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Spring Migration and Habitat Use by Seabirds in Eastern Lancaster Sound and Western Baffin Bay

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ABSTRACT. The status and distribution, during spring and early summer, of northern fulmars (*Fulmarus glacialis*), black-legged kittiwakes (*Rissa tridactyla*), thick-billed murres (*Uria lomvia*) and black guillemots (*Cepphus grylle*) were studied during aerial surveys in eastern Lancaster Sound (1976, 1978, 1979) and western Baffin Bay (1978, 1979). Fulmars were present in the study area by early May but most undertook a pre-laying exodus in late May before returning in early June to nest. During June and the first half of July, they were common along coasts and in offshore areas throughout the region. Kittiwakes returned in late May and numbers increased through June, both along coasts and offshore. Numbers offshore decreased after nesting, which begins in mid- to late June. Murres returned to the study area around mid-May and were abundant during June, especially near their colonies. Densities were generally highest along fast ice edges. Guillemots returned to the study area in the last half of May and were widespread along coasts, ice edges and in offshore areas during June. Densities were much lower after nesting, which commences in late June.

Densities of fulmars, murres and guillemots were much higher along fast ice edges than along ice-free coasts; the opposite was true of kittiwakes. Offshore, fulmars and kittiwakes preferred waters with little or no pack ice, whereas murres and guillemots preferred moderate to heavy pack ice. These habitat preferences affected the distributions of the species within the region.

Ice conditions in eastern Lancaster Sound were markedly different during each of the three years of study. Effects of different ice conditions on the species' distributions are assessed. Seabird distributions in six parts of the region are summarized.

Key words: fulmar, kittiwake, murre, guillemot, distribution, habitat use, Lancaster Sound, Baffin Bay

RÉSUMÉ. La position et la distribution, durant le printemps et le début de l'été, des fulmars boréaux (*Fulmarus glacialis*), des mouettes tridactyles (*Rissa tridactyla*), des marmettes de brunnich (*Uria lomvia*) et des guillemots noirs (*Cepphus grylle*) furent étudiées lors de relevés aériens dans la partie est du détroit de Lancaster (1976, 1978, 1979) et la partie ouest de la baie de Baffin (1978, 1979). Les fulmars étaient présents dans le territoire à l'étude au debut de mai. La majorité entreprit une excursion au large des côtes avant la periode de la ponte pour retourner à leur nid vers le début de juin. Durant les mois de juin et la première moitie de juillet, ils étaient groupés le long de la côte et au large dispersés au travers la région. Les mouettes retournèrent à la fin de mai et leur nombre augmenta en juin, tant le long de la côte qu'au large. Leur nombre au large diminua après la nidification, laquelle commença pendant la deuxième moitié de juin. Les marmettes sont retournées à la zone à l'étude vers la mi-mai et elles y étaient nombreuses durant le mois de juin, particulièrement près de leurs colonies. Leur densité était généralement élevée le long des banquises de glace fixe. Les guillemots sont retournés a la zone à l'étude lors la seconde moitié du moi de mai et se sont répartis le long des côtes, sur les banquises de glace fixe et au large des côtes durant le mois de juin. La densité était plus faible après la nidification, laquelle commença à le fin de juin.

La densité des fulmars, des marmettes et des guillemots était plus importante le long des bordures de glace fixe que le long de la côte sans glace: le contraire était vrai pour les mouettes. Au large, les fulmars et les mouettes ont préferé les eaux contenant peu ou pas de glace en dérive tandis que les marmettes et les guillemots ont préferé les eaux à concentration moyenne ou forte de glaces en dérives. Ces préférences d'habitat affectent la distribution des espèces dans la région.

Les conditions de glace dans la partie est du détroit de Lancaster étaient définitivement différentes durant chacune des trois années de l'étude. Les effets de différentes conditions de glace sur la distribution des espèces furent évalués. La distribution des oiseaux de mer dans six secteurs de la region est résumée.

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INTRODUCTION

Upwards of 1 000 000 seabirds nest along the coasts of eastern Lancaster Sound and western Baffin Bay (Brown *et al.*, 1975; Gaston, 1980). Several million non-breeding birds may spend all or part of the summer there and vast numbers migrate through to nesting and summering areas in the central Canadian High Arctic and northwest Greenland (Salomonsen, 1950; Nettleship, 1974; Brown *et al.*, 1975; Nettleship and Gaston, 1978). The principal species involved are the northern fulmar (*Fulmarus glacialis*), black-legged kittiwake (*Rissa tridactyla*), thick-billed murre (*Uria lomvia*), dovekie (*Alle alle*) and black guillemot (*Cepphus grylle*). Most nesting in the area is at several colonies bordering Lancaster Sound and Baffin Bay (Fig. 1).

Lancaster Sound and adjacent waters are considered to be one of the most productive marine areas in the Canadian Arctic (Nettleship and Smith, 1975; Milne and Smiley, 1978; Thomson, 1982). However, distributions and movements of seabirds in this area are, in general, poorly known. Ship-based sea watches (Brown *et al.*, 1975) have been restricted to the late summer-autumn period. Previous information about seabirds in spring and early summer is largely anecdotal and restricted to coastal observations (Hørring, 1937; Shortt and Peters, 1942; Duvall and Handley, 1946, 1948; Gunn, 1949; Ellis, 1956; Pattie, 1977).

This paper, based on aerial surveys, documents the status, distribution and habitat use of four of the major seabird species during spring and early summer (early May to mid-July). The fifth major species, the dovekie, is discussed in a separate paper (Renaud *et al.*, 1982).

METHODS

Aerial surveys of birds were conducted in all or part of the eastern Lancaster Sound-western Baffin Bay area in

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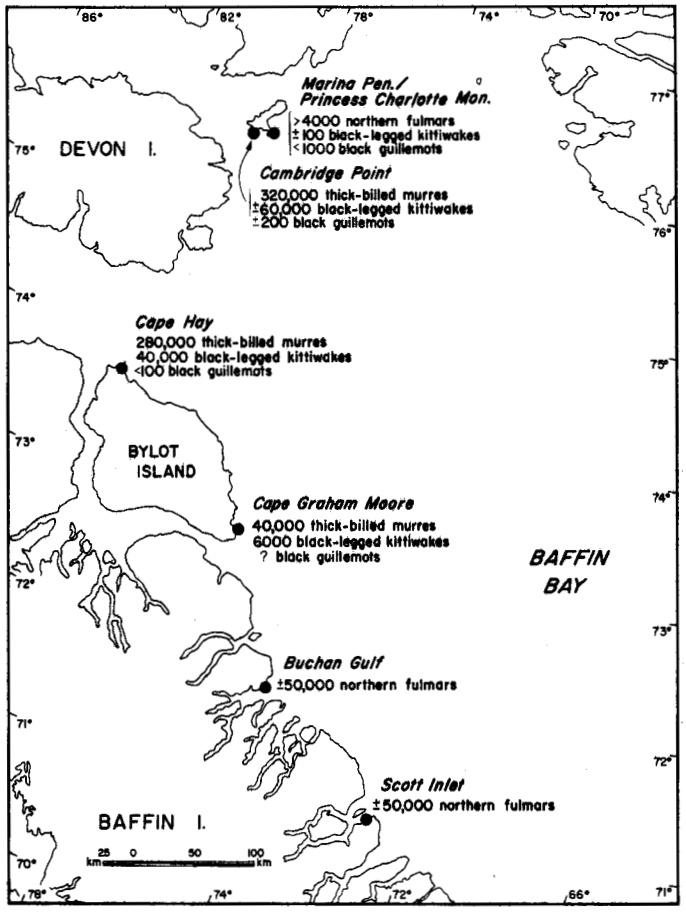

FIG. 1. Nesting colonies of seabirds in eastern Lancaster Sound and western Baffin Bay area. Data from Brown *et al.* (1975), and S.R. Johnson, D.N. Nettleship, W.E. Renaud (pers. comm.).

1976, 1978, and 1979. The degree and areas of coverage differed among years. Two main types of transects were flown: (1) 'coastal' transects, which were parallel to and centered 200 m from coasts and ice edges; and (2) 'offshore' transects, which were >7 km from any coast or ice edge.

Survey Coverage

1976. From 2 May-28 September, weekly surveys were conducted in eastern Lancaster Sound. The survey route consisted of eight north-south cross-sound transects spaced 14.8 km apart and of 'coastal' transects along south Devon Island and northwest Bylot and north Baffin islands, between 80°00'W and 83°30'W (Fig. 2).

1978. Surveys were conducted at weekly intervals from 4 May-10 October, except in late July and early August when the interval was about 10 days. 'Coastal' transects were flown along coasts and ice edges bordering northwest Baffin Bay and eastern Lancaster Sound. The area of coverage extended from southeast Ellesmere Island (76°30'N) south to Baffin Island at 70°30'N. Offshore waters (>7 km from any coast or ice edge) in parts of Jones Sound, eastern Lancaster Sound, northwest Baffin Bay, Pond Inlet and Navy Board Inlet were also sampled (Fig. 2).

1979. From 9 May-15 July, 'coastal' transects were flown from Cape Norton Shaw, Ellesmere Island (76°30'N), south to the Henry Kater Peninsula on Baffin Island (69°30'N). In addition, offshore areas of eastern Lancaster Sound and western Baffin Bay were sampled (Fig. 2). Coasts, ice edges and offshore eastern Lancaster Sound were surveyed at about 10-day intervals. Offshore Baffin Bay was surveyed three times in the 12-26 May period and twice in the 19-28 June period.

Because of local weather and ice conditions, not all areas were surveyed regularly, and total lengths of the transects differed among surveys. The transect width was always 400 m — 200 on either side of the aircraft. Table 1 summarizes the survey effort during each of the three years. In this paper only the spring and early summer (May to mid-July) distributions of the four seabird species are considered. Information about the later summer and fall distribution of seabirds is presented in McLaren and Renaud (1982).

Survey Procedures

All surveys were conducted from a twin-engine de Havilland Twin Otter equipped with a radar altimeter and a Global Navigation System. Survey altitude was 45 m ASL and ground speed was 160 km/h in 1976 and 185 km/h in 1978 and 1979.

Aerial surveys were flown with observers on both sides of the aircraft: one in the co-pilot's seat and one in the left rear seat, two seats behind the pilot. In 1976 and occasionally in 1978, a third observer was present behind the right front observer. Observers dictated into portable tape recorders all birds counted both on-transect (<200 m from the aircraft) and off-transect (>200 m from the aircraft). Information recorded included systematic information about the transect, each bird sighting, and the habitat below the aircraft at 2-min intervals.

A timing device was used to divide all transects into 2-min intervals (transect segments). For each transect segment the general habitat type and the type and degree of ice cover were recorded by each observer. The last segment of a transect was often less than 2 min in duration; its duration was recorded in seconds from a digital watch. This procedure permitted determination of the position of each sighting within about 5.3 km in 1976 and 6.2 km in 1978 and 1979, and also permitted calculation of densities on a 'per 2 min of survey' basis as well as a 'per transect' basis. On-transect counts were used to calculate apparent densities — the number of birds km^{-2}. Usually the counts of the right front and left rear observers were used. When (rarely) the front observer could not observe full-time because of navigational duties, the counts of the right rear observer were used.

Limitations and Biases of Aerial Surveys

Systematic aerial surveys have been used widely in the High Arctic to assess the status and distribution of birds

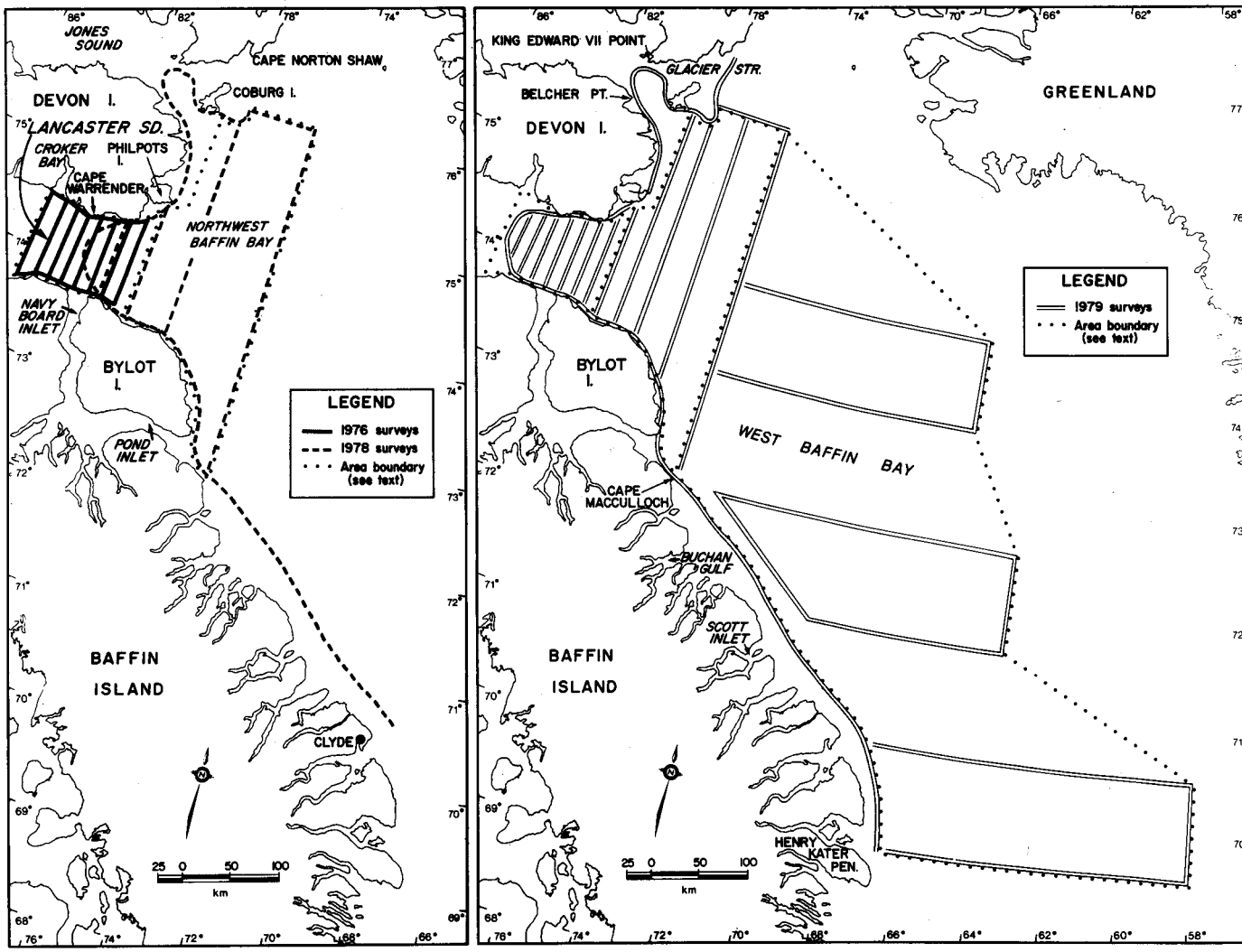

FIG. 2. Map of the study area, showing places mentioned in the text and routes surveyed repeatedly in 1976 and 1978 (left), and 1979 (right).

(e.g., Bradstreet, 1979; McLaren and McLaren, 1982; Renaud *et al.*, 1982). However, limitations and biases are inherent in aerial survey techniques (see Diem and Lu, 1960; Caughley and Goddard, 1972; Caughley, 1974; Caughley *et al.*, 1976).

