar breeding range, but with large gaps along the Eurasian coast of the Arctic Ocean. An account of its breeding distribution is given by Blomqvist & Elander (1981) and Abraham (1986). It breeds in single pairs or in small groups, almost exclusively in colonies of Arctic Terns *Sterna paradisaea*. It is a rare bird in the Svalbard area and only a few records of nesting have been reported (Løvenskiold 1964). However, observations indicate that Sabine's Gull may have nested at several localities in Svalbard in recent years (Norsk Polarinstitutt data base, unpublished). A few breeding localities are also known in High-Arctic Greenland (Blomqvist & Elander 1981; Hjort et al. 1983; Håkansson et al. 1988).

Pelagic distribution. – As shown on the pelagic distribution map, Sabine's Gull is a very uncommon seabird in the waters between Northwest Greenland and Frans Josef Land. The observations are scattered all over the study area, except for the southernmost parts southeast of Svalbard. A total of 16 birds was recorded in 11 different squares during the five years.

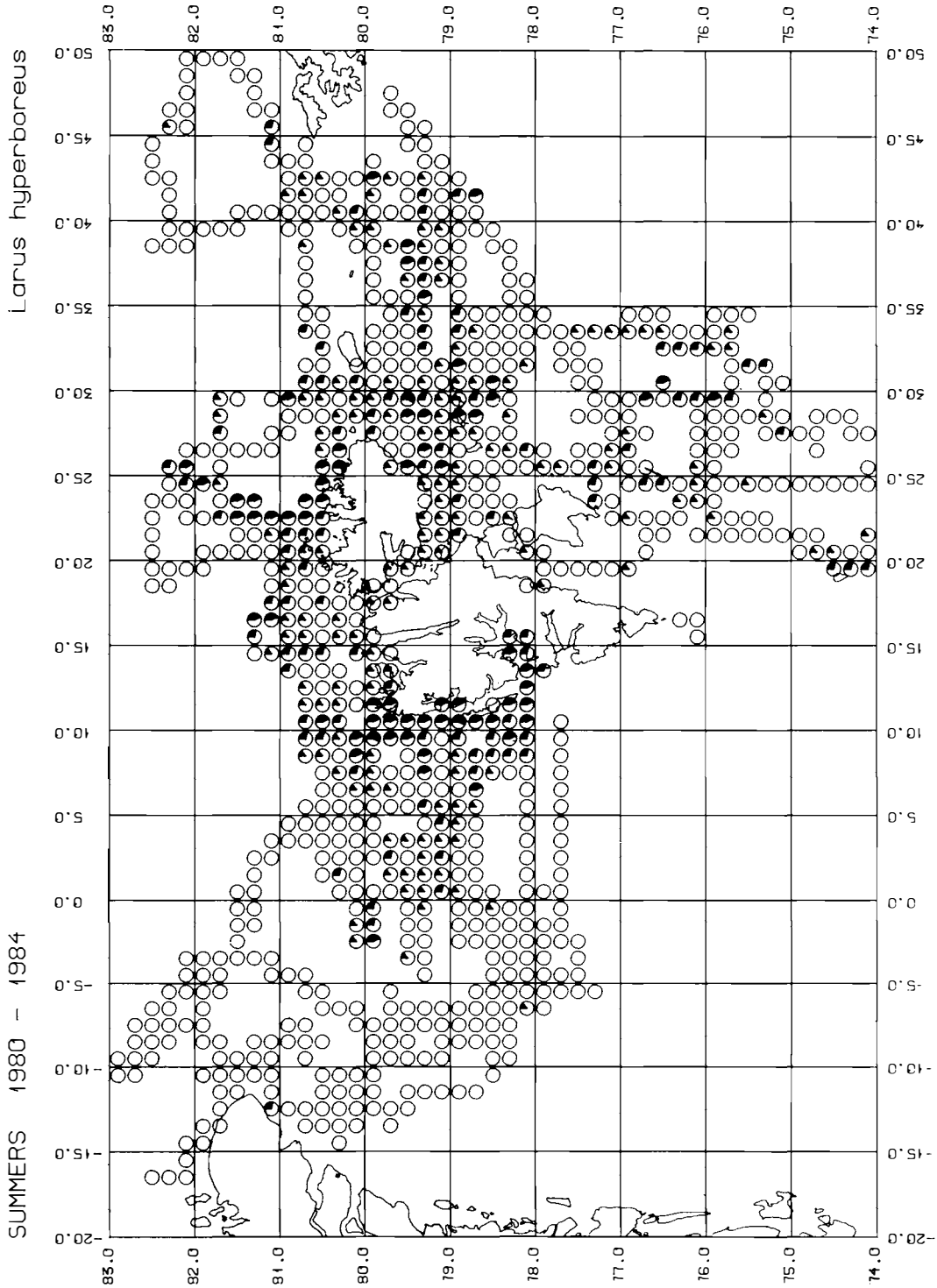


Map 12. Sabine's Gull

Glaucous Gull *Larus hyperboreus*

Breeding distribution. – The Glaucous Gull is a common breeding species all over Svalbard, including Bjørnøya. It is also widespread in Northeast Greenland (Evans 1984) and occurs in Frans Josef Land. Its status in the latter area is unknown, however (Golovkin 1984). This species nests in association with typical bird-cliff species, and with island colonies of eiders and geese. It preys both on the eggs and chicks of other bird species and utilizes a wide variety of marine food items. It will often also feed on garbage around human dwellings (Larsen 1965; Mehlum & Gjertz 1984; Lydersen et al. 1985).

Pelagic distribution. – The species is widely distributed in the pelagic regions studied. The highest abundance was recorded close to the western coast of Spitsbergen. Farther west in the Greenland Sea, the numbers declined, and it was almost absent from the waters off Northeast Greenland. The Glaucous Gull was distributed both in ice-covered waters and in areas with open waters (such as in the northwestern Barents Sea and along the western coast of Spitsbergen).

