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A 16-Year Record of Summer Birds on Truelove Lowland, Devon Island, Northwest Territories, Canada

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ABSTRACT. An annual census of adult birds was conducted on the 43 km^2 Truelove Lowland, Devon Island, N.W.T., Canada, in the summers of 1970-73 and 1978-89. Forty-three species were seen during 16 years. Of these, 18 species bred regularly on or immediately adjacent to the lowland and 10 were occasional breeders. In addition 15 species were visitors. The highest annual number for most breeding species was two to three times that of their lowest numbers, but some regular breeding species had far greater extremes.

Extensions of the breeding range of Pacific Loon (*Gavia pacifica*), Purple Sandpiper (*Calidris maritima*), Wheatear (*Oenanthe oenanthe*), and Water Pipit (*Anthus spinoletta*) to Devon Island are reported. It is suspected that Hoary Redpolls (*Carduelis hornemanni*) and Red Knots (*Calidris canutus*) also nested there once each.

A coefficient of detectibility is presented for the 16 most frequently seen species. Synchronous fluctuations in Snow Bunting (*Plectrophenax nivalis*) and Lapland Longspur (*Calcarius lapponicus*) populations were observed. A possible replacement of Black-bellied Plovers (*Pluvialis squatarola*) by Lesser Golden-Plovers (*P. dominica*) was detected. An abrupt disappearance of all colonies of breeding Arctic Terns (*Sterna paradisaea*) from the lowland was seen in 1989.

Key words: arctic birds, numbers, census, populations, breeding range

RÉSUMÉ. Au cours des étés de 1970 à 1973 et de 1978 à 1989, on a effectué un recensement annuel des oiseaux adultes sur les 43 km^2 de Truelove Lowland, dans l'île Devon située dans les T. N.-O. au Canada. Durant ces 16 années, on a observé 43 espèces d'oiseaux, sur lesquelles 18 se reproduisaient régulièrement sur les basses terres elles-mêmes ou dans les environs immédiats, et 10 étaient des reproducteurs occasionnels. De plus, 15 espèces y étaient de passage. Le nombre annuel le plus élevé pour la plupart des espèces reproductrices était de deux à trois fois supérieur à leur nombre le plus bas, mais pour certaines espèces qui se reproduisaient régulièrement, les extrêmes étaient beaucoup plus grands.

On rapporte aussi l'étendue des aires de reproduction dans l'île Devon, du huart à gorge noire d'Amérique (*Gavia pacifica*), du bécasseau violet (*Calidris maritima*), du traquet motteux (*Oenanthe oenanthe*) et du pipit spioncelle (*Anthus spinoletta*). On soupçonne que les sizerins blanchâtres (*Carduelis hornemanni*) et les bécasseaux maubèches (*Calidris canutus*) ont aussi niché une fois à cet endroit.

On présente un coefficient de détectabilité pour les 16 espèces observées le plus fréquemment. On a remarqué des fluctuations synchroniques chez les populations du bruant des neiges (*Plectrophenax nivalis*) et du bruant lapon (*Calcarius lapponicus*). On a émis l'hypothèse d'un remplacement possible des pluviers argentés (*Pluvialis squatarola*) par les pluviers dorés d'Amérique (*P. dominica*). En 1989, on a observé une disparition soudaine dans les terres basses de toutes les colonies reproductrices de sternes arctiques (*Sterna paradisaea*).

Mots clés: oiseaux arctiques, nombres, recensement, populations, aire de reproduction

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INTRODUCTION

Many of the previous studies of birds breeding in the High Arctic have been cited by Bliss *et al.* (1973), Freedman and Svoboda (1981, 1982) and Elander and Blomqvist (1986). Hussell and Holroyd (1974) provided an annotated list of birds observed on Truelove Lowland, Devon Island, Northwest Territories, Canada, in the summers of 1966-69. Renaud *et al.* (1979) considered the breeding birds found during 1976 on a northern Baffin Island site. Custer and Pitelka (1977) followed breeding densities of the Lapland Longspur (*Calcarius lapponicus*) for seven years near Barrow, Alaska. Ouellet (1990) updated avian zoogeography in the Arctic Islands.

From 1970 to 1973 and again from 1978 to 1989, we carried out a complete summer bird census of Truelove Lowland (75°41′N, 84°35′W), one of five contiguous lowlands on the northeastern coast of Devon Island (Fig. 1). The census was initiated in conjunction with other research (Pattie, 1977) and continued when it became apparent the results were unique. This paper lists 16 years of bird census results from that High Arctic site.

