

Colonies of Northern Fulmars and Black-legged Kittiwakes Associated with the Northeast Water Polynya, Northeast Greenland

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ABSTRACT. The first census of cliff-nesting seabirds dependent on the resources of the Northeast Water polynya was carried out in 1993. We made direct counts in six known colonies of the northern fulmar (*Fulmarus glacialis*) and used a combination of direct and photo counts in one colony of black-legged kittiwakes (*Rissa tridactyla*). Glaucous gulls (*Larus hyperboreus*) occurring at these colonies were also surveyed. A total of 1887 apparently occupied fulmar sites were counted, and a subjective attempt to correct for missed sites gave a total of 2550 apparently occupied sites, in which an estimated 1475 pairs laid eggs. The cliffs at Mallemukfjeld and a neighbouring unnamed cliff held 80% of the fulmar sites. Kittiwakes nested only at Mallemukfjeld, which held 873 apparently occupied sites in which an estimated 733 pairs initiated laying. The minimum glaucous gull population present in the six fulmar colonies was estimated at 22 occupied sites. The fulmar and kittiwake colonies at the Northeast Water polynya were larger than previously assumed. We present estimates based on daily variation in colony attendance of the effort required to detect annual differences in population size. There is now a basis for evaluating any future population changes in some of the most extreme high-arctic seabird populations.

Key words: northern fulmar, *Fulmarus glacialis*, black-legged kittiwake, *Rissa tridactyla*, seabirds, population monitoring, polynya, high Arctic, Greenland

RÉSUMÉ. On a effectué en 1993 le premier recensement des oiseaux marins nichant dans des falaises, qui dépendent des ressources de la polynie des eaux du Nord-Est. On a fait un comptage direct dans six colonies connues de fulmars boréaux (*Fulmarus glacialis*) et utilisé une combinaison de comptage direct et photographique dans une colonie de mouettes tridactyles (*Rissa tridactyla*). On a aussi relevé les goélands bourgmestres (*Larus hyperboreus*) présents dans ces colonies. On a compté un total de 1887 sites de fulmars apparemment occupés, et obtenu, en faisant une correction subjective pour les sites manqués, un total de 2550 sites apparemment occupés, où l'on estime que 1475 paires avaient pondu des oeufs. Les falaises de Mallemukfjeld et une falaise voisine innommée contenaient 80 p. cent des sites de fulmars. Les mouettes nichaient seulement à Mallemukfjeld, où se trouvaient 873 sites apparemment occupés dans lesquels on estime que 733 paires avaient commencé à pondre. La population minimale de goélands bourgmestres présente dans les six colonies de fulmars a été estimée à 22 sites occupés. Les colonies de fulmars et de mouettes de la polynie des eaux du Nord-Est étaient plus importantes qu'on l'avait supposé. On présente des estimations de l'effort requis pour détecter les différences annuelles de population, d'après les variations quotidiennes de présence dans les colonies. Il existe maintenant une base permettant d'évaluer tout changement futur de population dans certaines des populations les plus reculées d'oiseaux marins de l'Extrême-Arctique.

Mots clés: fulmar boréal, *Fulmarus glacialis*, mouette tridactyle, *Rissa tridactyla*, oiseaux marins, surveillance de la population, polynie, Extrême-Arctique, Groenland

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INTRODUCTION

Seabirds need access to foraging areas at sea, which limits their distribution in the Arctic where ice cover is dense. As a consequence, high-arctic seabird colonies are always situated near ice edges, recurring leads or polynyas (Brown and Nettleship, 1981; Massom, 1988). The "Danmark Expedition" to northeast Greenland in 1906–08 rediscovered the Northeast Water polynya (Inuit had lived in the area previously) and located one of the world's most extreme high-arctic seabird colonies, Mallemukfjeld, occupied by northern

fulmars (*Fulmarus glacialis*) and black-legged kittiwakes (*Rissa tridactyla*) (Manniche, 1910). In 1939, Pedersen (1942) identified two more distinct fulmar colonies near the polynya. However, these pioneers in the area gave only vague references to population size. The most recent published information came from short visits by geologists to most of the fulmar colonies and other sites in 1980 and 1985 (Hjort et al., 1983, 1988). They reported a total of five fulmar colonies, but pointed out that no kittiwakes were observed at the cliffs.

As part of an international research programme studying physical and biological processes in the polynya (Anony-

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mous, 1989), we performed the first quantitative survey of the cliff-nesting seabird species along the Northeast Water in 1993. On the basis of detailed observations of the species breeding at Mallekukfjeld, we estimate total numbers of breeders and non-breeders occupying the fulmar and kittiwake colonies near the polynya and provide a basis for assessing future population changes. Since the variation in numbers of birds in the colony has implications for population monitoring, data on diel and seasonal variation in nest site attendance are presented as well. In addition, the colour phase distribution of the northern fulmar population is described. Details of fulmar and kittiwake breeding ecology in the area will be presented elsewhere.

