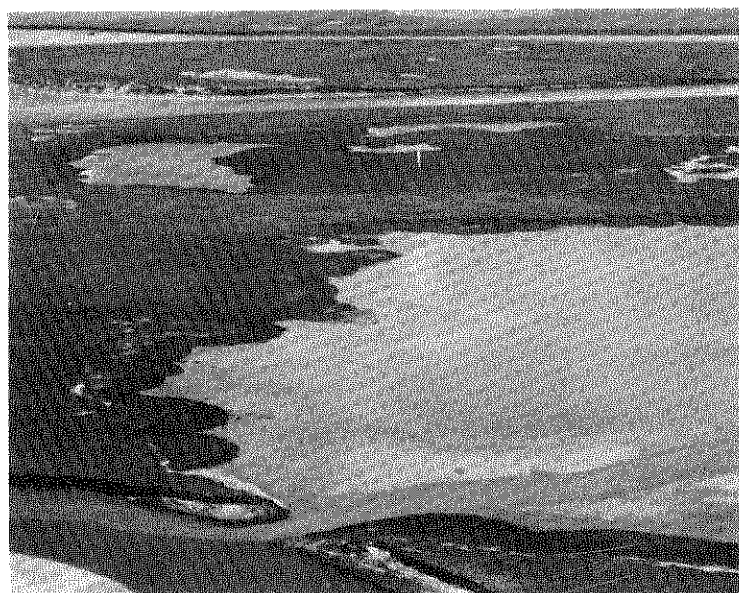


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Use of Wetland Habitats by Birds in the National Petroleum Reserve - Alaska



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COVER PHOTOS

Left: Aerial view of Alaska's Arctic Coastal Plain in July 1979. Lake orientation is about 10 degrees west of true north (top). Note the ice floes on Teshekpuk Lake (lower left). *Photo by NASA Ames.* Lower right: Aerial view of the Meade River near its delta on Alaska's Arctic Coastal Plain. Note the large lake (center) that has been breached by a channel (lower left) of the river.

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**USE OF WETLAND HABITATS BY BIRDS IN THE
NATIONAL PETROLEUM RESERVE—ALASKA**

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by

Dirk V. Derksen, Thomas C. Rothe, and William D. Eldridge

U.S. Fish and Wildlife Service
Office of Special Studies
1011 East Tudor Road
Anchorage, Alaska 99503

Abstract

Distribution, abundance, and use of wetland habitats by migratory birds were studied at two interior and three outer Arctic Coastal Plain sites in the National Petroleum Reserve in Alaska (NPR-A) in 1977 and 1978. Comparative data were collected in the same years from a Beaufort Sea coastal site near Prudhoe Bay.

Species composition of breeding birds varied between sites, especially between coastal areas and sites near foothills of the Brooks Range. Seasonal fluctuation in population densities were common with numbers greatest in June during breeding and August during migration. Population densities also differed between sites, perhaps due to variation in wetland composition and ratios of water cover to upland tundra.

Use of wetlands by loons, waterfowl, and shorebirds was quantified to assess relative values of seven classes of freshwater habitats. Wetlands with emergent *Arctophila fulva* were used most by these water birds. Breeding birds were especially dependent upon wetlands with emergent hydrophytes, although they used various types of wetlands during different activities and life stages. Most broods were found in wetlands with *A. fulva*, which afforded protective cover and substrate for aquatic invertebrates used as food by water birds. Wetlands and lakes without emergents were generally less attractive to breeding birds, but were especially important to molting geese.

Based on water bird distribution and densities and their dependence on Arctic Coastal Plain wetlands in NPR-A, petroleum exploration and production activities onshore and in the Beaufort and Chukchi seas may have significant adverse effects if not closely regulated and prohibited in some areas.

The 94,697-km² Naval Petroleum Reserve Number 4 in northern Alaska was established by Presidential declaration in 1923. Periodic oil and gas exploration sponsored by the U.S. Navy has occurred since about 1943. In 1976, management responsibility of the Reserve was transferred to the Department of the Interior and the area was renamed the National Petroleum Reserve in Alaska (NPR-A).

Much of the recent seismic testing and petroleum exploration in NPR-A has been in the Arctic Coastal Plain physiographic province (Payne et al. 1951), which has one of the largest and most stable collections of wetlands in North America (Wellen and Lumsden 1964). About one-half of NPR-A is within the Arctic Coastal Plain province of Alaska's North Slope. The dominant physical feature of this province is the extensive area of surface water in the form of wet meadows, ponds, lakes, and fluvial systems. Hussey and Michelson (1966) estimated that lake and marsh coverage on the Arctic Coastal Plain was 50%, or about 23,000 km², in NPR-A. These wetlands support large numbers of breeding and postbreeding loons, waterfowl, gulls, terns, and shorebirds. Interspersed upland tundra habitats are used by passerines, ptarmigan, and raptors.

Concern for these valuable wetlands and the avifauna that use them was expressed by Bartonck et al. (1971) and Brooks et al. (1971) when intensive onshore oil exploration and development were initiated in the Prudhoe Bay area of Alaska. King (1970) and Bergman et al. (1977) emphasized the importance of the Arctic Coastal Plain to waterfowl and shorebirds and recommended protection from oil development.

Bailey (1948) gave one of the earliest accounts of Arctic Coastal Plain birds. Gabrielson and Lincoln (1959), supplemented by Kessel and Gibson's (1978) update, provide the most complete records for the region. Pitelka (1974) summarized bird records for the Barrow area and coastal plain in northernmost NPR-A, and Kessel and Cade (1958) described the avifauna of the Colville River which bounds NPR-A to the east and to the south in the foothills. Maher (1959) presents one of the few reports from the foothills, at Kaolak River in western NPR-A, but studies to the east by Irving (1960) at Anaktuvuk Pass and by Sage (1974) in the Atigun and Sagavanirktok river valleys describe upland and riparian bird assemblages that extend through the foothills onto the coastal plain along drainages.

Bird communities near Prudhoe Bay on the eastern coastal plain have been studied by Norton et al. (1975) and Bergman et al. (1977). Schamel (1978) and Divoky (1978) described bird use of barrier islands in the Beaufort Sea near Prudhoe Bay and Johnson (1979) studied bird use of a Beaufort Sea lagoon. Salter et al. (1980) summarized distribution and abundance of Arctic Coastal Plain birds in northern Yukon and Northwest Territories in Canada.

Relatively little quantitative data are available on the use of various freshwater wetland habitats by birds on Alaska's Arctic Coastal Plain. Such information is essential if these species and their wetland habitats are to be protected with existing and new petroleum development in the Arctic. The present study was designed to (1) obtain data on distribution and abundance of water birds at selected locations in NPR-A, (2) determine the types of wetland habitat at selected sites and those used by breeding birds, and (3) provide recommendations for management of water bird habitats in relation to oil exploration and development in NPR-A.

Study Areas

NPR-A sites studied in 1977 included Meade River delta, Singiluk, and East Long Lake. In 1978, field work was again conducted at East Long Lake and at Square Lake and Island Lake. Study sites were selected to represent the following major habitat types in NPR-A: (1) river delta (Meade River delta site), (2) large lake regime (Island Lake and East Long

Lake sites), and (3) near-foothills (Singiluk and Square Lake sites). A sixth site, established in 1970 at Storkersen Point near the Prudhoe Bay oil fields (Bergman et al. 1977), was used in 1977 and 1978 to provide data representative of the eastern coastal plain.

All sites in NPR-A are 15.54 km² (3.22 x 4.83 km). Study areas were selected to include a diversity of wetland types; boundaries for each area followed section lines shown on topographic series maps published by the U.S. Geological Survey.

Conditions characteristic of all six study sites include continuous permafrost (Ferrians 1965), tundra vegetation (Britton 1957), cool summers (Wise et al. 1977), low regional and local relief (Sellman et al. 1975), poor drainage (Walker 1973), extensive wetlands, and ice-wedge polygons (Black and Barksdale 1949). All sites are in the unconsolidated Gubik Formation of Quaternary age (Black 1964) but surficial deposits vary considerably between sites.

The Meade River delta site (70° 48'N, 156° 22'W) is 55 km southeast of Barrow and 14.5 km upriver from Dease Inlet, at the head of the delta (Fig. 1). Relief is less than 10 m except in river-associated sand dunes. The site is floodplain and low terrace deposits of sand and silt grading into Eolian sand in the southern part of the area. Cool temperatures, easterly winds, and low humidity are the dominant summer climatological features in the delta (Wise et al. 1977).

Island Lake and East Long Lake study sites are in an area of large, NNW-SSE oriented lakes (Black and Barksdale 1949) near Teshekpuk Lake (Fig. 1), which is the largest on

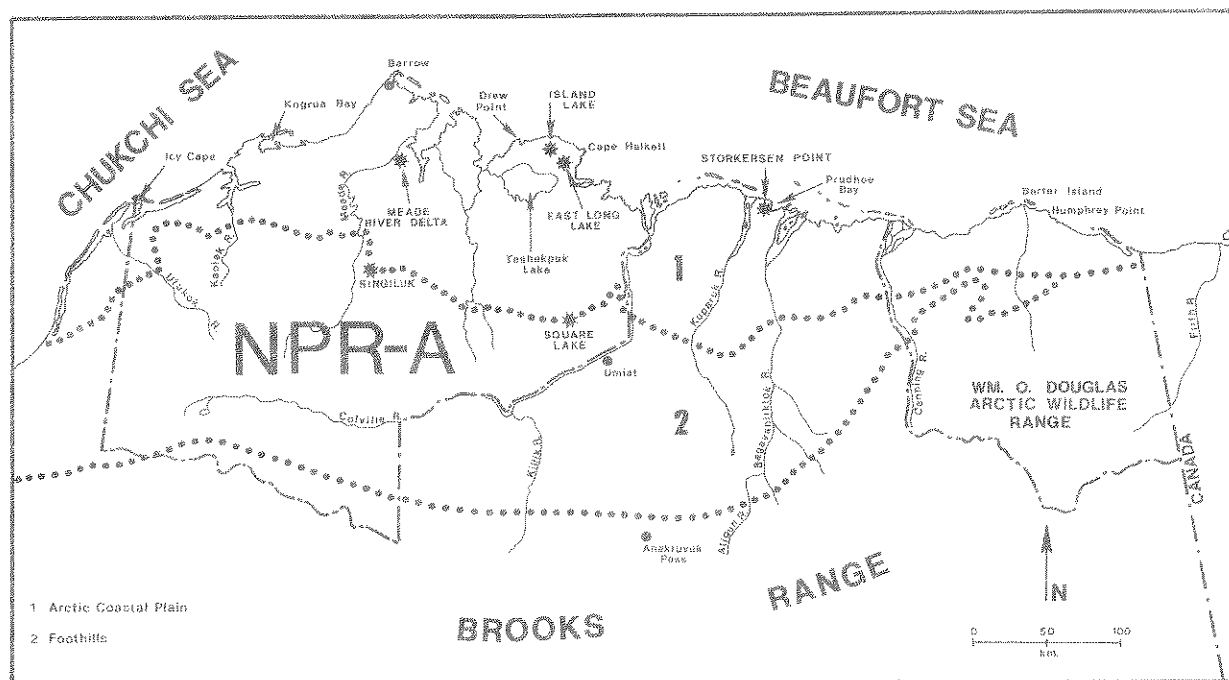


Fig. 1. Location of the five NPR-A and Storkersen Point study sites. Arctic Coastal Plain and Foothills provinces are identified.

the Arctic Coastal Plain. The Island Lake (70° 49'N, 153° 15'W) and East Long Lake (70° 39'N, 152° 43'W) study sites are 12.8 and 25.7 km south, respectively, of Lonely Distant Early Warning (DEW) site. This DEW site also was the location of the petroleum operations camp for NPR-A. Maximum elevation within the Island Lake study area is 6.7 m, although banks along larger lakes are up to 10 m in height. These two sites are located in areas of marine silt that contain fossil shells and bones of marine mammals. Maximum elevation at the East Long Lake site is 4.6 m along the banks of a small Beaded Stream. Island Lake had mean minimum and maximum ambient temperatures of -2.2° and 6.0°C, respectively, from 4 June to 13 August 1978. The mean minimum temperature at East Long Lake was 1.2°C and the average maximum was 10.3°C for the same time period. Extensive climatological data for this large lake area are found in Wise et al. (1977).

Singilik (70° 05'N, 156° 20'W), 138 km south of Barrow, and Square Lake (69° 40'N, 153° 02'W), 47 km northwest of Umiat (Fig. 1), are in the interior of the Arctic Coastal Plain near foothills of the Brooks Range. These study areas are characterized by flat to gently rolling terrain with upland heath-tussock communities dominated by *Eriophorum* spp. (Britton 1957). Woody plants such as *Salix* spp. were more abundant, especially along streams, at these sites than at those farther north. Singilik is at the southern margin of Eolian sand which forms a mantle over older marine deposits. The Square Lake site is in an area of upland silt which forms a boundary between the coastal plain and the Brooks Range foothills. Elevation is 22.9 to 30.5 m at Singilik and from 91.4 to 121.9 m at Square Lake, and regional relief is greater at both sites than at the other study areas. Singilik and Square Lake had warmer temperatures and less fog and wind than our sites nearer the Beaufort Sea. Wise et al. (1977) provided detailed climate data for Umiat, which are applicable to the Square Lake study site.

The Storkersen Point (70° 24'N, 148° 43'W) study site is on the Beaufort Sea coast between the Kuparuk and Sagavanirktok rivers, adjacent to the Prudhoe Bay oil field (Fig. 1). The area is characterized by small lakes, which are oriented with their long axis (generally NNW to SSE) perpendicular to prevailing winds (Sellman et al. 1975), and relief from sea level at coastal lagoons to 10 m a few km inland. For a more complete description of the study area and weather see Bergman et al. (1977).

Procedures

Wetland Classification and Composition

Ponds and lakes in the five NPR-A study sites were classified according to Bergman et al. (1977) who developed this system at the Storkersen Point study area near Prudhoe Bay. This system employs emergent vegetation, basin geomorphology, and water chemistry to define eight wetland categories. Flooded Tundra (Class I) includes

shallow waters formed during spring thaw when melt water overflows stream basins or is trapped in vegetated tundra depressions (Fig. 2). Shallow-*Carex* (Class II) ponds have a gently sloping shore zone surrounded by and usually containing emergent *Carex aquatilis* with a central open water zone (Fig. 3). Shallow-*Arctophila* (Class III) wetlands have a central zone of emergent pendant grass (*Arctophila fulva*) and shoreward stands of *A. fulva* or *C. aquatilis* (Fig. 4). Deep-*Arctophila* (Class IV) wetlands are large ponds or lakes without emergents in the central zone and *A. fulva* near the shore (Fig. 5).

