Seabirds of the Southeastern Beaufort Sea: Summary Report

THOMAS W. BARRY

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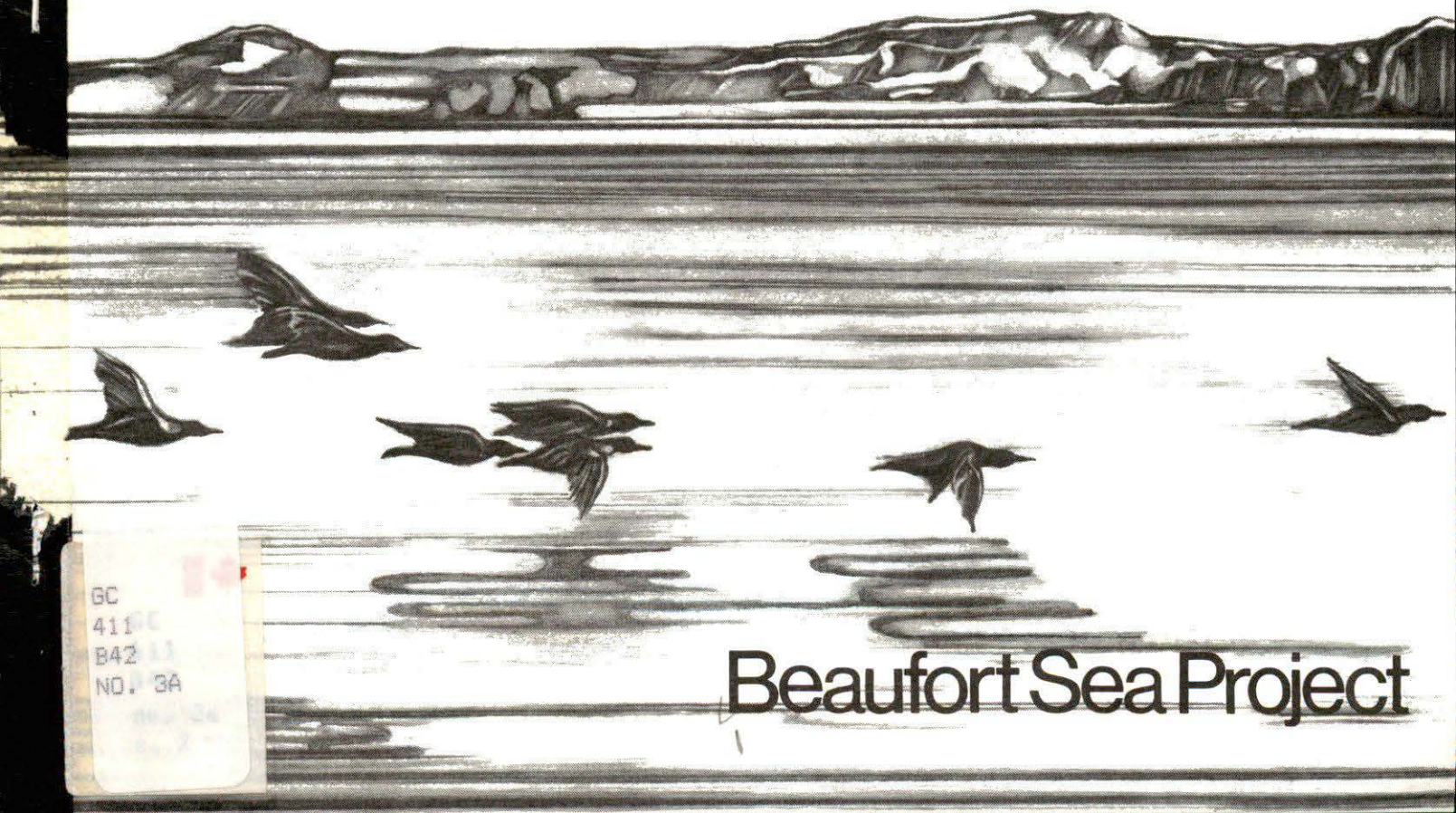

