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Progress Notes contain *interim* data and conclusions and are presented as a service to other wildlife biologists and agencies.

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Wildlife response to oil well drilling

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Abstract

The effect of oil drilling on wildlife in the vicinity of the Taglu G-33 site in the Mackenzie River delta was studied during June, July and August 1971. Aerial surveys of wildlife populations within 30 km of the rig site were made and some results compared with those from species surveyed the year before. Numbers and species of birds found in eight selected plots within 2.5 km of the Taglu site and in eight plots of comparable habitat in a control area of similar size 8 km distant were compared. Observations of drilling activities at the rig and of re-supply operations were made in an attempt to isolate disturbing influences.

Of the more abundant bird species, 43% were found to be noticeably less numerous than normal within 2.5 km of the rig during the summer drilling operations, 52% were not affected and 5% (two species) occurred more abundantly. Geese and swans, when moulting, or when in family-group flocks with downy young, moved or stayed more than 2.5 km from the drill rig. Other species apparently became accustomed to activity associated with the rig. Helicopters at low levels were apparently the most disturbing factor, directly affecting a circle of at least 2.5 km radius. Increased predation on nests from which birds were disturbed was an indirect result of their use. The Taglu site was comparatively tidy. Wildlife, such as grizzly bears, was not a problem in drilling activities.

Résumé

L'incidence du forage pétrolier sur la faune sauvage dans les parages du lieu de forage dit Taglu G-33, dans la région du delta du fleuve Mackenzie, a fait l'objet d'une étude en juin, juillet et août 1971. On a effectué des relevés aériens des populations d'animaux sauvages dans un rayon de 30 km du derrick pour en comparer les résultats à ceux qu'on avait obtenus l'année précédentes au sujet d'espèces qui avaient alors fait l'objet d'un relevé. Comparaison s'est faite, quant aux effectifs et espèces d'oiseaux présents, de huit parcelles de terrain choisies dans un rayon de 2.5 km de la tour de forage de Taglu à huit parcelles-témoins constituant un habitat comparable et situées dans une aire de semblables dimensions à 8 km des premières. L'observation s'est faite des travaux de forage et de l'exécution du ravitaillement afin d'isoler, en autant que faire se pouvait, tout facteur de perturbation.

Des espèces d'oiseaux les plus répandues, on en a trouvé 4.3% à présenter un effectif inférieur à la normale dans un rayon de 2.5 km du lieu de forage pendant l'exécution estivale de celui-ci, 52% à n'en pas sembler affectées et 5% (deux espèces) à compter là davantage de sujets. Oies et cygnes évitaient de s'approcher à moins de 2.5 km du lieu de forage lors de leur mue ou quand ils évoluaient en volées familiales assorties de petits duveteux. D'autres espèces ont paru s'accoutumer à l'activité fonction du forage. L'emploi d'hélicoptères à basse altitude semble avoir été le facteur le plus perturbant, tant directement en affectant un cercle de 2.5 km de rayon, qu'indirectement par l'accroissement de l'activité des prédateurs à l'encontre des nids dont les oiseaux étaient perturbés. Le lieu de forage de Taglu était relativement bien tenu et les animaux sauvages, tels que l'ours grizzli, n'ont en rien nui aux travaux de forage.

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Introduction

Oil exploration in the North American Arctic has prompted concern for Arctic ecosystems. Some people fear that wildlife is facing a serious threat to its existence; others are concerned that exploration and drilling will be curtailed needlessly during nesting and other critical periods for birds and animals. There has been little research either to support or to relieve these fears. Imperial Oil Limited, intending to continue a drilling program into the summer season of 1971, proposed and helped a study from June to August 1971 at their drilling site in the Mackenzie Delta. The study was to investigate effects on wildlife from the noise and activities associated with oil well drilling.

Imperial Oil's rig was at a site called Taglu G-33 on Fish Island, 69°22′N, 134°54′W (Fig. 1) on the south side of a delta channel marking the southeast boundary of the CWS's Kendall Island Migratory Bird Sanctuary (Fig. 2).

The drilling site

The drilling site on Fish Island was 9.6 km from the sea (Fig. 2) and about 1.5 m above normal tide and river levels. In February and March 1971, gravel was hauled 27 miles over ice roads from an esker at Ya Ya lakes near Tununuk at the south end of Richards Island to build a gravel pad 250 m long, 18 m wide and 1.5 m high. The pad served as a barrier against possible storm tides and as protection for the permafrost during drilling (Oilweek 1971). A roadway of fibreglass "mo-mat" and 3-in. (65 mm) planking ran most of the length of the pad.

The pad was used to store supplies, to connect the rig with the camp and the river, and to land helicopters. One of the main features of the drill site was the 43-m high drilling rig on pilings at the west edge of the pad, with geologists' shacks, diesel engines and stores of drill stem, casings and drilling mud arranged around it on their gravel pads or pilings.

The gravel pad extended north to a barge, filled with gravel, in the channel which served as an off-loading ramp for supply barges and as a float plane dock. The total area of river levee and tundra occupied by the rig and its on-site supply systems was about 8 ha.

