AERIAL SURVEYS OF BIRD POPULATIONS ALONG THE PROPOSED CROSS DELTA PIPELINE ROUTE, YUKON AND NORTHWEST TERRITORIES, JUNE-AUGUST, 1975

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ABSTRACT

Four aerial surveys of the cross delta route of the proposed Arctic Gas pipeline were flown during the period June-August, 1975. The surveys were flown in order (1) to determine the numbers of water birds along the route during the periods of nesting, of brood-rearing and moulting, and of spring and fall staging and migration; (2) to identify those areas along the route that are important to water birds; and (3) to compare the numbers of water birds along the cross delta route with the numbers along the circum-delta route.

Densities of water birds during the spring staging period and the nesting period were highest along the section of the route that traverses the outer Mackenzie Delta. Densities during the brood-rearing and moulting period and the fall staging period were highest along the section of the route to the southeast of the Mackenzie Delta. The density of broods of water birds was highest on that portion of the route to the east of the Mackenzie Delta. Scaup were the most numerous of the 31 species of birds that occurred along the route.

The outer Mackenzie Delta is probably the most important section of the cross delta route for water birds. For each of the major water bird groups, the highest density during a survey occurred at least once along the outer Mackenzie Delta section of the route.

The cross delta route appears to support more water birds than does the circum-delta route.

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The Arctic Gas Biological Report Series, of which this report is a part, is a series of consultant project reports presenting data based on field and laboratory studies. The format and presentation varies among reports in accordance with the author's discretion.

The data for this work were obtained as a result of investigations carried out by LGL Limited for Canadian Arctic Gas Study Limited. The text of this report may be quoted provided the usual credits are given.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

The cross delta route has recently been proposed to shorten the route of the Arctic Gas pipeline in the Mackenzie Delta area. This route diverges from the previously-planned circum-delta route on the Yukon North Slope. It then crosses Shallow Bay and the outer Mackenzie Delta to a junction at the southwest corner of Richards Island with a supply line originating at the Taglu Field (Figure 1). The line proceeds from this junction southeast to Thunder River, where it rejoins the previously-planned route and follows it southeastward up the Mackenzie Valley.

The circum-delta route (Figure 1) runs from the Yukon North Slope along the coastal tundra until it approaches the Mackenzie Delta. It then turns southward, remaining to the west of the delta, and turns eastward at the south end of the delta. After crossing the Mackenzie River near Arctic Red River, this route proceeds to a point west of Travaillant Lake where it is joined by the Richards Island supply line from the north. It then proceeds eastward to Thunder River, then southeastward up the Mackenzie Valley. On both the circum-delta route and the cross delta route a supply line runs westward from the Parsons Lake field to join each route.

A number of studies of water birds have been conducted in areas that would be traversed by the proposed cross delta route. Calef and Lortie (1971), Schweinsburg (1974), and Sharp *et al.* (1974) have reported on the breeding water bird populations of the Arctic Coastal Plain.

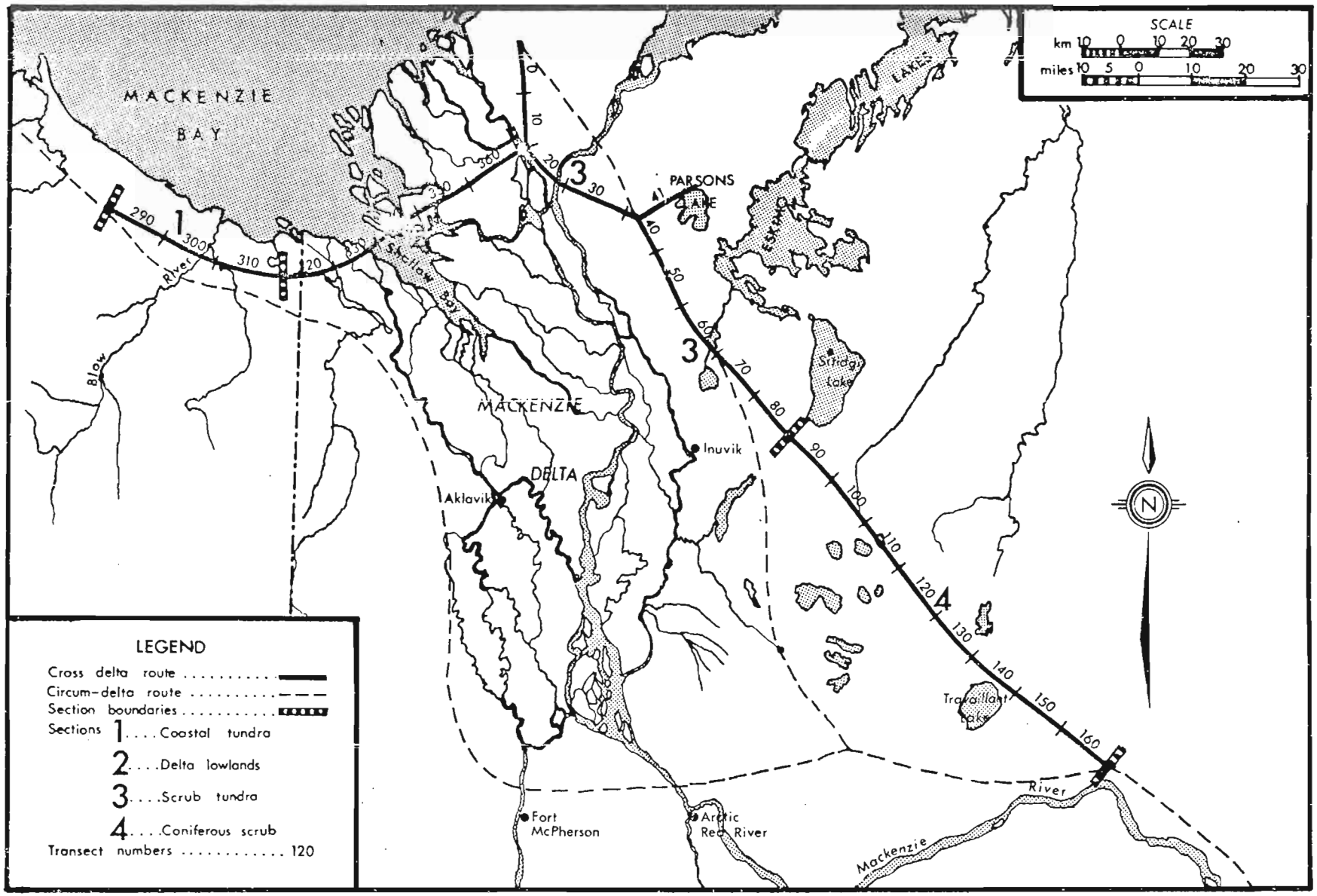


FIGURE 1. Habitat Sections and Aerial Transects along the Cross Delta Route.

Koski and Gollop (1974) and Koski (1975a, 1975b) have described the fall staging of Snow Geese, of other species of geese, and of Whistling Swans on the Arctic Coastal Plain and in the Mackenzie Delta. The U.S. Fish and Wildlife Service (USFWS), in cooperation with the Canadian Wildlife Service, has conducted annual surveys of waterfowl breeding pairs and waterfowl production in the Mackenzie Delta, on Richards Island, and in areas to the southeast of the Mackenzie Delta (Martel, in prep.). Campbell (1973), Campbell and Weber (1973), and Slaney (1974) have conducted aerial and ground surveys of water birds in sections of the Mackenzie Delta and Richards Island. Salter (1974a) has studied water birds along the circum-delta route on Richards Island and in the areas south and southeast of the delta. Jacobsen (1974) has provided a comprehensive literature review relevant to the water birds of the area.

These studies represent a sizeable quantity of ornithological information concerning areas that would be traversed by the cross delta route. However, they have generally concentrated on specific parts of the area, on specific pipeline routes, or on particular groups of water birds. Consequently, some areas that would be traversed by the cross delta route have not been studied comprehensively with respect to all water bird populations.

