

Birds of Sarcpa Lake, Melville Peninsula, Northwest Territories: Breeding Phenologies, Densities and Biogeography

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ABSTRACT. Forty species of birds were observed during field studies at Sarcpa Lake, Melville Peninsula, N.W.T. during the summers of 1981 and 1982. Evidence of breeding was found for 22 species and the first definite breeding records for the Melville Peninsula were obtained for Glaucous Gull, Pectoral Sandpiper and Semipalmated Sandpiper. A hybrid pair of gulls (Glaucous \times Herring Gull) also nested and this appears to be the first definite North American record of such a hybrid nesting. Fourteen additional breeding species expected to be present, based on maps in Godfrey (1966), were not found. Average breeding bird density ($35 \text{ pr} \cdot \text{km}^{-2}$) was comparable to that on Bylot Island, but considerably higher than that measured at other High Arctic sites. Neither average breeding bird densities nor phenologies changed appreciably from year to year despite a late spring melt in 1982. In both years birds began their breeding activities as soon as suitable nesting and feeding habitat became available. A biogeographic analysis based on the occurrence of breeding birds at 25 other sites across the Canadian Arctic indicates that the avifauna at Sarcpa Lake is more similar to those of High Arctic island sites than to those of mainland sites, but includes none of the species whose ranges are mainly within the Arctic Archipelago.

Key words: arctic biogeography, birds, phenology, nesting density, Melville Peninsula, multivariate analysis

RÉSUMÉ. Quarante espèces d'oiseaux ont été observées lors d'études sur le terrain au lac Sarcpa, dans la presqu'île Melville, aux T.N.-O., au cours des étés de 1981 et 1982. Vingt-deux espèces ont fait preuve d'activités de reproduction et les premières observations certaines d'accouplement sur la presqu'île Melville ont été notées pour le goéland bourgmestre, le bécasseau à poitrine cendrée et le bécasseau semi-palmé. Une paire hybride de goélands (bourgmestre et argenté) nicha aussi; leur observation semble être la première du genre en Amérique du Nord. Quatorze autres espèces devaient être présentes et en saison des nids selon les cartes de Godfrey (1966) n'y étaient pas. La densité moyenne des oiseaux en activités de reproduction ($35 \text{ paires par km}^{-2}$) était comparable à celle de l'île Bylot, mais était de beaucoup inférieure à celle d'autres sites dans le nord de l'Arctique. Même suivant une fonte printanière tardive en 1982, ni la densité moyenne d'oiseaux en activités de reproduction, ni la phénologie n'a varié de façon importante d'une année à l'autre. Au cours des deux années, les oiseaux ont commencé leurs activités aussitôt que l'habitat eut permis la construction de nids et l'alimentation. Une analyse biogéographique fondée sur la présence d'oiseaux en saison des nids à 25 autres sites dans l'Arctique canadien a signalé que l'avifaune du lac Sarcpa ressemble plus à celle des sites des îles du nord de l'Arctique qu'à celle des sites sur terre ferme, mais ne comprend aucune des espèces dont le domaine s'étend surtout sur l'archipel arctique.

Mots clés: biogéographie arctique, oiseaux, phénologie, densité des nids, presqu'île Melville, analyse à plusieurs variantes

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INTRODUCTION

The Melville Peninsula is one of the few remaining areas of the Canadian Arctic that has not been the subject of an intensive faunal investigation. This is particularly surprising because the peninsula was one of the first arctic regions visited by white explorers (Parry, 1824). It is also part of a relatively restricted area of mainland in the High Arctic (Bliss, 1977:3). The flora and fauna of the Melville Peninsula can therefore be expected to be more similar to natural communities of the Canadian Arctic Archipelago than to those of adjacent mainland regions.

The only published accounts on the birds of this region are included in Parry's narrative of his second voyage in search of a Northwest Passage (Parry, 1824), in a report on the Fifth Thule Expedition of 1921-24 (Hørring, 1937), in a posthumously published account of the British Canadian Arctic Expedition of 1936-37 (Bray, 1943), and in a paper on the birds of Foxe Basin, based on observations made during Fisheries Research Board surveys in 1955-1957 (Ellis and Evans, 1960). Parry and his crew made casual natural history observations in the vicinity of Igloolik, Quilliam Creek and Fury and Hecla Strait, along the northeast shore of the peninsula, during the winters of 1821-23. Bray spent the spring and summer of 1937 in the same region and often explored the coastal mainland of the peninsula. Both of these accounts pro-

vide only sketchy details of bird sightings and neither gives any information on the extensive upland interior regions of the Melville Plateau. Ellis and Evans (1960) also report on work done in the Igloolik region, from September 1955 to August 1966. During that period, Mogg Bay and North Ooglit Island were also visited but no mainland regions of the peninsula were visited. These authors provide a table summarizing the status of birds observed in each area visited and a few details on spring arrival dates.

In this paper we report on bird observations made during field studies at Sarcpa Lake ($68^{\circ}33'N$ $83^{\circ}19'W$) from 30 May to 21 August 1981, and 26 May to 4 August 1982. We have compiled data on each species observed to provide information on densities, habitat use and the timing of breeding seasons. Also, because Sarcpa Lake is near the southern edge of the High Arctic region as defined by climatic and vegetation characteristics (Bliss, 1977), we compared the breeding avifauna of Sarcpa Lake to those of other known sites in the Canadian Arctic to assess the biogeographic affinities of the breeding birds of this site.

METHODS

Study Area

Our main study area was a 13-km^2 region on the north side of Sarcpa Lake (Fig. 1). Here, the territories of many breeding

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bird pairs were mapped and a large number of individuals from these pairs were colour-banded. Our knowledge of this area was sufficient to allow easy detection of very local densities of birds. We also explored all of the area shown in Figure 1 at some time or another during the two summers. We are confident that within this larger region we recorded the presence of all breeding bird species.

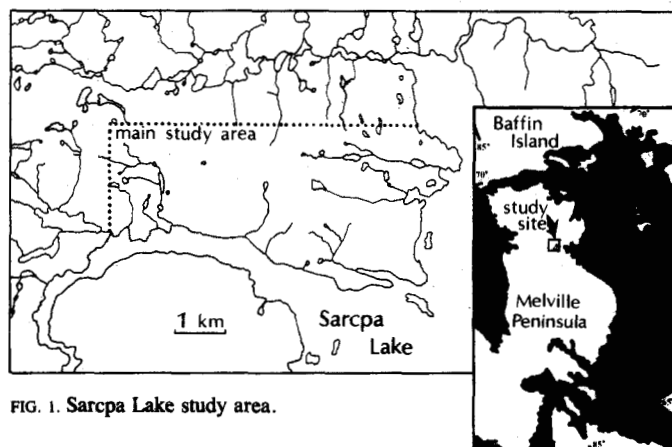


FIG. 1. Sarcpa Lake study area.

Phenologies

We compiled phenologies for the 12 most common breeding birds at Sarcpa Lake in 1981 to show the chronology of events during that breeding season (Fig. 2). For many nests or broods

found we were able to determine approximate dates of egg-laying, hatch and fledging either by direct observation, or by extrapolation using average incubation or fledging periods (Godfrey, 1966). Maximum error from these estimates is about two days. Phenologies for 1982 were similar to those for 1981 except that breeding activities for most species occurred a few days later, as indicated by the shift in clutch completion dates (Table 1).