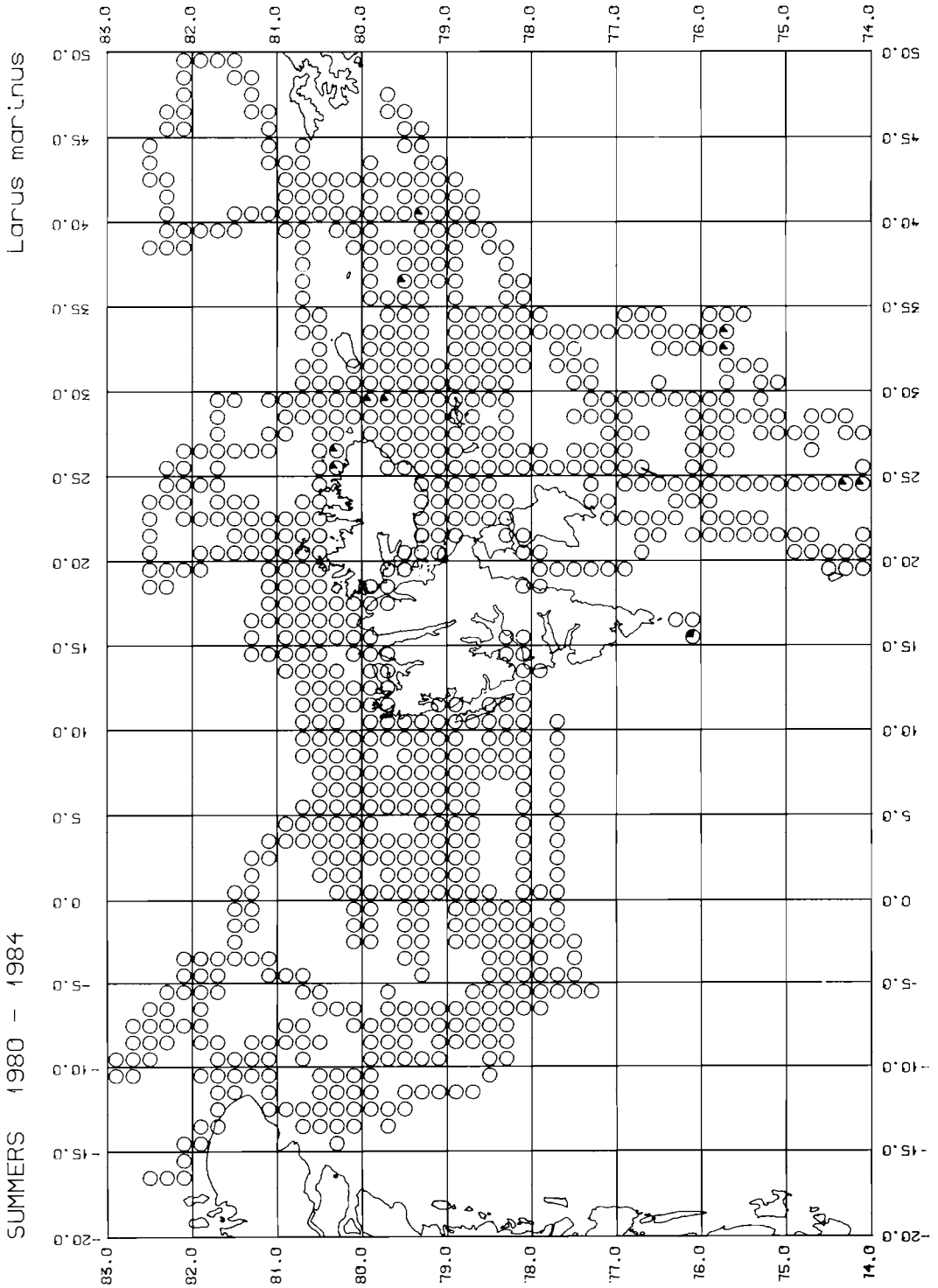


Map 13. Glaucous Gull

Great Black-backed Gull *Larus marinus*

Breeding distribution. – This species now breeds in single pairs at several localities along the western coast of Spitsbergen, but the total population probably amounts to less than 50 pairs. It has gradually expanded and increased in numbers during the last three decades (Norderhaug 1983). It also breeds at Bjørnøya in small numbers (Franeker & Luttick 1981), and is abundant along the coasts of the southern parts of the Barents Sea (Cramp & Simmons 1983). The Great Black-backed Gull is not known to breed in Northeast Greenland (Evans 1984) and Frans Josef Land (Golovkin 1984).

Pelagic distribution. – The distribution of observations of the Great Black-backed Gull during the censuses was very scattered, and the abundance very low. A total of only 15 individuals was recorded. All records were from east of 15°E. The results indicate that the species may be encountered fortuitously all over the Barents Sea area.

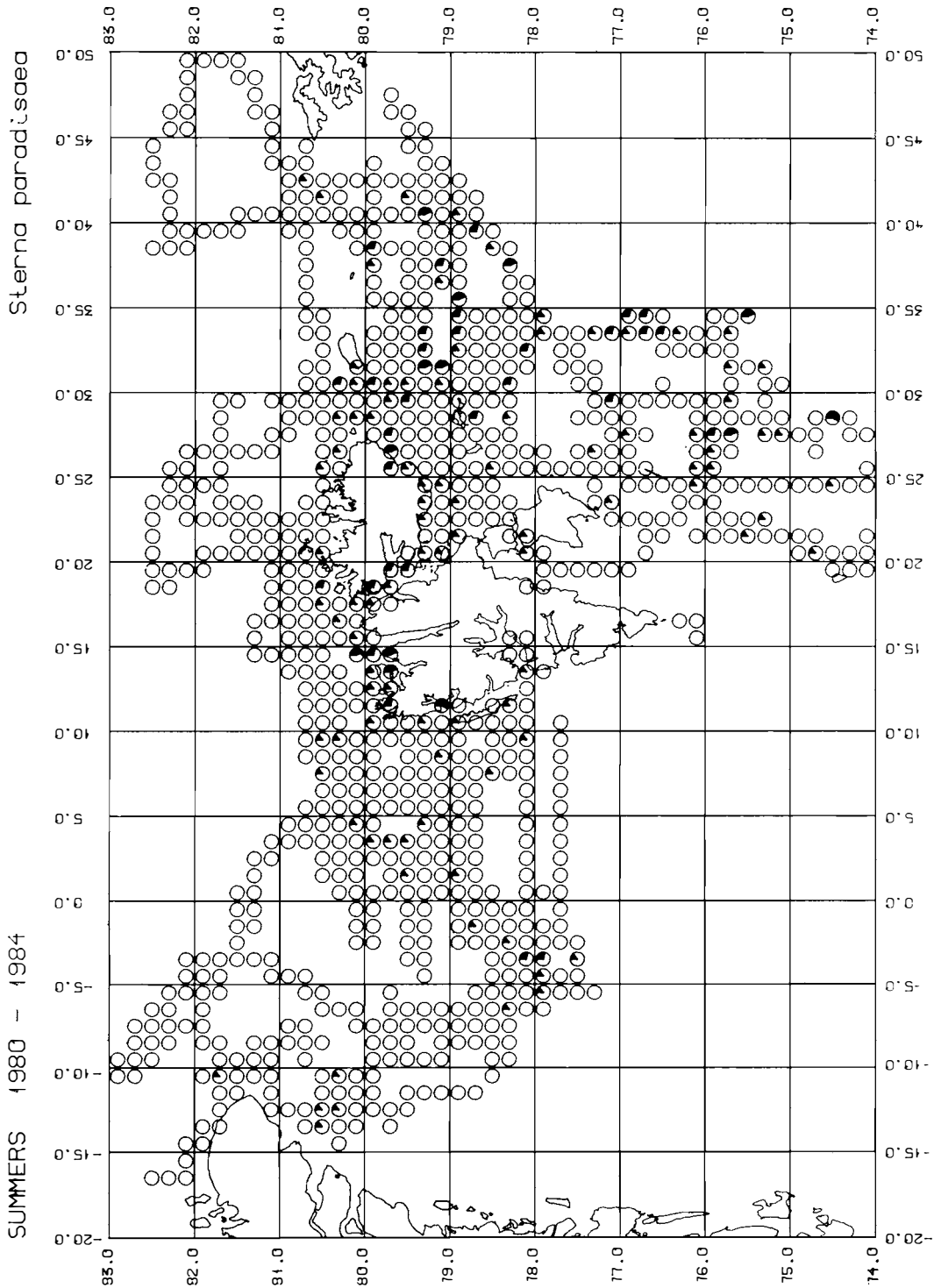


Map 14. Great Black-backed Gull

Arctic Tern *Sterna paradisaea*

Breeding distribution. – The Arctic Tern has a circumpolar breeding distribution, and is a common breeding species all over Svalbard, including the easternmost and northernmost islands (Løvenskiold 1964). It breeds on flat tundra along the coast and on small coastal islands. The species is also widespread along the coasts of Northeast Greenland (Evans 1984) and breeds in Frans Josef Land (Golovkin 1984). The Arctic Tern usually arrives in Svalbard by the end of May or early June, and leaves the breeding area in late August or September (Løvenskiold 1964).