METHODS

Study Area

Field work was carried out along the coast of Holm Land and Amdrup Land (Fig. 1). Glaciers cover most of the land area, but at the eastern part of Holm Land and at Kap Jungersen at Amdrup Land the late Palaeozoic limestone and sandstone sedimentary rocks (Escher and Watt, 1976) are exposed as 350–500 m high cliffs and talus slopes. The ice-free land areas along the coast are extremely barren, with less than 1% vegetation cover.

The study area is situated at the edge of the Northeast Water (NEW) polynya. Small areas and leads of open water are present all year round, but in average years the ‘summer polynya’ forms gradually in spring from about 15 May, reaches its maximum extent by the end of August, and closes again by rapid ice formation in mid September. At most, the polynya reaches from Nordostrundingen at 82°N to 77°N, and covers an area of about 25 000 km² (as in 1993), but typically the open water area does not exceed 17 000 km² (Pedersen et al., 1993; Gudmandsen et al., 1993, in press).

Fulmar Census

The census of northern fulmars was performed during the laying and incubation period, when the number of birds attending the colony was at a high level (Hatch, 1989). From vantage points along the top of the cliffs, sectors of the colonies along concave stretches of coastline could be overlooked. From each protruding point we counted all visible birds, and positions where birds were sitting (= ‘apparently occupied sites’; Nettleship, 1976). We made no attempt to distinguish between sites occupied by brooding birds and non-breeding prospectors.

Some cliff face areas and ledges were hidden by outcrops and overhangs. At each distinct section of the cliff, the observers subjectively judged the proportions of cliff face and ledges that were out of view, giving a crude correction factor to estimate the total population. Hence, the actual recorded number gives the minimum population size, and the corrected figure a ‘best estimate.’ At convex portions of the

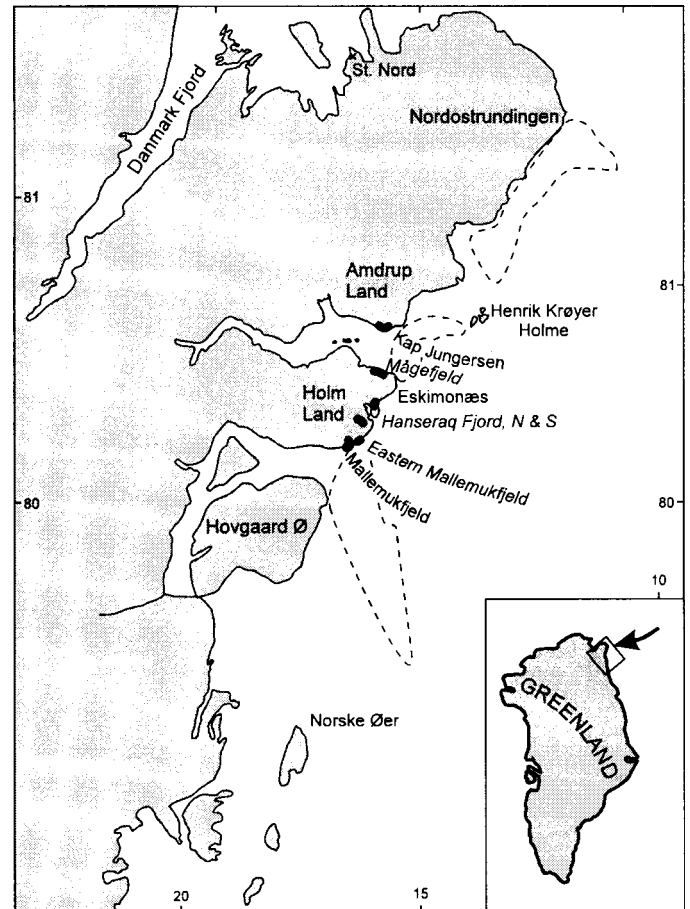


FIG. 1. Map of northern fulmar colonies (black marks at the coast, and names in italics) in Northeast Greenland along the Northeast Water polynya (exemplified by the dashed lines indicating approximate limits of open water as seen on a NOAA satellite image from 27 May 1993).

coastline, the cliff face could not be inspected, but from the traffic of arriving and departing birds it was obvious that those parts of the cliffs only held few birds (with some exceptions, see below). At Mallekukfjeld the cliffs were also inspected from below, either from the coastline and ice edge or from an inflatable boat. Although fulmar sites could not be counted from below, cliff sections with birds could be identified, and these inspections confirmed that at Mallekukfjeld very few fulmars frequented the convex cliff sections that could not be seen from above.

Two of the colonies, Hanseraq Fjord North and Mågefjeld, could not be surveyed from cliff edges, but were counted from a Bell 206 helicopter slowly passing the cliffs twice at a distance of about 100 m. At Eastern Mallekukfjeld the number of sites on one convex section was roughly estimated during a single helicopter pass, while one section of Kap Jungersen remained unsurveyed.

During field work between 15 May and 8 August at the largest colony at Mallekukfjeld (80°11'N, 16°38'W), we daily counted the number of birds present in eight fulmar (and one kittiwake) study plots (Fig. 2) with known numbers of breeding sites (sites occupied by pairs that laid an egg). A correction factor (k , = number of breeding pairs per bird

present) was calculated and applied to the census data to estimate total breeding populations.