Beaufort Sea Project

SEABIRDS OF THE SOUTHEASTERN BEAUFORT SEA : SUMMARY REPORT

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Beaufort Sea Technical Report #3a

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1. SUMMARY

During the seasons 1972, 1974, and 1975, the Canadian Wildlife Service coordinated surveys of seabirds that use the southeastern Beaufort Sea. Various survey methods were employed to determine temporal and spatial distribution of seabirds. From several points along the coast we made counts of spring migrants. Aerial surveys were used to learn the distribution and concentration of seabirds using open leads in the ice and throughout the open water season. Aerial surveys were also used to sample the coastal breeding and molting species. Aerial surveys in the fall sought to locate concentrations in the littoral zone. Radar echoes from flocks of birds migrating past the Distant Early Warning site at Komakuk Beach gave information not available to visual observers.

The southeastern Beaufort Sea coast is generally low and is composed of silt and sand. The shore is eroding rapidly and is broken by barrier beaches, lagoons, bays, and river deltas. The outflow of the Mackenzie River dominates the adjacent sea water. The climate is polar continental, and the southeastern Beaufort sea is normally ice-covered from October to mid-July. Open water leads often parallel the coast off Herschel Island, Cape Dalhousie, and Banks Island. These leads serve as traditional spring migration pathways for old squaw ducks, king eiders, common eiders, loons, jaegers, and gulls. Open leads north of Cape Dalhousie and Bathurst Peninsula and west of Banks Island attract large concentrations of eiders, old squaws, and loons during May and June. The reliance of sea birds on the leads being open when they arrive is shown by the fact that over 100,000 eider ducks died of starvation in the spring of 1964 when the ice cover was complete. One can speculate whether there would be a similar catastrophy should the leads be covered with oil.

By mid-June the spring migration is complete, and the numbers of birds found at sea is greatly reduced as they move to nesting sites. During July and August all ducks, geese, and swans become flightless when in their annual molt. The young have hatched and flocks consisting of family groups or of molting non-breeders move to protected areas that also have abundant food supplies. Probably the densest populations of water birds in the southeastern Beaufort Sea are found at certain barrier beaches, bays, islands, and littoral flats and marshes of river deltas during the molt and brood-rearing season.

Because water birds are quite helpless during the molt and brood-rearing season, critical coastal areas that are vulnerable

to oil spills have been delineated according to the birds' activity and the dates of use.

There are about 100 species of birds that use the southeastern Beaufort Sea and its littoral zone for migration, feeding, resting, nesting, and molting. Of the ten major species, numbering over two million individuals, some have been known to arrive in the open leads as early as April, whereas others remain as late as December. Oil spills or oil blowouts which pollute the leads and the littoral zone of the Beaufort Sea, would be disastrous to the sea birds. Clean up of oil pollution would be extremely difficult, if not impossible, under Arctic conditions.

2. INTRODUCTION

2.1 Nature and Scope of the Study

Most bird species in the Arctic are aquatic and migratory. Relatively few species occur in the Arctic, but large numbers of individual birds congregate in summer, many of which are economically important for native subsistence or for recreation. Nearly all of fifty-odd species occurring in the Beaufort Sea region are migratory. Some species such as glaucous gulls remain far north as long as open water permits. Others, such as Arctic terns and jaegers, have annual migrations of approximately 40,000 km.

The Beaufort Sea is that part of the Arctic Ocean adjacent to the north coast of Alaska and Canada, between Point Barrow on the west and Banks Island on the east. Certain species nest along the edge of the Beaufort Sea while others pass over en route to more distant nesting grounds. Nearly all species found in the region are bound to the sea at some time in their lives, whether for feeding, molting or resting.