Pelagic distribution. – The Arctic Tern was the 10th most numerous species in the censuses. As the distribution map shows, this species is almost missing in the northernmost parts of the area concerned. It was fairly common close to the shores, but was also recorded in mid-ocean regions in the Barents and Greenland Seas. In the Greenland Sea it seems to be associated with the marginal ice-zone. Some observations were also made off the coast of Northeast Greenland, probably of birds breeding along the adjacent coast.

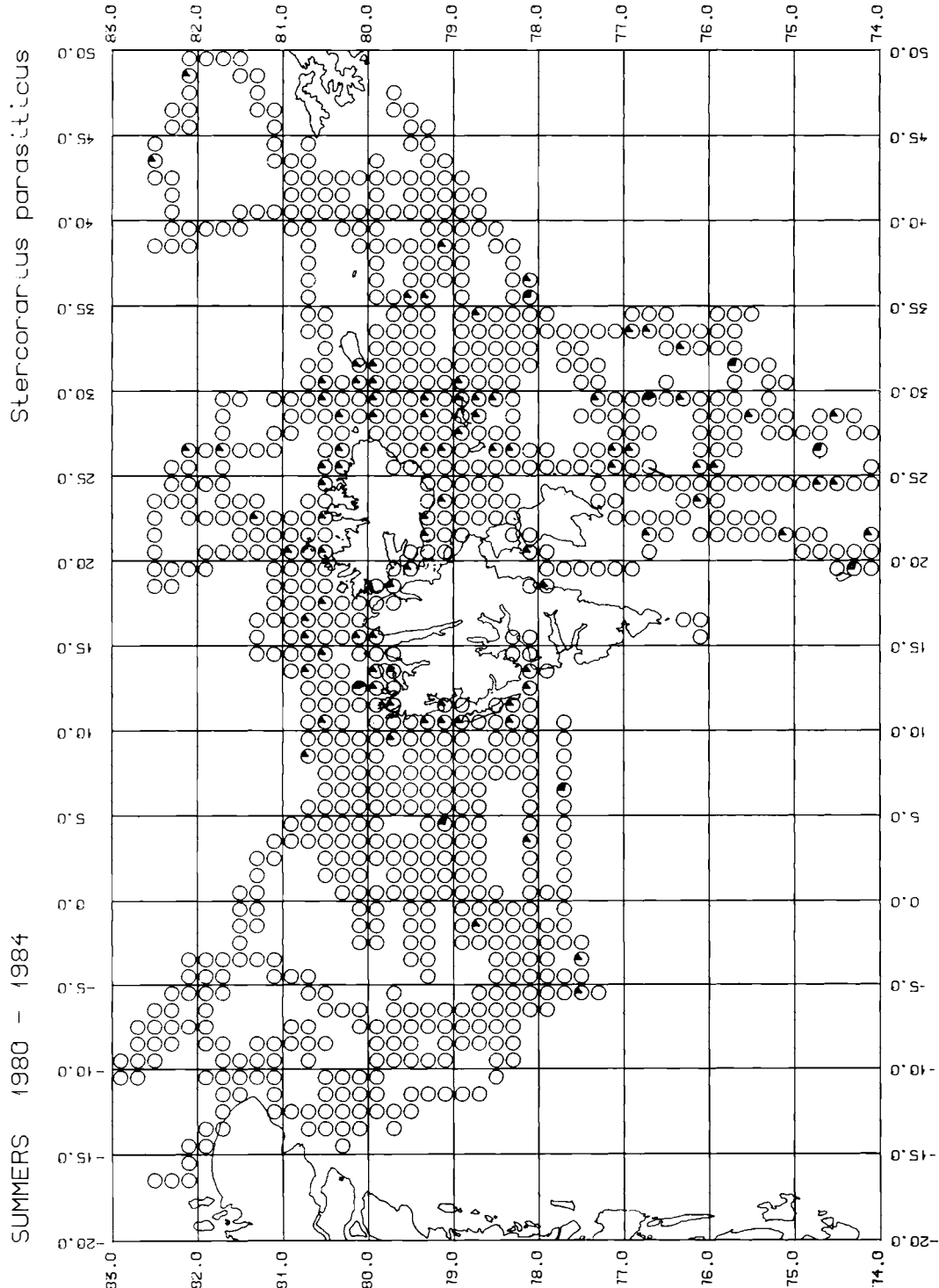


Map 15. Arctic Tern

Arctic Skua *Stercorarius parasiticus*

Breeding distribution. – The Arctic Skua is known as a solitary breeding species in most coastal areas in the Svalbard archipelago, but with its lowest abundance in the northeastern parts, where it nests on the tundra (Løvenskiold 1964). It is reported to be absent as a breeder in Northeast Greenland north of 76°N (Evans 1984). It is a scarce breeder in Frans Josef Land (Demente'ev & Gladkov 1951).

Pelagic distribution. – The Arctic Skua was less abundant in the investigated area than both the Pomarine and Long-tailed Skuas *Stercorarius pomarinus* and *S. longicaudus*, despite the fact that it is the only abundant breeding skua species in Svalbard. The observations were scattered over large parts of the study area, but the species was lacking in the northwestern parts of the Greenland Sea. Except for records in two blocks north of Frans Josef Land it was also absent from areas east of 40°E. This indicates that the breeding population in Svalbard probably feeds mainly in coastal areas during the months July–September.

