ARCTIC
VOL. 38, NO. 1 (MARCH 1985) P. 43-52

Effects of Snow and Ice on Waterfowl Distribution in the Central Canadian Arctic Islands

MARGARET A. McLAREN[1] and W. GEORGE ALLISTON[1,2]

ABSTRACT. Aerial surveys were conducted in 1974 and 1975 to determine distribution and abundance of waterfowl along the coasts of Somerset, Cornwallis, Little Cornwallis, and Byam Martin islands, Boothia Peninsula, as well as parts of Prince of Wales, Devon, Bathurst, and Melville islands. Waterfowl nested normally in 1975 but were prevented from doing so in 1974 by a late thaw. In 1974, but not in 1975, Barrow Strait was ice free by 1 June.

Densities of most species were lower in spring 1975 than in 1974, when inhospitable conditions inland forced the birds to concentrate in coastal areas. In late summer Brant (*Branta bernicla*) and Oldsquaw (*Clangula hyemalis*) were more numerous in 1975 than in 1974; Brant left the central High Arctic in midsummer 1974, but the reason for the smaller numbers of Oldsquaw is not evident. Both Snow Geese (*Chen caerulescens*) and eiders (*Somateria* spp.) were more abundant in late summer 1974 than in 1975. Many Snow Geese moved to southeastern Somerset Island and adjacent waters to moult in 1974. In 1975 many eiders and Snow Geese remained at inland locations with their broods.

Queens Channel, northern Somerset Island and Bellot Strait were particularly important to waterfowl, irrespective of spring phenology. Melville and Byam Martin islands were used by Brant, and Canada Geese (*Branta canadensis*) occurred mainly on the Boothia Peninsula. Snow Geese were abundant in both years in southeastern Somerset Island, particularly near Creswell Bay, where both breeding and moulting occurred. Coastal waters of Barrow Strait, Prince Regent Inlet and the Gulf of Boothia were heavily used by Oldsquaw in spring and summer, and Crooked Lake, Prince of Wales Island, was used by many moulting Oldsquaw in both years. Common Eiders (*S. mollissima*) occurred principally in Queens Channel, Barrow Strait and near Bellot Strait; King Eiders (*S. spectabilis*) also concentrated in the same areas but were more widely distributed throughout the study area.

Key words: Arctic Islands, N.W.T., waterfowl distribution, nonbreeding, aerial surveys, Brant, Snow Geese, Oldsquaw, eiders

RÉSUMÉ. Des inventaires aériens ont été effectués en 1974 et 1975 en vue de déterminer la distribution et l'abondance d'oiseaux aquatiques le long des côtes des îles Somerset, Cornwallis, Petite Cornwallis et Byam Martin, et de la presqu'île de Boothia ainsi que dans certaines régions des îles Devon, Bathurst, Melville et Prince-de-Galles. Les oiseaux aquatiques nichaient de façon normale en 1975 mais un dégel tardif les en empêcha en 1974. Le détroit de Barrow était libre de glace dès le 1er juin en 1974 mais non en 1975.

La densité de la plupart des espèces était inférieure au printemps de 1975 à celle de 1974 puisque des conditions intérieures inhospitalières forcèrent les oiseaux à s'installer surtout dans les régions côtières. Vers la fin de l'été, les bernaches cravants (*Branta bernicla*) et les canards à longue queue (*Clangula hyemalis*) étaient plus nombreux en 1975 qu'en 1974; les bernaches cravants quittèrent la partie centrale du nord de l'Arctique vers le milieu de l'été en 1974 mais la raison pour le nombre peu élevé de canards à longue queue est toujours inconnue. Les oies blanches (*Chen caerulescens*) et les eiders (*Somateria* spp.) étaient plus nombreux vers la fin de l'été de 1974 qu'en 1975. De nombreuses oies blanches se déplacèrent au sud-est de l'île Somerset et aux eaux environnantes pour la mue en 1975. En 1975, plusieurs eiders et oies blanches demeurèrent dans les régions intérieures avec leurs couvées.

Le détroit de la Reine, le nord de l'île Somerset et la détroit de Bellot sont d'une importance particulière aux oiseaux aquatiques, quelle que soit la phénologie printannière. Les bernaches cravants fréquentent les îles Melville et Byam Martin et la bernache canadienne (*Branta canadensis*) est trouvée surtout dans la presqu'île de Boothia. Les oies blanches furent abondantes durant les deux années dans le sud-est de l'île Somerset, en particulier près de la baie Creswell, où l'accouplement et la mue eurent lieu. Les canards à longue queue fréquentaient en grands nombres les eaux côtières du détroit de Barrow, de l'inlet Prince-Régent et du golfe de Boothia durant le printemps et l'été et le lac Crooked sur l'île Prince-de-Galles fut le site de mue de nombreux canards à longue queue durant les deux années. Les eiders communs (*S. mollisima*) étaient trouvés surtout dans le détroit de la Reine et le détroit de Barrow et près du détroit de Bellot; les eiders respectables (*S. spectabilis*) étaient aussi concentrés dans ces mêmes régions mais étaient plus largement distribués à travers l'aire d'étude.

Mots clés: îles arctiques, T. N.-O., distribution des oiseaux marins, non-accouplement, inventaires aériens, bernache cravant, oie blanche, canard à longue queue, eider

Traduit pour le journal par Maurice Guibord.

INTRODUCTION

Waterfowl that summer in the central Arctic Islands of Canada arrive in spring from several directions. Snow Geese winter along the eastern coast of the United States and are believed to migrate overland (Bellrose, 1976). King and Common eiders and Oldsquaw migrate westward through Lancaster Sound (Salomonsen, 1968; McLaren and McLaren, 1982); some Oldsquaw may also migrate overland (Bellrose, 1976). Many Brant that summer in the central Arctic winter in Puget Sound, Washington, but some winter in Europe and return to the central Arctic over the northern archipelago (Maltby-Prevett *et al.*,1975; Boyd and Maltby, 1979). Whatever their origin, waterfowl arrive in the central Arctic when the marine channels are still ice covered. In normal years, the only open water available to arriving waterfowl in June consists of leads and polynyas. These increase in extent as June progresses but most channels remain ice covered until late in the month.

In the High Arctic the restricted availability of open water in spring has a considerable effect on the distribution of arriving waterfowl, as does the progression of snowmelt on land. Snowmelt usually begins in late May or early June but may be delayed until mid- to late June, especially north of Barrow Strait. Since freeze-up of lakes and ponds and the first snowfall occur in late August or early September, waterfowl have, at best, a 90-day season in which to fledge their broods. When spring is late waterfowl, like many other species, do not at-

[1]LGL Ltd., environmental research associates, P.O. Box 280, King City, Ontario, Canada L0G 1K0
[2]Present address: R.R. 3, Wolfville, Nova Scotia, Canada B0P 1X0

tempt to nest (Bird and Bird, 1940; Marshall, 1952; Barry, 1967; Ryder, 1970). In such years waterfowl distribution throughout the summer season may be quite different from that in normal nesting years.