The birds nesting in Canada's western Arctic converge from wintering grounds in the Pacific and Antarctic oceans, and in North and South America, that is, from about one-third of the globe's surface. Of the birds nesting on the coasts of the Beaufort Sea and the Arctic Islands, approximately two-thirds migrate through the Great Plains and the Mackenzie Valley, while the rest travel through the Bering Strait and follow the coast of Alaska, Yukon, and the North-west Territories. Waterbirds moving along the narrow open water leads, which usually form between landfast ice and the Arctic pack in May and June, can become extremely concentrated under certain conditions.

Species using the Bering Strait and Arctic coast migration route include Arctic terns, Sabine's gulls and jaegers from the Antarctic and the South Pacific, Pacific brant from coastal Mexico and California, and eiders, murres and glaucous gulls from the North Pacific and the Bering Sea. Some species flying the interior migration routes also use the coast; for example, whistling swans move westward in the spring from the Mackenzie Delta along the Yukon and Alaska coasts. Many snow geese follow the coast of Tuktoyaktuk Peninsula en route from the Mackenzie Delta to Banks Island nesting grounds. They use the same route when migrating south in the fall.

The discoveries of oil and gas along the rim of the Beaufort Sea and the prospect of offshore drilling have shown the need for more reliable information about the marine avifauna. In the past, population estimates of Beaufort Sea birds were based on casual surveys, conducted as part of other studies or reconnaissances.

The determination of the number of birds, their migration routes, and the crucial dates when they are present is a complicated task requiring difficult and expensive logistics. The effects of ice and snow cover, and of weather systems on the seabirds vary from year to year. Unfortunately, 1974 was not a typical year; along with 1959 and 1964, 1974 was an extremely late season with persistent snow and ice cover. The late season had disastrous effects on the reproduction and distribution of the seabirds.

2.2 Objectives

The purpose of seabird studies, conducted as part of the Beaufort Sea Project, was to provide information about the timing, species composition and routes of migration of major bird species which occur in the Beaufort Sea, their offshore distribution, and the numbers, speeds and directions of movement of migrant flocks.

This summary report is, primarily, a digest of two published, technical reports which document the seabird research conducted under contract to Environment Canada in 1974 and 1975. They are listed below :

(1) Searing, G. F., Ernie Kuyt, W. John Richardson and Tom W. Barry. 1975. Seabirds of the Southeastern Beaufort Sea : Aircraft and Ground Observations in 1972 and 1974. Beaufort Sea Project Technical Report #3b, 257 pp.

(2) Richardson, W. John, Michael R. Morrell and Stephen R. Johnson. 1975. Bird Migration along the Beaufort Sea Coast : Radar and Visual Observations in 1975. Beaufort Sea Project Technical Report #3c, 131 pp.

Other sources of information which were useful in the preparation of this report were :

(a) Johnson, S. R., W. J. Adams and M. R. Morrell. 1975. The Birds of the Beaufort Sea : Part 1 (A Literature Review) and Part II (Observations of 1975 Spring Migration). Prepared under contract to the Canadian Wildlife Service, Edmonton, for the Beaufort Sea Project, 310 pp.

(b) Johnson, S.R., W. J. Adams and M. R, Morrell. 1975. The Birds of the Beaufort Sea : An Annotated Bibliography. Prepared under contract to the Canadian Wildlife Service, Edmonton, for the Beaufort Sea Project, 169 pp.

2.3 Relation to Offshore Drilling

Most of the bird species found in the Beaufort Sea region are protected by the Migratory Birds Treaty between Canada and the United States. In view of plans to begin offshore drilling in the Beaufort Sea in 1976 and, in the future, along the entire outer continental shelf of Alaska, knowledge of the life histories and ecology of seabirds is essential to predict and avoid harm to them through oil spills and industrial disturbances. The wise management of these birds and

their habitats requires an intimate knowledge of movements of the birds and of the areas of their concentration at various times of the year.