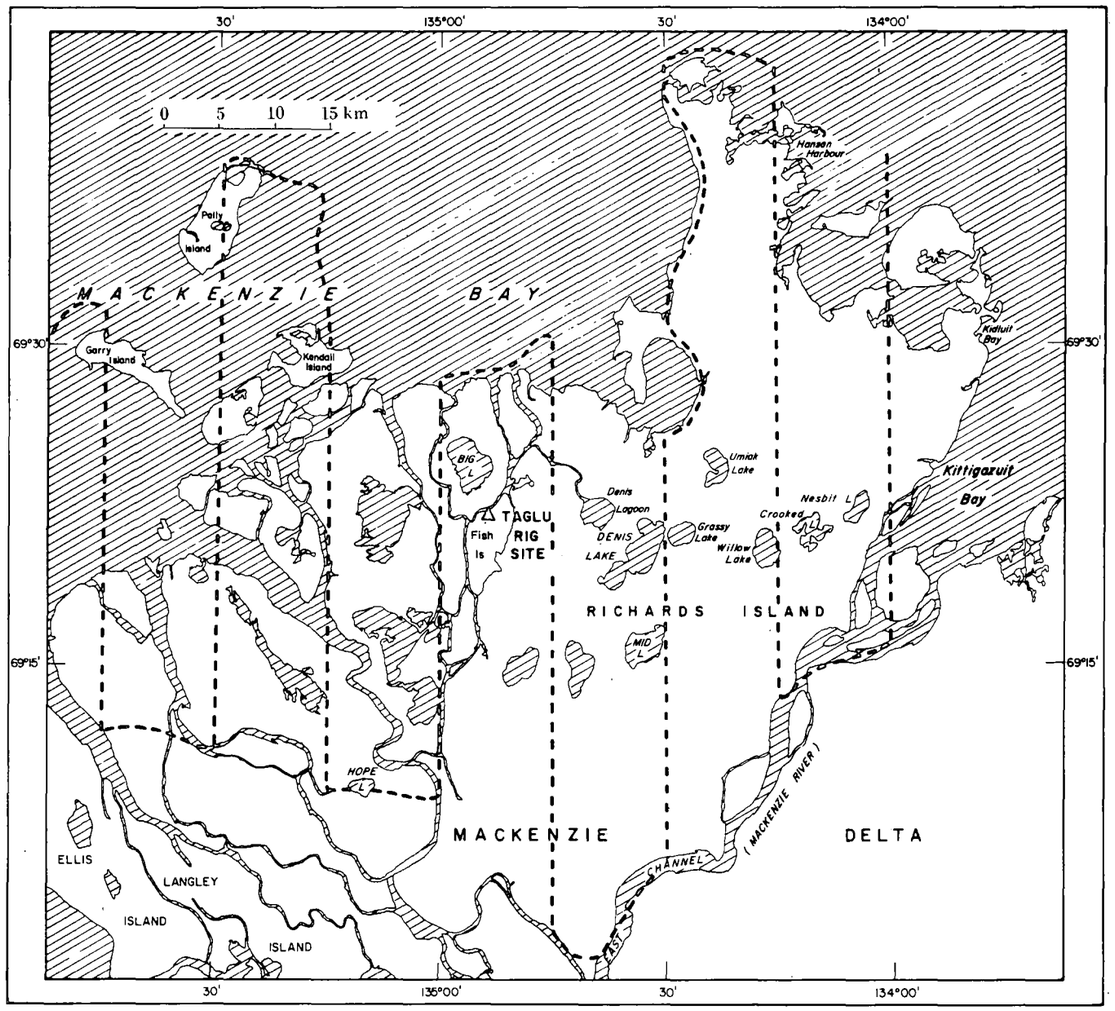

Figure 1
Rig site location and survey route

followed when wildlife population measurements were taken in the rig area.

To summarize, the Taglu G-33 rig site, when approached by aircraft, appears as a small spot of activity on the expanse of tundra. Quantitative measures of the noise levels and other variables of rig activity were not possible in this study; however, the qualitative observations made there can be related to wildlife population estimates.

Methods

A survey flight to sample bird and mammal populations in an area of 3000 km^2 around the rig site was made on 5 July with a STOL-equipped Cessna 185. The aircraft was flown 23 m above ground on transects spaced 9.6 km apart (Fig. 1). Along these routes, species found within 320 m of each side of the plane were recorded. An extrapolation factor of 23 (a ratio of the area observed on transects to the total area of habitat around the rig site) was used to obtain population estimates, except as noted in Table 1. These estimates were affected by visibility problems such as fog and secretiveness of moulting ducks. Open water areas were disregarded in extrapolating except for marine species.

The transects of the aerial survey were comparable to those in surveys conducted in 1970 by the senior author, which coincidentally radiated about 16 km from Taglu G-33, but were restricted to Snow Geese, White-fronted Geese, Canada Geese and swans.

To measure in detail the effect of a drilling rig on wildlife during the summer period, a study area of 2.4 km radius, centred at the rig site, was compared with a control area of similar size approximately 8 km northeast of the rig (Fig. 2) and partially sheltered behind some hills. Eight study plots, each 200 x 200 m, were marked out with fluorescent orange stakes in each corner. These plots were as similar as possible in terrain and botanical composition, and they represented such nesting habitats as sedge meadow, willow tundra, heaths, and bogs or marshes, although each plot did not include all habitats.

Although there was continuous daylight throughout the study period, observations were made between 0800 and 1800 hours at each plot for 1.5 hours. Six transects, north–south alternating with east–west, were walked every 3 days to count both bird species and numbers. Nests were marked and clutch sizes were recorded. Each nest was checked for changes in status during successive visits.

To discover how different modes of transportation affect wildlife, tests were made with a helicopter, fixed-wing aircraft, and boats. The helicopter was a large turbine-powered type; the fixed-wing, a single in-line piston engine type. These aircraft were flown at 90 m over nesting grounds and over the concentrations of Snow Geese and White-fronted Geese and swans. All distances observed on these flights were estimated visually. We also recorded wildlife response to an 8-hour tug boat trip and to our daily trips along channel routes to the study plots in a 16-ft aluminum boat powered by a 20 h.p. motor.

An Esterline-Angus activity recorder, connected to microswitches in nests, was used in an attempt to record incubation activity of birds nesting near the rig in relation to the arrival and departure of the helicopter, but data collected were inadequate for analysis. Casual daily observations of about 0.5-hour duration were made in an area of approximately 800 m radius from the rig site to gain an impression of the change in response of various species to rig activities.

Movement patterns of Canada Geese, White-fronted Geese, Snow Geese and swans around the rig and control areas were observed after the young had hatched and when the adults were in moult, 6 July to 8 August. During this period, 2 hours each day were spent on high ground and pingos, scanning by telescope to record positions of these birds on maps (Figs. 3–6). During the same period, each of four routes along connecting water bodies were travelled by boat every 4 days, each journey taking 6 hours. The positions of flocks seen during these trips were marked on the same maps.

Observations and results

Table 7 gives estimates of bird and mammal populations in the vicinity of Taglu G-33 rig from aerial surveys (see Fig. 1). Only the larger species could be identified from the aircraft. Population estimates of the four species of birds surveyed in 1970 as well as in 1971 are compared below:

	1970	1971
Whistling Swan	1300	1500
Canada Goose	225	250
White-fronted Goose	2300	475
Snow Goose	7000	6800

In rig area study plots, 20 bird species were found either nesting or presumed to be nesting on account of their behaviour (Table 2). There were 41 nests. Seventeen species were nesting in the study plots of the control area, but there were 56 nests. The hatching success of nests found in the control area was greater than that of nests in the rig area (Table 3).

Table 1 is not intended to be a complete list of the birds of the area. Several additional species were seen, but not in the study plots. Porsild (1943) gives a more complete list of the birds of the Mackenzie Delta, but he did not spend much time on the outer delta, with the result that some species, *e.g.* Hudsonian Godwit, uncommon at any time, are on our list and not on his.

Numbers of birds observed in or flying through the study plots showed that reactions to the drilling rig varied according to species (Table 4). Fifteen species occurred in significantly fewer numbers in the rig study plots than in the control plots. Whistling Swans were disturbed by the rig in all their activities except flight. Two species, Ravens and Whimbrels, were found in the rig area in significantly larger numbers.

Two pairs of Snow Buntings nested among the pallets of drilling supplies on the pad. These birds rarely nest in the Mackenzie Delta region because of their preference for rock piles, for which the pallets apparently provided a suitable substitute. We saw Ravens breaking open plastic bags of the sawdust sometimes used in the drilling process; perhaps they were feeding on insects. Rig personnel have commented that Ravens also break open bags of starch in search of insects,