Deep-open (Class V) lakes have abrupt shores, sublittoral shelves, and a deep central zone (Fig. 6). Basin-complex (Class VI) wetlands are large, partially drained basins that may contain any of the other seven types. Because two of the NPR-A study areas (Island Lake and East Long Lake) were entirely within huge Basin-complex wetlands, we determined composition of all study areas on the basis of component wetlands within these basins. Beaded Streams (Class VII) are small fluvial systems composed of a series of pools linked by channels formed in ice-wedges (Fig. 7). Coastal Wetlands (Class VIII) are ponds or lagoons directly influenced by sea water (Fig. 8). See Bergman et al. (1977) for a more detailed description of these wetlands, and Table 1 for a comparison with the U.S. Fish and Wildlife Service national wetland classification system (Cowardin et al. 1979). All wetlands within the study areas were classified in the field and types were recorded on aerial photographs of 1:24,000 or 1:36,000 scale. Wetland area for each class was then determined by tracing the perimeter of individual wetlands on photos with an electronic planimeter.

Bird Surveys

Weekly censuses were conducted in the 15.54-km² study areas from June to mid-August in 1977 and 1978. Large birds including loons, waterfowl, hawks, owls, gulls, terns, and jaegers were counted in the 15.54-km² study areas. Shorebirds and passerines were recorded in five to seven subplots of 0.16 km² (0.2 x 0.8 km) located within the boundaries of study areas.

Large birds were counted by two or three observers walking abreast in four 0.80-km strips through the 15.54-km² (3.22 x 4.83 km) study area. Shorebirds and passerines were censused during single passes through the 0.16-km² plots. Age and sex of morphologically distinct species were recorded.

Additional observations were made during aerial surveys of the Colville River delta and groundwork on the west shores of Teshekpuk Lake (Fig. 1) in July 1976.

Use of Wetlands

Use of wetlands by water birds was recorded systematically during the weekly bird surveys at each of the 15.54-km² study sites in 1978. Differential use of wetland classes was

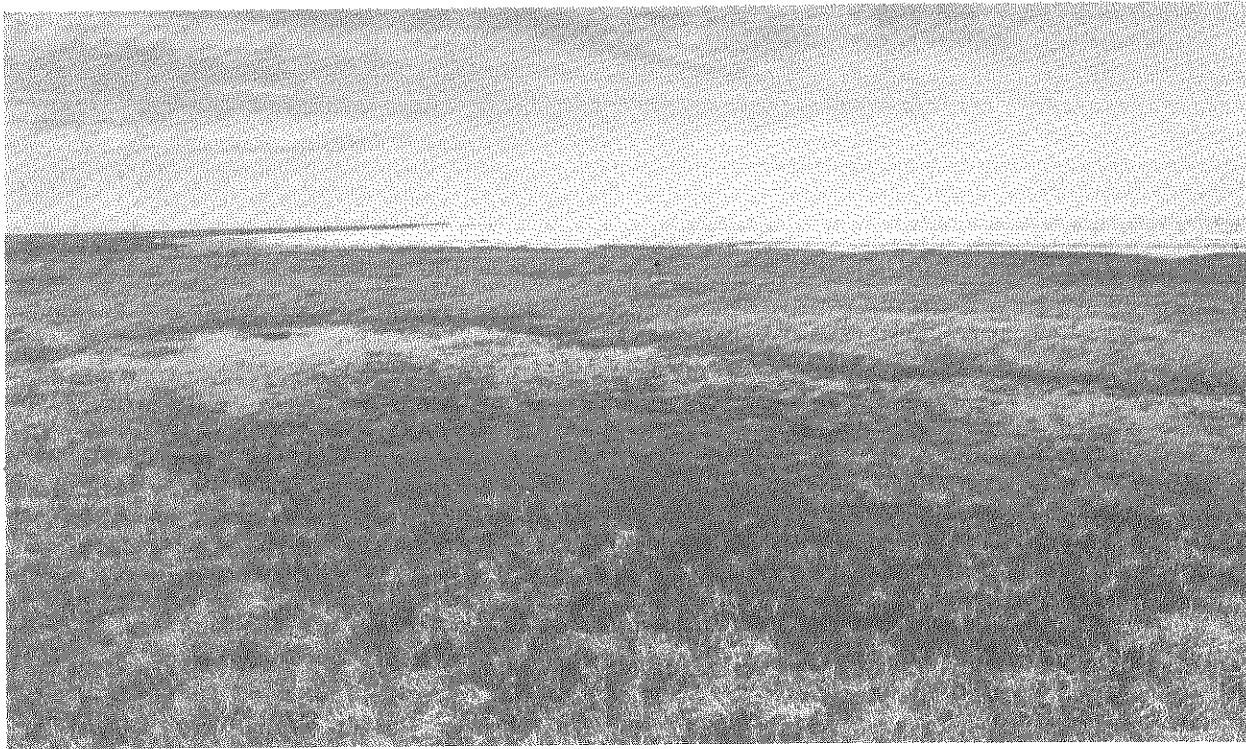


Fig. 2. Flooded tundra (Class I) in a shallow depression dominated by water-tolerant *Carex aquatilis*. Water seldom persists beyond June.

tested using chi-square contingency tables. The number of birds observed using wetlands on surveys was compared to the number of birds expected on those wetlands. Expected values were calculated by multiplying the total number of birds seen by the percent of the total surface area covered by each wetland class. Significant chi-square tables were further tested with analysis of cell residuals (Everitt 1977). For some species there were not sufficient sightings at each study area for statistical treatment.

Results

Wetland Composition

Wetland coverage in our NPR-A study areas ranged from 31.5% at Singiluk to over 85% at Island Lake (Table 2). All but one of the NPR-A study sites were dominated by the presence of Class I (Flooded Tundra) wetlands, which accounted for 43.0 to 63.3% of the total wetland areas

Table 1. Comparison of nomenclature used in Arctic Coastal Plain and National Wetland classification systems. When Bergman et al. (1977) wetlands contain more than one category of the Cowardin et al. (1979) hierarchical system, components are shown in parentheses.

Class (Bergman et al. 1977)	Cowardin et al. (1979)			
	System	Subsystem	Class	Subclass
Flooded Tundra (Class I)	Palustrine	None	Emergent wetland	Persistent
Shallow- <i>Carex</i> (Class II)	Palustrine	None	Emergent wetland (Unconsolidated bottom)	Persistent (sand organic)
Shallow- <i>Arctophila</i> (Class III)	Palustrine	None	Emergent wetland	Non-persistent
Deep- <i>Arctophila</i> (Class IV)	Palustrine (Lacustrine)	None (Limnetic littoral)	Emergent wetland (Unconsolidated bottom)	Non-persistent (sand organic)
Deep-open (Class V)	Lacustrine	Limnetic	Unconsolidated bottom	Organic (sand)
Basin-complex (Class VI) ^a			
Beaded Stream (Class VII)	Riverine	Lower Perennial	Emergent wetland	Non-persistent
Coastal (Class VIII)	Estuarine	Intertidal	Emergent wetland	Persistent

^aClass VI basins may contain the other seven wetland types of the Bergman et al. (1977) classification system. There is no equivalent unit in the Cowardin et al. (1979) classification system.



Fig. 3. Shallow-*Carex* (Class II) pond with open pools, emergent *Carex aquatilis*, and a low relief shoreline. Note the dry tundra in the foreground.



Fig. 4. Shallow-*Arctophila* (Class III) pond near East Long Lake containing central and shoreward stands of *Arctophila fulva*. (Photo by E. J. Taylor)



Fig. 5. Deep-*Arctophila* (Class IV) lake at the Square Lake study area. Note the sparse stand of *Arctophila fulva* in the foreground. The campsite is on the abrupt shore (7.6 m) in the background.

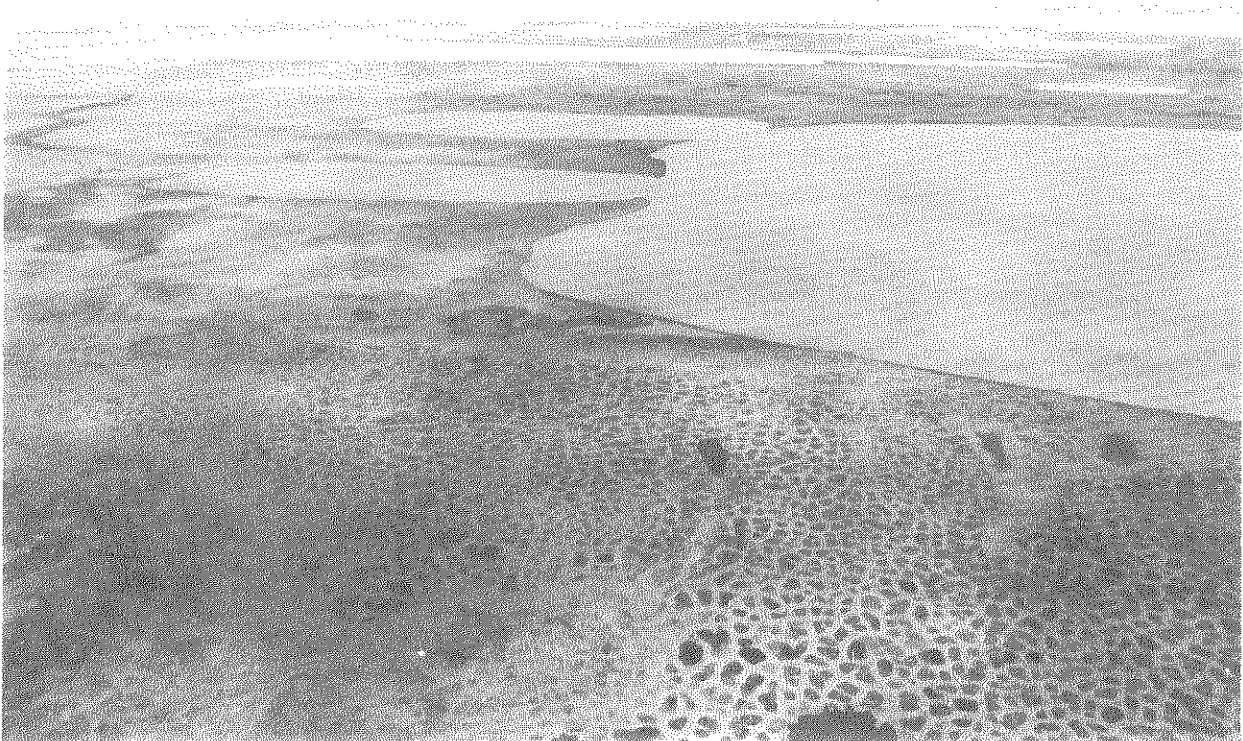


Fig. 6. Deep-open (Class V) lake near Cape Halkett. Water-filled polygons (Classes II and III wetlands) are in the foreground and smaller coalesced lakes in the upper left.

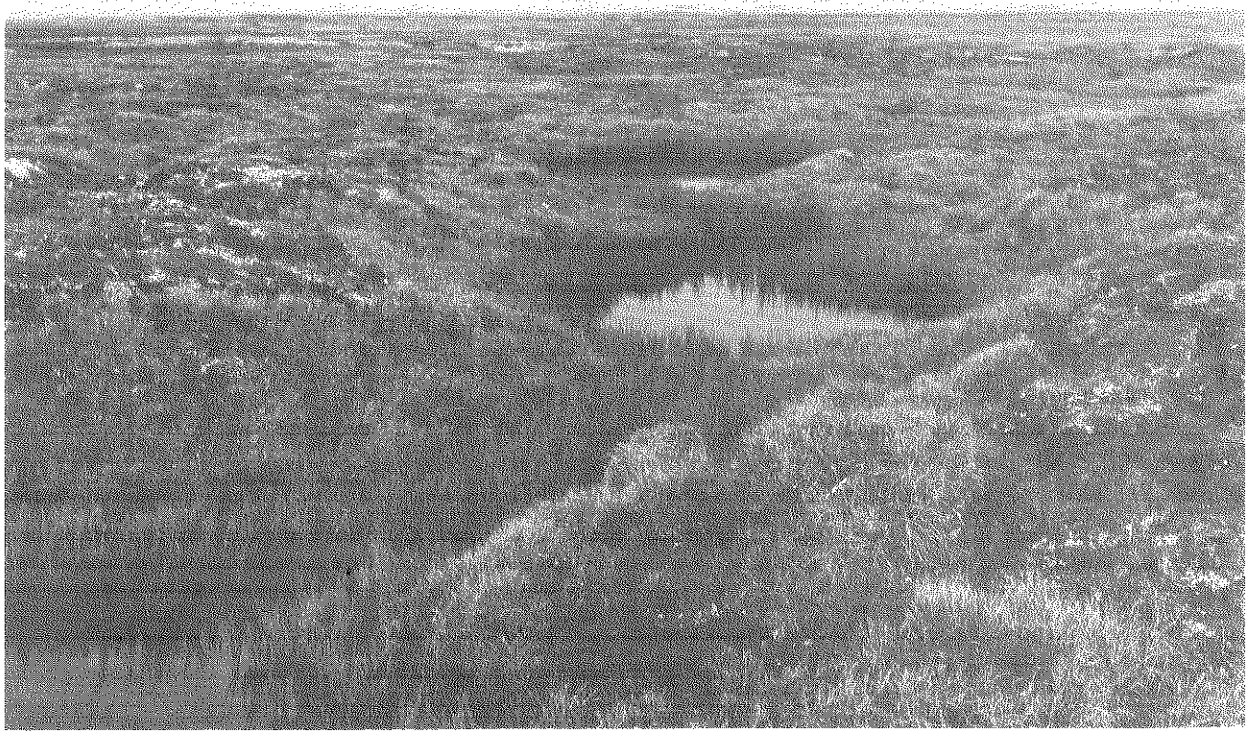


Fig. 7. Beaded Stream (Class VII) following ice-wedge troughs and intersections. Adjacent high center polygons are well drained, supporting lichens and shrubs.