Of all the environmental factors affecting the lives of seabirds in the Beaufort Sea region, ice conditions are the most critical. Consideration of ice conditions has to be an integral part of the analysis of data related to the birds' distributions.

Many breeding colonies of waterfowl, gulls and terns occur along the Beaufort Sea coastline. In addition, the coastal plain is used extensively for nesting by these species and by loons, shorebirds, jaegers, and several species of passerines. Many of these birds, both adults and young, use the sea during late summer for feeding and migration. The various uses of the Beaufort Sea by seabirds, whether for breeding, feeding, molting or migrating, must be considered in the event of an oil spill. Several of these uses have only been touched upon in this report.

3. CURRENT STATE OF KNOWLEDGE

The most comprehensive literature review concerning birds of the Beaufort Sea region was recently compiled by Johnson *et al* (1975). They review the distribution, seasonal ranges, migration patterns and breeding biology of over 100 species known to frequent the area, whether as commonly-occurring migrants or as rare year-round residents. Vermeer and Vermeer (1974)*have also prepared a useful abstracted bibliography on the problems of oil pollution of birds over a period of about 50 years.

4. STUDY AREA

4.1 Topography and Description

The study area includes both onshore and offshore areas from Clarence Lagoon, Y. T. to Cape Parry, N. W. T., more than 800 km to the east, and north to the northwest tip of Banks Island, N. W. T. The southeastern shore of the Beaufort Sea is the north coast of the mainland of Canada. Numerous small bays and several large ones, notably Liverpool Bay in the east, and Kugmallit Bay and Mackenzie Bay further west, indent the coastline (Figure 1).

Except in the Mackenzie Delta (a region of sparse, northern, coniferous woodland), the coastal zone from the Yukon-Alaska border to Cape Parry, and north to Sachs Harbour on Banks Island, is primarily low-Arctic tundra. In recent years, the Canadian Wildlife Service, Edmonton has attempted to classify, in detail, the vegetation types of the Mackenzie Delta and adjacent coasts.

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* Vermeer, R. & K. Vermeer. 1974. The Biological Effects of Oil Pollution on Aquatic Organisms : A Summarized Bibliography. Manuscript Report No.31. Canadian Wildlife Service, Pesticide Section, Edmonton. 68 pp.