There are two primary limitations to aerial surveys: (1) not all birds present are detected, and (2) recorded numbers of those that are detected are often estimates. Large and conspicuous species are more readily observed than are smaller, inconspicuous species. Also, large flocks are observed more readily than small flocks or individuals. No studies have been done to determine the proportion of birds that are actually observed during fixed-wing aerial surveys of high arctic coastal waters or open ocean. Stott and Olson (1972) compared simultaneous ground and aerial counts of sea ducks along the New England coast and found that aerial observers saw 20-81% of the ducks present. They suggested that detectability is poorer in coastal waters than in inland areas.

Detectability of birds at sea is affected by several factors, perhaps the most important of which are weather-related variables such as sun-glare, fog and precipitation. Birds are readily detectable even when quite distant from an aircraft, when the sea is flat and calm; in contrast, it is difficult to detect birds, particularly swimming birds, anywhere within the 200-m transect strip when there are waves 4 m in height, a condition encountered frequently in Baffin Bay. Moreover, there may be tremendous variability in sea state from coasts and ice edges to offshore areas, or even regionally within such habitats. Hence detectability may vary during an individual survey. Observer ability, fatigue, and mental attitude also influence the number of birds seen.

In addition, bird species are differentially detectable. Male eiders in highly contrasting breeding plumage, for example, are more easily identified than male oldsquaws. Patterns of behaviour also influence detectability. Molting eiders attempt to fly or swim away from an approaching aircraft, whereas molting oldsquaws often dive. Fulmars feed on the surface of the water but murres may spend 2-3 min below the surface while diving for food. Thus, for

TABLE 1. Number of square kilometres of aerial surveys flown in eastern Lancaster Sound and western Baffin Bay, May-October 1976, 1978 and 1979

		Survey Dates							
		2 - 22 May	23 May - 11 Jun	12 Jun - 2 Jul	3 - 15 Jul	18 Jul - 15 Aug	16 Aug - 9 Sep	10 - 28 Sep	30 Sep- 10 Oct
	Number of surveys								
	1976:	3	3	3	2	4	3	3	0
	1978:	3	3	3	2	3	3	3	2
	1979:	3	3	2	1	0	0	0	0
Area[a]	Year								
COASTS/FAST ICE EDGES									
Coburg Island area[b]	1978	185.8	180.1	198.8	125.2	249.8	157.1	146.6	46.4
	1979	187.1	185.3	184.4	95.3	—	—	—	—
N and E Devon Island	1978	186.3	163.3	179.2	128.7	176.5	222.2	201.9	172.1
	1979	114.3	116.0	123.0	36.7	—	—	—	—
SE Devon Island	1976	144.0	147.2	156.8	109.4	278.7	258.7	252.9	—
	1978	91.2	96.0	86.6	52.1	118.0	111.0	113.8	77.8
	1979	88.9	66.6	72.9	64.2	—	—	—	—
Lancaster Sound ice edge[c]	1978	106.4	90.8	103.0	63.6	—	—	—	—
	1979	63.4	57.0	108.8	—	—	—	—	—
N Baffin — NW Bylot islands	1976	142.3	136.7	124.9	100.8	243.3	191.2	154.2	—
	1978	12.7	21.8	22.4	12.9	24.2	21.6	20.6	13.5
	1979	52.6	23.2	40.3	36.6	—	—	—	—
N & E Bylot Island	1978	216.8	223.4	223.5	146.0	185.7	177.4	221.3	140.2
	1979	192.6	156.7	166.6	88.1	—	—	—	—
Pond Inlet ice edge	1978	80.0	80.2	94.4	57.1	46.0	—	—	—
	1979	78.4	23.2	35.1	9.6	—	—	—	—
E Baffin Island	1978	295.9	282.2	406.8	245.6	321.3	496.2	460.0	232.6
	1979	365.8	206.0	430.8	224.3	—	—	—	—
OFFSHORE AREAS									
Lancaster Sound	1976	670.3	672.9	701.4	520.1	1073.9	872.3	790.2	—
	1978	275.1	337.3	264.3	143.8	293.4	338.3	327.9	255.5
	1979	279.5	357.8	404.1	286.7	—	—	—	—
Baffin Bay	1978	877.2	877.2	872.3	387.3	168.7	1133.3	103.7	818.3
	1979	2411.0	1196.7	1400.2	—	—	—	1037.0	—

[a] Not all areas were necessarily surveyed during each survey.
[b] Includes coast of Coburg Island and fast ice edges across Jones Sound and east of Coburg Island from 4 May - 28 July; also southeast coast of Ellesmere Island from 21 July - 10 October.
[c] There was no ice edge across Lancaster Sound in 1976.

such diving species only some of the birds actually present on a transect strip are potentially visible at any given time.

Estimates of numbers generally become less accurate as flock size increases. Accuracy is further reduced when several hundreds (or thousands) of individuals of several species of birds and mammals are in sight continuously (often simultaneously diving, swimming and taking flight). Such situations are especially frequent along ice edges during late spring and early summer.

Densities presented must thus be considered as indices of population sizes rather than as unbiased estimates of actual numbers of individuals present. Such indices are useful in identifying the temporal and spatial distribution of a species but must not be used for detailed quantitative comparisons of the numbers of different species, since no corrections for differential detectability of species have been made. Furthermore, it must be recognized that even for a single species, apparent differences in densities among areas or surveys may be a result of variation in detectability rather than real differences in numbers.

In some studies involving aerial surveys (e.g. Nettleship and Gaston, 1978) seat correction factors have been used on the data to adjust for presumed better visibility from the front *vs.* the rear seat. Although seat position *per se* may influence the ability of an observer to see birds, the effects of this variable are difficult to separate from effects of observer ability, the many weather-related variables, and the behaviours of the individual species of birds. Seat correction factors are not used here.

Estimates of Numbers

The offshore portion of the study area was much larger than the coastal portion but the percent coverage offshore was much lower (averages of 3.1% coverage of the offshore area per survey in 1976; 1.0% in 1978 and 0.7% in 1979, *vs.* almost 100% coverage along coasts). Thus relative densities may not accurately reflect the actual distribution of a species, because even low densities offshore may represent very large numbers of birds. The relative importance of offshore and coastal areas can best be assessed on the basis of numbers present, rather than densities. Although it is not possible to calculate the actual numbers of birds present (see above), rough estimates nevertheless can be made, based on calculated densities and knowledge of the size of the area being sampled. These estimates can then be used to evaluate the distribution of a species in the area.

I have estimated the numbers of birds present in eastern Lancaster Sound and western Baffin Bay during each survey. The density in each area was calculated as follows:

$$\frac{\text{Sum of (length x density) for each transect in the area}}{\text{total length of all transects in the area}}$$

This value was then multiplied by the number of km^2 in the pertinent area to produce the estimated number of birds in the area.

Because of different ice conditions and survey patterns, the surveyed offshore area of eastern Lancaster Sound and northwest Baffin Bay was not constant for all three years. The offshore areas (km^2) within which surveys were conducted were as follows:

		2 May-11 Jun	12 Jun-2 Jul	3-15 Jul
Eastern Lancaster Sound	1976	7074	7800	8289
	1978	3689	3689	3689
	1979	7489	7489	9616
Northwest Baffin Bay	1978	33 094	33 094	33 094
	1979	33 663	33 663	—
West Baffin Bay	1979	185 948	185 948	—

Habitat Use

Information about habitat use was obtained from records of the habitat encountered during each 2-min transect segment in 1978 and 1979. For each transect segment, a broad habitat category was identified (coast, fast ice edge, offshore) and the average amount of pan ice covering the water on the transect was noted. No significant differences were found in a species' habitat preferences between 1978 and 1979 and the data for both years have been pooled. Differences in habitat preference were assessed by chi-square contingency tests and were regarded as statistically significant if $P<0.01$.

ICE CONDITIONS

Sea ice is a major factor influencing the numbers and distributions of seabirds in arctic waters (e.g., Brown, 1980). Changes in distribution of a species from one year to the next may in large part be a reflection of differing ice conditions. This section summarizes the ice conditions that prevailed in eastern Lancaster Sound and western Baffin Bay during the survey periods in 1976, 1978 and 1979. Figure 2 in Renaud *et al.* (1982) shows the ice conditions in the region in late May, 1978 and 1979.

Glacier Strait-Coburg Island-Jones Sound (Coburg Island Area)

There are two major recurrent fast ice edges in this region: the 'Glacier Strait ice edge' extends from the Marina Peninsula, Coburg Island, north to near Cape Norton Shaw, Ellesmere Island; the 'Jones Sound ice edge' extends north from Belcher Point, northeast Devon Island, toward King Edward VII Point, Ellesmere Island, and then southeast to Cape Spencer, Coburg Island. The positions of these edges were similar in 1978 and 1979 (no surveys were conducted here in 1976). In 1979, the Jones Sound ice edge broke back to the coast of Ellesmere Island in the first week of July, about 2-3 wk later than in 1978. Both edges, however, remained essentially intact until at least mid-July.

Northeast and East Devon Island

The positions of the landfast ice edge along these coasts of Devon Island were similar in 1978 and 1979. Except for

Belcher Point in 1979, headlands and seacliffs were virtually ice-free at their bases, whereas bays and inlets were covered with fast ice throughout the survey period.

Lancaster Sound

Ice conditions in Lancaster Sound in the spring and early summer were markedly different during 1976, 1978 and 1979. In 1976, packed drift ice characterized offshore areas in May; by the end of June, Lancaster Sound was essentially ice-free. A narrow band of landfast ice bordered both coastlines until mid-June, after which most coasts were ice-free. In 1978, fast ice covered all of Lancaster Sound west of a line between Cape Warrender (Devon Island) and Cape Hay (Bylot Island) until late July. East of the fast ice edge, extensive pack ice was generally present until mid-July. Moreover, shelves of landfast ice extended several km seaward from the coasts of Bylot Island and Devon Island until late June, effectively eliminating all coastlines in Lancaster Sound as useful marine habitat. In 1979, a fast ice edge again extended across Lancaster Sound, about 30 km west of its 1978 position. However, unlike 1978, Lancaster sound east of the ice edge was, for the most part, free of pack ice after mid-May, and the coastlines of Bylot and Devon islands were essentially ice-free by mid-May.

Bylot Island

Ice conditions along Bylot Island differed markedly between 1978 and 1979. In 1978 the entire north and northeast coasts were bordered by an extensive shelf of landfast ice until mid-July; in 1979, the coast west of Cape Hay was free of ice by early May and the northeast coast was, in general, ice-free by the first week of July. In 1979, there was a 3-4 km-wide shelf of fast ice in front of the Cape Graham Moore colony until early July; in 1978 the base of the colony was free of ice by the third week of June.

Pond Inlet Ice Edge and East Baffin Island

In 1979, the fast ice edge across the mouth of Pond Inlet had broken back to Baffin Island by 28 June. By 12 July the southeast corner of Bylot Island and about 50 km of the Baffin Island coast west of Cape Macculloch were ice-free. No degradation of this ice edge was noted prior to late July in 1978.

An ice shelf up to 35 km wide bordered the northeast coast of Baffin Island (south from Cape Macculloch) from early May to mid-July in both 1978 and 1979. The amount of pan ice along the ice edge varied from extremely heavy in the Buchan Gulf area to very light south of the town of Clyde.

Offshore Baffin Bay

Northwest Baffin Bay. In 1978, heavy pack ice with numerous cracks and leads persisted through the entire survey period. Ice cover averaged 50% at the beginning of July.

In early May 1979, open water extended about 30 km east of Devon Island. The remainder of northwest Baffin Bay was ice-covered, but the ice north of 74°30'N was thin refrozen pancake ice; to the south, there was heavy pack ice with a few small and often refrozen cracks. Clearing proceeded rapidly from the north and west; by mid-June this entire area was virtually ice-free.

Ice cover was significantly greater in northwest Baffin Bay in May 1978 than in May 1979 (Mann-Whitney U test, $P<0.001$, $z = 7.97$, $n = 231$, 464 transect segments).

West Baffin Bay. This area was not surveyed in 1978. From early May until mid-June 1979, pack ice cover averaged 90%, and leads and cracks were frequently refrozen. The amount of pack ice decreased after mid-June but ice cover averaged 60-85% in early July.

NORTHERN FULMAR

Results

1976. Except for over 1000 fulmars seen east of Cape Warrender, Devon Island, on 11 May, few fulmars were present in coastal areas of eastern Lancaster Sound prior to the second week of June. They became increasingly common thereafter, especially along the south coast. Large flocks were present in July: ~8500 individuals along Devon Island on 12-13 July (primarily along the fast ice edge across Croker Bay), and almost 10 000 along the fast ice edge across Navy Board Inlet on 12 July. From 6 June-13 July, coastal densities averaged 45.8 birds km^{-2}.

Densities and estimated numbers offshore in eastern Lancaster Sound were generally low from early May to mid-June 1976 (Table 2), averaging 0.5 birds km^{-2} and 3400 fulmars, respectively, during each of six surveys in that period. Fulmars were common thereafter, averaging 3.9 birds km^{-2} (31 000 birds) during surveys from 13 June-13 July.

1978. Fulmars were present along the fast ice edge across eastern Lancaster Sound on 29 April (P. Latour, pers. comm.). Over 2500 were counted on 'coastal' transects on 4-7 May, and an estimated 10 000 were offshore in eastern Lancaster Sound and northwest Baffin Bay.

After 7 May, 'coastal' densities decreased (Fig. 3). This decrease continued through late May and early June. The only areas where fulmars were numerous during this period were in front of the Buchan Gulf and Scott Inlet colonies — more than 13 500 were seen there on 2 June. Offshore densities also declined after mid-May and were lowest on 23-24 May (Table 2).

Fulmars were again common in much of the area by 8 June (Fig. 4). Almost 8000 birds were counted along coasts and ice edges on 8-10 June, including 3300 along the fast ice edge across Lancaster Sound. An estimated 38 000 fulmars were offshore in Lancaster Sound and northwest Baffin Bay. From 8 June until mid-July densities averaged

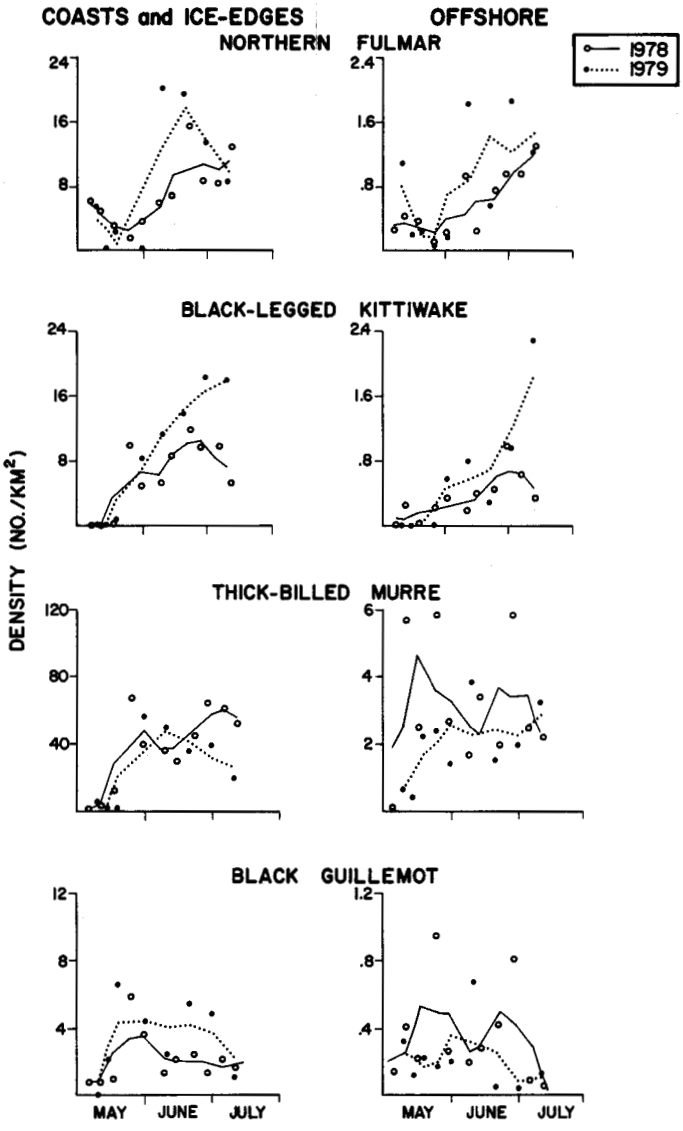

FIG. 3. Mean densities of seabirds recorded along coasts and fast ice edges and in offshore areas in eastern Lancaster Sound and western Baffin Bay, May-July 1978 and 1979. The curves are three-survey moving averages.