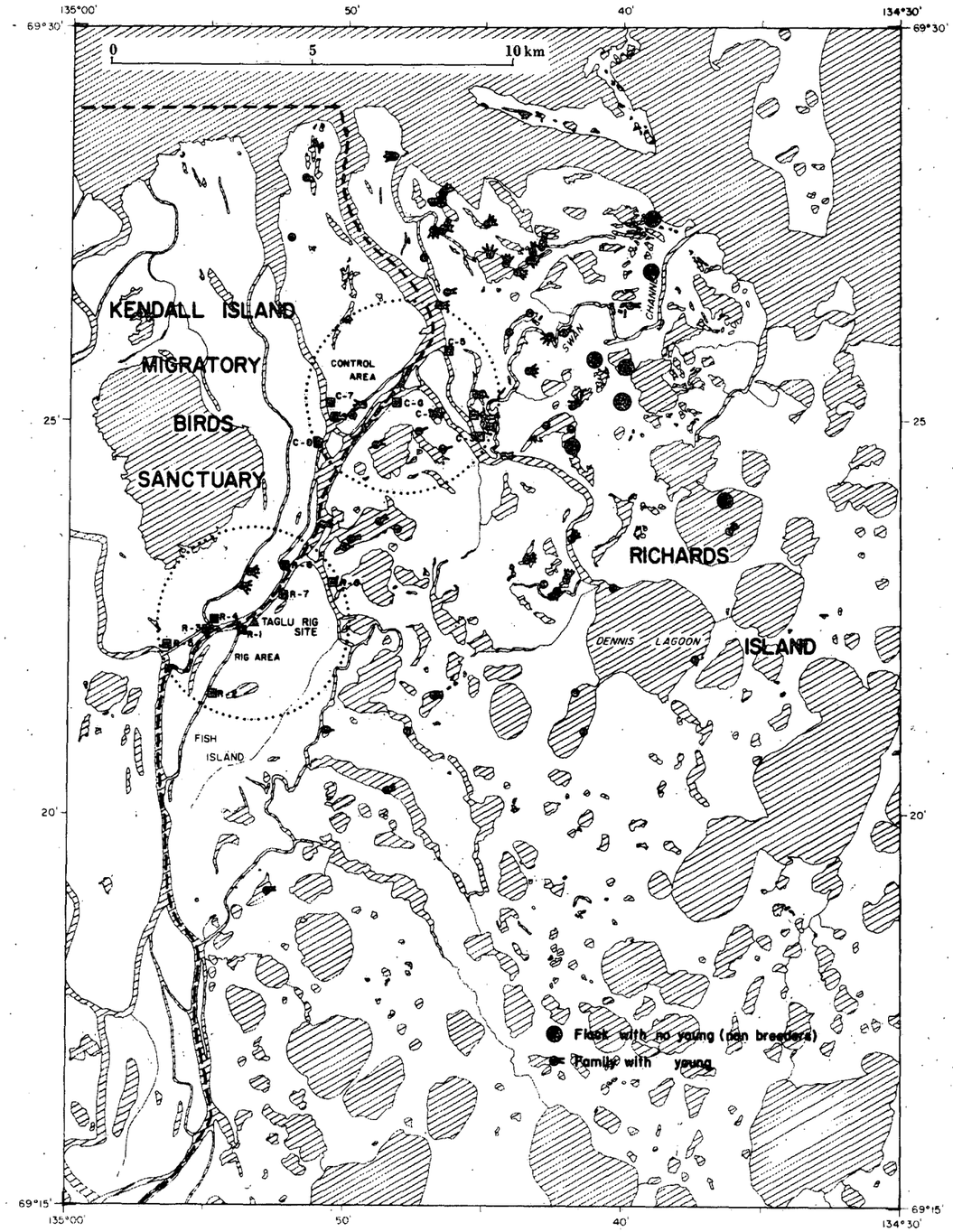

Figure 3
Observations of Whistling Swans, 6 July–7 Aug. 1971

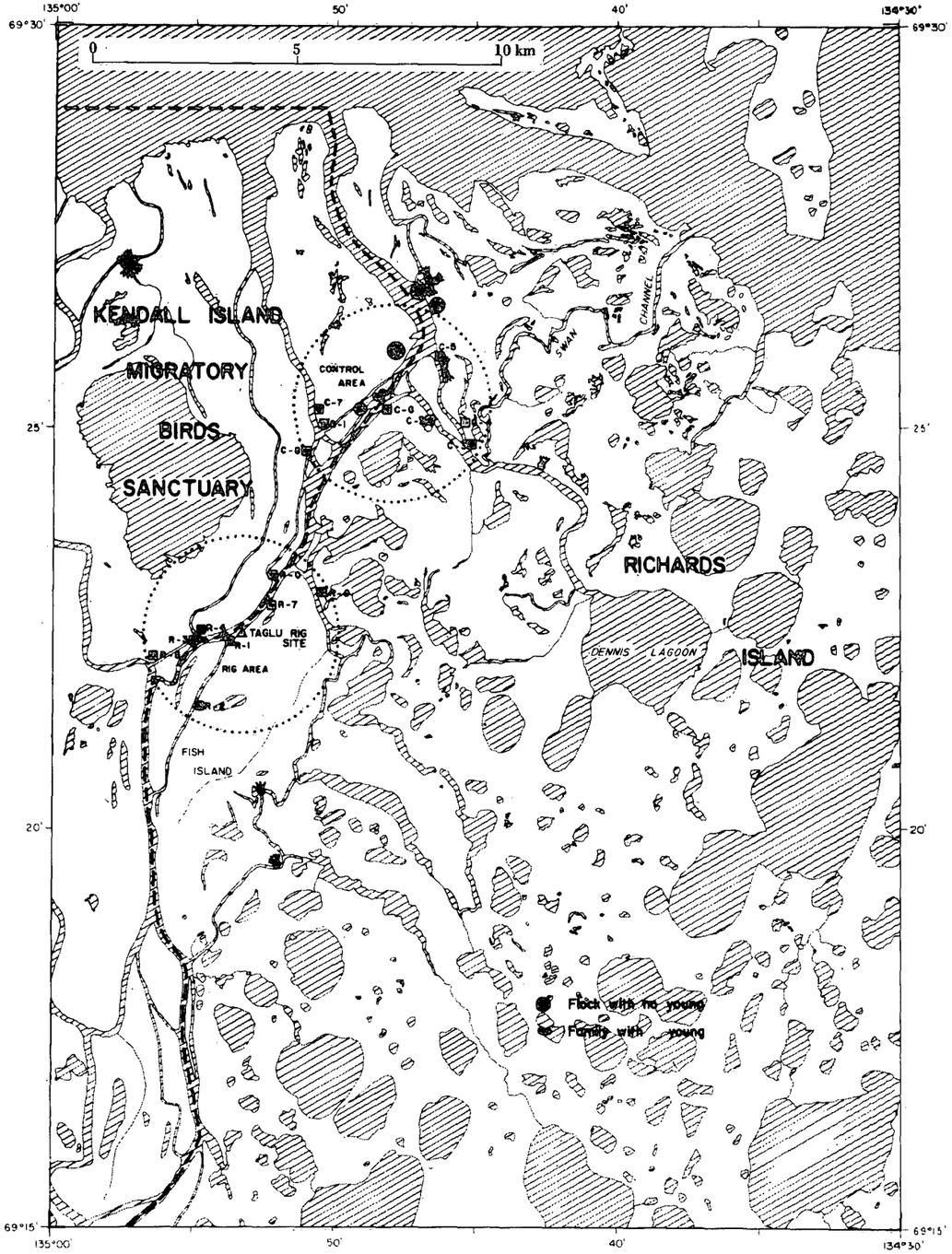

Figure 4
Observations of Canada Geese, 6 July–7 Aug. 1971

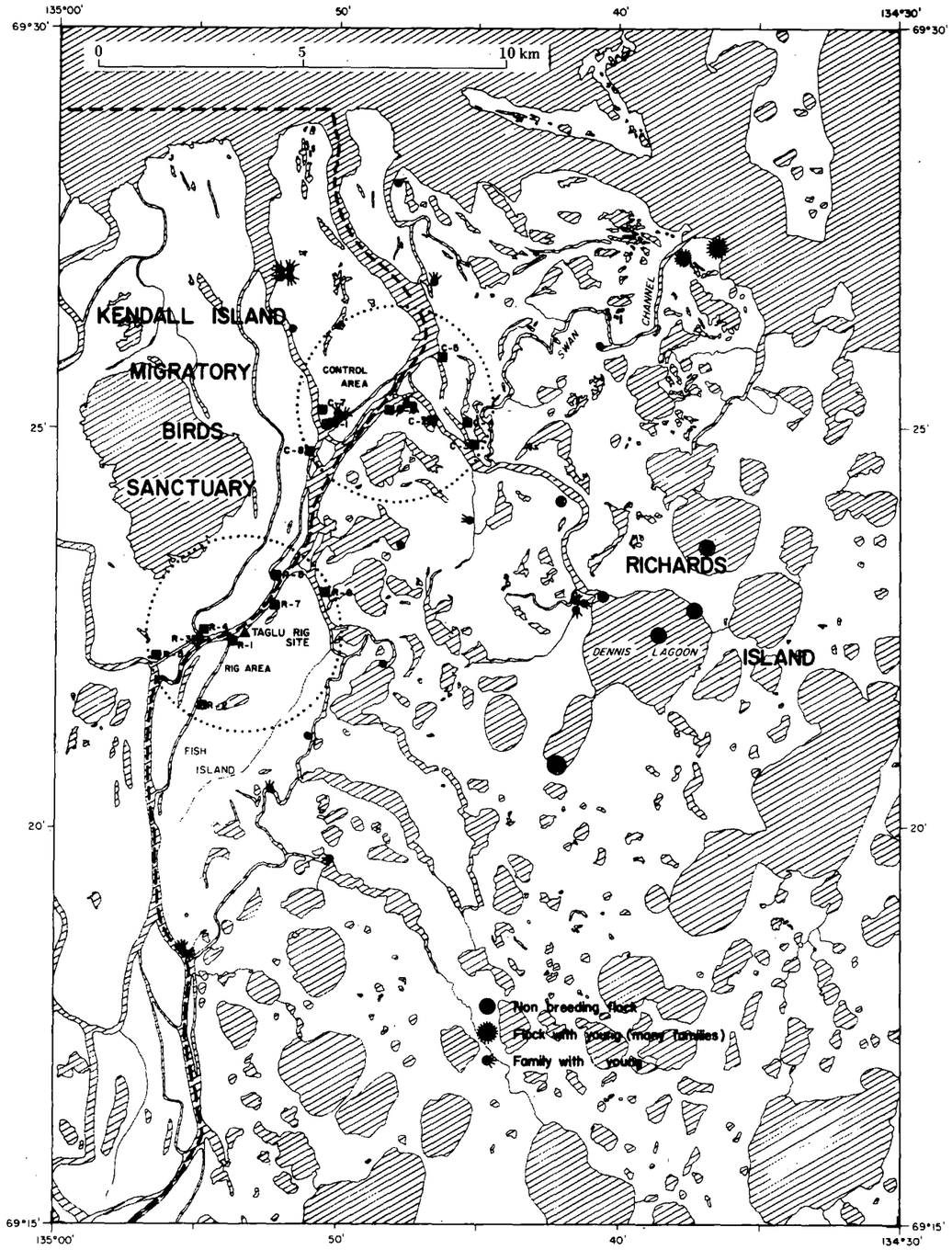

Figure 5
Observations of White-fronted Geese, 6 July–7 Aug. 1971

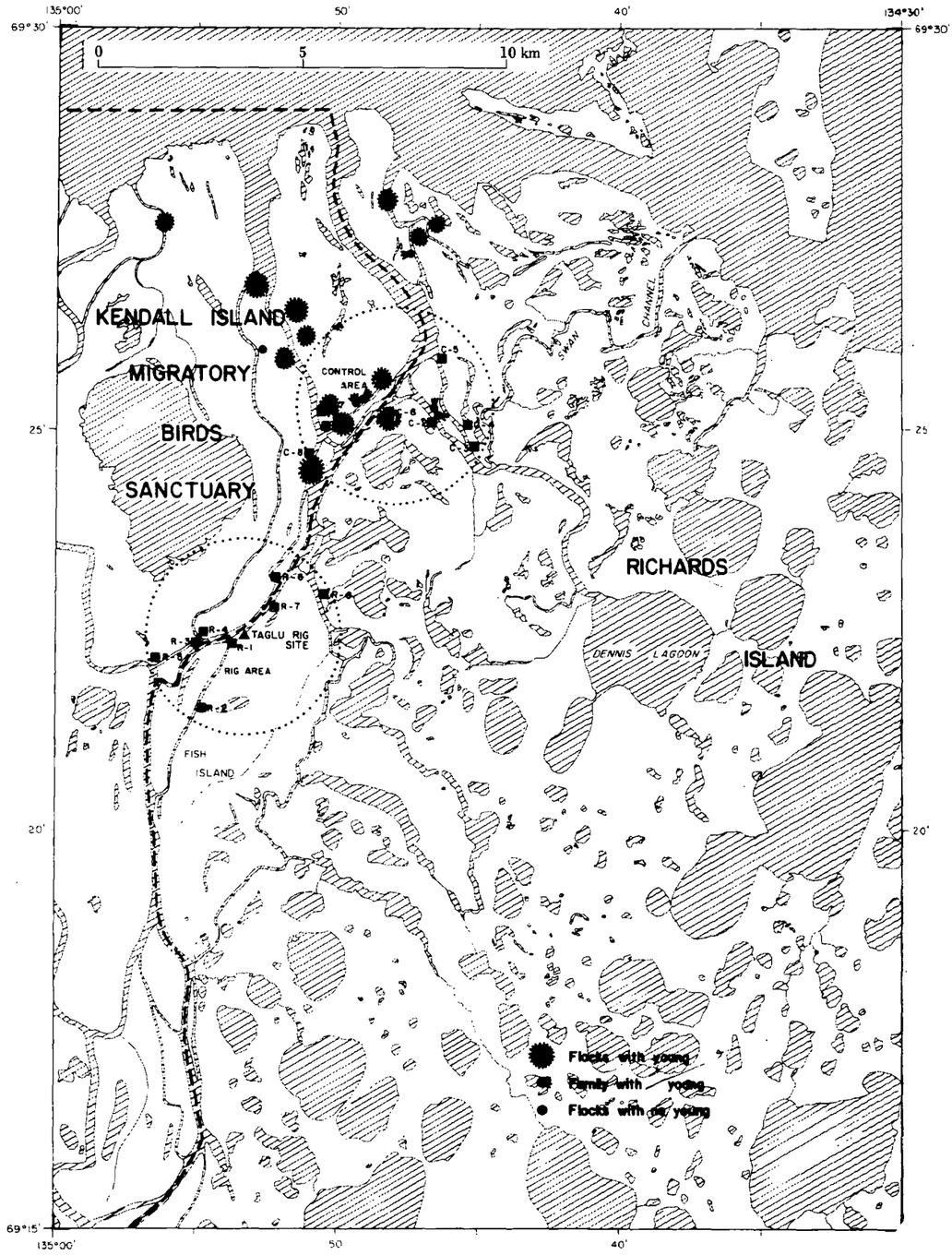

Figure 6
Observations of Snow Geese, 6 July–7 Aug. 1971

and commonly investigate almost anything kept under tarpaulins or in cardboard boxes.

Certain species showed signs of adapting to disturbances of rig activities. A ptarmigan roosted on one of the cross-bars of the drilling derrick. Sandhill Cranes, swans and gulls frequently fed within 800 m of the rig site and approached closer as the study progressed. Sandhill Cranes feeding near the rig rarely flushed when fixed-wing aircraft or helicopters passed over them.

We flew by helicopter from Taglu to Tununuk and back on June 12 and made the following observations: nesting Glaucous Gulls sat tight on their nests as the helicopter passed over at 90 m; three loons dove as the helicopter passed them; one ptarmigan flushed, and one ran away; and a Sandhill Crane and two large shorebirds flushed. The pilot lowered the helicopter to within 20 m of a nesting Whistling Swan and held that position for a few seconds; the swan did not leave the nest until the helicopter slowly moved to 10 m vertical distance, at which point the swan walked about 3 m from the nest and crouched down. When approached by a man on foot, swans usually leave the nest as soon as the intruder is visible, sometimes when he is as far as 1500 m away.