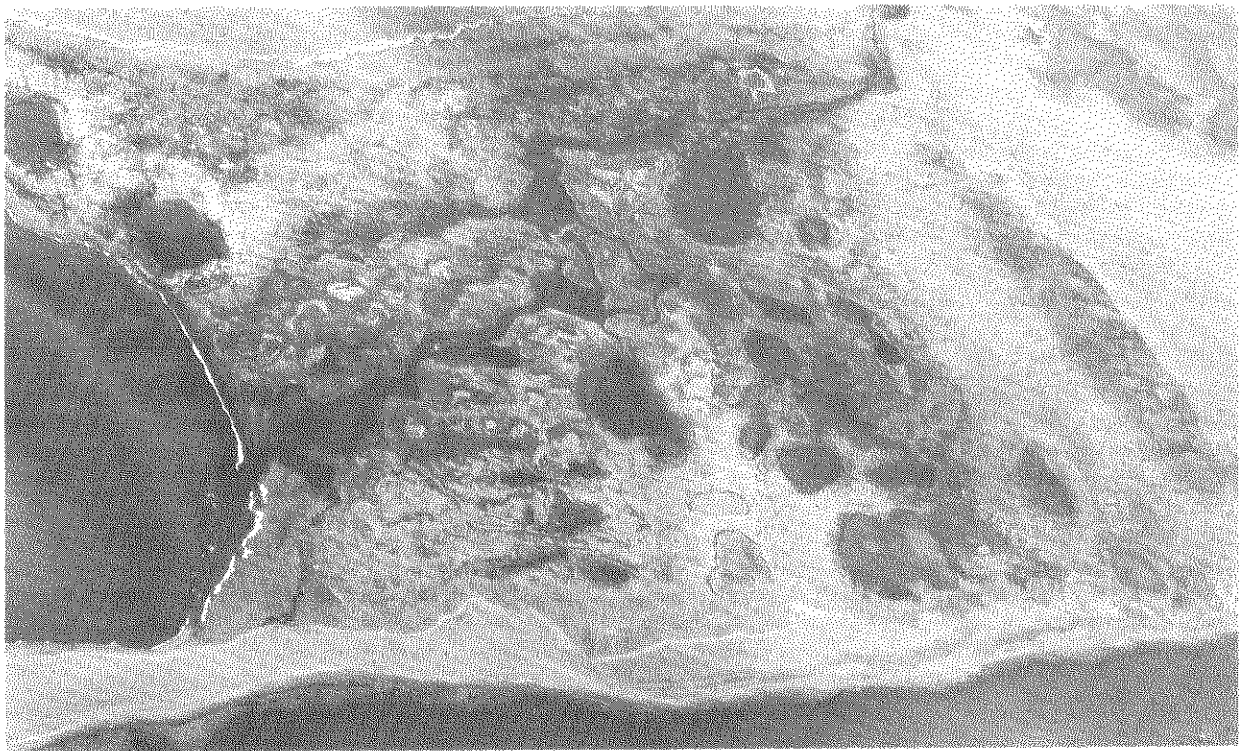


Fig. 8. Coastal wetlands (Class VIII) adjacent to the Beaufort Sea near Storkersen Point. Note driftwood line in upper portion of photo.

Table 2. Percentage composition of wetland habitat at Arctic Coastal Plain study sites^a.

Wetland class	East Long Lake	Island Lake	Meade River	Square Lake	Singiluk	Storkersen Point
I Flooded Tundra	48.1	63.3	51.3	43.0	46.6	51.2
II Shallow- <i>Carex</i>	16.2	14.5	15.7	7.1	2.1	32.4
III Shallow- <i>Arctophila</i>	6.1	7.9	1.4	1.4	0.5	4.5
IV Deep- <i>Arctophila</i>	4.7	0.8	1.7	48.4	45.5	2.9
V Deep-open	24.1	13.4	29.8	0.0	2.1	6.6
VII Beaded Stream	0.8	0.1	0.1	0.1	3.2	2.4
Wetland surface area (ha)	790.5	1,334.2	756.9	839.5	489.5	650.3
Percent of study site in wetlands	50.8	85.8	48.7	54.0	31.5	41.8

^aEach study site was 15.54 km² (1,554.0 ha).

(Table 2). These meadows or polygonal complexes are most frequently found in the broad depressions of large Basin-complexes (Class VI). Class VIII wetlands were only present about 1 km north of the Storkersen Point study area and along other stretches of the Beaufort Sea coast.

Large Lake Regime

Wetland composition at Island Lake and East Long Lake was characterized by the presence of large, oriented Class V (Deep-open) lakes and huge drained or partially drained basins (Fig. 9). These basins may be discrete or, more often, a complex of overlapping basins of various ages. Hussey and Michelson (1966) mapped drained basins, according to age, in an area south of Barrow, Alaska, and suggested that basin formation is a result of the quantity and distribution of ground ice. Lakes at Island Lake and East Long Lake are among the largest on the Arctic Coastal Plain. Island Lake was 7.7 km long with a surface area of 1,720 ha and East Long Lake was 7.8 km long with a surface area of 1,951 ha.

Maximum water depths in Island Lake and East Long Lake were 1.5 and 2.0 m, respectively. Shorelines of these large lakes have been classified (Derksen et al. 1979b), and shoreline configuration and lake evolution have been discussed by Weller and Derksen (1979). About 70% of the Island Lake study area is within a large drained basin, which accounts for the high percentage of Class I wetlands (Table 2) at this site.

River Delta

The Meade River delta study site and surrounding area had numerous river channels, oxbows, shallow ponds, and larger lakes (Fig. 9). Second generation wetlands (Hussey and Michelson 1966) made up 50% of the area. Approximately 15% of the study area may have been influenced by the effects of thaw and drainage near the river. Wetland composition within the study area was similar to that of Island and East Long Lakes (Table 2). Class V (Deep-open) lakes were common, but basin size was considerably smaller than basin sizes at Island Lake and East Long Lake. Perched ponds (Walker and Harris 1976) and lakes breached by river channels (Walker 1978) were also prominent adjacent to the study area.

Near-Foothills

Lake density in the southern Arctic Coastal Plain near foothills of the Brooks Range is low compared to coastal tundra from Barrow to the Colville River delta (Sellman et al. 1975). These lakes do not exhibit orientation of the elongate axis (Black and Barksdale 1949; Fig. 9), although C. Sloan (personal communication) identified orientation of troughs within the shallower irregular basin from color infrared LANDSAT imagery. Nearly all large lakes in this region had beds of *Arctophila fulva* along littoral shelves (Fig. 5), resulting in the designation of few Deep-open lakes and high proportions of Deep-*Arctophila* (Class IV) wetland at Singiluk (45.5%) and Square Lake (48.4%). Lakes at these study sites were ice-free about 2 weeks earlier than those closer to the coast such as the Meade River delta.

Coastal

Bergman et al. (1977) described wetlands at Storkersen Point on the Beaufort Sea coast. Class II wetlands were abundant (210.6 ha) at this site compared to NPR-A sites (Table 2). A Beaded Stream bisected the study area and formed a delta northwest of the northern boundary of the area. Class V lakes were smaller than those in the large lake regime in NPR-A. Drained basins were present, but were not as large or numerous as those near Teshekpuk Lake.

Water Bird Populations and Habitat Use

The following water bird group accounts describe relative abundance between sites and variations over the breeding seasons, then provide habitat use patterns in relation to available wetland types.

Common Loon

All four species of loons are found on the Arctic Coastal Plain, with all but the common loon (*Gavia immer*) found nesting on our study sites. Common loons were not seen at our study sites in NPR-A, although one bird was observed near the Beaufort Sea coast at Storkersen Point on 26 July 1978 (Table 3). Bergman et al. (1977) also noted common loons along the coast near Storkersen Point in 1972 and

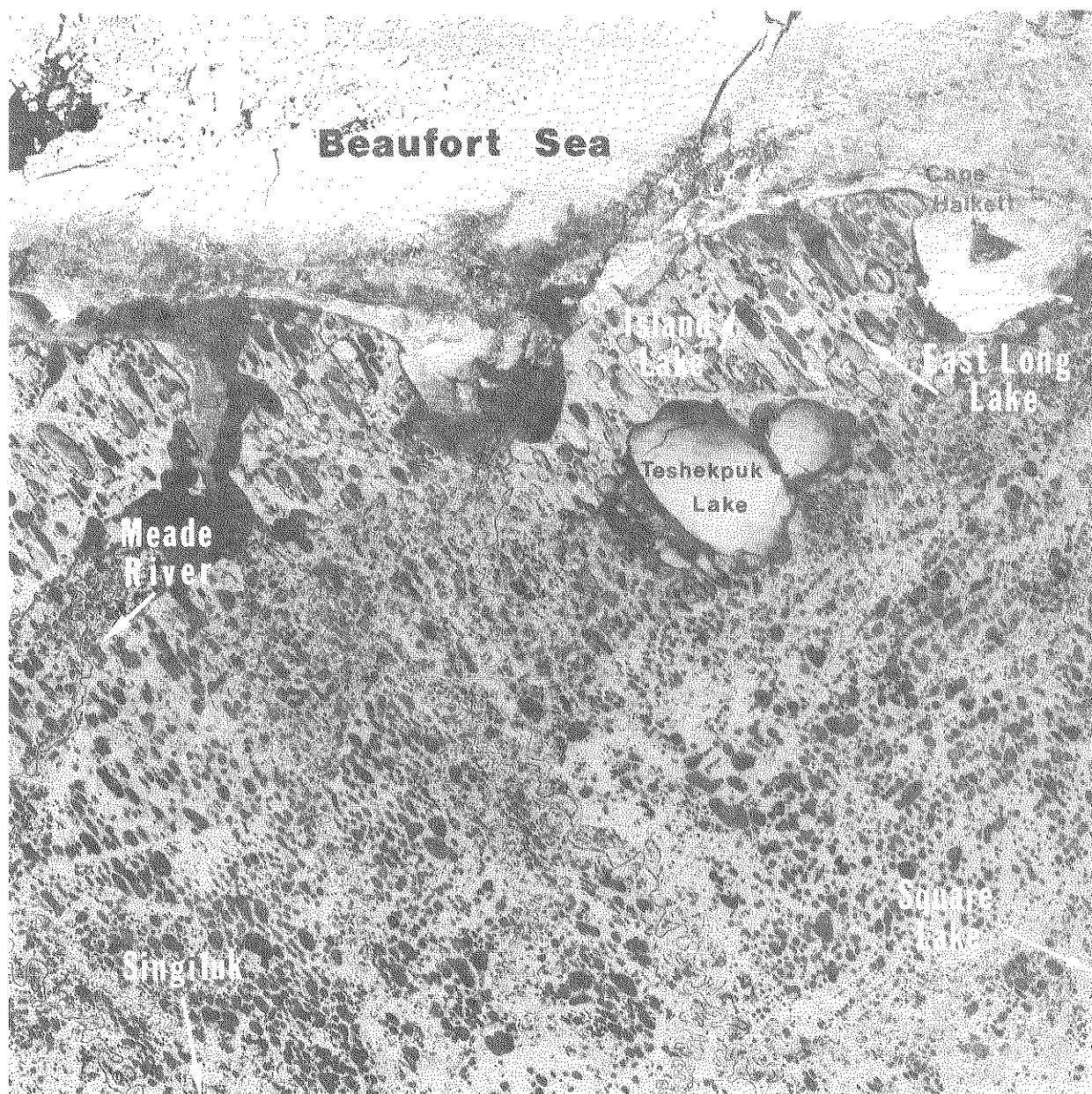


Fig. 9. LANDSAT image from 11 July 1977 showing location of NPR-A study sites. Note the pack ice in the Beaufort Sea and ice cakes on Teshekpuk Lake and large lakes southwest of Cape Halkett.

1975. No other records of this species are available for the Arctic Coastal Plain. Sage (1974) observed a pair of common loons on a lake in the foothills of the Brooks Range, although there was no indication of nesting.

Yellow-billed Loon

Yellow-billed loons (*Gavia adamsii*) were the least abundant of the three loons that breed on the Arctic Coastal Plain, and were recorded in surveys only at Square Lake (\bar{x} density = 0.1/km²). A pair of yellow-billed loons and two

chicks were seen on large lakes near the Singiluk study area in July 1977. Yellow-billed loons were seen regularly along the Meade River in July and August 1977, pairs were seen in both years at East long Lake, and one bird was seen near the Island Lake study area in 1978. Nests and broods were not found at Meade River, East Long Lake, or Storkersen Point. Sage (1971) found no evidence of yellow-billed loons on rivers or nearer than 110 km to the Arctic Ocean, but we discovered several nests on Class V lakes in the Colville River delta in 1976. Sjolander and Agren (1976) reported

Table 3. Species composition, status^a, and mean seasonal densities (birds/km²)^b of birds observed at Arctic Coastal Plain study sites in 1977 and 1978^c.

	Large Lake Regime						Delta		Near Foothills				Coastal		
	East Long Lake			Island Lake			Meade River		Singiluk		Square Lake		Storkersen Point		
	Status	1977	1978	Status	1978	Status	1977	Status	1977	Status	1978	Status	1977	1978	
Common loon (<i>Gavia immer</i>)	—					—				—		CV			
Yellow-billed loon (<i>G. adamsii</i>)	CV			CV		CV		UB		UB	0.1	CV			
Arctic loon (<i>G. arctica</i>)	CB	1.5	1.2	CB	0.8	CB	2.1	UB	0.6	CB	1.5	CB	1.9	1.6	
Red-throated loon (<i>G. stellata</i>)	CB	1.3	0.5	UB	0.1	UB	0.2	—		CV	—	CB	0.5	0.6	
Whistling swan (<i>Olor columbianus</i>)	UB	0.2	0.2	RV		UB	0.2	RV		RV	0.2	UB	0.3	0.1	
Canada goose (<i>Branta canadensis</i>)	RV	3.7	1.4	RV	6.6	—		CV		CV		UB	—	—	
Black brant (<i>B. bernicla</i>)	CB	5.4	9.1	CB	9.6	CB	0.3	—		—		UB	0.3	0.7	
White-fronted goose (<i>Anser albifrons</i>)	CB	1.1	1.0	CB	0.9	CB	0.7	CB	2.7	CB	0.8	CB	1.0	2.2	
Lesser snow goose (<i>A. caerulescens</i>)	UB			RV		RV		CV		—		M			
Mallard (<i>Anas platyrhynchos</i>)	CV			—		CV		—		—		CV			
Pintail (<i>A. acuta</i>)	UB	17.1	6.5	RV	2.3	UB	5.1	CB	3.2	UB	1.1	RV	14.1	6.2	
Green-winged teal (<i>A. crecca carolinensis</i>)	—		—			CV		—		UB		CV			
American wigeon (<i>A. americana</i>)	CV			CV		CV		CV		CV		CV			
Northern shoveler (<i>A. clypeata</i>)	CV	0.1	—	—		CV		CV		—		CV			
Greater scaup (<i>Aythya marila</i>)	CV			—		CV		UB	0.5	CB	0.8	CV			
Common eider (<i>Somateria mollissima</i>)	M			CV		—		—		—		RV			
King eider (<i>S. spectabilis</i>)	CV	—	0.3	CV	0.3	CV	0.1	UB	0.2	CB	0.2	CB	2.4	1.9	
Spectacled eider (<i>S. fischeri</i>)	CB	0.6	0.5	CB	0.1	CB	0.3	CV		—		UB	0.2	0.2	
Steller's eider (<i>Polysticia stelleri</i>)	—			—		—		CV		—		—			
Oldsquaw (<i>Clangula hyemalis</i>)	CB	3.2	3.3	CB	2.3	CB	1.1	CB	3.5	CB	4.6	CB	2.3	1.8	
White-winged scoter (<i>Melanitta deglandi</i>)										CB	1.0				
Surf scoter (<i>M. perspicillata</i>)	CV									CV		CV			
Red-breasted merganser (<i>Mergus serrator</i>)										CV		CV			
Marsh hawk (<i>Circus cyaneus</i>)												CV			
Rough-legged hawk (<i>Buteo lagopus</i>)	CV			—		—				CV					
Golden eagle (<i>Aquila chrysaetos</i>)						CV				CV		CV			
Gyr Falcon (<i>Falco rusticolus</i>)										CV					
Peregrine falcon (<i>F. peregrinus</i>)	CV									CV		CV			

Table 3. Continued.

