Waterbird Populations and Habitat Analysis of Selected Sites in NPRA

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INTRODUCTION

Intensive seismic testing and petroleum exploration in National Petroleum Reserve-Alaska (NPRA) was initiated in 1975. The Naval Petroleum Reserves Production Act of 1976 (42 U.S.C. 6501 et seq.) provides for protection of natural resources in the Reserve and places that responsibility with the Secretary of Interior. The Secretary delegated surface resource management authority to the Bureau of Land Management (BLM).

Migratory birds are an important resource in NPRA and the responsibility for their protection and management rests with the U. S. Fish and Wildlife Service (USFWS). The Office of Special Studies (USFWS) initiated a study in NPRA in 1977 to assess migratory bird populations and species composition, identify critical habitat and assess existing and potential impacts of petroleum development on migratory birds and their habitats. Data contained in this report is intended for use in a land management plan to be developed by BLM.

Fieldwork was conducted at three study sites within NPRA (see Fig. 1-4) from June to August, 1977. Study areas were selected to represent three habitat types in zones subject to petroleum development. They were: 1) the large lake regime near Teshekpuk Lake which is known for high concentrations of molting geese, 2) a delta system bordering the Meade River and adjacent to proposed sand removal sites and 3) a foothills region characterized by deeper lakes, more relief and woody vegetation than the coastal study sites.

Objectives of the 1977 field season common to each study site were: 1) to establish population data on waterbirds, 2) to relate activities such as road building, drilling operations and construction to ecological changes in wetlands, 3) to establish ground truth information from vegetation trend plots for wetland classification, 4) to measure physical and chemical characteristics of various wetland types for classification purposes, 5) to relate natural and artificially induced changes in water levels to changes in vegetation and invertebrate populations vital to waterbirds, 6) to document the relationship between aquatic invertebrates used by waterbirds and their distribution in different wetland types and 7) to evaluate caribou and other mammal use of the areas.

Additional objectives related to habitat use by molting geese at Teshekpuk Lake were: 1) to identify habitat characteristics that make these large lakes important goose molting areas, and 2) to determine feeding ecology of waterfowl molting in these lakes.

Field personnel included Keith A. Metzner and Christoper T. Todd at Singiluk, William D. Eldridge, Thomas C. Rothe and Carl J. Markon at Meade River Delta, Dirk V. Derksen, J. Christian Franson and Craig Kuchel at Teshekpuk Lake.

Dr. Milton W. Weller provided valuable advice in data collection and management, and contributed a report from which much of the section concerning habitat selection of molting geese is derived.

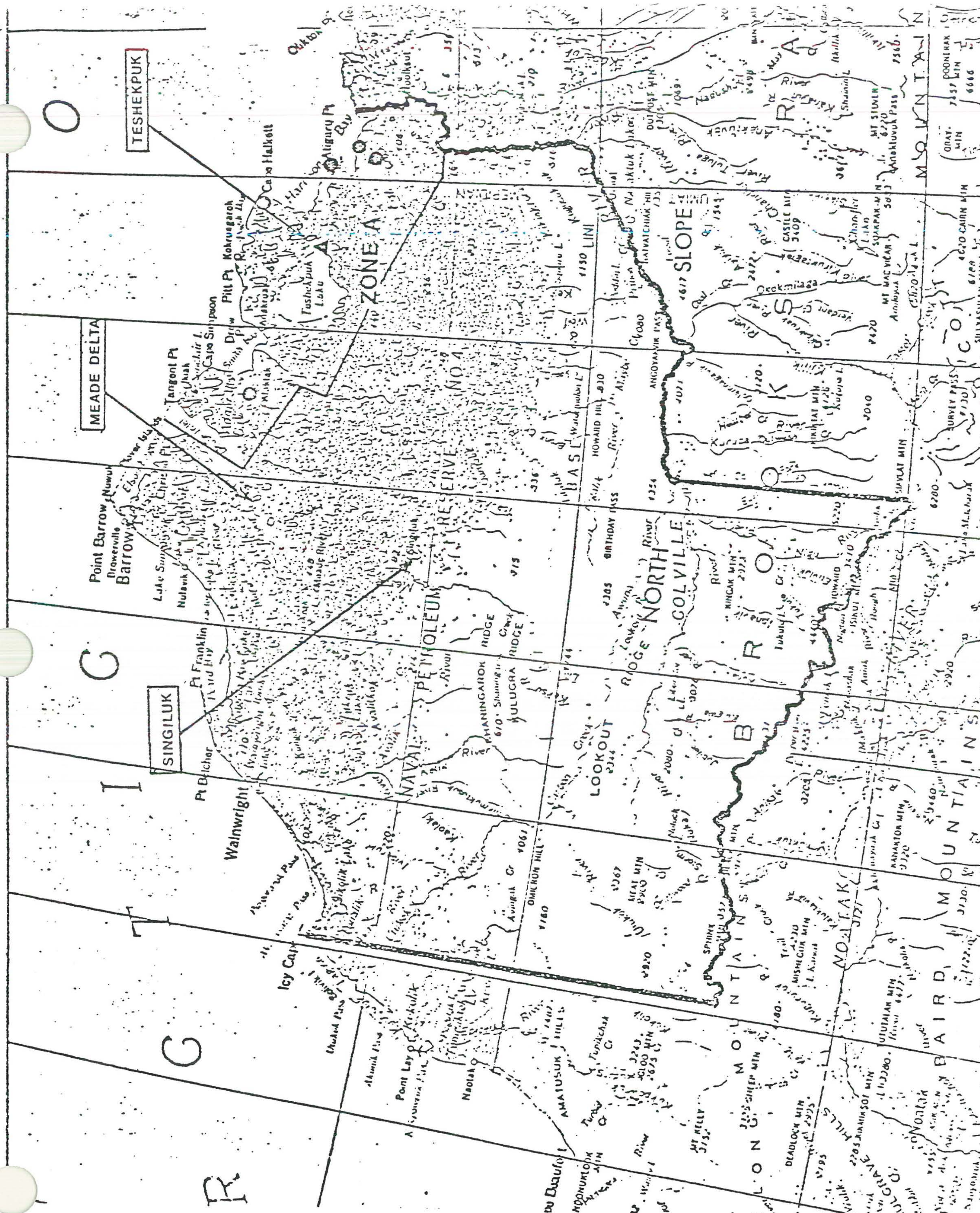

Fig. 1. Zone A, National Petroleum Reserve Alaska and locations of the 1975 (▲) and 1976-77 (●) drill sites. The three study sites are indicated by arrows.

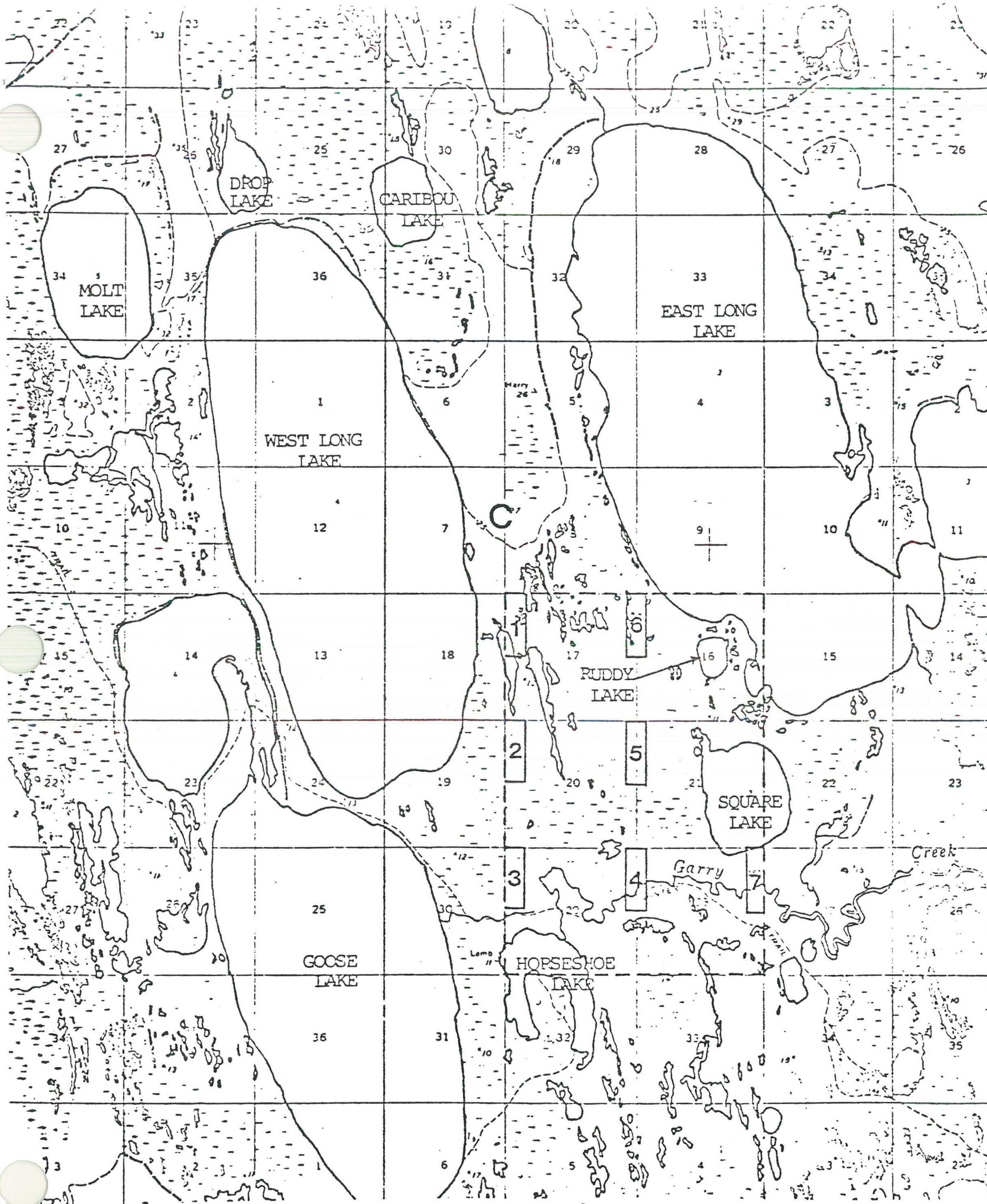

Fig. 2. N. E. Teshekpuk Lake 15.6 km^2 large bird census area (---), seven 0.16 km^2 small bird census areas and lakes censused for geese. Camp location is indicated by "C".

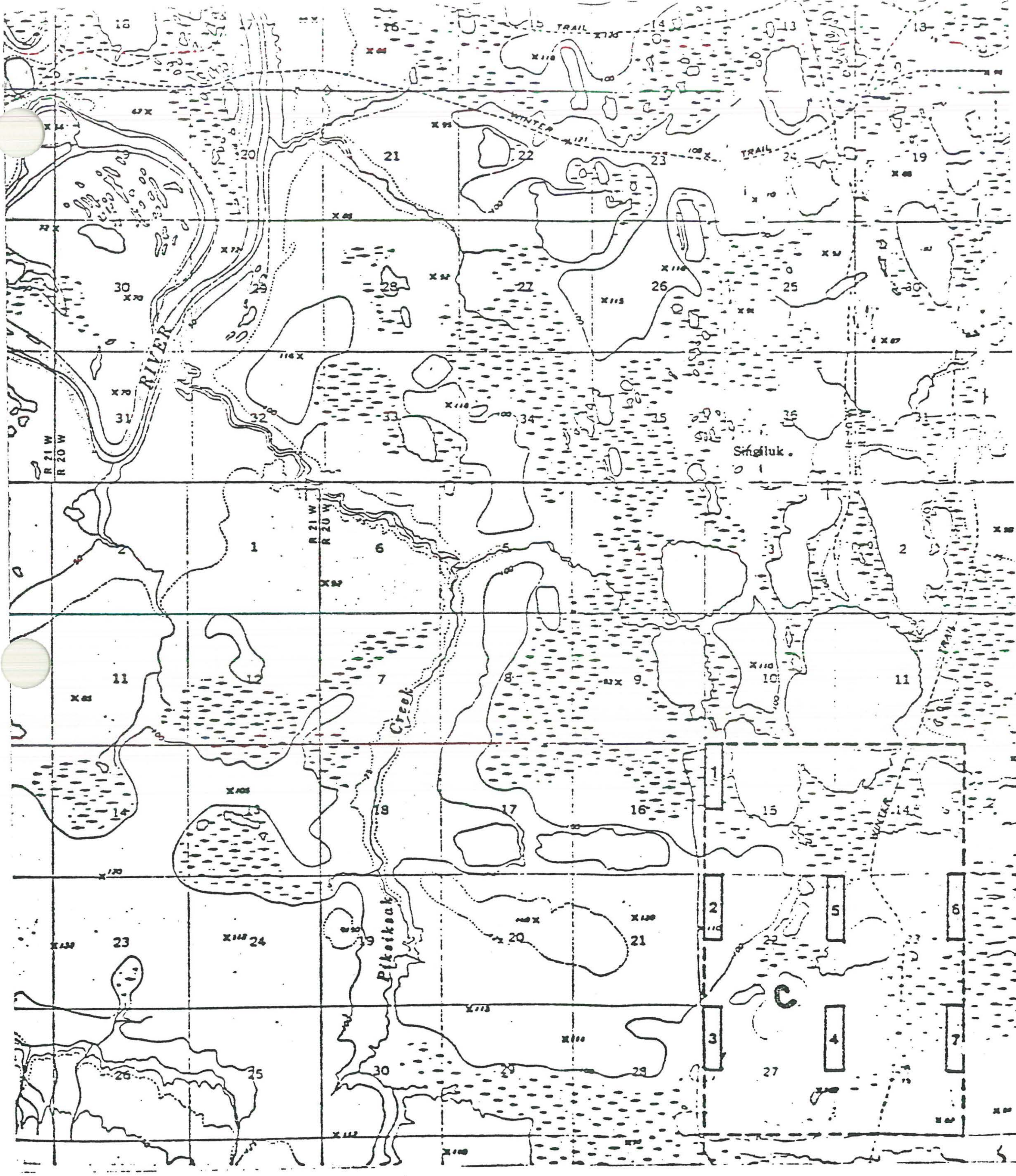

Fig. 3. Singiluk 15.6 km^2 large bird census area (---), seven 0.16 km^2 small bird census areas and camp (C) location.