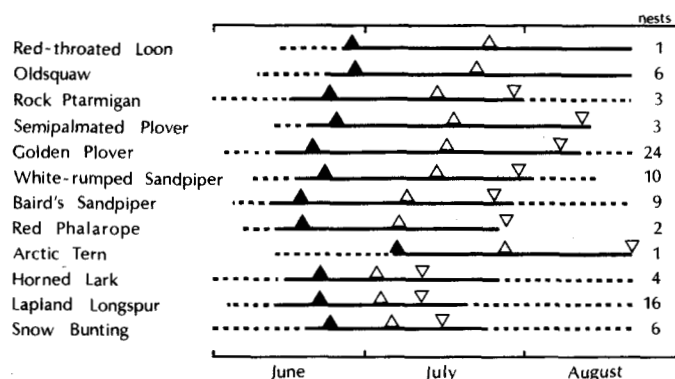


FIG. 2. Breeding phenologies for 12 bird species at Sarcpa Lake in 1981. Solid triangles (▲) are median clutch completion dates; open triangles (△) are median hatch dates; open, inverted triangles (▽) are median fledging dates. Dotted lines at left extend from first arrival to first egg laid in the population; solid lines from first egg to last young fledged; dotted lines at right from last fledged young to last departure. Some species undoubtedly remained at Sarcpa Lake after we left on 21 August 1981, but data are not extrapolated beyond that date. See Methods for further details.

TABLE 1. Total numbers of pairs, nests and broods¹, maximum nest density², and median clutch-completion dates for breeding birds in the main study area at Sarcpa Lake in 1981 and 1982

Species	Estimated Total Pairs ³		Maximum Nest Density (km ⁻²)		Number of Nests or (Broods) Found		Median Clutch-Completion Date (Sample Size)	
	1981	1982	1981	1982	1981	1982	1981	1982
Red-throated Loon	2	1	1	0	1	0	27 June (1)	—
King Eider	1	1	1	1	1	0(1)	—	—
Oldsquaw	15	15	3	3	0(8)	0(6)	28 June(6)	—
Rock Ptarmigan	25	25	3	—	2(6)	4(6)	23 June(3)	29 June(2)
Lesser Golden Plover	65	35	8	4	31	7	20 June(24)	19 June(3)
Semipalmated Plover	4	4	2	2	3	2(1)	24 June(3)	24 June(1)
Semipalmated Sandpiper	0	1	0	1	0	1	—	27 June(1)
White-rumped Sandpiper	20	20	8	5	16(3)	12(3)	22 June(10)	23 June(5)
Baird's Sandpiper	50	50	4	7	12(1)	15(7)	17 June(9)	18 June(7)
Pectoral Sandpiper	0	3	0	1	0	1	—	—
Dunlin	1	0	1	0	1	0	—	—
Red Phalarope	4	2	2	1	2	1	18 June(2)	—
Long-tailed Jaeger	2	2	1	1	1	1	—	23 June(1)
Arctic Tern	2	2	1	0	1	0	6 July(1)	—
Horned Lark	60	60	3	—	5(2)	5	21 June(4)	26 June(3)
Lapland Longspur	130	200	10	23	21	35	21 June(16)	24 June(13)
Snow Bunting	100	100	3	12	8	20	23 June(6)	25 June(15)
Total Nesting Pairs	461	446						
Mean Density (km ⁻²)	35.5	34.3						

¹Number-of-broods indicates only broods for which no nests were found.

²Maximum nest density = largest no. of nests found within any 1-km² area. Density values are given only when they could be determined accurately.

³Main study area = 13 km².

Bird Densities

To give some idea of maximum densities of breeding birds, we report the maximum number of nests and/or broods found within 1 km² (Table 1). In each case we are certain that this represents the actual density in the 1 km² sampled (because it was sampled intensively) but it is possible that some other 1-km² area within our main study area might have had a higher nesting density. We also used maps of territorial pairs, and our general knowledge of the breeding densities across the study area, to estimate the total number of breeding pairs of each species on the entire 13-km² area. We doubt that these estimates are out by more than 10%.

Biogeographic Analysis

Although Sarcpa Lake is located on the mainland it is geographically a High Arctic site (Bliss, 1977) and we supposed that its avifauna might be more similar to avifauna of the Arctic Archipelago than to other mainland areas. To objectively examine the relationship of the bird community at Sarcpa Lake to other arctic sites we plotted nonmetric multidimensional scaling ordinations of the avifauna from a number of arctic locations. The data for these analyses were obtained by

TABLE 2. Arctic avifaunas compared by multidimensional scaling ordinations

Locality	Site No.	No. of Breeding Species	Source
Sarcpa Lake, Melville Peninsula	1	22	This paper
Mackenzie Delta	2	87	Porsild, 1943
Anderson River (mouth)	3	58	Hart, 1959
Banks I.	4	39	Manning <i>et al.</i> , 1956
Mould Bay, Prince Patrick I.	5	18	MacDonald, 1954
Lake Hazen, Ellesmere I.	6	17	Nettleship and Maher, 1973
West-central Ellesmere I.	7	23	Parmelee and MacDonald, 1960
Truelove Lowland, Devon I.	8	22	Hussell and Holroyd, 1974
Prince of Wales I.	9	34	Manning and Macpherson, 1961
Cambridge Bay, Victoria I.	10	44	Parmelee <i>et al.</i> , 1967
Jenny Lind I.	11	35	Parmelee <i>et al.</i> , 1967
Perry River (mouth)	12	39	Hanson <i>et al.</i> , 1956
Adelaide Peninsula	13	35	Macpherson and Manning, 1959
Arctic Bay, Baffin I.	14	22	Renaud <i>et al.</i> , 1979
Southwest Bylot I.	15	32	Van Tyne and Drury, 1959; Kempf <i>et al.</i> , 1978
Pond Inlet, Baffin I.	16	34	Renaud <i>et al.</i> , 1981
Clyde, Baffin I.	17	25	Wynne-Edwards, 1952
Cumberland Peninsula, Baffin I.	18	27	Soper, 1946; Watson, 1963
Cape Searle, Baffin I.	19	29	Wynne-Edwards, 1952
Foxe Peninsula, Baffin I.	20	41	Soper, 1946
Bell Peninsula, Southampton I.	21	44	Sutton, 1932; Parker and Ross, 1973
Salmon Pond, Southampton I.	22	26	Parker and Ross, 1973
Chesterfield Inlet	23	39	Savile, 1951
Churchill, Manitoba	24	92	Jehl and Smith, 1970
Belcher Islands	25	27	Manning, 1976
Cape Henrietta Maria	26	33	Peck, 1972

recording the presence or absence of breeding birds from 25 sites that have been the subject of a major avifaunal investigation (Table 2). The sites were also chosen to represent the widest possible range of north-south and east-west arctic localities in Canada. Unfortunately many of the studies listed in Table 2 did not state how breeding status was determined and the remainder used a variety of criteria as evidence for breeding. To ensure some uniformity in our interpretation of breeding status, therefore, we used the breeding range maps in Godfrey (1966) to compile our presence/absence data, and updated these when data were available from more recent studies (see Table 2). The entire data set comprised 133 breeding species of which only 76 can be considered as arctic breeding birds (i.e. regularly breeding north of the treeline). To show clearly the relationships among the 26 sites based on their arctic bird communities we have displayed ordinations based on those 76 arctic bird species only.

Nonmetric multidimensional scaling (MDS) is a nonparametric ordination technique for the graphic display of similarities between samples (Shepard, 1980). Although quantitative analyses of an MDS plot are not feasible, points which are closer together on the plot are most similar. We compiled ordinations using our complete data set of 76 arctic species and 26 localities simultaneously, using the rectangular matrix option of the ALSCAL procedure (Young, 1980). Since our data matrices were rectangular we used an MDS variant called individual differences (Young, 1980; Gauch *et al.*, 1981) which simultaneously assigns MDS scores to both species and localities. For convenience of interpretation, however, we have displayed species and localities on separate ordination plots. Because MDS analysis of presence/absence data has rarely been used to date, we tested the robustness of our original (133 species) plot by randomly choosing a subset of 100 species for analysis. This sensitivity test had no qualitative effect on the ordinations produced, so we can conclude that our MDS plots represent an accurate configuration. A recent comparative study of nonmetric ordinations (Gauch *et al.*, 1981) demonstrates the usefulness of MDS ordinations for nonparametric ecological data, and recommends the ALSCAL procedure that we have used here.