STUDY AREA

Devon Island has no permanent human inhabitants. The 43 km^2 Truelove Lowland is a largely undisturbed and geographically discrete nesting site for birds. It is isolated from other nesting areas to the north, west, and most of the south by a 24 km long ocean shoreline and to the east and south by steep slopes or cliffs that rise 300 m to a barren plateau virtually uninhabited by birds (Bliss, 1977).

Post-glacial rebound following ice retreat brought the lowland above sea level. The upper limit of the 43 km^2 census area beside the plateau lies at 76 m a.s.l. Here an eroded upper marine limit dated at ca. 9450 years B.P. (Barr, 1971) is easily recognizable. Most of the census area is no higher than 25 m a.s.l. A combination of moraines and raised beach ridges impedes drainage and produces a multitude of shallow lakes covering 9.5 km^2, or about 22%, of the lowland. The low, raised beaches and moraines form a series of approximately 20 "steps." These are breached by only five small streams that drain the lakes and saturate several wet meadows. Wet meadows are also maintained by meltwater flowing from the plateau to the east.

Raised beaches, moraine tops, and barren rock outcrops are the driest habitats and together cover 13% of the lowland, rock outcrops supporting dwarf heather and arctic willow cover 12%, cushion plant-lichen and cushion plant-moss habitats cover 8%, and lichen barren on limestone pavement covers 4%. Saltwater marsh present along the coast covers no more than 0.5% of the area. The remaining 40.5% is moist meadow (Muc and Bliss, 1977).

The interspersion of many different ecosystems and the abundance of ecotones are a dominant feature of Truelove Lowland. Here the land meets the sea and abundant fresh

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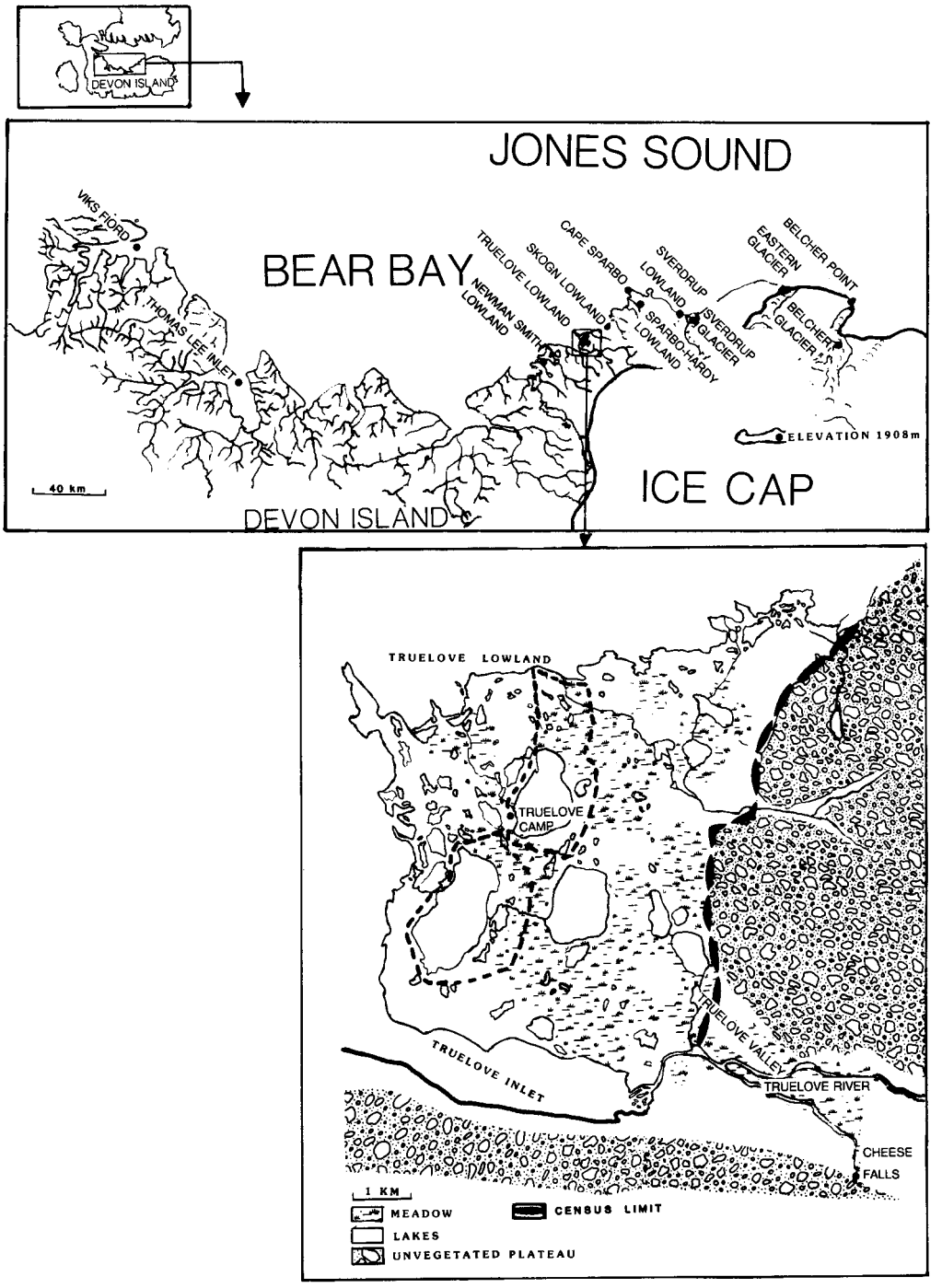