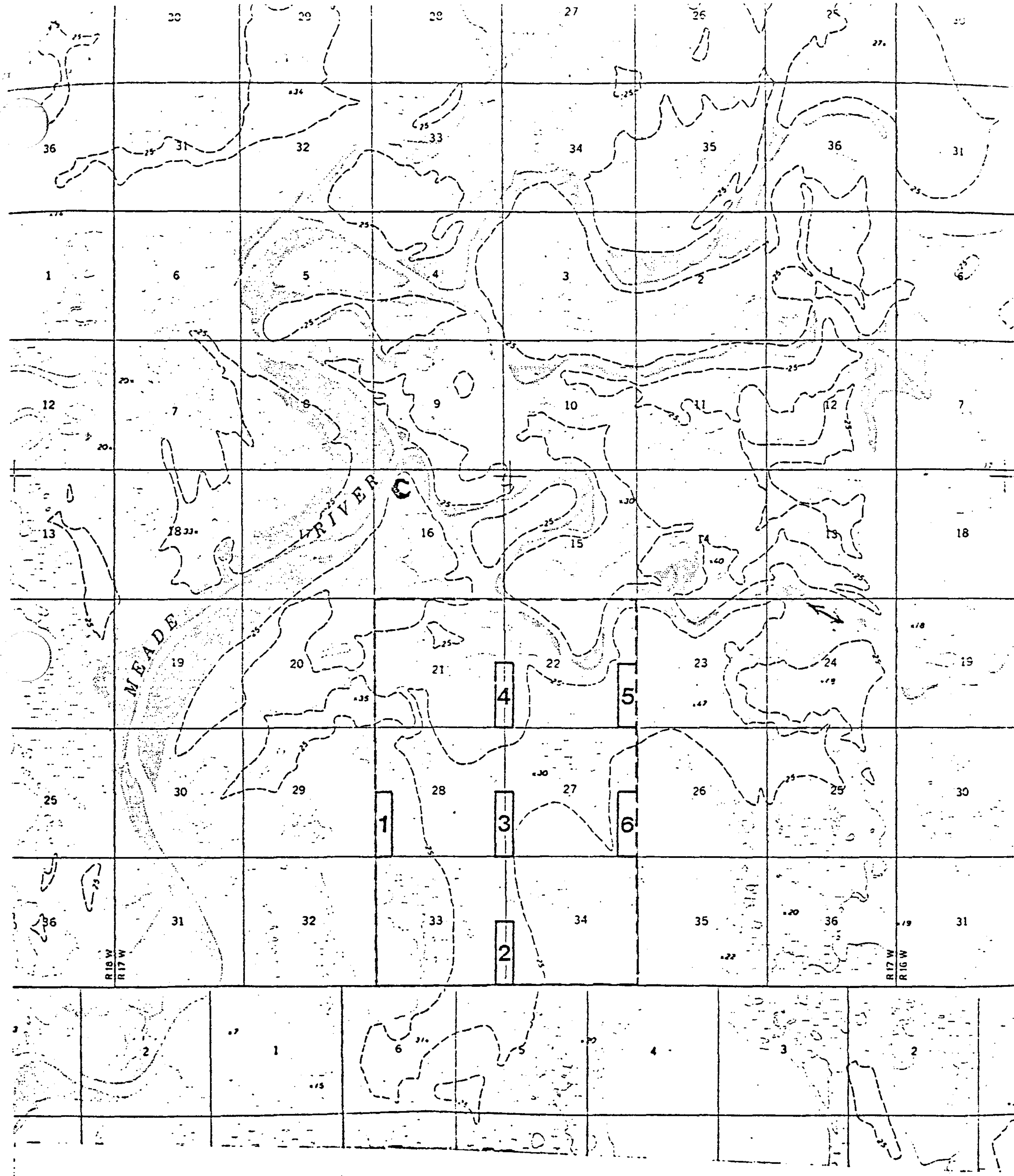

Fig. 4. Meade River Delta 15.6 km^2 large bird census area (---), six 0.16 km^2 small bird census areas and camp (C) location.

METHODS

Methods used for the various study components were standardized for each field camp, and are discussed below. Certain projects were restricted to one or more study sites and these are identified. Because an understanding of the classification system for Arctic Coastal Plain wetlands developed by Bergman et al. (1977) is essential to the interpretation of this report, major features of that system are presented in Table 1. Two wetland classes, not described by Bergman et al. (1977) but used in this report are also listed in Table 1.

Weather, Snow Melt, and Ice Conditions

Minimum and maximum daily temperatures were recorded at all sites with a Taylor min-max thermometer. Wind direction, velocity and cloud conditions were noted. Snow melt, ice melt and water conditions in ponds were recorded throughout the season.

Wildlife Studies

Bird Surveys

The phenology of arrival and presence for all bird species in or near the study areas were recorded daily. Birds were divided into two classes: 1) small birds - all shorebirds and passerines except the Common raven (*Corvus corax*) and 2) large birds - all waterfowl, loons, gulls, terns, jaegers, and raptors. Weekly censuses were conducted for large birds throughout the three 15.60 km^2 (6 $mile^2$) study areas and for small birds in seven 0.16 km^2 (40 acre) plots. Large birds were counted by two or three observers walking abreast lengthwise through the entire

Table 1. Wetland classification system of Bergman et al. (1977) with two additional pond types

Wetland class		Description
Class I:	Flooded Tundra	Shallow waters formed during spring thaw when melt water overflows stream basins or is trapped in vegetated tundra depressions. Such pools formed in low centers of polygonal ground often produce a mosaic pattern of ridges and flooded sedge.
Class II:	Shallow-*Carex*	Shallow ponds with a gently sloping shore zone surrounded by and usually containing emergent *Carex aquatilis* with a central open water zone. This class can be subdivided as IIa, vegetated shore zone, and IIb, unvegetated shore zones.
Class III:	Shallow-*Arctophila*	Ponds, or pools in beaded streams containing *Arctophila fulva* in the central zone and shoreward stands of *A. fulva* or *Carex aquatilis*. Shores are more abrupt than those of Class II ponds, and maximum water depths typically range from 20 to 50 cm.
Class IV:	Deep-*Arctophila*	Wetlands of either large pond or lake size that lack emergents in the central zone and contain stands of *Arctophila fulva* near the shore.
Class V:	Deep-open	Large, deep lakes that have abrupt shores, sublittoral shelves, and a deep central zone. Water depths are greater than in Deep-*Arctophila* wetlands, and *A. fulva* is absent or present in less than 5% of the shoreline.
Class VI:	Basin-complex	Large, partially drained basins that may contain nearly continuous water in spring due to flooding of the bottom by melt water. By mid-July, water levels recede leaving a pattern of green *Carex aquatilis* and open water where *Arctophila fulva* may grow along the margin of deeper pools or throughout shallow pools.

Table 1 (con't.) Wetland classification system of Bergman et al. (1977) with two additional pond types

Wetland class	Description
Class VII: Beaded Stream	Small, often intermittent, streams consisting of a series of channels formed in ice-wedges and linked to pools that develop at ice-wedge intersections.
Class VIII: Coastal Wetlands	Aquatic habitats that occupy low areas bordering the Beaufort Sea and within a zone directly influenced by sea water.
New Class: Upland Tundra	These ponds are characterized by depressions in upland tussock vegetation (*Eriophorum vaginatum spissum*) which fill with melt water and evolve from ephemeral pools to permanent ponds. Typically, these ponds in a mature stage are less than 10 meters by 3 meters and attain a maximum depth of one meter.
New Class: Ice-Wedge Pools	Small (<10 m) pools formed in ice-lens cracks in both high and low center polygon areas. Older, enlarged pools resembled Class II ponds and were more diverse than smaller, deep acid pools.

study area. Small birds were censused during single passes through the designated 0.16 km^2 plots. Species and sex (when recognizable) of birds were recorded on mimeo data forms.

No formal nest searches were conducted but nests found incidental to other activities were marked with numbered laths and revisited on the estimated hatching dates to determine success. Brood sightings were recorded by species and pond class (after Bergman et al. 1977).

In addition to regular censuses numbers of Red phalaropes (*Phalaropus fulicarius*) and Northern phalaropes (*Lobipes lobatus*) were recorded by pond class to determine wetland preferences of these species.

Although regular river surveys were not made at Meade River, periodic boat trips were made along various channels of the delta in July and August. Waterfowl and loons on the river were counted during these trips, and recorded as birds per kilometer of river.

Teshekpuk Lake Goose Molting Survey and Habitat Evaluation

Because of the importance of the Teshekpuk Lake area to molting geese, nine lakes in or adjacent to the 15.60 km^2 Teshekpuk site were censused for geese seven times between July 13 and September 7, 1977. Species, flock size and numbers of flying and flightless birds were recorded by lake during each census. Possible habitat factors affecting attractiveness of these lakes to geese were recorded. Census methods involved total counts by walking, or from a boat, airplane, or helicopter.

Observations of molting flightless geese feeding on a heavily utilized drained-basin shoreline were made for time-budget information.

Fifteen one m^2 exclosures were established to determine food preferences of geese utilizing this shoreline. Observations on the effects of rolligon tracks along this shoreline were also recorded. Data concerning time-budget and food preferences are not available for this report.

Observations on disturbances of low flying aircraft to flightless geese were recorded. Information collected included type and altitude of aircraft involved, distance from the geese, and reaction of the geese to the aircraft.

Data concerning molting geese at Teshekpuk Lake will be treated as one unit in "Results" under the section heading "Teshekpuk Lake Goose Molting Area".

Mammal Surveys

Herd size, adult to calf ratio, and direction of movement were recorded and tabulated by month for all caribou (Rangifer tarandus) and moose (Alces alces) observed.

All arctic fox (Alopex lagopus) observations were recorded and an attempt was made to locate active fox dens in and adjacent to each study area.

Small mammal traplines were established at Teshekpuk Lake and Singiluk to determine numbers of small mammals available for predators. A 750 meter trapline with three traps at each of 15 stations was established on each of the study sites. Traps were baited with peanut butter and bacon grease. The lines were trapped for one week at Teshekpuk Lake yielding 315 trap nights, and for 11 days at Singiluk yielding 489 trap nights. Snapped traps, presence of hair in traps, and predator activity were noted.

Observations on small mammals during regular activities were recorded.

Miscellaneous Surveys

Minnows were trapped at Singiluk to determine the species composition of possible food species for loons. Traps were baited with canned sardines, pilot bread and/or corn niblets and placed in shallow shoreward waters which were usually vegetated with *Arctophila fulva*.

Four core samples of an upland heath tussock community at Singiluk were collected on August 12 using a tin can with a diameter of 8.3 cm. Soil invertebrates will be identified to genus at the Institute of Arctic Biology, Fairbanks.

Twenty-three specimens of moths and butterflies from the Singiluk study area were collected for the Smithsonian Institution's Alaskan Lepidopetera Survey. Specimens are currently being identified to the subspecies level at the Institute of Arctic Biology in Fairbanks.

Aquatic Macroinvertebrate Surveys

A representative of wetland classes I-VII (Bergman et al. 1977) was selected at each study site to determine aquatic macroinvertebrate food resources available to waterbirds. Two pond classes not described by Bergman et al. (1977) were also sampled. Sampling techniques were identical to those of Howard (1974). Benthic and free-swimming invertebrates were collected by taking two Ekman dredge samples and three one-meter sweep net samples in both the open water and shoreward (usually vegetated) zones of each pond. Specific conductance, pH, temperature and water level changes were also recorded. Invertebrates were removed from the sampled material, tentatively identified, counted and preserved in 4% formalin solution for later volumetric analysis. Wetlands were sampled on or near June 22, June 30, July 13, July 27 and August 3 at each study site. Invertebrates were also surveyed opportunistically in the Meade River, river-influenced wetlands, and Beaded streams.

Pintail Food Habits Analysis

Thirteen Pintails were collected from the three study areas to determine food preferences. Attempts were made to observe the birds before they were collected. The esophagus was injected with 10% formalin immediately after death to halt digestive processes. Results of this analysis are not available for this report.

Habitat Analysis

Habitat evaluation on the three NPRA study sites was accomplished through: 1) classification of major wetlands, including macroinvertebrate sampling ponds, after Bergman et al. (1977) and detailed description and classification of emergent and adjacent upland vegetation communities after Webber and Walker (1975) and 2) low-level aerial photography of selected trend plots used in the classification process, of special wetland features important to waterbirds, and of wetland areas disturbed by oil development activities.

Information collected for wetland classification included: pH, temperature, specific conductance, basin morphology, surface area, maximum depth, vegetation cover, appearance of sediments, and use by waterbirds. Specific conductance and temperature were measured with Yellowsprings (S-C-T 1486) conductivity meters, and pH values were determined with Hach Chemical Company wide-range pH kits.

Several 4.60-hectare (11.3 acre) vegetation trend plots were selected on each study site based on unique or diverse vegetation communities that could be detected from aerial photography and that are subject to short term (3-5 year) ecological changes. The following number of trend plots were selected at each site: Meade River - 5, Teshekpuk Lake - 7, North Lake (near Teshekpuk Lake) - 7, and Singiluk - 5. Cover types in these plots, including upland and emergent vegetation, were classified by field crews according to Webber and Walker (1975) with modifications and mapped at a scale of 1:240. Reference plant collections were maintained for future reference.

Vertical aerial photographs were taken of trend plots and selected areas using a 35mm Canon F-1 with motordrive. The camera mount was modified from the Montana 35mm Aerial Photography System (Meyer 1973) to fit the belly port of a Cessna 180 aircraft provided by the Naval Arctic Research Laboratory (NARL), Barrow. Trend plots were photographed on Kodacolor II and either Ektachrome-X color infrared (CIR) or Aerochrome 2443 CIR films at scales of 1:3000 and 1:6000. Photo-mosaics of a goose feeding area near Teshekpuk (1:6000) and the shoreline of recently drained North Lake (1:12000) were produced from Kodacolor II. For a more detailed description of methods see Markon (1977). All aerial photography was accomplished August 1-13 to insure peak development and accentuation of _Arctophila fulva_, a dominant wetland emergent.

RESULTS

Weather, Snow Melt and Water Conditions

The 1977 spring thaw was unusually early, and when investigators arrived on June 9-10, snow cover was 20-40% at Barrow, 10-20% at Lonely DEW station, 1-5% at North Teshekpuk and Kogru, 0% at Meade River and 0-1% at Singiluk. Ponds were ice-free by June 10 at the Teshekpuk Lake and Singiluk sites, and by June 20 at Meade River. Large lakes retained ice until June 20 at Singiluk, July 11 at Meade River and mid-to late July at Teshekpuk Lake. The last ice jam on the main channel of the Meade River broke up on June 10, and the water level dropped rapidly (over two m) until June 23.

Data on weather conditions at the three study sites are presented in Table 2. Temperatures were mildest at Singiluk and coolest at Teshekpuk Lake. Skies were clear-partly cloudy on all areas approximately 60% of the season. Prevailing wind direction was NE to ENE at all sites, with higher velocities at the coastal sites.

Wildlife Studies

Bird Surveys

Seven to nine weekly bird censuses were conducted at each of the three study sites. Mean seasonal density and breeding status of all birds observed during regular surveys at each study site are presented in Table 3. A list of birds observed in or near the study areas but not during regular censuses is presented in Table 4. Densities of birds by study area for each survey are presented in Appendicies 1-3. Data on nest success and brood observations are presented in Tables 5 and 6,

Table 2. Summary of weather conditions at the Special Studies field camps, 1977

	Teshekpuk Lake	Meade River	Singiluk
Mean temperatures (°C)			
Daily minimum	2.3	4.7	4.3
Daily maximum	10.2	14.9	20.1
Extreme temperatures (°C)			
Minimum	-1.1	0.6	-3.9
Maximum	21.7	28.9	35.5
Prevailing wind direction	NE	NE	ENE
Sky conditions (% of days)			
Clear-partly cloudy	61.1	73.8	67.3
Overcast	29.6	18.0	31.0
Fog/rain	9.3	8.2	1.7

Table 3. Mean seasonal densities and breeding status of birds observed at the Meade River, Teshekpuk Lake and Singiluk study sites on at least one bird survey

Species	Study site: Meade River	Teshekpuk Lake	Singiluk
LOONS			
Arctic loon (*Gavia arctica*)	2.10 birds/km^2	1.54 birds/km^2	0.60 birds/km^2
Red-throated loon (*Gavia stellata*)	0.20	1.30	0.00
Yellow-billed loon (*Gavia adamsii*)	–[a,b]	.01[b]	–[a]
WATERFOWL			
Whistling swan (*Olor columbianus*)	0.20	0.21	–[a]
White-fronted goose (*Anser albifrons*)	0.70	1.09	2.70
Brant (*Branta bernicla*)	0.30	5.36	–
Canada goose (*Branta canadensis*)	–	3.73[b]	–[a,b]
Pintail (*Anas acuta*)	5.10	17.10	3.20
Oldsquaw (*Clangula hyemalis*)	1.10	3.17	3.50
Spectacled eider (*Somateria fischeri*)	0.30	0.62	–[a,b]
King eider (*Somateria spectabilis*)	0.10[b]	–	0.20
Scaup (*Aythya* sp.)	0.01[b]	–[a,b]	0.50
Mallard (*Anas platyrhynchos*)	–[a,b]	0.06[b]	–
American wigeon (*Anas americana*)	–[a,b]	0.04[b]	–[a,b]
Northern shoveler (*Anas clypeata*)	–[a,b]	0.06[b]	–[a,b]

Table 3 (con't.) Mean seasonal densities and breeding status of birds observed at the Meade River, Teshekpuk Lake and Singiluk study sites on at least one bird survey