We made other helicopter flights at 90 m, following channels to select barge routes and landing sites. During these flights three flocks of Canada Geese flushed, and Sandhill Cranes leaped off their nests. A flock of about 30 non-breeding swans in a lake sat tight on the water as the helicopter passed over; these birds appeared to be just beginning their moult. We circled down to about 20 m; they continued to sit until we were within 275 m but then swam ashore and started to run. Some tried unsuccessfully to fly away from the helicopter.

At an altitude of about 90 m the helicopter flew over a flock of 20 moulting adult White-fronted Geese with their young. They remained motionless, the flightless adults with heads and tails up in the defensive posture. The helicopter circled down to about 15 m and moved horizontally to within 12 m of the birds. They made no attempt to use their wings to flop along the water as is their habit when flightless.

We found that Snow Geese would leave their nests and fly about 0.8–2.4 km ahead of the helicopter when we were travelling at about 150 km/h at 90 m. The birds began to return to their nests when we were 800 m or more beyond the nest site. Wind direction, as it affected noise, seemed to be a factor in the distance at which the geese left their nests. Resettling on the nests took them up to 45 minutes after our passing, because fights resulted as the disturbed birds crossed the territories of others to regain their own nests. Meanwhile gulls and jaegers took advantage of the geese's absence to prey on the unguarded eggs more heavily than usual. White-fronted Geese are not colonial nesters; they use scrub willow for their nest sites, and so are almost impossible to see from the air. However, a few times we saw one bird of a pair, presumably the male, fly from the vicinity of the nest when the helicopter was overhead.

Non-nesting White-fronted and Snow Geese, generally 1- and 2-year-old birds, frequent the periphery of the nesting areas. They were seen to flush 3 km or more ahead of the helicopter, angling off from our flight path and seldom returning. During the moult the flightless birds run from an approaching boat or low flying aircraft.

The captain of the supply tug told us that swans would usually flush ahead of the boat two or three times in succession before peeling off and landing behind the tug. During our trip on the tug, 27 swans were sighted along the river. Twelve flushed off the river away from the boat; eight flushed ahead of us, peeled off and landed behind the boat, and the rest swam close to shore. Of five moulting swans, all attempted to fly, then two ran ashore and the other three swam off to the side of the river. Of 14 Red-throated and Arctic Loons seen, all flushed ahead of the boat or dove. Sixty White-winged Scoters on a sandbar next to the river all flushed, but two swimming scoters sat as the boat passed. Thirty widgeon and 50 Oldsquaws on a sandbar flushed when the barge approached within 275 m. Two Pintails were swimming in the river; both flushed at the boat's approach. Four Glaucous Gulls and eight Arctic Terns on the shore sat as the boat passed. We disturbed a Sandhill Crane which danced up and down, bouncing about 2 m straight up in the air; but it did not fly when the boat passed. Similar behaviour was observed from the aluminum boat.

A Pintail nest, found on 5 June, and a Whimbrel nest, found on 6 June, were situated about 180 m from the rig pad, directly under the regular path of the helicopter. These nests were robbed by jaegers. Two nearby Pintail nests were discovered on 8 June, one about 70 m off the rig pad and another about 365 m away. These also were under the helicopter's route, and were abandoned before the nest activity recording device could be set up on them. A Shoveler nest about 1.2 km from the rig site was robbed by a fox. A White-fronted Goose nest about 5 km northeast of the rig site and away from the helicopter route was eventually connected to the recording device; a record was made from 15–18 June. We found no significant effects of rig or helicopter activity on the incubation of the goose, and the eggs hatched successfully. These results are not conclusive, but suggest that lower nest success near the rig (shown in Table 3) may have been related to additional disturbance in the rig area, perhaps from helicopters.

The closest that swans nested to the rig was about 1 km away in plot R-4 (Fig. 2), but when the young hatched, the family moved toward the ocean down a back channel away from the rig. Other swans with young concentrated northeast of the rig site, in the control area and up to 6.4 km beyond that (Fig. 3). Generally speaking, there were more swans with young near the rig site than there were geese with young. The large concentrations of moulting, non-breeding swans did not approach closer than 8 km to the rig. In 1968, 1969 and 1970 the non-breeders as well as the adults with young used the area occupied by the rig.

The closest approach to the rig of a family of Canada Geese was 3.7 km (Fig. 4). Large flocks of Canada Geese came no closer than 8 km. Only a single flock of Brant was seen in the area in 1971. They remained about 13 km from the rig, probably because of their habitat preference. The closest approach of White-fronted Goose families to the rig site was about 2.8 km, these being two pairs of adult birds with eight young. Another family was found 3.7 km from the rig site (Fig. 5). Snow Geese stayed in large flocks with their young (Fig. 6), and 4.2 km was the closest that any of them approached the rig.

Movements of moulting, non-breeding White-fronted Geese followed a clear pattern. They moved out of the south end of the lake connected to Dennis Lagoon into the lagoon, then north down the channels. Adult White-fronted Geese with young were widely dispersed and stayed in small flocks composed of family groups. Snow Geese moved eastward from their nesting grounds just south of Kendall Island in 1968, 1969 and 1970, but in 1971 they avoided the rig area (Fig. 6).

When approached by a boat, White-fronted Geese in the water attempted to run ashore where family groups would split up, with goslings running in every direction. Snow Geese, on the other hand, would stay close together in tight flocks. When swans were approached by boat the adults would fly or swim off (the moult of parent swans not being completely synchronized) while the young climbed ashore and huddled together, where, with no adult birds to protect them, they were vulnerable to predation by foxes.

Using the top of the geologist's shack as a viewpoint during the drill stem tests, we observed further evidence of adjustment to drilling activities. During the first test, Glaucous Gulls nesting 1.2 km southeast of the plot stayed on their nests. One jaeger crossed over the tundra south of the rig site. A swan nesting about 1.6 km to the east of the rig site stayed on its nest and another fed nearby. A pair of White-fronted Geese landed next to the lake, 0.8 km northeast of the rig, and began to feed. During the second test a pair of swans dabbled unperturbed in the river across the channel. Sandhill Cranes feeding within 1.6 km of the rig looked up, but resumed feeding. A pair of loons continued to swim in a small lake 0.8 km northeast of the rig. Nesting Glaucous Gulls to the southeast of the rig seemed undisturbed, and a pair of swans continued feeding on the shore of Big Lake northwest of the rig site.

We observed little immediate reaction to the shock of velocity surveys. The only birds visible during the test were two pairs of swans within 1.6 km of the rig and two Sandhill Cranes within 0.8 km. None of these birds changed its movements after the first blast.

Observations of mammals (Fig. 7) indicated no significant reaction to the rig. In fact, a barren-ground grizzly bear spent 5 days ranging 90–1200 m from the rig. The bear fed on roots he dug along a channel levee and ran only when the helicopter passed overhead.

Discussion and conclusions

Results of the aerial survey of the outer part of the Mackenzie Delta indicate that this region supports and provides habitat for considerable numbers and variety of wildlife species. About 85% of the species are in the region for the summer months, but for many this short period includes the critical events of reproduction and rearing of young.

Statistical analyses of data collected on the study plots, and qualitative data obtained indicate that only 43% of the wildlife appears affected by human activities associated with well-drilling. Moulting flocks and family groups of Whistling Swans, White-fronted Geese, Canada Geese and Snow Geese avoided the rig area in 1971 more consistently than other species. White-fronted Geese could not be accounted for in the numbers of prior years. Pintails, Green-winged Teal and Scaup were affected by the Taglu operation. Ravens, as expected, were attracted to the rig area. Whimbrels occurred more frequently in the rig plots than in the control plots perhaps because the rig site was a traditional nesting area before the rig was established. The 1971 nest, approximately 230 m from the rig and under the helicopter route, was not successful.