FIG. 1. Detail of the relationship of Truelove Lowland to neighbouring lowlands. The inset shows the major physiographic features of the study area. The dashed lines show the location of two sample transects censused repeatedly (see text).

water provides a multitude of shore environments. The extensive wet and moist meadows grade up to the xeric beach ridge tops and down to brackish bays. Canadian shield granitic rock outcrops come up against the sedimentary limestone. Pushed beaches and alluvial fans of boulders end abruptly in moist, vegetated meadows. The high, largely unvegetated plateau with its cap of permanent ice drops abruptly to the snow-free, relatively verdant lowland.

Truelove Lowland is in a very interesting cusp between eastern and western and Low and High Arctic populations of migrant birds. Eastern species of Eurasian origin, based upon band returns, include the Brant (*Branta bernicla*) and Arctic Tern (*Sterna paradisaea*). Others that may have arrived from Greenland include the Hoary Redpoll (*Carduelis hornemanni*) and races of Red Knot (*Calidris canutus*) and Ringed Plover (*Charadrius hiaticula*). The Yellow-billed Loon (*Gavia adamsii*) and the Pacific Loon (*G. pacifica*) have western origins. The Glaucous Gull (*Larus hyperboreus*),

White-rumped Sandpiper (*Calidris fuscicollis*), and Baird's Sandpiper (*C. bairdii*) were all recognized by Renaud *et al.* (1979) as High Arctic species. These same authors considered the Water Pipit (*Anthus spinoletta*), Lesser Golden-Plover (*Pluvialis dominica*), and Pectoral Sandpiper (*Calidris melanotos*), all of which nested at least once on Truelove Lowland, to be Low Arctic species.

METHODS

Each annual census took 3-16 days, depending upon weather and the numbers of observers. One to nine observers followed established routes set 100 m apart. All of the counts took place between mid-July and early August (Table 1). The mean distance walked each year was 349 km (S.D. 44) and the mean time to complete the annual census was 132 hours (S.D. 23). Since the large lakes were scanned from their shores, the distance walked each year was considerably less than the theoretical 430 km that would have been walked had the 9.5 km^2 of lakes not been present.

The routes followed a spiral pattern moving inward from the outer limits of the lowland. During the first years the person on the innermost line recorded landmarks and took the outermost line next time; adjacent observers used him as a guide. Although the census area remained the same, during 1978-89 the individual routes were drawn on the detailed map of the lowland published by Muc and Bliss (1977). We found it easier to follow the map than to keep a constant pace and orientation with the adjacent observer. After 1978 the lowland was divided into a north and south segment and, while still worked from the outside in, the south half was censused before the northern segment. Where practical, the camp vicinity served as the start and terminus of each observer's daily route (Fig. 1).

Repeated counts on a sample 5 km transect in 1972 revealed that birds were least visible during periods of precipitation, high winds, and between 2100 and 0400 hours. Light was not a factor since at this latitude there is no sundown from 20 April until 17 August. Therefore, census counts were customarily conducted between 0800 and 1900 hours Central Daylight Saving Time and were delayed or terminated if there was precipitation or winds of more than 15 knots. Because weather conditions and availability of observers varied, the dates for initiating and completing the census were not constant, but all counts were completed within the 15 July and 10 August extremes. Although young birds were enumerated, only adult bird records were used to prepare Table 1.

We attempted to identify and record the species, sex, and age of each bird seen. An estimate of the right-angle flushing distance in 10 m intervals from the line of march was also recorded. Proximity to and communication with other observers prevented most count duplication. Because individual birds of different species were not visible to the same extent during censusing, Emlen's (1971) "coefficient of detectibility" (CD) was determined for the most abundant species (Table 2). The CD is an estimate of the fraction of each species present that was actually counted and permits estimates of total numbers and densities. Because numerous sightings in each interval at right angles to the line of march were needed in CD calculations, we used 10 m intervals to 100 m, lumped 100-200 m observations, and pooled many years' data. We calculated CDs only for species seen at least 150 times and rounded off CDs to the nearest tenth.