Species	Study site: Meade River	Teshekpuk Lake	Singiluk
SHOREBIRDS			
Pectoral sandpiper (*Calidris melanotos*)	22.90 birds/km^2	36.28 birds/km^2	24.10 birds/km^2
Red phalarope (*Phalaropus fulicarius*)	20.60	32.49	4.00
Dunlin (*Calidris alpina*)	21.10	12.77	0.50
Semipalmated sandpiper (*C. pusilla*)	7.00	6.07	6.90
Black-bellied plover (*Pluvialis squatarola*)	6.30	4.42	3.20
Northern phalarope (*Lobipes lobatus*)	4.20	13.27	9.70
Long-billed dowitcher (*Limnodromus scolopaceus*)	3.70	4.04	-[a,b]
Ruddy turnstone (*Arenaria interpres*)	0.20	-	-
American golden plover (*Pluvialis dominica*)	-[a]	3.54	1.30
Bar-tailed godwit (*Limosa lapponica*)	-	-	11.20
Baird's sandpiper (*C. bairdii*)	-	0.12[b]	-
GULLS, TERNS, and JAEGERS			
Glaucous gull (*Larus hyperboreus*)	1.10	0.65	-[a,b]
Sabine's gull (*Xema sabini*)	0.70	0.26	-[a,b]
Arctic tern (*Sterna paradisea*)	0.70	0.80	0.90

Table 3 (con't.) Mean seasonal densities and breeding status of birds observed at the Meade River, Teshekpuk Lake and Singiluk study sites on at least one bird survey

Species	Meade River	Study site Teshekpuk Lake	Singiluk
Parasitic jaeger (*Stercorarius parasiticus*)	0.40 birds/km^2	0.42 birds/km^2	0.30 birds/km^2
Long-tailed jaeger (*Stercorarius longicaudus*)	0.20	0.15[b]	0.40
Pomarine jaeger (*Stercorarius pomarinus*)	0.20[b]	0.01[b]	-[a,b]
PASSERINES			
Savannah sparrow (*Passerculus sandwichensis*)	-	-	12.00
Lapland longspur (*Calcarius lapponicus*)	24.10	64.22	42.30
Snow bunting (*Plectrophenax nivalis*)	-	-	-
Yellow wagtail (*Motacilla flava*)	-	0.80	-
Redpoll (*Carduelis* sp.)	0.30	-	0.10
OTHER			
Willow ptarmigan (*Lagopus lagopus*)	0.10	-	1.10
Sandhill crane (*Grus canadensis*)	0.01[b]	-	-
Snowy owl (*Nyctea scandiaca*)	0.01[b]	-	-[a,b]

a Observed rarely in or near the study area, but not during surveys
b No indication of nesting in or near the study site

Table 4. Birds not observed on regular bird surveys but seen in or near at least one study site. Total numbers for the season are less than five for any species

Species	Study site Meade River	Teshekpuk Lake	Singiluk
Steller's eider (*Polysticta stelleri*)			X
Green-winged teal (*Anas carolinensis*)	X		
Bonaparte's gull (*Larus philadelphia*)			X
Least sandpiper (*Calidris minutilla*)			X
White-rumped sandpiper (*Calidris fuscicollis*)			X
Golden eagle (*Aguila chrysaetos*)	X		
Short-eared owl (*Asio flammeus*)			X
Common raven (*Corvas corax*)			X
Ruby-crowned kinglet (*Regulus calendula*)			X
Tree sparrow (*Spizella arborea*)			X
Gray-cheeked thrush (*Catharus minimus*)			X
Hermit thrush (*Moctacilla flava*)			X
Snow bunting (*Plectrophenax nivalis*)	X		X
White-crowned sparrow (*Zonotrichia leucophrys*)			X

Table 5. Number of nests and success of nests located at the three study sites in 1977

Species	Singiluk			Teshekpuk Lake			Meade River		
Arctic loon	3[a]	3[b]	100%[c]	6[a]	4[b]	75[c]	8[a]	5[b]	60%[c]
Red-throated loon	–	–	–	7	5	60	1	1	0%
Whistling swan	–	–	–	1	1	0%	–	–	–
White-fronted goose	2	2	100%	1	1	0%	1	1	0%
Brant	–	–	–	4	4	0%	9	9	56%
Pintail	1	1	100%	1	1	0%	1	0	0%
Oldsquaw	1	1	100%	2	2	50%	5	4	25%
King eider	1	1	0%	–	–	–	–	–	–
Spectacled eider	–	–	–	1	1	0%	1	1	100%
Northern phalarope	10	3	100%	2	0	?			
Red phalarope	–	–	–	5	1	100%	6	0	?
Pectoral sandpiper	–	–	–	2	0	?	2	0	?
Semipalmated sandpiper	2	1	100%	2	1	0	5	1	100%
Long-billed dowitcher	–	–	–	2	2	100%	1	0	?
Dunlin	1	0	?	4	1	0	4	1	100%
Black-bellied plover	1	1	100%	–	–	–	1	0	?

Table 5 (con't.) Number of nests and success of nests located at the three study sites in 1977

Species	Singiluk			Teshekpuk Lake			Meade River		
Bar-tailed godwit	1	1	100%	-	-	-	-	-	-
Long-tailed jaeger	1	1	100%	-	-	-	-	-	-
Glacous gull	-	-	-	1	0	?	2	2	100%
Sabine's gull	-	-	-	1	1	0	-	-	-
Arctic tern	-	-	-	1	0	?	2	1	100%
Lapland longspur	9	3	100%	5	1	100%	5	3	100%
Common redpoll	2	2	100%	-	-	-	1	0	?
Unidentified passerine	2	0	?	-	-	-	-	-	-
Willow ptarmigan	11	11	82%	-	-	-	-	-	-

[a] Number of nests located

[b] Number of nests relocated

[c] Percentage of relocated nests that were successful

Table 6. Frequency of occurrence of broods by species and pond class (Bergman et al. 1977) from Meade River, Teshekpuk Lake and Singiluk study sites

Species	N	I	II	III	IV	V	VI	VII	River	Upland tundra pool
Arctic loon	17	0	24%	0	24%	18%	35%	0		
Red-throated loon	2	0	0	0	0	0	100%	0		
Whistling swan	3	0	0	0	33%	66%	0	0		
White-fronted goose	6	0	0	0	33%	33%	0	17%	17%	
Brant	8	0	0	0	0	75%	13%	12%		
Oldsquaw	13	0	23%	8%	38%	8%	15%	8%		
Pintail	9	0	11%	0	66%	0	0	11%		11%
Spectacled eider	11	0	64%	0	0	27%	0	0	9%	
King eider	3	0	0	0	100%	0	0	0	0	
Scaup	1	0	0	0	0	100%	0	0	0	
Arctic tern	2	0	50%	0	50%	0	0	0	0	
Glaucous gull	4	0	0	0	0	80%	20%	0	0	
Sabines' gull	2	0	0	0	0	50%	50%	0	0	

respectively. For the purposes of this report the coastal study site near the Meade River delta will be referred to as the "Meade River" study site, the site near Teshekpuk Lake will be referred to as "Teshekpuk Lake" study area, and the site furtherest inland, near Singiluk, will be referred to as the "Singiluk" study area.

Pintails (*Anas acuta*) were the most common waterfowl at Meade River and Teshekpuk Lake but Oldsquaws (*Clangula hyemalis*) were more common at Singiluk. The Pectoral sandpiper (*Calidris melanotos*) was the most common shorebird at all sites and the Lapland longspur (*Calcarius lapponicus*) was the most common passerine. A brief summary of seasonal abundance and habitat preference for major species follows:

Loons

Arctic Loons (*Gavia arctica*) - Mean seasonal densities of Arctic loons were higher at Meade River (2.10 birds/km^2) and Teshekpuk Lake (1.50 birds/km^2) than Singiluk (0.60 birds/km^2) perhaps reflecting the greater number of water bodies on coastal areas. Loons established territories by late June and nesting commenced in late June or early July. Numbers remained constant until late July when groups of unsuccessful or nonbreeders were seen congregating on large lakes and rivers.

Nests and broods were found on all study areas and in various pond classes, from Shallow-*Arctophila* (Class IIb) to drained Basin-complexes (Class VI) (see Table 6).

Red-throated Loon (*G. stellata*) - Red-throated loons were less common than Arctic loons on the coastal sites and were not observed at Singiluk. Numbers remained constant until groups of up to 11 unsuccessful or nonbreeders were observed in late July. Communal feeding of breeding Red-throated loons was observed at Teshekpuk and Meade River.

Red-throated loons preferred pools in heavily vegetated drained Basin-complexes (Class VI) for feeding and nesting activities. They were regularly observed along the Meade River and occasionally in Beaded streams.

Yellow-billed Loon (*Gavia adamsii*) - Yellow-billed loons were observed within the study site at Teshekpuk Lake and in surrounding areas at Meade River and Singiluk. Regular observations of Yellow-billed loons, apparently nonbreeders, were made along the Meade River in July and August.

No nests or broods were sighted at any of the study sites, but one brood was seen approximately four kilometers south of the Singiluk area in a Deep-open lake (Class V). Yellow-billed loons were observed only on Deep-open lakes (Class V) at Teshepuk Lake and only on the river at Meade River.

Waterfowl

Whistling Swans (*Olor columbianus*) - Mean seasonal densities of Whistling swans at Teshekpuk Lake (0.21 birds/km^2) and Meade River (0.20 birds/km^2) were similar during 1977 but much lower at Singiluk where only four were observed. Swans attempted to build nests or platforms within both coastal study sites but were not successful. Swan broods were sighted adjacent to the Meade River study site and within a few kilometers of the Singiluk site. Nonbreeding swans concentrated in the Meade River delta where groups of two to 37 swans were observed feeding and loafing on sandbars through the first week in July. By mid-July only a few remained at Meade River and three molted at the Teshekpuk site.

Swans were observed feeding in Deep-*Arctophila* ponds (Class IV), Deep-open ponds and lakes (Class V), drained Basin-complexes (Class VI), and the Meade River. Swans preferred larger wetlands (>30 hectare) and all brood sightings were on large Deep-open lakes (Class V) or large, Deep-*Arctophila* lakes (Class IV).

White-fronted Goose (*Anser albifrons*) - The seasonal mean density of White-fronted geese was higher at the Singiluk site (2.70 bird/km^2) than at Meade River (0.70 birds/km^2) or Teshekpuk Lake (1.09 birds/km^2). At least one nest was attempted at each study site but only a nest at Singiluk was successful. Broods were observed within the Singiluk site and near the coastal sites. White-fronted geese molted in or near all study sites, particularly Teshekpuk Lake (see Teshekpuk Lake Goose Molting Area). Migrating flocks were observed in late July and early August at all study sites.

White-fronted geese utilized Deep-open (Class V) lakes and Basin-complexes (Class VI) for feeding, loafing, and molting. Nests were found on upland areas near large lakes on the coastal sites but also near small, shallow ponds at the Singiluk site. Bergman et al. (1977) also found six of eight nests near Shallow-*Carex* ponds (Class II). Flightless adults with broods were observed on a Beaded stream (Class VII) and the Meade River. Extensive grazing of grasses and sedges occurred along stream banks and river outlets. Migrating flocks of geese used the Meade River sandbars for feeding and loafing in late summer.

Brant (*Branta bernicla*) - More brant were observed at Teshekpuk than Meade River, reflecting molting concentrations there. No brant were observed at the Singiluk site. Nine nests were found at Meade River and four at Teshekpuk Lake but only five nests (at Meade River) were successful. Three broods were observed at the Meade River study site and none were seen at Teshekpuk, although broods were observed adjacent to both areas. Migrating flocks were observed at the coastal sites in late July and early August. Brant molted on both areas, but in considerably higher numbers at Teshekpuk Lake (see Tehsekpuk Lake Goose Molting Area).

Brant, like White-fronted geese and Whistling swans, preferred Deep-open lakes (Class V) and drained Basin-complexes (Class VI) for most activities. Eight of nine nesting attempts at Meade River were found on raised mounds (hydrolaccoliths) in a flooded sedge (*Carex aquatilus*) area of one drained Basin-complex (Class VI). At Storkersen Point 10 of 11 Black brant nests were beside Deep-*Arctophila* ponds (Class IV) within large drained Basin-complexes (Class VI) (Bergman et al. 1977). Adults and young moved considerable distances, congregating in groups of 30 or more birds on large, Deep-open lakes (Class V). Flightless adult brant with broods were known to travel several kilometers along a Beaded stream (Class VII) towards the Meade River. These streams may provide important mobility to molting waterfowl and young.

Canada Geese (Branta canadensis) - Mean density of Canada geese was significant only at Teshekpuk Lake (3.70 birds/km^2) where they molted in large flocks (see Teshekpuk Lake Goose Molting Area). Only two Canada geese were observed at Singiluk and none at Meade River. No nests or broods were found in or near any of the study areas.

Lesser Snow Geese (Chen caeruelescens) and Ross' Geese (Chen rossii) were observed only near the Teshekpuk Lake study area. Lesser snow geese molted in small numbers on the large lakes near the Teshekpuk study site but were not known to breed. Four Ross' geese were observed in mid-September only (King 1977).

Pintails - Pintails were the most abundant waterfowl at Meade River (5.10 birds/km^2) and Teshekpuk Lake (17.10 birds/km^2) but not at Singiluk (3.20 birds/km^2). Numbers of pintails decreased on all study sites in mid-to late July due to molting, and increased in late July as birds began flying and staging for migration.

At least one nest was found on each study area but only the nest at Singiluk was successful. Eight Pintail broods were observed at Singiluk, one at Meade River, and none at Teshekpuk Lake (see Table 6). Mild weather at Singiluk early in the year may contribute to higher nest success there by attracting birds most likely to produce.

Pintails utilized all wetland classes from Flooded-tundra (Class I) to Beaded streams (Class VII) and occasionally the Meade River. Deep and Shallow-Arctophilla wetlands (Class IV and III) and drained Basin-complexes (Class VI) were preferred molting and feeding areas due to high invertebrate populations and available cover, supporting observations by Bergman et al. (1977). Upland Tundra Ponds with dense invertebrate populations received extensive use by pintails early in the year (see Macroinvertebrate Survey). Molting Pintails also utilized Beaded streams (Class VII) and the Meade River for transportation and feeding while flightless. Pintails with broods preferred (66% of all sightings) Deep-Arctophila (Class IV) wetlands.

Oldsquaws - Oldsquaws were the most abundant waterfowl at Singiluk (3.50 birds/km^2) and second in abundance at Teshekpuk (3.20 birds/km^2) and Meade River (1.10 birds/km^2). Male Oldsquaws were less abundant in mid-to late July on all areas reflecting the molt migration. By mid-July, hens with broods accounted for the majority of observations.

Four nests were found at Meade River, two were found at Singiluk and one at Teshekpuk. Nine Oldsquaw broods were sighted at Singiluk, two at Meade River and none at Teshekpuk.

Oldsquaws used Shallow-Carex ponds (Class IIb), open perimeters of large, Deep-open lakes (Class V) and the Meade River extensively early in the season then concentrated feeding activities later in Deep-open lakes (Class V) and Deep-Arctophila (Class IV) wetlands. Oldsquaw broods were observed most frequently (76% of all observations) on Deep-Arctophila ponds (Class IV), Shallow-Carex ponds (Class IIb), and drained Basin-complexes (Class VI). In late July flocks of up to 250 Oldsquaws were observed on Deep-open lakes (Class V) in the Singiluk area.

Spectacled Eiders (Somateria fischeri) - Spectacled eiders were common at Teshekpuk Lake (0.60 birds/km^2) and Meade River (0.30 birds/km^2) but only two were observed at Singiluk. Males left the coastal sites by July 1 and Spectacled eider numbers declined through the season until females with broods remained.

One nest was found at Meade and one unsuccessful nest at Teshekpuk Lake. Ten broods were observed in or near the Meade River area and one at Teshekpuk Lake. Shallow-Carex (Class IIb) ponds that retained water late in the season were preferred (64% of all observations) by eiders with broods. One Spectacled eider brood was observed on the Meade River. Adults generally fed in the more heavily vegetated ponds (Classes III and IV).

King Eider (S. spectabilis) - King eiders were sighted regularly only at Singiluk (0.20 birds/km^2), and only in June at Meade River (0.10 birds/km^2). No King eiders were seen at Teshekpuk Lake. A marked increase in numbers of hen eiders at Singiluk was noted in late July.

Only one nest, unsuccessful, was found at Singiluk but four broods were sighted. No nests or broods were found in or near the coastal sites.