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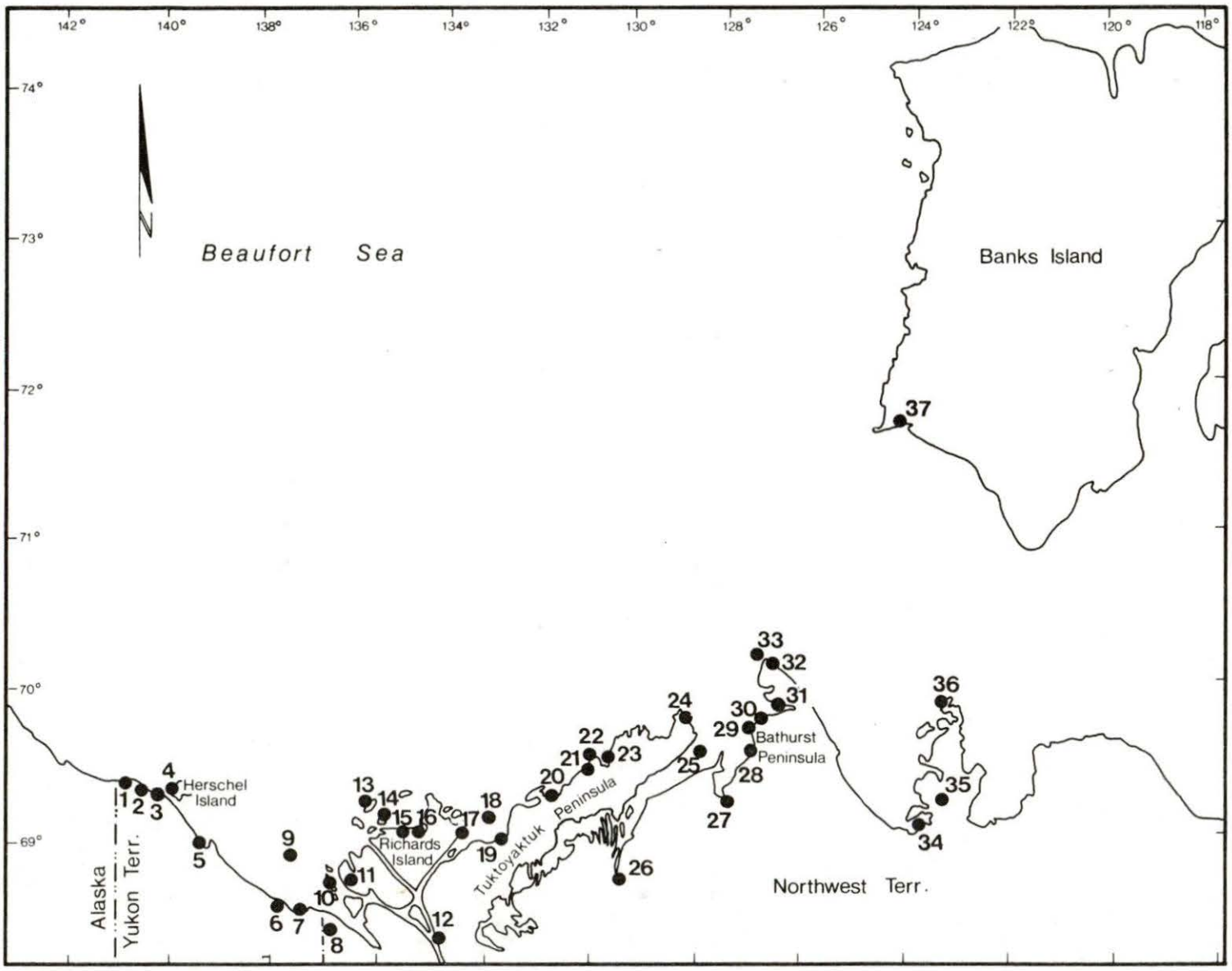

FIGURE 1. Map of the Southeastern Beaufort Sea

The portion of the Yukon coast included in the study area forms part of the Arctic Coastal Plain. This post-glacial plain is relatively flat, sloping from 300 m elevation in the south to sea level along the coast. Several large river deltas and many lakes are present. The smaller lakes are typically shallow, and bordered with emergent vegetation. The larger lakes are deep and have sedge-marsh shorelines. Riparian deposits of sand and gravel form numerous low-lying islands, such as Kendall Island and Pelly Island - and spits along the coast and offshore. The islands in the river deltas are usually low mudflats. Herschel Island, off the Yukon coast, rises to 180 m above sea level; a long gravel spit, Avedlek Spit, extends from its southeastern corner. Habitat in the higher areas of the Yukon North Slope is predominantly dry, sedge-herbaceous tundra; in areas of low relief, a tussock tundra predominates.

Although much of the Mackenzie Delta is sparse boreal forest, the northern portion gives way to scrub tundra, and finally to low arctic tundra near the coast. The Delta itself is 160 km wide, dissected by the many channels and sandbars of the Mackenzie River. The islands of the Delta are composed of stratified mud, sand and gravel, and often contain numerous lakes. The pre-glacial fluvial deposits of the Mackenzie River have formed a chain of outlying islands of higher elevation than the rest of the delta. The eastern portion of Mackenzie Bay is shallow, and its shoreline is barely above sea level.