The number of birds present in the designated study plots was also used to describe seasonal and daily variation in colony attendance of both species, and to establish a baseline for identifying future population changes. Occasionally fog

prevented counting birds at some plots, but in the data analysis missed plots were prorated from their average contribution to daily totals (Hatch, 1989). To measure diel variation in attendance, we counted fulmars in plot L (Fig. 2) and the ledges below every hour, and kittiwakes every second hour (see dates in Fig. 5).

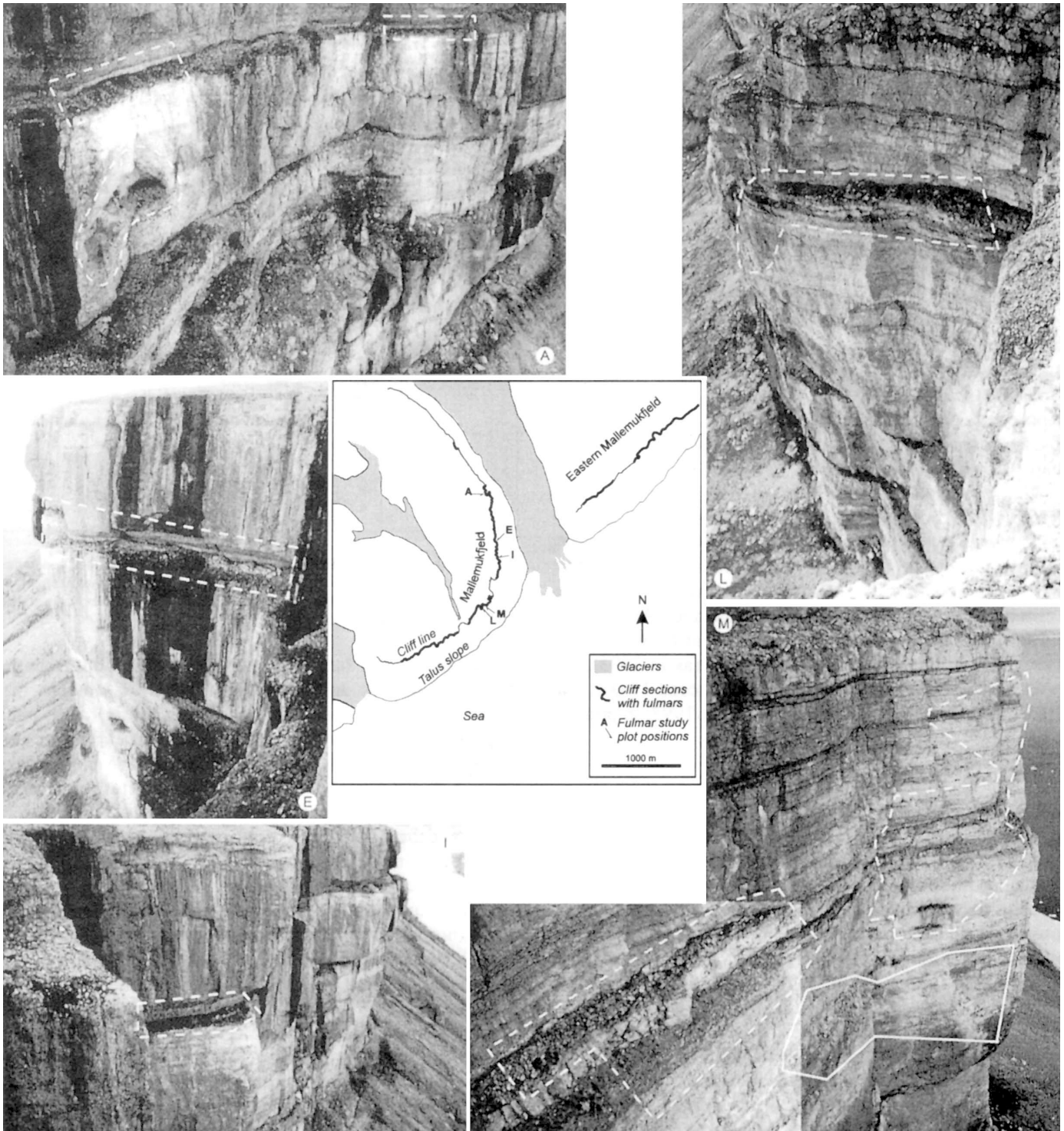


FIG. 2. Location and delineation of eight fulmar study plots (dashed lines) and one kittiwake study plot (solid line) on Mallekufjeld; only the quantitative plots used in this study are given.

Fulmar Colour Phases

Colour phases of the fulmars were recorded at the main colony at Mallekufjeld. At six sectors of the colony, all sitting birds were inspected through a 20× telescope and assigned to one of the colour phase classes LL (double-light), L (light), D (dark) or DD (double-dark) defined by Fisher (1952) and refined by van Franeker and Wattel (1982). The appearance of the birds' plumage varied considerably with light conditions, and the colour phases were therefore determined only on overcast days, when we considered light most neutral for the purpose.