King eiders preferred large, Deep-Arctophila lakes (Class IV) at Singiluk and all brood sightings (4) were on Deep-Arctophila wetlands. At Storkersen Point, 12 of 19 (69%) observations of eider broods were on Shallow-Carex ponds (Class IIb) similar to spectacled eiders. However, the majority of all observations occurred on Deep-Arctophila (Class IV) wetlands (Bergman et al. 1977).

Scaup (Aythya sp.) - Scaup were regularly sighted at Singiluk (0.50 birds/km^2) but rarely seen at Meade River or Teshekpuk Lake. Flocks of 100 birds were observed at Teshekpuk in mid-July and another group of 500 on September 9 (J. King, 1977). Flocks of 250 birds were observed at Singiluk in late July. Only three Scaup were observed at Meade River.

No nests were found at any of the study areas, however one brood was observed on a Deep-open lake (Class V) at Singiluk. Scaup were observed most frequently on Deep-open lakes (Class V) where sediment dwelling invertebrates and fingernail clams were available.

Small numbers of Mallards (Anas platyrhynchos), American wigeons (A. americani), Northern shovelers (A. clypeata), and Green-winged teal (A. carolinensis) were sighted in or near at least one of the study areas, usually in early June.

Shorebirds

Shorebird activity declined markedly after mid-July on all study areas but increased in early August as birds prepared for migration. Differences in abundance were noted between coastal and inland sites particularly during mid-July. While numbers of most shorebirds decreased after July 1 on the coastal sites, they increased on the Singiluk area, and then declined.

Pectoral sandpipers were the most abundant shorebird on all study areas and were more common at Teshekpuk Lake (36.28 birds/km^2) than

Singiluk (24.10 birds/km^2) or Meade River (22.90 birds/km^2). Seasonal abundance varied between the coastal sites and Singiluk. Highest densities were recorded early and late in the season at the coastal sites and at mid-season at Singiluk, suggesting an inland migration of birds from the coast during mid-July.

Red phalaropes were second in abundance at Teshekpuk Lake (32.49 birds/km^2) and the Meade River (20.60 birds/km^2) but considerably less common at Singiluk (4.00 birds/km^2). Numbers of Red phalaropes declined markedly after early to mid-July on all sites. Observations of Northern and Red phalaropes were recorded by pond class and are presented in Table 7. Phalaropes used all wetland classes but use shifted to larger lakes (Class IV, V and VI) in July when smaller ponds dried.

Dunlins (Calidris alpina) were third in shorebird abundance over the three areas, although noticeably less abundant at Singiluk. Numbers at Meade River and Teshekpuk Lake fluctuated during the season, however small flocks of 5 to 15 birds were observed congregating at Meade River by mid-July.

The remaining shorebirds do not approach Pectoral sandpipers, Red phalaropes or Dunlins in abundance although some are locally important. The mean seasonal density of Bar-tailed godwits (Limosa lapponica) was 13 birds/km^2 at Singiluk, but this species was not observed at Meade River or Teshekpuk. Long-billed dowitchers (Limnodromus scobpaceus) were common at Meade River (3.70 birds/km^2) and Teshekpuk Lake (4.04 birds/km^2), but only six were observed at Singiluk. Densities of Northern phalaropes, Semipalmated sandpipers and Black-bellied plovers were similar

Table 7. Wetland use by Red and Northern Phalaropes

	Wetland class %(n)								
	I	II	III	IV	V	VI	VII	Upland tundra pond	Ice wedge pool
Northern phalaropes									
June T (160)	11% (18)	6% (10)	4% (7)	14% (23)	35% (56)	17% (27)	.6% (1)	11% (18)	
July/August T (381)	3% (13)	8% (30)	6% (24)	33% (126)	22% (83)	23% (89)	4% (14)	.5% (2)	
Red phalaropes									
June T (153)	7% (11)	22% (34)	8% (13)	9% (14)	10% (16)	42% (65)			
July/August	1% (4)	12% (33)	.4% (1)	.7% (2)	9% (24)	76% (208)			.4% (1)
Unknown phalaropes									
June					100% (70)				

at all sites, which suggests an even distribution of these species across the coastal plain.

Habitat utilization by shorebirds varied with species but general trends were evident. Flooded tundra ponds (Class I) and Shallow-*Carex* ponds were utilized heavily by a variety of shorebirds until they dried. Frequent sightings of shorebirds probing in exposed sediments of these ponds were made late in the season but most use shifted to larger water bodies, particularly exposed shorelines of Deep-open lakes (Class V) and drained Basin-complexes (Class VI). Flocks of up to 200 semipalmated sandpipers were observed on these wetlands at Singiluk, late in the season.

Nests of shorebirds were difficult to locate but most of the nests found were on rims of low-center polygons in Flooded tundra (Class I).

Gulls, Terns and Jaegers

Glaucous Gulls (*Larus hyperboreus*) - Numbers of Glaucous gulls remained constant at Teshekpuk Lake (0.70 birds/km^2) and Meade River (1.10 birds/km^2) through the season but only four were observed early in June at Singiluk. Gulls nested on both coastal areas in small numbers, preferring islands in large wetlands (Class V and VI). Predation by Glaucous gulls on various species of waterbird nests was observed.

Sabines' Gull (*Xema sabini*) - Densities of Sabines' gulls were less than Glaucous gulls on each area and nests were attempted at Meade River and Teshekpuk Lake, but not Singiluk. At Meade River a small increase in Sabines' gulls was noted shortly before the end of July, when they left the area. Sabines' gulls preferred larger wetlands (Class V and VI) but were occasionally seen feeding in Shallow-*Arctophila* ponds (Class II).

Arctic Terns (Sterna paradisea) - Densities of Arctic terns were common on all areas and constant until late July. Nests were attempted on all study areas but broods were sighted only at Meade River and Singiluk. Terns preferred islands in small (Class II and III) or large wetlands for nesting. Arctic terns were observed feeding in a variety of wetland types and streams, probably in pursuit of nine-spined sticklebacks (Pungitus pungitus).

Jaegers (Stercorarius sp.) - Jaegers were seen regularly on all areas throughout the season. The Parasitic jaeger (S. parasiticus) was most common at Meade River (0.40 birds/km^2) and Teshekpuk Lake (0.40 birds/km^2) but not Singiluk (0.30 birds/km^2). The Long-tailed jaeger (S. pomarinus) was more common at Singiluk (0.40 birds/km^2) than Teshekpuk Lake (0.20 birds/km^2) or Meade River (0.20 birds/km^2). The Pomarine jaeger (S. pomarinus) was seen once at Teshekpuk Lake and occasionally at Meade River.

Although breeding was suspected at Meade River, nests or young were found only of Long-tailed jaegers at Singiluk. Breeding of the Pomarine jaeger, Snowy owl, and Short-eared owl on the North Slope of Alaska is correlated with numbers of microtines (Pitelka et al. 1955). Low microtine rodent numbers were suspected on all areas (see Small Mammal Surveys) and may have contributed to the low density of predatory birds observed on all study areas.

Passerines

Lapland Longspurs - The Lapland longspur was the most abundant passerine on all sites with a seasonal mean density of 43.53 birds/km^2 for all areas. Longspur numbers diminished in mid-to late July, but a large migration and reverse-migration was observed at Teshekpuk Lake in mid-July.

Other passerines observed in small numbers at one or more sites are listed in Tables 3 and 4.

Raptors

One Golden eagle (Aguila chrysaetos) was observed in August along the Meade River, but none were seen at the other sites.

The Snowy owl was observed occasionally at Meade River, once at Singiluk and not at all at Teshekpuk Lake. No nests or young were observed on any of the study areas.

Mammal Surveys

Caribou - Data concerning caribou herd size, age composition and direction of travel are presented in Table 8 for each area. Largest numbers of caribou were observed at Teshekpuk Lake, where herds of nearly 500 animals were seen. Most movement was towards the coast in June and inland during July and August. The land corridor between East and West Long Lake (see Figure 2) was used heavily by migrating caribou.

Caribou were observed rarely at Meade River in June, and in small groups or individually in July and August. Early movements of caribou were north towards the coast but directed movements were not discerned in July. Caribou utilized the dune areas bordering the river delta extensively in July for relief from mosquitos.

At Singiluk caribou were observed regularly in June and July but in smaller numbers as the season progressed. After July 20 only bulls remained on the area. In early June it appeared that most of the herds

Table 8. Caribou herd size, composition and direction of movements at Teshekpuk Lake, Meade River and Singiluk

Date	Number of observations	Mean herd size (min, max)	Mean % composition adult	calf	Direction of travel	
		Teshekpuk Lake				
11 June - 1 July	15	157 (8, 450)	62%	38%	North South	93% 7%
2 July - 6 August	36	67 (1, 487)	79%	21%	South North	67% 33%
		Meade River				
11 June - 1 July	4	3 (1, 5)	100%	00%	-	64%*
2 July - 6 August	49	2 (1, 9)	97%	03%	North South	33% 3%
		Singiluk				
9 June - 1 July	26	6 (1, 17)	98%	02%	-*	
2 July - 12 August	43	3 (1, 30)	97%	03%	-*	

* - direction of travel not obvious

were moving south and west of the area, but no directed movements were noted in late June through August.

Arctic Fox - Data concerning numbers of Arctic foxes and dens observed on the three study areas are presented in Table 9. Fox were seen rarely on all areas and active dens were found only at Singiluk.

Small Mammals

No mammals were trapped during 489 trap nights at Singiluk or 315 trap nights at Teshekpuk Lake in July and no evidence of escaped animals was found. Eleven lemming sightings were recorded during the summer at Singiluk and one at Meade River. Two Greenland-collared lemmings (*Dicrostonyx greenlandicus*) were observed at Teshekpuk Lake, but not within the 15.60 km^2 study area.

Miscellaneous Mammal Observations

On June 14 one Barren Ground Grizzly Bear (*Ursus arctos*) was observed sleeping near the Singiluk field camp. On July 1 another Grizzly bear was observed within the study area, and fresh tracks were found on July 18 along Piksiksak Creek, a tributary to the Meade River near Singiluk. No bears were observed at the coastal sites although eskimos reported one observation approximately 16 km upstream from the Meade River field camp.

An adult cow moose with two yearlings were observed on the Meade River approximately 2 km west of the Meade River field camp on July 23.

Arctic Ground Squirrels (*Spermophilus parryii*) were abundant along sand dunes and sandy bluffs near the Meade River camp. They were observed occasionally on the Singiluk study area but none were seen at Teshekpuk Lake.

Table 9. Number of Arctic fox sightings and active dens for each study site

	Singiluk	Teshekpuk Lake	Meade River
Number of sightings	21	25	17
Number of active dens	3	0	0

Aquatic Macroinvertebrates

Volumetric anlysis and identification of invertebrates by species are not available for this report. Numbers of invertebrates belonging to various taxa (Table 10) have been summarized for preliminary evaluation.

Combined invertebrate population data from the three study sites are presented in Figures 5-7 by pond class after Bergman et al. (1977). Two highly productive pond types not described by Bergman et al. (1977) were also sampled on at least one of the study sites. For this analysis midge larvae (Tendipedidae) and earthworms (Oligochaeta) are considered sediment dwellers only. Regional differences in pond populations were apparent because Meade River ponds were generally more productive than Singiluk or Teshekpuk Lake ponds, with one exception (Upland tundra ponds). However, the relative abundance of total invertebrates in different pond classes was similar among study areas.

A description of invertebrate populations and trends by pond class follows:

Flooded-tundra (Class I) - Flooded tundra comprises a large percentage of total wetland types on the Arctic Coastal Plain during June (Bergman et al. 1977). During June invertebrate populations are diverse and dominated by fairy shrimp (Anostraca), springtails (Collembolla), snails (Gastropoda) and water fleas (Cladocera). Earthworms and midge larvae are available in high numbers early in June. Nearly all Flooded tundra ponds are dry by July 1. Because of solar heating these wetlands develop invertebrate populations early in the season and are

Table 10. List of invertebrates from Meade River, Teshekpuk Lake and Singiluk

Class--Hydrozoa

Class--Turbellaria

Class--Oligochaeta

Class--Crustacea
  Subclass--Branchiopoda
    Order--Anostraca
    Order--Notostraca
    Order-Cladocera
    Order-Copepoda
    Order-Ostracoda
    Order-Amphipoda

Class--Arachnida
  Order--Acari (=Hydracarina)

Class--Insecta
  Order--Collembola
  Order--Trichoptera
  Order--Plecoptera
  Order--Coleoptera
  Order--Diptera
    Family--Tipulidae
    Family--Culicidae
    Family--Tendipedidae
    Family--Muscidae

Class--Gastropoda

Class--Pelecypoda

[1] Nomenclature based on Pennak (1953) and Usinger (1971)

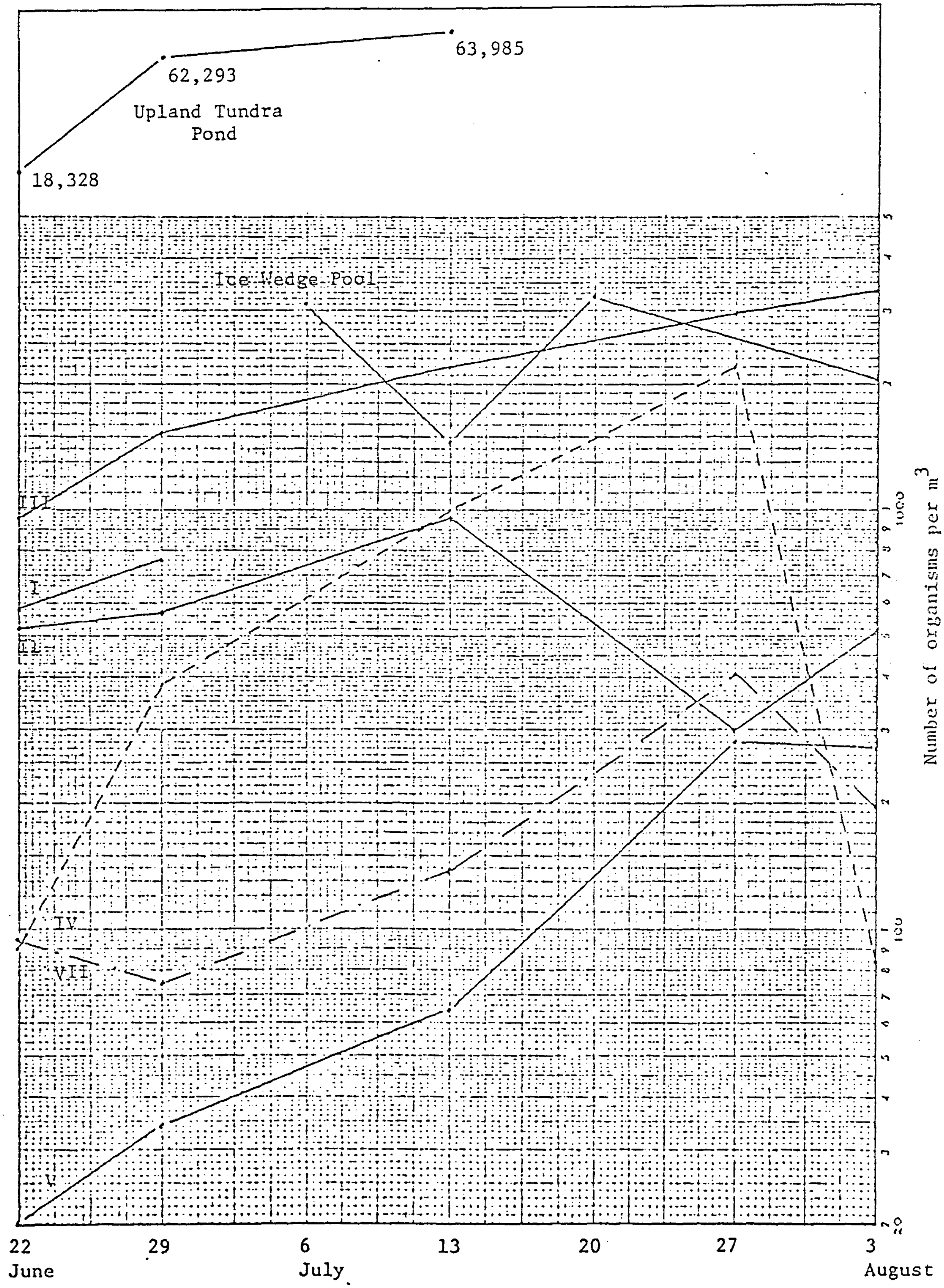

Fig. 5. Numbers of invertebrates collected in sweep-net samples by pond class.