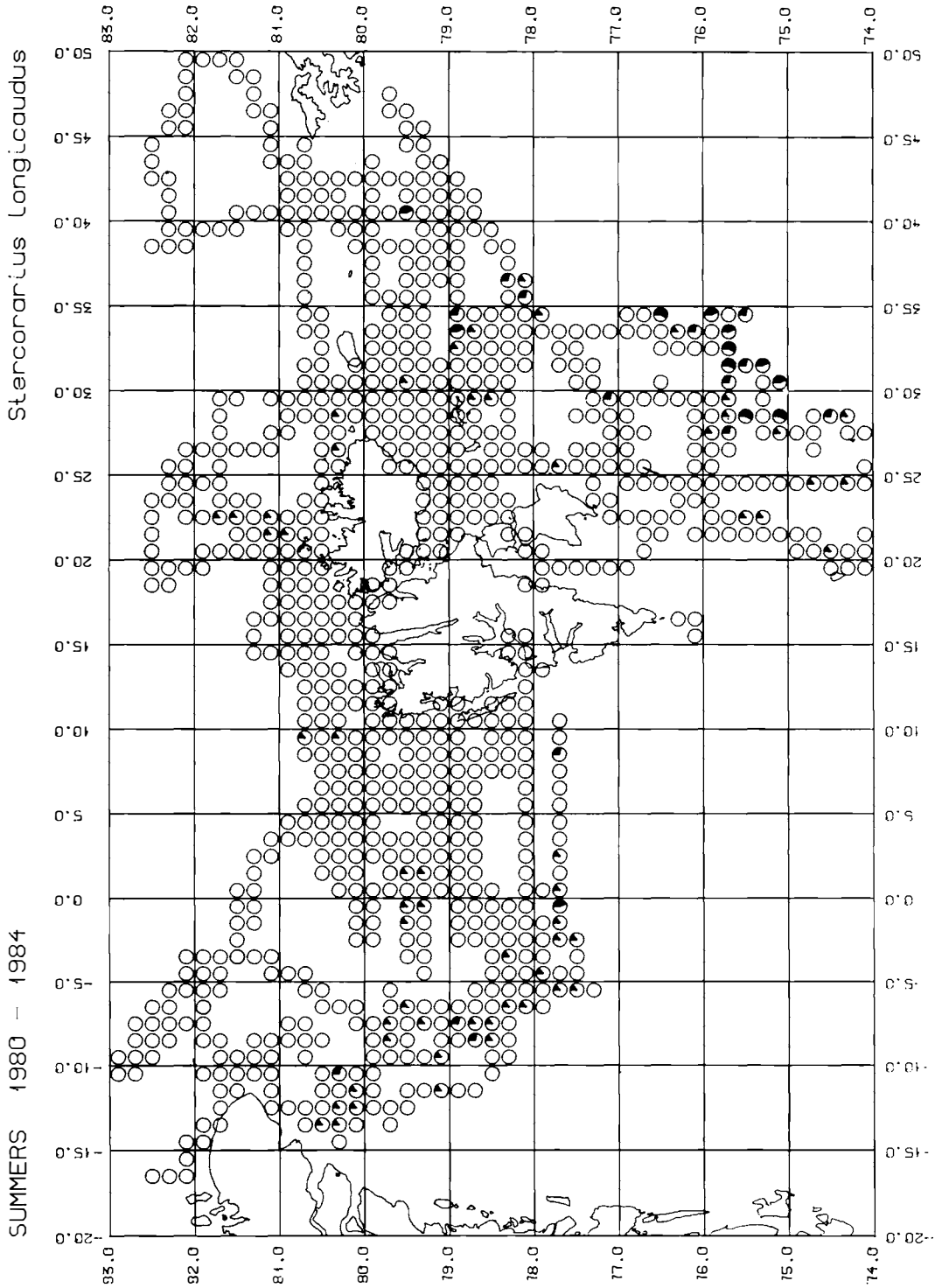


Map 16. Arctic Skua

Long-tailed Skua *Stercorarius longicaudus*

Breeding distribution. – The Long-tailed Skua breeds in Svalbard in very low numbers and only a few nests have been found along the western coast of Spitsbergen (Løvenskiold 1964). It also breeds over most of the northern and eastern parts of Greenland (Evans 1984), but it is not recorded as a breeding bird in Frans Josef Land. It is scarce in Novaja Zemlja and on the Murmansk coast but more abundant in the inland tundra zones in northern Fennoscandia and the USSR (Cramp & Simmons 1983).

Pelagic distribution. – The distribution map of this species distinguishes between two important geographical areas of abundance. One stretches southeastwards from the northeastern coast of Greenland to the middle of the Greenland Sea, the other is in the central to northwestern parts of the Barents Sea. This distribution pattern is probably influenced by the presence of migratory birds, the Greenland Sea birds probably originating from Greenland and migrating southwards to the Atlantic. The Barents Sea birds may be individuals originating from arctic USSR and migrating westwards through the Barents Sea, before turning southwards into the Atlantic. However, it cannot be ruled out that the Barents Sea birds belong to the same general population as the Greenland Sea birds, and that a large part of them are indeed non-breeders spending the summer in pelagic areas (cf. the Pomarine Skua *Stercorarius pomarinus*).