TERRAIN AND HABITATS

Melville Peninsula

The Melville Peninsula is largely a plateau (called the Melville Plateau) of Archean or Proterozoic granites rising from 50 to 450 m above sea level (Douglas *et al.*, 1972). Around most of the peninsula this plateau rises abruptly from the lowlands within 5 km of the coast and extends across the peninsula. The only extensive area of lowlands is a region of Ordovician rock in the northeast corner of the peninsula. Previous faunal investigations have explored only these lowlands and adjacent islands: areas mainly of shale beaches and marshes.

The plateau itself has a rolling topography with frequent elevation changes of 200 m or more within a few kilometres. The land is generally well drained, with numerous large lakes and rivers. Extensive well-vegetated areas, like our main

study area, do not seem to be very common in this region (based on aerial photographs and our own aerial reconnaissance). Thus our Sarcpa Lake study area is something of an oasis on a granitic landscape. Our explorations north and west from this area, for example, revealed that these granitic regions were often almost devoid of bird life.

Sarcpa Lake Region

Our study area is essentially a large hill rising from lake level (54 m) to 80 m between the north and west shores of the lake (Fig. 1). The north half of this hill is mainly a rugged granitic fell field with large boulders and glacial erratics, dotted with many small ponds, marshy areas and vegetated meadows.

Our main study area, on south- and west-facing slopes of this hill, is well vegetated with large solifluction slopes, several wet meadows, and scattered drier upland ridges. Within this area there are only 14 permanent tundra ponds larger than 1 ha; the largest pond is 3.4 ha. We classified the habitats into the following six major types, accompanied by estimates of their relative representation in the main study area: ponds and small lakes (<5%), wet sedge meadows (10%), solifluction zones (30%), *Dryas*-lichen ridges (20%), boulder fields and exposed rock (25%), and disturbed areas (10%).

CLIMATE AND WEATHER

The climate on the Melville Peninsula is a typical "Polar Climate" characteristic of other High Arctic sites (Koeppel and de Long, 1958).

In 1981 snow melt began in late May and the first patches of bare ground appeared on 1 June. Ponds began to open up on 4 June and all were completely ice-free by 20 June. By 27 June only a few "permanent" snow patches in sheltered areas remained. Much of June was characterized by warm, sunny weather. The mean June temperature (1.7°C) was slightly warmer than the long-term June average from Hall Beach (0.3°C), 85 km east (Environment Canada, 1981). The mean July temperature (4.7°C) was slightly cooler than the Hall Beach average (4.9°C). During the nesting season (mid-June to late July) there were a few short periods (11 days total) of foul weather (sleet, hail, fog and snow) which had an adverse effect on nesting birds. Throughout the summer, rains were infrequent and usually light, except for a large storm in early August when 41.7 mm of rain (more than one fifth of the annual average precipitation) was recorded in one week at Hall Beach (Environment Canada, 1981).

In 1982 spring was about ten days later, as measured by snow melt and breakup in ponds. There were a few bare patches of ground when we first arrived in late May but frequent snow storms prevented permanent bare patches from appearing until 9 June. Ponds began to open up on 14 June and most of the latter half of June was warm and sunny. Melt was rapid and only "permanent" snow patches remained by 27 June. The mean June temperature was 2.4°C. Much of July was also sunny (mean temperature 9.1°C), with infrequent light rains and a severe storm late in the month. The nesting season began

five days later than in 1981 but was virtually free of periods of foul weather.

Fog was recorded on only eleven days in 1981 and on seven days in 1982. Winds, however, are often very strong (up to 9 m·s⁻¹ recorded in 1982) and periods of relative calm (<1 m·s⁻¹) are rare. As expected at this latitude, the sun is up continuously throughout the breeding season from late May until late July.

ANNOTATED LIST OF BIRDS

We include in this list only new information which we think will be useful to other field biologists working in this area. We obtained no information on clutch sizes, nest construction, food habits and behaviour that cannot be found in a number of other studies from High Arctic sites (Drury, 1960, 1961a, 1961b; Hussell and Holroyd, 1974; Parmelee *et al.*, 1967; Parmelee and MacDonald, 1960; Wynne-Edwards, 1952).

Immediately following the name of each species we have designated its abundance and status based on the following definitions. Species' abundances are based on the maximum number of individuals seen on a single day as follows: (1) abundant, >50; (2) common, 11-50; (3) uncommon, 2-10; and (4) rare, 1. For breeding species abundance indicates the number of breeding pairs in our study area. Status categories are: (1) breeder — positive breeding evidence obtained (i.e. active nest or flightless young); (2) transient — passage migrant that regularly passes through the Sarcpa Lake area on either spring or fall migration, or both; (3) visitor — unusual species not expected to occur regularly in the area.

RED-THROATED LOON (Gavia stellata)

Uncommon breeder. In 1981 we found one nest from which a single young was raised; two other breeding pairs suspected. Adults seen regularly flying over study area 13 June - 20 August. Estimating about two months between hatching and fledging, the young loon from the nest would not have been flying until late September (Fig. 2). We expect that any family groups would have moved out of our area well before then, as Red-throated Loons are known to move toward larger bodies of water, and particularly toward salt water, soon after the young hatch (Davis, 1972). No nests found in 1982, but pairs or single birds seen regularly 14 June - 30 July. A group of six loons was seen displaying together on Sarcpa Lake on 27 June.

ARCTIC LOON (Gavia arctica)

Rare breeder. Adult with one large young found 17 August 1981 in the extreme southwest corner of the study area. One or two adults seen on several occasions after 16 June either swimming on Sarcpa Lake or flying overhead.

In 1982 a pair of loons nested on the same lake used in 1981, and we frequently saw a pair of loons on Sarcpa Lake throughout July. First recorded on small ponds on 18 June.

YELLOW-BILLED LOON (Gavia adamsii)

Rare visitor. One adult seen swimming on Sarcpa Lake on 25 July 1982.

SNOW GOOSE (*Chen caerulescens*).

Abundant transient. Recorded 7 June - 3 July 1981 and 6 June - 3 July 1982. Up to 80 birds seen on one day (13 June 1981). In 1981, 19 (6%) of the 330 geese seen were blue phase, and in 1982 five (2%) of the 266 geese were blues. Both ratios of blue:white geese were somewhat higher than the 1% blue phase recorded at a loose colony of about 300 birds in the Roche Bay area, on the coast due east of Sarcpa Lake (Reed *et al.*, 1980). We expect that many of the Snow Geese we saw were associated with the Roche Bay colony.

CANADA GOOSE (*Branta canadensis*).

Uncommon transient. Several single birds and pairs seen flying over 13 - 19 June 1981 and 12 June - 13 July 1982.

KING EIDER (*Somateria spectabilis*).

Abundant transient; uncommon breeder. Flocks of males and females seen regularly 6 - 21 June 1981 and 10 - 27 June 1982. The largest flock contained 300 birds. One or two courting pairs seen regularly on small ponds in the latter part of June and early July in both years. On 1 August 1982 a female with at least three young was seen on a medium-sized pond.

OLDSQUAW (*Clangula hyemalis*).