10.0 birds km^{-2} along coasts and ice edges (Fig. 3). Fulmars were common in virtually all of the survey area, and large concentrations were noted along northeast Bylot Island and the fast ice edge across Pond Inlet (Fig. 5). Large numbers were also present offshore in late June and early July (Table 2), and these high numbers persisted until mid-August when concentrations began to occur along the coast of Devon Island (McLaren and Renaud, 1982).

1979. An estimated 8000 fulmars were present in eastern Lancaster Sound on 9 May; 750 were counted along south Devon Island and north and east Bylot Island. After that date, however, numbers decreased sharply (Fig. 3). From 12 May-1 June, 'coastal' densities averaged 0.2 birds km^{-2} north of Clyde. On 17 May, over 1400 fulmars were seen along the ice edge south of Clyde, but on 24 May, only 100 were counted there. Numbers offshore also decreased during this period. On 12-15 May, the highest densities were recorded in Lancaster Sound (Table 2) but on 17-21 May densities were highest south of 70°30'N. On 24-26 May, densities and estimated numbers were low throughout western Baffin Bay.

Fulmars returned to the area in early June. On 10-11 June, and again on 19-23 June (Fig. 6), almost 12 000 were counted along coasts and ice edges — particularly along Bylot and Baffin islands — and a similar number was estimated to be present in offshore Lancaster Sound. Fulmars were common in Baffin Bay in the last half of June, especially in northwest Baffin Bay (Table 2).

Coast and ice edge densities decreased in late June and early July, particularly in Lancaster Sound and along Bylot Island. Much of this decrease was probably due to the disintegration of the fast ice edges across the sound and along northeast Bylot Island in early July.

Flock Size. Fulmars offshore in Baffin Bay in 1978 and 1979 were widely dispersed and generally observed as single birds (Table 3). They were seen on only 16% of the transect segments prior to the start of nesting in early June, but on 42% thereafter.

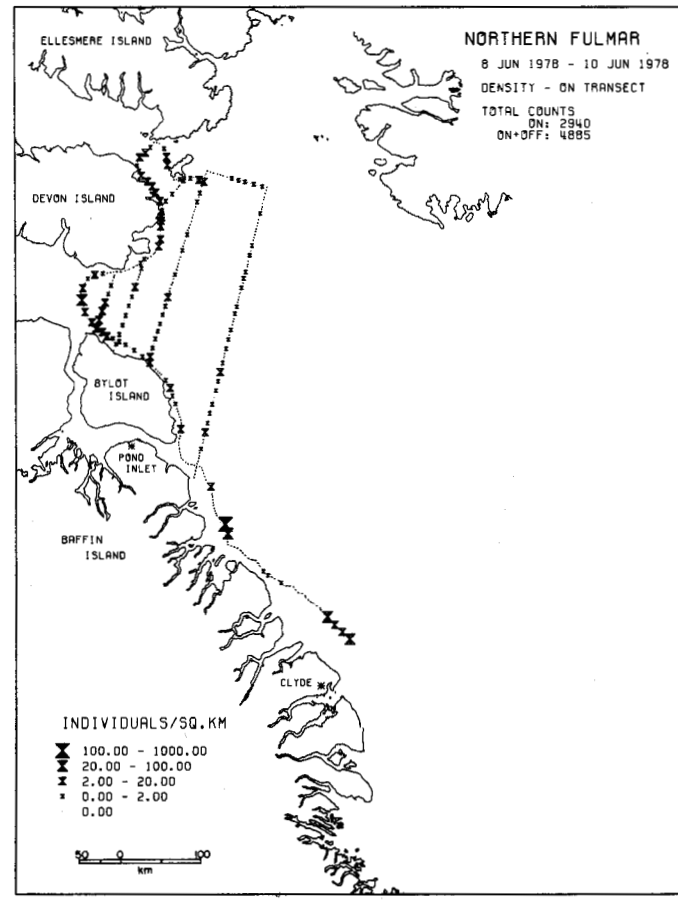

FIG. 4. Distribution of northern fulmars in eastern Lancaster Sound and western Baffin Bay, 8-10 June 1978. Dotted lines indicate path of survey. Symbols are densities (birds/km^2) in transect segments of length about 12 km (4 min of survey).

TABLE 2. Recorded densities (birds km^{-2}) and estimated numbers of northern fulmars in offshore areas of eastern Lancaster Sound and western Baffin Bay, early May to mid-July 1976, 1978 and 1979

	2-9[a] May	9-15[b] May	16-21 May	23-26 May	30 May-1 Jun	6-11 Jun	13-16 Jun	19-23 Jun	26 Jun-1 Jul	4-8 Jul	9-15 Jul
1976											
Lancaster Sound	(0.31)	(0.90)	(0.43)	(0.09)	(0.47)	(0.66)	(3.66)	(3.27)	(4.21)	(5.96)	(2.20)
	2193	6367	3042	637	3325	4669	28 548	25 506	32 838	49 402	18 236
1978											
Lancaster Sound	(1.54)	(0.65)	(2.03)	(0.30)	(0.39)	(2.46)	(0.71)	(1.25)	(0.39)	(2.23)	—[c]
	5681	2398	7489	1107	1439	9075	2619	4611	1439	8226	—
Northwest Baffin Bay	(0.13)	(0.50)	(0.08)	(0.10)	(0.18)	(0.84)	(0.25)	(0.82)	(1.17)	(0.90)	—
	4428	16 548	2544	3432	5976	29 337	8152	27 284	38 767	29 806	—
1979											
Lancaster Sound	(1.06)	(1.35)	(0.24)	(0.12)	(0.23)	(1.71)	—	(1.71)	(1.84)	—	(1.19)
	7935	10 108	1764	874	1754	12 810	—	12 793	13 788	—	11 452
Northwest Baffin Bay	—	(0.10)	(0.23)	(0.01)	—	—	—	(0.83)	(3.00)	—	—
	—	3433	7889	391	—	—	—	28 045	101 046	—	—
West Baffin Bay	—	(0.12)	(0.22)	(0.04)	—	—	—	(0.27)	—	—	—
	—	14 510	40 230	7233	—	—	—	51 080	—	—	—

[a] 9 May 1979.
[b] 9 May 1976, 1978.
[c] Indicates area not surveyed.

Habitat Use. In May and early June, prior to nest initiation, fulmars occurred in similar densities on coastal and ice edge transects. Densities were much lower offshore (Table 4). In each of these habitats, densities decreased with increasing ice cover, although in offshore areas fulmars were evenly distributed over waters with up to 90% ice cover, avoiding only the heaviest pack ice.

From early June until mid-July, which includes most of the incubation period (Nettleship, 1977), fulmar densities were significantly higher along fast ice edges than along ice-free coasts (Table 4, $X^2 = 126.7$, df = 3, $P<0.001$). However, this difference was wholly attributable to the presence of fulmars along the fast ice edge off east Baffin Island. Two fulmar colonies are situated on the east coast of Baffin Island and there was little or no ice-free coastline within 160 km of these colonies at this time. There were no significant differences between coastal and ice edge densities north of Bylot Island. Densities offshore were much lower than along interfaces. In all habitats fulmars avoided areas of heavy pack ice, preferring instead areas of moderate to no ice cover.

Discussion

Fulmars that summer in the Canadian Arctic winter offshore in open-water areas in south Baffin Bay, Davis Strait, Labrador Sea and the north Atlantic Ocean (Fisher, 1952; Palmer, 1962). In this study, fulmars returned to the eastern Lancaster Sound-west Baffin Bay area in late April, and by mid-May were commonly distributed throughout much of this region. D.N. Nettleship (pers. comm.) reported fulmars at the Prince Leopold Island colony in

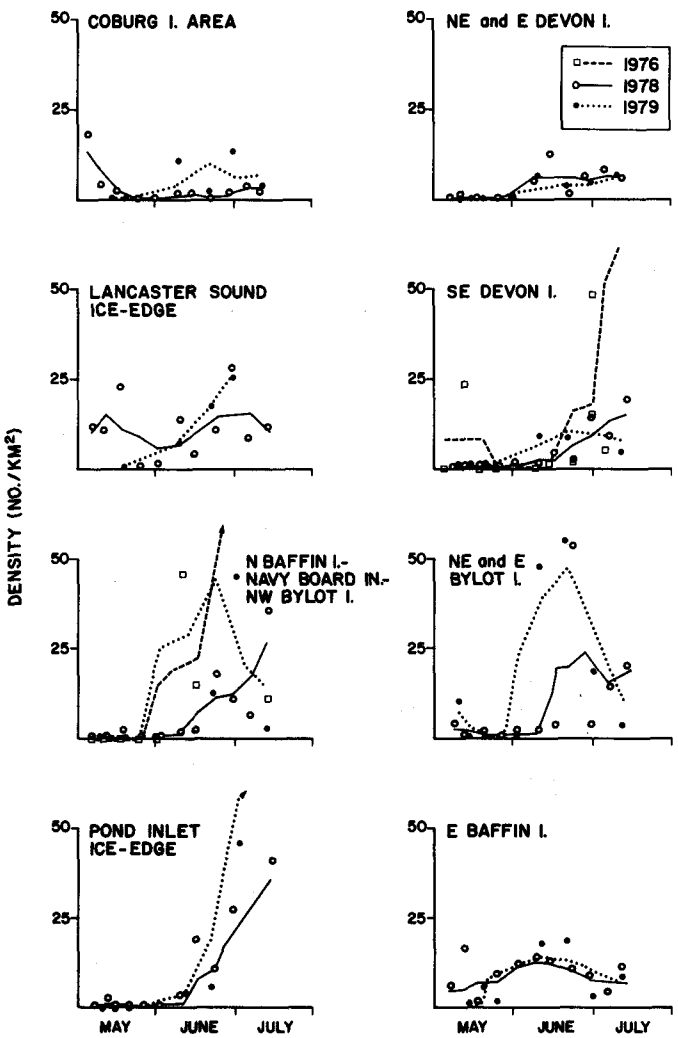

FIG. 5. Mean densities of northern fulmars recorded in various sections of the study area, May-July 1976, 1978 and 1979. Plotted as in Fig. 3.

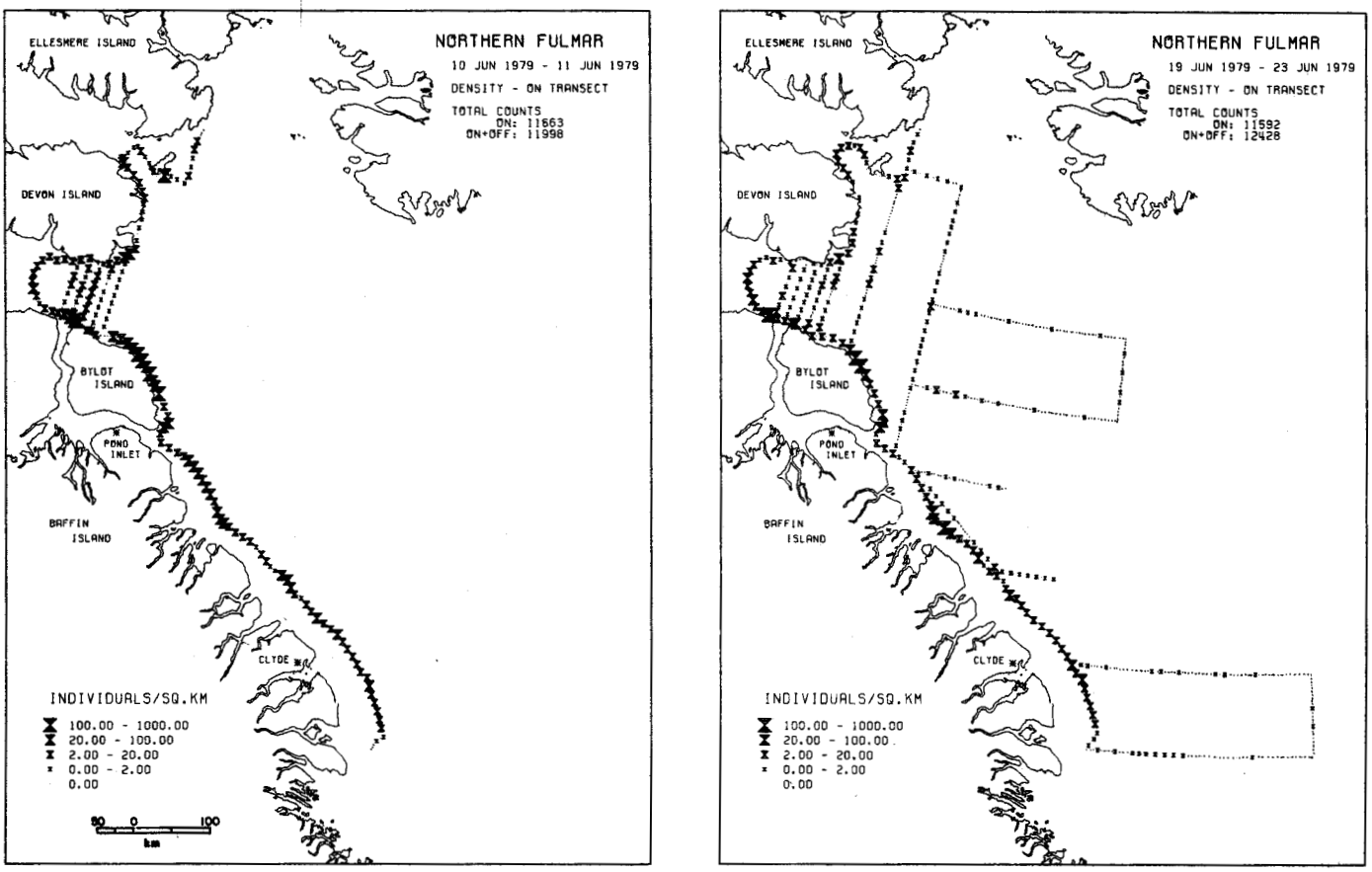

FIG. 6. Distribution of northern fulmars in eastern Lancaster Sound and western Baffin Bay, 10-11 June 1979 (left), and 19-23 June 1979 (right). Plotted as in Fig. 4.

eastern Barrow Strait, about 250 km west of the study area, by the first week of May in 1976. In the latter half of May most fulmars apparently move away from their colonies. Such a departure was noted at Prince Leopold Island in 1975 (D.N. Nettleship, pers. comm.), and during this study few fulmars were seen at the Princess Charlotte Monument and Buchan Gulf colonies in late May 1978. This departure from the colonies (and other parts of eastern Lancaster Sound and western Baffin Bay, Fig. 3) presumably represents the pre-laying exodus (Dunnet *et al.*, 1963; Macdonald, 1977), a period which has been associated with the need to feed intensively at sea in order to acquire energy reserves necessary for egg-laying and incubation. Where fulmars move to at this time is unknown. There is some indication that the move is not northward: only one fulmar was seen during high level (200 m ASL) reconnaissance surveys of (1) coasts of southeast Ellesmere Island and northwest Greenland and (2) offshore Baffin Bay north of 76°N on 31 May-1 June 1978 (W.E. Renaud, pers. comm.). The low densities and numbers recorded even in the southernmost parts of Baffin Bay during surveys in late May 1979 suggest that during the exodus most fulmars move completely out of the region, possibly to areas off south Baffin Island (Davis Strait) or, perhaps, west Greenland.