	Large Lake Regime						Delta		Near Foothills				Coastal		
	East Long Lake			Island Lake		Meade River		Singiluk		Square Lake		Storkersen Point			
	Status	1977	1978	Status	1978	Status	1977	Status	1977	Status	1978	Status	1977	1978	
Willow ptarmigan (<i>Lagopus lagopus</i>)	UB					UB	0.1	CB	1.1	CB	3.8	UB			
Rock ptarmigan (<i>L. mutus</i>)	—									RV	0.1	CV	0.1		
Sandhill crane (<i>Grus canadensis</i>)				CV		CV				CV		CV			
American golden plover (<i>Pluvialis dominica</i>)	CB	3.5	1.6	CB	0.6	UB		UB	1.3	CB	4.1	CB	5.4	4.7	
Black-bellied plover (<i>P. squatarola</i>)	CB	4.4	1.1	CB	1.7	UB	6.3	UB	3.2	CB	2.8	CB	1.9	1.9	
Semipalmated plover (<i>Charadrius semipalmatus</i>)				—						CV		CV			
Whimbrel (<i>Numenius phaeopus</i>)	—			—		—				CV		CV			
Bar-tailed godwit (<i>Limosa lapponica</i>)	CV	—	0.1					UB	11.2	RV	1.2	CV			
Buff-breasted sandpiper (<i>Tryngites subruficollis</i>)	UB			CV						UB	0.3	CB	0.6	3.7	
Silt sandpiper (<i>Micropalama himantopus</i>)	CV			CV				—		CB	3.3	RV			
Long-billed dowitcher (<i>Limodromus scolopaceus</i>)	UB	4.0	1.5	CV	0.4	UB	3.7	CV		UB	5.8	RV	1.2	0.8	
Ruddy turnstone (<i>Arenaria interpres</i>)	UB		0.2	UB	0.3	UB	0.2			—		UB	1.1	2.4	
Pectoral sandpiper (<i>Calidris melanotos</i>)	CB	36.3	18.5	CB	13.0	CB	22.9	CB	24.1	CB	11.6	CB	24.3	20.1	
Red knot (<i>C. canutus</i>)	—											CV			
Dunlin (<i>C. alpina</i>)	CB	12.8	16.0	CB	12.8	CB	21.1	UB	0.5	CV	0.2	CB	15.5	15.7	
Sanderling (<i>C. alba</i>)	—											CV			
White-rumped sandpiper (<i>C. fuscicollis</i>)								CV				CV			
Baird's sandpiper (<i>C. bairdii</i>)	RV	0.1						—				UB	0.9	2.8	
Least sandpiper (<i>C. minutilla</i>)	—			—				CV				—			
Semipalmated sandpiper (<i>C. pusilla</i>)	CB	6.3	3.1	CB	1.4	CB	7.0	CB	6.9	CB	15.5	CB	11.6	17.2	
Western sandpiper (<i>C. mauri</i>)	—			—		—		—		CV	0.1	CV			
Red phalarope (<i>Phalaropus fulicarius</i>)	CB	32.5	25.7	CB	13.7	CB	20.6	UB	4.0	RV	0.3	CB	26.5	26.4	
Northern phalarope (<i>P. lobatus</i>)	CB	13.3	9.8	RV	1.0	RV	4.2	CB	9.7	CB	16.8	UB	1.6	3.6	
Common snipe (<i>Gallinago gallinago</i>)										RV	0.3				
Parasitic jaeger (<i>Stercorarius parasiticus</i>)	UB	0.4	0.4	UB	0.4	UB	0.4	UB	0.3	UB	0.4	UB	0.5	0.5	
Pomarine jaeger (<i>S. pomarinus</i>)	M			M	0.1	M	0.2	CV		M	0.1	M			
Long-tailed jaeger (<i>S. longicaudus</i>)	RV	0.2	0.1	RV		UB	0.2	UB	0.4	UB	0.3	RV	0.2	0.1	
Glaucous gull (<i>Larus hyperboreus</i>)	UB	0.7	0.4	UB	1.4	UB	1.1	CV		UB	0.3	UB	0.6	0.5	

Table 3. Continued.

	Large Lake Regime					Delta		Near Foothills				Coastal		
	East Long Lake			Island Lake		Meade River		Singiluk		Square Lake		Storkersen Point		
	Status	1977	1978	Status	1978	Status	1977	Status	1977	Status	1978	Status	1977	1978
Bonaparte's gull (<i>L. philadelphia</i>)								CV				CV		
Sabine's gull (<i>Xema sabini</i>)	UB	0.3	0.3	RV		CB	0.7	CV		CV		CV		
Arctic tern (<i>Sterna paradisea</i>)	UB	0.8	0.5	RV	0.1	UB	0.7	UB	0.9	UB	1.3	RV		
Short-eared owl (<i>Asio flammeus</i>)	CV			CV		CV		CV		UB		CV		
Snowy owl (<i>Nyctea scandiaca</i>)	RV			CV	0.1	CV		CV		CV		RV		
Say's Phoebe (<i>Sayornis saya</i>)						—		—				CV		
Horned lark (<i>Eremophila alpestris</i>)												CV		
Barn swallow (<i>Hirundo rustica</i>)	—					—						CV		
Common raven (<i>Corvus corax</i>)						—		CV		RV		CV		
Bluthroat (<i>Luscinia svecica</i>)						—				CV				
Ruby crowned kinglet (<i>Regulus calendula</i>)								CV						
Yellow wagtail (<i>Motacilla flava</i>)				—				UB	0.8	UB	0.4			
Rusty blackbird (<i>Euphagus carolinus</i>)				—						CV				
Redpoll (<i>Carduelis</i> sp.)						CV	0.3	UB	0.1	CB	1.5	UB		
Savannah sparrow (<i>Passerculus sandwichensis</i>)	CV					CV		UB	12.0	UB	2.7			
Tree sparrow (<i>Spizella arborea</i>)										CV	0.4			
Lapland longspur (<i>Calcarius lapponicus</i>)	CB	64.2	47.6	CB	24.3	CB	24.1	CB	42.3	CB	42.5	CB	20.4	36.7
Snow bunting (<i>Plectrophenax nivalis</i>)	CV			CV		CV						UB	0.6	1.1
Species Breeding	25			16		23		23		27		25		
Species Total	45			36		40		41		53		62		

^aStatus: CB = Common Breeder; UB = Uncommon Breeder; M = Migrant; RV = Regular summer visitor; CV = Casual or accidental visitor; — = Not present.

^bMeans were determined from weekly surveys, June through August.

^cMeade River and Singiluk sites were studied in 1977, East Long Lake and Storkersen Point in 1977 and 1978, and Island Lake and Square Lake in 1978.

that only one yellow-billed loon pair nested on each lake in an area 80 km southeast of Barrow. By comparison, several pairs of arctic (*Gavia arctica*) and red-throated (*Gavia stellata*) loons nested in single basins at Storkersen Point (Bergman and Derksen 1977) as well as our NPR-A sites (this study). It appears that breeding densities of yellow-billed loons are lower because they defend larger territories than either arctic or red-throated loons.

Little information is available on habitats used by yellow-billed loons. Sage (1971) found a breeding pair on a lake that had dense stands of emergent *Arctophila fulva* and a pair on a lake with no emergents. All of our observations of this species were on Class V (Deep-open) lakes or on large flowing bodies of water such as the Meade River. An open moat around a large ice cake in Teshekpuk Lake was used by yellow-billed loons for feeding in mid-July 1976.

Arctic Loon

Bailey (1948), Gabrielson and Lincoln (1959), Palmer (1962), and Pitelka (1974) identified the arctic loon as a common species nesting on the Arctic Slope. Our weekly surveys showed that arctic loons were the most abundant loon at all study sites in 1977 and 1978, and it was considered a common breeder. Mean seasonal densities ranged from 0.6/km² at Singilik to 2.1/km² at Meade River (Table 3), which was comparable to the range of densities at Storkersen Point (Bergman et al. 1977). Petersen (1979) found much higher (9.6/km²) densities of breeding arctic loons on the Yukon-Kuskokwim River Delta, Alaska, on the Bering Sea where milder climate and longer summers are more attractive to nesting birds. Arctic loons are also found on the upper and middle Colville River (Kessel and Cade 1958) and much farther inland along the upper Kaolak River (Maher 1959) and Sagavanirktok River (Sage 1974) valleys in the Brooks Range foothills.

Wetlands that contained *Arctophila fulva* (Classes III, IV, and VII) were preferred habitats for arctic loons (Table 4). Bergman and Derksen (1977) found 66% of all arctic loon nests in Deep-*Arctophila* (Class IV) wetlands. Class IV wetlands are relatively shallow and ice-free earlier and used significantly ($P < 0.01$) more than Class V (Deep-open) lakes in June (Table 4). However, nesting (July) and post-nesting (August) use of Class V lakes was significant ($P < 0.05$) at all sites. Differential use of Beaded Streams (Class VII) by arctic loons between sites (Table 4) may be due to the presence of *Arctophila fulva* in individual pools (beads), which would provide protective cover and a greater abundance and diversity of invertebrates (Bergman et al. 1977). Arctic loons did not use Class I (Flooded Tundra) wetlands, nor did they show preference for Class II (Shallow-*Carex*) wetlands except at Square Lake where values were highly significant ($P < 0.01$) for all months

Table 4. Seasonal habitat selection^a by arctic loons at four sites on the Arctic Coastal Plain in 1978.

Study site and month	Wetland class					
	I	II	III	IV	V	VII
East Long Lake ($\chi^2 = 638.83$, $n = 111$)						
June	-9.02	+2.11	+4.00	+15.08	1.70	+3.45
July	7.76	1.94	+9.45	+18.65	-3.62	0.72
August	-4.90	+0.39	+0.73	+14.90	2.30	0.46
Island Lake ($\chi^2 = 858.50$, $n = 69$)						
June	5.01	1.57	1.12	+24.61	+3.16	-0.12
July	11.73	-3.68	2.62	+4.62	+21.29	-0.28
August	6.97	2.19	-1.55	+2.50	+12.71	0.17
Storkersen Point ($\chi^2 = 1,211.90$, $n = 120$)						
June	-10.15	5.68	+4.05	+35.47	+1.80	+3.24
July	8.85	5.18	1.88	+15.29	+16.61	+3.55
August	5.02	1.30	-1.06	+10.83	+6.59	0.77
Square Lake ($\chi^2 = 417.11$, $n = 174$)						
June	5.50	+8.18	0.90	+0.42	...	+16.44
July	7.48	+4.07	-1.03	+5.25		+4.97
August	-10.45	+9.72	1.43	+5.72	---	0.38

^aThe tabular adjusted residuals are measures of deviation from expected values. + = preference, - = avoidance. Critical values are 1.96 ($P < 0.005$), 2.58 ($P < 0.01$).

^bNo Class V wetlands present.

(Table 4). Flooded Tundra and small Shallow-*Carex* wetlands were avoided apparently because of the lengthy distance of open water required for takeoff and landing. Brood habitat included Classes II, III, and IV wetlands and Deep-open lakes (Table 5).

Table 5. Number of broods on Arctic Coastal Plain wetlands at Meade River, East Long Lake, Island Lake, Singilik, Square Lake, and Storkersen Point in 1977 and 1978.

Species	Wetland class							Totals
	I	II	III	IV	V	VII	River	
Yellow-billed loon	0	0	0	1	0	0	0	1
Arctic loon	0	13	6	20	5	0	0	44
Red-throated loon	0	3	5	2	0	0	1	11
Whistling swan	0	0	0	1	2	4	0	7
Snow goose	0	0	0	0	0	1	0	1
White-fronted goose	0	2	0	8	8	14	1	33
Black brant	0	4	0	0	16	5	0	25
Oldsquaw	0	7	2	16	9	2	0	36
Pintail	0	4	0	12	0	1	0	17
Spectacled eider	0	10	1	2	4	0	1	18
King eider	0	2	0	7	0	0	0	9
Greater scaup	0	0	0	9	1	0	0	10
White-winged scoter	0	0	0	6	0	0	0	6
Totals	0	45	14	84	45	27	3	218

Red-throated Loon

Red-throated loons occurred in much lower densities than arctic loons and were not recorded during surveys at the two sites near the Brooks Range foothills (Table 3). However, they were found in small numbers on lakes near the Square Lake study area. The highest mean seasonal red-throated loon densities were at East Long Lake in 1977 (1.3/km²). Davis (1972) found that distance to the coast of Hudson Bay was an important factor influencing the distribution of red-throated loons because they fed their young with fish gathered from the sea. Bergman and Derksen (1977) noted similar behavior at Storkersen Point where red-throated loons flew from nest ponds to the Beaufort Sea to capture fish for their young. Further inland, in large lakes near East Long Lake, red-throated loons were observed capturing whitefish (*Coregonus* sp.), which they took to adjacent nest ponds. It is apparent that reliance on fish limits the distribution of red-throated loons to coastal areas and where freshwater fishes are available.

Red-throated loons used Class III (Shallow-*Arctophila*) wetlands during all months at East Long Lake ($P < 0.01$), and during June and July at Storkersen Point (Table 6). Loons also used Class IV (Deep-*Arctophila*) wetlands during June and August ($P < 0.01$) at Storkersen Point. Red-throated loons fed in pools of Beaded Streams (Class VII) that contained stands of *Arctophila fulva* throughout the summer at East Long Lake. Much of the Beaded Stream at Storkersen Point was either too deep or swift to support *Arctophila fulva*, which may account for the relative lack of use by red-throated loons (Table 6).

Table 6. Seasonal habitat selection^a by red-throated loons at two sites on the Arctic Coastal Plain in 1979.

Study site and month	Wetland class					
	I	II	III	IV	V	VII
East Long Lake ($\chi^2 = 485.59$, $n = 60$)						
June	4.31	+ 2.08	+10.07	- 0.99	2.52	+ 2.95
July	5.88	0.52	+12.87	+ 1.15	2.82	+11.37
August	5.67	+ 1.04	+ 9.69	0.04	2.70	+14.51
Storkersen Point ($\chi^2 = 539.73$, $n = 48$)						
June	8.40	3.80	+27.88	+ 5.56	- 2.18	- 1.29
July	4.78	1.24	+15.51	0.81	1.24	+ 1.30
August	2.42	+ 1.39	0.51	+ 5.22	0.63	0.37

^aThe tabular adjusted residuals are measures of deviation from expected values. + = preference, - = avoidance. Critical values are 1.96 ($P < 0.05$), 2.58 ($P < 0.01$).

Whistling Swan

King (1970) estimated 800 whistling swans (*Olor columbianus*) on Alaska's Arctic Slope. This population winters in Chesapeake Bay (Sladen 1973) and represents about 1.3% of a 14-year mean of 62,000 that breed in Alaska (King 1973).