In this paper we document the differences in waterfowl distribution over a large portion of the central District of Franklin, N.W.T. (Fig. 1) in spring and late summer 1974 and 1975, two years with different seasonal phenologies. Conditions in 1974 were unusual in two respects: (1) Barrow Strait was free of landfast ice before 1 June (Fig. 1); and (2) snowmelt on land was so late that many species did not nest. In 1975 conditions were more normal: in early June the only open water present consisted of shoreleads and polynyas but snowmelt was under way. We also present a few data from spring 1976, when the phenology was similar to 1974.

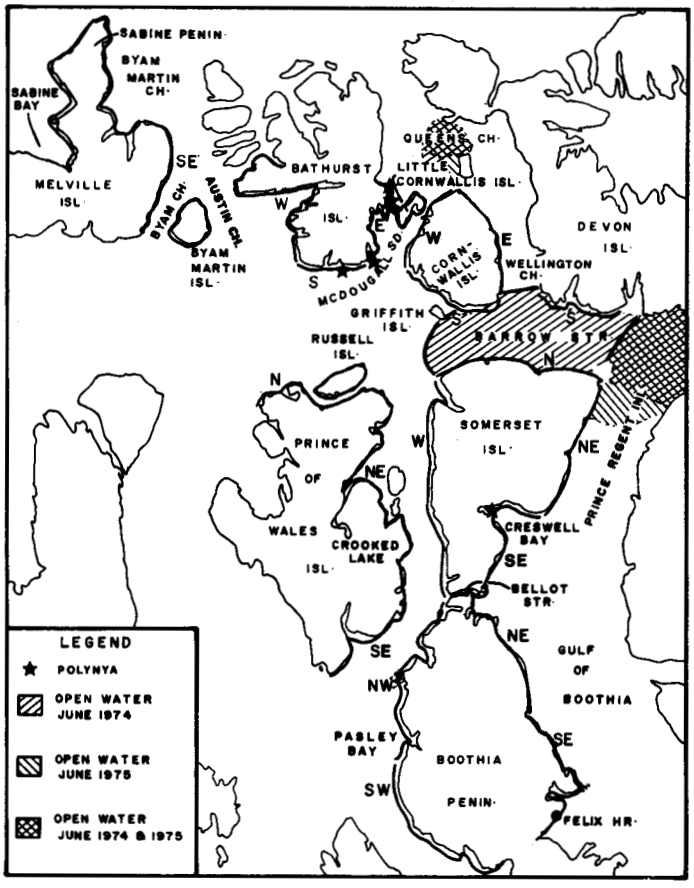

FIG. 1. Ice conditions in the central District of Franklin in early June 1974 and 1975. Solid white indicates landfast ice. Thick lines along coasts show survey routes, and divisions correspond to those used in Table 1 and in the text.

The data presented here were obtained by aerial surveys as part of a broader study of bird distribution in the central Arctic. Most of the following data pertain to coastal areas, but we also present selected results (unusual concentrations, range extensions) from surveys of inland areas in the same years. Further details of inland distribution of waterfowl and general distribution of other species are available in Davis *et al.* (1974) and Alliston *et al.* (1976).

METHODS

Surveys were conducted in the periods 3-29 June and 31 July-4 September 1974, 1-24 June and 25 July-31 August 1975, and 1-20 June 1976. In 1974 and 1975 most surveys were from a Cessna 337 aircraft; a few surveys were from a de Havilland Twin Otter. In 1976 surveys were from a Bell 206 or FH 1100 helicopter. Survey altitude was 30-40 m and ground speed was 160-170 $km \cdot h^{-1}$. Observers sat on both sides of the aircraft. For each bird sighting, the observer dictated (into a tape recorder) species, number, habitat, and whether the birds were within 200 m of the transect centre line. Total transect width was 400 m. Transects were centred either 200 m off the shore or (when present) ice edge, or directly over the shore or ice edge. With the exception of eiders (see below), most waterfowl were concentrated on the water within 200 m of the coast or ice edge. As a result, most birds were on transect whether it was centred over the water's edge or over open water. Table 1 summarizes survey effort in 1974 and 1975.

Aerial surveys permit coverage of a large area but cannot provide absolute population estimates. The proportion of birds present that are detected depends on many factors, including wave height, light intensity and direction, and observer experience, ability, and fatigue (Martinson and Kaczynski, 1967; Diem and Lu, 1960). Stott and Olson (1972) found that the proportion of ducks along coasts seen by observers in fixed-wing aircraft varied from 20-81%. Use of a pilot observer as well as differing aircraft types probably contributed to this wide range. Since our pilots were not observers, we believe our survey results to have been more consistent. Nevertheless, the proportion of waterfowl detected is unknown.

RESULTS

Recorded densities of the five major waterfowl species along coasts and ice edges are presented in Figures 2-5. Sections of particular coastlines referred to in the text are shown on Figure 1. Densities are expressed as number of birds per square kilometre of transect for all species except eiders. Because eiders flushed far ahead of the airplane, it was frequently difficult to determine whether they originated on the transect strip. Thus, for eiders only, results are expressed as numbers of birds on- plus off-transect per linear kilometre. Because of the very small areal extent of polynyas, the total number of birds counted (followed by year of observation) is given in the figures.

As mentioned above, Barrow Strait was free of ice before 1 June 1974. In other parts of the study area the only open water consisted of polynyas and cracks in the fast ice until mid-June, when shoreleads began to appear. In 1975 shoreleads had appeared by early June in southern portions of the study area and by mid-June in northern portions. Barrow Strait remained covered by fast ice until 24 June 1975, but a large polynya had appeared off Somerset Island by mid-June. The recurring polynyas present in McDougall Sound in 1974 were also open in 1975. Bradstreet (1979) and Smith and Rigby (1981) give

TABLE 1. Number of kilometres surveyed along coasts in the central Canadian Arctic in 1974 and 1975

		Northern Islands			
		No. of Km Surveyed		Survey Coverage Index[1]	
		Late Spring	Late Summer	Spring	Late Summer
Melville I.					
SE coast	1974	155	0	1	0
	1975	155	310	1	2
Sabine Pen.	1974	0	0	0.8 (0-1)[2]	0
	1975	460	948	1	2 (1-2)
Byam Martin I.	1974	0	0	0	0
	1975	140	280	1	2
Bathurst I.					
W coast	1974	516	156	1.2 (0-2)	0.4 (0-1)
	1975	611	774	1.4 (1-2)	1.8 (0-2)
S coast	1974	179	85	1.6 (0-2)	0.8 (0-1)
	1975	108	209	1	1.9 (1-2)
E coast	1974	454	412	1.8 (1-2)	1.6 (1-2)
	1975	208	491	0.8 (0-2)	2
Islands in McDougall Sd.	1974	143	402	0.6 (0-1)	1.7 (0-2)
	1975	161	417	0.7 (0-2)	1.8 (0-2)
Cornwallis I.					
W coast	1974	51	277	0.3 (0-1)	1.8 (0-2)
	1975	140	360	1	2.3 (2-3)
S coast	1974	655	203	3.5 (1-7)	1
	1975	148	407	0.8 (0-4)	2.1 (2-3)
E coast	1974	66	16	0.6 (0-1)	0.1 (0-1)
	1975	32	235	0.3 (0-1)	2
Devon I.					
S coast	1974	348	206	1 (0-3)	0.6 (0-2)
	1975	540	481	1.6 (0-2)	1.4 (1-2)