Fulmars returned to eastern Lancaster Sound and northern Baffin Bay in the first week of June. In 1978, almost 61 000 were estimated to be in this region on 8-10 June, compared to 6000 on 23-24 May and 13 000 on 29 May-2 June. Their return coincides with the commencement of egg-laying: the median dates of egg-laying at the Prince Leopold Island colony in 1976 and 1978 were 10 June and 11 June, respectively (D.N. Nettleship, pers. comm.).

From early June on, fulmars were common in most parts of the study area. The large flocks seen along the ice edges northeast of Coburg Island and along east Baffin Island were likely foraging birds from nearby colonies. However, the composition of the large offshore component is not known. In late June of both 1978 and 1979, an increase in fulmar numbers was noted in northwest Baffin Bay. In addition, in late June of all three years there was an influx of fulmars into Lancaster Sound (as well as to northeast Bylot Island in 1978 and 1979). Many of these birds, at least in 1978, may have been unsuccessful or non-nesters from the colonies in Barrow Strait and Lancaster Sound. D.N. Nettleship (pers. comm.) estimated that 80% of the breeding-age fulmars at Prince Leopold Island did not nest in 1978. These birds would have been forced to move into eastern Lancaster Sound and Baffin Bay to feed because of the presence of fast ice throughout

TABLE 3. Offshore distribution of seabirds in Baffin Bay, May-July 1978 and 1979

Species	Date	No. of transect segments[a]	% of segments[a] with sightings	Flock size information: no. single birds	Flock size information: no. flocks	Flock size information: average flock size[b]
Northern fulmar	1-11 May	123	9	9	5	2.0
	12-21 May	1220	22	346	91	3.7
	22-31 May	621	5	37	14	6.2
	1- 9 June	123	13	26	1	3.0
	10-19 June	241	33	194	21	2.9
	20-30 June	800	44	896	230	3.8
	1-10 July	109	49	177	30	3.4
Black-legged kittiwake	12-21 May	1220	3	18	17	11.6
	22-31 May	621	4	28	7	11.6
	1- 9 June	123	17	34	12	3.4
	10-19 June	241	24	68	11	9.3
	20-30 June	800	30	298	113	5.9
	1-10 July	109	53	83	32	5.1
Thick-billed murre	12-21 May	1220	29	145	529	11.4
	22-31 May	621	45	243	562	10.9
	1- 9 June	123	63	92	131	6.6
	10-19 June	241	67	208	234	5.7
	20-30 June	800	60	1034	846	4.9
	1-10 July	109	86	168	120	3.6
Black guillemot	12-21 May	1220	20	209	113	4.4
	22-31 May	621	24	139	90	4.4
	1- 9 June	123	34	34	27	2.6
	10-19 June	241	26	60	43	3.1
	20-30 June	800	18	137	86	2.8
	1-10 July	109	20	18	5	3.2

[a] A transect segment represents 2 min of survey and includes about 6 km of transect.
[b] Excluding single birds as flocks.

most of Lancaster Sound and all of Barrow Strait. Nesting success of fulmars in 1979 is not known; however, fast ice again covered Barrow Strait and much of Lancaster Sound until mid-July and it is likely that birds nesting west of the study area, whether or not successful, would have had to forage in easternmost Lancaster Sound and Baffin Bay that year. The increase may also have consisted of, at least in part, an incursion of non-breeders into the area. Subadult fulmars were present along the Pond Inlet ice edge in late June of 1978 (Bradstreet, 1982).

The very different ice conditions in Lancaster Sound in 1976, 1978 and 1979 affected fulmar distribution in those years. Fulmar densities in the open part of Lancaster Sound during the first half of May were similar in 1978 and 1979 and about twice as high as in 1976. As well, hundreds were present along the fast ice edge across the sound in 1978 and 1979. The much higher densities in 1978 and 1979 were probably caused by the complete absence of open water west of the fast ice edge in those years. Similarly, from early June to mid-July in 1978 and 1979, fulmars were commonly seen offshore in Lancaster Sound and along the fast ice edge across the sound. The somewhat higher densities in 1979 than in 1978 may have been due to the reduced amount of pack ice offshore in 1979 (fulmars tend to avoid offshore areas with extensive pack ice). However, densities offshore were much higher in 1976 than in 1978 or 1979; this may have been because birds concentrated in large numbers along the fast ice edge across the sound when it was present in 1978 and 1979, or because birds had moved into adjacent areas of Baffin Bay in those years.

BLACK-LEGGED KITTIWAKE

Results

1976. Kittiwakes were first seen on 20 May, and were present in low densities along south Devon Island until 21 June (Fig. 7). Densities were substantially higher thereafter. Large flocks of kittiwakes were first seen near the Cape Hay colony on 30 May. Many thousands (e.g. 11 000 on 6 June) were seen along northwest Bylot Island throughout June and July, but numbers were low west of Navy Board Inlet.

Large numbers of kittiwakes were first noted offshore in Lancaster Sound on 30 May-1 June (Table 5). Densities were higher west of 81°W; birds in that area may have been migrating through the sound to nesting colonies farther west. After that survey, estimated numbers offshore were much lower.

1978. A few hundred kittiwakes were seen on 15-18 May, primarily near Coburg Island. On 23 May over 3500 were recorded near the colony at Cambridge Point, Coburg Island, but few were seen elsewhere along coasts. However, kittiwakes began to appear offshore at this time: an estimated 7900 were present on 22-24 May, primarily in Baffin Bay (Table 5).

Kittiwakes were common and widespread on 29 May-2 June (Fig. 8); more than 7600 were recorded. Virtually all seen were north of Pond Inlet with flocks of 600, 300 and 3500 near the colonies at Cape Graham Moore, Cape Hay and Cambridge Point, respectively. After mid-June kittiwakes were common and widespread throughout the area and 'coastal' densities increased in late June (Figs. 3, 7). During this period, large concentrations briefly occurred in specific areas. For example, 1500 kittiwakes were along the fast ice edge east of Baffin Island on 15 June and 2200 were along northwest Bylot Island on 19 June, but few were seen in either area again.

Kittiwake numbers offshore increased in late May (Fig. 3). An estimated 13 000 were present on 30 May-1 June, primarily in northwest Baffin Bay. Throughout June, densities were generally similar in Lancaster Sound and northwest Baffin Bay (Table 5). Numbers peaked in late June when an estimated 44 000 kittiwakes were present, primarily in Baffin Bay.

Kittiwake densities decreased in all areas in July (Fig. 7). This drop may have been associated with a movement

TABLE 4. Habitat utilization by northern fulmars in eastern Lancaster Sound and western Baffin Bay, May and early June 1978, and 1979

Habitat & % pack ice cover	May to early June							early June to mid-July						
	No. of transect segments[a]	% of segments[a] with fulmars	# segments with density[b] 0	0.1-2.1	2.1-21.5	21.5+	Mean density[b]	No. of transect segments[a]	% of segments[a] with fulmars	# segments with density[b] 0	0.1-2.1	2.1-21.5	21.5+	Mean density[b]
COASTS	66	26	49	11	5	1	2.6	190	61	74	63	41	12	6.5
0 - 5%	17	47	9	3	5	0	1.8	127	69	39	45	31	12	9.2
6 - 25%	14	7	13	0	0	1	8.7	47	43	27	14	6	0	0.7
26 - 50%	9	11	8	1	0	0	0.1	10	60	4	4	2	0	0.8
51 - 75%	7	29	5	2	0	0	0.2	6	33	4	0	2	0	2.9
76 - 90%	12	17	10	2	0	0	0.1	0	—	0	0	0	0	—
91 - 99%	7	43	4	3	0	0	0.2	0	—	0	0	0	0	—
100%	0	—	0	0	0	0	—	0	—	0	0	0	0	—
FAST ICE														
EDGES	1313	34	866	242	160	45	3.4	1572	88	193	352	786	241	13.9
0 -5%	392	49	201	108	69	14	4.4	957	90	88	197	515	157	15.1
6 - 25%	102	38	63	19	14	6	5.2	215	88	25	43	116	31	12.8
25 - 50%	110	34	73	17	14	6	3.4	118	86	17	32	48	21	14.1
51 - 75%	114	32	78	16	15	5	2.8	92	76	22	26	33	11	14.3
76 - 90%	164	27	119	25	13	7	2.0	83	82	15	24	34	10	8.7
90 - 99%	392	24	298	53	34	7	1.6	105	75	26	29	39	11	7.8
100%	39	13	34	4	1	0	0.6	2	0	0	1	1	0	3.4
OFFSHORE	2509	21	1980	456	71	2	0.3	1553	54	714	649	187	3	1.0
0 - 5%	229	36	146	63	19	1	0.6	645	76	158	386	128	3	1.7
6 - 25%	80	49	41	35	4	0	0.4	159	70	48	78	33	0	1.1
26 - 50%	94	37	59	29	5	1	0.9	119	55	53	52	14	0	0.8
51 - 75%	117	25	88	25	4	0	0.4	124	31	85	37	2	0	0.3
76 - 90%	393	30	274	102	17	0	0.4	265	29	188	69	8	0	0.4
91 - 99%	1370	15	1164	186	20	0	0.1	212	26	156	54	2	0	0.3
100%	226	8	208	16	2	0	0.1	29	10	26	3	0	0	<0.1

[a] A transect segment represents 2 min of survey and includes about 6 km of transect.
[b] Density expressed as number of birds km^{-2}.

to nesting colonies. In 1978, kittiwakes nested in late June and early July.

1979. Kittiwakes were first seen on 17-22 May, when an estimated 9500 were in offshore Baffin Bay, including almost 5000 south of 70°30'N. Over 400 were seen along the Baffin Island ice edge south of the town of Clyde at that time, but few were seen along coasts and ice edges north of Clyde. On 1 June kittiwakes were common north of Pond Inlet. Concentrations were noted near the Cape Graham Moore colony and along north Bylot Island and an estimated 4700 birds were offshore in Lancaster Sound.

After 10 June kittiwakes were common in most of the survey area (e.g. Fig. 9); they were recorded on 94% of all transects flown from 10 June-15 July. Densities along coasts and ice edges average >15 birds km^{-2} during this period; almost 15 000 were counted on 28 June-2 July. Concentrations included 1700 along the Lancaster Sound ice edge, 1500 near Cape Hay, Bylot Island, and 4700 along south

TABLE 5. Recorded densities (birds km^{-2}) and estimated numbers of black-legged kittiwakes in offshore areas of eastern Lancaster Sound and western Baffin Bay, early May to mid-July 1976, 1978 and 1979

	2-9[a] May	9-15[b] May	16-21 May	23-26 May	30 May-1 Jun	6-11 Jun	13-16 Jun	19-23 Jun	26 Jun-1 Jul	4-8 Jul	9-15 Jul
1976											
Lancaster Sound	(0)	(0)	(0)	(0.01)	(1.33)	(0.31)	(0.38)	(0.80)	(0.20)	(0.64)	(0.10)
	0	0	0	71	9408	2193	2964	6240	1560	5305	829
1978											
Lancaster Sound	(0)	(0)	(0)	(0.12)	(0.60)	(0.47)	(0.36)	(0.88)	(0.63)	(0.34)	—[c]
	0	0	0	443	2250	1734	1325	3246	2324	1254	—
Northwest Baffin Bay	(0)	(0.02)	(0.13)	(0.24)	(0.33)	(0.17)	(0.51)	(0.44)	(1.28)	(0.78)	—
	0	822	1097	7800	10 819	5542	17 031	14 469	42 196	25 774	—
1979											
Lancaster Sound	(0)	(0)	(0)	(0.02)	(0.63)	(0.92)	—	(0.90)	(1.42)	—	(2.43)
	0	0	0	117	4748	6858	—	6726	10 649	—	23 374
Northwest Baffin Bay	—	(0)	(0.07)	(0.03)	—	—	—	(0.52)	(1.09)	—	—
	—	0	185	854	—	—	—	17 376	36 669	—	—
West Baffin Bay	—	(0)	(0.05)	(0.02)	—	—	—	(0.09)	—	—	—
	—	0	9331	2914	—	—	—	17 061	—	—	—

[a] 9 May 1979.
[b] 9 May 1976, 1978.
[c] Indicates area not surveyed.

Devon Island, all on 30 June. An estimated 46 000 kittiwakes were offshore in northwest Baffin Bay and eastern Lancaster Sound on 28 June-2 July.

Kittiwake numbers remained high on 9-15 July. Virtually all of the 10 000 counted along coasts and ice edges were north of Pond Inlet. Flocks of >1000 birds were seen near colonies on Coburg and Bylot islands, and >3500 were counted along the south coast of Devon Island. An estimated 23 000 were offshore in Lancaster Sound.

Flock Size. During the initial stages of spring migration, kittiwakes offshore were seen infrequently and in flocks averaging 12 birds. By early July, however, they were seen on more than 50% of the transect segments, but most birds were singles or in small flocks (Table 3).

Habitat Use. During spring and early summer, kittiwake densities were significantly higher along coasts than along fast ice edges (X^2 = 38.0, df = 3, P<0.001); densities along both interfaces were much higher than in offshore areas (Table 6). In all habitats, densities were highest in areas where pack ice cover was ≤25%.