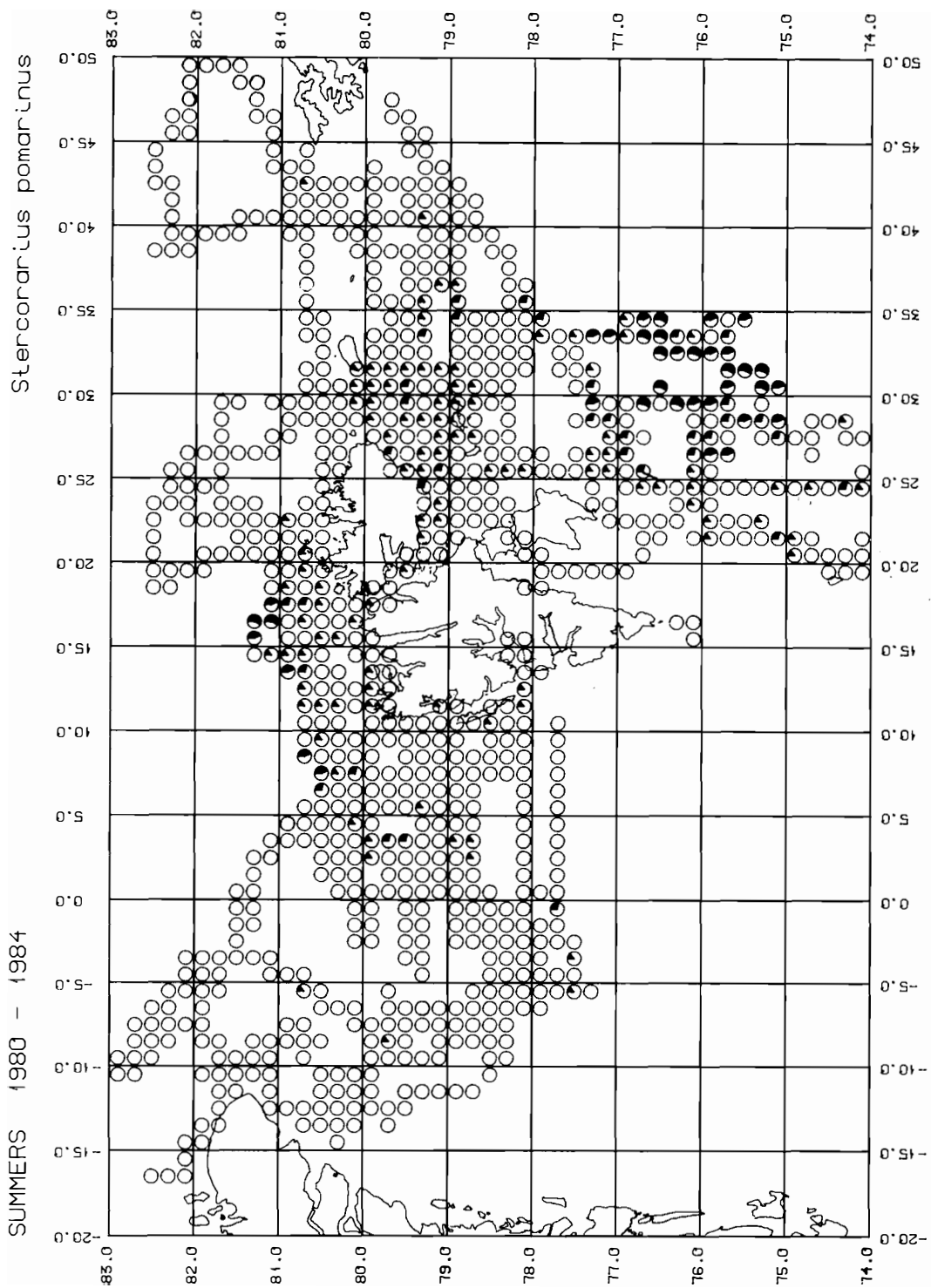
Map 17. Long-tailed Skua

Pomarine Skua *Stercorarius pomarinus*

Breeding distribution. – The Pomarine Skua is not a common breeding bird in Svalbard, and the only breeding record is from Tusenøyane in 1984 (Løvenskiold 1964; Bentz 1986). The closest known breeding localities are in the northern parts of Novaja Zemlja (Cramp & Simmons 1983). It does not breed in either Northeast Greenland or Frans Josef Land, but it does breed in most arctic parts of the USSR and North America bordering the Arctic Ocean (Muus et al. 1981; Cramp & Simmons 1983).

Pelagic distribution. – Even though this species is not known to breed regularly within the study area, it was the most abundant of all the skua species recorded during the censuses. The largest concentrations of birds were encountered in the northwestern part of the Barents Sea (southeast of Edgeøya and Hopen). Another concentration was recorded along the ice-edge north of Spitsbergen. The species was also recorded in abundance in the waters between Nordaustlandet, Kvitøya and Kong Karls Land.

The individuals observed are probably non-breeding and migratory birds from the USSR, which utilize the rich food resources of the Barents Sea and the marginal ice-zone before migrating southwards through the northern Atlantic to the wintering areas (Demente'ev & Gladkov 1951; Løvenskiold 1964). September is given as the main departure period from the breeding range (Demente'ev & Gladkov 1951). They were often seen chasing Kittiwakes *Rissa tridactyla* and stealing their food.

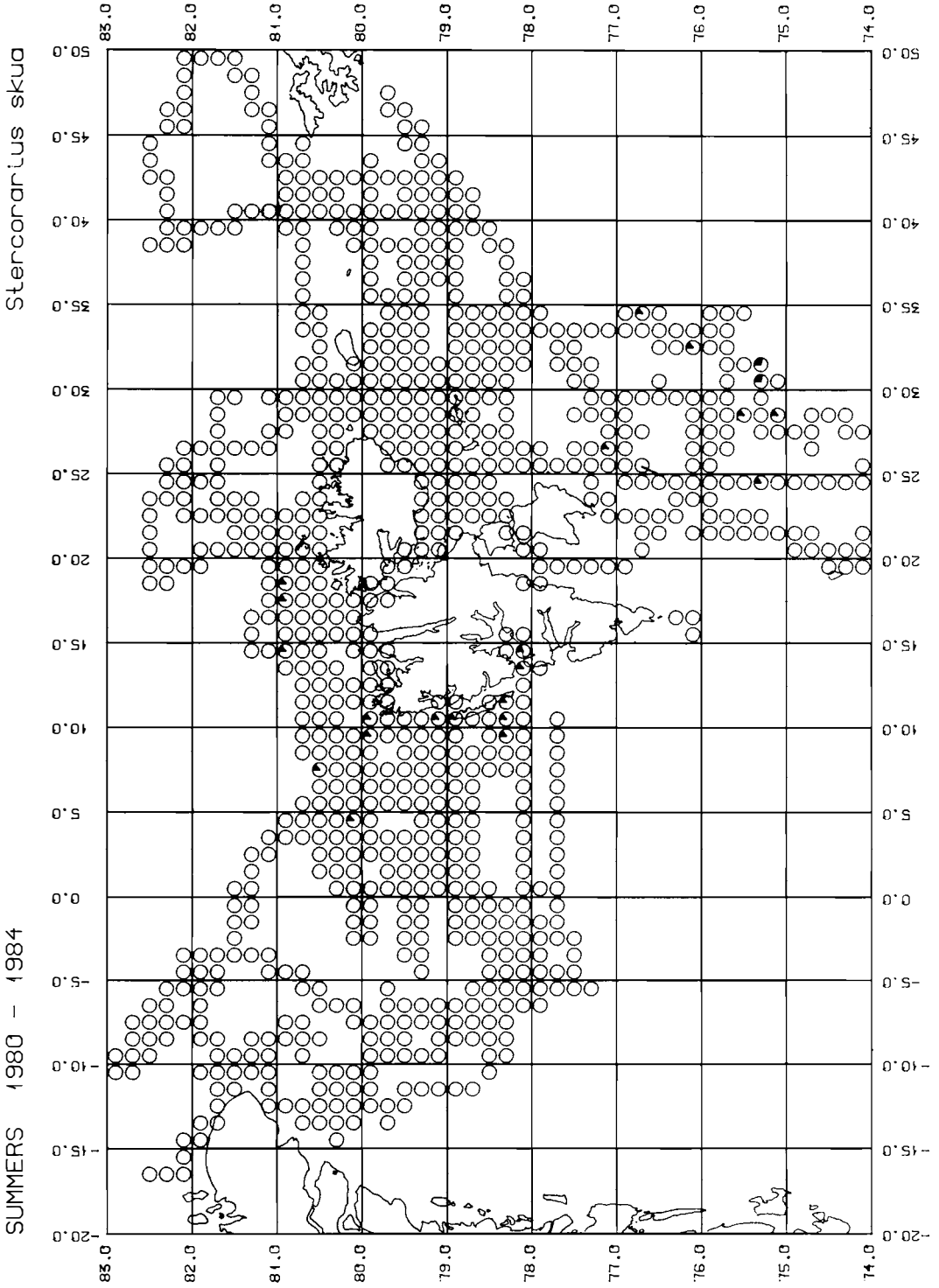


Map 18. Pomarine Skua

Great Skua *Stercorarius skua*

Breeding distribution. – Probably less than 10 pairs of Great Skuas breed yearly along the western coasts of Spitsbergen and on the island of Hopen. On Bjørnøya the breeding population has apparently increased sharply since the species' establishment around 1970, to about 20 pairs in 1980 (Vader 1980; Franeker & Luttick 1981). The first reported breeding in Svalbard (except for Bjørnøya) was in 1976 (Larsen 1977). No breeding localities of Great Skuas outside Svalbard are known north of Iceland and Northern Norway. Recoveries of ringed individuals prove an immigration from British colonies (Vader 1980; R. Barrett pers. comm.; Mehlum unpublished).

Pelagic distribution. – Our observations of Great Skuas were confined to the northwestern part of the Barents Sea and waters west and north of Spitsbergen (north to about 81°N). During the years of immaturity the north Atlantic subspecies of the Great Skua is known to have a wide marine range, extending north to the Greenland Sea, especially birds in their third year (Cramp & Simmons 1983). Most of the individuals observed are probably immatures and non-breeders. Many non-breeding individuals are also regularly seen along the Svalbard coasts during summer, and up to 100 birds may be observed at Bjørnøya (Vader 1980).