Aerial surveys were conducted along the cross delta route in 1975 to gather information concerning water bird populations along the route. The specific objectives of the surveys were the following:

1) to determine the species and numbers of water birds that use the area along the proposed route during the periods of nesting, of brood-rearing and moulting, and of spring and fall staging and migration;
2) to identify the areas along the route that are important to water birds during these periods; and
3) to compare the cross delta route with the circum-delta route in terms of their importance to water birds.

The data from this study, when combined with data from other studies, will provide baseline information that can be used to assess the potential impact of the proposed Arctic Gas pipeline on water bird populations and to develop environmental recommendations with respect to the pipeline.

METHODS

Four aerial surveys were conducted along the proposed cross delta route during the late spring and summer of 1975. These were flown on June 5, June 20, July 31, and August 30.

The dates were chosen to correspond to times when important seasonal activities of the birds were estimated to have occurred. The survey of June 5 corresponded to the period of spring arrival; the survey of June 20 to the nesting period; the survey of July 31 to the time of brood rearing and moulting; and the survey of August 30 to the fall staging and migration period.

Surveys were flown in fixed-wing aircraft, either a twin-engine Piper Aztec or a single-engine Cessna 185. The pilot followed the pipeline route which was depicted on topographic maps. The surveys were conducted at heights varying between 100 and 150 feet above ground level and at air speeds of 90 to 120 mph. Two observers, one at each side of the aircraft, identified and counted all water birds and other conspicuous birds that were seen within a 1/8 mi (200 m) strip on the observer's side of the plane.

Observations were recorded on cassette tapes and were later transcribed to data sheets. The data were then transferred to a computer system for analysis. A small quantity of data was lost as a result of malfunctions of tape recorders during the surveys.

The route was divided into 10-mi transects, according to the milepost designations shown on preliminary alignment sheets prepared by Canadian Arctic Gas Pipeline Limited (1975). The transects are shown in Figure 1. The data were recorded separately for each 10-mi transect. For purposes of analysis the transects were pooled into four sections according to their physical features and characteristic vegetation (Figure 1). These sections were the following:

1) coastal tundra--the Yukon North Slope (milepost 290 to milepost 320);
2) delta lowland--the outer Mackenzie Delta (milepost 320 to milepost 372);
3) scrub tundra--Richards Island to south end of Sitidgi Lake (milepost 0 to milepost 90); and
4) coniferous scrub--Sitidgi Lake to Thunder River (milepost 90 to milepost 172).

For the purposes of this study, water birds were defined to be those groups of birds that are attracted to or dependent on an aquatic or semi-aquatic habitat. These birds include waterfowl such as swans, geese, and ducks; other diving birds such as loons and grebes; and gulls, terns, and Sandhill Cranes.

RESULTS

Total Density Indices

Figure 2 presents the density indices for total water birds that were calculated for each section on each survey. Density indices during the spring staging and breeding periods were highest in the delta lowland section. Density indices during the brood-rearing and fall staging periods were highest in the coniferous scrub section. The highest density index for the entire period (62.9 water birds/sq mi) occurred in the coniferous scrub section on August 30--largely the result of one flock of 700 scaup on a single lake. The lowest density indices were found consistently on the coastal tundra section.

Despite the apparent differences in the density indices for the different sections, density indices did not differ significantly among sections on any of the four surveys.

Numbers and Density Indices of Water Bird Species

The numbers and density indices of the birds observed along each of the four sections of the cross delta route are presented in Tables 1 to 4. Density indices are given for water birds only, because of the difficulty of detecting most terrestrial birds from aircraft. A complete transect-by-transect summary of data from each survey is given in Appendix 1. The scientific names of the birds recorded are listed in Appendix 2.

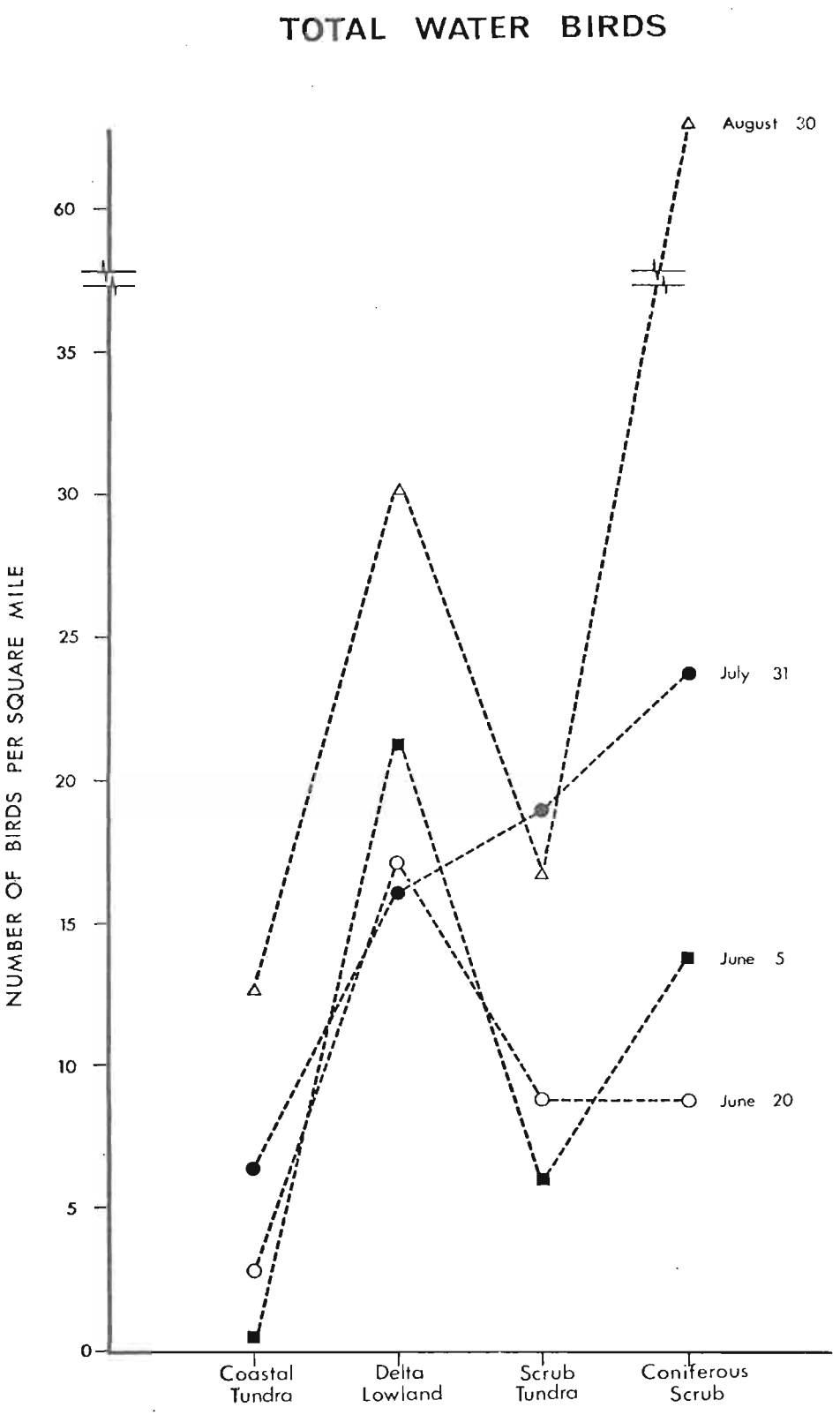


FIGURE 2. Density Indices of Total Water Birds along Sections of the Cross Delta Route.

TABLE 1. Numbers and Density Indices of Birds Observed During Aerial Surveys of the Coastal Tundra Section of the Cross Delta Route, 1975.