Discussion

Kittiwakes that summer in the eastern Canadian Arctic winter pelagically in open-water areas of Davis Strait, the Labrador Sea and the north Atlantic Ocean (Godfrey, 1966; Brown *et al.*, 1975). In this study they returned to Baffin Bay in mid-May. Spring migration was, at least initially, conducted on a broad front offshore; however, the presence of thousands of kittiwakes along the fast ice edge east of Baffin Island in mid-June of both 1978 and 1979 indicated that this ice edge was an important migra-

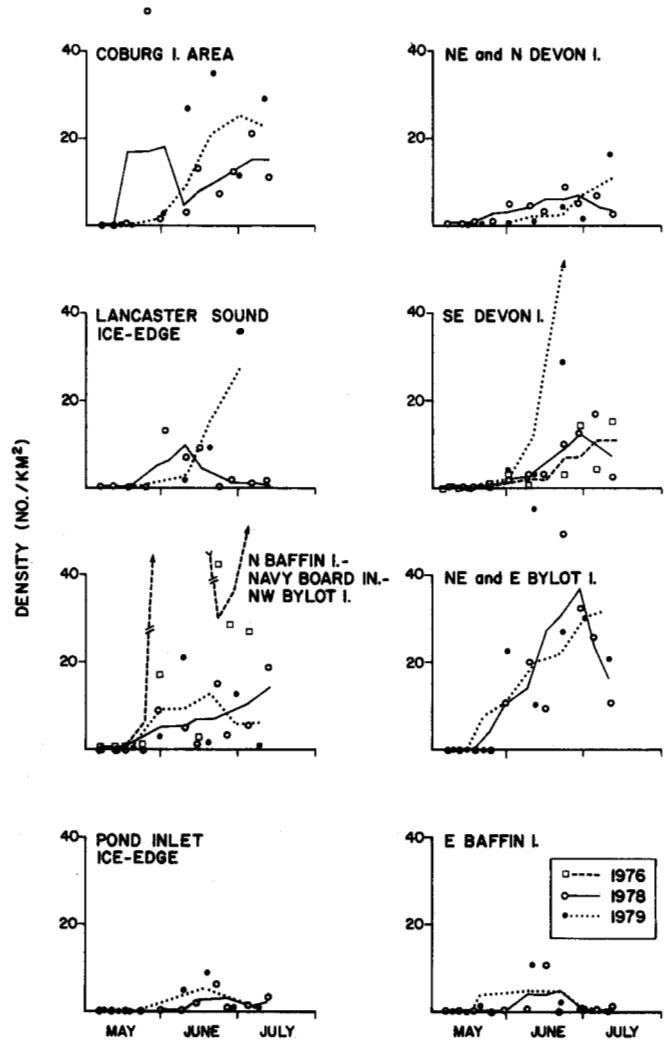

FIG. 7. Mean densities of black-legged kittiwakes recorded in various sections of the study area, May-July 1976, 1978 and 1979. Plotted as in Fig. 3.

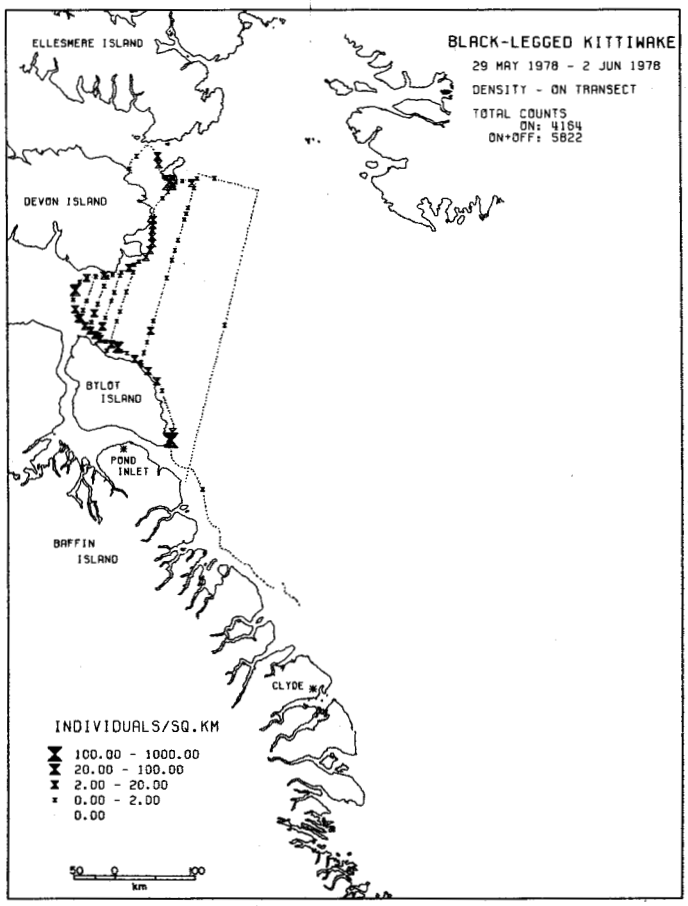

FIG. 8. Distribution of black-legged kittiwakes in eastern Lancaster Sound and western Baffin Bay, 29 May-2 June 1978. Plotted as in Fig. 4.

tion route. That kittiwakes did not use this edge as a migration route earlier may have been due to the presence of heavy pack ice along the edge in May and early June.

The first large flocks of kittiwakes generally arrive at eastern and central arctic colonies at the very end of May or early June. In both 1978 and 1979, large flocks were first seen near the Bylot Island colonies during surveys between 29 May and 2 June. In 1976, large flocks began arriving at their colony on Prince Leopold Island on 27 May (D.N. Nettleship, pers. comm.). However, this timing may be influenced substantially by ice conditions, at least in western Lancaster Sound and Barrow Strait. The time of arrival of kittiwakes at the Prince Leopold Island colony in 1978 is not known, but no birds were seen during flights around the island on 26 May and 13 June (pers. obs.). With the exception of a lead in Prince Regent Inlet east of southern Somerset Island, there was in 1978 no open water (and hence no foraging area) west of the fast ice edge across Lancaster Sound prior to mid-July. Very few kittiwakes were seen along the lead in Prince Regent Inlet during a survey there on 7 June 1978 (W.E. Renaud, pers. comm.). It appears that the kittiwakes that would normally be at colonies in Barrow Strait by early June were forced to remain in eastern Lancaster Sound or northwest Baffin Bay in 1978 because of extensive ice cover. Indeed, the return of such birds to northwest Baffin Bay in mid-June, after inspecting the colonies and finding them unsuitable for nesting, might explain the increased numbers in offshore Baffin Bay after mid-June in 1978 (Fig. 3).

From mid-June through mid-July, kittiwakes were common and widespread throughout much of the survey area. Concentrations were regularly present near the colonies on Bylot and Coburg islands. There were, however, other areas where large flocks regularly occurred. In both 1978 and 1979, several thousand kittiwakes were present along northeast Bylot Island in the latter half of June. These birds may have included feeding birds from colonies to the south and west as well as late migrants moving into the area.

Kittiwake concentrations were also noted along the southeast coast of Devon Island in late June and early July of 1976 and 1979. The absence of large numbers in this area in 1978 was probably due to the presence of a shelf of landfast ice off southeast Devon Island until early July. Kittiwakes

TABLE 6. Habitat utilization by black-legged kittiwakes in eastern Lancaster Sound and western Baffin Bay, mid-May to mid-July 1978 and 1979

Habitat & % pack ice cover	No. of transect segments[a]	% of segments[a] with kittiwakes	# segments with density[b] 0	0.1-2.1	2.1-21.5	21.5+	Mean density[b]
COASTS	205	65	71	41	52	41	36.7
0-5%	131	76	32	29	37	33	43.2
6-25%	50	54	23	8	12	7	32.9
26-50%	14	43	8	4	2	0	0.8
51-75%	6	33	4	0	1	1	20.8
76-90%	4	0	4	0	0	0	0.0
91-99%	0	—	0	0	0	0	—
100%	0	—	0	0	0	0	—
FAST ICE EDGES	2286	54	1059	457	593	177	7.0
0-5%	1161	65	408	275	373	105	8.9
6-25%	286	62	108	65	85	28	7.6
26-50%	179	56	79	30	55	15	6.1
51-75%	156	45	86	32	28	10	3.9
76-90%	176	37	111	31	24	10	3.5
90-99%	315	19	254	24	28	9	1.9
100%	13	0	13	1	1	0	0.0
OFFSHORE	3227	23	2499	606	117	5	0.4
0-5%	762	48	398	288	72	4	1.0
6-25%	228	39	139	78	11	0	0.7
26-50%	192	37	120	64	8	0	0.5
51-75%	220	26	162	52	6	0	0.3
76-90%	549	16	461	79	8	1	0.3
91-99%	1104	5	1052	44	8	0	0.1
100%	172	3	167	1	4	0	0.1

[a] A transect segment represents 2 min of survey and includes about 6 km of transect.
[b] Density expressed as number of birds km^{-2}.

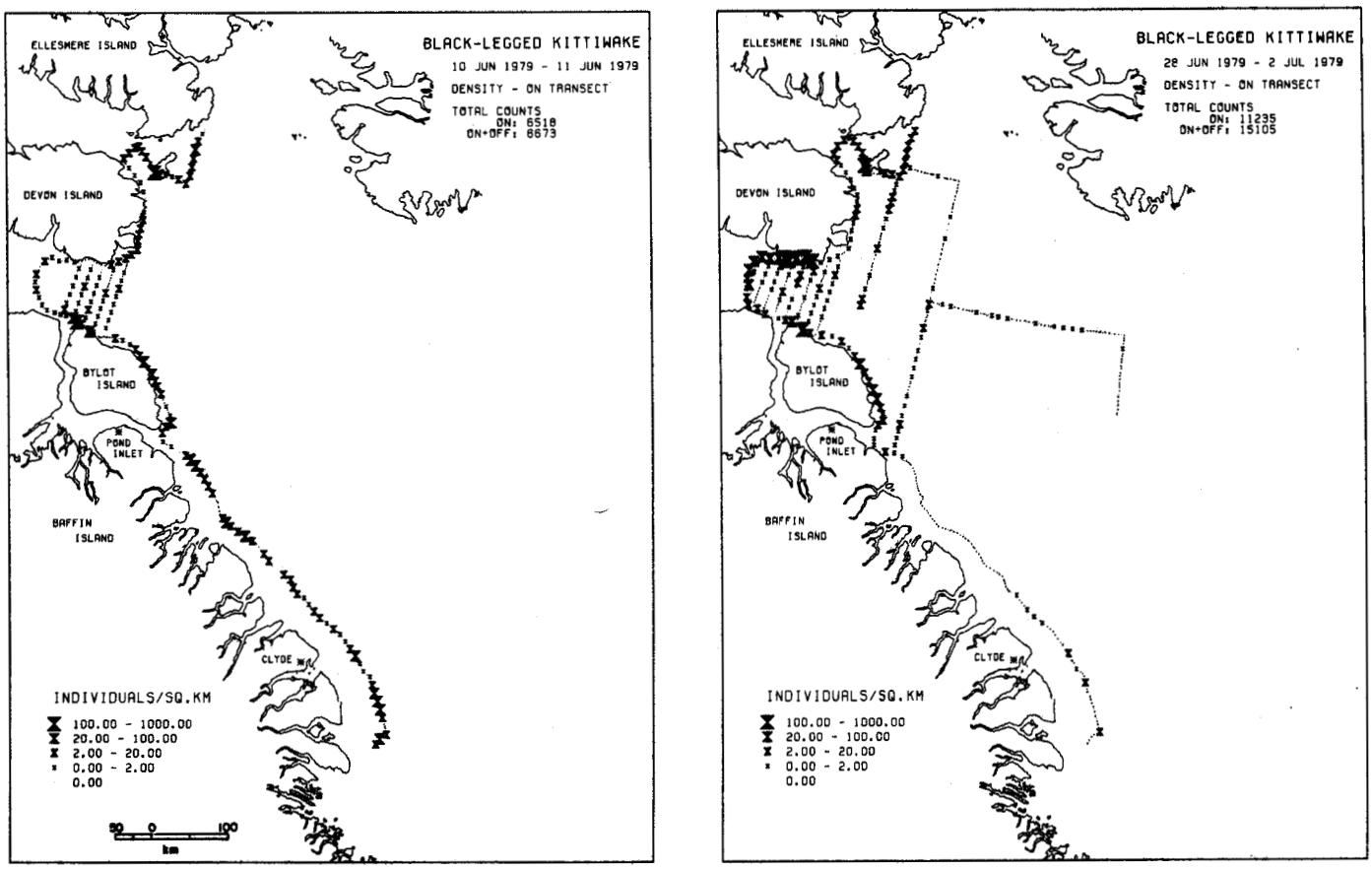

FIG. 9. Distribution of black-legged kittiwakes in eastern Lancaster Sound and western Baffin Bay, 10-11 June 1979 (left), and 28 June-2 July 1979 (right). Plotted as in Fig. 4.

prefer ice-free coasts to fast ice edges. The much higher densities in 1979 than in 1976 suggest that many birds in 1976 were feeding birds from colonies in Barrow Strait. In 1979 no open water was available for feeding by kittiwakes west of Cape Warrender.

In both 1978 and 1979 kittiwake numbers offshore in Baffin Bay were highest in late June. The cause of this buildup is not known. Possibly these birds were unsuccessful nesters from colonies at and west of Prince Leopold Island; only 20% of the usual number of kittiwakes nested at Prince Leopold Island in 1978 (D.N. Nettleship, pers. comm.). There is no information on kittiwake nesting success at colonies in and near Barrow Strait in 1979, but ice conditions at those sites were very similar in the two years. Thus these birds may also have been nesting adults forced to forage in Baffin Bay because of the extensive fast ice covering Lancaster Sound. A third possibility is that these birds were immature; Salomonsen (1967) noted that subadult kittiwakes from Greenland colonies wander north in the summer months, often moving close to their natal colonies.

THICK-BILLED MURRE

Results

1976. An estimated 66 000 thick-billed murres were offshore in Lancaster Sound on 10-11 May. Few were seen along the coast. Numbers offshore remained high through early June, averaging 70 000 murres during each of five surveys from 10 May-7 June. Thereafter, numbers offshore were much lower (Table 7). In May murres were widely and evenly distributed throughout Lancaster Sound. In June and July, however, average densities were much higher close to the Cape Hay colony in the southeast part of the Sound. Densities were higher east of 81°W (6.0 birds km^{-2}) than west of 81°W (1.6 birds km^{-2}). East of 81°W, densities were much higher in the south half of the sound (9.9 bird km^{-2}) than in the north half (2.2 birds km^{-2}).

Murre densities along south Devon Island averaged 7.3 birds km^{-2} from 16 May-5 July (Fig. 10). Densities were somewhat higher west of Cape Warrender (9.6 birds km^{-2}). Concentrations were frequently seen along the fast ice edge across Croker Bay.

Murres were first seen near the Cape Hay colony on 16 May and >15 000 were counted on 23 May. Thousands were seen regularly along Bylot Island west of Cape Hay during June and early July. Except for a few large flocks seen irregularly along north Baffin Island, murres were uncommon along and west of the Navy Board Inlet ice edge.