		Southern Islands			
		No. of Km Surveyed		Survey Coverage Index[1]	
		Late Spring	Late Summer	Spring	Late Summer
Prince of Wales I.					
N coast	1974	142	183	1	1.3 (1-2)
	1975	331	222	2.3 (1-3)	1.6 (0-2)
NE coast	1974	216	494	0.7 (0-1)	1.5 (1-2)
	1975	309	463	1 (0-2)	1.4 (0-2)
SE coast	1974	241	451	0.6 (0-1)	1.1 (1-2)
Russell I.	1974	280	257	1.6 (1-2)	1.4 (1-2)
	1975	362	484	2	2.7 (2-3)
Somerset I.					
N coast	1974	574	558	2.7 (2-3)	2.6 (2-3)
	1975	291	610	1.4 (1-2)	2.9 (2-3)
NE coast	1974	0	195	0	1.1 (1-2)
	1975	367	555	2	3
SE coast	1974	253	719	1.2 (1-2)	3.3 (3-4)
	1975	330	690	1.5 (1-2)	3
W coast	1974	428	526	1.3 (0-2)	1.6 (1-2)
	1975	0	911	0	2.8 (2-3)
Bellot Strait	1974	262	117	3.8 (3-4)	1.7 (0-2)
	1975	119	56	1.7 (1-2)	0.8 (0-1)
Boothia Pen.					
NE coast	1974	175	396	0.8 (0-1)	1.8 (1-2)
	1975	393	372	1.8 (1-2)	1.7 (1-2)
SE coast	1974	328	103	1	0.3 (0-1)
	1975	529	288	1.6 (1-2)	0.9 (0-1)
NW coast	1974	582	674	1.6 (1-2)	1.8 (1-2)
	1975	510	367	1.4 (1-2)	1
SW coast	1974	248	222	1	0.9 (0.1)
	1975	452	224	1.9 (2-3)	0.9 (0-1)

[1]Total km surveyed divided by km for one complete coverage. Complete coverage is defined as the maximum extent of our surveys in either year or season.
[2]Numbers in parentheses are the minimum and maximum number of times any part of the area was surveyed.

further details on the patterns of ice break-up in the central Arctic.

Fairly extensive areas of open water occurred each August in the eastern and southern parts of the study area. In August 1974 the ice in Barrow Strait west of Cornwallis Island broke up but it cleared very little that year. In 1975 considerable areas of open water were present in west Barrow Strait and in Byam, Austin, and Byam Martin channels. Landfast ice remained around Melville Island's Sabine Peninsula, but shore-leads were present along most of this coastline.

Tundra Swan (Cygnus columbianus)

Nine swans were observed along southwestern Boothia Peninsula in spring 1974 and 10 were observed there in spring 1975, when we also saw three along southeastern Boothia Peninsula. Swans were seen in late summer only in 1975, when 22 were recorded along southwestern Boothia Peninsula. We also saw one swan during an inland survey on southern Bathurst Island on 16 July 1975.

Godfrey (1966) shows southern Boothia Peninsula as part of the breeding range of Tundra Swans but gives no specific nesting locality. McLaren and McLaren (1984) have documented a major nesting area for this species about 50 km south of the Boothia Peninsula. We found no evidence of nesting on Boothia Peninsula in 1974 or 1975, but WGA observed a family group with three flightless young about 25 km west of Felix Harbour on 22 July 1977.

Canada Goose (Branta canadensis)