DATE SURVEYED / AREA SURVEYED	JUNE 5 7.5 mi²		JUNE 20 6.3 mi²		JULY 31 7.5 mi²		AUGUST 30 3.8 mi²	
	NO.	DENSITY*	NO.	DENSITY	NO.	DENSITY	NO.	DENSITY
WATER BIRDS								
Arctic Loon			2	0.3	9	1.2	1	0.3
Loon spp.							2	0.5
Loon, grebe or duck					8	1.1	1	0.3
Whistling Swan					2	0.3	2	0.5
Ducks:								
Mallard			1	0.2				
Pintail			3	0.5				
Scaup spp.			6	1.0	2	0.3		
Oldsquaw	2	0.3	2	0.3	15	2.0	36	9.6
King Eider			2	0.3				
White-winged Scoter			1	0.2				
Red-breasted Merganser	1	0.1						
Diving duck spp.			1	0.2	4	0.5		
Duck spp.					2	0.3		
Total Ducks	3	0.4	16	2.5	23	3.1	36	9.6
Sandhill Crane							5	1.3
Arctic Tern					6	0.8		
Total Water Birds	3	0.4	18	2.9	48	6.4	47	12.5
OTHER BIRDS†								
Willow Ptarmigan			4					
Parasitic Jaeger					3			
Long-tailed Jaeger			1		1			
Jaeger spp.	1				2			

* Density indices are in units of birds per square mile.

† Density indices have only been calculated for water birds.

TABLE 2. Numbers and Density Indices of Birds Observed During Aerial Surveys of the Delta Lowland Section of the Cross-Delta Route, 1975.

DATE SURVEYED	JUNE 5		JUNE 20		JULY 31		AUGUST 30	
AREA SURVEYED	13.1 mi²		13.1 mi²		13.1 mi²		6.6 mi²	
	NO.	DENSITY*	NO.	DENSITY	NO.	DENSITY	NO.	DENSITY
WATER BIRDS								
Arctic Loon			7	0.5	28	2.1	5	0.8
Red-throated Loon					4	0.3		
Loon spp.					6	0.5	1	0.2
Loon, grebe or duck					2	0.2	2	0.3
Whistling Swan	54	4.1	13	1.0	48	3.7	8	1.2
Canada Goose	2	0.2	2	0.2				
White-fronted Goose	4	0.3	12	0.9			35	5.3
Dark goose spp.							22	3.3
Ducks:								
Mallard	2	0.2						
Pintail	30	2.3	24	1.8	5	0.4		
American Wigeon							64	9.7
Dabbling duck spp.	1	0.1			3	0.2	9	1.4
Scaup spp.	103	7.9	62	4.7	8	0.6	7	1.1
Oldsquaw			13	1.0	2	0.2		
White-winged Scoter	9	0.7	54	4.1				
Scoter spp.	2	0.2			2	0.2	14	2.1
Red-breasted Merganser	1	0.1			4	0.3		
Diving duck spp.	1	0.1	2	0.2				
Duck spp.					27	2.1	14	2.1
Total Ducks	149	11.4	155	11.8	51	3.9	108	16.4
Sandhill Crane	4	0.3	8	0.6	2	0.2	17	2.6
Glaucous Gull	52	4.0	2	0.2	2	0.2		
Mew Gull	1	0.1						
Gull spp.					1	0.1		
Arctic Tern	10	0.8	25	1.9	65	5.0		
Total Water Birds	276	21.1	224	17.1	209	16.0	198	30.2
OTHER BIRDS†								
Bald Eagle			1					
Marsh Hawk							2	
Pomarine Jaeger	15							
Parasitic Jaeger			1					
Jaeger spp.	71		5					
Short-eared Owl					1			
Common Raven							1	

* Density indices are in units of birds per square mile.

† Density indices have only been calculated for water birds.

TABLE 3. Numbers and Density Indices of Birds Observed During Aerial Surveys of the Scrub Tundra Section of the Cross Delta Route, 1975.

DATE SURVEYED / AREA SURVEYED	JUNE 5 25 mi² NO.	JUNE 5 25 mi² DENSITY*	JUNE 20 25 mi² NO.	JUNE 20 25 mi² DENSITY	JULY 31 25 mi² NO.	JULY 31 25 mi² DENSITY	AUGUST 30 22.5 mi² NO.	AUGUST 30 22.5 mi² DENSITY
WATER BIRDS								
Arctic Loon			13	0.5	53	2.1	45	2.0
Red-throated Loon			3	0.1	4	0.2		
Loon spp.					5	0.2	11	0.5
Loon, grebe or duck			7	0.3	21	0.8	11	0.5
Whistling Swan	2	0.1	29	1.2	36	1.4	23	1.0
White-fronted Goose	20	0.8	10	0.4				
Dark goose spp.	4	0.2						
Ducks:								
Mallard			3	0.1	3	0.1		
Pintail	10	0.4	16	0.6	36	1.4	2	0.1
Green-winged Teal	2	0.1						
American Wigeon	1	0.0**	1	0.0			30	1.3
Dabbling duck spp.	1	0.0					9	0.4
Scaup spp.	12	0.5	53	2.1	18	0.7	156	6.9
Common Goldeneye			2	0.1				
Oldsquaw	35	1.4	38	1.5	53	2.1		
Common Eider			1	0.0				
White-winged Scoter	6	0.2	17	0.7	15	0.6		
Surf Scoter			8	0.3				
Scoter spp.			1	0.0	56	2.2	37	1.6
Diving duck spp.	37	1.5	10	0.4	11	0.4	8	0.4
Duck spp.	7	0.3	2	0.1	132	5.3	47	2.1
Total Ducks	111	4.4	152	6.1	324	13.0	289	12.8
Sandhill Crane	2	0.1	1	0.0	5	0.2		
Glaucous Gull	1	0.0	1	0.0	2	0.1		
Mew Gull			1	0.0				
Arctic Tern	5	0.2	5	0.2	26	1.0		
Total Water Birds	145	5.8	222	8.9	476	19.0	379	16.8
OTHER BIRDS†								
Marsh Hawk					1		1	
Willow Ptarmigan	1		11					
Rock Ptarmigan			1					
Ptarmigan spp.	17		1					
Pomarine Jaeger	1							
Parasitic Jaeger			3					
Long-tailed Jaeger			2		1			
Jaeger spp.			1					
Common Raven					2			

* Density indices are in units of birds per square mile.

† Density indices have only been calculated for water birds.

** Less than 0.05.

TABLE 4. Numbers and Density Indices of Birds Observed During Aerial Surveys of the Coniferous Scrub Section of the Cross Delta Route, 1975.

DATE SURVEYED / AREA SURVEYED	JUNE 5 20.5 mi²		JUNE 20 20.5 mi²		JULY 31 20.5 mi²		AUGUST 30 20.5 mi²	
	NO.	DENSITY*	NO.	DENSITY	NO.	DENSITY	NO.	DENSITY
WATER BIRDS								
Arctic Loon	4	0.2	7	0.3	29	1.4	37	1.8
Loon spp.			2	0.1	2	0.1	13	0.6
Loon, grebe or duck	2	0.1	4	0.2	9	0.4	31	1.5
Whistling Swan	3	0.2	3	0.2	17	0.8	9	0.4
Ducks:								
Mallard	4	0.2	14	0.7	1	0.0	2	0.1
Pintail	6	0.3	12	0.6	8	0.4	2	0.1
Green-winged Teal					2	0.1		
American Wigeon	2	0.1	4	0.2				
Dabbling duck spp.	4	0.2	1	0.0**	24	1.2	20	1.0
Scaup spp.	142	6.9	82	4.0	225	11.0	714	34.8
Common Goldeneye	3	0.2	3	0.2				
Oldsquaw	7	0.3	3	0.2	3	0.2	1	0.0
White-winged Scoter	60	2.9	27	1.3			6	0.3
Surf Scoter			6	0.3				
Scoter spp.					32	1.6	24	1.2
Red-breasted Merganser	4	0.2	6	0.3				
Diving duck spp.	16	0.8	3	0.2	76	3.7	12	0.6
Duck spp.	10	0.5			38	1.9	421	20.5
Total Ducks	258	12.6	161	7.9	409	20.0	1202	58.6
Mew Gull	4	0.2						
Bonaparte's Gull			1	0.0				
Arctic Tern	16	0.8	3	0.2	23	1.1		
Total Water Birds	287	14.0	181	8.8	489	23.8	1292	62.9
OTHER BIRDS†								
Bald Eagle	1							
Willow Ptarmigan	3							
Rock Ptarmigan	1		2					

* Density indices are in units of birds per square mile.

† Density indices have only been calculated for water birds.