Common breeder. Oldsquaw nested locally on medium-sized ponds (1-3 ha) but were nowhere very common. In 1981 first arrivals appeared on 9 June, within a day of leads opening up in the ponds on which they eventually nested; by 11 June courting pairs were encountered regularly. Although we found no nests, up to three young broods were seen on one pond and seven broods were recorded in all. Twice we saw apparent creches of 2-3 broods attended by more than one female. The last Oldsquaw was sighted on 7 August, only two weeks after our estimate of peak hatch. Oldsquaws are known to move their broods to large lakes (Palmer, 1976:369) so we expect that some birds probably remained on Sarcpa Lake until late August/early September. From our estimated phenology of this species (Fig. 2), we calculate that average fledging date would be about 30 August (given 35 days between hatching and first flight; Palmer, 1976).

In 1982 the first Oldsquaw appeared on 16 June, two days after the first ponds opened up. No nests were found but six broods were observed.

RED-BREASTED MERGANSER (*Mergus serrator*).

Uncommon visitor. Single birds seen 14 and 20 July 1981, both flying around erratically and calling, suggesting that they may have had young nearby. In 1982 pairs of mergansers seen on 19, 21, 23 and 25 June. Sarcpa Lake is more than 500 km north of the mainland breeding range of this species but is at the same latitude as the breeding range on Victoria and Baffin islands (Parmelee *et al.*, 1967; Renaud *et al.*, 1981). It can be expected to breed on the Melville Peninsula.

ROUGH-LEGGED HAWK (*Buteo lagopus*).

Rare breeder. Two adult birds (both light-phase) first seen 6 June 1981 in the vicinity of an old nest site which had obviously been used for many years. On 9 July this nest contained

three eggs. No other Rough-legged Hawks were recorded, and this pair was seen only within 1 km of the nest site.

In 1982 Rough-legged Hawks, including a dark-phase bird, were regularly seen soaring over the study area between 29 May and 22 July. On 1 August an active nest was found on a small cliff along the Kingora River, 15 km northeast of our study area.

PEREGRINE FALCON (*Falco peregrinus*).

Rare transient. Single birds on 20, 23 June and 21 August 1981, and 5, 12, 15 June and 2 August 1982.

GYRFALCON (*Falco rusticolus*).

Rare transient. Single white-phase birds seen on 24 July and 8 August 1981; none in 1982.

ROCK PTARMIGAN (*Lagopus mutus*).

Abundant breeder. Males began displaying by 5 June in 1981 and continued aerial displays until 19 June. Females began moulting into summer plumage about 4 June. By 1 July both males and females were extremely inconspicuous. We found three nests and five broods during July, and we saw no flightless young after 1 August (Fig. 2).

In 1982 pairs or small groups were encountered in late May and females had already begun to moult. A cold period in early June caused the birds to regroup into flocks; we saw a flock of 65 birds on several days. Intense display activity began on 12 June. We found four nests and six broods.

The seven nests found in both years were in a variety of habitats: small patches of *Cassiope* on exposed rock, *Dryas*-lichen tundra, solifluction zone, and one on a small hummock in wet sedge meadow.

BLACK-BELLIED PLOVER (*Pluvialis squatarola*).

Uncommon transient. Seven birds recorded, 7 - 13 June 1981; all were aggressively chased by Golden Plovers. In 1982, 12 birds observed 11 - 29 June. It seems unlikely that Black-bellied Plovers nest on the upland tundra of the Melville Plateau, but they were at least as common as Golden Plovers on the shale beaches along the east coast at Roche Bay on 8 July 1981, where a nest was found (Lyon, Cartar and Montgomerie, in prep.). They were also recorded breeding on Igloodik Island by Ellis and Evans (1960).

LESSER GOLDEN PLOVER (*Pluvialis dominica*).

Abundant breeder. Recorded daily 2 June - 21 August 1981. First display flights noted 5 June. All nests were on *Dryas*-lichen tundra. All young from the nests that we found should have fledged by 15 August (Fig. 2).

In 1982 recorded daily 6 June - 2 August. Probably because of the relatively late spring there was a noticeable decline in the number of breeding pairs in our area in 1982 (Table 1).

SEMIPALMATED PLOVER (*Charadrius semipalmatus*).

Uncommon breeder. Arrived 12 June 1981 and often seen performing display flights from then until 26 June. Three nests found, all on disturbed areas; these probably represent the entire 1981 breeding population in the study area. Last recorded

14 August, only two days after the last young from these broods would have fledged, by our estimate (Fig. 2).

In 1982 first seen 12 June; display flights noted up to 28 June. Two nests were found and one additional brood observed.

RUDDY TURNSTONE (*Arenaria interpres*).

Rare transient. One bird seen, 14 - 15 June 1981. Not recorded at Sarcpa Lake in 1982 but a large flightless young with one adult was observed at Hall Beach on 4 August. Ellis and Evans (1960) record turnstones as breeding at both Igloodik and Mogg Bay.

RED KNOT (*Calidris canutus*).

Rare transient. Single bird seen with three Lesser Golden Plovers on 6 June 1982.

SANDERLING (*Calidris alba*).

Rare transient. Single birds observed 16 June 1981 and 18 June 1982.

SEMIPALMATED SANDPIPER (*Calidris pusilla*).

Uncommon breeder. Two birds recorded 10 June 1981; one of these was performing a low display flight.

In 1982 first recorded 18 June but not noted again until we found a nest on 30 June; first breeding record for the Melville Peninsula.

WHITE-RUMPED SANDPIPER (*Calidris fuscicollis*).

Common breeder. Recorded daily 7 June - 6 August 1981 and last seen on 14 August (Fig. 2). Nested very locally on solifluction slopes and in wet sedge meadows. Displaying males very prominent 8 - 20 June.

In 1982, white-rumps seen regularly 9 June - 31 July. Displaying males noted 12 June - 15 July.

BAIRD'S SANDPIPER (*Calidris bairdii*).

Abundant breeder. Recorded daily 4 June - 8 August, 1981; last seen 20 August (Fig. 2). Display flights seen regularly 4 - 19 June. Nests mostly on dry *Dryas*-lichen areas, often on ridges. In 1982, first seen 28 May and recorded daily 7 June - 3 August.

PECTORAL SANDPIPER (*Calidris melanotos*).

Uncommon breeder. Single birds recorded 6, 10, 20 and 22 June 1981 but no evidence of breeding.

In 1982 up to three displaying males seen regularly 15 - 21 June. A nest with four eggs found in wet sedge meadow 24 June, but was preyed upon before the eggs hatched. First breeding record for the Melville Peninsula.

PURPLE SANDPIPER (*Calidris maritima*).

Rare visitor. One bird recorded, 11 July 1981. In 1982 single birds or pairs seen 13 - 19 June.

DUNLIN (*Calidris alpina*).

Rare breeder. At least one pair regularly seen displaying and calling after 6 June 1981. One nest found in a wet sedge meadow; preyed upon before hatch. Last recorded on 25 June.

In 1982 single birds seen 14, 16 and 18 June; no evidence of breeding in our area.

RED PHALAROPE (*Phalaropus fulicaria*).

Uncommon breeder. Small flocks arrived 6 June 1981 and courting birds seen regularly for two weeks. Two nests found less than 3 m apart in a wet sedge meadow beside a small pond. Recorded daily until 17 July and last seen on 25 July, about two days before the last young from these nests should have fledged (Fig. 2).

In 1982 first seen on 11 June and up to three pairs seen regularly until 18 June. One nest found in wet sedge meadow close to the 1981 nest sites.

POMARINE JAEGER (*Stercorarius pomarinus*).

Rare visitor. Single light-phase birds seen 22 June 1981, and 24 June and 11 July 1982.

PARASITIC JAEGER (*Stercorarius parasiticus*).