Canada Geese were seen primarily along the coasts of

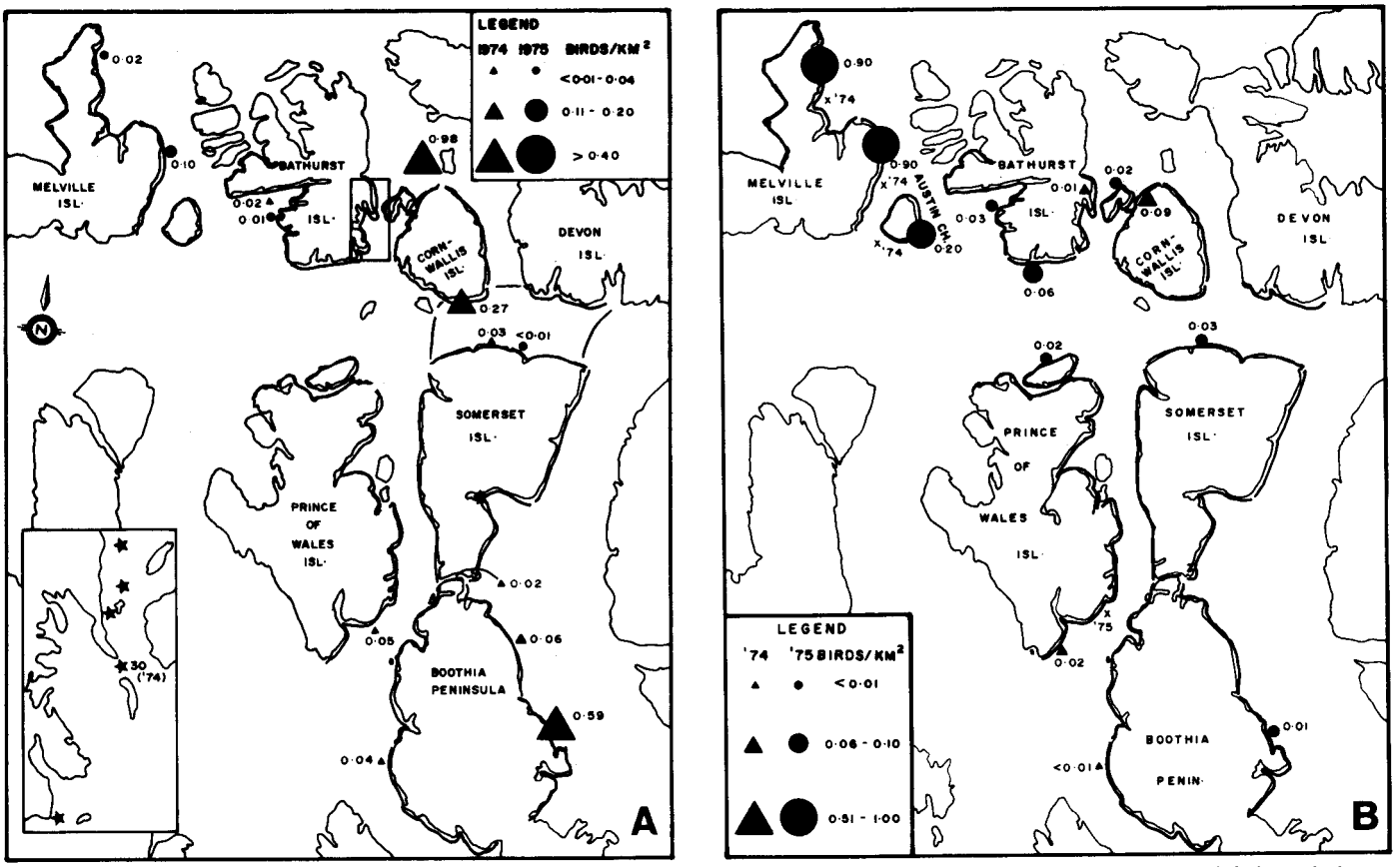

FIG. 2. Density-indices of Brant. (A) spring; (B) late summer. An "x" indicates not surveyed in the year shown. For "spring", inset at lower left shows the locations of polynyas (stars) in McDougall Sound. Total number of birds seen (followed by year of observation) is given for polynyas.

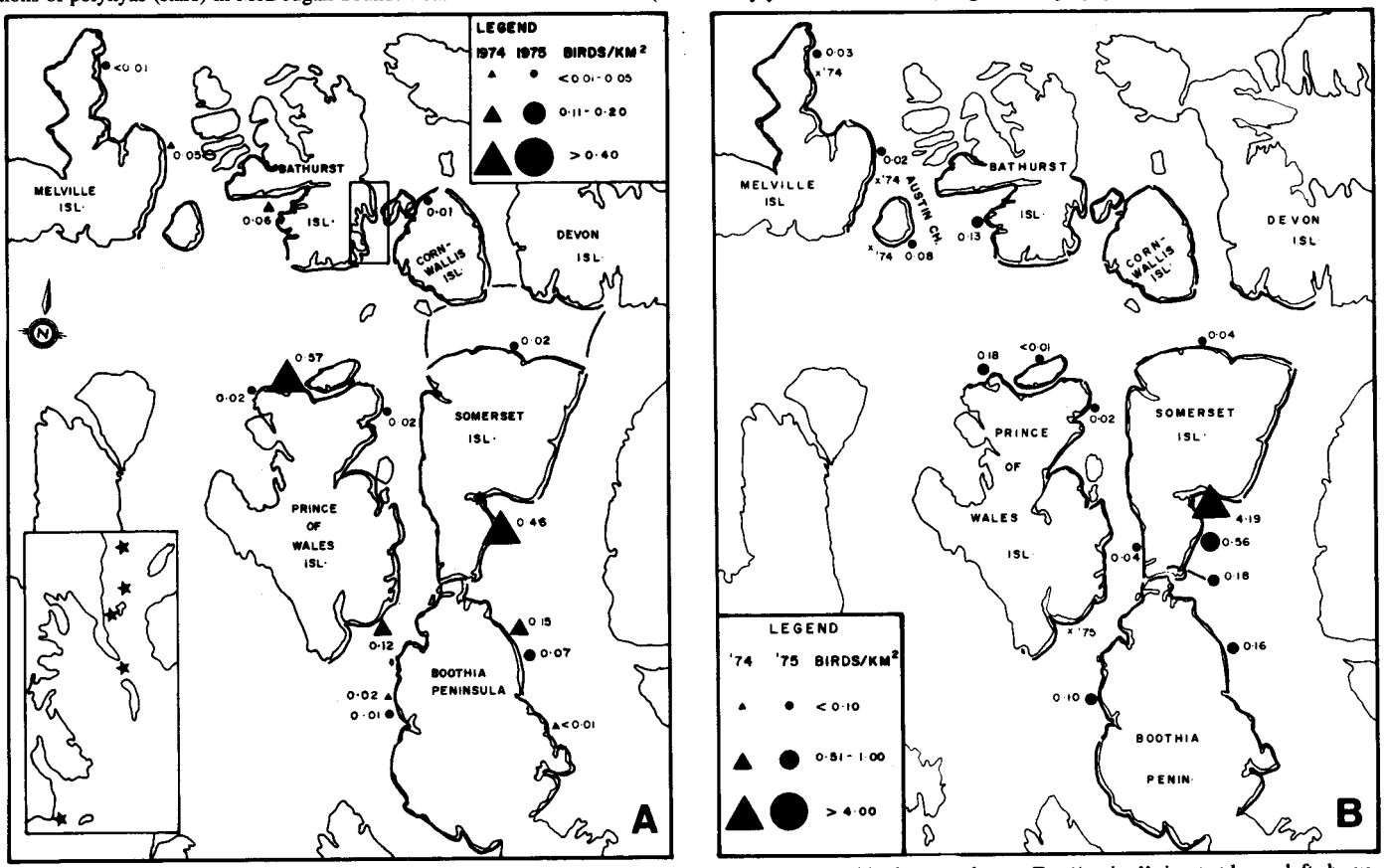

FIG. 3. Density-indices of Snow Geese. (A) spring; (B) late summer. An "x" indicates not surveyed in the year shown. For "spring", inset at lower left shows the locations of polynyas (stars) in McDougall Sound. Total number of birds seen (followed by year of observation) is given for polynyas.