The coastal area east of the Mackenzie Delta is generally low, flat and wet. At Parry Peninsula, on the extreme eastern edge of the study area, low-lying sand and gravel bars give way to coastal cliffs and numerous offshore islands. Maitland Point also has steep shoreline cliffs. A series of pingoes, or small raised mounds, on Tuktoyaktuk Peninsula break the flat, prairie-like appearance of the eastern Beaufort Sea coastline.

4.2 Climate

The climate of the study area is classified as polar continental, characterized by long, cold winters and short, cool summers. In winter, temperatures may fall below -50°C. The humidity is low and little snow falls in the region. Summers are cloudy and wet. An extreme high of 34°C was recorded at Aklavik; offshore, however, temperatures remain cold throughout the season. The growing season is short, less than 75 days. Spring break-up typically occurs over most of the coastal area during May or June, and the country freezes again in September or October. Dates of break-up and freeze-up are more variable at sea. Although the growing season lasts only a few months, it is effectively lengthened by continuous daylight, from June 6 to July 7 at the latitude of Inuvik, and from May 9 to August 4 at Sachs Harbour on Banks Island.

4.3 Oceanography and Ice Conditions

Currents in the southern Beaufort Sea follow the continental shelf in a counter-clockwise direction. Beyond the outer continental shelf, currents are primarily wind-driven and predominantly in a clockwise direction. Gale winds blow over the sea frequently, occasionally reaching hurricane force along the shores. These winds govern ice degradation, shoreline erosion and accretion, and nearshore sediment transport.

Ice conditions are largely governed by wind and, as a result, vary from day to day. The Beaufort Sea includes three zones of ice conditions : (1) shorefast ice, (2) seasonal pack ice, and (3) polar pack ice. Although shorefast ice and pack ice typically break up during the summer, onshore winds may move the polar pack near the coast, even during the height of the summer season, severely limiting the extent of open water. Such was the case in 1974; ice cover during the summer was more extensive than usual and much of the Beaufort Sea remained ice-covered throughout the entire season.

5. METHODS

Table 1 summarizes the various sea-bird aerial surveys and migration watches in the south-eastern Beaufort Sea, conducted by the Canadian Wildlife Service, Edmonton or under contract to Environment Canada. Some of the details of these census programs are described below. For more information, the reader is referred to Richardson *et al* (1975), and Searing *et al* (1975).

5.1 Aerial Surveys in Early Spring, 1974.

Aerial surveys of the ice-free portions of the southern and south-eastern Beaufort Sea were conducted by Renewable Resources Consulting Services Ltd., of Edmonton, from April 21 to May 31 in 1974. These flights were essentially random searches for open water leads which were then surveyed according to normal transect techniques, that is, in strips 0.8 km wide.

A Cessna 337 aircraft was used for five surveys, each of which required three days of flying. The dates were April 21-24, May 1-5, May 13-15, May 21-27 and May 29-31.

The surveys were flown at a speed of 160 km/hr at an altitude of 45 m above sea level. Two observers recorded all birds seen, and a third observer acted as navigator and recorded ice and weather conditions.

TABLE 1. SUMMARY OF SEABIRD CENSUS PROGRAMS IN THE SOUTHEASTERN BEAUFORT SEA, 1972 to 1975.