Black-legged Kittiwake Census

Parts of the kittiwake colony were counted from two vantage points. In one study plot, holding approximately 11% of the population, the birds were counted daily, and the number of nests was counted in late egg to early chick stage (Nettleship, 1976; Harris, 1987). From observations in that study plot, the proportion of pairs laying at least one egg was also determined.

Most kittiwakes nested on parts of the cliff not visible from above, and these sections were counted as “number of sites with birds” from projected 24 × 36 slides (Ektachrome 100) taken on two occasions: first, on 26 June (egg stage) with a 400 mm telephoto lens from an inflatable boat approximately 400 m from the cliff, and second, on 5 July with a 105 mm telephoto lens from a BO 105 helicopter slowly approaching and passing the colony. Previous observations at the study plot had indicated that gradually approaching helicopters did not cause panic among the kittiwakes on the cliff. On the slides, only sites with one or two birds were counted and considered equivalent to an occupied nest, because unattended nests could not be reliably identified on the background of the light limestone rocks.

Glaucous Gull Census

The glaucous gull (*Larus hyperboreus*) population was counted while conducting the fulmar survey. We recorded freshly built nests and defensive pairs.

RESULTS

Fulmar Population

The northern fulmars were breeding at six colonies at the edge of the Northeast Water (Fig. 1). The northernmost colony was at Kap Jungersen on Amdrup Land and the remaining five on the eastern coast of Holm Land down to the southernmost colony at Mallekufjeld (Table 1). Some of the colonies were situated near each other, but for convenience they are treated here as separate colonies. We recognize Mallekufjeld and the neighbouring Eastern Mallekufjeld (no official name) as separate colonies although they have

TABLE 1. Number of apparently occupied sites, and number of individuals at six northern fulmar colonies in Northeast Greenland.

Colony	Survey date	Observed # of		Estimated # of ¹		
		Sites	Birds	Sites	Birds	Pairs ²
Mallekufjeld	June-July	1141	1310	1350	1550	775
East. Mallekufjeld	June 06	351	405	725	850	425
Hanseraq Fjord, S	June 13	132	155	175	200	100
Hanseraq Fjord, N	July 24	45		50	50	25
Mågefjeld	July 24	110		100	125	50
Kap Jungersen	July 05	108	127	150	175	100
Total		1887	1997	2550	2950	1475

¹ Figures rounded to nearest 25.

² Calculated from estimated number of birds by a k-factor of 0.50 (see Results).

been treated together by previous visitors to the area.

The total of 1887 apparently occupied sites holding 1997 individuals (Table 1) represents the minimum population size. By applying correction factors for the estimated proportions of breeding sites not visible during the survey, the total population may be estimated at 2550 apparently occupied sites.

From eight study plots (Fig. 2) containing a total of 101 breeding pairs (egg laid) at Mallekufjeld, the mean k-value (number of breeding pairs per bird present) for the period 1 June to 15 July (n = 45 days) was 0.50 (SD = 0.04). Applying this factor to the total number of birds estimated on the six colonies gives an active breeding population of 1453–1485 pairs (95% confidence limit). This estimate does not include a cliff section at Kap Jungersen where the traffic of flying birds suggested that fulmar sites were also present on ledges invisible from the cliff edge and not assessed from the helicopter. That section may have held an additional 20–100 sites.

Mallekufjeld (80° 11' N, 16° 38' W) and neighbouring Eastern Mallekufjeld (80° 12' N, 16° 31' W) hold about 52% and 28%, respectively, of the estimated population of fulmars along the polynya. These cliffs provide special physical conditions for nesting: impressive 140 m high, flat-topped limestone cliffs with about 200 m of talus sloping to sea level (Fig. 3). At the vertical (slight overhang) cliff face are three storeys of ledges from one to three metres deep, and almost all fulmars nest on these ledges, which offer shelter from a substantial overhang. Most nests are situated on southeast-facing cliff sections overlooking the sea, but at Mallekufjeld birds nest up to 2 km inland on east-facing cliffs above a glacier (map in Fig. 2). Pedersen (1942: Fig. 18) indicated that fulmars were also breeding just west of Mallekufjeld (west of the western glacier), but we did not observe any birds on this part of the coastline, where there are only small cliffs.

Hanseraq Fjord South (80° 16' N, 16° 41' W) is a small colony where the nests are thinly distributed over approximately 2 km of low cliff facing NNE. The cliff is very eroded, and there is a long slope of loose scree and gravel from the plateau above the colony to the edge, but the indented cliff edge allows views to most of the fulmar sites.



FIG. 3. Two of the northern fulmar breeding cliffs in Northeast Greenland: the flat-topped limestone cliffs of Mallekufjeld (front) and neighbouring Eastern Mallekufjeld (across the glacier, photo of 21 May 1993).

Hanseraq Fjord North ($80^{\circ}20'N$, $16^{\circ}14'W$) is the smallest colony. All sites were at the vertical east-facing section, and most of the 45 sites recorded were located at a single long ledge. The colony cannot be surveyed from the cliff edge.