To test the repeatability of our counts, two routes, a southern one of 9.5 km and a northern one of 10.4 km, were censused at two- or three-day intervals ten times in 1982 and eight times in 1983. Dashed lines in Figure 1 show the location of these transects. These routes covered a portion of each major habitat found on the lowland. Over the years we also conducted transect counts on the contiguous lowlands to see if Truelove Lowland was a reasonably representative lowland.

In 1981 we conducted a strip census on the 12 km^2 Alexandra Fiord lowland on Ellesmere Island immediately following a breeding pairs count on that lowland by Freedman (Freedman and Svoboda, 1981). Freedman's count took 129 man-hours of observation; ours was completed in 23. When we applied CDs our results ranged from identical to differences of no more than 10% for any species for which Freedman counted at least 10 birds. On this basis it is safe to say that on arctic lowlands the strip census methods we used yielded comparable results in much less time than a breeding pairs census.

RESULTS

The number of adults seen in the annual censuses and their breeding status appear in Table 1. Records obtained at other times of occasional visitors or of scarce or cryptic species that were overlooked during the censuses are marked with an asterisk. These supplemental records were not included in the annual totals but serve to indicate an occasional presence.

Breeding range extensions to Devon Island were confirmed by finding nests with eggs or recently fledged young of Pacific Loons, Purple Sandpipers (*Calidris maritima*), Wheatears (*Oenanthe oenanthe*), and Water Pipits. Despite a failure to find nests or fledglings, distraction displays lead us to suggest that both Hoary Redpolls and Red Knots nested at least once. These are also breeding range extensions but, since eggs or young were not found, they appear in Table 1 as visitors rather than occasional breeders.

Although Pacific Loons were first seen in 1985, their first attempt at breeding was in 1988, when they succeeded in hatching young. In 1989 they nested again on the shore of the same lake that lies adjacent to the sea near the mouth of the Truelove River. Red-throated Loons (*Gavia stellata*) had never been seen to nest beside this lake. A single pair of Purple Sandpipers hatched young on the rocky limestone shingle of Rocky Point on the northwestern point of the lowland in 1989. During each of three years the Wheatears nested in the same rock outcrop near where our census limit intersected the Truelove River. Sightings of Wheatears by Hussell and Holroyd (1974) were within a few hundred metres of this site. The Water Pipit nest found protected by an overhanging rock in a moist meadow in 1984 was 1 km upriver from the mouth of the the Truelove River. The site where we suspected the Hoary Redpolls nested was about 3 km upriver from the mouth of the Truelove River. The suspected Red Knot nest site was along a high dry beach ridge about 2 km below the mouth of the Truelove River.

Large, noisy birds, birds that customarily sat on water, or those with a contrasting colour or pattern were easiest to see and thus had the largest CDs, whereas small, quiet, cryp-

TABLE 1. Synopsis of annual adult bird census on Truelove Lowland, Devon Island, N.W.T., 75°41'N, 84°35'W (actual count)