** Less than 0.05.

Thirty-seven species of birds were identified during the course of the four surveys; 31 of these were recorded within the 1/4-mi transect width. The largest number of species in a section (25) was recorded for the scrub tundra section. The largest number of species on any of the four surveys (26) was recorded during the June 20 survey. During this survey, the scrub tundra section contained the largest number of those species (21).

The most numerous group of water birds was the diving ducks. The two species of scaup were the most abundant of these, comprising nearly 70% of the identified diving ducks. (From the air the two species of scaup could not be reliably separated.)

The short coastal tundra section consistently contained the fewest species and the lowest density indices along the route (Table 1). The Oldsquaw was the commonest species recorded here; it occurred in largest numbers on the August 30 survey.

The delta lowland section had the highest density indices of water birds during the two June surveys and high density indices during the July 31 and August 30 surveys (Table 2). The highest density indices of Whistling Swans, Sandhill Cranes, and Arctic Terns were found consistently on this section. Geese were also comparatively common along this section.

Density indices of water birds on the scrub tundra section, though often high, were rarely as high as those on the delta lowland or coniferous scrub sections (Table 3). There were two exceptions--the density indices of Arctic Loons and Oldsquaws were generally highest on the scrub tundra section.

The coniferous scrub section of the cross delta route had especially high density indices of water birds during the July 31 and August 30 surveys (Table 4). The totals for this section were influenced greatly by the large numbers of ducks. Scaup were the most abundant of these ducks; they comprised more than 50% of the ducks that were identified.

Figures 3 and 4 show the density indices of each of the major groups of water birds for each of the surveys and each of the sections of the route. Loons, geese, dabbling ducks, diving ducks, and gulls each represent more than one species; swans, cranes, and terns each represent a single species.

Density indices on each transect in each section were compared for each water bird group on each survey. Density indices differed significantly among the four sections in only two cases (Kruskal-Wallis: terns June 20; $H = 13.4$; $df = 3$; $n = 26$; $P < 0.01$: diving ducks July 31; $H = 8.3$; $df = 3$; $n = 26$; $P < 0.05$). The density index for Arctic Terns on the June 20 survey was significantly higher in the delta lowland section than the density indices for the other sections (one-tailed Mann-Whitney: *vs* coastal tundra; $U = 0.0$, $n = 3, 5$; $P = 0.018$: *vs* scrub tundra; $U = 3.0$; $n = 5, 10$; $P < 0.01$: *vs* coniferous scrub; $U = 1.5$; $n = 5, 8$; $P < 0.003$).

FIGURE 3. Density Indices of Loons, Swans, Geese, and Dabbling Ducks along Sections of the Cross Delta Route.

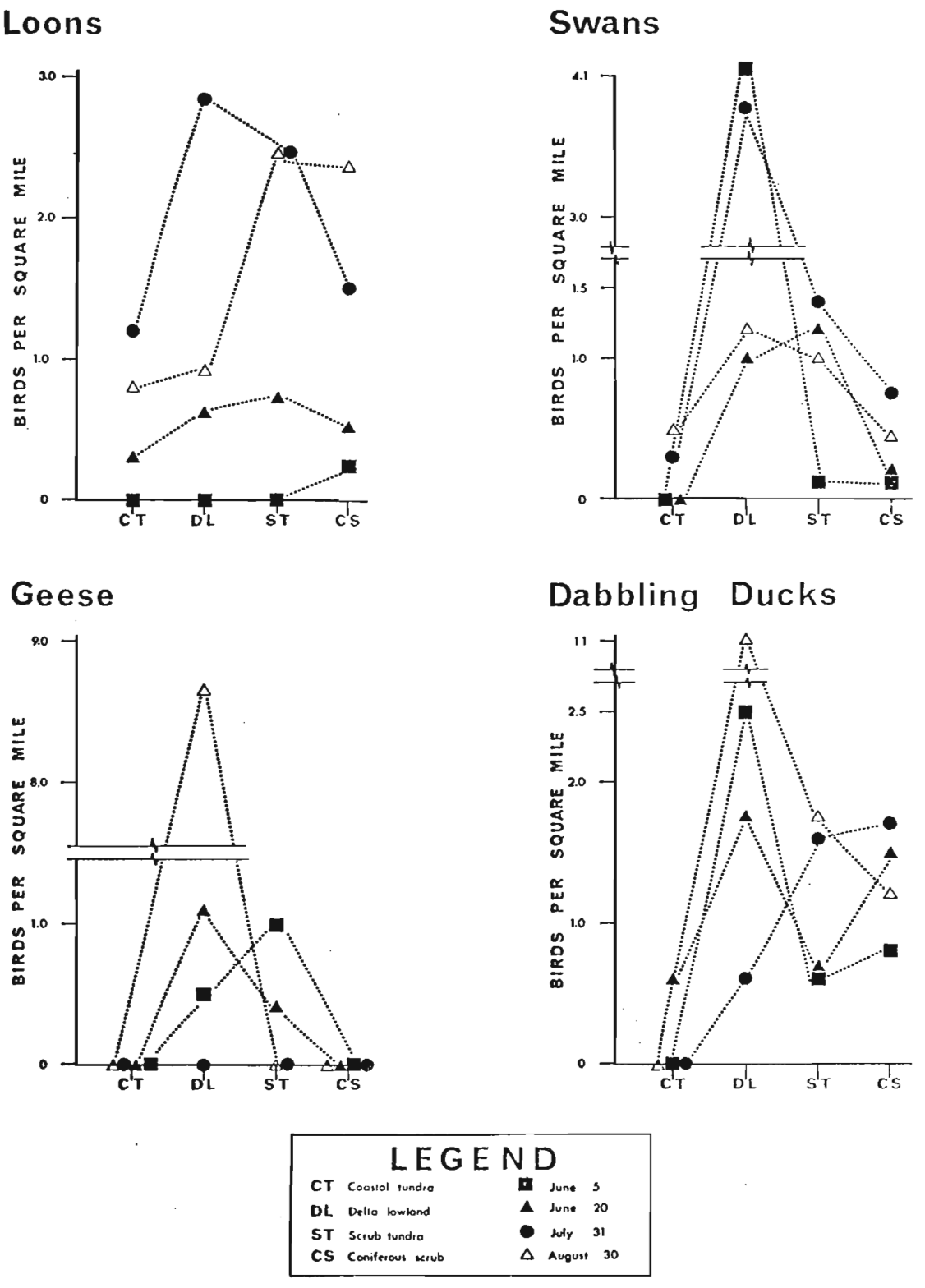
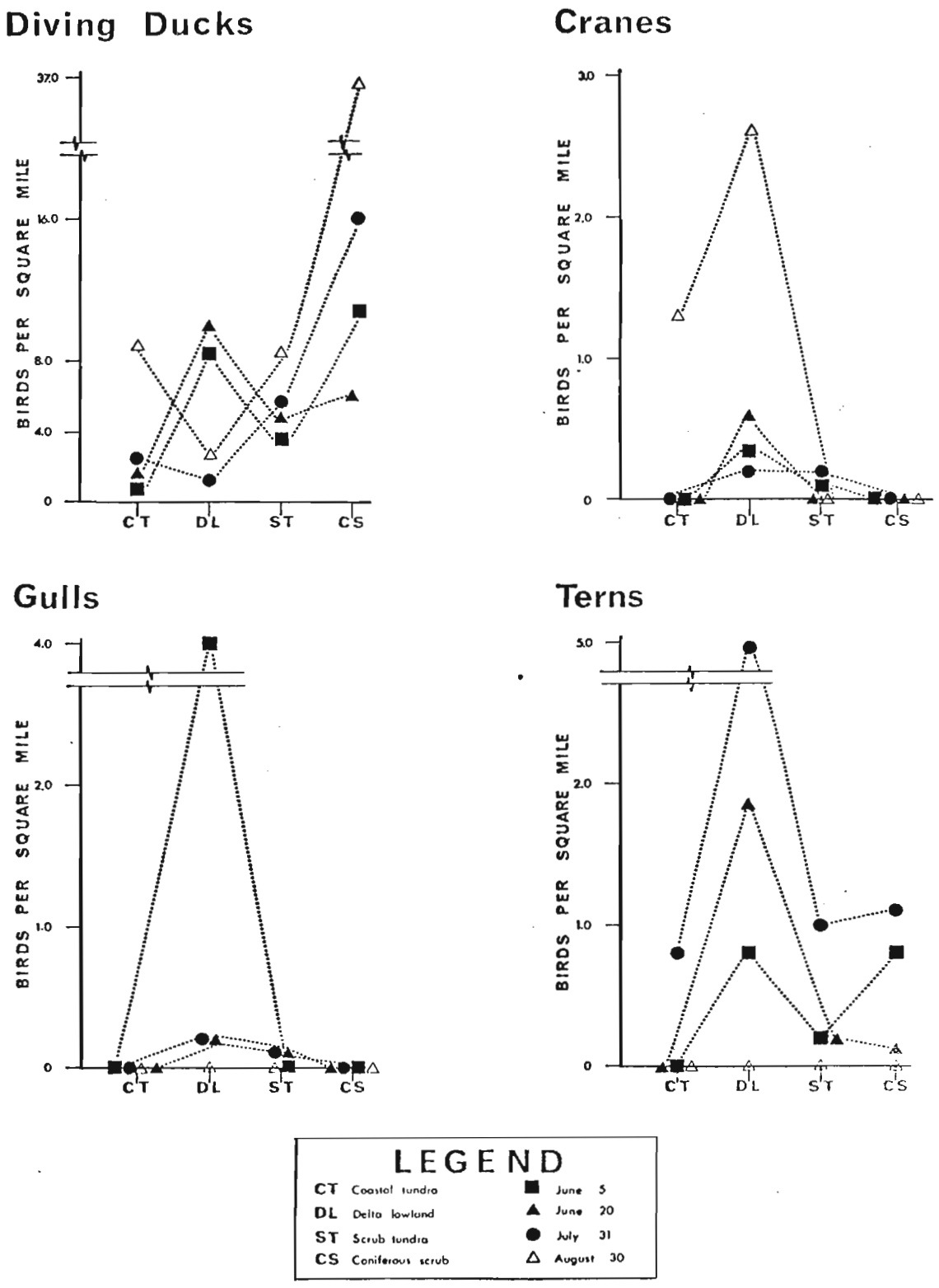