Mågefjeld ($80^{\circ}27'N$, $16^{\circ}12'W$) at the entrance to Ingolf Fjord is a north-facing low cliff with a huge slope of gravel down to the cliff edge. Most fulmar sites are located low at the vertical part of the cliff. The colony cannot be surveyed from above, nor can the sites be seen from below.

Kap Jungersen ($80^{\circ}37'N$, $16^{\circ}10'W$) is a south-facing cliff line that is very indented, and vantage points allow good views of many sections with fulmar sites. But one low-lying section on the cape is invisible from above and probably holds some fulmar sites not quantified in this study; if these sites could have been counted, Kap Jungersen would probably be the third largest fulmar colony at the Northeast Water. Disregarding the unsurveyed section, almost the entire colony was found along approximately 2 km of cliff line west of the peak of Kap Jungersen; only a group of six sites was located east of the peak.

Breeding sites in all colonies were situated at inaccessible ledges, well protected from the potential mammalian predators in the area, arctic fox (*Alopex lagopus*), ermine (*Mustela erminea*) and polar bear (*Ursus maritimus*).

Colour Phases

The northern fulmar population breeding at the NEW polynya showed all colour shades from the white LL to the darkest grey, DD; the majority was assigned to phase D (Table 2). The ratio between light (LL + L) and dark (D + DD) was 12:88, and 97.8% of the birds may be termed “coloured” (= L, D, DD) (van Franeker and Wattel, 1982).

There was great variation within the D-category. Some birds were light grey on the crown, nape, throat and breast, but had very dark upper wings and back, while others were nearly uniformly light to dark grey without falling into the DD category. Also, some very light birds had traces of grey on the crown and nape or sides of breast, making them borderline cases of phase L/LL (van Franeker and Wattel, 1982).

Kittiwake Population

Kittiwakes bred only at Mallekufjeld where they nested on narrow ledges unsuitable for fulmars. Combining direct counts and photo counts, the total kittiwake population was 873 apparently occupied sites. Of 94 nests in the study plot, eggs were laid in 79 (84%). Applying this correction factor to the total number of sites counted, an estimated 733 pairs of

kittiwakes initiated breeding in the colony during 1993.

Glaucous Gull Population

The population of glaucous gulls was very small; in total we recorded only 22 pairs at five of the fulmar colonies surveyed. Most pairs (13) were found at Mallemukfjeld, four at Kap Jungersen, three at Mågefjeld, one each at Hanseraq Fjord North and Eastern Mallemukfjeld. However, at Mallemukfjeld we once witnessed 16 birds scared out from the lower parts of a large cliff invisible from above, and a number of pairs may have been overlooked here as well as on other cliffs.

TABLE 2. Numbers and proportions of colour phases of northern fulmars nesting at Mallemukfjeld, Northeast Greenland.

Colour phase ¹	Number observed	Proportion (%)
LL	10	2.2
L	45	9.8
D	373	81.3
DD	31	6.8

¹ as in Fisher (1952), refined by van Franeker and Wattel (1982).

Colony Attendance

The number of birds attending the colony varied over the breeding season. In the kittiwake colony, major fluctuations occurred when the birds occupied their sites in the spring, and levelled off from about the time laying began at 12 June (Fig. 4). Fulmar numbers peaked shortly after the median laying date (31 May) and, despite marked fluctuations, tended to decrease gradually until a sharp drop occurred from the last days of July (Fig. 4). For population monitoring purposes, repeated counts within 50 days from the first laying date have been proposed for the black-legged kittiwake (Hatch and Hatch, 1988). At Mallemukfjeld, the mean number of kittiwakes present at the study plot during the egg stage (first egg laid 12 June) was 103.3 (SD = 8.7) as indicated by the dashed line in Figure 4. Similarly, in the eight fulmar study plots, a mean of 203.2 (SD = 17.4) birds was recorded during the main egg period between 1 June and 15 July (n = 45 days). Regression of the number of birds against day during the proposed census periods was not significant for the kittiwake (slope 0.02 birds·day⁻¹, *p* = 0.83), but was significantly negative for the fulmar (slope -0.82 birds·day⁻¹, *p* = 0.0001).

None of the species showed any clear diel variation in colony attendance in the continuous daylight (Fig. 5).