Rare transient. Single bird recorded 15 August 1981. Ellis and Evans (1960) recorded them breeding at both Igloodik and Mogg Bay.

LONG-TAILED JAEGER (*Stercorarius longicaudus*).

Uncommon breeder. Recorded daily 7 June - 21 July 1981. Groups of up to seven adults often seen harassing shorebirds. One nest found on an area of dry *Dryas*-lichen tundra was preyed upon before the eggs hatched. Last recorded on 3 August.

In 1982 seen daily 11 June - 3 August. A nest on *Dryas*-lichen tundra produced one young.

HERRING GULL (*Larus argentatus*).

Rare breeder. The only individual observed was the one mated to the Glaucous Gull noted below, and it was never seen very far from the nest site in either year. Herring Gulls have previously been recorded breeding at Igloodik (Ellis and Evans, 1960) but no details were given. These authors make particular note of their difficulty in distinguishing Herring and Thayer's gulls in the field, so the validity of their record may be somewhat in doubt.

THAYER'S GULL (*Larus thayeri*).

Uncommon visitor. Up to five birds in adult plumage seen often around our camp 6 June - 21 August 1981 and 18 June - 16 July 1982.

GLAUCOUS GULL (*Larus hyperboreus*).

Uncommon breeder. One or two adults seen often around our camp 2 June - 20 August 1981, probably from a nest found about 2 km north of camp. This appears to be the first definite breeding record of this species for the Melville Peninsula.

The other nest in 1981 was 4 km west of camp and was attended by both a Glaucous Gull and a Herring Gull (Fig. 3). The young from this hybrid pair appeared distinctly different at about 3 wk old; one was dark brown and the other was a very light buff colour. Ingolfsson (1970) reports that in Iceland *hyperboreus* × *argentatus* hybrids are common, apparently as

a result of a recent (about 1930) major invasion of *argentatus* into Iceland, where *hyperboreus* was already a common breeding bird. In North America these two species are narrowly sympatric and are apparently reproductively isolated although a few apparent hybrids have been collected, usually on the wintering grounds. All of the apparent North American hybrids examined by Ingolfsson (1970) were morphologically very close to one or the other of the putative parental types. Since the Melville Peninsula is north of the major mainland range of the Herring Gull (Godfrey, 1966) the occurrence of an occasional hybrid pair there may be similar to the situation in Iceland. To our knowledge there is no previous report of a mated *hyperboreus* × *argentatus* pair from North America.

In 1982 the Glaucous × Herring pair again nested in the same place as in 1981. The Glaucous Gull was apparently the first to return; it was seen alone at the frozen and snow-covered nest site on 10 June. One or two adults were seen regularly near our camp 10 June - 24 July.

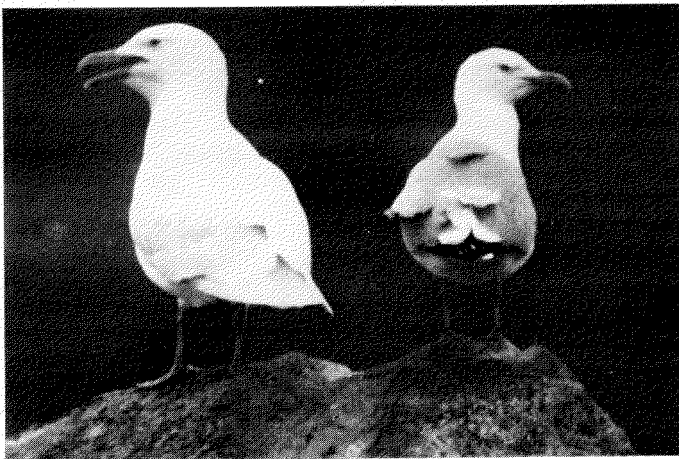


FIG. 3. Mated Glaucous (left) × Herring Gull (right) pair that nested at Sarcpa Lake in both 1981 and 1982.

SABINE'S GULL (*Xema sabini*).

Rare visitor. Single birds flew over on 20 June 1981 and 29 June 1982. Breeding records from Igloolik suggest that they may breed regularly in lowland marshes along the east coast of the peninsula and on N. Ooglit Island (Ellis and Evans, 1960).

ARCTIC TERN (*Sterna paradisaea*).

Uncommon breeder. First recorded 12 June 1981; not again until 21 June, after which one to four birds seen daily through the summer. One nest with two young ~1 wk old found 2 August on a small rocky inlet in Sarcpa Lake, 30 m offshore. These young would have fledged about 21 August (Fig. 2).

In 1982 up to seven birds seen regularly 17 June - 23 July. At least one and possibly two pairs of terns bred on the same island used by the pair of Arctic Loons.

SNOWY OWL (*Nyctea scandiaca*).

Rare visitor. Single birds seen 25 June 1981 and 10, 15 and 29 June 1982. We found no old nesting mounds or pellets to suggest that these birds might breed here, even in good lemming years.

HORNED LARK (*Eremophila alpestris*).

Abundant breeder. Recorded daily 2 June - 21 August 1981, with aerial display songs until 10 July. In 1982, Horned Larks seen daily 28 May - 3 August. All nests found on dry *Dryas*-lichen areas.

COMMON RAVEN (*Corvus corax*).

Uncommon visitor. One or two Ravens heard or seen every few days all summer, 4 June - 19 August 1981, and 5 June - 26 July 1982. There can be little doubt that they breed somewhere in the vicinity of Sarcpa Lake though not within our study area. Bray (1943) found one nest on the coast at Quilliam Creek.

WATER PIPIT (*Anthus spinoletta*).

Uncommon breeder. One or two birds seen 14 June - 9 August 1981, always in the same general area near Sarcpa Lake shore, and flight songs occasionally heard there. On 21 July one adult accompanied by fledged young seen in the same locality.

In 1982 pipits seen occasionally 12 June - 2 July in a few rocky valleys and flight songs frequently heard; no nests or broods found.

WHITE-CROWNED SPARROW (*Zonotrichia leucophrys*).

Rare visitor. Single individual seen around our camp for most of the day on 30 June 1982, where it sang several times. Godfrey (1966) notes a few other "casual" records for this species in the High Arctic, including one record from the Melville Peninsula.

LAPLAND LONGSPUR (*Calcarius lapponicus*).

Abundant breeder. Common everywhere 3 June - 21 August 1981. Male display flights very common in June. Nests found mainly on dry *Dryas*-lichen tundra but occasionally on hummocks in wetter habitats.

In 1982 longspurs first seen 28 May, and common 7 June - 3 August. Numbers were very low until 12 June when a large influx occurred. Despite the late spring, and a concomitant delay in the longspur nesting season by three days, the overall population density of longspurs in 1982 was at least 50% higher than that in 1981 (Table 1).

SNOW BUNTING (*Plectrophenax nivalis*).

Abundant breeder. Although we saw singing male buntings at Hall Beach on 30 May 1981, indicating that they had been there for a while, they did not appear at Sarcpa Lake until 1 June. From then on they were very common until we left on 21 August. Males sang and fought with each other throughout June. Nests were found both in disturbed habitats (old barrels, broken-down buildings, etc.) and in crevices on rock ridges and boulder fields. Increasingly larger flocks of recently fledged young Horned Larks, Lapland Longspurs and Snow Buntings were seen throughout August.

In 1982 Snow Buntings were first recorded on 27 May and remained in flocks until 12 June. Singing males were numerous from 12 June to the end of June. Buntings remained at Sarcpa Lake at least until 28 August (B. Tipping, pers. comm. 1982).