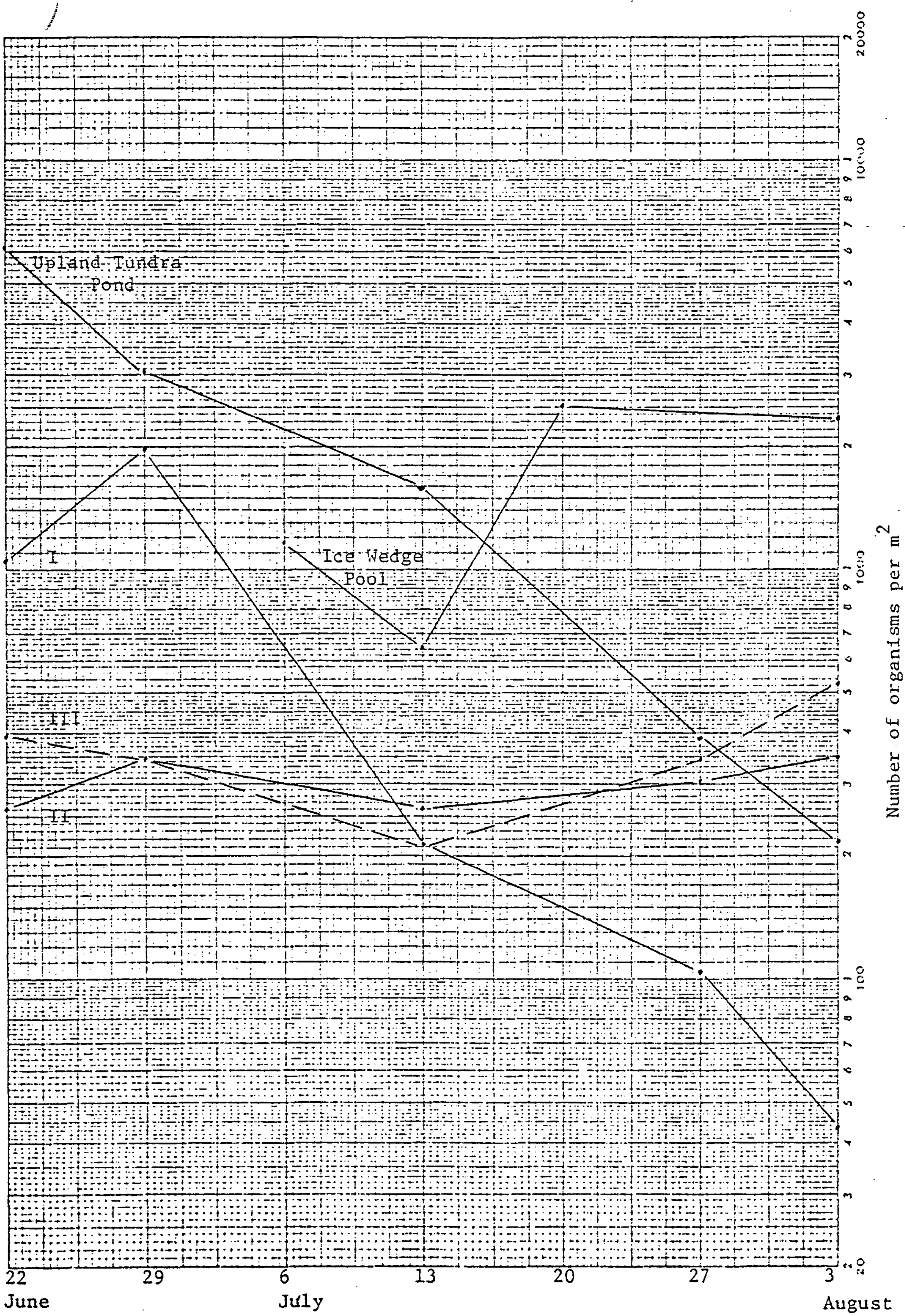

Fig. 6. Numbers of sediment dwelling invertebrates collected in smallest pond classes.

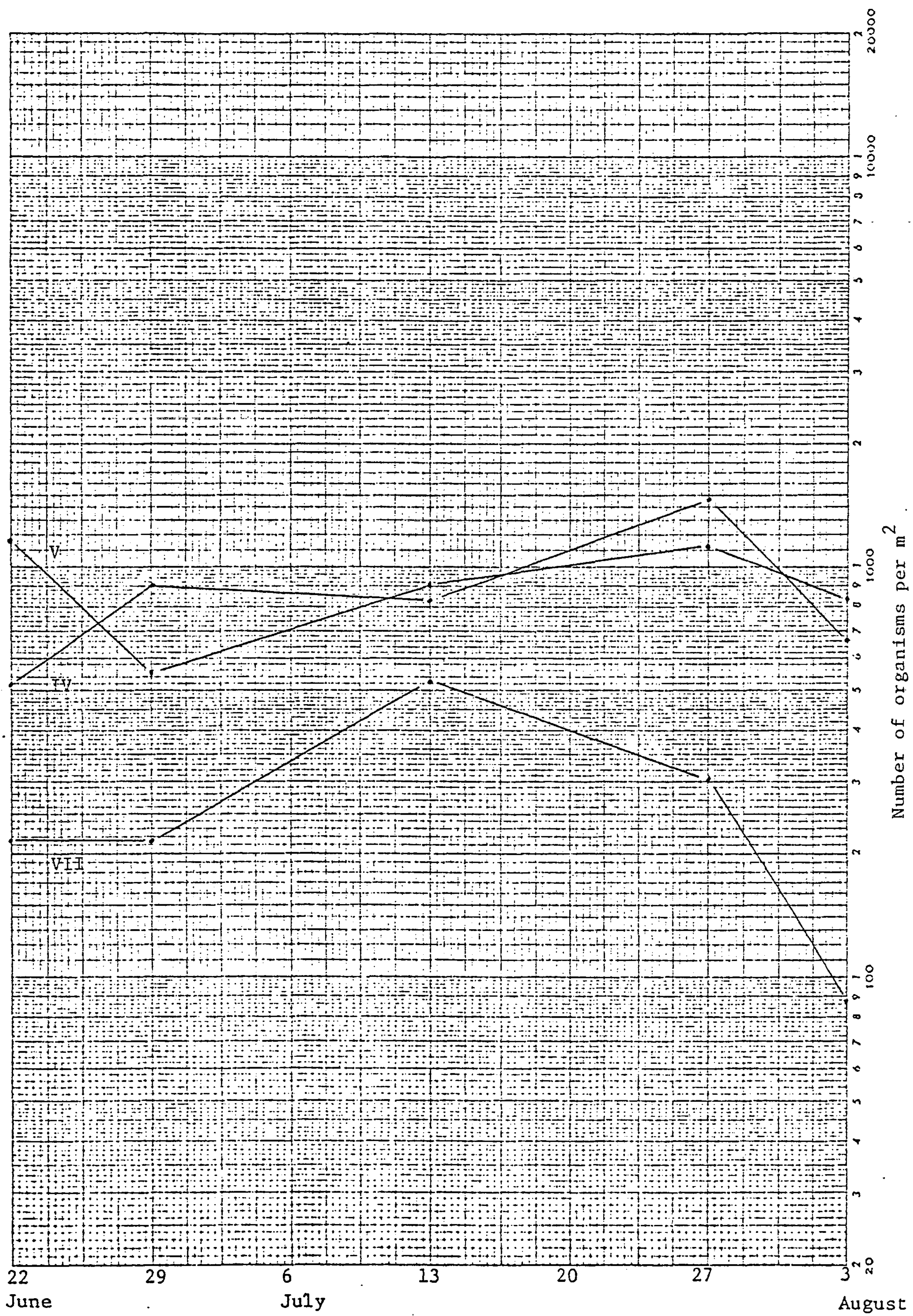

Fig. 7. Numbers of sediment dwelling invertebrates collected in larger pond classes.

important to waterbirds until dry and invertebrates become available in other wetlands. Some shorebirds, particularly plovers, continue to probe the exposed vegetated basins during the late summer.

Shallow-Carex (Class II) - Shallow-*Carex* ponds were second in abundance to tundra ponds at Storkersen Point (Bergman et al. 1977). These ponds retain water longer than Class I wetlands, however approximately 75% of Class IIa ponds (with vegetated shoreline) and 50% of the Class IIb ponds (unvegetated shoreline) were dry by mid-July at Meade River.

Shallow-*Carex* ponds were the most diverse ponds sampled, supporting 21 invertebrate taxa. Water fleas (Cladocera) comprised 35% of the total number of organisms collected and peak numbers occurred in mid-July. Copepods (Copepoda) and fairy shrimp were also dominant organisms in the water column. Midge larvae and earthworms were not as abundant in Class II ponds as in Class I ponds in June, but more were present in July. The total invertebrate population was densest in mid-to late July due to warming water and the concentrating effect of evaporation.

When water was standing, Shallow-*Carex* ponds received intensive use by a variety of shorebirds and waterfowl, particularly eiders and Pintails. Shorebirds also fed on exposed sediments after water evaporation, until departure in August.

Shallow-Arctophila (Class III) - Shallow-*Arctophila* ponds are less common than Class I and II ponds but important because of water permanence and vegetation coverage. The importance of the *Arctophila fulva*-*Carex aquatilis* edge to invertebrates was documented by Bergman et al. (1977). Shallow-*Arctophila* ponds were highly productive at Meade River but less so at Teshekpuk Lake. There was less diversity in Shallow-*Arctophila* ponds than the previous classes (15 taxa) and water fleas accounted for 76% of the total number of organisms. Fairy shrimp, stoneflies (Plecoptera), seed shrimps (Ostracoda) and snails were also important organisms in the water column. Numbers of midge larve and earthworms in the sediment were similar to that in Shallow-*Carex* (Class II). A variety of shorebirds and waterfowl, particularly Pintails, utilized Shallow-*Arctophila* ponds throughout the season.

Deep-Arctophila (Class IV) - Deep-*Arctophila* ponds are common on the coastal plain and extremely important to waterfowl and shorebirds (Bergman et al. 1977). Deep-*Arctophila* ponds were highly productive at Teshekpuk Lake but less so at Meade River, where the *Arctophila fulva* bed was sparse in the pond sampled. Diversity of organisms was higher (17 taxa) than pond Class III however water fleas also comprised 76% of total numbers of organisms collected. A steady increase in total numbers of invertebrates was noted through the season. Caddisflies (Trichoptera), copepods and snails were important organisms in the water column. Numbers of midge larvae and earthworms were higher in Deep-*Arctophila* ponds than previous classes and fingernail clams (Pelecypoda) were found for the first time in the sediments.

Waterfowl, loons and shorebirds were observed nesting, molting and/or feeding in Deep-*Arctophila* ponds. Data collected from the three study sites support the conclusion of Bergman et al. (1977) that this class is one of the most important to waterbirds.

Deep-Open (Class V) - Deep-Open lakes are common on the Arctic Coastal Plain, however their contribution in invertebrate food resources is limited because diversity (5 taxa) and total invertebrate numbers are markedly less than the previous pond types (see Figure 5). Caddisflies and copepods were dominant among organisms in the water column, but the ratio of numbers of water column dwellers to sediment dwellers is markedly less than other pond classes. No water fleas were collected in these ponds. Midge larvae were the dominant invertebrate food organism in this class and fingernail clams were more common.

Although invertebrate food sources are lower in the water column, these lakes are important to waterfowl, particularly Oldsquaws, brant, and loons as molting and feeding areas. Populations of sediment dwellers remain high and become available to dabbling ducks and shorebirds as water levels recede in late summer. Fish found in these lakes, particularly sticklebacks, are probably important to loons.

Drained Basin-complex (Class VI) - Drained basins are common on the Arctic Coastal Plain and extremely important to waterfowl (Bergman et al. 1977). A variety of wetland types (Class I-IV) may occur in these drained basins resulting in the greatest diversity of vegetation types (Bergman et al. 1977). Because wetland Classes I-IV were sampled for macroinvertebrates separately, no attempt was made to sample them within a Class VI Basin-complex. "Grab" samples indicate that heavily vegetated ponds in a Basin-complex support invertebrate populations similar to Shallow and Deep-*Arctophila* ponds (Class III and IV).

Beaded stream (Class VII) - Although more diverse (16 taxa) in macroinvertebrates than Deep-open (Class V) lakes, Beaded streams were only slightly more productive (see Figure 5) and water fleas comprised only 10% of the total number of organisms collected. Snails and midge larvae were dominant organisms. Total numbers of invertebrates peaked in mid-July, similar to Class II and III ponds.

A variety of waterbirds were observed on Beaded streams, including Pintails, Brant and White-fronted geese with broods. These streams may provide an important means of transportation for flightless adults and young. Grayling (*Thymallus arcticus*) and whitefish (*Oregonus* sp.) were observed in the streams and Arctic terns frequently fed there.

Upland-tundra ponds - This pond type was found in the foothills region and was not previously described from the coastal plain. Little is known concerning the distribution of this pond class in the foothills region.

Upland-tundra ponds were 20 to 30 times more productive in invertebrates than any other pond class (see Figure 5). However, diversity was low (5 taxa) and water fleas comprised 94% of the total number of organisms collected. Numbers of sediment dwellers, particularly midge larvae, were considerably higher in Upland-tundra ponds, especially early in the season. Dense populations of invertebrates developed by mid-June in these ponds, which is considerably earlier than other pond classes.

Extensive use of Upland-tundra ponds by waterfowl, particularly Pintails, was noted in mid-to late June. The dense populations of water fleas available early in the season may contribute to the attractiveness of the area to potential nesters, and to the higher nest sucess of waterfowl in the foothill region.

Ice-wedge pools - Although this wetland type was not described by Bergman et al. (1977) these pools were found on all study sites, particularly in the coastal areas.

Invertebrate populations developed early in these pools and were denser than all pond classes except Upland-tundra ponds. These pools contained abundant fairy shrimp, copepods and water fleas. Fairy shrimp were dominant in these pools throughout the season but could rarely be found in other pond classes after June.

Although Ice-wedge pools produced dense populations of invertebrates, use by waterbirds is not well documented. Occasionally Pintails were flushed from these pools late in the season at Meade River.

Habitat Evaluation

Wetland Classification

Water chemistry and physical features of wetlands in various classes at Meade River Delta (35) and Singiluk (30) are presented in Tables 11 and 11a. Only one wetland of each class was examined at Teshekpuk and values are not included. In general, pH and conductance values were highly variable within wetland classes at all sites, and are probably more influenced by type of substrate and water sources than by the size/depth/vegetation criteria of Bergman et al. (1977). Hydrogen ion concentrations (pH) were nearly all circumneutral (7.5-8.5) but several alkaline ponds near Meade River had pH values over 10.0. Specific conductances ranging from 30-430 micromhos/cm are well within the limits of fresh water (Cowardin et al. 1977) and are less saline than those found by Bergman et al. (1977) near the Beaufort Sea coast.

Table 11. Mean chemical and physical parameters of wetland classes at Meade River. Numbers in parentheses indicate range

Class	Sample size	pH	Conductivity (micromhos/cm)	Maximum depth (cm)
II	13	8.0 (6.5-10.0+)	118 (75-190)	38 (10-75)
IIb - III	1	8.7	180	20
III	6	8.8 (7.5-10.0+)	217 (100-430)	65 (10-150+)
IV	7	8.1 (7.4- 9.0)	173 (60-450)	155 (30-290)
V	11	7.9 (7.5- 8.5)	107 (78-150)	- (50-200+)
VI	1	8.0	140	50
VII	2	7.0 (6.5- 7.5)	108 (71-145)	150 (150)
Ice-wedge pools	5	6.6 (6.0- 7.5)	174 (70-300)	77 (20-150)

Table 11a. Mean chemical and physical parameters of wetland classes at Singiluk

Class	Sample size	pH	Conductivity (micromhos/cm)	Maximum depth (cm)	Vegetation (% cover) *Carex*	*Arctophilla*
I	2	7.75	81	12	>50%	
II	1	8.0	74	50	10%	
IIb	5	8.1	85.4	140	8%	
III	1	7.5	54	100	10%	90%
IV	4	8.0	75.8	174	3.75%	10%
V	5	7.75	64	313	2%	5%
VI	1	7.5	94	15	75%	
VII	6	7.6	78.8	200	5.8%	21.7%
Upland tundra pond	5	6.1	49.4	57	22%	

Two wetland types not included by Bergman et al. (1977), were examined in 1977, Ice-wedge pools at Meade River and Teshekpuk, and Upland tundra ponds at Singiluk. Both of these wetland types have low pH values (5.5-6.5) probably because of organic acid inputs from peat substrates. Concurrently low specific conductances (30-130 micromhos/cm) are probably a result of pH-crabonate interactions. Both types contained high densities of invertebrates relative to other classes and were used frequently by shorebirds and waterfowl.