We cannot generalize from limited observations in one season about the effects of Taglu well-drilling operations on wildlife. Some species are apparently not affected during drilling and associated activities while others are. Of the affected species, some react more radically than others. The White-fronted Goose population moved out of both rig and control study areas, their numbers declining from 2300 in 1970 to 475 in 1971, while the Whistling Swan population only shifted a few kilometres away.

Our observations during helicopter flights suggest that effects of rig activity on wildlife are also indirect. Gulls and jaegers are not frightened by helicopters; they can take the eggs of geese and other birds which are frightened from their nests. The more subtle effects of noise levels, camp and rig sanitation, camp movements, boat operations, and changes in terrain, were not studied quantitatively.

Wildlife population studies on the Taglu rig site in later years could indicate the permanency of any effects. Similarly, it might be found that, should the site be abandoned, an island of gravel might artificially enhance the nesting habitat for some species, as the stacks of pallets did for Snow Buntings.

A more thorough investigation of a helicopter route or an air corridor to and from the rig might prove to be one of the most successful means of minimizing disturbance of nesting waterfowl. Field biologists commonly observe that for some reason wildlife is more easily disturbed by helicopters than by fixed-wing aircraft. In the course of our field trials it became evident that the higher the aircraft was above ground the less it disturbed birds and mammals. Altitudes of 150 m seemed a satisfactory height for slight disturbance on most occasions, but this should be verified.

Acknowledgements

We appreciate the co-operation and concern of the employees of Imperial Oil Limited at Inuvik and the Taglu well site in seeing that our study requirements were readily met. We are especially grateful to Tom Watmore, Imperial Oil Ltd., Edmonton; Alex Hemstock, Imperial Oil Ltd., Calgary; and W.J.D. Stephen and A. Goodman, CWS, for assistance with planning, statistical analysis and review of the manuscript.

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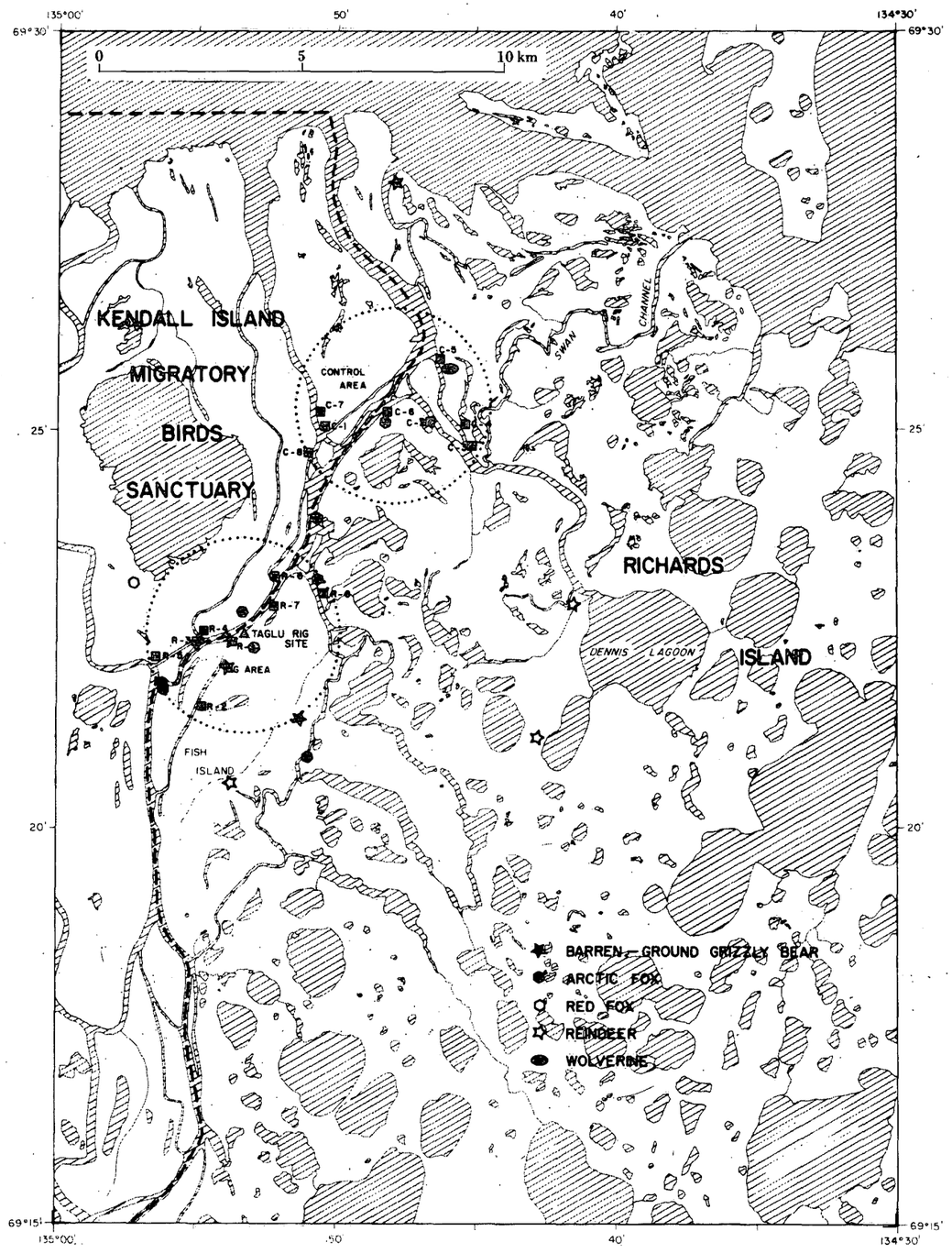

Figure 7
Observations of mammals, 6 July–7 Aug. 1971

Table 1
Bird and mammal population estimates in vicinity of Taglu rig by aerial survey (2978.5 km^2 extrapolation: 23 times area surveyed) 5 July 1971 (See Fig. 1)

Common name	Latin name	Estimated population
Common Loon*	*Gavia immer*	1
Arctic Loon	*Gavia arctica*	184
Red-throated Loon	*Gavia stellata*	23
Unidentified loons		300
Whistling Swan	*Olor columbianus*	1500
Canada Goose	*Branta canadensis*	250
Pacific Brant	*Branta bernicla nigricans*	375
White-fronted Goose	*Anser albifrons*	475
Snow Goose	*Chen caerulescens*	6800
Mallard	*Anas platyrhynchos*	194
Pintail	*Anas acuta*	775
Green-winged Teal	*Anas carolinensis*	175
American Widgeon	*Mareca americana*	2400
Shoveler	*Spatula clypeata*	120
Scaup	*Aythya sp.*	1403
Oldsquaw	*Clangula hyemalis*	736
White-winged Scoter	*Melanitta deglandi*	935
Surf Scoter	*Melanitta perspicillata*	115
Unidentified ducks		790
Rough-legged Hawk*	*Buteo lagopus*	15
Golden Eagle*	*Aquila chrysaëtos*	10
Willow Ptarmigan	*Lagopus lagopus*	850
Sandhill Crane	*Grus canadensis*	298
Hudsonian Godwit	*Limosa haemastica*	46
Parasitic Jaeger	*Stercorarius parasiticus*	70
Glaucous Gull	*Larus hyperboreus*	470
Sabine's Gull	*Xema sabini*	20
Arctic Tern	*Sterna paradisaea*	1000
Raven	*Corvus corax*	45
Barren-ground grizzly bear*	*Ursus arctos*	5
Red fox*	*Vulpes fulva*	20
Arctic fox*	*Alopex lagopus*	30
Arctic ground squirrel*	*Citellus parryi*	150
Beaver*	*Castor canadensis*	4
Greenland collared lemming*	*Dicrostonyx groenlandicus*	—
Muskrat*	*Ondatra zibethica*	—
Reindeer*	*Rangifer arcticus*	12
White whale*	*Delphinapterus leucas*	70

*Extrapolation factor not used because of rarity of species, specialized habitat, or difficulty of visibility.