Aerial surveys in NPR-A revealed highest whistling swan densities southeast of Teshekpuk Lake and east to the Colville River (R. King, personal communication). We observed swans at all of our Arctic Coastal Plain study sites (Table 3), but breeding pairs were recorded only at East Long Lake and Meade River. Broods of two, three, and four cygnets were observed at these two sites. King (1970) determined a mean brood size of 2.2 cygnets per pair for the Arctic Coastal Plain, which is lower than 3.57 cygnets per pair reported for Yukon River delta whistling swans. Lensink (1973) attributed high productivity in the delta to the more favorable climate there.

King and Hodges (1981) tested 10 independent variables for correlation with whistling swan density in the Yukon-Kuskokwim River Delta, Alaska. They found significant correlations between the number of swans counted in air surveys and linear miles of lake shoreline, number of lakes, and number of small islands, which they concluded were the most important features to breeding birds. Small sample sizes made it impossible to test our observations with chi-square analysis. Therefore, we evaluated habitat preference based on frequency of occurrence of sightings combined from four study areas (Table 7) in 1978. Swans used Deep-*Arctophila* wetlands almost exclusively in June and July. They were observed feeding on *Arctophila fulva*, which may be a key species in their summer diet. These larger wetlands also provide ample space to take flight. Swans also were seen on Deep-open lakes and on the Meade River during molt, and a family group of seven was observed on the Beaufort Sea near Prudhoe Bay. At Meade River groups of 2 to 37 nonbreeders fed and loafed on river bars and partially drained basins breached by the river. Small groups of swans completed the wing molt at several study sites.

Table 7. Percent frequency of occurrence^a of whistling swans by wetland class at Storkersen Point, Square Lake, East Long Lake, and Island Lake in 1978.

Month	Wetland class							
	I	II	III	IV	V	VII	VIII	N
June	0	0	0	90.6	4.7	4.7	0	43
July	0	0	0	54.9	35.3	0	9.8	51
August	0	0	0	79.3	20.7	0	0	29

^aIncludes observations from weekly surveys and sightings made during other fieldwork.

Canada Geese

Canada geese (*Branta canadensis*) were observed at all study sites except Meade River (Table 3). There was no evidence of breeding at any of the NPR-A sites and no broods were observed during extensive aerial surveys of a 2,000-km² area of large lakes northeast of Teshekpuk Lake from 1976 through 1979 (J. King, personal communication). No Canada goose broods were seen during July, August, and September 1977 and 1978 air surveys that covered 95,044-km² of NPR-A (R. King, personal communication).

Canada geese breed on the Arctic Coastal Plain and barrier islands near Prudhoe Bay (Gavin 1975, 1979). One nest was found on the Storkersen Point study area in 1978, which is the first record from that site in 8 years (Bergman et al. 1977; this study). Kessel and Cade (1958) found 200-300 pairs of breeding Canada geese in the Arctic Foothills province along bluffs and steep talus slopes of the Colville River above Umiat (Fig. 1).

King (1970) estimated 15,000 molting Canada geese along the Beaufort Sea coast from Smith Bay to the Canning River (Fig. 1) and suggested that most of these birds were nonbreeders from interior Alaska south of the Brooks Range. King and Hodges (1979) summarized air survey results from 1957-78 for a 2,000-km² area northeast of Teshekpuk Lake. They determined that this unique area supported up to 50,000 molting geese of four species. Derksen et al. (1979b) evaluated the distribution of Canada geese in this large lake area and found most to be inland west of Cape Halkett (Fig. 1) during the flightless period.

Nonbreeding Canada geese first arrived at East Long Lake and Island Lake on 10 and 11 June, respectively. Peak buildup of Canada geese at these two sites was in mid-July. Derksen et al. (1979b) showed that molting Canada geese preferred Deep-open (Class V) lakes at East Long Lake and Island Lake. Birds capable of flight fed in upland sites and occasionally in Classes I and II wetlands in early June, but as flight feathers were lost in July they shifted to large Class V lakes (Table 8) where open water afforded safety from predators and adjacent shorelines provided ample food (Derksen et al. 1979b).

Table 8. Seasonal habitat selection^a by Canada geese at two sites in NPR-A in 1978.

Study site and month	Wetland class					
	I	II	III	IV	V	VII
East Long Lake ($\chi^2 = 545.24$, $n = 320$)						
June	5.83	+13.95	3.35	2.92	2.19	+ 1.45
July	15.22	7.48	5.04	4.39	+29.05	+ 0.75
August	1.27	2.62	1.52	1.32	+ 5.35	0.54
Island Lake ($\chi^2 = 686.18$, $n = 230$)						
June	- 3.85	- 2.08	- 1.48	- 0.45	- 1.99	0.16
July	-20.13	11.14	7.92	- 2.43	+46.99	- 0.86
August	- 6.03	- 2.51	- 1.79	- 0.55	+12.70	0.19

^aThe tabular adjusted residuals are measures of deviation from expected values. + = preference, - = avoidance. Critical values are 1.96 ($P < 0.05$), 2.58 ($P < 0.01$).

Black Brant

Gabrielson and Lincoln (1959) considered black brant (*Branta bernicla nigricans*) common nesters on the Alaskan Arctic coast from Point Hope on the Chukchi Sea to Barter Island near the Canadian border (Fig. 1). Palmer (1976) identified the Beaufort Sea coastal fringe as the principal

brant breeding area on Alaska's North Slope. In NPR-A, black brant were found breeding at Meade River, Island Lake, and East Long Lake, but not at the southern edge of the coastal plain at Singilik or Square Lake (Table 3). The southern limit of this species on the Arctic Coastal Plain is not precisely known, but we suggest that brant do not regularly breed farther than 40 km inland from the Beaufort Sea coast. In early August adults with young were seen 23 and 28 km inland near Kogrue Bay and Teshekpuk Lake (Fig. 1), respectively, and pairs were observed 47 km inland south of Barrow (R. King, personal communication). There are records of brant farther inland in the Foothills Province (Kessel and Cade 1958) and even in mountain passes (Cade 1955; Irving 1960) during migration in May.

Breeding pairs of black brant arrived the first week of June at Meade River, Island Lake, East Long Lake, and Storkersen Point. Populations remained relatively stable through the summer at Meade River and Storkersen Point. Flocks of nonbreeders and failed breeders migrating from Canada, western Alaska, and Wrangel Island, U.S.S.R. (King and Hodges 1979) first arrived in late June and early July at Island Lake and East Long Lake. Peak populations of molting brant occurred on 24 July at East Long Lake (Fig. 10) where wing feather molt lasted about 3 weeks (Derksen et al. 1979b). There were few molting birds at Island Lake and East Long Lake after 5 August, although adults with young remained on the study area through September.

BLACK BRANT 1978

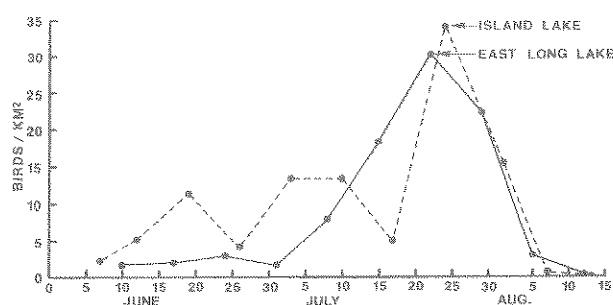


Fig. 10. Summer populations of black brant at two study sites in 1978.

Bergman et al. (1977) showed that brant used coastal wetlands (73% frequency) during migration, then shifted to Class IV wetlands (91% frequency) for nesting. Our observations from the large lake regime northeast of Teshekpuk Lake revealed that brant selected larger bodies of water with emergent vegetation (Class IV) for nesting in June (Table 9). The presence of small islands for nest sites also was important although nests were sometimes found along shorelines of larger vegetated wetlands. Most broods, however, were found on large Class V lakes (Table 5) that do not support emergent vegetation. We observed downy brant in small creeks with several adults move from Class IV to

Table 9. *Seasonal habitat selection^a by black brant at two sites in NPR-A in 1978.*

Study site and month	Wetland class					
	I	II	III	IV	V	VII
East Long Lake ($\chi^2 = 10,167.59$, $n = 2,989$)						
June	- 7.40	0.86	- 1.96	+14.58	3.71	+33.54
July	224.29	94.62	59.38	51.74	+375.58	+120.32
August	9.69	4.43	2.57	2.57	+14.50	+15.24
Island Lake ($\chi^2 = 12,392.31$, $n = 1,226$)						
June	8.45	3.33	2.37	+75.36	2.41	0.26
July	172.75	55.70	39.61	+11.64	+330.72	4.28
August	5.12	1.60	1.14	0.35	+ 9.91	0.12

^aThe tabular adjusted residuals are measures of deviation from expected values. + = preference, - = avoidance. Critical values are 1.96 ($P < 0.05$) 2.58 ($P < 0.01$).

Deep-open (Class V) lakes where they grazed with adults. At Storkersen Point brant moved broods from wetlands near the coast to Beaufort Sea lagoons. Mickelson (1975) reported similar brant brood movement from lakes to tidal sloughs and a river on the Yukon-Kuskokwim Delta, Alaska. Sedges and grasses preferred by brant were most abundant in wet meadows adjacent to Deep-open lakes (Derksen et al. 1979b), which very likely induced brood movements and distribution. As is true among duck broods (Bengtson 1971), food availability may be an important factor influencing brant brood movements between wetland habitats.

White-fronted Geese

King (1970) stated that white-fronted geese (*Anser albifrons*) were fairly evenly distributed throughout the lake areas of the Arctic Slope. Our data from the Arctic Coastal Plain province supports King's aerial observations. Mean seasonal densities of breeding white-fronted geese were from 0.7/km² at Meade River near the Beaufort Sea to 2.7/km² inland 138 km at Singilik (Table 3). Although densities are low north of the Brooks Range, King (1970) estimated 50,000 white-fronted geese on the Arctic Slope, which represents about 67% of the mid-continent winter population (Bellrose 1976).

White-fronted geese migrate to the large regime northeast of Teshekpuk Lake to molt (King and Hodges 1979). We found white-fronted geese molting in small groups of 5 to 20 at Meade River, Singilik, Square Lake, Island Lake, and Storkersen Point and in larger flocks of up to 600 near East Long Lake. Although molting flocks of white-fronted geese are found over most of their Arctic Coastal Plain breeding range, they are apparently most concentrated on a few lakes near Teshekpuk Lake. Derksen et al. (1979b) showed that this population was largely separated from other geese molting in this area. Furthermore, white-fronted geese do not shift to coastal wetlands like brant and Canada geese, perhaps because of their food preferences and their interior

migration route through Canada to south central United States wintering areas (Bellrose 1976).

White-fronted geese nested on upland sites or polygonal ridges near Shallow-Carex and *Arctophila* wetlands. Family groups and pairs grazed in upland sites during June and July. Postbreeding birds including failed breeders, selected Deep-open lakes for the annual molt in July and August (Table 10), where they fed on grasses and sedges in wet meadows (Derksen et al. 1979b). Bergman et al. (1977) showed that Deep-open lakes were used at a frequency of 94% by white-fronted geese during the postbreeding period in August at Storkersen Point. At East Long Lake, Beaded Streams were preferred ($P < 0.01$) throughout the summer by white-fronted goose pairs and pairs with broods (Table 10). Streams that connect lakes may be important corridors of travel which allow adults with broods to use several lakes without leaving the protection of the water. Forty-two percent of white-fronted goose broods were found on Beaded Streams (Table 5).

Table 10. *Seasonal habitat selection^a by white-fronted geese at East Long Lake in 1978.*

Study site and month	Wetland class					
	I	II	III	IV	V	VII
East Long Lake ($\chi^2 = 6,904.36$, $n = 181$)						
June	1.49	1.27	1.40	+ 0.78	2.61	+28.05
July	4.11	- 4.06	2.35	2.05	+ 0.01	+51.02
August	13.92	- 6.36	3.68	3.21	+ 5.10	+97.41

^aThe tabular adjusted residuals are measures of deviation from expected values. + = preference, - = avoidance. Critical values are 1.96 ($P < 0.05$), 2.58 ($P < 0.01$).

Lesser Snow Geese

Migrating lesser snow geese (*Anser caerulescens caerulescens*) were seen in June at all study sites except Square Lake (Table 3), but regular sightings during July and August were made only at East Long Lake where a few molted on Deep-open lakes (Derksen et al. 1979b). Apparently, lesser snow geese nested over much of the Arctic Coastal Plain (Gabrielson and Lincoln 1959) before 1900, but there have been few records in recent years. A pair nested on the East Long Lake study area in 1978 and fledged one young. Aerial surveys conducted in 1979 from Cape Halkett to Drew Point (Fig. 1) and south to Teshekpuk Lake revealed 86 adults and two broods of two and four (J. King, personal communication). A small colony of lesser snow geese nest on Howe Island in the Sagavanirktok River delta near Prudhoe Bay. Fewer birds have been seen in recent years, possibly due to disturbance from intensive helicopter traffic.

Farther east there is a major fall staging area near the Canning River delta (Fig. 1) within the boundary of William O. Douglas Arctic National Wildlife Range. Michael Spindler (personal communication) recorded 80,000 lesser snow geese while traveling from the outer delta to Barter

Island in September 1979. These birds migrate west from breeding grounds in the MacKenzie and Anderson river delta and other Canadian nesting areas (Barry 1967).

Pintail

The pintail (*Anas acuta*) is probably the most numerous duck on the Arctic Coastal Plain, especially in the western half (Gabrielson and Lincoln 1959). Densities were equal to or greater than those of other duck species at all sites near the coast, but ranked second to oldsquaws (*Clangula hyemalis*) near the foothills (Table 3). Maher (1959) recorded only one bird during two field seasons on the Kaoluk River in the northern foothills, but Irving (1960) considered them the most numerous resident duck at Anaktuvuk Pass in the Brooks Range (Fig. 1).

The most dynamic facet of pintail populations is the periodic drought displacement of birds to the arctic from the southern prairies where the species is highly mobile and adapted to temporary wetlands (Derrickson 1978). Such an occurrence was documented from this study in 1977 by Derksen and Eldridge (1980). The greatest density recorded was 45.6/km² at East Long Lake on 20 June 1977. In 1978 populations declined as much as 62% but remained above average. Superimposed on the annual variations are low densities during molt in the latter half of July and subsequent premigration increases in August (Fig. 11).