1978. An estimated 1800 murres were offshore in Lancaster Sound on 5 May. None was seen elsewhere. By 8 May, however, substantial numbers had moved into the survey

TABLE 7. Recorded densities (birds km^{-2}) and estimated numbers of thick-billed murres in offshore areas of eastern Lancaster Sound and western Baffin Bay, early May-mid-July 1976, 1978 and 1979

	2-9[a] May	9-15[b] May	16-21 May	23-26 May	30 May-1 Jun	6-11 Jun	13-16 Jun	19-23 Jun	26 Jun-1 Jul	4-8 Jul	9-15 Jul
1976											
Lancaster Sound	(0)	(9.30)	(13.34)	(9.81)	(6.43)	(10.18)	(2.93)	(7.82)	(0.61)	(2.66)	(1.36)
	0	65 788	94 367	69 396	45 486	72 013	22 854	60 996	4758	22 049	11 273
1978											
Lancaster Sound	(0.49)	(17.99)	(6.74)	(13.74)	(1.01)	(2.37)	(3.78)	(3.43)	(3.87)	(2.70)	—[c]
	1807	66 365	24 864	50 687	3726	8743	13 944	12 653	14 276	9960	—
Northwest Baffin Bay	(0)	(4.43)	(2.13)	(5.14)	(3.19)	(1.52)	(4.12)	(1.43)	(6.60)	(2.62)	—
	0	146 699	70 353	170 112	105 546	50 168	136 336	47 466	218 430	86 582	—
1979											
Lancaster Sound	(0.42)	(0.62)	(0.53)	(1.02)	(0.25)	(3.09)	—	(1.37)	(1.67)	—	(3.54)
	3163	4660	3957	7675	1870	23 134	—	10 289	12 541	—	34 080
Northwest Baffin Bay	—	(0.27)	(1.82)	(4.71)	—	—	—	(0.64)	(3.43)	—	—
	—	9079	61 345	158 492	—	—	—	21 519	115 548	—	—
West Baffin Bay	—	(0.37)	(1.77)	(2.09)	—	—	—	(1.78)	—	—	—
	—	63 541	407 028	388 588	—	—	—	331 069	—	—	—

[a] 9 May 1979.
[b] 9 May 1976, 1978.
[c] Indicates area not surveyed.

area. An estimated 213 000 were offshore; densities were highest in Lancaster Sound (Table 7). On 22-24 May, almost 30 000 murres were seen along coasts and ice edges, about four times as many as on 15-18 May. Concentrations were noted along the landfast ice edges in front of the colonies near Cape Graham Moore and Cape Hay, Bylot Island; along the Lancaster Sound fast ice edge; and at the base of the murre colony at Cambridge Point, Coburg Island (Fig. 11). An estimated 220 000 murres were present offshore in northwest Baffin Bay and Lancaster Sound.

Numbers of murres offshore decreased after 24 May, especially in Lancaster Sound (Table 7). Numbers and densities along the ice edge across Lancaster Sound increased at the same time (although the increase was not large enough to account fully for the decrease in offshore waters). Murres were also abundant along the Jones Sound ice edge on 30 May. However, few birds were seen near the colonies at Cambridge Point and Cape Graham Moore. This distribution pattern persisted until mid-June, except that numbers decreased along the Lancaster Sound fast ice edge. On 15 June, >4000 murres were present along the landfast ice edge along east Baffin Island; this was the first occasion when murres were common in that area. In contrast, relatively few murres were along the ice edge across Pond Inlet or along Bylot Island.

Murre numbers increased in late June. Almost 40 000 murres were counted along coasts and ice edges on 26-30 June (Fig. 11); an estimated 92 000 murres were within 7 km of the coasts and ice edges in the survey area. An estimated 218 000 murres were present offshore in Baffin Bay. Densities remained high through mid-July. Areas

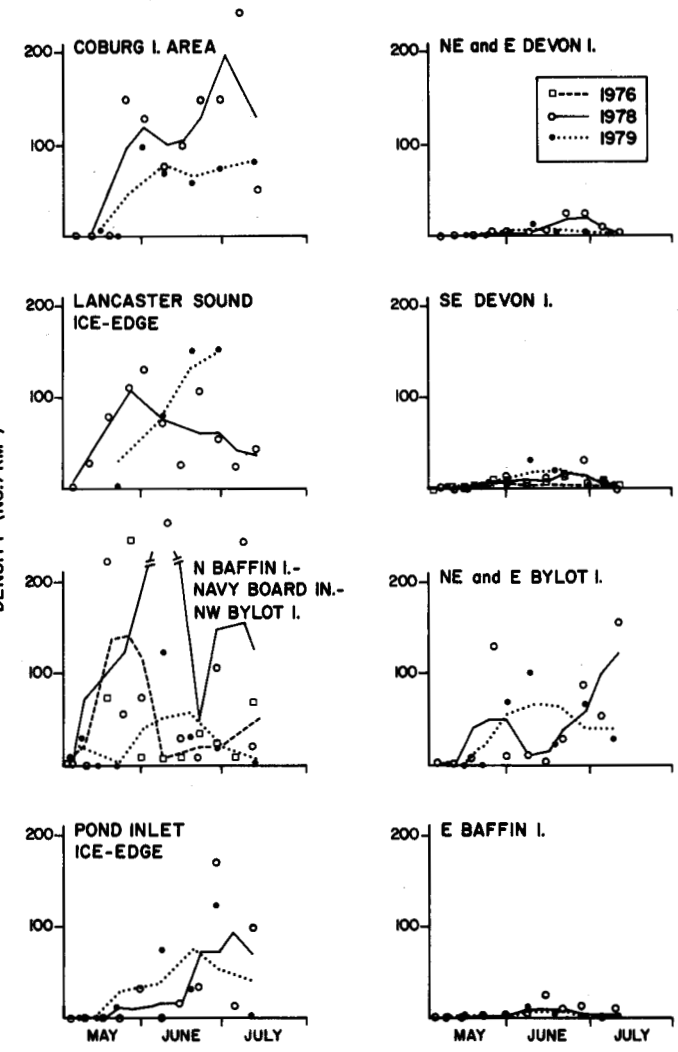

FIG. 10. Mean densities of thick-billed murres recorded in various sections of the study area, May-July 1976, 1978 and 1979. Plotted as in Fig. 3.

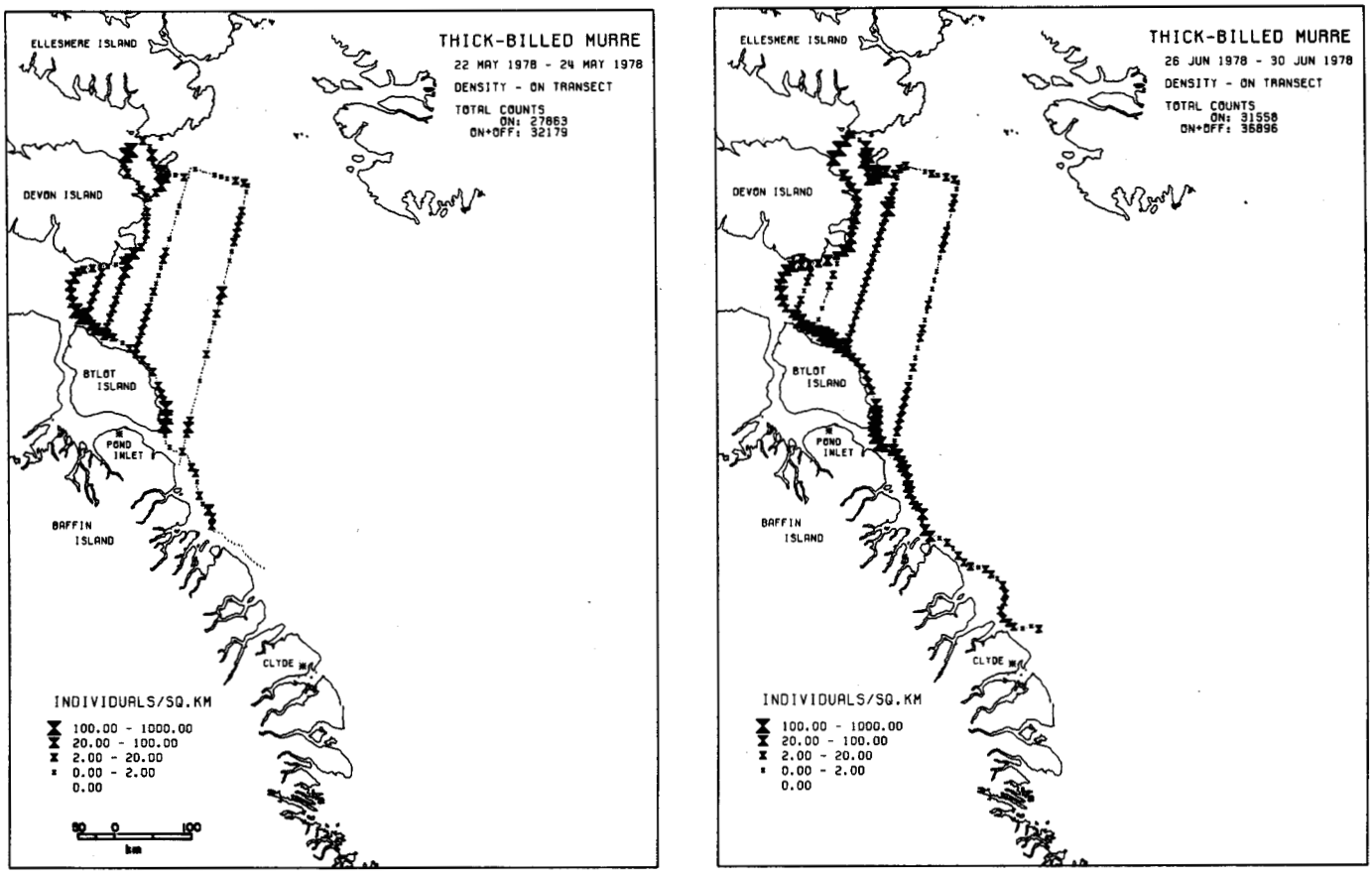

FIG. 11. Distribution of thick-billed murres in eastern Lancaster Sound and western Baffin Bay, 22-24 May 1978 (left), and 26-30 June 1978 (right). Plotted as in Fig. 4.

where large concentrations regularly occurred in late June and early July included the ice edges across the mouth of Jones Sound — 17 000 on 4 July — and across Lancaster Sound and Pond Inlet on 26 June — 3700 and 5700 birds, respectively.

1979. About 600 thick-billed murres were seen at the base of the Cape Hay colony on 9 May. On 12-15 May, murres were uncommon along coast and ice edges but about 77 000 were estimated to be offshore in eastern Lancaster Sound and western Baffin Bay (Table 7). Murres were also uncommon along coasts and ice edges on 17-22 May (Fig. 4), but almost 500 000 were estimated to be widely distributed offshore. Densities were highest in southeast Baffin Bay, south of 71°N and east of 58°W. Most murres in that area were probably en route to nesting colonies along the west coast of Greenland. Numbers offshore were also high on 24-26 May (Table 7), but densities were highest in northwest Baffin Bay.

Murres were abundant along coasts and ice edges after 1 June (Fig. 3). Over 15 000 were counted on 1 June; the largest concentrations seen were near the Cape Graham Moore and Cape Hay colonies, and along the Jones Sound ice edge. Almost 35 000 were recorded on 10-11 June — they were common throughout the entire area — and over 23 000 were recorded during each of two surveys between 19 June and 2 July (Fig. 12). Large concentrations were noted near Cambridge Point (5300 murres) and along fast ice edges across Jones Sound (4600 murres), Lancaster Sound (9400 murres) and Pond Inlet (1600 murres). Densities along coasts and ice edges were much lower by 9 July (Fig. 3), although ~9000 murres were recorded in the Coburg Island area. An estimated 360 000 murres were offshore in Lancaster Sound and Baffin Bay on 19-23 June.

Flock Size. During May, murres offshore in Baffin Bay were seen on about 35% of the transect segments; the average flock size was 10-15 birds; by late June, the frequency of sightings was much higher (~80%), but the average flock size was less than 4 birds (Table 3).

Habitat Use. During spring and early summer, thick-billed murre densities were significantly higher along fast ice edges than along ice-free coastlines (Table 8; $X^2 = 61.1$, df = 3, $P<0.001$). In both areas densities tended to decrease with increasing pan ice along the interface. Along ice edges, densities were higher in areas with <25% ice cover than in areas with 25-90% ice cover ($X^2 = 150.1$, df = 3, $P<0.001$). Along coasts the sample size was smaller but the corresponding difference was also significant ($X^2 = 12.1$, df = 1, $P<0.001$).

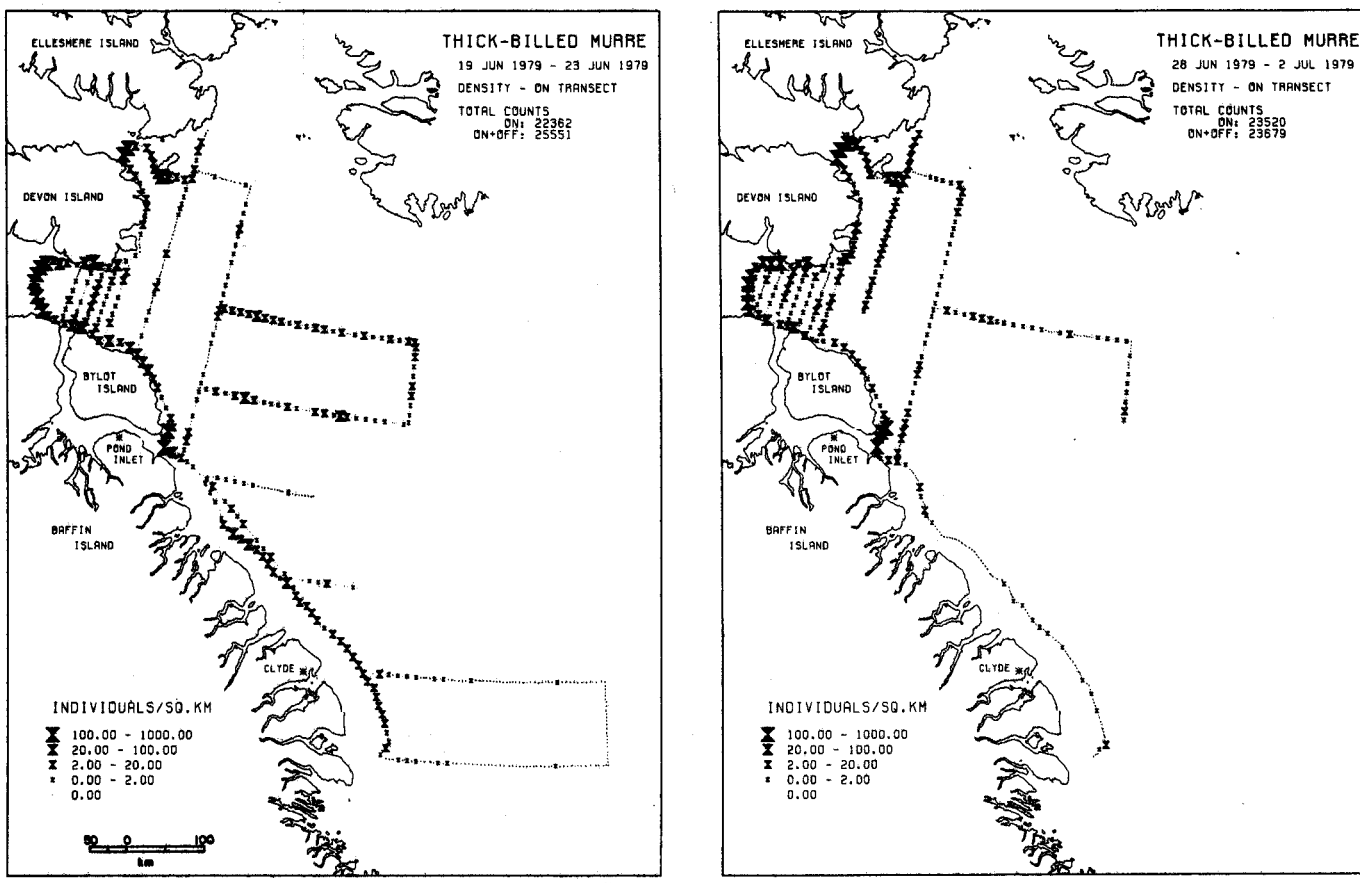

FIG. 12. Distribution of thick-billed murres in eastern Lancaster Sound and western Baffin Bay, 19-23 June 1979 (left), and 28 June-2 July 1979 (right). Plotted as in Fig. 4.