FIGURE 4. Density Indices of Diving Ducks, Cranes, Gulls, and Terns along Sections of the Cross Delta Route.



The density index for diving ducks on the July 31 survey was significantly higher in the coniferous scrub section than the density indices for the other sections (one-tailed Mann-Whitney: *vs* coastal tundra; $U = 3.0$; $n = 3, 8$; $P < 0.042$: *vs* delta lowlands; $U = 0.5$; $n = 5, 8$; $P < 0.002$: *vs* scrub tundra; $U = 19.5$; $n = 8, 10$; $P < 0.05$).

Productivity

Table 5 presents the numbers of broods of water birds and the numbers of young birds that were recorded on each section of the route during the July 31 survey. These results have also been included in Tables 1 to 4. Density indices for the number of broods were higher on the coniferous scrub and the scrub tundra sections than they were on the delta lowland and the coastal tundra sections. Most of the observed broods were of diving ducks; of these, scaup broods were the most abundant.

Several Arctic Loons and Whistling Swans were observed on nests during the July 31 survey, suggesting that the survey was too early for an adequate determination of productivity for these birds. For this reason, brood counts for these species from the August 30 survey have been included in Table 5. The number of broods of Arctic Loons on the August 30 survey was greatest along the scrub tundra and coniferous scrub sections.

TABLE 5. Numbers of Broods of Water Birds, and Numbers of Young Birds on the July 31 Aerial Survey of the Cross Delta Route, 1975.

SECTION	COASTAL TUNDRA		DELTA LOWLAND		SCRUB TUNDRA		CONIFEROUS SCRUB	
AREA SURVEYED (SQ MI)	7.5		13.1		25.0		20.5	
	NUMBER OF BROODS	NUMBER OF YOUNG	NUMBER OF BROODS	NUMBER OF YOUNG	NUMBER OF BROODS	NUMBER OF YOUNG	NUMBER OF BROODS	NUMBER OF YOUNG
Arctic Loon	1	1	1	1	5	6	3	5
Arctic Loon**			1	1	9	12	7	8
Red-throated Loon					1	1		
Whistling Swan			1	1*	1	1	1	1*
Whistling Swan**					2	6		
Pintail							1	5
Dabbling duck spp.							3	18
Scaup spp.			1	3	2	15	11	51(75)
Oldsquaw	2	13				(50)		
White-winged Scoter					1	9		
Scoter spp.					2	14	1	4
Red-breasted Merganser.			1	3				
Diving duck spp.					2	7	3	13
Duck spp.					13	75(12)	3	12
Loon, grebe or duck					1	2		
Sandhill Crane					1	1		
TOTAL	3	14	4	8	29	131	26	109
DENSITY INDEX(/SQ MI)	0.4	1.9	0.3	0.6	1.2	5.2	1.3	5.3

* Possibly more than one young.
** Brood results from August 30 survey.
( ) Denotes large flocks consisting of a mixture of adults and young. They have not been included in totals or densities.

Important Transects for Water Birds

Table 6 identifies for each of the four surveys and for each major water bird group those 10-mi transects on which relatively high density indices were recorded. Transect numbers correspond to the preceding milepost number of each transect (as taken from preliminary alignment sheets [Canadian Arctic Gas Pipeline Limited, 1975]). The locations of transects are shown in Figure 1.

The symbols used in Table 6 represent, for each water bird group during each survey, the comparative position of the density indices for each transect relative to the mean density index. In order to assess the relative importance of those transects on which a water bird group was recorded, they were the only transects included in the calculation of the mean. The important transects for a water bird group on a particular survey were considered to be those with density indices which were at least twice as large as this mean density index.

From Table 6 it is apparent that the important transects for swans and for terns were concentrated in the delta lowland section and the northern portion of the scrub tundra section. Geese and cranes were restricted mainly to this area.

The most widely dispersed groups of water birds were the ducks and the loons; they occurred virtually throughout the area. The dabbling ducks showed no trend towards a concentration of important transects in

TABLE 6. Comparative Density Rankings† of Water Bird Groups on Transects along the Cross Delta Route, 1975.

WATER BIRD GROUP	SURVEY	MEAN DENSITY INDEX*	TRANSECTS††																											
			COASTAL TUNDRA SECTION			DELTA LOWLAND SECTION					SCRUB TUNDRA SECTION										CONIFEROUS SCRUB SECTION									
			290	300	310	320	330	340	350	360	0	10	20	30	40	41	50	60	70	80	90	100	110	120	130	140	150	160		
Loons	June 5	1.6																							•					
	June 20	1.0		•		•		•		∇	•		∇	∇		ϕ				•		•				•	•	∇		
	July 31	2.2	•	•	•	•	•	•	∇	ϕ	ϕ	ϕ	ϕ	•	∇	•	•	•	•	•	•		∇	•	•	•	•	∇		
	August 30	2.5		•	•	•	•		•	•	•	ϕ	∇	∇		N		•	•	∇		∇	ϕ	∇	∇	•	•	•		
Swans	June 5	4.7				♦		•		•						•								•						
	June 20	1.7				•	•		∇	•	ϕ	ϕ	•	•							•		•							
	July 31	3.2			•		•	♦	•	•	∇	∇		•		•				•			•	∇		•				
	August 30	1.5			∇		∇	∇	∇		•	∇	•	•		N			∇	•			•		•	•	•			
Geese	June 5	2.4				•	•					•	•			ϕ														
	June 20	1.6				•		∇	•		•			∇		•														
	July 31	0.0																												
	August 30	21.1						∇		•						N														
Dabbling Ducks	June 5	2.5				♦	•								•	∇			•		•		•	•	•			•		
	June 20	1.5		•	•	∇		∇	ϕ	∇	∇	•	∇	•		•	•	•		•	∇	•	∇		∇	∇		∇		
	July 31	2.9							•	•		♦	•						•			•		•	•	•	•	∇		
	August 30	9.3							•	♦			•	∇		N					•	•	•		•					
Diving Ducks	June 5	9.9			•	•	•	ϕ	•					•	•	•	•		∇	∇		∇	•	ϕ	•		•	ϕ		
	June 20	6.1	•	•	•	•	•		•	♦	•	•	•	∇	•	∇	•	•	∇	∇	•	•	∇	•	∇	•		ϕ		
	July 31	9.2		•	•	•	•	•	•	•	•		•	ϕ		•		•	•	ϕ	ϕ	∇	•	♦	∇	•	•	♦		
	August 30	30.3			•	•			•				•			N		ϕ		•	•	•	•	♦	•	•	•	•		
Cranes	June 5	0.6				•		•	∇		∇																			
	June 20	0.8				•			•	∇			•																	
	July 31	1.3								•	∇																			
	August 30	8.8			•	∇										N														
Gulls	June 5	3.9				♦	•	•											•						•		•			
	June 20	0.5								∇		•						•								•				
	July 31	0.5					•	•		•						∇														
	August	0.0														N														
Terns	June 5	1.6						•	•	•			•						•						•			ϕ		
	June 20	1.3				•	•	ϕ	ϕ	∇			•	•		•							•					•		
	July 31	2.3			∇	•	•	∇	ϕ	♦	•	•	ϕ	•		•		•	•		•		ϕ	•	•	•				
	August 30	0.0														N														