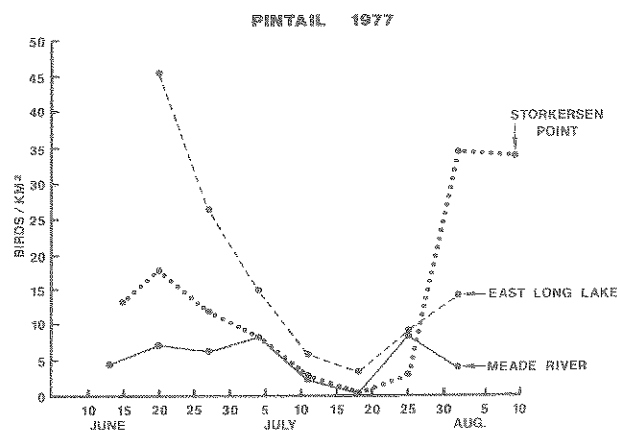


Fig. 11. Summer populations of pintail at three study sites in 1977.

Although pintails are abundant on the coastal plain, sex ratios are heavily skewed toward males, and most are probably nonbreeders (Bergman et al. 1977; Derksen and Eldridge 1980). Nesting is more regular on the western coastal plain (Pitelka 1974), encompassed by NPR-A, and the easternmost Alaskan records are from near Prudhoe Bay (Gavin 1975; Bergman et al. 1977). We found no more than one nest at each study site and none during the single season at Island Lake. Broods were observed at Singiluk (eight), Square Lake (two), and Meade River (one).

Table 11. Seasonal habitat selection^a by pintails at three sites on the Arctic Coastal Plain in 1978.

Study site and month	Wetland class					
	I	II	III	IV	V	VII
East Long Lake ($\chi^2 = 6,116.28$, $n = 681$)						
June	12.43	9.13	+57.48	+ 0.96	11.70	+ 6.96
July	13.98	6.38	+50.94	+ 1.04	8.18	+ 4.77
August	19.50	4.18	+24.26	+49.71	11.41	1.82
Storkersen Point ($\chi^2 = 8,036.59$, $n = 652$)						
June	20.03	13.19	+79.51	+ 5.32	4.54	0.42
July	9.00	6.08	+40.47	1.52	2.34	1.38
August	27.47	7.17	+56.22	+43.97	5.23	4.21
Square Lake ($\chi^2 = 12,365.71$, $n = 172$) ^b						
June	1.60	+ 2.72	+ 1.77	2.20	-	+31.07
July	- 6.94	1.13	+ 0.36	+ 0.12	-	+114.67
August	8.99	+ 5.08	1.23	+ 2.53	-	+64.16

^aThe tabular adjusted residuals are measures of deviation from expected values. + = preference, - = avoidance. Critical values are 1.96 ($P < 0.05$), 2.58 ($P < 0.01$).

^bNo Class V wetlands present.

Pintails preferred *Arctophila* wetlands, including Beaded Streams, throughout the summer (Table 11). When pintails first arrived in spring they fed in the only water areas available, Flooded Tundra meadows, but soon moved to Shallow-*Arctophila* ponds (Bergman et al. 1977). At Square Lake Shallow-*Arctophila* ponds were uncommon (Table 2) and pintails used Beaded Stream *Arctophila* beds and Shallow-*Carex* ponds. The Beaded Stream at Storkersen Point was underutilized, probably because *Arctophila* was not abundant there.

The dense cover of Shallow-*Arctophila* ponds was preferred in July at the onset of molt but some of these ponds later became dry, causing a shift in use to Deep-*Arctophila* ponds and, at Square Lake, to Beaded Streams. Observations at all sites on Deep-*Arctophila* ponds accounted for 70% of brood sightings (Table 5) and there is a strong preference for this class during the August staging period (Table 11). At Island Lake the unique shallow Class V lakes provided accessible feeding for postmolt flocks. Basin-complexes with *Arctophila* pools supported high densities of pintails for the entire season at Meade River, East Long Lake, and Storkersen Point (Bergman et al. 1977).

Pintails may be attracted to *Arctophila* wetlands because of their feeding habits. With their long necks they can use deeper ponds than other dabbling ducks. *Arctophila* beds seed profusely in shallow ponds and stream floodplains that are dry by August. When reflooded in spring these beds are used intensively by pintails that often consume high proportions of plant material (Bellrose 1976) and select seed-rich areas (Krapu 1974a). *Arctophila* wetlands also produce more diverse communities of invertebrates (Bergman et al. 1977) that are important to breeding birds (Krapu 1974b).

Oldsquaw

Among north slope duck species the oldsquaw is the most ubiquitous and abundant regular breeder (Bailey 1948; Gabrielson and Lincoln 1959). It is recorded as a common breeder near Barrow (Pitelka 1974), at all NPR-A study sites (Table 3), and eastward along the Canadian arctic coast (Barry 1960). Sage (1974) noted that oldsquaws were common and bred on numerous ponds and lakes south into the Sagavanirktok and Atigun valleys, but Maher (1959) considered them rare on the upper Kuoluk River in the foothills of southwestern NPR-A.

The highest mean densities of oldsquaws were recorded at Singituk and Square Lake near the foothills (Table 3), but they were numerous at all sites. Local populations were moderately stable during June when breeders established territories. Paired males remained with their hens longer than most sea ducks, but began leaving nesting areas during late July (Fig. 12; Alison 1975) to molt in the nearshore waters of the Beaufort Sea (Vermeer and Anweiler 1975; Schamel 1978; Johnson 1979). From late July through August females and broods gathered to molt on large inland lakes or coastal lagoons (Alison 1975; Bergman et al. 1977), which resulted in lower densities of birds at Meade River where they left the study area, and at Storkersen Point where they moved to the Beaufort Coast (Fig. 12). All other sites had higher densities because of the concentrations on large lakes.

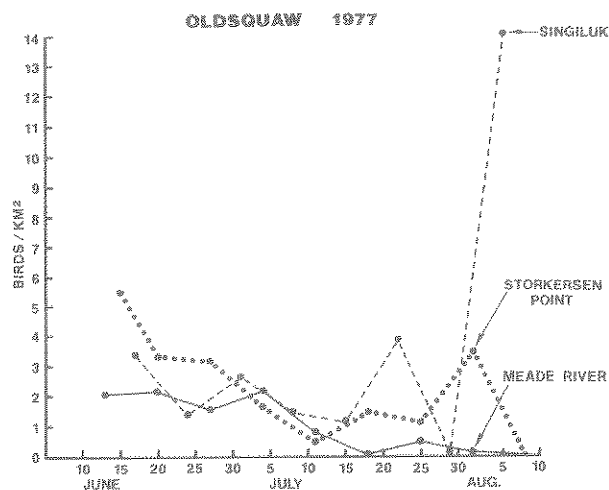


Fig. 12. Summer populations of oldsquaw at three study sites in 1977.

Habitat selection by oldsquaws (Table 12) was generally similar to that reported at Storkersen Point (Bergman et al. 1977). Birds congregated in spring on open-water moats of large lakes and used Deep-*Arctophila* wetlands as they became ice-free. Breeding pairs dispersed to smaller Shallow-*Carex* ponds at East Long Lake and Square Lake, Shallow-*Arctophila* ponds at Storkersen Point, and Deep-*Arctophila*

Table 12. Seasonal habitat selection^a by oldsquaws at four sites on the Arctic Coastal Plain in 1978.

Study site and month	Wetland class					
	I	II	III	IV	V	VII
East Long Lake ($\chi^2 = 9,907.12$, $n = 375$)						
June	7.40	+ 1.94	0.07	+ 6.12	+ 3.77	+24.10
July	7.31	+ 0.37	1.30	+24.15	4.28	+96.42
August	30.71	13.08	7.64	7.08	+55.51	2.86
Island Lake ($\chi^2 = 1,119.45$, $n = 192$)						
June	9.19	+ 0.69	0.72	+ 7.43	+10.94	0.22
July	22.73	7.13	4.52	1.55	+43.13	+ 4.13
August	8.74	2.74	1.95	0.60	+16.92	0.21
Storkersen Point ($\chi^2 = 630.99$, $n = 143$)						
June	-13.05	+ 1.21	+ 6.13	+12.78	+ 0.66	+15.52
July	- 7.50	+ 1.35	+ 3.84	+ 7.69	+ 7.13	+ 2.53
August	6.04	4.09	1.28	+ 6.52	+17.10	0.93
Square Lake ($\chi^2 = 182.71$, $n = 179$)						
June	3.00	0.72	0.90	+ 3.22	^b	+ 5.30
July	9.42	+ 7.71	1.29	+ 5.39		+ 4.49
August	8.77	+ 0.23	1.20	+ 8.57		+ 4.60

^aThe tabular adjusted residuals are measures of deviation from expected values. + = preference, - = avoidance. Critical values are 1.96 ($P < 0.05$), 2.58 ($P < 0.01$).

^bNo Class V wetlands present.

wetlands at all sites into July. During July postbreeding and nonbreeding birds preferred Deep-*Arctophila* and Deep-open lakes. Beaded Streams were used significantly ($P < 0.01$) more than expected throughout the summer at Square Lake, through July at East Long Lake and Storkersen Point, but only during July at Island Lake.

Nearly all oldsquaw broods were seen on Deep-*Arctophila* (44%), Deep-open (25%), and Shallow-*Carex* (19%) wetlands (Table 5), all characteristically with central zones of open water. Our observations generally support those of Alison (1976) that older broods use larger wetlands. During the August molt and staging period oldsquaws strongly preferred Deep-open lakes at all sites except Square Lake (Table 12) where Deep-open lakes did not occur (Table 2). Flocks of birds also selected Deep-*Arctophila* wetlands at Square Lake and Storkersen Point.

Habitat selection by oldsquaws reflects preferences of strongly territorial breeding birds (Alison 1975) for small discrete wetlands, the combination of cover and water permanence for broods in Deep-*Arctophila* ponds, and open-water areas important to all diving species, especially during molt.

Spectacled Eider

The summer breeding range of the spectacled eider (*Somateria fischeri*) is centered on the Yukon-Kuskokwim Delta, but extends in a coastal band along the Bering and Beaufort Seas east to the Colville River delta (Gabrielson

and Lincoln 1959; Dau and Kistchinski 1977). Spectacled eiders are listed as occasional breeders at Barrow (Pitelka 1974), but were more common at our Meade River, East Long Lake, and Island Lake sites (Table 3), within a breeding area surmised by Bailey (1948). Occasional breeding has been recorded at Storkersen Point (Bergman et al. 1977; Table 3) and Prudhoe Bay (Gavin 1975). An affinity for coastal areas is apparent, and spectacled eiders have only been seen near the foothills as casual visitors at Singilik; thus, the most important North Slope breeding range lies within NPR-A boundaries.

Spectacled eiders were most numerous at East Long Lake but densities were relatively low at all four sites near the coast (Table 3). Nests or broods were found on each of these study areas. Seasonal changes in populations could not be detected from weekly census data but males had left the study areas by 8 July in both years. During July and August females with broods were seen, occasionally accompanied by groups of hens ("aunts"), similar to common eiders, *Somateria mollissima* (Guignion 1967).

There were insufficient observations of spectacled eiders to test habitat preferences, but sightings at East Long Lake indicate that they are similar to those of oldsquaws. Shallow-*Arctophila* ponds and Deep-open lakes were used only during June, but Shallow-*Carex* ponds were used increasingly throughout the summer. Deep-*Arctophila* ponds were used extensively during July and less so during August (Bergman et al. 1977). Broods were most often seen on Shallow-*Carex* ponds (56%) and Deep-open lakes (22%) (Table 5). Like oldsquaws, spectacled eiders dive for invertebrates and generally prefer open-centered wetlands.

King Eider

Gabrielson and Lincoln (1959) indicated that Alaskan king eiders (*Somateria spectabilis*) were most abundant near Barrow; however, Pitelka (1974) considered them only irregular breeders there. Furthermore, we found no evidence of breeding at Meade River delta, within 55 km of Barrow, or at the other NPR-A sites near the coast (Table 3). The most productive breeding areas of king eiders are east of the Colville River. They are considered regular breeders at Storkersen Point (Bergman et al. 1977; Table 3) and are relatively numerous near Oliktok (Divoky 1979), Prudhoe Bay (Gavin 1975; Schamel 1978), Barter Island (Spindler 1978), Humphrey Point (Dixon 1943), and in the Canadian arctic (Barry 1968). Breeding was recorded at both near-foothills sites, but there is no evidence that it occurs south of the coastal plain.

At Storkersen Point, king eider population densities were second only to pintails, but they were low at all sites in NPR-A (Table 3). Males abandoned nesting hens in late June and early July (Fig. 13) and were observed on molt migrations to coastal waters where they move westward (Barry 1968; Flock 1973) around Point Barrow (Thompson and Person 1963; Johnson 1971). Unlike oldsquaws, eiders spend relatively little time staging in nearshore waters during late

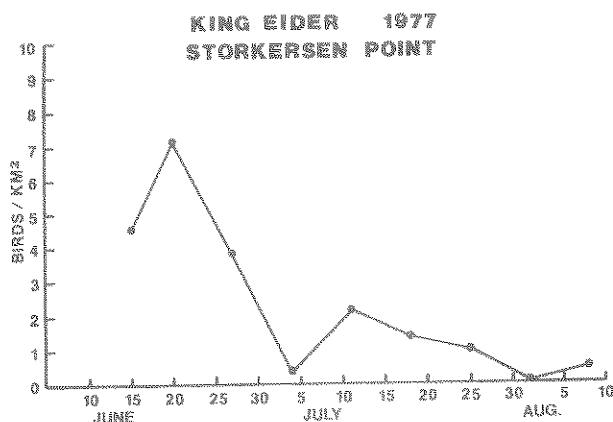


Fig. 13. Summer population of king eider at Storkersen Point in 1977.

summer (Schamel 1978) but are found along their migration paths 13-16 km from shore (Bartels 1973).

Sufficient wetland use data on king eiders was collected in 1978 only at Storkersen Point (Table 13). Wetland preferences were the same as those reported by Bergman et al. (1977) at this site. Shallow- and Deep-*Arctophila* wetlands were differentially selected during nesting in June. Deep-open lakes were preferred only in July, probably by postbreeding groups. Frequent use of Deep-*Arctophila* ponds through July and August resulted from strong selection by hens and broods (78% of observations). All other broods were seen on Shallow-*Carex* ponds (Table 5).

Table 13. Seasonal habitat selection^a by king eiders at Storkersen Point, 1978.

Study site and month	Wetland class					
	I	II	III	IV	V	VII
Storkersen Point ($\chi^2 = 1,564.79$, $n = 177$)						
June	11.96	- 2.25	+23.79	+11.54	3.10	+ 6.09
July	11.42	+ 0.11	2.42	+16.27	+ 7.49	+10.22
August	5.78	3.91	1.23	+31.42	0.66	0.89

^aThe tabular adjusted residuals are measures of deviation from expected values. + = preference, - = avoidance. Critical values are 1.96 ($P < 0.05$), 2.58 ($P < 0.01$).