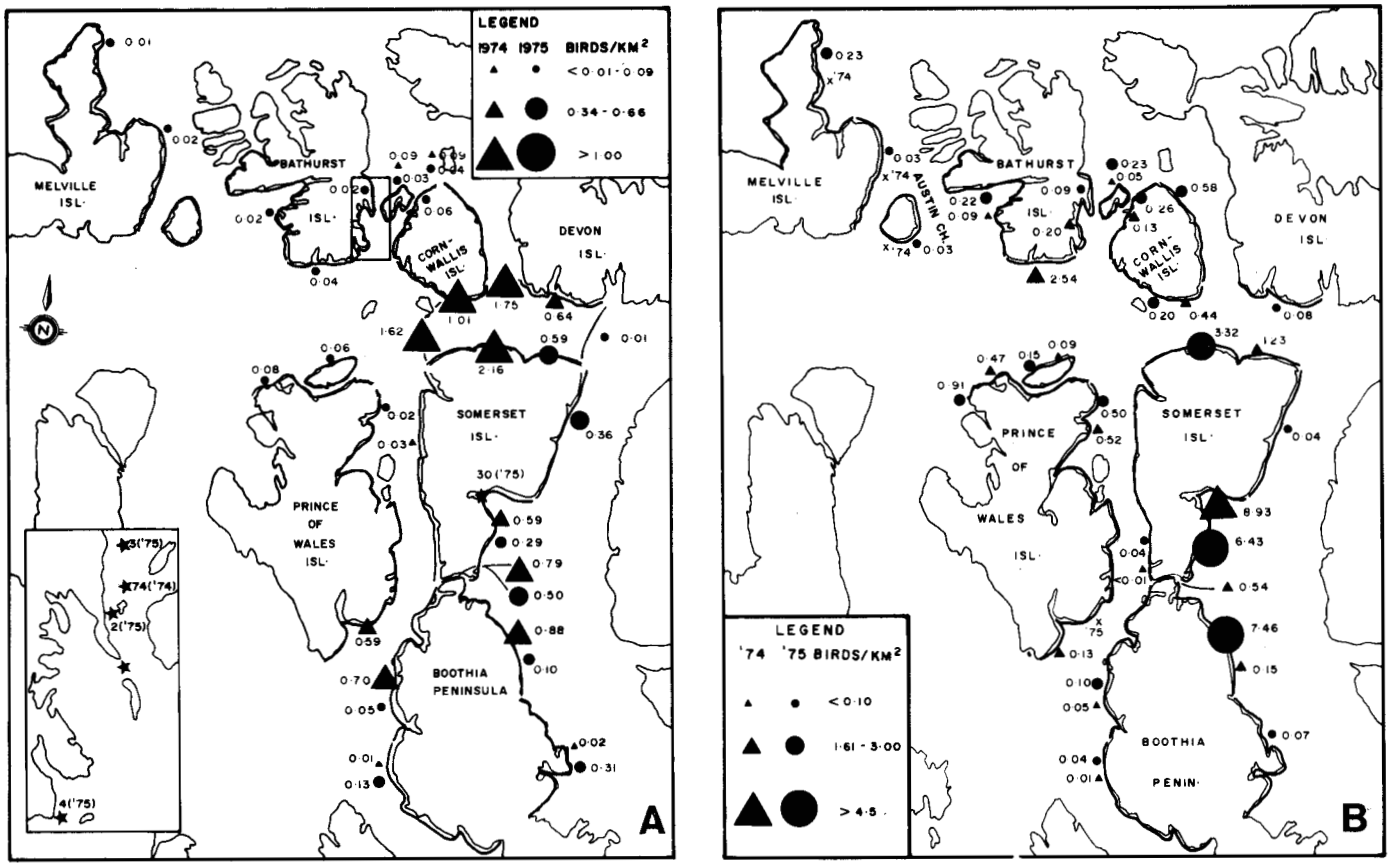

FIG. 4. Density-indices of Oldsquaw. (A) spring; (B) late summer. An "x" indicates not surveyed in the year shown. For "spring", inset at lower left shows the locations of polynyas (stars) in McDougall Sound. Total number of birds seen (followed by year of observation) is given for polynyas.

Boothia Peninsula. In spring of both years the largest numbers seen in the study area were along southwestern Boothia Peninsula near Pasley Bay (spring 1974 — 29 of 50, spring 1975 — 18 of 30). In late summer 1974 one flock of three adult Canada Geese with seven flightless goslings was seen in Pasley Bay. In August 1975 most Canada Geese seen were along the east coast of Boothia Peninsula (45 along each of the northeast and southeast coasts) but 32 birds were also seen in Pasley Bay. In late summer 1975 two small flocks (10 and 13 birds) were seen along southeastern Somerset Island.

Nesting Canada Geese have not previously been reported north of Felix Harbour near the base of Boothia Peninsula (Godfrey, 1966). We found two nesting pairs in the Wrottesley River valley (northern Boothia Peninsula), the brood mentioned above at Pasley Bay, and two nesting pairs at Sanagak Lake (central Boothia Peninsula).

Brant (Branta bernicla) (Fig. 2)

The distribution of Brant was strongly influenced by year-to-year differences in ice and snow cover. Most Brant in the study area nest on the northern islands, particularly Melville Island, where little snow-free land or open water was available in spring 1974. At that time most Brant were in large flocks in open water in the south and east parts of the study area (Fig. 2A). In spring 1975 most of the few Brant seen were along coasts of Bathurst and Melville islands. Observation of young in mid-July 1975 indicated that Brant had begun to nest in early June. In June 1976, another late spring, large flocks of Brant were seen in Barrow Strait (0.86 birds·km^{-2} along southern Cornwallis Island and 0.27 birds·km^{-2} along the Wellington Channel ice edge).

We did not survey Melville Island in late summer of 1974, but Brant did not nest that year and most had left the Sabine Bay-Eldridge Bay area by 6 August 1974 (L. Maltby, pers. comm. 1975). Elsewhere we observed only small (up to 25 birds), scattered flocks of Brant. In 1975, when Brant nested, the highest numbers (flocks of up to 200 birds) and densities found in late summer were along the coasts of Melville and Byam Martin islands. We saw seven broods along the coast of Melville Island and one along each of Byam Martin, Bathurst, and Somerset islands. Small flocks were also observed at scattered locations elsewhere in the study area.

Snow Goose (Chen caerulescens) (Fig. 3)

Most Snow Geese arrived in the study area in mid-June. Our surveys were spread rather uniformly throughout June, but of the total number of Snow Geese seen in spring, 88% were recorded after 18 June in 1974 and 95% were recorded after 13 June in 1975. In 1974 Snow Geese were frequently recorded along coasts and were most abundant along northern