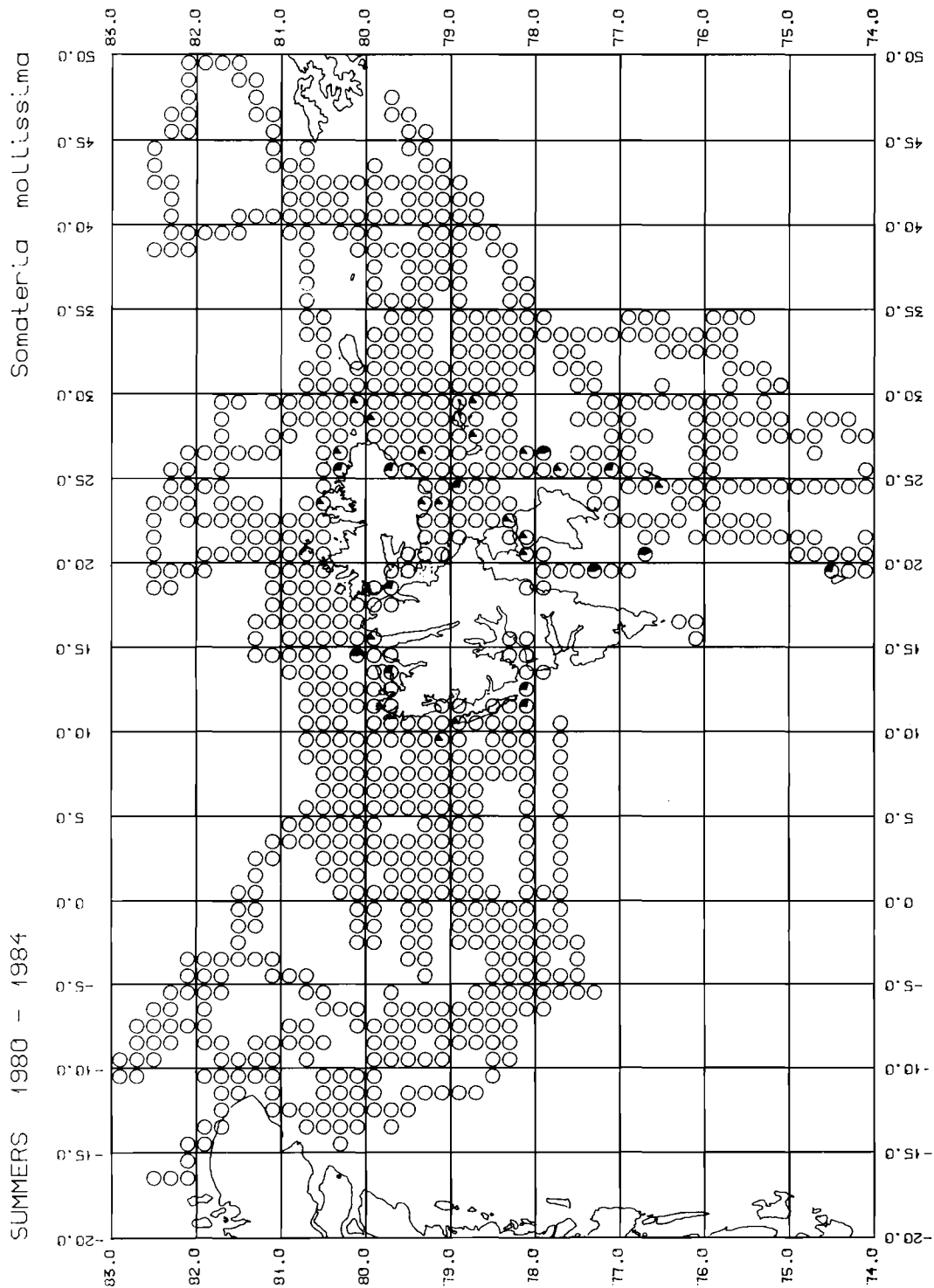
Map 19. Great Skua

Common Eider *Somateria mollissima*

Breeding distribution. – The Common Eider breeds abundantly on small islands and in coastal areas all along the coasts of Svalbard. The largest breeding concentrations are found on small islands along the western coast of Spitsbergen (Løvenskiold 1964). It also breeds in East Greenland north to Nordostrundingen (81°N) (Muus et al. 1981; Hjort et al. 1983; Håkansson et al. 1988) and in Frans Josef Land (Cramp & Simmons 1983). The Eiders arrive in Svalbard waters in the spring as soon as there are coastal areas with open water. They are usually waiting at the ice-edge outside the fiords and coasts until their nesting islands are free of snow and surrounding sea-ice. Breeding normally starts in June.

Pelagic distribution. – The distribution map does not reflect the true distribution patterns of the Eider in this region. Most Eiders gather in shallow water close to the shores after the breeding season before leaving Svalbard in the late autumn (Løvenskiold 1964; Karlsen & Mehlum 1986). The map shows that the species can also be encountered in small numbers farther out at sea, but no observations were recorded in mid-ocean areas (no records west of 9°E and east of 30°E).

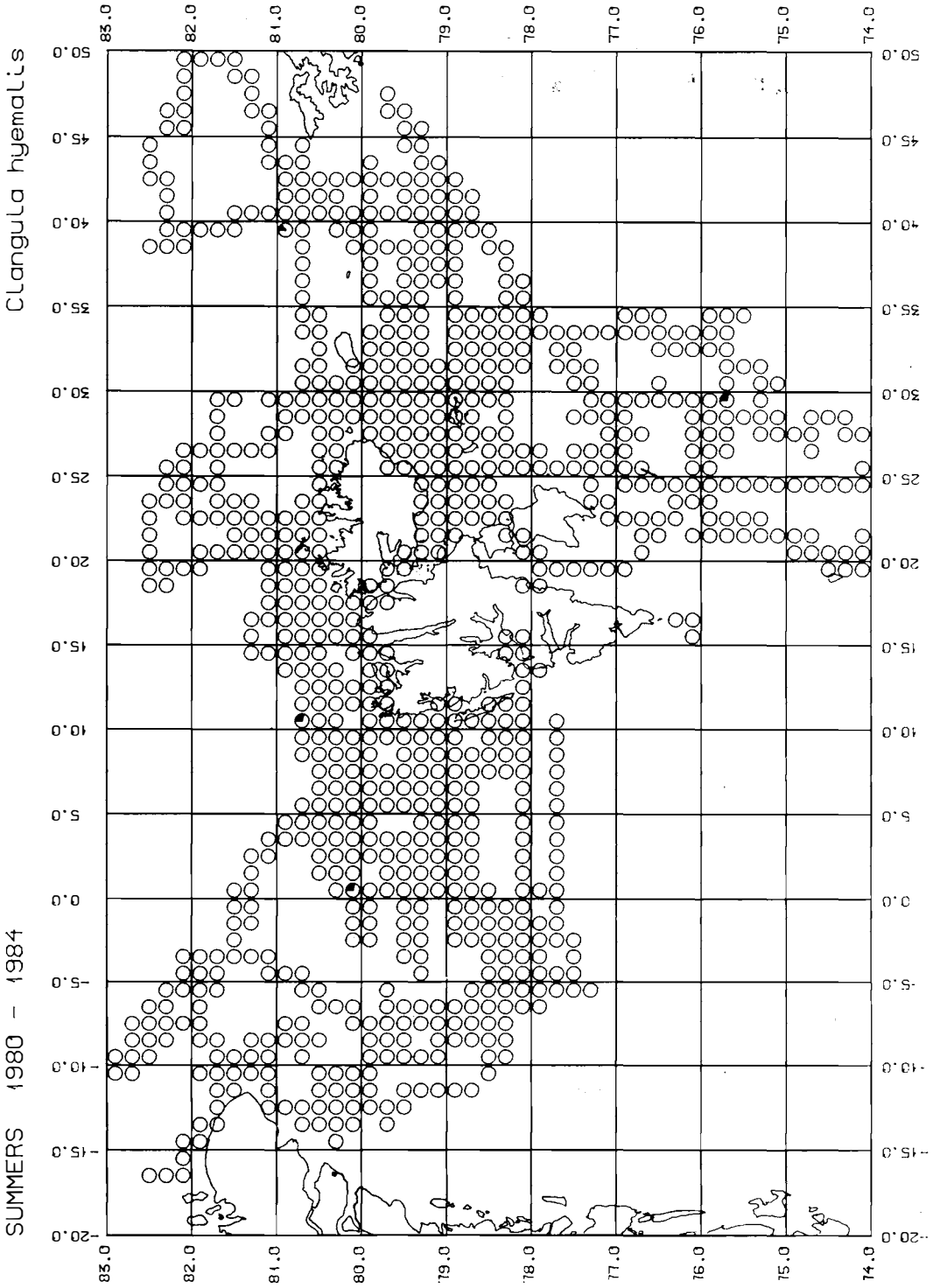
Only four recoveries of ringed Svalbard Eiders exist, of which one is from Iceland and the other three from the coasts of Northern Norway (Mehlum unpublished). The main wintering area is probably the coast of Northern Norway (Røv & Parker unpublished).