Species	1970 22 Jul-6-Aug	1971 2-10 Aug	1972 16-21 July	1973 21-29 July	1978 18-29 July	1979 16-21 July	1980 18-24 July	1981 16-25 July	1982 16-22 July	1983 16-20 July	1984 15-22 July	1985 16-20 July	1986 16-19 July	1987 16-19 July	1988 16-18 July	1989 15-19 July
Yellow-billed Loon V *Gavia adamsii*	0	0	0	0	0	0	0	1	0	1*	0	0	0	1	0	0
Red-throated Loon R *Gavia stellata*	55	107	52	72	108	76	92	68	64	76	86	71	40	34	44	85
Pacific Loon O *Gavia pacifica*	0	0	0	0	0	0	0	0	0	0	0	2*	3	0	2	2
Northern Fulmar V *Fulmarus glacialis*	0	0	0	0	0	0	0	1*	0	0	0	0	0	0	0	0
Brant O *Branta bernicla*	0	0	4	0	0	0	0	0	0	0	2	0	0	2	0	0
Snow Goose R *Chen caerulescens*	12	10	0	12	2	0	0	0	8	6	8	8	2	1	11	8
Oldsquaw R *Clangula hyemalis*	172	142	225	297	305	211	198	232	214	189	249	152	191	189	196	247
Common Eider R *Somateria mollissima*	12	7	166	63	79	76	4	77	46	42	19	10	4	30	13	32
King Eider R *Somateria spectabilis*	51	4	20	41	58	42	25	75	32	37	5	1	12	21	25	24
Unidentified female eider *Somateria* sp.						45	34									
Rock Ptarmigan R *Lagopus mutus*	3	10	0	2	0	0	1	2*	1	3	2*	1	3	3	1	2
Peregrine Falcon R *Falco peregrinus*	0	0	0	0	0	0	3	3*	1	6*	1*	3*	2	4*	0	5*
Lesser Golden-Plover R *Pluvialis dominica*	2*	0	0	0	6	4	28	23	13	9	14	34	25	22	33	20
Black-bellied Plover R *Pluvialis squatarola*	12	10	31	23	24	31	24	24	18	16	9	18	11	4	11	4
Ringed Plover O *Charadrius hiaticula*	0	2	0	0	0	0	0	3*	0	0	0	0	0	0	0	0
Ruddy Turnstone R *Arenaria interpres*	0	18	22	13	2	0	13	6	31	23	11	8	13	37	34	2
Red Knot V(O?) *Calidris canutus*	0	1	16	0	25	0	0	3	11	24	11	23	11	65	16	6*
Purple Sandpiper O *Calidris maritima*	5	9	20	7	24	0	0	3	0	0	0	2*	0	0	1	2*
Pectoral Sandpiper O *Calidris melanotos*	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
White-rumped Sandpiper R *Calidris fuscicollis*	5	6	25	14	14	5	40	25	31	49	68	15	63	22	3	13
Baird's Sandpiper R *Calidris bairdii*	35	68	13	24	95	129	111	187	251	397	210	197	133	189	239	167
Sanderling V *Calidris alba*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Dowitcher V *Limnodromus* sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Red Phalarope R *Phalaropus fulicarius*	6	6	15	41	51	2	6	21	11	16	16	10	2	15	7	3*
Pomarine Jaeger V *Stercorarius pomarinus*	0	0	0	0	0	0	0	0	0	0	0	0	1*	0	0	0
Parasitic Jaeger R *Stercorarius parasiticus*	24	8	10	11	30	17	7	14	9	11	8	6	12	7	4	8

(continued)

TABLE 1 — Continued

Species	1970 22 Jul-6-Aug	1971 2-10 Aug	1972 16-21 July	1973 21-29 July	1978 18-29 July	1979 16-21 July	1980 18-24 July	1981 16-25 July	1982 16-22 July	1983 16-20 July	1984 15-22 July	1985 16-20 July	1986 16-19 July	1987 16-19 July	1988 16-18 July	1989 15-19 July
Long-tailed Jaeger O *Stercorarius longicaudus*	88	13	22	62	111	124	147	105	72	33	58	43	32	50	35	38
Thayer's Gull V *Larus thayeri*	0	0	0	0	0	0	0	0	3*	0	0	0	0	0	0	0
Glaucous Gull R *Larus hyperboreus*	57	62	30	40	67	92	109	115	100	54	119	67	83	88	85	91
Ivory Gull V *Pagophila eburnea*	3*	1*	0	0	0	0	0	0	0	1*	7*	2*	0	0	0	0
Black-legged Kittiwake V *Rissa tridactyla*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Sabine's Gull V *Xema sabini*	0	0	1	0	1	0	0	0	0	0	1*	0	0	0	0	0
Arctic Tern R *Sterna paradisaea*	57	93	51	105	83	65	91	140	90	93	119	87	74	45	64	1
Black Guillemot V *Cepphus grylle*	2*	2*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Snowy Owl V *Nyctea scandiaca*	0	0	0	0	1	0	0	0	1*	1	0	0	0	1*	0	0
Horned Lark O *Eremophila alpestris*	0	0	0	0	5	5	9	2	0	10	2	2	0	0	0	0
Barn Swallow V *Hirundo rustica*	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Water Pipit O *Anthus spinoletta*	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Common Raven O *Corvus corax*	0	5	2	0	6	2	0	1	2*	2	3	1	1	4	2*	2
Wheatear O *Oenanthe oenanthe*	1*	0	0	0	0	0	8*	2*	0	0	0	0	0	0	0	0
Hoary Redpoll V (O?) *Acanthis hornemanni*	0	0	0	0	1*	0	0	1*	0	0	1*	0	0	0	0	0
Savannah Sparrow V *Passerculus sandwichensis*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Lapland Longspur R *Calcarius lapponicus*	62	50	41	49	101	87	76	154	153	193	224	207	141	74	83	78
Snow Bunting R *Plectrophenax nivalis*	221	74	138	307	377	241	230	421	645	721	568	551	604	356	220	57
Total Adult Birds	877	709	904	1480	1575	1255	1247	1697	1803	2007	1614	1513	1462	1259	1127	881

* Birds seen on study area outside of census periods; not included in totals.
R Regular breeding species.
O Occasional breeding species.
V Visiting species.