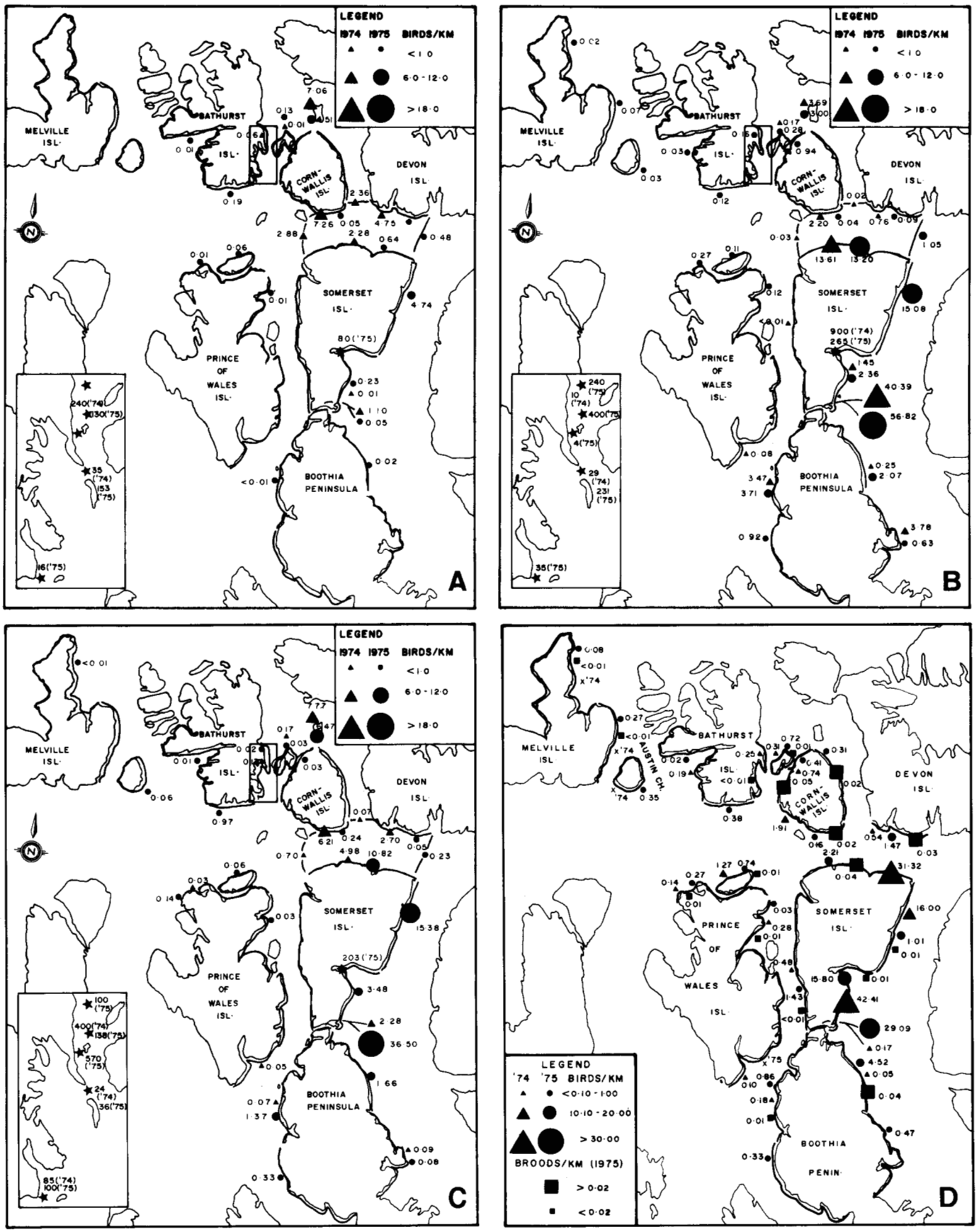

FIG. 5. Density-indices of King and Common eiders. (A) Common Eider, spring; (B) King Eider, spring; (C) unidentified eiders, spring; (D) all eiders, late summer. An "x" indicates not surveyed in the year shown. For "spring", inset at lower left shows the locations of polynyas (stars) in McDougall Sound. Total number of birds seen (followed by year of observation) is given for polynyas.

Prince of Wales Island and southeastern Somerset Island. In spring 1975 Snow Geese moved inland soon after they arrived and few were seen along coasts.

In late summer 1974 southeastern Somerset Island (mainly Creswell Bay) was the only coastal area where Snow Geese were observed. The species was much more widely distributed in late summer of 1975, when it was observed in 13 of the 23 coastal areas surveyed (Fig. 3B). Again, however, the highest density was along southeastern Somerset Island.

Snow Geese use coastal lowlands and waters for moulting and brood rearing in summer. Although small groups of 10-75 geese were seen in various inland areas, by far the most heavily used area was the coast and adjacent lowlands of southeastern Somerset Island. We recorded 2067 Snow Geese on southern Somerset Island on 12 July 1974, and J.D. Heyland (pers. comm. 1974) estimated 2700 Snow Geese north of Creswell Bay and 575 elsewhere on southern Somerset Island on 26 July 1974. We counted (from surveys and photos) 1013 Snow Geese without young plus 504 adults with 737 goslings in the lowlands north of Creswell Bay on 23 July 1975, and 223 Snow Geese elsewhere on southeastern Somerset Island on 22 July 1975. In late summer of 1974 we saw only one brood on southeastern Somerset Island.

Oldsquaw (Clangula hyemalis) (Fig. 4)

In spring 1974 Oldsquaw were most abundant along the ice edges of Barrow Strait, but moderate numbers also occurred along southeastern Somerset Island, southeastern Prince of Wales Island, northeastern and northwestern Boothia Peninsula, and in Bellot Strait. Oldsquaw were not seen in the western portions of the study area, where there was little open water. In spring 1975 Oldsquaw were more widely distributed than in 1974 and occurred in much smaller flocks. This species was again relatively common along southeastern Somerset Island and in Bellot Strait in 1975. Despite the reduced amount of open water available compared to 1974, the highest density of Oldsquaw in spring 1975 was again along northern Somerset Island. In spring 1976, when ice conditions were similar to 1974, Oldsquaw were again common in Barrow Strait with densities of 0.14 and 0.47 birds·km^{-2} respectively along the ice edges across Wellington Channel and western Barrow Strait, and 1.87 birds·km^{-2} along southern Cornwallis Island. Although the density of Oldsquaw in spring was relatively high along the ice edge across western Barrow Strait in both 1974 and 1976, most (66% and 77% respectively) Oldsquaw observed there were along the segment between Cornwallis and Griffith islands.

In late summer recorded densities of Oldsquaw were generally similar in the two years. The only exception was northeastern Boothia Peninsula, where Oldsquaw were much more abundant in 1975 than in 1974.

Many of the Oldsquaw observed in the early part of August in both years were flightless, moulting birds. In Creswell Bay all of 14 Oldsquaw collected in 1975 were males (Alliston *et al.*, 1976); most females probably remained inland with broods. In addition to their use of coasts, moulting Oldsquaw were abundant on Crooked Lake, Prince of Wales Island. An estimated 3500 Oldsquaw in 1974 and 2600 in 1975 moulted there.

King (Somateria spectabilis) and Common (S. mollissima) Eiders (Fig. 5)

King Eider and Common Eider females are impossible to distinguish during aerial surveys. In spring most birds were paired and we assumed each female to be the species of the male she accompanied. In later summer almost all eiders seen were females and could not be identified to species. Even in spring a considerable proportion of eiders were not identifiable to species; a separate map (Fig. 5C) is presented for these observations.

Eiders were by far the most abundant waterfowl in the study area, and King Eiders were considerably more abundant and widespread than Common Eiders. The latter occurred primarily in the eastern part of the study area from Bellot Strait to Queens Channel. Within the study area, Common Eiders are known to nest only on southern Cornwallis and Devon islands and northern Somerset Island (Godfrey, 1966). King Eiders nest throughout the study area (Godfrey, 1966).

Common Eiders were most abundant along the coasts and ice edges of Barrow Strait and in the open water of Queens Channel in spring 1974 (Fig. 5A). The species also occurred in moderate numbers in Bellot Strait. In spring 1975 when Barrow Strait was ice covered, Common Eiders were observed in about equal densities along northeastern Somerset Island and in Queens Channel, but the species was generally less abundant than in 1974. In 1976 Common Eiders were again abundant in Barrow Strait (1.36 birds·km^{-1} and 0.08 birds·km^{-1} respectively along the ice edges across Wellington Channel and western Barrow Strait, and 14.1 birds·km^{-1} along southern Cornwallis Island).