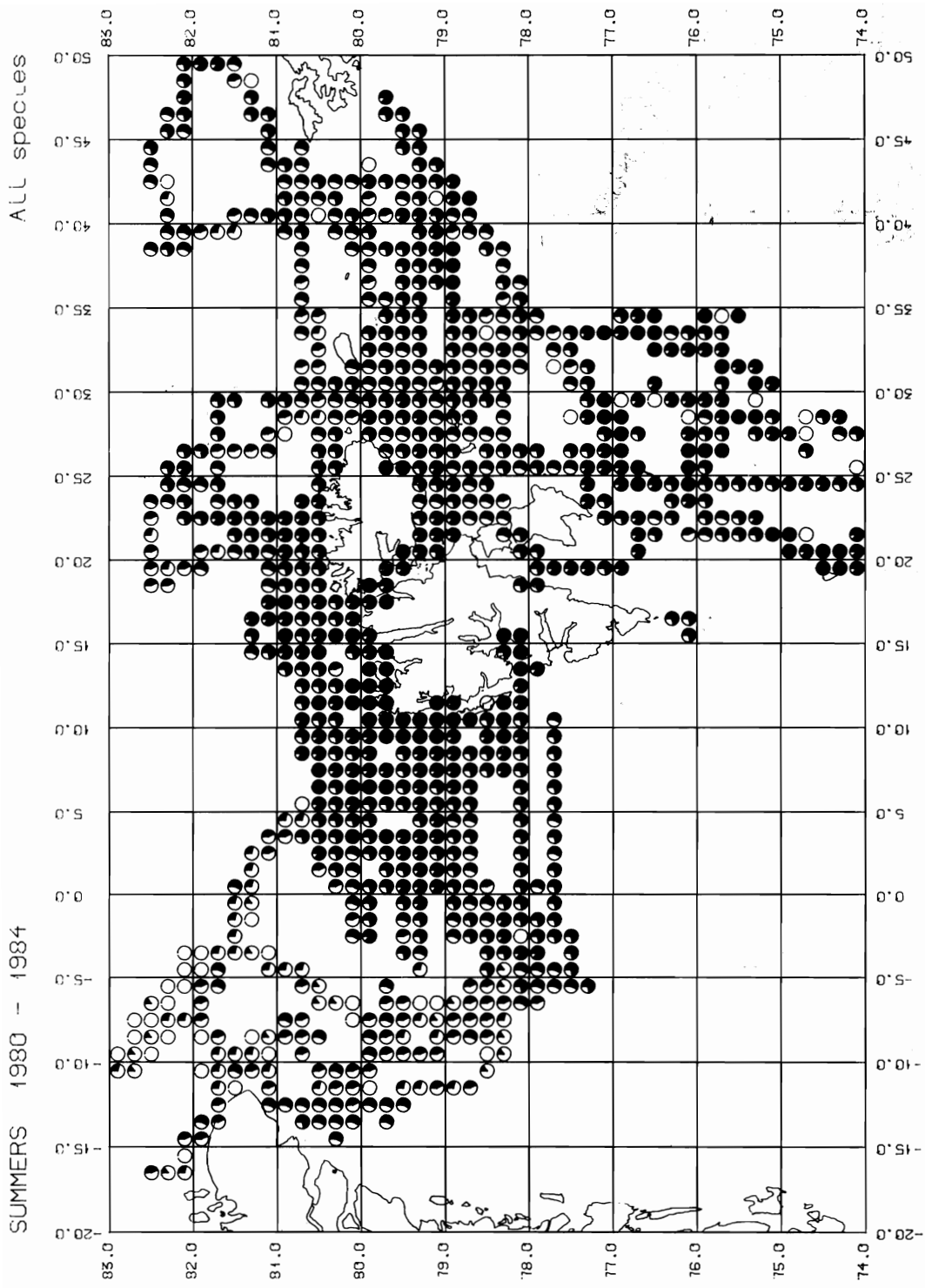
Long-tailed Duck *Clangula hyemalis*

Breeding distribution. – The Long-tailed Duck breeds in small numbers on the coastal tundra all over Svalbard except in the northeastern parts (Løvenskiold 1964). It is also present as a breeder in Northeast and North Greenland (Muus et al. 1981), but not in Frans Josef Land (Cramp & Simmons 1977).

Pelagic distribution. – This species is known to be more pelagic than the Eider *Somateria mollissima* outside the breeding season, and it winters in northern waters (Cramp & Simmons 1977). The pelagic habits are reflected in the distribution map given for this species. The total number of individuals observed was only 26, recorded in four different blocks. Three of these blocks were in the northern pack-ice zone. The low number of birds observed indicates that the species is not common in the waters investigated. Even though the total number of birds observed was low, the distribution pattern was quite different from the other duck species included in this paper, the Eider, which was confined to areas closer to the coasts of Svalbard.