Census Technique	No. of observations	Period(s) of Observations	Area of Observations	Affiliation of Observer(s)
Aerial surveys	5 flights	Apr.21 to May 31 1974	Random search at open water and leads, between Herschel Island, Cape Parry and Banks Island	Renewable Resources Consulting Services, Edmonton.
Aerial surveys	12 flights	June 6 to Oct. 17, 1974	Definite offshore transects between Alaska/Yukon border in west, Cape Parry in east, and N.W. tip of Banks Island to the N. (See Figs. 3 to 7)	Renewable Resources Consulting Services, Edmonton.
Aerial surveys	6 flights	June 27 to Sept. 17, 1974	Regular census at 90 coastal water-bodies between Komakuk, Y.T. and Tuktoyaktuk Peninsula	Canadian Wildlife Service, Fort Smith.
Visual migration watch	Staggered watches of 4 hours each	May 29 to June 16, 1972	Alongshore census of bird migration past Cape Dalhousie	Canadian Wildlife Service, Edmonton.
Radar migration watch	Continuous time-lapse film (one frame/48 sec)	May 12 to July 8, 1975	74 km radius at Komakuk, Y.T.	LGL Limited, Edmonton.
Visual migration watch	Total of 741 hours of observation	May 9 to July 9, 1975	Alongshore census of bird migration past Komakuk, Y. T. and Clarence Lagoon, Y.T.	LGL Limited, Edmonton.
Aerial surveys	7 flights	May 14 to July 9, 1975	Random search at open water up to 280 km north of Komakuk, Y.T.	LGL Limited, Edmonton.

5.2 Aerial Surveys during June - October, 1974.

Twelve aerial surveys were conducted by Renewable Resources Consulting Services between June 6 and October 17 in 1974; each survey required several days to complete. Table 2 presents a monthly summary of the success of census efforts. The variability is largely due to weather conditions. The impossibility of standardizing survey methods reduces the reliability of month-to-month comparisons of the distribution and relative numbers of birds in the Beaufort Sea, and also the accuracy in estimating the absolute numbers of birds.

Table 2. Success of Offshore Aerial Surveys for Seabirds in 1974.

Month	Number of Transect Segments Surveyed	Area Surveyed (km^2)	Percent surveyed of total study area*
June	737	2383	1.3
July	967	3108	1.7
August	553	1787	1.0
September	420	1360	0.7
October	118	389	0.2

* Total study area = 186,480 km^2.

During each aerial survey, the date, time, transect and segment number, ice and water conditions, and the meteorological and ornithological data were recorded.

After the survey, all data were transcribed onto coding forms. The coding forms were then sent to LGL Limited of Edmonton for analysis. The staff key-punched and verified the data, checking for impossible or implausible notations by means of a validation program.

5.3 Coastal Surveys, 1974

A complete census of waterbirds was attempted on 90 bodies of water between Komakuk, Y. T., and the eastern tip of Tuktoyaktuk Peninsula, N. W. T. (Figure 2). The sites were censused six times from a Cessna 185 aircraft between June 27 and September 27, 1974. A circular flight pattern around each site was made in order to count all the birds on or over each body of water, and up to 1.6 km inland from the shore.

5.4 Coastal Migration Watch, 1972

During 1972, two observers counted migrating birds passing Cape Dalhousie, from May 29 to June 16. They counted all birds within 0.8 km