The highest density of King Eiders in spring was recorded in Bellot Strait in both years (Fig. 5B). Moderate densities were recorded along northern Somerset Island in both years and along northeastern Somerset Island in 1975 (there was no open water along northeastern Somerset Island in 1974). Although large numbers of King Eiders were found in Bellot Strait in early June 1975 (over 9200 birds on 3 June), use of this area was not as prolonged as it was in 1974. Comparatively few King Eiders (only 788 birds) were seen there on 15 June 1975, when a wide offshore lead had opened in the Gulf of Boothia. Over 1100 King Eiders were counted during a survey over only a portion of that lead. There were no locations where high densities of unidentified eiders were recorded in spring that did not also have high densities of either King or Common eiders.

In late summer 1974 eiders were very abundant along northern and southeastern Somerset Island. Over 13 000 eiders were seen on one day along each of these coasts. Lesser numbers occurred along northeastern Somerset Island. In 1975 densities of eiders were generally lower along coasts in late summer, presumably because many females were attending broods at inland locations. The highest density was again

along southeastern Somerset Island, and a high density was also found in Bellot Strait. Densities along northern Somerset Island were not remarkable in late summer 1975. None of the eiders without broods in late summer were flightless, moulting birds.

Eiders apparently undertook a pre-moult migration from the central High Arctic in mid-August. In 1974 the number of eiders recorded along southeastern Somerset Island decreased from 15 009 birds on 10 August to 1681 birds on 24 August. Similarly, numbers recorded along northern Somerset Island declined from 13 034 to 3486 birds between 11 and 20 August. In 1975 much smaller numbers of eiders used northern Somerset Island and no sharp decrease was noted in August. However, a decrease similar to that in 1974 was observed along southeastern Somerset Island, where 13 653 eiders were seen on 10 August but only 3107 on 20 August.

Many eiders nested successfully in 1975, and 129 broods were seen along coasts in late summer. (Although eider broods in other areas may coalesce into "creches" containing many young and attended by several females [Munro and Bédard, 1977], we saw only groups with five or fewer young attended by one female.) The highest densities of eider broods were frequently found at different locations from those with the highest densities of eiders without broods. The highest densities of broods were found along the three coasts of Cornwallis Island, southern Devon Island, northeastern Boothia Peninsula, and northern Somerset Island. The last is the only location where large numbers of eiders without broods occurred. High densities of broods along the coast may represent high nesting densities, lack of appropriate brood-rearing habitat in the adjacent inland areas, or both. In many cases the latter seems more likely since many of the locations with high brood densities were adjacent to barren areas with few ponds and little vegetation. This is the case along all of the coast of Cornwallis Island, as well as along northern Somerset and southern Devon islands.

DISCUSSION

Geese

When snow conditions permit, both Snow Geese and Brant begin to nest in mid-June, very shortly after their arrival. Thus, in years of normal or early thaw, such as 1975, very few are seen along coasts in spring. On the other hand, in years of late thaw, such as 1974, geese remain in coastal areas. Snow Geese tended to be most common adjacent to known nesting areas such as southeastern Somerset Island and northern Prince of Wales Island. However, Brant, which in the central High Arctic nest primarily on Bathurst and Melville islands, were seen most commonly to the east and south of these islands. This distribution was probably a result of the lack of either open water near or snow-free land at nesting areas even in late June 1974. Snowmelt in more southerly areas had begun by about 20 June 1974.

Late summer densities of Brant along coasts were higher in 1975 than in 1974. As mentioned above, most Brant had probably left the study area by the second week of August in 1974, and the main area where this species would have been expected, along the coast of Melville Island, was not surveyed in August 1974.

In late summer 1974 Snow Geese were seen only along southeastern Somerset Island. This restricted distribution probably reflects the importance of southeastern Somerset Island as a moulting area. J.D. Heyland conducted banding drives at Creswell Bay in July 1974. Of the ten previously banded geese that he captured, eight were hatched in three distinct and distant areas (Cape Hatt, northern Baffin Island; near Eureka Sound, Axel Heiberg Island; and southern Bathurst Island) (Canadian Wildlife Service banding records). Snow Geese normally return to their natal areas in spring and adults remain in these areas to moult (Cooke *et al.*, 1975). Many juvenile geese also remain in their natal areas to moult, but Abraham (1980) has shown that some young geese do migrate to distant moulting areas. Three of the geese Heyland captured were adult females, which was unexpected at Creswell Bay.

The presence of these banded geese, as well as the increase in numbers between early (2067 geese) and late (3275 geese) July 1974 suggests an immigration to southeastern Somerset Island prior to the wing moult. In years when a late thaw prevents nesting, larger numbers of geese, including some adults, apparently undertake this pre-moult migration. In 1975 only 1740 Snow Geese (excluding goslings) were found on southeastern Somerset Island in late July, and in contrast to 1974, numerous small groups, many containing young, were observed along other coasts and in inland areas (Alliston *et al.*, 1976).

Ducks

Oldsquaw and both eider species arrive in the central High Arctic in late May and early June, when the land is still snowbound and many marine channels are covered by fast ice. These arriving ducks depend on finding open water for survival (Barry, 1968), and the parts of the study area that are ice free in early June each year are consistently heavily utilized. Such areas included Bellot Strait, portions of Queens Channel, the recurring polynyas shown on Figure 1, and, usually, portions of eastern Barrow Strait (although in occasional years — e.g., 1978 and 1979 — all of Barrow Strait and most of Lancaster Sound to the east are covered by fast ice until mid-July [Smith and Rigby, 1981]).

Oldsquaw and eiders dispersed into newly available areas throughout June, showing preference for particular coasts. Even though shoreleads did develop in the western portion of the study area by late June 1975, few ducks occurred there. Northern Somerset Island, on the other hand, appears to be a preferred area. Almost equal densities of King Eiders were found there in 1974 and 1975 despite the fact that the coast was ice free throughout June in 1974 and, except for shoreleads and a polynya that appeared in mid-June, ice covered in 1975. Although between-year values were different, the highest den-

sity recorded for Oldsquaw in both years was along northern Somerset Island.

Late summer densities were generally higher in 1975 than in 1974 for Oldsquaw and lower for eiders. The higher densities of Oldsquaw in 1975 are not readily explicable, especially since most females did not have broods in 1974 and many presumably would have moulted with the males at the coast. The smaller numbers of Oldsquaw moulting in Crooked Lake, Prince of Wales Island, in 1975 may indicate that coasts were used preferentially, but why this should be so is unknown.

Three interacting factors probably account for the higher densities of eiders in late summer 1974. Since little open water occurred north or west of Barrow Strait in spring, eiders that would normally have nested in these areas may have remained in the relatively southerly waters of the study area throughout the summer. Second, the almost complete lack of nesting in 1974 would have resulted in few immatures in the study area in 1975 (eiders did nest in the study area in 1973 — e.g., Maltby, 1978). Third, in 1975 many adult females probably remained with their broods on inland lakes and ponds.