Greater Scaup

Gabrielson and Lincoln (1959) considered the west coast of Alaska as the major breeding range of greater scaup (*Aythya marila*). Greater scaup were listed as casual visitors at Barrow (Pitelka 1974), East Long Lake, and Meade River delta in NPR-A (Table 3). Okpilak River delta (Spindler 1978), and for several years at Storkersen Point (Bergman et al. 1977). A brood was seen in the Colville River delta but most North Slope breeding records are from the foothills region (Kessel and Cade 1958; Maher 1959). Notable breeding populations were reported near Anaktuvuk Pass

(Irving 1960), in the Atigun-Sagavanirktok River valleys (Sage 1974), and Square Lake. One brood was seen at Singiluk.

Densities of scaup were moderately high in June at both near-foothills sites, and the highest recorded was 2.4/km² at Square Lake on 8 July. Irving's (1960) records indicate that scaup nest from early to mid-June in the mountains. Five nests were found at Square Lake, the earliest backdated to initiation on 24 June. Drakes left the area to molt around mid-July and the first flightless male was seen on 18 July. Broods were first observed the last week in July and densities increased as mixed-sex flocks gathered through August.

Greater scaup used all wetland classes in early June but moved to Deep-*Arctophila* lakes when they had open water. The latter wetland class provided 77% of all observations in June, 92% in July, and 100% in August. Molting males also used similar Beaded Stream habitat during July. Nine of 10 brood sightings were on Deep-*Arctophila* lakes (Table 5).

White-winged Scoter

During the breeding season white-winged scoters (*Melanitta deglandi*) have been seen from Barrow to Demarcation Point on the Canada border (Gabrielson and Lincoln 1959) but they are more abundant in interior Alaska and Canada (Bellrose 1976). Most observations were of stragglers and migrants, but Irving (1960) reported white-winged scoters as common breeders near Anaktuvuk Pass and collected a brood on the Killik River. Our Square Lake site had a moderate resident population and was the only NPR-A site where the species was seen. The single nest found there is the northernmost Alaska record.

Densities of white-winged scoters increased at Square Lake to a high of 1.8/km² on 1 July (Fig. 14). The largest flock seen was 44 males. From 19-30 July males were not observed on the study area and probably were beginning postnuptial molt (Dement'ev and Gladkov 1967). In behavior similar to greater scaup, white-winged scoters used Deep-*Arctophila* lakes almost exclusively, amounting to 94% of all observations in June and 100% from July through August. All brood sightings also occurred on this wetland class (Table 5).

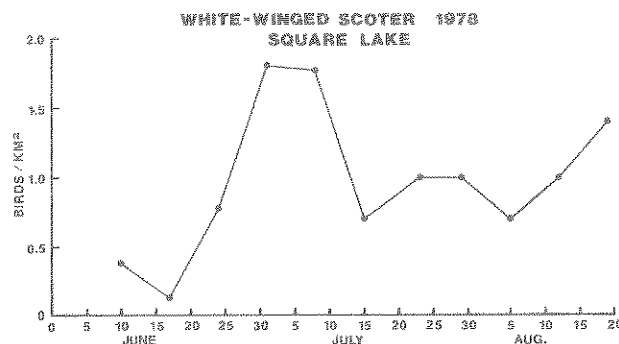


Fig. 14. Summer populations of white-winged scoter at Square Lake in 1978.

The single nest found was well hidden in a dense upland thicket of dwarf birch (*Betula nana*), approximately 6 m from a large Deep-*Arctophila* lake. The nest site was similar to those described by Brown (1977) in Alberta. Nest initiation was backdated from hatching (8 August) to 4 July. Seven of nine eggs hatched and the ducklings were led to water within 30 h of the start of hatch.

Other Ducks

Small numbers of eight other duck species were seen at one or more of our NPR-A sites (Table 3), mostly in early June. Although there is no record of mallards (*Anas platyrhynchos*) at Barrow (Pitelka 1974), they were seen nearby in the Meade River delta and at East Long Lake. They may occur more frequently to the east near Prudhoe Bay where Gavin (1975) has reported irregular breeding (Bergman et al. 1977). Green-winged teal (*Anas crecca carolinensis*) are occasionally seen near the coast, but nesting was recorded only at Square Lake near their known breeding range in the foothills (Kessel and Cade 1958; Irving 1960; Sage 1974). American wigeon (*Anas americana*) have been seen in many locations on the North Slope and were recorded at all NPR-A sites. Broods have been seen in the Brooks Range (Irving 1960) and at Umiat (West and White 1966). All of these dabbling duck species are probably more common in years of drought on the southern prairies.

Common eiders occur along the entire Arctic coast (Gabrielson and Lincoln 1959) especially during migrations. Breeding is widespread coastally but is more concentrated on the barrier islands east of the Colville River (Schamel 1974; Gavin 1979) and near Icy Cape on the Chukchi Sea (Divoky 1978). The Steller's eider (*Polysticia stelleri*) is relatively uncommon and was seen only at Singiluk, but breeding has been recorded along the entire north coast of Alaska (Gabrielson and Lincoln 1959). Surf scoters (*Melanitta perspicillata*) have been seen at many locations but breeding records are not clear (Gabrielson and Lincoln 1959). Reed (1956) observed a hen and brood on the Kikiakrorak River in eastern NPR-A. Red-breasted mergansers (*Mergus serrator*) are regular stragglers, mostly on rivers (Gabrielson and Lincoln 1959). Nests or broods have been found on the Kaolak (Maher 1959), Atigun (Sage 1974), and Firth rivers (Dixon 1943), and near Anaktuvuk Pass (Irving 1960).

Six species of ducks may occur only rarely in NPR-A and were not seen during our investigations: gadwall, *Anas strepera* (Child 1972); redhead, *Aythya americana* (Kessel and Cade 1958); lesser scaup, *Aythya affinis* (Irving 1960; Hall 1975); common goldeneye, *Bucephala clangula* (Kessel and Cade 1958; Irving 1960); and black scoter, *Melanitta nigra* (Gabrielson and Lincoln 1959; Watson and Divoky 1972). The authors also saw black scoters in the Colville River delta on 27 June and off Point McIntyre near Storkersen Point on 30 June 1976. The latter record was during westward migration at their western landfall in

crossing Prudhoe Bay. Four flocks, the largest with 59, totaled 127 birds.

Red Phalarope

Red phalaropes (*Phalaropus fulicarius*) ranked either first or second in abundance among shorebirds at study sites near the coast, but were much less common at Square Lake and Singilik (Table 3). At our sites, red phalaropes were most numerous in June; numbers gradually declined in July, then dropped off sharply in late July and early August (Fig. 15). At Storkersen Point and Island Lake an influx in early August occurred as birds staged for migration. Red phalarope migration occurs in stages based on sex and age with females departing for the Beaufort Sea coast in late June and early July, males in mid- to late July, and juveniles in August (Connors et al. 1979).

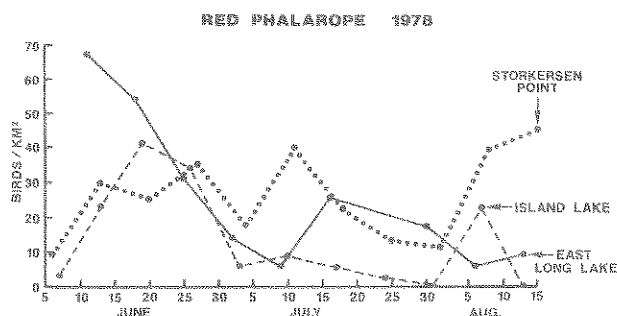


Fig. 15. Summer populations of red phalarope at three study sites in 1978.

Connors et al. (1979) suggested that red phalaropes shift from almost exclusive use of tundra for breeding activities to heavy dependence on littoral areas by postfledging juveniles and adult males. They reported that the differences in migration schedules of adult males and females and juveniles coincided with differences in habitat use. Females rarely appeared in littoral sites, male use of littoral habitats depended on annual variations in the timing of sea-ice, and juveniles extensively used the littoral zone, particularly along the Beaufort Sea shorelines as they accumulated fat for migration. Our data indicate that red phalaropes utilize Flooded Tundra in early June, although use was less than expected at all sites because of the extensiveness of this habitat type (Table 14). Various other wetland types also were important at particular sites in June. Beaded Streams were used significantly ($P < 0.05$) more than expected at all sites in June and appear to be an important source of food early in the season. Shallow-*Carex* and Shallow-*Arctophila* wetlands were used more than expected at Island Lake and Storkersen Point in June (Table 14). In July and August most use was concentrated on Shallow-*Carex* and Shallow-*Arctophila* wetlands although Beaded Streams and Flooded Tundra were still used. The importance of Deep-*Arctophila*

Table 14. Seasonal habitat selection^a by red phalaropes at three sites on the Arctic Coastal Plain in 1978.

Study site and month	Wetland class					
	I	II	III	IV	V	VI
Island Lake ($\chi^2 = 27,839.97$, $n = 383$)						
June	7.27	+10.82	+ 2.77	+ 1.06	5.81	+26.43
July	1.40	+ 3.90	1.48	0.45	0.75	0.16
August	29.86	9.36	6.66	+253.18	8.94	0.72
East Long Lake ($\chi^2 = 4,643.61$, $n = 1,147$)						
June	5.09	4.30	4.83	3.33	2.04	+76.97
July	31.83	+16.97	+ 3.09	+19.32	+10.40	+ 4.22
August	6.28	+ 8.96	+ 0.80	0.80	2.08	+ 7.92
Storkersen Point ($\chi^2 = 1,875.88$, $n = 686$)						
June	5.14	0.95	+11.24	+ 7.27	3.27	+ 2.23
July	11.79	3.31	+ 6.00	+38.84	+ 1.53	+ 0.90
August	35.21	+42.37	+ 0.18	0.28	5.95	- 4.87

^aThe tabular adjusted residuals are measures of deviation from expected values. + = preference, - = avoidance. Critical values are 1.96 ($P < 0.05$), 2.58 ($P < 0.01$).

wetlands differed in varying degrees between periods and sites. Use in July and August was generally higher than expected although these wetlands were also important in June at Storkersen Point. Use of Deep-open lakes was less than expected at all sites except East Long Lake in July.

Northern Phalarope

Northern phalaropes (*Phalaropus lobatus*) were less common than red phalaropes at all sites except Singilik and Square Lake (Table 3). Although they were common at the East Long Lake site in 1977 and 1978, numbers were low at Storkersen Point, Meade River, and Island Lake. Numbers of northern phalaropes were highest in early June and decreased in late June and early July (Fig. 16). A premigration increase to 20.4 and 8.8 birds/km² occurred at East Long Lake and Storkersen Point, respectively, in mid-July as northern phalaropes staged in large flocks up to 1,500 birds. By early August there were few northern phalaropes at our study sites.

Trends in habitat use by northern phalaropes were similar to red phalaropes (Table 15). Flooded Tundra and Beaded Streams were important wetlands in June. Use of Shallow-*Carex* and Shallow-*Arctophila* wetlands varied among study areas, but generally they were more important in July and August as Flooded Tundra dried. Deep-*Arctophila* wetlands were important throughout the summer at Storkersen Point, but were used less than expected at the other sites. Deep-open wetlands were used less than expected or as expected at East Long Lake in summer 1978. This wetland type did not occur at Square Lake so no comparisons can be made.

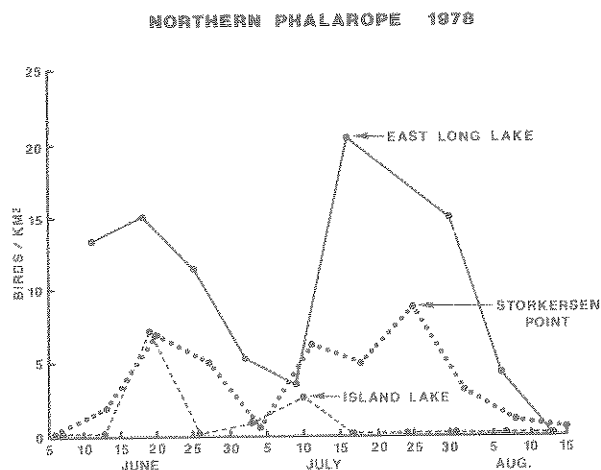


Fig. 16. Summer populations of northern phalarope at three study sites in 1978.

Table 15. Seasonal habitat selection^a by northern phalaropes at three sites on the Arctic Coastal Plain in 1978.

Study site and month	Wetland class					
	I	II	III	IV	V	VII
East Long Lake ($\chi^2 = 4,029.20$, $n = 270$)						
June	8.25	5.13	+ 6.37	+ 1.42	7.54	+83.23
July	10.88	+10.68	+ 5.06	+13.64	8.10	+ 9.74
August	3.15	1.69	+ 2.46	+ 4.33	2.17	+18.14
Storkersen Point ($\chi^2 = 967.80$, $n = 108$)						
June	3.90	1.78	+10.46	+ 7.43	1.87	1.10
July	12.36	- 2.12	+ 0.20	+43.14	3.21	+ 4.47
August	3.76	+ 3.34	0.80	+ 4.84	0.98	0.58
Square Lake ($\chi^2 = 4,002.74$, $n = 74$)						
June	2.45	+ 9.23	1.11	2.97	^b	+14.47
July	2.62	+ 3.52	0.65	3.70		+73.25
August	3.45	+ 1.28	0.47	+ 2.88		0.13

^aThe tabular adjusted residuals are measures of deviation from expected values. + = preference, - = avoidance. Critical values are 1.96 ($P < 0.05$), 2.58 ($P < 0.01$).

^bNo Class V wetlands present.

Pectoral Sandpiper

Pitelka (1959) considered pectoral sandpipers the most numerous and widespread shorebird on the Alaskan tundra. Pectoral sandpipers were the most abundant shorebird at all study sites in 1977 but were second or third in 1978 when mean seasonal densities declined by as much as half (Table 3). Variation in populations of pectoral sandpipers between years seems to be related to differences in spring melt and availability of food resources (Pitelka 1959; Holmes and Pitelka 1968). Pectoral sandpipers have a flexible territorial system and are capable of compressing territories and

increasing densities when and where food is abundant (Pitelka 1959; Holmes and Pitelka 1968). There is a progressive movement of postbreeding males, postbreeding females, and fledged juveniles to the coast from mid- to late July (Pitelka 1959; Connors et al. 1979). Premigration population increases in late July and early August were recorded at several but not all of our study sites.

Connors et al. (1979) include pectoral sandpipers in a shorebird group more restricted to tundra than coastal habitats. These sandpipers preferred drier sites on all study areas. At East Long Lake in 1978 99% of all June and July observations of pectoral sandpipers were on Flooded Tundra. However, pectoral sandpipers use littoral habitats of Shallow-*Carex*, Shallow-*Arctophila*, and Deep-open wetlands, particularly in late July and August.