Table 2
Bird species found in Taglu rig and control study plots

Common name	Latin name	Observed		Nesting	
Arctic Loon	*Gavia arctica*	R	C		
Red-throated Loon	*Gavia stellata*	R	C		
Whistling Swan	*Olor columbianus*	R	C	R	C
Canada Goose	*Branta canadensis*	R	C		
Pacific Brant	*Branta bernicla nigricans*		C		
White-fronted Goose	*Anser albifrons*	R	C		C
Snow Goose	*Chen caerulescens*		C		
Mallard	*Anas platyrhynchos*	R	C	R	
Pintail	*Anas acuta*	R	C	R	
Green-winged Teal	*Anas carolinensis*	R	C	R	C
American Widgeon	*Mareca americana*	R	C		
Shoveler	*Spatula clypeata*	R	C	R	C
Scaup	*Aythya* sp.	R	C		
Oldsquaw	*Clangula hyemalis*	R	C		
White-winged Scoter	*Melanitta deglandi*	R	C		
Rough-legged Hawk	*Buteo lagopus*	R	C		
Golden Eagle	*Aquila chrysaëtos*		C		
Marsh Hawk	*Circus cyaneus*	R			
Gyrfalcon	*Falco rusticolus*		C		
Willow Ptarmigan	*Lagopus lagopus*	R	C	R	C
Sandhill Crane	*Grus canadensis*	R	C	R	C
Black-bellied Plover	*Squatarola squatarola*		C		
Common Snipe	*Capella gallinago*	R	C	R	C
Whimbrel	*Numenius phaeopus*	R	C	R	
Pectoral Sandpiper	*Erolia melanotos*	R	C	R	C
Stilt Sandpiper	*Micropalama himantopus*	R	C	R	C
Semipalmated Sandpiper	*Ereunetes pusillus*	R	C	R	C
Hudsonian Godwit	*Limosa haemastica*		C		
Northern Phalarope	*Lobipes lobatus*	R	C	R	C
Parasitic Jaeger	*Stercorarius parasiticus*	R	C		
Long-tailed Jaeger	*Stercorarius longicaudus*	R	C		
Glaucous Gull	*Larus hyperboreus*	R	C		
Sabine's Gull	*Xema sabini*		C		
Arctic Tern	*Sterna paradisaea*	R	C		
Short-eared Owl	*Asio flammeus*		C		
Raven	*Corvus corax*	R	C		
American Robin	*Turdus migratorius*		C		
Yellow Warbler	*Dendroica petechia*	R	C	R	C
Rusty Blackbird	*Euphagus carolinus*	R	C		
Hoary Redpoll	*Acanthis hornemanni*	R	C	R	
Common Redpoll	*Acanthis flammea*		C		C
Savannah Sparrow	*Passerculus sandwichensis*	R	C	R	C
Tree Sparrow	*Spizella arborea*	R	C	R	C
White-crowned Sparrow	*Zonotrichia leucophrys*	R	C	R	
Fox Sparrow	*Passerella iliaca*	R	C	R	C
Lapland Longspur	*Calcarius lapponicus*	R	C	R	C

Table 3
Nesting success of birds in Taglu rig and control study plots

	Control	Rig
Nests found	27	20
Nests destroyed	7	7
Nests abandoned	1	3
Nests hatched	19	10

Table 4
Comparison of 35 species of birds observed in the Taglu rig and control study plots

Species	No. of observations		Statistical significance
	Rig	Control	
Arctic Loon	20	13	Not significant
Red-throated Loon	7	2	Not significant
Whistling Swan	2	24	(χ^2 = 20.54, df 1)*
Whistling Swan (flying)	22	20	Not significant
Canada Goose	10	38	(χ^2 = 16.33, df 1)
White-fronted Goose	51	160	(χ^2 = 56.56, df 1)
Mallard	11	4	Not significant
Pintail	72	456	(F = 8.23, df 1,94)†
Green-winged Teal	9	37	(χ^2 = 17.02, df 1)
Shoveler	12	18	Not significant
Scaup	1	26	(χ^2 = 23.15, df 1)
Oldsquaw	38	24	Not significant
White-winged Scoter	1	6	Not significant
Rough-legged Hawk	2	5	Not significant
Willow Ptarmigan	17	25	Not significant
Sandhill Crane	38	46	Not significant
Common Snipe	35	58	(F = 7.29, df 1,94)
Whimbrel	42	1	(χ^2 = 39.08, df 1)
Pectoral Sandpiper	15	40	(F = 7.75, df 1,94)
Stilt Sandpiper	8	4	Not significant
Semipalmated Sandpiper	27	79	(F = 31.30, df 1,94)
Northern Phalarope	33	252	(F = 21.84, df 1,94)
Parasitic Jaeger	17	32	(χ^2 = 4.43, df 1)
Long-tailed Jaeger	10	26	(χ^2 = 7.10, df 1)
Glaucous Gull	16	60	(χ^2 = 25.47, df 1)
Arctic Tern	2	7	Not significant
Raven	29	11	(χ^2 = 4.82, df 1)
Yellow Warbler	19	22	Not significant
Rusty Blackbird	4	1	Not significant
Hoary Redpoll	13	10	Not significant
Common Redpoll	112	110	Not significant
Savannah Sparrow	158	223	(F = 7.09, df 1,94)
Tree Sparrow	61	43	Not significant
White-crowned Sparrow	5	6	Not significant
Fox Sparrow	10	10	Not significant
Lapland Longspur	51	200	(F = 11.40, df 1,13)

*χ^2 = chi-square; df = degrees of freedom.
†F = the calculated value from an analysis of variance, and indicates the significance of difference between observations in the rig and control study plots.