BREEDING PHENOLOGIES

As expected in the brief growing season at a High Arctic site, the breeding phenologies, particularly of land birds, were highly synchronized (Fig. 2). Among the eight species which feed mainly on tundra insects, median clutch-completion dates fell within a one-week period (17 - 24 June) in 1981 and within a 12-day period (18 - 29 June) in 1982 (Table 1). In each year land bird nests were started within a day or two of the appearance of large snow-free patches.

In both years, species which feed largely on the water (Red-throated Loon, Oldsquaw and Arctic Tern) began nesting at least several days later than the land birds. This reflects the later opening up of water bodies, well after large areas of land became snow-free.

The late spring melt was largely responsible for the slight delay in clutch completion in 1982. Note, however, that the three passerine birds (larks, longspurs and buntings) were delayed more (two to five days) than any of the shorebirds (one day at most) and that Rock Ptarmigan apparently suffered the greatest delay in their breeding season owing to the late spring (Table 1).

The general pattern that emerges from these observations is that each species probably nests as early as it can find both a nest site and a place to feed. Because of the interspecific variation in incubation and fledging periods, however, there is considerable variation among species in the dates when young birds begin to move about on the tundra, and when both adults and young begin their fall migration. Of the species we observed at Sarcpa Lake probably only Rock Ptarmigan and Ravens are year-round residents.

BREEDING DENSITIES

In general, the density and dispersion of breeding birds at Sarcpa Lake varied little from year to year (Table 1). There were, however, two notable exceptions; Golden Plover density decreased by about 45% and Lapland Longspur density increased by about 55%. These changes are reflected both in the maximum nest density found in a single km² and in the total number of nests found of each of these species. We believe that the late spring melt in 1982 was the cause of reduced breeding density in Golden Plovers. Of the eight land birds that we studied in detail, Golden Plover has the longest nest initiation-to-fledgling period (Fig. 2). Since numbers of Golden Plovers were high early in the season, it seems likely that many pairs simply did not breed in 1982. This would be expected in late seasons when there might not be enough time to raise a brood before the August snows begin. The change in population density of longspurs is not so easy to account for. Long-term studies at other sites have shown that longspur populations may fluctuate between years by as much as a factor of two (Custer and Pitelka, 1977) either because of locally bad weather which causes shifts in settling patterns or as a result of actual population level changes reflecting previous breeding success. No appreciable changes in population density were noted for any of the other species that we studied.

The overall density of breeding birds at Sarcpa Lake (about

35 pr·km⁻²; Table 1) was similar to that at Bylot Island (33 pr·km⁻²; Van Tyne and Drury, 1959), another Eastern Arctic site close to the same latitude. This density was, however, higher than those recorded for any other High Arctic island site, whether higher or lower in latitude than Sarcpa Lake, but lower than that for any other mainland arctic site studied (see Freedman and Svoboda, 1982 for a summary).

In the two years of our study, Rock Ptarmigan (1.9 pr·km⁻²), Lapland Longspur (10 - 15.4 pr·km⁻²), and Golden Plover (2.7 - 5.0 pr·km⁻²) densities were considerably higher than those recorded at other Eastern Arctic localities. Only one other site that has been studied in the Eastern Arctic has higher densities of Baird's Sandpipers (3.9 pr·km⁻²; 10 pr·km⁻² on Bylot Island — Van Tyne and Drury, 1959), White-rumped Sandpipers (1.5 pr·km⁻²; 3.4 pr·km⁻² on Jenny Lind Island — Parmelee *et al.*, 1968), and Snow Buntings (7.7 pr·km⁻²; 9.8 - 10.6 pr·km⁻² at Alexandra Fjord on Ellesmere Island — Freedman and Svoboda, 1982). Thus the breeding bird community at Sarcpa Lake is characterized by a few common species breeding at relatively high densities, and a larger number of relatively uncommon breeding bird species.

RANGES OF BREEDING BIRDS ON THE MELVILLE PENINSULA

Based on range maps in Godfrey (1966) we expected to find an additional 14 species breeding at Sarcpa Lake: Yellow-billed Loon, Brant (*Branta bernicla*), Snow Goose, Canada Goose, Gyrfalcon, Willow Ptarmigan (*Lagopus lagopus*), Black-bellied Plover, Ruddy Turnstone, Sanderling, Parasitic Jaeger, Thayer's Gull, Sabine's Gull, Snowy Owl, and Common Raven. Although we saw each of these species during 1981 and/or 1982, except Willow Ptarmigan and Brant, there is no evidence that any of them breed in the vicinity of Sarcpa Lake. As noted above in the Annotated List, there are recent breeding records for Snow Goose, Black-bellied Plover, Ruddy Turnstone, Parasitic Jaeger, Sabine's Gull, and Raven from the north and east coastal lowlands. Of these we expect that only Raven might breed in the upland interior of the peninsula. There are much older records for Canada Goose (Preble, 1908) and Sanderling (Bent, 1927) on the east coast but no details are given that would allow us to assess the validity of these records. These species might also be expected to breed on the coastal lowlands but are unlikely in the interior of the peninsula. Parry's party (1824) and Bray (1943) both saw Brant along the northeast coast and at least one Brant was seen near Hall Beach during a summer goose survey (Reed *et al.*, 1980). Ellis and Evans (1960) list Brant as a breeding species at Igloodik but do not provide any information of how this status was determined. Finally, we can find no breeding records whatever (neither published nor in the records of the National Museum of Canada) for Yellow-billed Loon, Gyrfalcon, Willow Ptarmigan, Red Knot, or Thayer's Gull on the peninsula.

BIOGEOGRAPHIC ANALYSIS

The ordination of arctic bird species demonstrates a clear Subarctic-to-High Arctic trend (Fig. 4). The birds in the lower right corner of the ordination include colonial seabirds [e.g.

Thick-billed Murre (*Uria lomvia*), Black-legged Kittiwake (*Rissa tridactyla*)] and species whose ranges are restricted almost entirely to the High Arctic Archipelago [e.g. Common Ringed Plover (*Charadrius hiaticula*), Northern Wheatear (*Oenanthe oenanthe*), Red Knot]. Birds in the centre of the ordination include both High Arctic species that also occur on the northern mainland [e.g. Black-bellied Plover, Lapland Longspur, White-rumped Sandpiper] and species nesting largely on the mainland but as far south as the treeline [e.g. Common Loon (*Gavia immer*), Canada Goose, Red-necked Phalarope (*Phalaropus lobatus*), Semipalmated Sandpiper]. Finally, the upper left corner is composed entirely of species nesting along the treeline, either on the tundra or within the Boreal forest [e.g. Smith's Longspur (*Calcarius pictus*), Whimbrel (*Numenius phaeopus*), Long-billed Dowitcher (*Limnodromus scolopaceus*)].

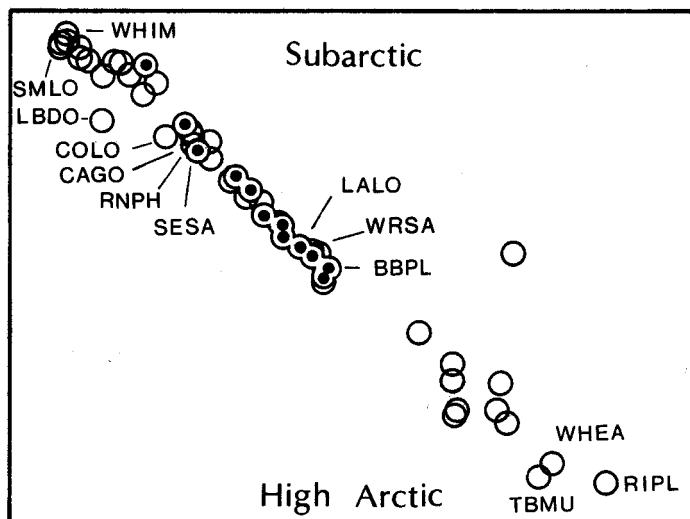


FIG. 4. Nonmetric multidimensional scaling ordination of 76 arctic bird species based on their breeding occurrence at 26 arctic localities. Species breeding at Sarcpa Lake are denoted by \odot . Positions of species used as examples in the Biogeographical Analysis section are indicated by four-letter codes derived from the species' common name as follows: BBPL — Black-bellied Plover, CAGO — Canada Goose, COLO — Common Loon, LALO — Lapland Longspur, LBDO — Long-billed Dowitcher, RNPH — Red-necked Phalarope, RIPL — Common Ringed Plover, SESA — Semipalmated Sandpiper, SMLO — Smith's Longspur, TBMU — Thick-billed Murre, WHEA — Northern Wheatear, WHIM — Whimbrel, WRSA — White-rumped Sandpiper.