† Explanation of symbols
- • 0.0 < density index ≤ mean
- ∇ mean < density index ≤ 2 x mean
- ϕ 2 x mean < density index ≤ 4 x mean
- ♦ 4 x mean < density index
- N transect not surveyed

†† See Figure 1 for the locations of the transects.

* Mean density index (in units of birds per square mile) of those transects on which the group was observed.

any section. The important transects for diving ducks were concentrated in the coniferous scrub section and the southern portion of the scrub tundra section. The important transects for loons were concentrated in two areas--the more important of these was the northern portion of the scrub tundra section and the adjoining portion of the delta lowlands; the less important was the northern portion of the coniferous scrub section.

DISCUSSION

Limitations of Aerial Survey Data

Data collected on aerial surveys do not yield absolute densities of water bird populations; the data obtained do, however, yield indices of population density which can be used in comparisons of data.

Martinson and Kaczynski (1967) have shown that aerial survey results generally underestimate both the total number of waterfowl present and the number of different species that are present. Detectability of these birds varies according to species; it also varies with the observer and the location of the observer in the aircraft. The USFWS has devised means of calculating correction factors for waterfowl species; but because the calculation of such factors requires counts of waterfowl on the ground in conjunction with the results of aerial surveys, these factors could not be obtained for this study. Accordingly, the results presented are probably underestimations of the actual numbers of birds that were present during the surveys. The amount of this underestimation is probably greater for some species than it is for others.

Data were gathered on only four days during the period June 5 to August 30, 1975. Survey times were chosen in order to coincide generally with the periods of spring staging, of nesting, of brood-rearing and moulting, and of fall staging and migration; it is felt that the data are representative of the general use made of the area by water birds

during these periods. However, because the breeding cycles of different species of water birds are not in synchrony, the results are more representative of these periods for some species than they are for others. Important changes in the use of the areas by water birds may have occurred between the dates of the surveys. The nature and timing of these changes is not known.

Importance of Sections of the Route to Water Birds

Coastal Tundra Section

There was little apparent water bird activity along the coastal tundra section during the surveys of June 5, June 20, or July 31. Oldsquaws were the most regularly recorded species along this section. This finding agrees with that of Schweinsburg (1974) and Sharp *et al.* (1974) who reported that the Oldsquaw was the commonest water bird along the coastal pipeline route and on numerous tundra lakes on the Yukon North Slope. On June 5 most bodies of water were frozen along this section, which explains the very low numbers of water birds that were recorded at that time.

On August 30, the highest density of Oldsquaws on any survey was found on this section. Schweinsburg (1974) recorded large numbers of this species along nearby coastal areas on September 2, 1971, as well as on other surveys during the month of August. Moulting of large numbers of Oldsquaws takes place along the coast of the Beaufort Sea during July and August (Bartonek, 1969; Bartels, 1973) and migration

westward peaks during early September (Gollop and Davis, 1974). It is probable that a small percentage of the Oldsquaws, such as the ones observed on the August 30 survey, use the inland lakes as well as the coastal waters for premigratory staging or as a stopping place during migration.

Delta Lowland Section

The highest density index of water birds on the June 5 survey was recorded in the delta lowlands, a result of the early opening of water areas there. Those species which arrive early were relatively numerous there; Whistling Swans, Glaucous Gulls, Pintail, and scaup were the most numerous of these. Snow Geese may have arrived in the delta lowlands and departed by May 20 (when a partial reconnaissance survey was flown). Slaney (1974) indicated that areas of heavy use by arriving Snow Geese were located on the eastern edge of the delta lowland section.

Relatively high density indices of water birds on the delta lowland section were also found on the June 20 survey; however, changes were noticed in the relative abundances of many of the water bird groups. Numbers of Whistling Swans and Glaucous Gulls had decreased sharply; those of Pintail and scaup had also decreased, but to a lesser degree (scaup were still the commonest water birds on this section). Large increases occurred in the numbers of White-winged Scoters, and lesser increases occurred in the numbers of Arctic Terns and White-fronted Geese. The first Arctic Loons in this section were seen during the June 20 survey.

Few broods were recorded in the delta lowland section on the July 31 survey. Unusually high water levels in the delta lowlands during June may have delayed nesting so that eggs had not hatched at the time of the survey and broods were not evident (W.R. Koski, pers. comm.). In support of this premise, Koski sighted several broods of ducks along the western part of the delta lowlands section during the August 30 survey, but his data for this section were not recorded due to a tape recorder malfunction. These broods were not included in the results because of the incomplete nature of the data.

On June 20 the geese along the delta lowland section were recorded as pairs or as single birds; these were probably breeding birds. Slaney (1974) indicated that relatively high breeding densities of White-fronted Geese were found on the eastern edge of the delta lowland section. White-fronted Geese usually finish incubation in early July (Barry, 1967) and it is probable that they had moved to brood-rearing areas by the time of the survey.

The highest density indices of loons and of terns that were recorded on any survey were found in the delta lowland section on the July 31 survey. The density index for swans was also high during this survey. Because of the low productivity of loons and swans in this area, the high density indices of these birds probably resulted from an influx of unsuccessfully-breeding adults or of subadult birds. Slaney (1974) reported concentrations of subadult swans moulting in the Mackenzie Delta,

and Koski (1975b) estimated that 76% of adult Whistling Swans in the outer Mackenzie Delta in 1975 were non-breeding or unsuccessfully-breeding birds.

The high density indices of terns indicate the importance of the delta lowland section to these birds. Campbell and Weber (1973) found their highest densities of terns in the treed portion of the delta. They found a mean density of 3.1 terns/sq mi there, somewhat lower than the density of 5.0 terns/sq mi recorded along the cross delta route on July 31.

The August 30 survey showed that water birds in the delta lowlands had increased in numbers from the previous three surveys. Sandhill Cranes, dark geese, and dabbling ducks had especially high densities--the highest densities recorded for these groups during the study. Three additional flocks of geese were recorded along this section but outside the aerial transect strip.

The large increase in the numbers of dabbling ducks in this area was caused by an increase in the numbers of American Wigeon. The increase in the numbers of Sandhill Cranes occurred to the west of Shallow Bay, within the area where Campbell and Weber (1973) observed a tenfold increase in the density of Sandhill Cranes in early September, 1972.

Late summer staging by large numbers of Black Brant, White-fronted Geese, and Snow Geese in the outer Mackenzie Delta is well known (Godfrey,

1966; Barry, 1967; Campbell and Weber, 1973; Slaney, 1974; Schweinsburg, 1974). Snow Geese had not arrived in the delta from their breeding areas on Banks Island and the Anderson River Delta by August 30, and the dark species of geese were the only geese sighted on the August 30 survey. Koski and Gollop (1974) and Koski (1975a, 1975b) indicated that concentration areas for Snow Geese and White-fronted Geese lie along the cross delta route. In September, 1975, the areas around Shallow Bay were extensively used by these birds (Koski, 1975b).