TABLE 2. Coefficients of detectibility for Truelove Lowland birds calculated from census period data

Species	Coefficient of detectibility (CD)
Red-throated Loon *Gavia stellata*	0.9
Oldsquaw *Clangula hyemalis*	1.0
Common Eider *Somateria mollissima*	1.0
King Eider *Somateria spectabilis*	0.8
Lesser Golden-Plover *Pluvialis dominica*	0.9
Black-bellied Plover *Pluvialis squatarola*	0.9
Ruddy Turnstone *Arenaria interpres*	0.9
White-rumped Sandpiper *Calidris fuscicollis*	0.5
Baird's Sandpiper *Calidris bairdii*	0.9
Red Phalarope *Phalaropus fulicarius*	0.9
Parasitic Jaeger *Stercorarius parasiticus*	0.6
Long-tailed Jaeger *Stercorarius longicaudus*	0.6
Glaucous Gull *Larus hyperboreus*	0.8
Arctic Tern *Sterna paradisaea*	0.7
Lapland Longspur *Calcarius lapponicus*	0.6
Snow Bunting *Plectrophenax nivalis*	0.7

tically patterned species had the smallest CDs (Table 2). Table 3 provides an indication of the constancy with which birds were encountered during repeated counts along the two routes shown as dashed lines in Figure 1. These counts together with the CDs provided indications of short-term variation in the presence or visibility of different species. Data obtained from the test routes for the two periods immediately preceding the annual census are presented in Table 3. Results from the week immediately before the annual census were our first choice for comparative purposes. After 25 July adult Snow Buntings and Lapland Longspurs began molting remiges and rectrices, and the test route data confirmed that they then became secretive (Green and Summers, 1975; Pattie, 1977). This behaviour may have reduced the numbers of these two species counted in 1970, 1971, 1973, and 1978, when the censuses were not completed until molt was under way.

Annual variation in total numbers of birds of all species (Fig. 2) was tested with a correlation matrix among years. The 1981 results correlated strongly ($r = 0.92$, $n = 16$, $\alpha = 0.001$) with the results of all years except 1971, 1972, and 1973. The lowest correlations were between those of 1972 and the other years.

TABLE 3. Results of duplicate counts along specific transects

	9.5 km southern route				10.4 km northern route			
	1982		1983		1982		1983	
	12 July	14 July	10 July	13 July	12 July	14 July	12 July	15 July
Red-throated Loon *Gavia stellata*	4	5	14	12	4	4	7	7
Oldsquaw *Clangula hyemalis*	41	30	18	20	7	7	18	18
Common Eider *Somateria mollissima*	2	3	0	12	2	11	2	0
King Eider *Somateria spectabilis*			3	2	2	2	3	12
Lesser Golden-Plover *Pluvialis dominica*			4	5				
Black-bellied Plover *Pluvialis squatarola*	1	5	10	10	1	1		
Ruddy Turnstone *Arenaria interpres*			3	8	1	0		
Red Knot *Calidris canutus*			0	2				
White-rumped Sandpiper *Calidris fuscicollis*	0	3	4	8	1	1		
Baird's Sandpiper *Calidris bairdii*	1	7	3	6	0	2	2	1
Red Phalarope *Phalaropus fulicarius*			1	0				
Parasitic Jaeger *Stercorarius parasiticus*					1	2	2	3
Long-tailed Jaeger *Stercorarius longicaudus*	5	15	5	10	3	5	4	8
Thayer's Gull *Larus thayeri*			2	1				
Glaucous Gull *Larus hyperboreus*	9	14	7	6	4	2	3	1
Arctic Tern *Sterna paradisaea*	20	25	34	37	4	3	3	0
Snowy Owl *Nyctea scandiaca*					0	1		
Common Raven *Corvus corax*							0	4
Lapland Longspur *Calcarius lapponicus*	5	11	16	21	8	11	9	7
Snow Bunting *Plectrophenax nivalis*	8	11	22	24	11	12	29	25