Classification of wetlands within the system developed by Bergman et al. (1977) required certain modifications because characteristics of some ponds were intermediate between wetland classes. Because the classes are based on a successional process of deepening through thawing and drainage of wetlands, intermediate stages should be expected.

Aerial photography and trend plots

Infrared and true-color aerial photographs were taken of 19 trend plots during 1977. The 1:6000 scale photography proved most practical for covering target areas and production of cover maps, but 1:3000 was useful in discerning details of vegetation and land forms. The cover types of Webber and Walker (1975) with necessary local modifications (Table 13) were more than adequate for distinction on 1:6000 scale products on the coastal sites, but were less useful at Singiluk. Cover maps will provide a sound basis for re-examination of these trend plots in three to five years. Typical signatures (CIR) of wetland classes designated by Bergman et al. (1977) are presented in Table 12. Figures 8

Table 12. Typical color infrared signatures of the wetland types of Bergman et al. (1977)

Wetland class		Description
Class I:	Flooded Tundra	Grey blue
Class II:	Shallow-*Carex*	Green blue
Class IIa:	Shallow-*Carex* with open center	Green blue with orange in center (decayed plant remains) or dark brown to black (shallow open water).
Class III:	Shallow-*Arctophila*	Bright red to greenish red
Class IV:	Deep-*Arctophila*	A combination of Class III and open water (dark blue to black).
Class V:	Deep-open	Dark blue to black (open water) sometimes with a small amount of *Arctophila* (reddish) along the edges.
Class VI:	Basin-complex	Not detectable because of the small amount of area covered by the photograph. Usually a combination of other types.
Class VII:	Beaded Stream	Identifiable more by its shape than any particular signature but would contain small amounts of Class II, III and IV.
Class VIII:	Coastal Wetlands	No photo coverage was obtained of areas with this classification.

and 9 are examples of product cover maps using cover types from Table 13. Photo-mosaics of Teshekpuk (1:6000) and North Lake (1:12,000) had sufficient detail for discrimination of hydrolaccoliths, ice wedge cracks and tracks of vehicles and caribou. Results from the low level flights will be compared to medium level (1:60,000) BLM CIR photography or EROS LANDSAT imagery of the same areas.

Teshekpuk Lake Goose Molting Area

The large lake regime from the Kogru River west to Drew Point and south from the coast to Teshekpuk Lake (Figure 2) attracts thousands of geese and Black Brant (*Branta bernicla*) from Russia, Canada and the United States during the annual molt (King 1970; King and Hodges 1977). King and Hodges (1977) found that 11 percent of the total world population of Black Brant use the Teshekpuk Lake area during the summer months. They suggest that the entire nonbreeding segment of Brant from nesting areas north of Bering Strait from Canada, Alaska and Siberia molt here. This important waterfowl molting area is unique to the Arctic Coastal Plain.

Density and Species Composition

Evaluation of goose density for the area from Kogru River to Drew Point and south to Teshekpuk Lake was completed by J. G. King (USFWS) on July 13, 1977. King estimated 22,075 Brant, 12,490 Canada geese, 2,287 White-fronted geese and 179 Snow geese in this approximately 730 mi^2 (1,891 km^2) area. King and Hodges (1977) estimated a total of 31,912

Table 13. Vegetation-landform types of Webber and Walker (1975) used in mapping trend plots in NPR-A, 1977.

Characteristic Species	Characteristic Microsite
Most Common Types:	
1. *Dryas integrifolia* and crust lichens. Several other cushion dicotyledons and fruticose lichens.	Tops of high-centered polygons, small ridges and high creek bluffs.
2. *Dryas integrifolia* and *Cetraria* spp. Several other fruticose lichens and sedges. Few or no crustose lichens.	Dry polygon rims, and well drained areas.
3. *Carex aquatilis* and/or *Eriophorum angustifolium* and *Dryas integrifolia*. Several other sedges and dwarf willows. Very few or no lichens.	Polygon rims and flat areas that are not continually wet.
4. *Carex aquatilis* and/or *Eriophorum angustifolium* and *Drepanocladus* spp., usually with *Pedicularis sudetica*. No lichens. (moist in July).	Centers of many low-centered polygons, troughs and poorly drained areas, such as pond margins.
5. *Carex aquatilis* and *Scorpidium scorpioides*. No lichens. (standing water in July)	Very wet areas where there is shallow standing water throughout the summer. Wet polygon troughs and pond margins.
6. *Carex aquatilis* and/or *Arctophila fulva*. No mosses or lichens.	Standing water of moderate depth (30-100 cm). Lake margins and thermokarst pits.
(7a)7. No vegetation.	Deep water (> 100 cm).
8. *Saxifraga oppositifolia* and *Salix reticulata* often with *Juncus biglumis* and several lichens.	Frost boils.
Snowbanks and Pingos:	
9. *Cassiope tetragona* and *Salix rotundifolia*.	Snowbanks.
10. Diverse vegetation with *Dryas integrifolia*, *Oxytropis nigrescens* and *Carex rupestris*. Several lichens and mosses.	Pingos.
Stream, River, and Lake Margins:	
(11a)11. Diverse vegetation with *Salix rotundifolia*, *Chrysanthemum integrifolium* and *Oxyria digyna*.	Slumping river bluffs, areas of erosion and/or solifluction.
12. *Carex aquatilis* and *Dupontia fisheri* with *Saxifraga hirculus* and other dicotyledons.	Stream banks.
13. *Salix lanata* and *Carex aquatilis*. Shrubby willows with a Type 12 understory.	Stream and lake banks.

Table 13 (con't.) Vegetation-landform types, supplemental to Webber and Walker (1975), used in mapping trend plots in NPR-A, 1977.

	Characteristic species	Characteristic microsite
7b.	No vegetation, sand or mud.	River banks, lakeshores, old beaches.
7c.	No vegetation, peat or peat/ sand mixture.	River banks, lakeshores, old beaches.
11b.	Primary: Salix phlebophylla, Dryas integrifolia, Astragalus alpinus. Secondary: Astragalus umbellatus, Dupontia fischeri, Lagotis glauca, Oxyria digyna.	High, moist peninsula with slump bank vegetation and dwarf willow carpet.
11c.	Dupontia fischeri, Eriophorum vaginatum, Salix arctica and patches of bare sandy soil.	Leveled slump banks and old beaches of river channels and drained lakes.

Meade River
Plot 4

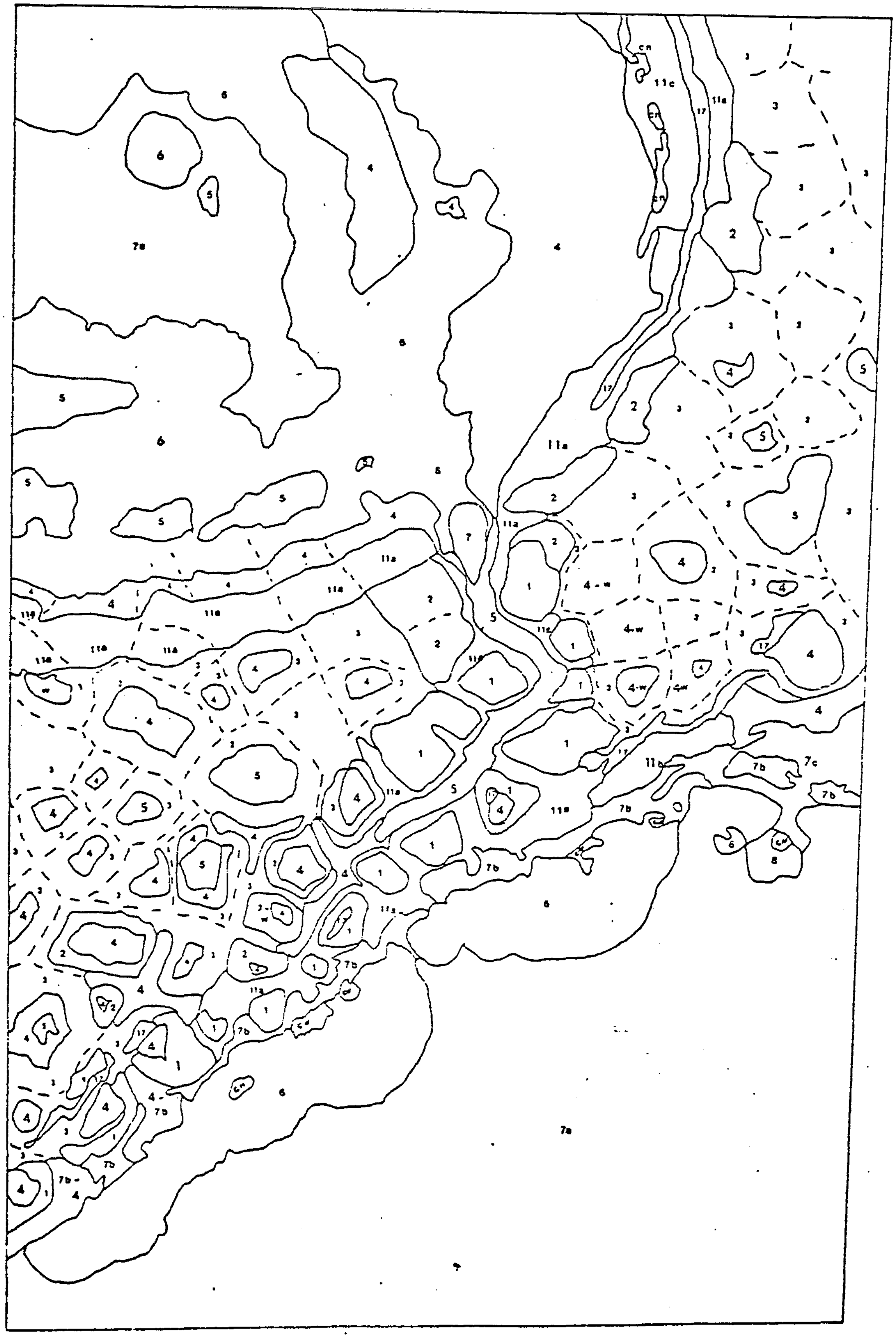

Fig. 8. Cover map of a Meade River trend plot using cover types of Webber and Walker (1975) with modifications (see Table 13).

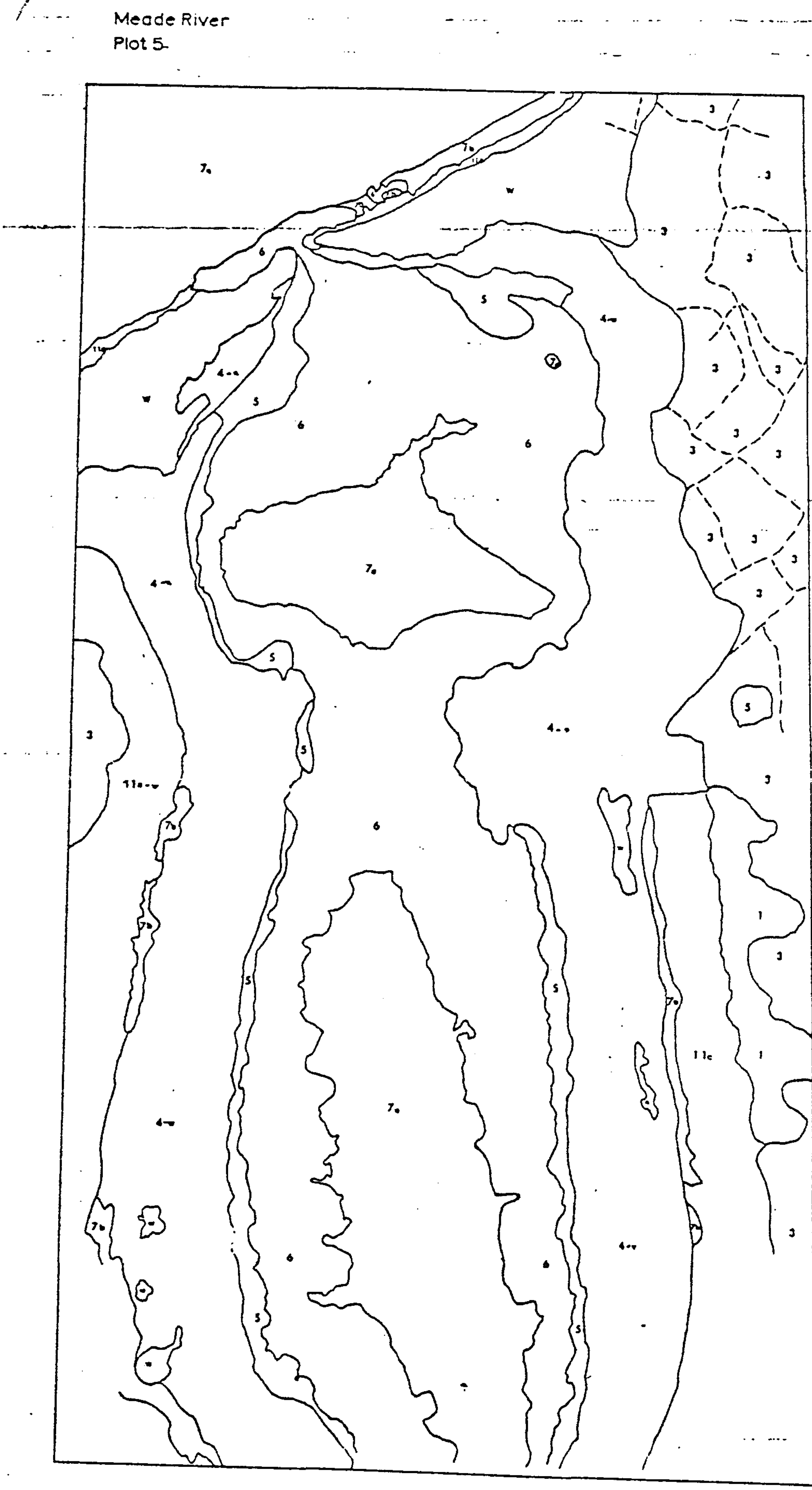

Fig. 9. Cover map of a Meade River trend plot using cover types of Webber and Walker (1975) with modifications (see Table 13).

molting birds of these four species in this same area in 1976. Although many other wetland areas in NPRA attract molting geese during the summer months, the largest concentrations of birds use the Teshekpuk Lake area.

Table 14 is a summary of goose density and composition from July 13 to September 7, 1977 for nine lakes in and adjacent to the 15.60 km^2 (6 mi^2) N. E. Teshekpuk Lake study area (Figure 2). Three species of geese and Brant occur regularly in this area dominated by large lakes (Class V and VI). Brant were the most abundant species using the nine lakes in the study area. Canada geese (Branta canadensis) were second in abundance, followed by White-fronted geese (Anser albifrons) and Snow geese (Anser caerulescens). Four Ross' geese (Anser rossii) were observed on August 18, but are considered rare on the Arctic Coastal Plain in NPRA. Peak numbers of molting geese and Brant occurred between July 10-30 with over 4,900 flightless birds using lakes in the study area on July 13 (Table 14).

Flock Size

Counts of geese from June 11 to August 7, 1977 at the N. E. Teshekpuk Lake study area showed that 76.0 percent of all White-fronted goose flocks observed were composed of 20 or fewer birds (Table 15). By comparison, 43.3 and 46.0 percent of Brant and Canada goose flocks, respectively, exceeded 20 birds. Only White-fronted geese and Brant nest in the area. Larger flocks of Canada geese ($\bar{x}$ = 42.8 birds; range = 1-240) and Brant ($\bar{x}$ = 49.1; range = 1-690) were probably unsuccessful or nonbreeding birds.