Murre densities were much lower offshore (Table 8). In that habitat, however, densities were higher in light to heavy pack ice (6-90%) than in areas with no ice or >90% ice.

Discussion

Thick-billed murres that summer in the eastern Canadian Arctic spend the winter off southwest Greenland and Newfoundland (Tuck, 1961; Gaston, 1980). Although early migrants reached eastern Lancaster Sound and northwest Baffin Bay by the first week of May during this study, the major influx into this area began about mid-May and continued throughout May and into June. In all three years of study, estimated numbers present were highest during surveys from 22-26 May. Migration was predominantly offshore, at least prior to mid-June. The fast ice edge east of Baffin Island may be an important migration route in June.

Large numbers of murres first appeared at colonies in the last half of May. The first large flocks were seen in 1978 near the Coburg Island, Cape Graham Moore and Cape Hay colonies on 23 May, 22 May and 15 May, respectively. In 1976, more than 12 000 were at the base of the Cape Hay colony on 24 May, and large numbers first appeared on the cliffs at Prince Leopold Island on 23 May (Gaston and Nettleship, 1981). Egg-laying usually begins about 20 June, although median laying dates are in late June or early July (Gaston and Nettleship, 1981). In 1978 laying was delayed about three weeks, with the peak of egg-laying occuring on 24 July at Cape Hay (L. Patterson, pers. comm.) and on 18 July at Prince Leopold Island (D.N. Nettleship, pers. comm.). After the initial influx of birds to their colonies in late May, varying numbers were present in front of the colonies as prospecting birds arrived and then departed again prior to laying (cf. Tuck, 1961). Thus, during June, murres were widespread and common throughout much of eastern Lancaster Sound and western Baffin Bay. Important areas included the fast ice edges across Jones Sound, Lancaster Sound, Navy Board Inlet, and Pond Inlet, all of which are close to colonies, and pack ice areas of Lancaster Sound and northern Baffin Bay. Murres concentrate along ice edges in spring to feed on arctic cod and other organisms (Bradstreet, 1980; Bradstreet and Cross, 1982).

The conditions that were responsible for the delayed nesting in 1978 may also have been responsible for the large numbers present (an estimated 220 000 birds) in offshore northwest Baffin Bay in late June in that year. These birds may have been breeding adults waiting for the Prince Leopold Island and Cape Hay colonies to become suitable

TABLE 8. Habitat utilization by thick-billed murres in eastern Lancaster Sound and Western Baffin Bay, early May-mid July 1978 and 1979

Habitat % pack ice cover	No. of transect segments[a]	% of segments[a] with murres	# segments with density[b] 0	0.1-2.1	2.1-21.5	21.5+	Mean density[b]
COASTS	222	51	109	63	31	19	11.4
0-5%	131	60	52	46	21	12	14.0
6-25%	52	46	28	11	8	5	9.0
26-50%	18	22	14	3	0	1	1.7
51-75%	9	44	5	1	2	1	4.5
76-90%	11	9	10	1	0	0	<0.1
91-99%	1	0	0	1	0	0	0.4
100%	0	0	0	0	0	0	0.0
FAST ICE EDGES	2672	73	998	392	722	560	35.6
0-5%	1248	78	269	191	411	377	55.9
6-25%	301	72	83	47	100	71	37.8
26-50%	214	59	87	40	62	25	12.1
51-75%	196	54	91	35	42	28	13.3
76-90%	242	48	125	33	56	28	26.3
90-99%	441	29	313	46	51	31	5.0
100%	30	0	30	0	0	0	0.0
OFFSHORE	3811	49	1946	947	828	90	2.8
0-5%	801	63	294	313	188	6	2.0
6-25%	230	71	66	80	77	7	6.2
26-50%	203	67	68	55	73	7	4.0
51-75%	229	70	69	76	78	6	3.9
76-90%	630	60	250	171	177	32	4.6
91-99%	1470	35	959	247	233	31	2.0
100%	248	3	240	5	2	1	0.2

[a] A transect segment represents 2 min of survey and includes about 6 km of transect.
[b] Density expressed as number of birds km^{-2}.

for nesting, which in 1978 did not happen until mid-July. Estimates offshore in late June 1979 were only about half those in 1978. Egg-laying at Cape Hay in 1979 started in late June, with a peak in early July (Birkhead and Nettleship, 1981). There is no information from Prince Leopold Island for 1979. Consequently, more breeding birds may have been at the Cape Hay colony in late June 1979 than in 1978, and concomitantly, fewer would have been offshore. The difference between years may also have been due to murres' preference for pack ice areas rather than ice-free waters. Ice cover in northwest Baffin Bay averaged 62% on 26 June 1978, but only 4% on 28 June 1979.

BLACK GUILLEMOT

Results

1976. A few hundred guillemots were present in easternmost Lancaster Sound on 2-3 May. Several thousands were present on 9 May, mostly offshore. On 23-24 May high densities were recorded along south Devon Island (Fig. 13), particularly west of Cape Warrender, and concentrations were also seen along northwest Bylot Island. Numbers offshore decreased after 9 May (Table 9), presumably as birds moved to nesting areas both inside and outside the survey area; after the end of May only a few hundreds birds were estimated to be offshore during each survey. On 20-21 June high densities were again recorded along Devon Island west of Cape Warrender (15.2 birds km^{-2}) and along north Baffin Island (13.3 birds km^{-2}), but densities were much lower in all areas thereafter (Fig. 13).

1978. Guillemots were present north of Bylot Island on 4 May. Densities and numbers remained generally constant through mid-May (Fig. 3). However, a major movement of guillemots into the area had occurred by 22-24 May when an estimated 44 000 were present offshore and more than 2000 were seen along ice edges and coasts (Fig. 14). Following this major movement, densities and numbers along 'coastal' transects decreased (Fig. 3) and this decline con-

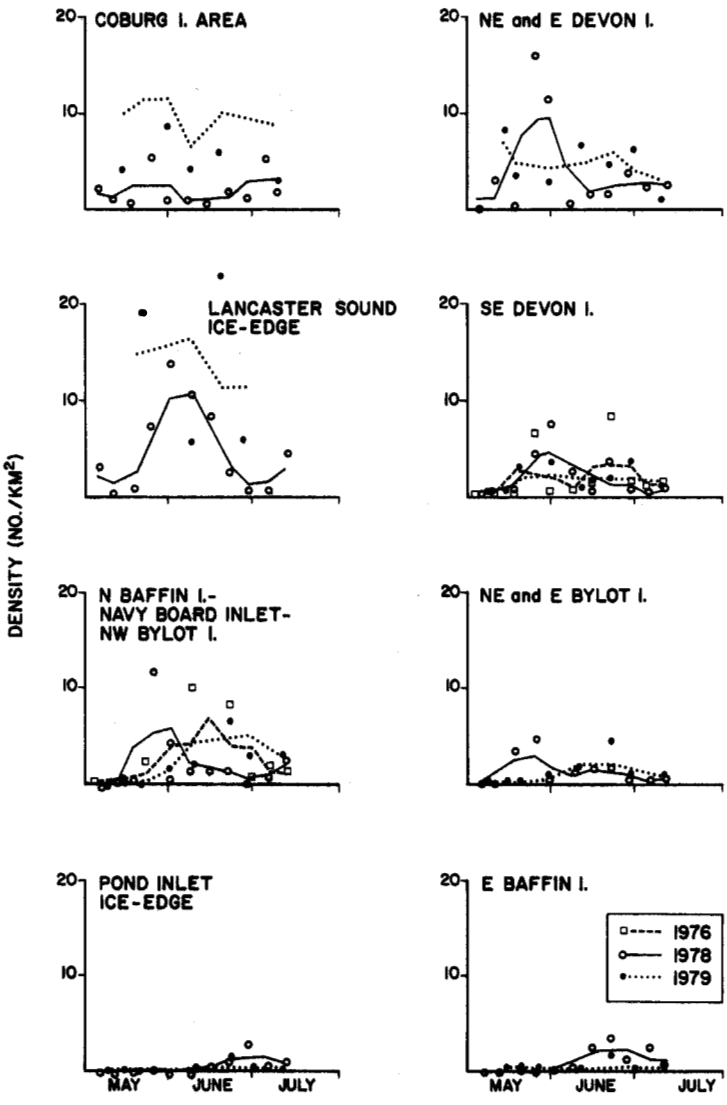

FIG. 13. Mean densities of black guillemots recorded in various sections of the study area, May-July 1976, 1978 and 1979. Plotted as in Fig. 3.

TABLE 9. Recorded densities (birds km^{-2}) and estimated numbers of guillemots in offshore areas of eastern Lancaster Sound and western Baffin Bay, early May-mid July 1976, 1978 and 1979

	2-9[a] May	9-15[b] May	16-21 May	23-26 May	30 May-1 Jun	6-11 Jun	13-16 Jun	19-23 Jun	26 Jun-1 Jul	4-8 Jul	9-15 Jul
1976											
Lancaster Sound	(0.06)	(0.55)	(0.24)	(0.36)	(0.13)	(0.05)	(0.05)	(0.01)	(0.04)	(0.01)	(<0.01)
	424	3891	1698	2547	920	354	390	78	312	83	32
1978											
Lancaster Sound	(0.33)	(0.50)	(0.10)	(1.52)	(0.10)	(0.10)	(0.43)	(1.14)	(0.92)	(0.12)	—[c]
	1217	1846	369	5607	369	369	1586	4205	3394	443	—
Northwest Baffin Bay	(0.18)	(0.54)	(0.31)	(1.17)	(0.36)	(0.21)	(0.42)	(0.35)	(0.82)	(0.10)	—
	6100	17 883	10 316	38 794	11 781	7043	13 739	11 538	26 995	3196	—
1979											
Lancaster Sound	(0.32)	(0.19)	(0.05)	(0.16)	(0.18)	(0.59)	—	(0.08)	(0.02)	—	(0.13)
	2418	1451	365	1181	1320	4402	—	586	181	—	1280
Northwest Baffin Bay	—	(0.08)	(0.38)	(0.30)	—	—	—	(0.03)	(0.05)	—	—
	—	2489	12 683	10 162	—	—	—	1036	1684	—	—
West Baffin Bay	—	(0.13)	(0.21)	(0.15)	—	—	—	(0.06)	—	—	—
	—	15 392	38 467	27 852	—	—	—	10 569	—	—	—

[a] 9 May 1979.
[b] 9 May 1976, 1978.
[c] Indicates area not surveyed.

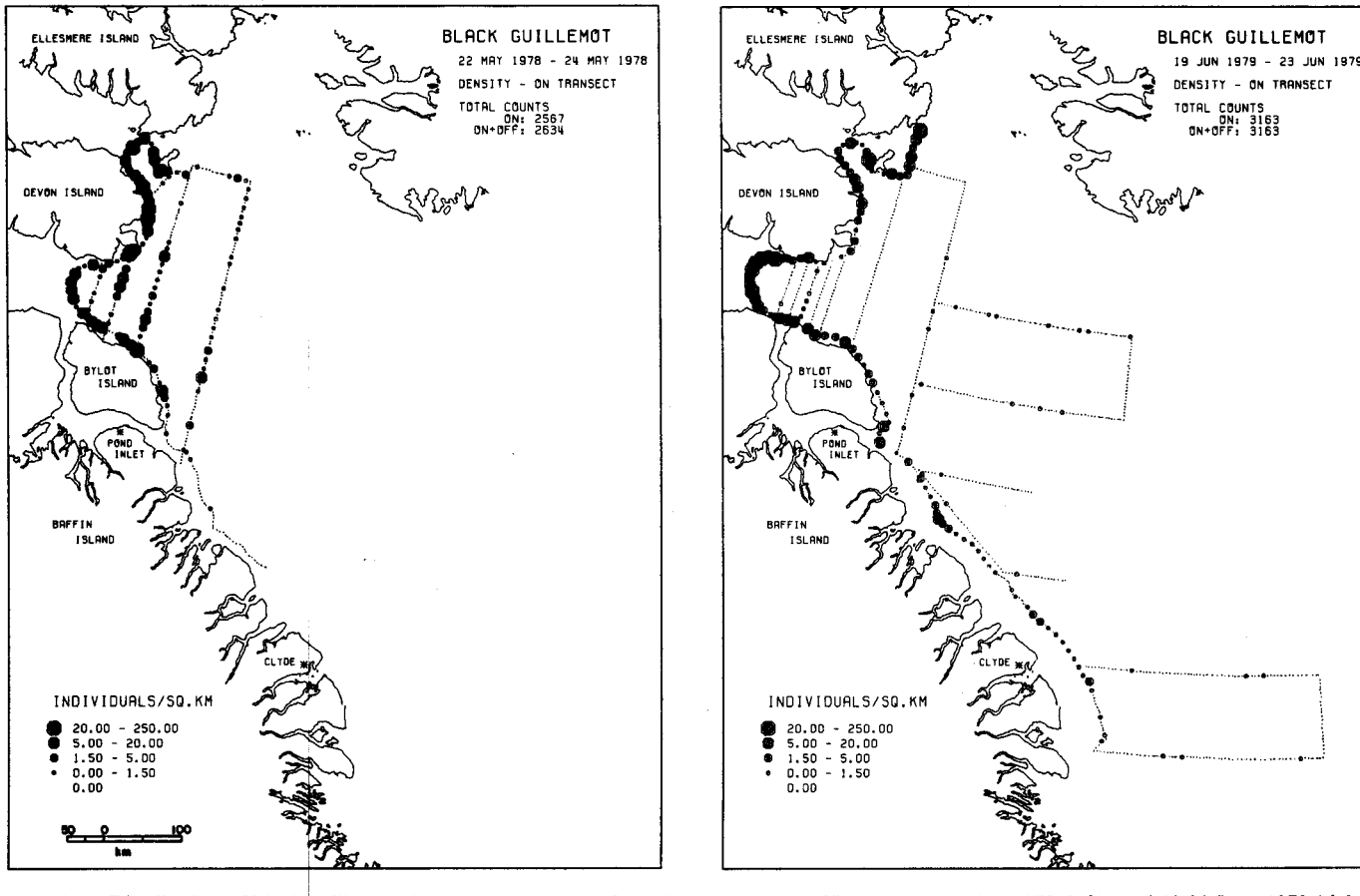

FIG. 14. Distribution of black guillemots in eastern Lancaster Sound and western Baffin Bay, 22-24 May 1978 (left), and 19-23 June 1979 (right). Plotted as in Fig. 4.

tinued throughout June and the first half of July. During this period concentrations were seen along the Lancaster Sound ice edge in the first half of June and the northeast Devon Island-Jones Sound ice edge area in late June and early July (Fig. 13). Variable but at times large numbers and densities were recorded along the northeast coast of Devon Island from May through mid-July.

After the peak in late May, numbers of guillemots offshore decreased sharply (Table 9) and remained generally similar until late June, when a second influx apparently occurred. On 27-28 June estimated numbers offshore in Baffin Bay more than doubled, to about 27 000 birds (Table 9). No increase was noted in Lancaster Sound. Estimated numbers were much lower on 4-5 July.

1979. Guillemots were present in Lancaster Sound on 9 May. Almost 1000 were seen along coasts and ice edges on 12-15 May, primarily along northeast Devon Island and the Glacier Strait ice edge. More than 3600 guillemots were counted on 20-21 May; they were very common along ice edges across Glacier Strait and Lancaster Sound, where over 1500 and 1200 birds, respectively, were recorded. Large numbers were also present offshore on 24-26 May; densities were highest in northwest Baffin Bay (Table 9).