The Sarcpa Lake avifauna comprises species whose breeding ranges include both the islands and the mainland, and species nesting primarily on the mainland. Absent are species whose breeding range is restricted to the High Arctic Archipelago. Only one treeline species is represented (Dunlin) and it is a rare component of the Sarcpa Lake bird community.

The ordination of 26 arctic localities based on 76 arctic breeding bird species revealed that the breeding bird community at Sarcpa Lake is more similar to those of Arctic Island sites than to other mainland sites (Fig. 5b).

What have we learned from these ordinations that was not obvious from a simple inspection of breeding-range maps?

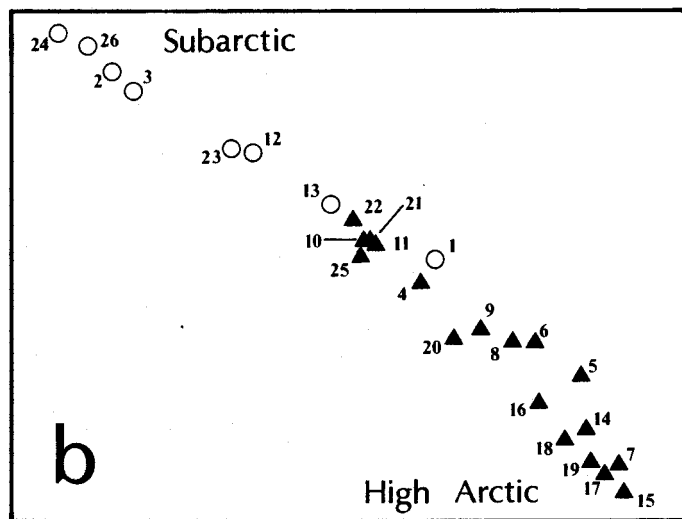
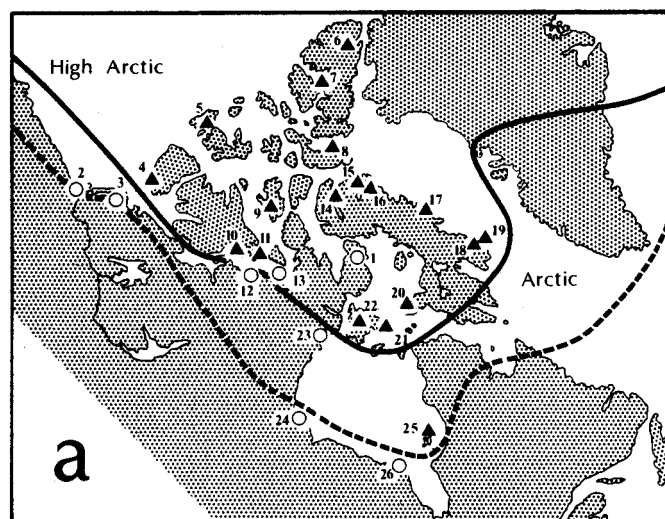


FIG. 5. (a) Arctic localities used in MDS ordinations in relation to traditional High and Low Arctic zones. High Arctic- Low Arctic boundary from Bliss (1977:3); Low Arctic- Subarctic boundary from Polunin (1951).

(b) Nonmetric multidimensional scaling ordination of 26 arctic localities based on the presence/absence of 76 arctic bird species. Localities are numbered as in Table 2; (\blacktriangle) denotes island sites, (\circ) denotes mainland sites.

One major difficulty in making any biogeographic conclusions about an avifauna is that breeding bird communities are often composed of species with very different biogeographic affinities (Renaud *et al.*, 1979), so that an overall assessment can be very subjective. Our MDS ordinations help to make this assessment more objective by treating each community as a single assemblage, and grouping together similar assemblages, regardless of the biogeographic affinities of their component species. We thereby obtain an objective analysis of the distribution of both birds and sites relative to traditional biogeographic zones, and to each other. This analysis could be further enriched by quantifying the abundance of each species present at a locality, but these data are rarely available from arctic studies (see Freedman and Svoboda, 1982).

A comparison of Figures 5a and 5b also reveals that the biogeographic affinities of arctic bird communities are more or

less consistent with arctic biogeographic zones delimited by climatic or vegetation criteria (Bliss, 1977; Polunin, 1951). For example, sites 2, 3, 24 and 26 are all grouped at the Subarctic end of our ordination (Fig. 5b) and all four are clearly at or just south of the Arctic/Subarctic boundary (Fig. 5a). Similarly, sites 12 and 23 are grouped together on the ordination, and these are the only two mainland Low Arctic sites in our sample.

The only mainland sites that fall within the High Arctic zone (Fig. 5a), as defined by Bliss (1977), are the Adelaide Peninsula (site 13) and Sarcpa Lake (site 1). On the ordination (Fig. 5b), site 13 is at the Low Arctic end of putative High Arctic sites, but Sarcpa Lake falls "higher" than at least five other High Arctic localities. We conclude, therefore, that the Sarcpa Lake bird community is a High Arctic avifauna.

The only major discrepancy between our ordination and the zone boundaries shown on Figure 5a is the Belcher Islands (site 25). These islands are well south of the High Arctic/Low Arctic boundary but fall well within the High Arctic grouping on the ordination (Fig. 5b). The High Arctic nature of the Belcher Islands bird community, and presumably also its flora and other fauna, is not surprising considering the maritime cooling influence of Hudson Bay. We suggest, therefore, that the Belcher Islands should be included within the High Arctic zone.