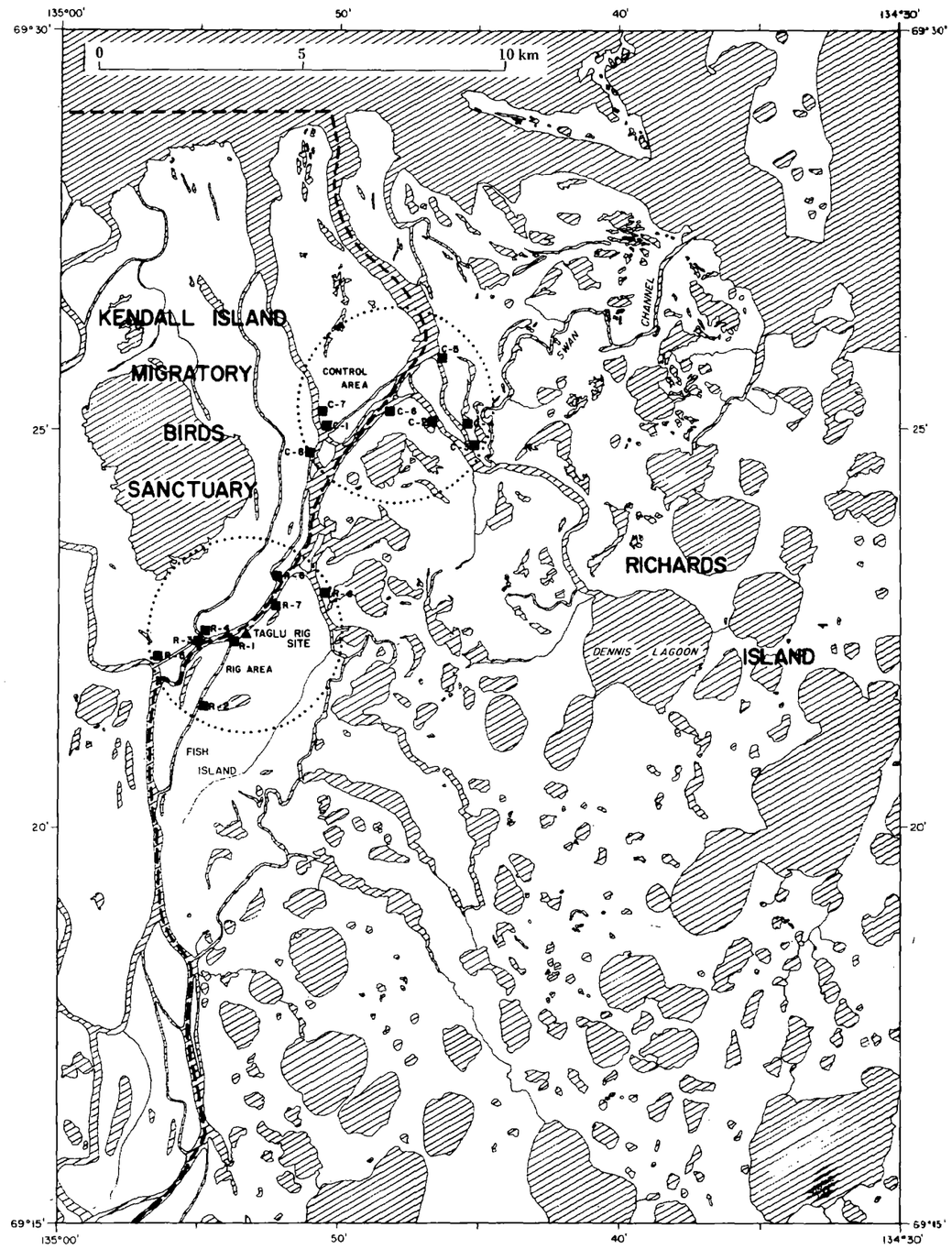

Figure 2
Location of study plots rear the rig (R-1 to R-8) and in the control area (C-1 to C-8)

On the tundra around the drilling rig were a storage tank, separator unit, and a flare pit. A rig sump for expended drilling mud, and a gravel dike lined with polyethylene and containing fuel bladders were nearby. About 30 people occupied the camp. The living quarters, a cluster of industrial trailers, were on pilings just off the southeast edge of the pad. Near them were sumps for sewage and liquid kitchen wastes and a portable oil-fired incinerator for garbage. Settling tanks near the living quarters stored wash-water pumped from the river.

Rig re-supply

Drinking water was brought daily by a helicopter which also hauled men, groceries, and some drilling tools in and out of the camp during the spring break-up. The helicopter was flown on a route prescribed by Imperial Oil in consultation with CWS, and was designed to avoid disturbing birds in the Kendall Island Migratory Bird Sanctuary. The helicopter could not always fly at the same altitude because of the differences in its loads. With a heavy load, as much as 5 km was required to gain 100 m. Helicopters from other Imperial Oil camps were flown to the rig about once a week but did not necessarily use the scheduled routes.

Beginning 1 July, daily re-supply was done by a twin-engine Otter on floats which could not closely follow the prescribed route because of varying wind directions. Like the helicopter, the Otter flew no fixed time schedule. Later, in August and September, a tug was used to move equipment from the rig site to other areas. About mid-August a freighter canoe powered by an outboard motor went into service to locate and mark channels for the tug. A few employees also used the canoe for fishing.

Rig activities

Drilling began in April. On our arrival on 4 June, the crews were casing a section of the hole. Under pressure from the mud pumps, mixed cement was pumped between the casing pipe and the walls of the hole. The pumping of cement is the noisiest aspect of the casing process. Routine rig activities are relatively noisy, ranging from 82 dB in the 'doghouse' (a control room adjacent to the rig) to 104 dB when tripping.

An important part of a drilling operation is a drill stem test, in which hydrocarbons in the formation being tested are forced to the surface and into a pipe from the hole to the flare pit. When the first pressure started, muddy water poured from the pipe into the flare pit. Next, accompanied by hissing noises, gas condensate was bled out of the pipe into the flare pit and ignited. The ignition was followed by rumblings which subsided as the line was closed off to allow pressure to build again. A similar test was completed on 12 July but the hydrocarbons were bled through a separator unit and condensate was burned in a 12-m vertical flare stack, standard equipment for further testing. This event was the Taglu gas discovery. The gas was "sweet", that is it contained no hydrogen sulphides.

Drilling ceased in mid-August. Additional tests (standard seismic velocity survey) included detonation of charges of dynamite, ranging from 38 to 61 kg, dropped into holes drilled into the ground at distances of about 135 m from the rig. Each blast threw frozen soil from the shot holes.

As part of camp maintenance, used engine oil was collected in catching pans and transferred to 45-gallon (200-litre) drums. When enough oil was collected, it was dumped into a gravel-lined sump and burned.

In general, the rig site was clean compared to other industrial activities (Oilweek 1971). A few empty cement bags and polyethylene remnants blew out on the tundra, and there were usually some discarded styrofoam coffee cups beneath the pilings of the rig, but when there was little drilling going on rig hands were organized to clean up the site. Once a full bag of drilling cement fell from a pallet suspended from the helicopter, but it buried itself from sight in the tundra.

A garbage pile, including food scraps from the rig doghouse, accumulated off the gravel pad on one side of the rig. Deep ruts led from the pad to this spot. Tin cans and other bits of scrap metal, cement bags and paper accumulated and were eventually burned there, but the camp incinerator 180 m away could easily have been used instead. Several ravens were in the habit of scavenging this doghouse garbage pile. Eventually a wire mesh cage was erected around it so that empty cement bags and other refuse could be burned without blowing away. A barren-ground grizzly bear had been foraging near camp earlier, and could have been attracted again to this refuse pile. On the other hand, the camp incinerator is credited with absence of problems with scavengers.

Dry garbage, food scraps and empty cans were burned daily in the camp incinerator. The burnt cans were removed later to be crushed and buried when the camp sump was refilled. Barren-ground grizzly bears seen near the camp never visited the incinerator, nor did ravens scavenge in it. We observed no foxes or fox tracks around it, although we learned from camp residents that arctic foxes and red foxes visited the incinerator during the winter.

We were told that Imperial Oil was experimenting with a small type of mud sump at Taglu. However, these sumps were not successful. Much of the drilling mud was pumped toward the river where it formed a grey sludge on the shore. Imperial Oil had apparently obtained a permit from Canadian Fisheries Service to dump sludge in the river on the assurance that no Dowacide fungicide was being used in the drilling mud. The rig sump was to be filled in after drilling ceased and when the ground was frozen enough to allow vehicles on the tundra.

Wet sewage and waste sumps were flooded at spring break-up. The sumps were allowed to settle until late July, but when they were pumped out the hose was allowed to sink to the bottom of the sump so that the contents were pumped directly into the channel, somewhat downstream from the wash water intake. The only wildlife observed at the sumps was a Mew Gull (*Larus canus*), the only one seen in the study areas. The gull skimmed over the sump surface picking up floating debris.

Off-duty crews generally slept, ate, or occupied themselves in the recreation room. Only one person was known to walk about on the tundra; he picked flowers and reported flushing a duck off a nest. A few others fished from shore with no success. A stray sled dog wandered into camp and stayed, taking a daily stroll over the tundra. He sometimes