Dunlin

Dunlins (*Calidris alpina*) were third or fourth in abundance at sites closest to the coast in 1977 and 1978, but were uncommon in the southern coastal plain (Table 3). Holmes (1970) reported that in Alaska dunlins are widespread with little population variation from year to year. However, Baker and Baker (1973) found large year-to-year shifts in foraging behavior and habitat use by dunlins in the eastern arctic. Differences in population densities and feeding behavior could be due to successive occupation by morphologically different subspecies (Holmes 1970). Dunlins establish 12- to 15-acre territories in early June which are utilized for all life functions until young hatch in early to mid-July (Holmes 1966). Dunlins remain on the tundra longer than other shorebirds due to the strong territorial system but shift to littoral wetland areas in mid-summer when young hatch. We recorded a gradual decline in dunlin populations from mid-June to mid-August.

Dunlins utilize a wide range of habitat types and appear to be a broad-niched species (Holmes 1966; Baker and Baker 1973; Baker 1979). Habitat selection varies with moisture conditions and food availability (Holmes 1966). Feeding activities are concentrated on Tipulid larvae and a high overlap with the diet of pectoral sandpipers occurs throughout the year (Holmes 1966; Holmes and Pitelka 1968). After leaving fledged young on wetter sites, adults return to upland areas for flocking and departure to the coast (Holmes 1966).

Other Shorebirds

We recorded 17 other species of shorebirds at six study sites in 1977 and 1978. Densities varied considerably between sites and years (Table 3). Semipalmated sandpipers (*Calidris pusilla*) were considered a common breeding species at all sites each year, with highest densities recorded at Storkersen Point. Holmes and Pitelka (1968) described their distribution as coastal and along river corridors. Semipalmated sandpipers are one of the earliest shorebirds to migrate to winter areas, flocking in early July and departing by the end of July (Holmes and Pitelka 1968). Semipalmated sandpipers are considered a broad-niched

species (Baker and Baker 1973) and utilize both inland tundra and coastal habitats throughout the season (Connors et al. 1979; this study). Shorelines of ephemeral Class II wetlands were important feeding sites in late June and early July. Breeding cycles and behavior of semipalmated sandpipers are discussed by Ashkenazie and Safriel (1979).

Bar-tailed godwits (*Limosa lapponica*) were second in abundance at Singiluk in 1977, and were regularly sighted at Square Lake in 1978, but were uncommon at coastal sites. American golden plovers (*Pluvialis dominica*) and black-bellied plovers (*P. squatarola*) were present in low numbers at all sites. Activities of these species are restricted almost entirely to drier areas throughout the summer with some movement to littoral habitats later (Connors et al. 1979; this study). The buff-breasted sandpiper (*Tryngites subruficollis*), observed in small numbers at all sites except Meade River and Singiluk, also utilized drier habitats. This sandpiper was a common breeder at Storkersen Point and one of the latest nesting of all shorebirds (Bergman et al. 1977). Long-billed dowitchers (*Limnodromus scolopaceus*) and ruddy turnstones (*Arenaria interpres*) were observed in low numbers at all sites.

Observations of other species were sporadic during each season (Table 3) and data are insufficient for comments on habitat use.

Discussion

Species Composition

Although there are notable differences in avifauna between Storkersen Point and the western coastal plain sites, the greatest dissimilarity is between coastal and near-foothills areas. The Singiluk and Square Lake sites were located at the interface of northern foothills tussock tundra-tall shrub habitats with the morphologically unique wetlands of the southern coastal plain.

Species richness was greatest at Storkersen Point, where marine and tundra species were present. However, of 62 species recorded in 1977 and 1978 only 25 (40.3%) nested (Table 3). The greater percentage of visitors at this site, when compared to inland sites located in NPR-A, may be due to the effects of the Beaufort Sea coast in channeling movements of birds, as in the Barrow region (Pitelka 1974). Storkersen Point is also located between two major rivers that may be followed north to the coast by redpolls (*Carduelis* sp.), horned larks (*Eremophila alpestris*), and other casual visitors from shrub and mountain valley habitats (Bergman et al. 1977). Barn swallows (*Hirundo rustica*) and Say's phoebes (*Sayornis saya*) may be attracted to buildings (Kessel 1979) in the Prudhoe Bay oil development area where snow buntings (*Plectrophenax nivalis*) were found nesting in structures, discarded barrels, and other debris that provided crevices.

Species richness was next highest at Square Lake near the southern margin of the Arctic Coastal Plain. Twenty-seven

of 53 species seen (50.9%) (Table 3) were known breeders. Shrub height, especially *Salix* spp., was significantly greater at the southern Arctic Coastal Plain sites of Singiluk and Square Lake, which attracted four breeding passerines. Closer to the Beaufort Sea coast where shrubs were prostrate as a result of more severe climate, lapland longspurs (*Calcarius lapponicus*) were the only breeding passerines on tundra habitats. Falconiformes breed on the Arctic Coastal Plain along rivers where steep bluffs provide nest sites. Gyrfalcons (*Falco rusticolus*), peregrine falcons (*Falco peregrinus*), and rough-legged hawks (*Buteo lagopus*) nest along the Colville River bluffs (Kessel and Cade 1958; White and Cade 1971) about 40 km south of the Square Lake study site where gyrfalcons and peregrine falcons were seen hunting. Although habitats were similar to those at Square Lake, no falconiformes were seen at Singiluk, perhaps because of Singiluk's greater distance from known breeding sites (Ritchie 1979).

East Long Lake and Island Lake had 25 and 16 breeding birds, respectively (Table 3), although the study sites were only about 25 km apart. More varied and interspersed wetland habitats and greater area of dry upland sites at East Long Lake attracted more species than the more homogeneous wetland habitat at Island Lake (Table 2). East Long Lake had a greater percentage of Classes IV and VII wetlands which were important to water birds. Upland species such as the buff-breasted sandpiper and willow ptarmigan (*Lagopus lagopus*) were seen rarely because of the large percentage of wetland (85.8%) in the Island Lake study area.

Species composition of breeding birds at Meade River was most like the East Long Lake study site (Table 3). Only lesser snow geese, buff-breasted sandpiper, northern phalarope, and long-tailed jaeger (*Stercorarius longicaudus*) were not found breeding at one or the other site (Table 3). There were no breeding birds characteristically associated with fluvial waters at Meade River. Yellow-billed, arctic and red-throated loons, whistling swans, and greater scaup actively fed and loafed on river channels and oxbows. Kessel and Cade (1958) provided a list of birds found in fluvial habitats along the Colville River and its tributaries.

Density

Alaska's Arctic Coastal Plain supports relatively low breeding densities of most water birds (King 1970; Bergman et al. 1977; this study) compared to more productive wetlands farther south and west. King and Lensink (1971) summarized aerial survey data and reported breeding densities of 257.4 ducks/km² for the Yukon River flats in interior Alaska and 124.1 ducks/km² in the Yukon-Kuskokwim Delta on the west coast. Breeding duck densities on the Arctic Coastal Plain of NPR-A were estimated to be 2.8/km² in both 1977 and 1978 (King 1979). Our ground surveys in NPR-A revealed breeding duck densities of 8.9 to 19.2/km² in 1977 and 9.8 to 11.7/km² in 1978. Comparative density data for other water bird groups

in wetland habitats other than the Arctic Coastal Plain are not available, but shorebirds dependent on wetland habitats may be as dense on the Arctic Coastal Plain as elsewhere.

Despite low breeding densities of some groups, large numbers of water birds annually use the Arctic Coastal Plain. King (1979) estimated 5.4 and 4.9 million water birds on the Arctic Coastal Plain of NPR-A in July 1977 and July 1978, respectively. Shorebirds represented 91% of the total in 1977 and 93% in 1978. Aerial surveys indicate that habitats up to 50 km inland from the Beaufort Sea have the highest concentrations of breeding water birds (King 1979; U.S. Fish and Wildlife Service unpublished maps). Coastal areas in NPR-A from Cape Halkett to Barrow (Fig. 1) are especially important for breeding water birds, and for some it is the primary breeding range. Some river deltas also have higher densities of certain species than adjacent tundra habitats.

Postbreeding congregations of water birds have been recorded in nearshore waters of the Beaufort and Chukchi seas, and in freshwater lakes on the Arctic Coastal Plain. Shallow coastal lagoons protected by barrier islands are important to oldsquaws during molt in August and September. Johnson (1979) counted 106,000 birds in Simpson Lagoon 25 km west of Prudhoe Bay in September 1977. Ongoing studies by our group indicate that tidal flats of barrier island lagoons rich in *Carex subspathacea* and *Puccinellia phryganodes* attract up to 15,000 migrating black brant at Icy Cape (Fig. 1) in late August and September.

Wetland Use

Classes III (Shallow-*Arctophila*) and IV (Deep-*Arctophila*) wetlands were the principal breeding habitat for loons, black brant, oldsquaws, white-winged scoters, and king eiders. These wetlands were characterized by dense stands of *Arctophila fulva*. This grass is a key habitat stimulus because it is used as food by grazing waterfowl, affords protective cover and nest material for loons, provides substrate for aquatic invertebrates, and perhaps is important in cycling of nitrogen, phosphorus, and other nutrients (Kadlec 1979). Brood observations were most frequent in Class IV wetlands which may be related to the greatest populations of aquatic invertebrates and the most dense escape cover available among all types. Patterson (1976) determined that habitat requirements of duck broods included both escape cover and food availability. Krapu and Swanson (1975) noted that aquatic invertebrates were a prime source of highly digestible protein which was especially important in the diet during early growth of pintails (Krapu and Swanson 1977).

The attractiveness of Deep-open (Class V) lakes, north-east of Teshekpuk Lake, to molting geese seems to be related to abundant nutrient-rich sedges and grasses along shorelines and safety from predators provided by large expanses of open water. However, Deep-open lakes elsewhere in NPR-A were not intensively used by molting geese. Diving

species such as red-throated loons, oldsquaws, and greater scaup were attracted to Deep-open lakes because of the availability of invertebrates and anadromous whitefish (*Coregonus* spp.). Resident ninespine stickleback (*Pungitius pungitius*), blackfish (*Dallia pectoralis*), and large populations of Chironomidae larvae and Sphaeriidae mussels also were important to diving birds.

Beaded Streams (Class VII) were least abundant compared to other wetland types, but because pools often contained stands of *Arctophila fulva* and submergent vegetation they were attractive to loons, white-fronted geese, oldsquaws, king eiders, and phalaropes. Breeding red-throated loons, whistling swans, and white-fronted geese tended to use these systems throughout the summer while pintails, oldsquaws, and king eiders exploited them only during June and July. Beaded Streams were important transportation corridors for larger water birds that had broods and were flightless. Movement over considerable distances, without travel across tundra where fox predation would occur, was possible between lakes connected by Beaded Streams. These streams also contribute to replacement of water lost through evaporation in larger basins.

Class II (Shallow-*Carex*) wetlands are probably the second most abundant type on the Arctic Coastal Plain of NPR-A. Because of the considerable variation in depth, size, and shape (Bergman et al. 1977) they received use by most water birds but seemed especially important to arctic loons and spectacled eiders with broods, oldsquaws, and phalaropes. The most diverse taxa of aquatic invertebrates was found in Shallow-*Carex* wetlands, where Cladocera made up 35% of all organisms collected (Derksen et al. 1979a). Although individual types vary in value to birds, most species obtain breeding requirements by seasonally utilizing several different types. Decrease in Class II wetland depth, as a result of evaporation, exposed sediments (Bergman et al. 1977) which we found to be favored feeding sites in late July and August for pectoral sandpipers, semipalmated sandpipers, black-bellied and American golden plovers, and ruddy turnstones.

The most dominant and widely distributed wetland type in NPR-A was Flooded Tundra (Class I). This type may make up as much as 50% of the total surface area of all wetlands on the Arctic Coastal Plain in NPR-A. Class I wetlands seemed to be the least important to all water birds despite their tremendous surface area. The duration of Flooded Tundra habitat is short because of the rapid loss of standing water to evaporation and runoff. Loons, swans, and diving ducks were never observed on Flooded Tundra. Geese grazed on water-tolerant sedges and grasses in June but moved to Deep-open lakes during the wing molt. Bergman et al. (1977) suggested that this type seemed most important to phalaropes, and although we noted both red and northern phalaropes feeding in Flooded Tundra in early spring, our data revealed little use of this habitat by all species. Flooded Tundra is important in the stability and dynamics of larger basins and is a major source of water for recharge of Classes II, III, IV, and V wetlands that are fed by surface runoff, sheet flow, or Beaded Streams.

Management Recommendations

Exploration for petroleum is expected to continue in NPR-A either under the direction of the Federal Government or through lease sales to petroleum companies. If marketable quantities of petroleum are discovered it will be important to consider wetland habitats that could be adversely affected during development and production. Impacts on wildlife resources in NPR-A, on about 58% of the Alaskan Arctic Coastal Plain, would be cumulative with those on current production and exploratory leases covering more than 4,000 km² between the Canning and Colville Rivers (Fig. 1). Based on our quantitative assessment of the relative value of Arctic Coastal Plain wetlands to water birds, we offer the following recommendations for habitat protection and consequently the stability of populations.

Weller (1978) suggested that the best management for freshwater marshes may be through preservation to maintain high productivity of characteristic flora and fauna. We support the recommendation of Bergman et al. (1977) to preserve large blocks of water bird habitats from petroleum development because of the Coastal Plain's homogeneous mosaic of wetland types and relatively uniform distribution of water birds. The only arctic preserve established, the William O. Douglas Arctic Wildlife Range (Fig. 1), contains less than 13% of the Arctic Coastal Plain province with only a narrow zone of wetland habitat along the Beaufort Sea. If leasing, exploration, and production plans are also evaluated in moderately large blocks, the subtle cumulative impacts associated with piecemeal development may be avoided.

Deep-open lakes and adjacent wet sedge-grass meadows used by molting geese in the Cape Halkett area should be protected from all exploration and development activities (Derksen et al. 1979b). Criteria for selecting other conservation units should include high-density or unique breeding, molting, and staging areas; sites representative of different Coastal Plain physiographic sections; and areas that have additional wildlife and natural resource values (i.e. caribou range, fisheries, recreation potential). Primary consideration should be given to areas within a few kilometers of the coast, especially those with contingent barrier island lagoon systems and river deltas.

Wetlands that support emergent *Arctophila fulva* are important and vulnerable because of their relatively low abundance in NPR-A and their high use by water birds. Filling of wetlands, water extraction, or other developmental activities is likely to cause severe damage to Classes III, IV, and VI wetlands and Beaded Streams (Class VII).

Beaded Streams should not be diverted, channelized, or have constricting culverts emplaced because of their importance in maintaining water levels in contiguous ponds, lakes, and meadows (Craig and McCart 1975). If culvert crossings cannot be properly designed, use of bridges that do not alter stream hydrology would ensure greater protection of important habitat. Rolligon trails, gravel roadways, drill pads, facility pads, and airstrips should be carefully sited to avoid wetlands, preferably on dry upland tundra. Roads and

pipeline pads should have structures to provide adequate cross-drainage of spring melt water and sheetflow, especially through wet meadows and in crossing drained lake basins.

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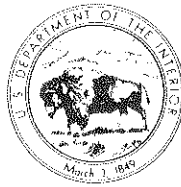
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