TABLE 14. GOOSE DENSITY AND SPECIES COMPOSITION AT N. E. TESHEKPUK LAKE STUDY AREA

		Number of geese/lake									
Date	Species	Molt Lake	Drop Lake	Caribou Lake	W. Long Lake	E. Long Lake	Goose Lake	Horseshoe Lake	Square Lake	Ruddy Lake	TOTALS
July 13[a] (Fixed wing Beaver)[b]	White-fronted goose	0	0	0	0	0	840	0	0	0	840
	Snow goose	0	0	15	0	0	0	0	0	0	15
	Canada goose	100	0	200	0	750	20	0	100	0	1170
	Brant	0	0	300	0	2600	0	0	50	0	2950
	TOTALS	100	0	515	0	3350	860	0	150	0	4975
July 18 (Helicopter)[b]	White-fronted goose	0	0	0	0	100	594	–	75	0	769
	Snow goose	0	0	19	0	3	0	–	0	0	22
	Canada goose	75	0	135	0	1300	100	–	0	0	1610
	Brant	0	0	40	0	1950	107	–	125	50	2272
	TOTALS	75	0	194	0	3353	801	–	200	50	4673
July 27-29 (Avon boat and walking)[b]	White-fronted goose	0	0	0	25	–	–	0	5	0	30
	Snow goose	0	0	17	0	–	–	0	0	0	17
	Canada goose	6	36	30	132	–	–	0	59	55	318
	Brant	0	0	33	0	–	–	0	60	20	113
	Unidentified dark geese	25	6	0	0	–	–	0	0	0	31
	TOTALS	31	42	80	157	–	–	0	124	75	509
August 6-7 (Avon boat and walking)[b]	White-fronted goose	0	0	0	10	–	43	–	–	–	53
	Snow goose	0	0	6	6	–	0	–	–	–	12
	Canada goose	0	6	46	25	–	7	–	–	–	84
	Brant	0	0	7	9	–	76	–	–	–	92
	Unidentified dark geese	0	0	0	18	–	6	–	–	–	24
	TOTALS	0	6	59	68	–	132	–	–	–	265

TABLE 14 cont. GOOSE DENSITY AND SPECIES COMPOSITION AT N. E. TESHEKPUK LAKE STUDY AREA

		Number of geese/lake									
Date	Species	Molt Lake	Drop Lake	Caribou Lake	W. Long Lake	E. Long Lake	Goose Lake	Horseshoe Lake	Square Lake	Ruddy Lake	TOTALS
August 16 (Fixed wing C-185)[b]	White-fronted goose	0	0	0	0	15(2)[c]	96	0	0	0	111
	Snow goose	0	0	0	0	0	0	0	0	0	0
	Canada goose	0	0	0	6	8	10	18	0	0	42
	Brant	0	0	7	4(2)[c]	2	0	0	3	0	16
	Unidentified dark geese	0	0	0	0	6	1	0	0	0	7
	TOTALS	0	0	7	10	31	107	18	3	0	176
August 18[d] (Fixed wing C-185)[b]	White-fronted goose	0	0	0	0	–	7	0	0	0	7
	Snow goose	0	0	0	0	–	0	0	10	0	10
	Canada goose	0	0	0	0	–	0	0	0	0	0
	Brant	0	0	0	0	–	0	0	0	0	0
	Ross' goose	0	0	0	0	–	0	0	4	0	4
	TOTALS	0	0	0	0	–	7	0	14	0	21
September 7[d] (Fixed wing C-185)[b]	White-fronted goose	0	0	0	0	0	0	0	0	0	0
	Snow goose	0	0	0	0	0	0	0	0	0	0
	Canada goose	0	0	0	0	55	0	0	0	0	55
	Brant	0	0	0	0	10	20	0	0	0	30
	TOTALS	0	0	0	0	65	20	0	0	0	85

[a] Data from James G. King, U.S.F.W.S., Juneau, Alaska.

[b] Census method.

[c] Number in parentheses represents brood size.

[d] Data from Rodney King, U.S.F.W.S., Anchorage, Alaska.

TABLE 15. FLOCK SIZE OF GEESE OBSERVED AT N. E. TESHEKPUK LAKE STUDY AREA - JUNE 11 TO AUGUST 7, 1977

Species	Flock size						
	0-5	6-10	11-20	21-50	51-100	101-200	>200
White-fronted Goose	18 (36.0)[a]	8 (16.0)	12 (24.0)	6 (12.0)	3 (6.0)	2 (4.0)	1 (2.0)
Snow Goose	4 (40.0)	3 (30.0)	1 (10.0)	2 (20.0)	0	0	0
Canada Goose	11 (14.5)	16 (21.1)	14 (18.4)	16 (21.1)	7 (9.2)	9 (11.8)	3 (3.9)
Brant	22 (29.7)	13 (17.6)	7 (9.4)	15 (20.3)	10 (13.5)	3 (4.1)	4 (5.4)

[a] percent of flocks observed for each species is given in parentheses.

Chronology of Feather Molt

The flightless period in all species of geese at the N. E. Teshekpuk Lake study area was July 5 to August 7 (Figure 10). Flightless Brant were first observed on July 7 and for the last time on August 7. The last flightless birds of other species were seen five to seven days earlier (Figure 10).

Habitat Preference

All lakes within the area surveyed were used by geese, but larger lakes generally were most attractive to molting birds (Table 14). Size of lakes is probably an important factor in selection by molting geese because of the security provided by large lakes from terrestrial predators and the greater longevity of ice floes used as resting areas. However, stage of lake development rather than size alone appears to be important in selection because some large lakes (e.g. East Long Lake) attract many more molting birds than other lakes of similar size (e.g. West Long Lake - see Table 14). East Long Lake is a partially drained basin (second generation) that attracted up to 3,300 geese. This lake is characterized by: 1) shorelines with gentle slopes, 2) moist, Carex-dominated vegetation adjacent to open water and 3) presence of a shallow lagoon system on the west shore that provides important loafing, feeding and watering areas. West Long Lake has approximately the same surface area as East Long Lake, but possible factors that make this lake unattractive to geese include: 1) precipitous shorelines (1-5 m) on the east and north ends which makes access and visibility difficult, 2) generally

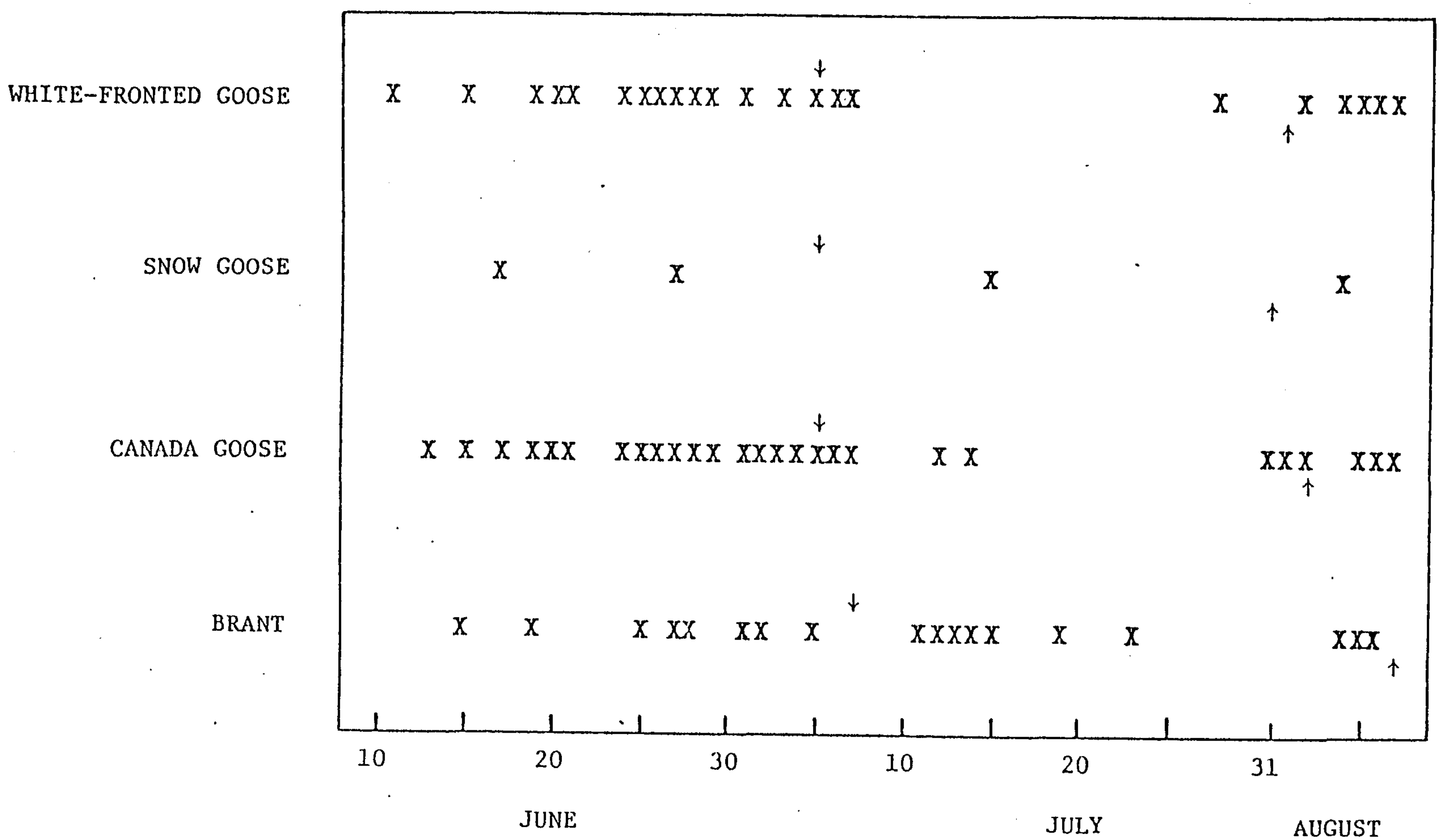

Figure 10. Duration of flightless period for geese at N. E. Teshekpuk Lake study area. X indicates dates flying birds were observed and arrows indicate first (↓) and last (↑) days flightless geese were seen.

dry upland tundra vegetation adjacent to the lake on all shores rather than preferred succulent species, 3) shifting ice floes through mid-July and 4) absence of adjacent lagoons. Differences in depth and turbidity among lakes may also contribute to their attractiveness to geese.

Ice condition is probably an important factor in determining use of lakes by geese. Ice conditions were monitored on East and West Long Lakes during mid-July when geese and Brant were first assembling in the area. Prevailing NNE winds kept north and east shorelines ice-free on most days. Accumulation of small floes and trash ice on west shorelines precluded use of such areas until ice had melted. Ice conditions determined from July, 1976 9 x 9 inch color aerial photographs (BLM) and molting geese and Brant density determined from July, 1976 census data are currently being compared and evaluated.

The following ground truth information was obtained on important molting lakes at the N. E. Teshekpuk Lake study site: 1) distribution of emergent and submergent vegetation, 2) species composition of vegetation communities adjacent to lakes, 3) salinity and conductivity, 4) pH, 5) turbidity, 6) depth and 7) nutrient content of sedges and grasses. Aerial photo coverage of the Teshekpuk Lake Special Area will be analyzed using these parameters and 1977 and 1978 distribution of molting geese to determine conditions that make certain lakes attractive to molting birds. Identification of specific lakes and wetland areas that should receive special protection from low-level aircraft flights, from physical damage to vegetation food sources adjacent to lakes and from other disturbances will be made and identified on suitable maps.

Feeding Behavior and Food Habits

Although analysis of time budgets of feeding geese is not yet complete it is apparent that there is differential utilization of habitats for feeding by molting geese and Brant. Brant feed on new growth of *Carex* spp. along the moist moss-dominated zones of second generation basin shores. Canada geese feed on drier upland sites dominated by mature *Carex*-*Eriophorum*-*Salix* communities and White-fronted geese use intermediate areas.

Foods utilized by geese have not yet been assessed in detail, but it was obvious that sedges and grasses growing in moist areas such as: 1) lake inlets and outlets, 2) lagoon systems adjacent to lakes and 3) low moss-dominated shorelines were preferred. A limited number of exclosures were established in 1977 to determine food selection by molting geese on a preferred shoreline, but results are not available for this report. Traditional feeding areas receive significant enrichment from goose droppings. Plants preferred by grazing geese and Brant probably have nutrient levels above areas not receiving intensive use by geese. More exclosures will be established and final assessment of nutrient levels of grasses and sedges will be made in 1978.

DISCUSSION AND RECOMMENDATIONS

Although extensive information on wetlands and waterfowl of the Arctic Coastal Plain of Alaska is lacking, certain characteristics of this ecosystem are widely recognized. The Arctic Coastal Plain represents one of the largest and most stable collections of wetlands in North America covering 65,000 km^2 (Wellein and Lumsden 1964) of which lakes and ponds comprise 50-75% (Black and Barksdale 1949). King (1970) considered 59,000 km^2 to be suitable waterfowl habitat. The Arctic Coastal Plain is considered a simple ecosystem which causes extreme oscillations in wildlife populations (Bergman 1974). Such systems represent a type of stability that can only exist in large areas (Dunbar 1973). The evolution of wetland types within the system is recognized as a basin-deepening process through thawing of the permafrost, and drainage through breaching of banks, but time factors involved are unknown (Bergman et al. 1977).

Bergman et al. (1977) noted the following characteristics of bird populations using the Arctic Coastal Plain; 1) small numbers of breeders, 2) few resident species, 3) high-percentage of water related birds, 4) low-density populations and 5) dominantly invertebrate feeders (except geese). Chernov (1962) also notes that birds of the Arctic Coastal Plain are entomaphagus, particularly during the breeding season, however studies of food habits are generally lacking. Shorebirds, a dominant group of the Arctic Coastal Plain, rely heavily on sediment dwellers such as midge larvae (Holmes and Pitelka 1968). A variety of waterfowl, particularly young birds, are known to utilize invertebrate food sources (Chung 1961; Bartonek and Hickey 1969, Sugden 1969, and Bartonek 1972). The importance of invertebrates to laying waterbirds has been established in other areas (Leitch 1964; Bengtson 1971; and Krapu 1974). In addition to food habits studies, a better understanding of the species composition, seasonal abundance and distribution of invertebrate food resources has been needed.

Our understanding of the wetland ecosystem on the Arctic Coastal Plain was increased considerably with the long-term effort by Bergman et al. (1977) at Storkersen Point. Significant data were collected concerning: 1) development of a Arctic Coastal Plain wetland classification system, 2) determination of wetland preferences by waterbird species, 3) knowledge of seasonal abundance and distribution of invertebrate food resources and 4) determination of the effects of oil spill on wetlands and invertebrate populations. Results of this effort provided a sound basis for land-use recommendations on the coastal wetlands near Prudhoe Bay, however application of these results to less developed areas of the Arctic Coastal Plain could not be made without further research.

Signficance of the USFWS-Special Studies Effort to Land Use Planning

The Special Studies field effort in 1977 provided additional important baseline data on population composition, density and seasonal abundance of waterbirds and invertebrate food resources.
Many of the results from Bergman et al. (1977) were similar to those of the widely distributed study areas on NPRA. General agreement between the 1977 Special Studies effort and Bergman et al. (1977) include similarities in: 1) species composition of breeding birds, 2) occurrence

and characteristics of wetland classes, with the exception of two new types and river-influenced wetlands, 3) wetland preferences of various waterbird species and 4) invertebrate population distribution, abundance and composition. The most noticeable differences in results from the two efforts occured at Singiluk, furthest inland, and Teshekpuk Lake where large numbers of molting geese congregate.

In addition to establishing baseline data for widely distributed areas within NPRA, the 1977 Special Studies effort adapted the Webber and Walker (1975) classification system for upland and wetland tundra vegetation communities to low-level (1:6000) infrared and true color photography. Signatures identified on the low-level photography will be compared to medium-level BLM photographs (1:60,000) or high-level EROS-LANDSAT imagery, after the multi-stage technique of Meyer (1973). Results of this analysis are not yet available but will be valuable for habitat analysis on NPRA.