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REFERENCES

- BENT, A.C. 1927. Life histories of North American shorebirds. United States National Museum Bulletin 142. 420 p.
- BLISS, L.C. (ed.). 1977. Truelove Lowland, Devon Island, Canada: A High Arctic Ecosystem. Edmonton: University of Alberta Press. 714 p.
- BRAY, R. 1943. Notes on the birds of Southampton Island, Baffin Island and Melville Peninsula (with comments by T.H. Manning). *Auk* 60:508-539.
- CUSTER, T.W. and PITELKA, F.A. 1977. Demographic features of a Lapland Longspur population near Barrow, Alaska. *Auk* 94:505-525.
- DAVIS, R.A. 1972. A comparative study of the use of habitat by arctic loons and red-throated loons. Ph.D. thesis, University of Western Ontario. 290 p.
- DOUGLAS, R.J.W. (ed.). 1972. Geology and Economic Minerals of Canada. Geological Survey of Canada, Economic Geology Report No. 1. 838 p. + maps.
- DRURY, W.H. 1960. Breeding activities of Long-tailed Jaeger, Herring Gull, and Arctic Tern on Bylot Island, Northwest Territories, Canada. *Bird-Banding* 31:63-78.
- . 1961a. Studies of the breeding biology of Horned Lark, Water Pipit, Lapland Longspur and Snow Bunting on Bylot Island, Northwest Territories, Canada. *Bird-Banding* 32:1-46.
- . 1961b. The breeding biology of shorebirds on Bylot Island, Northwest Territories, Canada. *Auk* 78:176-219.
- ELLIS, D.V. and EVANS, J. 1960. Comments on the distribution and migration of birds in Foxe Basin, Northwest Territories. *Canadian Field-Naturalist* 74:59-70.
- ENVIRONMENT CANADA. 1981. Meteorological observations in northern Canada. *Monthly Record* 66 (6):1-15.
- FREEDMAN, B. and SVOBODA, J. 1982. Populations of breeding birds at Alexandra Fjord, Ellesmere Island, Northwest Territories, compared with other arctic localities. *Canadian Field-Naturalist* 96:56-60.
- GAUCH, H.G. Jr., WHITTAKER, R.H. and SINGER, S.B. 1981. A comparative study of nonmetric ordinations. *Journal of Ecology* 69:135-152.
- GODFREY, W.E. 1966. The Birds of Canada. National Museum of Canada Bulletin No. 169. 428 p.
- HANSON, H.C., QUENEAU, P. and SCOTT, P. 1956. The geography, birds, and mammals of the Perry River region. Arctic Institute of North America, Special Publication No. 3:1-96.
- HÖHN, E.O. 1959. Birds of the mouth of the Anderson River and Liverpool Bay, Northwest Territories. *Canadian Field-Naturalist* 73:93-114.
- HÖRRING, R. 1937. Birds. Report of the Fifth Thule Expedition, 1921-24. 2(6):1-134.
- HUSSELL, D.J.T. and HOLROYD, G.L. 1974. Birds of the Truelove Lowland and adjacent areas of northeastern Devon Island, N.W.T. *Canadian Field-Naturalist* 88:197-212.
- INGOLFSSON, A. 1970. Hybridization of Glaucous Gulls (*Larus hyperboreus*) and Herring Gulls (*Larus argentatus*) in Iceland. *Ibis* 112:340-362.
- JEHL, J.R. and SMITH, B.L. 1970. Birds of the Churchill region, Manitoba. Manitoba Museum of Man and Nature, Special Publication No. 1. 87 p.
- KEMPF, C., HARMEL, X., SITTLE, B. and PIANTANIDA, A. 1978. Notes géomorphologiques, ornithologiques et mammalogiques sur L'île Bylot et la région de Pond Inlet-Canada. Rapport d'expédition 1977. Groupe de Recherche en Ecologie Arctique, Scheltigheim, France.
- KOEPE, C.E. and DE LONG, G.C. 1958. Weather and Climate. New York: McGraw-Hill. 341 p.
- MACDONALD, S.D. 1954. Report on biological investigations at Mould Bay, Prince Patrick Island, N.W.T. National Museum of Canada Bulletin 132:214-238.
- MACPHERSON, A.H. and MANNING, T.H. 1959. The birds and mammals of Adelaide Peninsula, N.W.T. National Museum of Canada Bulletin 161:1-63.
- MANNING, T.H. 1976. Birds and mammals of the Belcher, Sleeper, Ottawa and King George Islands, and Northwest Territories. Canadian Wildlife Service Occasional Paper No. 28. 42 p.
- , HÖHN, E.O. and MACPHERSON, A.H. 1956. The birds of Banks Island. National Museum of Canada Bulletin 143:1-144.
- MANNING, T.H. and MACPHERSON, A.H. 1961. A biological investigation of Prince of Wales Island, N.W.T. Transactions of the Royal Canadian Institute 33(2):116-239.
- NETTLESHIP, D.N. and MAHER, W.J. 1973. The avifauna of Hazen Camp, Ellesmere Island, N.W.T. *Polarforschung* 43:66-74.
- PALMER, R.S. 1976. Handbook of North American Birds. Vol. 1, Loons to Flamingoes. Vol. 3, Waterfowl (concluded). New Haven: Yale University Press. 560 p.
- PARKER, G.R. and ROSS, R.K. 1973. Notes on the birds of Southampton Island, Northwest Territories. *Arctic* 26:123-129.
- PARMELEE, D.F., GREINER, D.W. and GRAUL, W.D. 1968. Summer schedule and breeding biology of the White-rumped Sandpiper in the central Canadian Arctic. *Wilson Bulletin* 80:4-30.
- PARMELEE, D.F. and MACDONALD, S.D. 1960. The birds of west-central Ellesmere Island and adjacent areas. National Museum of Canada Bulletin 169:1-103.
- PARMELEE, D.F., STEPHENS, H.A. and SCHMIDT, R.H. 1967. The birds of southeastern Victoria Island and adjacent small islands. National Museum of Canada Bulletin 222. 229 p.
- PARRY, W.E. 1824. Journal of a second voyage for the discovery of a north-west passage from the Atlantic to the Pacific performed in the years 1821-22-23 in His Majesty's ships the *Fury* and *Hecla* under the orders of Captain William Edward Parry, R.N., F.R.S., and Commander of the Expedition. New York: E. Duyckinck, G. Long, Collins and Co. 571 p.

- PECK, G.C. 1972. Birds of the Cape Henrietta Maria region, Ontario. *Canadian Field-Naturalist* 86:333-348.
- POLUNIN, N. 1951. The real Arctic: suggestions for its delimitation, subdivision and characterization. *Journal of Ecology* 39:308-315.
- PORSILD, A.E. 1943. Birds of the Mackenzie Delta. *Canadian Field-Naturalist* 57:19-35.
- PREBLE, E.A. 1908. A biological investigation of the Athabaska-Mackenzie region. *North American Fauna* 27:1-574.
- REED, A., DUPUIS, P., FISCHER, K. and MOSER, J. 1980. An aerial survey of breeding geese and other wildlife in Foxe Basin and northern Baffin Island, Northwest Territories, July 1979. *Canadian Wildlife Service Progress Notes*, No. 114. 21 p.
- RENAUD, W.E., JOHNSON, S.R. and HOLLINGDALE, P.D. 1979. Breeding birds of Arctic Bay, N.W.T., with notes on the biogeographic significance of the avifauna. *Arctic* 32:122-134.
- RENAUD, W.E., JOHNSTON, W.G. and FINLEY, K.J. 1981. The avifauna of the Pond Inlet region, N.W.T. *American Birds* 35:119-129.
- SAVILE, D.B.O. 1951. Bird observations at Chesterfield Inlet, Keewatin, in 1950. *Canadian Field-Naturalist* 65:145-157.
- SHEPARD, R.N. 1980. Multidimensional scaling, tree-fitting, and clustering. *Science* 210:390-398.
- SOPER, J.D. 1946. Ornithological results of the Baffin Island expeditions of 1928-1929 and 1930-1931, together with more recent records. *Auk* 63:1-24, 223-239, 419-427.
- SUTTON, G.M. 1932. The Birds of Southampton Island. *Memoirs of the Carnegie Museum* 12(2):1-275.
- VAN TYNE, J. and DRURY, W.H. 1959. The birds of southern Bylot Island, 1954. *Occasional Papers of the Museum of Zoology, University of Michigan*, 615:1-37.
- WATSON, A. 1963. Bird numbers on tundra in Baffin Island. *Arctic* 16:101-108.
- WYNNE-EDWARDS, V.C. 1952. *Zoology of the Baird Expedition (1950)*. 1. The birds observed in central and southeast Baffin Island. *Auk* 69:353-391.
- YOUNG, F.W. 1980. The ALSCAL Procedure. In: Lindsey, W.W. and Douglas, S.K. (eds.). *SAS Supplementary Library*. Cary, North Carolina: SAS Institute. 5-18.