Based upon the results of the four surveys in 1975, the delta lowland section appears to be the most important section of the cross delta route for water birds. On at least one survey, each major group of water birds attained its highest density index along the delta lowland section. For this reason it is probably important to all water bird populations at some time during the summer season.

Scrub Tundra Section

Numbers of water birds along the scrub tundra section were low on the June 5 survey. Most of the larger lakes had extensive ice cover at this time, and only the smaller ponds were free of ice. At this time Oldsquaws and White-fronted Geese were the two commonest species present. Because most observations of White-fronted Geese were of pairs, densities of this species were probably representative of breeding densities along this section. The Oldsquaws were probably still in migration at this time--they were moving eastward past Komakuk on the Yukon coast on June 5, 1975 (S.R. Johnson, pers. comm.).

The number of Oldsquaws along this section on the June 20 survey was similar to that of the earlier survey, but the number of geese had decreased. Whistling Swans and loons (particularly Arctic Loons) showed the most marked increases on the June 20 survey. Density indices of both are probably representative of breeding densities (observations were mostly of paired or single birds). These density indices, and the number of broods recorded, both indicate the importance of the scrub tundra section to breeding loons and swans. The density index of swans (1.2/sq mi) is similar to the average breeding densities in the northern Mackenzie Delta area (1.2-1.6/sq mi) for the years 1948-1954 (Martel, in prep.). The density index of loons (0.6/sq mi) is similar to that reported by Campbell and Weber (1973) (0.5/sq mi) in their study area at Kittigazuit Bay.

The July 31 survey indicated the importance of the scrub tundra section for the production of young ducks. Many of the broods of ducks could not be identified; of those that could be identified, Oldsquaws were the most numerous, followed by scoters and scaup.

Swans were present in the scrub tundra section on the July 31 survey in numbers similar to those of the June 20 survey. Arctic Loons, Pintails, scoters, and Arctic Terns showed the greatest increases in abundance. The Pintails were adult birds which were present in flocks, probably in the process of moulting. The density index of Arctic Loons (for both this section and the delta lowland section)(2.1/sq mi) was approximately twice the maximum density recorded by Campbell and Weber (1973). This

high density probably results from the appearance of adult birds with their young on the bodies of water; in June many of these adults would have been on nests where they could not readily be detected from the air.

Numbers of loons along the scrub tundra section were still high on the August 30 survey (unlike the delta lowlands, where the numbers decreased sharply). Numbers of swans also remained high, but Pintails and Oldsquaws showed marked decreases, presumably a result of southward migration by Pintails and a westward movement by Oldsquaws along the Beaufort Sea coast. Numbers of American Wigeon and scaup increased markedly, although American Wigeons were found at a much higher density in the delta lowland section and scaup were found at a much higher density in the coniferous scrub section.

Results of the four surveys indicate that the scrub tundra section is important as a nesting area for Arctic Loons, Whistling Swans, White-fronted Geese and some species of diving ducks. This section is also important during late summer for Arctic Loons, Whistling Swans, and some duck species. However, the importance of this area to the various water birds is often intermediate between that of the delta lowlands section and that of the coniferous scrub section.

Coniferous Scrub Section

During the June 5 survey, diving ducks were relatively numerous along the coniferous scrub section. The most numerous diving ducks were scaup and scoters. The coniferous scrub and delta lowland sections,

which are the first sections to open in the spring, appear to be the most important sections of the cross delta route for diving ducks arriving in the vicinity of the Mackenzie Delta. Arctic Terns appeared to be in migration through the coniferous scrub section at this time.

Overall numbers of water birds had decreased by the June 20 survey because of a decrease in the numbers of scoters, scaup, and terns. Dabbling ducks (Mallards and Pintails) showed an increase in numbers at this time. Although their numbers were not large, their occurrence as pairs or single birds indicated that these birds probably nested along this section.

The number of broods recorded along the coniferous scrub section on the July 31 survey indicates the importance of this section as a nesting and brood-rearing area. Broods of diving ducks, particularly scaup, were the most numerous, but broods of dabbling ducks and Arctic Loons were also present. Numbers of adult or subadult Whistling Swans, Arctic Loons, and Arctic Terns in the coniferous scrub section showed a marked increase at this time.

Results of the August 30 survey showed a further large increase in the numbers of scaup in the coniferous scrub section, and hence in the total numbers of water birds present. This increase was caused by the sighting of a large flock of 700 scaup on an unnamed lake northwest of Travaillant Lake.

Numbers of loons also increased at this time. A simultaneous decrease in loons in the delta lowlands was noted, suggesting a net movement south. Salter (1974b) also reported a southerly autumn movement of loons in the Mackenzie Valley. A westward movement by loons along the Beaufort Sea coast also occurs (Gollop and Davis, 1974).

The coniferous scrub section is important primarily to diving ducks (particularly scaup). It is of particular importance during the periods of brood-rearing and moulting and of fall staging and migration, when the densities of scaup along this section were the greatest that were recorded for any species during this study.

Comparison of Cross Delta and Circum-Delta Routes

In 1973 Salter (1974a) conducted three aerial surveys along those parts of the circum-delta route that run from Fort McPherson to Thunder River and from Taglu Field on Richards Island to the junction of the Richards Island and Prudhoe Bay supply lines. These surveys covered that part of the circum-delta route that contains water bird habitat. It is thus possible to compare the water bird populations along the cross delta and circum-delta routes.

In comparing the two routes there are two possible sources of error for which corrections could not be made. It has been assumed that the abilities of the different observers were comparable and that the detectabilities of water birds in different areas were the same. In fact,

however, the detectability of water birds in the delta lowlands is probably lower than other areas because of the large amount of emergent vegetation present (W.R. Koski, pers. comm.). The magnitudes of possible errors due to these assumptions are unknown.

Differences Between Years

Before the results from surveys of the two routes can be compared, annual variations in water bird numbers must be considered. The numbers of water birds, particularly ducks, in northern areas are known to fluctuate considerably from year to year (Hansen and McKnight, 1964). This fluctuation is to some extent correlated with drought conditions on the prairies. Martel (in prep.) supports this correlation with data from the Mackenzie Delta region.

The only data which are directly comparable between years are those of the USFWS, which conducted aerial surveys during early June of both 1973 and 1975 over the same series of transects in the Mackenzie Delta (Voelzer and Jensen, 1973, 1975). In 1973 they recorded density indices of 4.2 dabbling ducks/sq mi and 9.2 diving ducks/sq mi. In 1975 their density indices were 1.9 dabbling ducks/sq mi and 7.4 diving ducks/sq mi. The ratios of the numbers of birds recorded in 1975 to the numbers recorded in 1973 were thus 0.44 for dabbling ducks and 0.80 for diving ducks.

The USFWS data show that there were greater numbers of ducks present in their study area in early June of 1973 than there were in early June of

1975. If it is assumed that these ratios can be applied to the overall region for the early June period, then the 1973 data obtained by Salter for the circum-delta route can be multiplied by the above-mentioned ratios to correct for the differences in years. The assumption that ratios from the Mackenzie Delta can be applied to neighbouring areas may be invalid; it has been employed, nevertheless, because these ratios are the only directly comparable data that are available from this area for the two years.

Table 7 lists the density indices for ducks in early June along both routes and the results after corrections have been made for the differences between years. (The scrub tundra section for the circum-delta route is considered to be that portion of the Richards Island supply line that runs from Taglu Field to the south end of Sitidgi Lake. The coniferous scrub section of the route is considered to be the portion that runs from Fort McPherson to Thunder River and the portion that runs from the south end of Sitidgi Lake to a junction with the Fort McPherson-Thunder River section.) When the 1973 data have been corrected for differences between years, the results indicate that in early June the cross delta route supported slightly higher densities of ducks along the scrub tundra and the coniferous scrub sections than did the circum-delta route.

The assumption that the ratios of USFWS results for the Mackenzie Delta can be applied to areas near the delta has been made only for the numbers of ducks recorded on the early June surveys; comparable data for the overall numbers of water birds and for the later survey times are both

TABLE 7. Density Indices of Ducks in Early June on Sections of the Circum-Delta and Cross Delta Routes.