A third segment of the wetlands analysis is the current aerial bird survey by USFWS-Migratory birds. Results of these surveys will provide an index of abundance for some species and reliable total counts for others. Analysis of transect data should indicate areas with highest waterbird densities. This information, combined with aerial interpretation of habitats through the multi-stage approach and our understanding of wetland types important to waterbirds will provide a sound base for: 1) land use decisions affecting waterbirds over large areas of NPRA, 2) a continuing analysis of the effect of conflicting land uses on waterbirds and wetlands important to waterbirds.

Special Studies will concentrate efforts in 1978 on areas known to be important to waterfowl. The large lakes surrounding Teshekpuk Lake have been identified as a unique area in NPRA extremely important to molting geese. However, little is known concerning: 1) the habitat factors which attract geese to this area, 2) the feeding ecology of molting geese using the areas and 3) the effect of oil-related development activities on geese and their food resources. These questions will be addressed during the second season of the two-year effort initiated at Teshekpuk Lake in 1977.

Results of the study at Singiluk in 1977 indicate that we understand less of the ecology of the interior coastal plain than the coastal areas. Fauna, flora and wetland types not found on the Arctic Coastal Plain were encountered in the foothills region. Because of a milder climate and earlier snow melt, the interior zones may provide important early holding areas for waterbirds migrating towards coastal areas. Production of waterfowl was greater, and nest success higher at Singiluk than the coastal sites indicating that this area may be more attractive to potential nesters, or that environmental conditons are more favorable for production. Additional field work near Umiat is proposed for 1978 to collect additional baseline data on the foothill region and answer questions raised at Singiluk in 1977.

Land Uses Detrimental to Wetland Resources in NPRA

The most serious wide-spread threat to the waterfowl and wetlands of the Arctic Coastal Plain is oil and gas-related development activities.

Bergman (1974) notes that "although the impact of development has been assessed mainly along the proposed route of the Trans-Alaska pipeline, oil spills and disturbances probably will be more frequent in the oil fields where pipeline systems and roads link oil wells to the main pipeline." Detrimental effects from these activities include: 1) oil contamination of wetland areas through spills, 2) destruction of habitat from construction activities and 3) disturbances to birds from men and machines involved in oil development. Areas involving stream or river drainages or areas where melt water flows rapidly across the tundra surface are particularly subject to damage (Bergman et al. 1977).

The most intensive study on the direct effect of oil spills to tundra wetlands occurred at Storkersen Point (Bergman et al. 1977; Derksen et al. 1977). Evidence gathered from severly contaminated ponds indicate that no organisms useful to feeding birds existed after a heavy spill, and fewer birds used the ponds in subsequent years (Bergman et al. 1977). Long term effects of the various intentional spills at Storkersen Point are currently being monitored by USFWS-Special Studies.

Damage to wetland habitats from construction activities can occur through a variety of ways including: 1) construction of drill pads which destroy or drain wetlands, 2) construction of haul roads which fill and drain wetlands or block drainage, 3) alteration and destruction of vegetation communities and drainage patterns by winter rolligon traffic, 4) destruction of dunes and sandbars due to gravel removal and 5) water removal for drilling operations. Studies concerning the immediate and long-term impact of these disturbances are being conducted in the Prudhoe Bay region and on a more limited scale in NPRA by USFWS-Special Studies. At Teshekpuk Lake extensive damage to a preferred goose feeding site on East Long Lake was documented in 1977 through vegetation plots and low-level color and color-infrared photography. Rolligon traffic on a winter trail has resulted in destruction of vegetation and alteration in drainage patterns on this intensively grazed area. Evaluation of this disturbance will be completed in 1978.

Currently, the most widespread direct disturbance to waterfowl from mechanical activities in NPRA is low-level aircraft activity. At Teshekpuk Lake helicopters and fixed-wing aircraft consistently violated minimum specified flight altitudes. Molting geese and brant were observed to abandon feeding sites and move to open water when aircraft approached at altitudes of 500 feet and at distances up to one mile. These interruptions in feeding may interfere with fat storage essential for fall migration. The combined effect of damage to traditional and nutrient-enriched feeding areas and disturbance to feeding and resting birds could have serious impacts on the status of some species. The effect of low-level aircraft activity on breeding birds is not known but wary birds, such as White-fronted geese, are likely to be affected.

Recommendations for Land-Use Plans and Future Studies

Results of previous studies (Bergman et al. 1977) and the 1977 Special Studies effort in NPRA allow comments on means of reducing damage from oil-related activities within NPRA. These include:

1) activities that destroy or alter drainage patterns of Class IV, VI, VII, VIII and Upland Tundra ponds should be prohibited. Activities included are construction of drill pads, haul roads, winter roads, and pipelines within one kilometer of these wetlands. Construction activity in all areas should be minimized during the period May 15 to October 1, 2) low-level aircraft activity should be minimized during the breeding season and during July on goose molting areas, 3) oil contingency plans for rapid clean-up should be operational and 4) oil development activities should be monitored.

Until all data is analyzed from the 1977 and 1978 field seasons Special Studies is not in a position to delineate special-use areas other than the large-lake regime near Teshekpuk Lake, known for high concentrations of molting geese. Specific boundaries for this area will be determined following the 1978 field season. Presently this area within Zone A is subject to the most intensive oil exploration and drilling and efforts should begin to protect it. To maintain the stability of the arctic ecosystem we anticipate the need to establish large reserves within NPRA. Determination of these areas will be based on: 1) ground and aerial survey results and 2) analysis of aerial photography based on a knowledge of wetlands preferred by waterbirds.

An extensive data base is needed for a sound land management policy. Because of the lack of information concerning the Arctic Coastal Plain research is currently needed and will continue to be needed. Special Studies will expend approximately 280 man-days at Teshekpuk Lake and 140 man-days at Umiat in 1978 to meet objectives established for the projects. However, more questions will continue to be raised regarding wetland resources in NPRA and we foresee a continuing research effort, although less intense than current programs. We feel research should be directed toward: 1) continuing the development of a wetland classification system that will permit analysis of wetlands based on their importance to waterbirds, as determined from aerial and on-ground reseach efforts, 2) monitoring the evolution of wetlands through drainage by natural and artificial processes and 3) collection of additional baseline data concerning waterbird population densities and production. These efforts will provide data for a continuing analysis of land use programs in NPRA. Recommendations for specific projects will be made after all data is analyzed.

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Appendix 1. Densities of breeding birds during seven survey periods on the 15.54 km^2 N. E. Teshekpuk Lake study area

Species	20,21[2] June	27,28[2] June	4,5 July	11,12 July	18,19 July	25,26 July	1,2 Aug	Mean
	No. per Km^2							
Arctic Loon (*Gavia arctica*)	2.44	1.93	2.12	1.03	0.77	1.67	0.84	1.54
Red-Throated Loon *Gavia stellata*	1.93	0.90	0.90	1.74	0.64	1.87	0.90	1.30
Whistling Swan (*Olor columbianus*)	0.39	0.26	0.26	0.26	0	0.13	0.19	0.21
Brant (*Branta nigricans*)	3.35	1.67	0.19	5.15	4.57	10.03	12.61	5.36
White-Fronted Goose (*Anser albifrons*)	2.32	1.42	3.47	0.13	0	0	0.32	1.09
Pintail (*Anas acuta*)	45.56	26.38	15.06	5.98	3.28	9.20	14.28	17.10
Spectacled Eider (*Lampronetta fischeri*)	1.42	0.39	1.03	0.51	0.39	0.58	0.06	0.62
Oldsquaw (*Clangula hyemalis*)	1.54	1.67	3.09	1.29	3.41	3.41	7.79	3.17
Parasitic Jeager *Stercorarius parasiticus*)	0.39	0	0.58	0.64	0.51	0.51	0.32	0.42
Glaucous Gull (*Larus hyperboreus*)	0.51	0.39	0.51	0.58	0.84	1.16	0.59	0.65
Sabine's Gull (*Xema sabini*)	0	0.13	0.64	0.32	0.45	0.19	0.13	0.26
Arctic Tern *Sterna paradisaea*)	2.06	0.64	0.54	0.45	0.90	0.90	0.71	0.80
Pectoral Sandpiper (*Calidris melanotos*)	41.59	23.00	67.26	10.62	5.31	25.66	80.53	36.28
Dunlin (*Calidris alpina*)	25.66	15.93	15.93	9.73	5.31	12.39	4.42	12.77
Long-Billed Dowitcher (*Limnodromus scolopaceus*)	4.42	2.65	7.96	2.65	7.08	0.88	2.65	4.04
Semipalmated Sandpiper (*Calidris pusillus*)	10.62	7.96	9.73	7.08	3.54	3.54	0	6.07
Red Phalarope (*Phalaropus fulicarius*)	53.10	42.48	41.59	58.41	15.04	10.62	6.19	32.49
Northern Phalarope (*Lobipes lobatus*)	22.12	7.08	12.40	14.16	11.50	15.04	10.62	13.27
Lapland Longspur (*Calcarius lapponicus*)	72.57	39.82	23.01	14.16	10.62	5.31	284.07	64.22
American Golden Plover (*Pluvialis squatarola*)	0	0.88	0	0	4.42	12.39	7.08	3.54

[1]Densities of small birds based on seven 220 X 880 yard transects (=1.13 Km^2)

[2]Large bird surveys on 20 and 27 June based on 7.77 Km^2

Appendix 2. Densities of breeding birds per km^2 at Singiluk in 1977

	17-18 June	24-25 June	1-2 July	8-9 July	15-16 July	22-23 July	29-30 July	5-6 August	Average
Arctic loon (*Gavia arctica*)	0.7	0.8	0.6	0.2	0.5	0.6	0.8	0.8	0.6
White-fronted goose (*Anser albifrons*)	6.5	7.4	1.3	1.0	0	0.3	0.7	4.1	2.7
Pintail (*Anas acuta*)	4.1	8.7	5.1	1.8	1.5	0.8	2.3	1.2	3.2
Scaup sp. (*Aythya* sp.)	1.0	1.2	0.8	0	0.2	0.3	0.3	0	0.5
King eider (*Somateria spectabilis*)	0.1	0	0.3	0	0.3	0.3	0.6	0.4	0.2
Oldsquaw (*Clangula hyemalis*)	3.4	1.4	2.7	1.5	1.2	3.9	0.2	13.8	3.5
Willow ptarmigan (*Lagopus lagopus*)	2.8	1.9	0.7	0.5	0.5	0.4	0.6	1.2	1.1
American golden plover (*Pluvialis dominica*)	4.4	1.8	0	1.8	0	0.9	0	-	1.3
Black-bellied plover (*Pluvialis squatarola*)	2.7	1.8	3.5	3.5	4.4	2.7	3.5	-	3.2
Bar-tailed godwit (*Limosa lapponica*)	12.4	8.8	8.8	15.9	20.3	6.2	6.2	-	11.2
Pectoral sandpiper (*Calidris melanotos*)	10.6	7.1	13.2	25.6	82.0	12.4	17.6	-	24.1
Dunlin (*Calidris alpina*)	0	0	0.9	0.9	1.8	0	0	-	0.5
Semipalmated sandpiper (*Calidris pusillus*)	7.1	5.3	16.8	9.7	7.9	1.8	0	-	6.9
Red phalarope (*Phalaropus fulicarius*)	10.6	0	3.5	10.6	3.5	0	0	-	4.0
Northern phalarope (*Lobipes lobatus*)	15.9	7.9	18.5	13.2	7.9	2.7	1.8	-	9.7
Parasitic jaeger (*Stercorarius parasiticus*)	0.2	0.5	0.1	0.3	0.3	0.3	0.4	0.5	0.3
Long-tailed jaeger (*Stercorarius longicaudus*)	0.8	0.3	0.7	0.6	0.1	0.5	0.1	0.1	0.4
Arctic tern (*Sterna paradisaea*)	1.2	0.7	1.1	0.7	1.2	0.5	1.6	0.3	0.9
Yellow wagtail (*Motacilla flava*)	0.9	0	0.9	3.5	0	0	0	-	0.8
Redpoll sp. (*Acanthis* sp.)	0	0	0	0	0	0.9	0	-	0.1
Savannah sparrow (*Passerculus sandwichensis*)	7.1	19.4	27.3	15.9	11.5	2.7	0	-	12.0
Lapland longspur (*Calcarius lapponicus*)	64.4	84.7	64.4	36.2	20.3	12.4	14.1	-	42.3

Appendix 3. Densities of Breeding Birds per km^2 at Meade River

	$\bar{x}$	13 June	20 June	27 June	4 July	11 July	18 July	25 July	1 August	8 August
Arctic loon (*Gavia arctica*)	2.1	1.5	2.6	1.7	1.4	1.7	2.3	2.8	2.8	2.4
Red-throated loon (*Gavia stellata*)	0.2		0.2	0.2	0.1	0.1	0.2	0.3	0.3	0.2
Whistling swan (*Olor columbianus*)	0.2	0.4			0.8		0.1		0.1	0.1
Black brant (*Branta bernicla*)	0.3		0.5	0.3	0.4	0.2		0.6		1.0
White-fronted goose (*Anser albifrons*)	0.7	2.3	1.2	1.8	0.2	0.2				0.6
Pintail (*Anas acuta*)	5.1	4.4	7.1	6.2	8.5	2.5	0.5	8.6	5.0	2.7
Spectacled eider (*Somateria fischeri*)	0.3	0.4	0.8	0.5	0.1	0.3	0.2		0.1	0.1
Oldsquaw (*Clangula hyemalis*)	1.1	2.1	2.2	1.6	2.2	0.8	0.1	0.5	0.2	
Parasitic jaeger (*Stercorarius parasiticus*)	0.4	1.4	0.5	0.6	0.3	0.1		0.2	0.1	0.1
Long-tailed jaeger (*Stercorarius longicaudus*)	0.2		0.3	0.2	0.3	0.3		0.5	0.1	
Glaucous gull (*Larus hyperboreus*)	1.1	1.2	1.0	1.4	1.1	1.6	0.8	1.2	1.0	0.8
Sabine's gull (*Xema sabini*)	0.7		0.3		0.3	2.3	1.3	1.2	1.2	0.1
Arctic tern (*Sterna paradisaea*)	0.7	0.6	0.5	0.4	0.5	1.2	0.6	1.5	0.6	0.2
Willow ptarmigan (*Lagopus lagopus*)	0.1	0.2	0.1			0.3				
Black-bellied plover (*Pluvialis squatarola*)	6.3	6.2	3.7	7.4	4.9	9.9	9.9	7.4	1.2	
Ruddy turnstone (*Arenaria interpres*)	0.2			1.2						
Pectoral sandpiper (*Calidris melanotos*)	22.9	61.8	37.1	19.8	16.1	14.8	7.4	17.3	8.6	
Dunlin (*Calidris alpina*)	21.1	21.0	14.8	21.0	38.3	14.8	18.5	29.6	11.1	
Semipalmated sandpiper (*C. pusilla*)	7.0	16.1	1.2	7.4	19.8	9.9	1.2			
Red phalarope (*Phalaropus fulicarius*)	20.6	74.1	48.2	30.9	16.1	4.9	6.2	3.7	1.2	
Redpoll (*Acanthis* sp.)	0.3		2.5							
Lapland longspur (*Calcarius lapponicus*)	24.1	39.5	30.9	39.5	8.6	21.0	14.8	30.9	7.4	

Appendix 3a.

Densities of birds not known to breed at Meade River, 1977

	$\bar{x}$	13 June	20 June	27 June	4 July	11 July	18 July	25 July	1 August	8 August
Scaup (*Aythya* sp.)	0.01		0.1							
King eider (*Somateria spectabilis*)	0.10	0.4	0.3	0.5						
Unidentified eider	0.10					0.4		1.0		
Sandhill crane (*Grus canadensis*)	0.01								0.1	
Pomarine jaeger (*Stercorarius pomarinus*)	0.20	1.4	0.1	0.1						
Snowy owl (*Nyctea scandiaca*)	0.01									0.1
Long-billed dowitcher (*Limnodromus scolopaceus*)	3.70	7.4	1.2	1.2	8.6	9.9	1.2			
Northern phalarope (*Lobipes lobatus*)	4.20	1.2	3.7	2.4	3.7	2.5	1.2	2.4	16.1	
Snow bunting (*Plectrophenax nivalis*)	0.80			5.2						