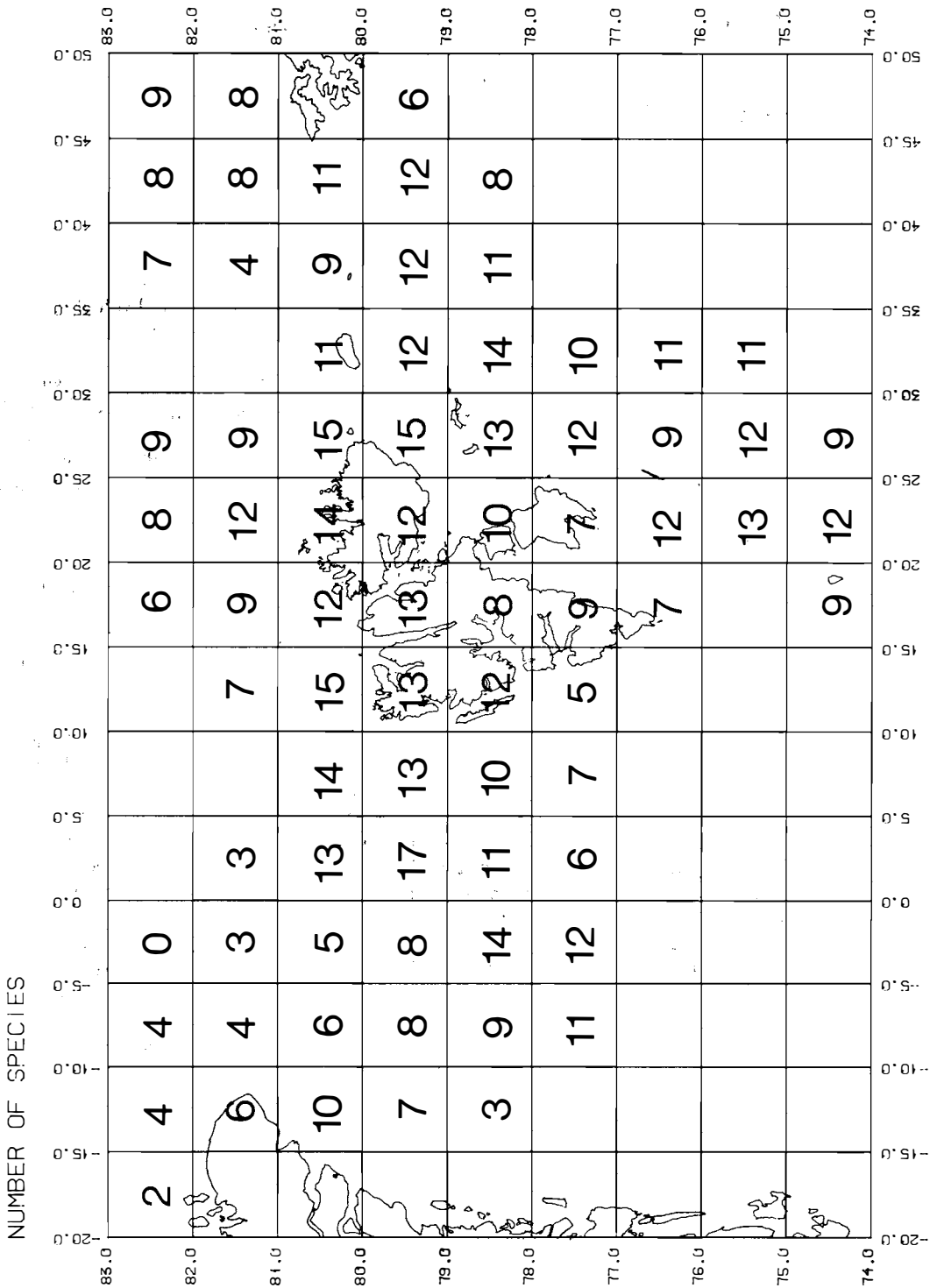
Map 21. Long-tailed Duck



ALL species

SUMMERS 1980 - 1984

Map 22. Summary map of all species.



Map 23. Number of species observed in each sub-unit.

Discussion

The census data from the five years 1980–1984 are combined in the distribution maps presented in this paper. This procedure will mask differences of abundance and distribution between years. However, the main purpose of the paper is to present the average distribution patterns for the five studied summer seasons in order to identify pelagic areas generally important to seabirds during the months July–September. Distribution maps for each of the five years are not presented since only parts of the total area were censused each year, and because the census effort in each block was limited.

As seen from the distribution maps seabirds are abundant in most parts of the study area. An abundance map of all species combined is presented in Map 22. Large concentrations were recorded in the Greenland Sea off the western coast of Spitsbergen, in the waters north of Spitsbergen north to the pack-ice in the Arctic Ocean, in the northernmost part of the Barents Sea between Svalbard and Frans Josef Land, and in the northwestern part of the Barents Sea towards the southeastern parts of Svalbard. Although the highest numbers of seabirds were recorded in these waters, the individual seabird species showed distinct distribution patterns. These differences in distribution may be influenced by the location of breeding colonies, migration patterns and feeding habits. The number of species observed in each block (1°N/S and 5°E/W) is shown in Map 23. The rather low abundances in the western part of the Fram Strait are also reflected in a generally low species diversity in this area. An exception is, to a certain degree, the Nordøstvandet polynya south of Nordostrundingen, Greenland's easternmost point.

Three species, the Black Guillemot, Ross' Gull, and the Ivory Gull, were closely associated with ice-filled waters in the northern parts of the study area. This pattern is in agreement with reports from other regions (Brown & Nettleship 1981; Blomqvist & Elander 1981). The abundance of Black Guillemots more than 200 km from the nearest shore, however, is very different from the near shore distribution of this species in more temperate regions (Cramp 1985). Their pelagic distribution in arctic areas is probably related to the availability of crustaceans and fish associated with the sea-ice.

Our seabird observations may be biased in several ways, so the maps have to be viewed with some caution. First of all some species are more easily overlooked than others. This group includes the alcids, with their dark plumage which is not easily detected on the sea surface, especially in rough sea. They also dive for food and may not be present on the sea surface when the ship is passing by. Other species, like fulmars and gulls (except for Ross' Gull), are attracted by ships and may follow them for hours. There is always the possibility that individuals of these species may be recorded several times, and during more than one 10-minute watch. Differences in weather conditions, such as visibility, wind and waves, may also influence the detectability of the birds. The ship probably attracts relatively more birds when it moves slowly through more or less heavy ice than when it is in open water, and this will artificially increase the figures from the ice-covered areas as compared with those from ice-free waters.

In the maps presented here the abundance categories in each block may be influenced by the types of bias mentioned above. In addition, the results in some blocks may not be representative because of low observation effort (small number of 10-minute watches).

It has to be emphasized that in this study the pelagic abundances of seabirds are presented as relative values (i.e. the mean number of individuals observed per 10-minute watch). The transect width was unlimited, and therefore absolute numbers of seabirds seen per square unit could not be computed. In other recent studies a fixed transect width, usually 300 m, has been applied (see Tasker et al. 1984 for review). The capacity of shipboard surveys to provide reasonable values of the absolute sizes of seabird populations at sea is questioned by Brown (1986, p. 3). He argues that 'most shipboard observations are made in the course of limited transects that cover only a very small fraction of a marine area, and do not even cover all the habitats within it'. I agree with Brown that given the limitations of the capacity of the methods applied during the censuses, the goal should be to refine the measurements of relative variations in numbers of seabirds. These relative abundances of different species may then be compared with each other and interpreted in terms of the occurrence of physical and biological oceanographic phenomena.

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