DISCUSSION

The population survey and estimates showed that the northern fulmar colonies in Northeast Greenland are substantially larger than previous information had suggested. The first record (1907) from the area stated that “the Fulmars were

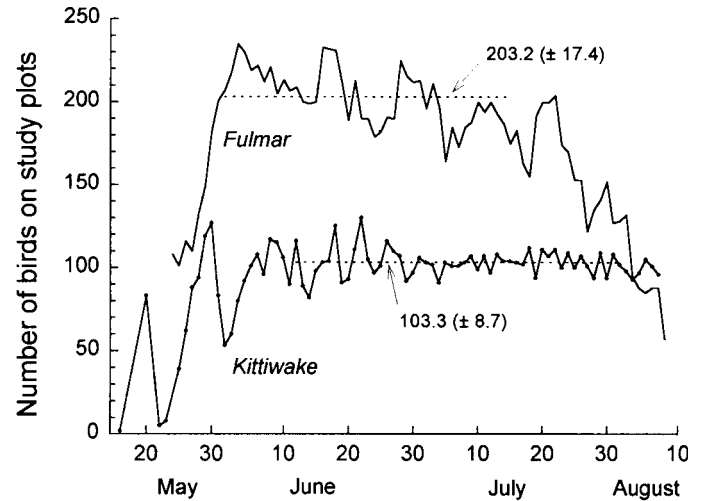


FIG. 4. Colony attendance of fulmars and kittiwakes on study plots at Mallemukfjeld, 1993; dashed lines indicate means during the proposed census periods (see text).

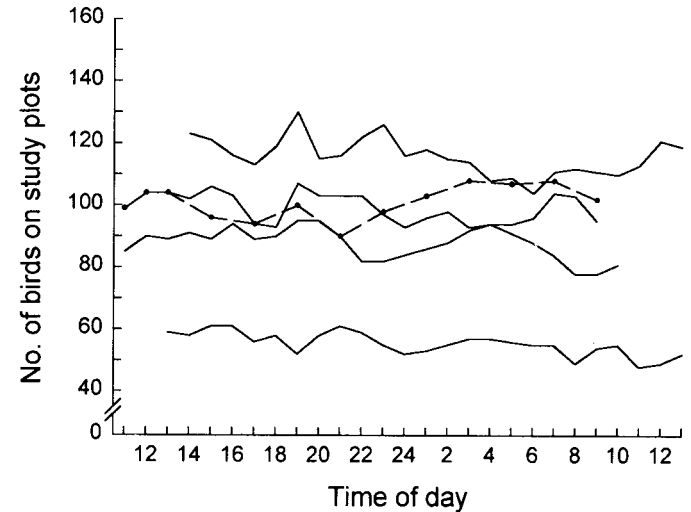


FIG. 5. Colony attendance during full-day counts in one kittiwake study plot (dashed line with symbols, July 15–16) and selected fulmar plots, from top to bottom: June 4–5, June 25–26, July 15–16, and August 5–6.

present in greater numbers—by hundreds but not by thousands” (Manniche, 1910:123), and in 1939 “hundreds” of fulmars were seen circling around the cliffs at Kap Jungersen (Pedersen, 1942:72). In 1980, Hjort et al. (1983) noted approximately 250 birds at Mallemukfjeld and up to 50 birds at each of the four small colonies. We directly counted 2000 birds at nesting ledges in 1993, and comparing this count to the old information one could suspect a population increase during this century. Nevertheless, the difference is more likely caused by different survey procedures. Except for visits in 1980, all observations must have been made from the sea ice below the cliffs where the breeding sites on the deep ledges are not visible; the early observers could record mainly the traffic of flying birds high up at the 400 m tall cliffs.

There is, however, one observation suggesting that the northern fulmar has expanded its range in Northeast Greenland: a new colony of approximately 150 individuals was

established between 1964 (and most likely after 1976) and 1987 at Hvalrosø, about 630 km south of Mallemukfjeld (Stemmerik, 1990). This colony is near a small coastal polynya.

The nearest neighbouring fulmar colonies to the Northeast Water are at Spitsbergen, 560 km to the east. According to the most recent information, the known fulmar population (some colonies have not been quantified recently) of Spitsbergen (excluding Bear Island) may be at least 35 000 pairs (F. Mehlum, Norwegian Polar Institute, pers. comm. 1994). In Greenland, the fulmar breeding sites are few and largely confined to West Greenland, and apart from the new colony at Hvalrosø mentioned above, the only other East Greenland fulmar colonies are situated near Scoresby Sound around 70°N (Salomonsen, 1950).

Manniche (1910) mentioned that black-legged kittiwakes were breeding at Mallemukfjeld and other cliffs between 80°10' and 80°20'. On modern updated maps this area corresponds to the coastline from west of Mallemukfjeld to just north of Hanseraq Fjord, but in 1993 the kittiwake was found breeding only at Mallemukfjeld, and none at all were observed during the visits to other seabird cliffs at the Northeast Water. Regarding population size, "some 100 individuals" were counted here on 9–10 June 1907, "it is however probable, that a greater number were nesting on these places" (Manniche, 1910:163). The colony could very well have been of the same size in 1907 as today, and there is no basis for assuming any significant population change over the 86 years that have passed since the colony was first discovered. But the kittiwake has recently established a small colony (8 pairs in 1989, ca. 15 pairs in 1993) near Danmarkshavn, about 390 km south of Mallemukfjeld (Boertmann, 1994; J. Graugaard, pers. comm. 1994). The nearest neighbouring major kittiwake colonies are situated at Spitsbergen, where the most recent available data indicate a population of roughly 200 000 pairs (F. Mehlum, pers. comm. 1994).