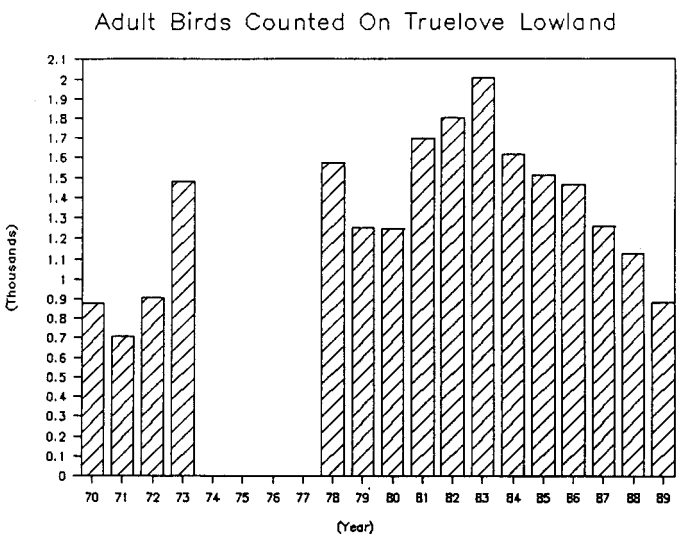

FIG. 2. Total adult birds counted during the annual censuses on Truelove Lowland, Devon Island.

Lapland Longspur and Snow Bunting (*Plectrophenax nivalis*) populations appeared to fluctuate synchronously (Fig. 3). This was tested using the Spearman rank correlation (r_s). The result indicated a high degree of synchrony (r_s = 0.83, α = 0.001, n = 16). On the other hand, populations of Black-bellied Plovers (*Pluvialis squatarola*) and Lesser Golden-Plovers illustrated negative correlation for the years both were present in the census (Fig. 4) (r_s = −0.533, α = 0.05, n = 12) as well as for the entire 16 years (r_s = −0.443, α = 0.05, n = 16).

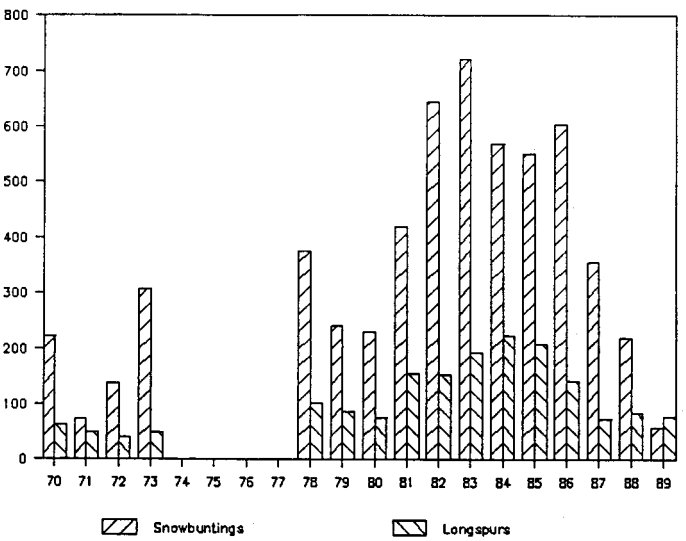

FIG. 3. Comparative abundance of adult Snow Buntings and Lapland Longspurs showing pattern of population fluctuation.

DISCUSSION

Density and Diversity

The density and diversity of birds listed in Table 1 were far lower than one would find in a temperate clime with comparable habitat diversity. But Truelove Lowland had far higher bird densities and much greater species diversity than found

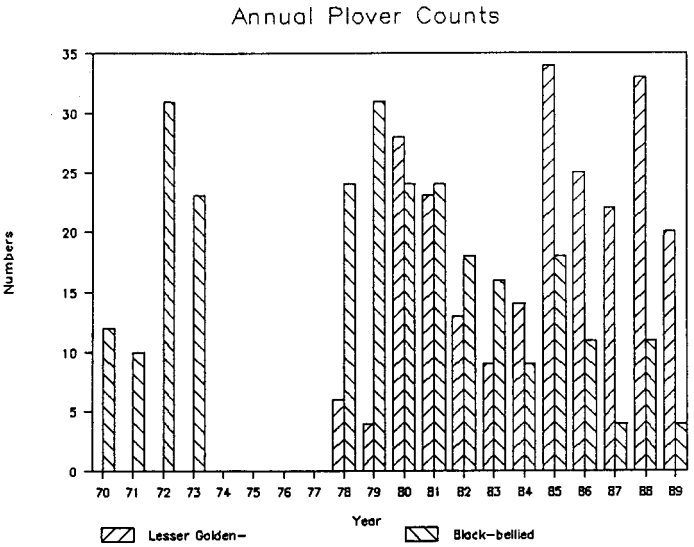

FIG. 4. Pattern of abundance of two species of plovers showing how the apparent invasion of Lesser Golden-Plovers and their population growth appears to coincide with a decline in Black-bellied Plover populations.

on the other four nearby lowlands. The increased edge effect, interspersion, habitat diversity, moister conditions brought about by the comparatively low relief and blocked drainage, and greater vegetative cover on Truelove are the most visible causes of the differences among the lowlands. Based upon plant associations, a warmer microclimate must exist near the mouth of the Truelove River. This may be the result of reflection of the sun by nearly intersecting cliffs. It was in this area that all but one of the nests representing breeding range extensions were found.