Virtually all of the eiders seen in late summer were females. An eastward migration of male King and Common eiders through Lancaster Sound in July and early August has been documented (McLaren and McLaren, 1982). These birds presumably include males from the central Arctic enroute to moulting areas off western Greenland and at other locations (Salomonsen, 1968; Palmer, 1976). Almost all female eiders without broods also leave the central and eastern Canadian Arctic before undergoing the wing moult. Virtually the only flightless females that have been observed in these areas in late summer have been those accompanying broods (McLaren and McLaren, 1982; this study). The major passage of females eastward through Lancaster Sound occurs about 15-25 August (McLaren and McLaren, 1982), and this timing is consistent with decreases in numbers observed during this study.

SUMMARY AND CONCLUSIONS

In the Canadian central High Arctic the rate of disappearance of snow on land determines whether waterfowl will nest, and this in turn influences both the numbers of birds using coastal waters and the duration of such use. In nesting years, i.e., years with early to normal snowmelt, few geese use coastal waters in spring. In late summer of such years geese tend to occur in coastal waters adjacent to their nesting areas. In years when geese do not nest, they do use coastal waters, primarily east and south of Cornwallis Island, in spring. In late summer of years when a late thaw prevents nesting, Brant depart from the central High Arctic in early August, whereas Snow Geese from several islands congregate on southeastern Somerset Island.

Ducks tend to arrive in the High Arctic earlier than geese and to exhibit similar patterns of distribution, if not density, regardless of whether the thaw is early or late. Patterns of distribution in spring are controlled primarily by the location of open water. Patterns of distribution of ducks are also similar in late summer whether or not nesting occurred. Oldsquaw moult in the central High Arctic, and moulting flocks occur in many of the same areas each year. Most eiders do not moult in the central High Arctic. Male eiders leave the central Arctic in midsummer. Female eiders without broods constitute by far the greatest proportion of birds seen in marine areas in August even in years when nesting occurs, and the largest numbers occur in the same areas each year. Most of these females leave the central High Arctic in mid-August. Small numbers of eider females with broods also occur along coasts and are still present in late August.

ACKNOWLEDGEMENTS

The studies reported here were part of a more extensive research effort carried out by LGL Ltd. under contract to Polar Gas Project, which provided excellent logistic assistance. The surveys were conducted by M. Bradstreet, R. Davis, K. Finley, C. Holdsworth, P.L. McLaren, L. Ratcliffe, W. Renaud, R. Salter, R. Wypkema, and the authors. We thank P.L. McLaren and W.J. Richardson of LGL Ltd. and an anonymous reviewer for suggesting improvements to the manuscript.

REFERENCES

ABRAHAM, K.F. 1980. Moult migration of Lesser Snow Geese. Wildfowl 31:89-93.

ALLISTON, W.G., BRADSTREET, M.S.W., McLAREN, M., DAVIS, R.A., and RICHARDSON, W.J. 1976. Numbers and distribution of birds in the central District of Franklin, N.W.T. June-August 1975. Unpublished report by LGL Ltd. for Polar Gas Project, Toronto. 583 p. [Available from the Arctic Institute of North America Library, University of Calgary, 2500 University Dr. N.W., Calgary, Alberta, Canada T2N 1N4.]

BARRY, T.W. 1967. The geese of the Anderson River delta, N.W.T. Unpublished Ph.D. thesis, University of Alberta, Edmonton. 212 p.

_____. 1968. Observations on natural mortality and native use of eider ducks along the Beaufort Sea coast. Canadian Field-Naturalist 82:140-144.

BELLROSE, F.C. 1976. Ducks, Geese and Swans of North America. Harrisburg: Stackpole Books. 544 p.

BIRD, C.G., and BIRD, E.G. 1940. Some remarks on non-breeding in the Arctic, especially in Northeast Greenland. Ibis 4:671-678.

BOYD, H., and MALTBY, L.S. 1979. The Brant of the western Queen Elizabeth Islands, N.W.T. In: Jarvis, R.L., and Bartonek, J.C. (eds.). Management and Biology of Pacific Flyway Geese: A Symposium. Corvallis, OR: OSU Bookstores, Inc. 5-21.

BRADSTREET, M.S.W. 1979. Thick-billed Murres and Black Guillemots in the Barrow Strait area, N.W.T., during spring: distribution and habitat use. Canadian Journal of Zoology 57:1789-1802.

COOKE, F., MacINNES, C.D., and PREVETT, J.P. 1975. Gene flow between breeding populations of Lesser Snow Geese. Auk 92:493-510.

DAVIS, R.A., BRADSTREET, M., HOLDSWORTH, C., McLAREN, M., and RICHARDSON, W.J. 1974. Studies of the numbers and distribution of birds in the central Canadian Arctic — 1974: a preliminary report. Unpublished report by LGL Ltd. for Polar Gas Project, Toronto. 238 p. [Available from the Arctic Institute of North America Library, University of Calgary, 2500 University Dr. N.W., Calgary, Alberta, Canada T2N 1N4.]

DIEM, K.L., and LU, K.H. 1960. Factors influencing waterfowl censuses in the parklands, Alberta, Canada. Journal of Wildlife Management 24:113-133.

GODFREY, W.E. 1966. The Birds of Canada. National Museum of Canada Bulletin 203:1-428.

McLAREN, M.A., and McLAREN, P.L. 1984. Tundra Swans in northeast Keewatin District, N.W.T. Wilson Bulletin 96:6-11.

McLAREN, P.L., and McLAREN, M.A. 1982. Waterfowl populations in eastern Lancaster Sound and western Baffin Bay. Arctic 35:149-157.

MALTBY, L.S. 1978. Birds of the coastal zone of Melville Island, 1973-1975. Canadian Field-Naturalist 92:24-29.

MALTBY-PREVETT, L., BOYD, H., and HEYLAND, J.D. 1975. Observations in Iceland and northwest Europe of brant from the Queen Elizabeth Islands, N.W.T., Canada. Bird-Banding 46:155-161.

MARSHALL, A.J. 1952. Non-breeding among Arctic birds. Ibis 94:310-333.

MARTINSON, R., and KACZYNSKI, F. 1967. Factors influencing waterfowl counts on aerial surveys, 1961-66. U.S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report-Wildlife No. 105:1-15.

MUNRO, J., and BEDARD, J. 1977. Crèche formation in the Common Eider. Auk 94:759-771.

PALMER, R.S. (ed.). 1976. Handbook of North American Birds. Vol. 3. Waterfowl (Part 2). New Haven and London: Yale University Press. 560 p.

RYDER, J.P. 1970. A possible factor in the evolution of clutch-size in Ross's Goose. Wilson Bulletin 82:5-13.

SALOMONSEN, F. 1968. The moult migration. Wildfowl 19:5-24.

SMITH, M., and RIGBY, B. 1981. Distribution of polynyas in the Canadian Arctic. In: Stirling, S., and Cleator, H. (eds.). Polynyas in the Canadian Arctic. Canadian Wildlife Service Occasional Paper 45:7-28.

STOTT, R.S., and OLSON, D. 1972. An evaluation of waterfowl surveys on the New Hampshire coastline. Journal of Wildlife Management 36:468-477.