It is puzzling that no kittiwakes at all were observed at Mallemukfjeld in 1980 (Hjort et al., 1983). It cannot be ruled out that the colony at Mallemukfjeld was simply overlooked during the brief visit on 11 July, as the colony is not very easily recognized from above unless the observers negotiate certain uninviting vantage points. However, from other areas it is well known that in years with unfavourable conditions kittiwake breeding can fail completely, and although failed breeders stay at or near the colonies, attendance may be erratic (Kampp, 1984; Birkhead and Nettleship, 1988; Murphy et al., 1991; Hatch et al., 1993), reducing the chance of detecting the presence of a small population. The teams of geologists compiling the information presented by Hjort et al. (1983) spent almost two months in various areas along the Northeast Water, and only two individuals were recorded from a research vessel at the eastern edge of the polynya in 1980 (Hjort et al., 1987). By contrast, up to 18 kittiwakes per hour passed by Eskimonæs in late July 1993 (C. Hjort, unpubl. data) and they were seen daily in all parts of the polynya from the research vessels *Polarstern* and *Polar Sea* operating in the Northeast Water throughout the summer. In

fact, the polynya opened up later in 1980 than in average years, whereas in 1993 the ice breakup was normal and during the summer the polynya became larger than usual (Pedersen et al., 1993; Gudmandsen et al., 1993, in press). Thus, conditions may have been particularly favourable for the seabirds, allowing for high breeding success and colony attendance in 1993. It is possible that under poor conditions, for example in years of late ice breakup, the kittiwakes may avoid this extreme high-arctic area and not attend their usual breeding sites at the Northeast Water.

The glaucous gull is not restricted to a few breeding sites as are the other two species, but is known to inhabit a number of small colonies in most of Northeast Greenland (Manniche, 1910; Pedersen, 1942) where it probably relies mainly on marine food sources in leads and local polynyas. A similar distribution pattern has been found in high-arctic regions of eastern Canada (Nettleship, 1974b; Brown and Nettleship, 1981). In the Northeast Water where the glaucous gull breeds in association with the fulmar and kittiwake, we have seen that these species contribute considerably to the glaucous gull's diet (mainly eggs and chicks but also injured and dead adults).

The first quantitative study of northern fulmars and black-legged kittiwakes along the Northeast Water has established a base for assessing future changes in populations associated with the polynya. Detection of population changes or fluctuations is especially interesting in the high Arctic where the species occur at the extreme limits of their range. Remote sensing and climate models suggest that the effects of climate change may be amplified and thus detectable sooner at high latitudes (Massom, 1991; Chapin, 1992), and probably the distribution and numbers of arctic seabirds would be affected (Brown, 1991). Of course, population changes may not be caused by climate alone; the boreal fulmar in the Atlantic has undergone a substantial population increase and expansion of its breeding range over the last centuries. But the arctic populations are considered not to have undergone a similar change, and recent discoveries of major fulmar breeding sites in the Canadian Arctic were considered results of increased survey intensity, not of a population increase (Fisher, 1952; Salomonsen, 1965; Nettleship, 1974a, b). The northern fulmar colonization of Northeast Greenland is not recent: fulmar bones were excavated in 1993 from old Inuit camp sites at Eskimonæs at the edge of the polynya. Preliminary archaeological dating suggests that the fulmars were hunted by settlers in the area 2800–2300 years ago. Fulmar bones have also been recovered from 300 to 500 year old Thule culture sites at the Northeast Water polynya, along with bones of king eiders (*Somateria spectabilis*), ivory gulls (*Pagophila eburnea*) and unidentified large gulls (C. Andreasen, University of Greenland, pers. comm. 1994).

The seabirds can be used as important marine indicators in connection with monitoring programmes. Population fluctuations and trends can be detected in kittiwake populations relatively soon after a change in the marine environment (Chapdelaine and Brousseau, 1989), and according to Hatch and Hatch (1988), the mean number of birds in study plots

during egg and early chick stage is a reliable observation unit for assessing population changes in this species. Because breeding success and attendance patterns can vary considerably between different parts of a colony, however, it is recommended for monitoring purposes to define many (randomly chosen) study plots instead of a few plots that may not be representative for the colony (Harris, 1987; Hatch and Hatch, 1988). But conditions at Mallekufjeld allowed designation of only one plot comprising approximately 11% of the entire kittiwake colony, that may serve as a reference for future evaluation of population change and breeding success. Among the northern fulmars at Mallekufjeld eight study plots were designated, altogether holding nearly 7% of the estimated breeding population in the Northeast Water (Fig. 2).

For future visits to the area, it may be valuable to know how many individual counts (observation days) of birds in attendance in the study plots would be necessary to detect a certain change in the seabird populations. Disregarding for this purpose any potential spatial variation within the colony, the number of counts required during the egg-stage can be calculated from the observed variation in number of birds recorded in study plots (Wanless et al., 1982; Hatch and Hatch, 1988). With the observed variation in kittiwake attendance, only five counts will be sufficient to detect a change of 27% between years at Mallekufjeld, with 95% confidence of finding a significant difference between means at the 0.05 significance level, while 11 counts would detect a 15% change, and 22 counts a 10% change (Fig. 6). Even as many as 34–50 counts will only detect a change of 6.5% to 8% with the specified confidence and probability. As stated by Hatch and Hatch (1988:618), “greater sensitivity using present techniques is precluded by the inherent variability among daily counts.”