The coefficients of detectibility reported in Table 2 may now be used to estimate actual numbers from data obtained on transects walked in other parts of the High Arctic. They also allow calculation of annual population estimates of the 16 most frequently counted species in this study. In some cases it was necessary to pool several years' data to establish the CDs. Since CDs could not be calculated for all species, they were not used to prepare Table 1.

Counts of species with (1) a high proportion of territorial pairs varied less than counts of species with (2) a low proportion of territorial pairs and/or many wandering flocks of nonbreeders. Examples of the first category include the Red-throated Loon, Oldsquaw (*Clangula hyemalis*), Arctic Tern, Lapland Longspur, Snow Bunting, and Black-bellied and Lesser Golden-Plovers. The second category includes King Eiders (*Somateria spectabilis*), Common Eiders (*S. mollissima*), Glaucous Gulls, and Long-tailed Jaegers (*Stercorarius longicaudus*). Census results were thus most meaningful for species with fewer wandering nonbreeders.

Fluctuations in Numbers

After 1978, when we adopted a uniform mid-July timing for the census, there was only a slightly more than twofold variation in the total numbers of all adult birds, but the long-term amplitude of fluctuation in numbers varied among species. Such aquatic species as the Arctic Tern, Red-throated Loon, and Oldsquaw exhibited only a threefold extreme in numbers until 1989, when the entire breeding population of Arctic Terns failed to appear. Breeding populations of Baird's Sandpipers and Red Phalaropes (*Phalaropus fulicarius*)

exhibited perturbations of 30 and 25 times respectively of their low numbers. Common Eiders, King Eiders, Red Knots, and Long-tailed Jaegers, which in some years consisted mostly of mobile flocks of nonbreeders, also often revealed extreme annual fluctuations. Other regularly seen species had long-term fluctuations between 3 and 25. Not all populations rose and fell synchronously.

Snow Bunting populations may have been depressed by some scientific collecting prior to 1970 and more intensive collecting in conjunction with bioenergetic studies in 1970-72. We saw evidence of Inuit hunting birds on the lowland only twice during the study but, based upon the few spent cartridges found, assumed it unlikely that they took many birds.

Competition among Plovers

The driest sandy or gravelly beach ridges or moraine tops provided nesting sites for Black-bellied Plovers. Adjacent, slightly hummocky vegetated areas on the sides of the lower ridges were used by Lesser Golden-Plovers. The Black-bellied and Lesser Golden-Plover populations are difficult to analyze. Black-bellied Plovers were initially more numerous but, as the Lesser Golden-Plovers became more numerous, Black-bellied Plover numbers declined. The Spearman rank correlation analysis showed negative correlation for the two populations at the 10% level of confidence, suggesting species replacement or competition may have been taking place.

Hussell and Holroyd (1974) saw seven adult Lesser Golden-Plovers and reported one nest in 1967. They saw single birds, but no evidence of breeding, on five dates in 1966, 1968, and 1969. None was seen in 1970-73, although a pair was reported in late June 1970. From 1978 through 1988, however, nesting occurred each year. Their numbers increased substantially in 1980. That year Lesser Golden-Plovers were seen pursuing Black-bellied Plovers on three occasions. Since 1980, there have been further observations of Lesser Golden-Plovers pursuing Black-bellied Plovers. In no instance was a Black-bellied Plover seen pursuing a Lesser Golden-Plover. These observations suggest competition. Lesser Golden-Plovers actively defended dry beach ridges adjacent to their own nest sites against Black-bellied Plovers that nested only on the dry beach ridges. Both species occupied adjacent wet meadow areas after hatching. The frequent nesting by Lesser Golden-Plovers at this latitude either calls into question the placement of this species in the category of a Low Arctic species by Renaud *et al.* (1979) or it suggests that the transition zone between Low and High Arctic is much broader than they propose. It is also possible that the transition zone has moved north since 1976.

SUMMARY

The work reported here provides a long-term record of bird populations at a discrete High Arctic site. Breeding range extensions for 4 species were documented. Populations of Snow Buntings and Lapland Longspurs fluctuated synchronously during the 16 years. Those of Lesser Golden-Plovers and Black-bellied Plovers exhibited an inverse relationship after the Lesser Golden-Plovers reoccupied the lowland. The total magnitude of long-term variation in numbers of adult birds was between two and three times. Adult numbers of some species remained relatively constant from year to year but those of other species fluctuated by much greater magnitudes.

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