	DENSITY INDEX (DUCKS/SQ MI)		
	CIRCUM-DELTA		CROSS DELTA
	1973†	1973 DATA CONVERTED TO 1975 VALUES††	1975
SCRUB TUNDRA			
Dabbling ducks	0.7	0.3	0.6
Diving ducks	3.7	3.0	3.6
CONIFEROUS SCRUB			
Dabbling ducks	0.7	0.3	0.8
Diving ducks	11.4	9.1	11.3

† From Salter (1974a).

†† 1973 results have been converted by multiplying them by the ratio of ducks recorded in 1975 to those in 1973 by USFWS for identical transects in the Mackenzie Delta.

lacking. However, the larger number of ducks recorded in the delta in early June of 1973 suggests that the numbers of ducks (and presumably of total water birds) were larger in the vicinity of the delta throughout the summer of 1973 than they were in 1975. The presumed higher densities during 1973 should be borne in mind when comparing data which could not be corrected for differences between years in the numbers of birds present.

Differences Between Routes

Table 8 lists the density indices of the major water bird groups that were recorded on surveys of the cross delta and circum-delta routes during three time periods: early June, mid- to late June, and early August. Results are presented for the scrub tundra and coniferous scrub sections--the only sections of the two routes which are directly comparable. Results have not been corrected for the known differences between years.

On the scrub tundra section, results from the two routes were similar for the early June surveys. However, for the mid- to late June surveys and the early August surveys, the density indices for the cross delta route were considerably higher than for the circum-delta route. The groups which contributed most to this difference were ducks and swans during both periods and loons during early August.

For the coniferous scrub section, density indices were similar on both routes for the two June survey periods. In early August, however,

TABLE 8. Density Indices* of Water Birds on Sections of the Circum-Delta Route During 1973† and the Cross Delta Route during 1975.

	JUNE 1-5		JUNE 20-JULY 2		JULY 31-AUGUST 2	
	CROSS DELTA 1975	CIRCUM-DELTA 1973	CROSS DELTA 1975	CIRCUM-DELTA 1973	CROSS DELTA 1975	CIRCUM-DELTA 1973
SCRUB TUNDRA SECTION						
Loons	-	0.1	0.6	0.5	2.5	0.3
Swans	0.1	0.1	1.2	0.5	1.4	0.3
Geese	1.0	0.6	0.4	-	-	0.4
Dabbling ducks	0.6	0.7	0.7	-	1.6	-
Diving ducks	3.6	3.7	5.2	1.6	5.9	1.5
Total ducks	4.4	4.5	6.1	1.9	13.0	6.2
Cranes	0.1	-	-	-	0.2	-
Gulls	0.0**	0.1	0.1	0.1	0.1	0.1
Terns	0.2	0.1	0.2	0.1	1.0	0.4
Total water birds	5.8	5.5	8.9	3.1	19.0	7.7
CONIFEROUS SCRUB SECTION						
Loons	0.2	1.0	0.4	1.1	1.5	1.3
Swans	0.1	0.2	0.2	0.2	0.8	0.4
Geese	-	-	-	-	-	-
Dabbling ducks	0.8	0.7	1.5	0.3	1.7	0.4
Diving ducks	11.3	11.4	6.3	7.6	16.4	2.8
Total ducks	12.6	13.6	7.9	9.6	20.0	7.2
Cranes	-	-	-	-	-	-
Gulls	0.2	0.9	0.0	0.3	-	0.5
Terns	0.8	0.1	0.2	0.0	1.1	-
Total water birds	13.9	15.9	8.8	11.3	23.8	10.5

* Density indices are in units of birds per square mile.

† From Salter (1974a).

** Less than 0.05.

the density index of water birds for the cross delta route was twice as large as that of the circum-delta route. The major component of this increase was the large increase in the number of diving ducks present along the cross delta route in early August--a time when the numbers of diving ducks decreased along the circum-delta route.

Results of aerial surveys along a proposed pipeline route are greatly affected by local concentrations within the 1/4 mi corridor that is surveyed. Minor route changes to avoid concentration areas could thus have a great effect on the density of water birds along the pipeline route. A notable example is a small unnamed lake northwest of Travaillant Lake on the cross delta route which was heavily utilized by diving ducks at the times of the July and August surveys. Avoidance of this lake by the cross delta route would probably lessen the importance to water birds of the coniferous scrub section of the cross delta route in comparison to the coniferous scrub section of the circum-delta route. (Repeated heavy usage of this lake by diving ducks in future years should first be confirmed.)

For the two sections of the two routes which are directly comparable, the cross delta route supports similar or greater numbers of water birds (according to season) than does the circum-delta route. The cross delta route also contains the delta lowlands section--an area that is important to water birds. Although the circum-delta route also contains a section to the west of the Mackenzie Delta, this section is well-drained with few lakes and contains little favourable water bird habitat (Poston *et al.*, 1973).

In order to compare the numbers of birds present along the two routes, the uncorrected density indices for each section have been averaged over the three time periods and multiplied by the number of miles of proposed pipeline in each section of the two routes (as given in Tull [1975]). This calculation indicates that 1.6 water birds were present along the cross delta route for every water bird present along the circum-delta route. There are two sources of bias in the above result which must be borne in mind--the data have not been corrected for the differences in numbers of water birds during the two years when the surveys were conducted (a bias that apparently tends to inflate the total numbers of birds along the circum-delta route in comparison with the cross delta route) and the section of the circum-delta route from Fort McPherson to the Yukon North Slope has been omitted from the overall results (a bias that tends to deflate the total numbers of birds along the circum-delta route in comparison with the cross delta route). (Water birds on the Yukon North Slope have been omitted from the calculations for both routes.) Of the two biases, the lack of a correction for the differences between years is probably the more important; this suggests that the calculated ratio of 1.6:1 is probably lower than actual ratio.

The results suggest that there are more water birds present along the cross delta route than are present along the circum-delta route during the period from early June to early August. The large numbers of geese that are known to stage in the outer Mackenzie Delta during August

and September (Koski, 1975b) have not been considered in reaching this conclusion. These numbers of geese further emphasize the importance of the cross delta route to water birds.

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APPENDICES

APPENDIX 1. Numbers and Densities of Birds Recorded on Each 10-Mile Transect During Aerial Surveys of the Cross Delta Pipeline Route, 1975.

This appendix consists of a computer printout which is stored in the library of the Edmonton branch office of LGL Limited. This appendix is available upon request.

APPENDIX 2. Scientific Names of Birds Identified During the 1975 Study.

Common Loon	*Gavia immer*
Arctic Loon	*Gavia arctica*
Red-throated Loon	*Gavia stellata*
Whistling Swan	*Olor columbianus*
Canada Goose	*Branta canadensis*
Black Brant	*Branta nigricans*
White-fronted Goose	*Anser albifrons*
Mallard	*Anas platyrhynchos*
Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
American Wigeon	*Anas americana*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Common Goldeneye	*Bucephala clangula*
Oldsquaw	*Clangula hyemalis*
Common Eider	*Somateria mollissima*
King Eider	*Somateria spectabilis*
White-winged Scoter	*Melanitta deglandi*
Surf Scoter	*Melanitta perspicillata*
Black Scoter	*Melanitta nigra*
Red-breasted Merganser	*Mergus serrator*
Rough-legged Hawk	*Buteo lagopus*
Bald Eagle	*Haliaeetus leucocephalus*
Marsh Hawk	*Circus cyaneus*
Gyrfalcon	*Falco rusticolus*
Willow Ptarmigan	*Lagopus lagopus*
Rock Ptarmigan	*Lagopus mutus*
Sandhill Crane	*Grus canadensis*
Pomarine Jaeger	*Stercorarius pomarinus*
Parasitic Jaeger	*Stercorarius parasiticus*
Long-tailed Jaeger	*Stercorarius longicaudus*
Glaucous Gull	*Larus hyperboreus*
Mew Gull	*Larus canus*
Bonaparte's Gull	*Larus philadelphia*
Arctic Tern	*Sterna paradisaea*
Short-eared Owl	*Asio flammeus*
Common Raven	*Corvus corax*