Because of the greater variation in fulmar numbers (Fig. 4), population monitoring by counts of birds at the study plots will be less accurate than for the kittiwake. With the variation observed in the fulmar attendance between 1 June and 15 July, 13 counts (days) would be required to detect a 27% change between years with the same confidence and prob-

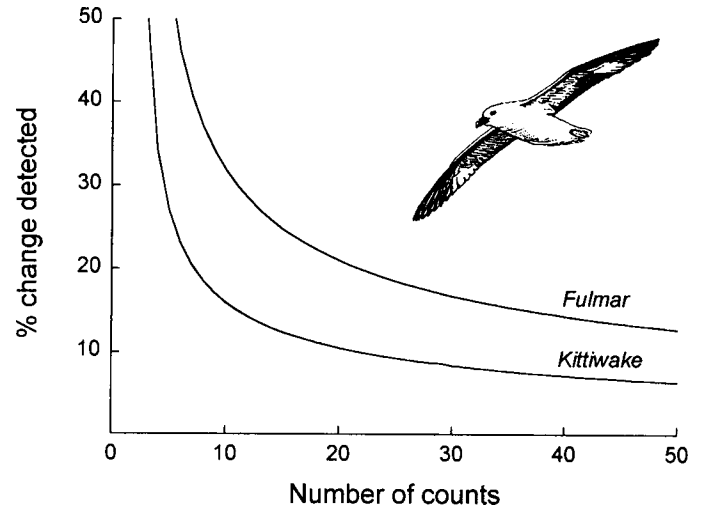


FIG. 6. Number of counts (on different days) required to detect a certain population change between years with 95% confidence of finding a significant difference between means at the 0.05 significance level.

ability as specified above for the kittiwake (Fig. 6). As many as 22 counts would detect a 20% change and, at best, counts at all 45 days would detect only changes of at least 14%. Because variation in attendance is less in the early part of the breeding season, counts performed only during June may give slightly more accurate estimates than the same number of counts dispersed over the entire egg-stage. Judged from the 1993 data, population counts can be performed at any time of the day, since none of the species showed any clear diel rhythm in attendance. As a reference for future surveys, the weekly statistics on plot counts of both species are given in Table 3.

The colour phases of the birds could appear very different in changing light and at different angles. Hence, the figures for proportions of colour phases in the population may only be considered an approximate figure. This will always be the case when assigning categories to the non-discrete polymorphism in the Atlantic populations of the northern fulmar. The colour phase distribution in the Northeast Greenland population is very similar to that reported from west

TABLE 3. Weekly statistics on total numbers of northern fulmars and black-legged kittiwakes present in designated study plots¹ at Mallekufjeld in 1993.

Period (week)	Northern Fulmar				Black-legged Kittiwake					
	Mean	(±95% C.L.)	Min	Max	N ²	Mean	(±95% C.L.)	Min	Max	N
May 25 – 31	141.4	(±35.1)	101	201	7	109.7	(±58.2)	83	127	3
Jun 01 – 07	220.6	(± 8.9)	207	235	7	84.3	(±19.3)	53	108	7
Jun 08 – 14	207.7	(± 7.1)	199	221	7	102.1	(±13.7)	82	117	7
Jun 15 – 21	215.6	(±16.0)	189	233	7	103.6	(±10.8)	91	125	7
Jun 22 – 28	192.4	(±14.0)	179	225	7	109.4	(±10.1)	97	130	7
Jun 29 – 05 Jul	201.1	(±16.8)	164	215	7	99.1	(± 5.4)	91	106	7
Jul 06 – 12	189.3	(± 8.9)	173	200	7	102.1	(± 3.5)	97	107	7
Jul 13 – 19	178.3	(±13.6)	155	193	7	103.9	(± 5.1)	94	112	7
Jul 20 – 26	179.1	(±20.6)	153	204	7	106.4	(± 4.3)	100	111	7
Jul 27 – 02 Aug	133.9	(± 9.3)	122	152	7	100.8	(± 7.0)	94	109	6
Aug 03 – 08	83.5	(±14.1)	57	95	6	97.5	(± 5.0)	93	105	6

¹ Data on northern fulmar combined from the 8 plots defined in Fig. 2.

² Number of days counted

Spitsbergen—as correctly surmised by van Franeker and Wattel (1982)—where the proportion of LL:L:D:DD phases in a sample of 5352 birds was 0.2:5.0:85.1:9.7 (Pennycuik and Webbe, 1959). The main difference between the two populations seems to be an even smaller share of LL birds (0.2% versus 2.2%) in the Spitsbergen population than in Northeast Greenland.

In summary, the Northeast Water holds a considerably larger population of northern fulmars and black-legged kittiwakes than previously known or suspected, and there is now established a basis for assessing future changes in the high-arctic seabird populations associated with the polynya.

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