Guillemots were common along coasts and ice edges during June. The largest concentrations continued to be seen in the Coburg Island-northeast Devon Island area and along the Lancaster Sound ice edge (Fig. 13). During two surveys in the 19-30 June period, 2800 and 3100 guillemots were recorded along coasts and ice edges. Densities were again highest along the Glacier Strait and Lancaster Sound ice edges, although on 19-23 June, higher than usual numbers were also seen along Bylot Island and the fast ice edge east of Baffin Island (Figs. 13, 14). Numbers offshore in June were lower than in late May (Table 9).

Densities decreased in most areas in early July (Fig. 13). Almost 50% of the birds seen on 9-15 July were near the colony on the west side of Coburg Island. The Lancaster Sound ice edge, where several hundred guillemots were seen regularly during surveys in June, had broken up by 9 July. Guillemots that frequented the edge may have dispersed into offshore areas, as the density in Lancaster Sound increased about sixfold between late June and mid-July (Table 9).

Habitat Use. During spring and early summer, black guillemot densities were higher along fast ice edges than along coasts, although the difference was not significant. As with murres, densities tended to decrease with increasing pan ice along the interface. Along fast ice edges, densities were higher in areas with <25% ice cover than in areas with >25% ice cover ($X^2 = 62.4$, df = 3, $P<0.001$).

Guillemot densities offshore were lower than along interfaces. Offshore, as with murres, densities were highest in light to heavy pack ice and lowest in ice-free areas and areas with total ice cover (Table 10).

TABLE 10. Habitat utilization by black guillemots in eastern Lancaster Sound and western Baffin Bay, early May to mid-July 1978 and 1979

Habitat & % pack ice cover	No. of transect segments[a]	% of segments[a] with guillemots	# segments with density[b]				Mean density[b]
			0	0.1-2.1	2.1-21.5	21.5+	
COAST	233	51	115	74	39	5	1.8
0-5%	131	50	65	42	22	2	1.9
6-25%	55	62	21	22	9	3	2.4
26-50%	18	44	10	4	4	0	1.8
51-75%	10	40	6	3	1	0	0.6
76-90%	12	50	6	3	3	0	1.2
91-99%	7	0	7	0	0	0	0.0
100%	0	—	0	0	0	0	—
FAST ICE EDGES	2816	47	1481	703	483	149	3.1
0-5%	1283	60	512	364	304	103	4.7
6-25%	311	55	141	81	68	21	3.9
26-50%	229	49	117	62	38	12	2.0
51-75%	203	46	109	55	33	6	1.8
76-90%	250	38	156	66	25	3	1.1
91-99%	498	19	404	75	15	4	0.4
100%	42	0	42	0	0	0	0.0
OFFSHORE	3995	21	3163	722	109	1	0.3
0-5%	810	7	754	52	4	0	0.1
6-25%	230	27	167	55	8	0	0.3
26-50%	211	32	143	65	3	0	0.3
51-75%	240	35	155	74	11	0	0.4
76-90%	650	35	421	196	33	0	0.4
91-99%	1580	21	1251	278	50	1	0.4
100%	274	1	272	2	0	0	<0.1

[a] A transect segment represents 2 min of survey and includes about 6 km of transect.
[b] Density expressed as number of birds km^{-2}.

Discussion

Small numbers of black guillemots winter in the North Water of northern Baffin Bay and in open-water areas of northwest Baffin Bay (Shortt and Peters, 1942; Renaud and Bradstreet, 1980). However, most of those that summer in the eastern Canadian Arctic probably winter in open-water areas south of Baffin Bay (cf. Salomonsen, 1967). During this study migration into Baffin Bay was in May, with the major movement occurring about 20-25 May. Because the large colonies in the High Arctic are situated west of the survey area (Brown *et al.*, 1975), most guillemots observed at this time were probably transients. Indeed, numbers recorded during subsequent surveys in all three years did not approach those noted from 20-25 May. Spring migration was primarily offshore; guillemots were generally absent along the Baffin Island ice edge but were widespread throughout much of western Baffin Bay in May and early June.

Guillemots normally begin to nest in late June or early July (cf. Nettleship, 1977), although in 1978 nest initiation was about three weeks late (D.N. Nettleship, pers. comm.).

During June, guillemots were widespread throughout the area, both along coasts and ice edges and offshore. Numbers near known colonies (Cape Hay on Bylot Island; Coburg Island) may fluctuate markedly as prospecting birds visit nesting sites and then depart. Although the distribution of nesting sites in this area is poorly known (cf. Brown *et al.*, 1975), the locations of some sites can be inferred from guillemot distribution during late June and early July. At this time, nesting guillemots are likely to be within a few km of the nest sites. Important areas include the northeast and east coast of Devon Island, the southwest and the southeast headlands of Coburg Island (Cape Spencer, Marina Peninsula/Princess Charlotte Monument), Cape Norton Shaw on Ellesmere Island, and Cape Hay on Bylot Island. Concentrations along the ice edge off Buchan Gulf and Scott Inlet on east Baffin Island suggest that colonies may also be situated at these sites. However, the only observations of nesting colonies in 1978 were at Princess Charlotte Monument (an estimated 500 pairs, S.R. Johnson, pers. comm.) and at Cape Hay (50-100 pairs, W.E. Renaud, pers. comm.). In view of the consistently high densities recorded along east and northeast Devon Island, there is probably a substantial nesting population along those coastlines. On the other hand, the fairly low numbers regularly recorded along northeast and east Bylot Island suggest that few guillemots nest there; suitable nesting habitat exists only at several of the headlands along the east coast.

In late June 1978, very large numbers of black guillemots (an estimated 27 000) were offshore in northwest Baffin Bay; in 1979, however, <2000 were estimated to be present during the same period. This difference may be due to the delayed nesting season in 1978. It is possible that the large numbers in 1978 included breeding birds that had not yet moved to colonies and were forced to wait in Baffin Bay because of the fast ice covering Lancaster Sound. As stated above, nesting was about three weeks later than normal at Prince Leopold Island (D.N. Nettleship, pers. comm.), and it is logical to assume a similar delay at other sites. There is no information on the chronology of the 1979 nesting season. If it were a normal season, nesting birds would have been near their colonies in late June (although in 1979, there was no open water near the colonies west of the study area prior to July). The amount of pack ice in Baffin Bay may also have been a factor in the large difference in numbers between the two years. Like murres, guillemots prefer offshore areas with moderate to heavy pack ice, a condition present in northwest Baffin Bay in late June 1978; in 1979, however, that area was virtually ice-free.

Similarly, densities offshore in eastern Lancaster Sound were about three times higher in 1978 (0.43 km^{-2}) than in 1976 (0.19 km^{-2}). The difference may have been due to the presence of large numbers of guillemots that normally nest in the central Arctic, west of the study area; these birds may have been forced to remain in the eastern part of the sound until the fast ice to the west broke up. In 1979, the average offshore density (0.19 km^{-2}) was much lower than in 1978, but in that year distribution may have been affected by the almost complete absence of pack ice.

GEOGRAPHIC SUMMARY

Aerial surveys in 1976, 1978 and 1979 encompassed an area extending almost 800 km north-to-south and >500 km east-to-west. Although ice conditions differed among the three years, especially in Lancaster Sound, and these differences affected seabird distribution, it is nonetheless possible to present a general summary of the distributions of fulmars, kittiwakes, murres and guillemots in various parts of the overall area in spring and early summer.

Coburg Island Area. Northern fulmars are present in this area in early May. The largest concentrations occur near the Princess Charlotte Monument colony, although birds are also present along the Jones Sound ice edge and offshore in Jones Sound and Lady Ann Strait. During the pre-laying exodus in the second half of May and early June fulmars are virtually absent but after mid-June they are widely distributed throughout the area, especially along the fast ice edges.

Kittiwakes return to this area in late May and early June. They are common thereafter, both along the Coburg Island coast and along the two offshore fast ice edges. In July numbers increase near the Cambridge Point colony and decrease along the offshore ice edges, a reflection of the tendency of kittiwakes to remain close to the colonies during nesting.

Murres are common in this area by late May and remain common through mid-July. Preferred sites include fast ice edges, especially the Jones Sound ice edge between Ellesmere and Devon islands. Because of prevailing northwesterly winds, this edge generally has little or no pan ice against it.

Some black guillemots winter in parts of this area where open water exists (Renaud and Bradstreet, 1980). The major immigration occurs in late May and from then through mid-July guillemots are common and widespread. Densities and numbers are highest along fast ice edges.

Devon Island. Northern fulmars and black-legged kittiwakes are present along northeast and east Devon Island after early June. They are nowhere concentrated, but are instead widely distributed throughout. Black guillemots are common along both ice edges and coasts of northeast and east Devon Island after mid-May, and probably nest here. Thick-billed murres, on the other hand, are seen only in small numbers after early June.

Eastern Lancaster Sound. Northern fulmars are present in eastern Lancaster Sound by early May. By late May, very few remain; the majority undertake a pre-laying exodus out of the sound. They return in early June and numbers and densities increase gradually through June, both along coasts and ice edges and offshore. In late June and early

July, several thousand fulmars are often present along the coasts and fast ice edges in the area.

Kittiwakes return to Lancaster Sound in late May and early June. Initially, at least, most individuals are offshore, possibly migrating to colonies west of the study area. After the first week of June, thousands are present along northwest Bylot Island. In 1976 and 1979, large concentrations of kittiwakes were seen regularly from mid-June to mid-July along the south coast of Devon Island.

Murres return to eastern Lancaster Sound in the first half of May. Initially most stay offshore, although the numbers present may depend on the amount of pack ice. After mid-May numbers offshore decrease, but murres become common along the coasts and ice edges. In both 1978 and 1979 many thousands were regularly seen along the ice edge across Lancaster Sound and near the colony west of Cape Hay.

Black guillemots are present in eastern Lancaster Sound in early May. (In fact, small numbers winter in areas with open water [Renaud and Bradstreet, 1980].) Peak spring migration occurs during the last third of May, mostly offshore. Most of these birds are likely transients moving to the large nesting colonies to the west. Guillemots are common along fast ice edges in eastern Lancaster Sound from late May until the end of June. Relatively few are present along ice-free coastlines.

Bylot Island. Kittiwakes, murres and guillemots all arrive at the Cape Graham Moore colony on southeast Bylot Island in mid- to late May. During June, all three species are common along the entire north and east coasts. Peak numbers are present during the last half of June. Northern fulmars are uncommon along Bylot Island in May. In June and the first half of July, however, they are common along the entire north and east coast.

Pond Inlet - East Baffin Island ice edge. In June, the ice edge east of Baffin Island is a migration route for black-legged kittiwakes and thick-billed murres. After migration, fulmars, murres and guillemots are common along the edge. These birds are presumably foraging and may be breeding birds from nearby colonies on Baffin and Bylot islands, although some non-breeding fulmars have been recorded along the Pond Inlet ice edge. Numbers and distributions of birds in this area during June and early July are in large part a function of the amount of pack ice against the edge.

Offshore Baffin Bay. The largest part of the survey area consists of offshore areas of Baffin Bay. Although densities of birds are generally low offshore, the very large area involved means that total numbers of birds offshore are often high — frequently higher than in coastal areas. Birds offshore are generally widely dispersed and their distribution is often related to the prevailing ice conditions.

Northern fulmars are widespread throughout Baffin Bay in early May. During the pre-laying exodus in the second half of May, most appear to leave the area; the somewhat higher density recorded in south Baffin Bay at this time suggests that, during their exodus, many fulmars move into Davis Strait. Numbers increase again in June, and very large numbers are present in the northwest in late June.

Black-legged kittiwakes migrate on a broad front across Baffin Bay. Peak spring migration is in late May and early June. Like fulmars, many kittiwakes are present offshore in Baffin Bay in late June.

Hundreds of thousands of thick-billed murres are present offshore in Baffin Bay from mid-May onward. During migration in May they occur in a small number of large flocks and are widespread throughout Baffin Bay. After migration they are seen more frequently but in smaller numbers, and most are in the northwest.

Thousands of black guillemots are present offshore in Baffin Bay during migration in May. Numbers probably decrease thereafter, although an estimated 28 000 guillemots were present in the northwest in late June 1978.

CONCLUDING REMARKS

Although seabirds are widely distributed throughout the eastern Arctic in the spring and early summer, their distributions vary both temporally and spatially, primarily in response to a variety of physical, especially ice, conditions.

During spring migration, enormous numbers of birds are offshore. In addition to those discussed in this paper, glaucous gulls (*Larus hyperboreus*), Thayer's gulls (*L. thayeri*), ivory gulls (*Pagophila eburnea*), arctic terns (*Sterna paradisaea*) and dovekies (*Alle alle*) also migrate north offshore (pers. obs.; Renaud *et al.*, 1982). Their distributions at this time depend to a large degree on the presence or absence of pack ice. Fulmars and kittiwakes (and other gulls) are surface feeders and tend to occur in areas where pack ice is not extensive. Alcids, on the other hand, associate with moderate to heavy pack ice. Renaud *et al.* (1982) attributed the small number of dovekies in eastern Lancaster Sound and northwest Baffin Bay in 1979, as opposed to 1978, to the unusually small amount of pack ice present there in 1979. Although trophic relationships have not been studied in offshore areas, some alcids may be attracted to pack ice by food availability. Arctic cod (*Boreogadus saida*) and the amphipod *Apherusa glacialis*, two important food items of some murres and other alcids, often occur at the undersurface of pack ice (Cross, 1982).

In addition to birds offshore, enormous flocks also feed along fast ice edges and coasts in the spring. Fulmars, murres and guillemots are the main species along ice edges. Bradstreet (1980, 1982) and Bradstreet and Cross (1982) documented the under-ice community and trophic relationships along fast ice edges. Coastal species include oldsquaws and eiders which require shallow waters for benthic feeding. The presence of fast ice along coastlines may make potential feeding areas of these species inaccessible, and substantially affect their distributions (McLaren and McLaren, 1982).

After migration, there is a general shift of birds from a broad offshore distribution to concentrations, presumably consisting of nesting birds, near colonies. This shift is especially noticeable in kittiwakes and other gulls, which are rarely seen far offshore after mid-July (pers. obs.). Although some decrease in numbers of fulmars and murres offshore also occurs as the breeding season commences, large numbers of these species may still be found offshore. The age and sex composition of the offshore component is not known but may include foraging breeders and non-breeding adults, and may be augmented by an influx of subadult birds in late June (cf. Bradstreet, 1982).

The large numbers of birds offshore in northwest Baffin Bay in late June 1978 may have been a consequence of the unusual ice conditions in Lancaster Sound (i.e., almost total ice cover) in that year. Birds that normally forage throughout Lancaster Sound in June and July were forced to move to the easternmost areas of Lancaster Sound and to Baffin Bay.

Seabird densities in Baffin Bay and eastern Lancaster Sound are substantially higher than in areas to the west (pers. obs.; W.E. Renaud, pers. comm.). Although some of the seabirds seen during this study were transients moving to colonies west of the study area and Greenland, most probably bred in the study area. Colonies are both more numerous and larger in eastern Lancaster Sound and Baffin Bay than in areas to the west. The general absence of colonies west of Lancaster Sound is likely due to (a) the absence of suitable nest sites and (b) the typical presence of multi-year ice and complete ice cover, which would eliminate any feeding areas, for much of the year. These two conditions are not found in the eastern Arctic.

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