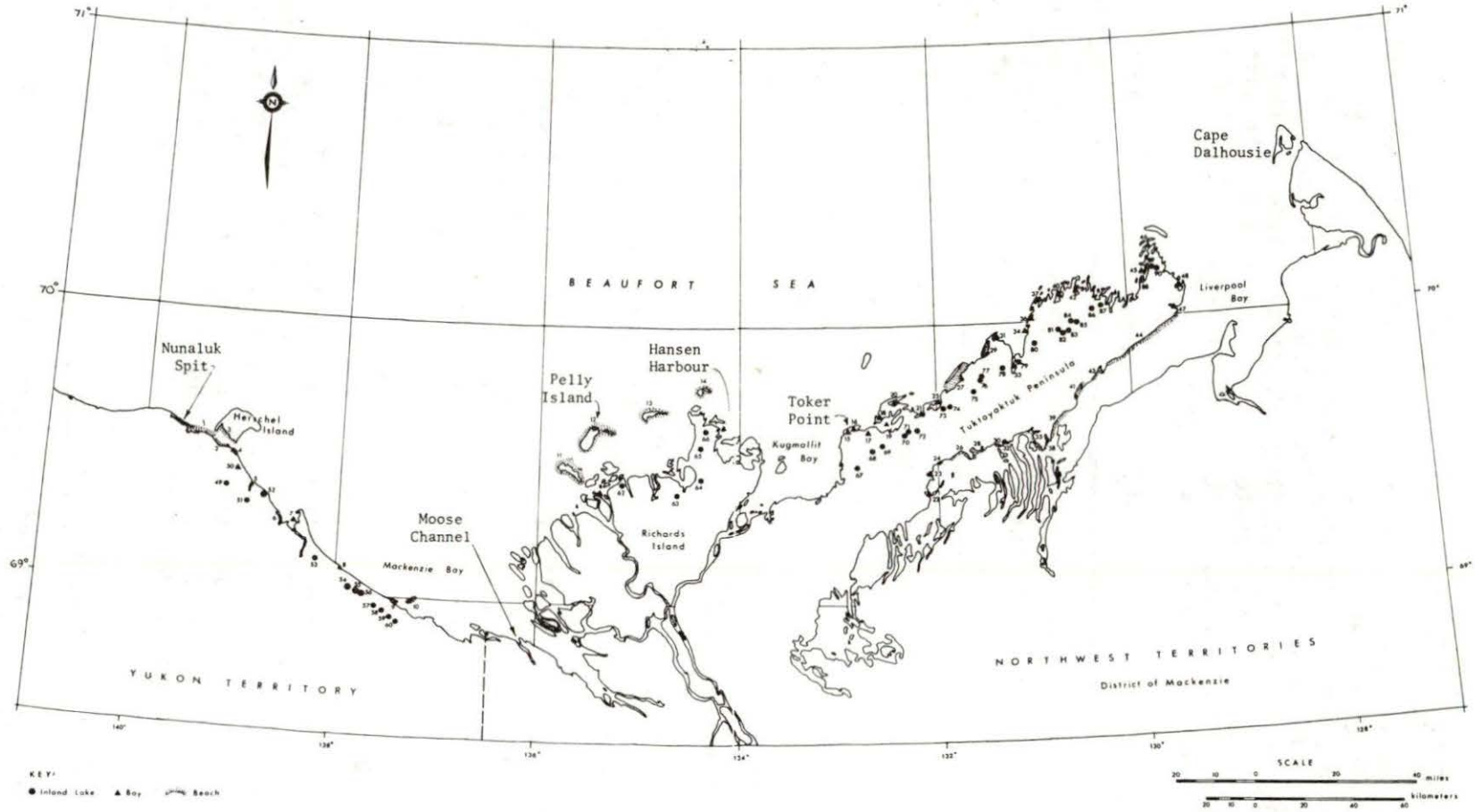

FIGURE 2. The locations of 90 coastal lakes, lagoons and bays surveyed for seabirds in 1974; taken from Searing *et al.* (1975).

of either side of their observation station. The observations were made during the 24-hour daylight, with staggered watches of four hours each.

5.5 Spring Migration Study, 1975

Because the summer of 1974 was atypical in ice and weather conditions, the spring migration was resurveyed in 1975 - this time using radar, ground and aircraft observations.

5.5.1 Radar

Radar data were recorded through time-lapse and still photography of the Plan Position Indicator (PPI) of the surveillance radar station at Komakuk Beach, Y. T. (69°36'N, 140°11'W). A PPI is the standard, map-like display upon which surveillance radar data are normally presented. The Komakuk radar is a medium-powered L-band surveillance radar. Moving Target Indicator circuitry (MTI) permitted detection of birds in the presence of echoes from stationary objects. Except for the MTI, no special circuits were used; hence, the data obtained were stable and of high quality compared to those obtained in other radar studies of bird migration elsewhere in the world.

An almost continuous time-lapse film of the PPI display, at one 35 mm frame per 48 seconds, was obtained for the period May 12 to July 8, 1975. During time-lapse filming, the PPI displayed an area of 74 km radius centered at the radar site. There was no difficulty in identifying bird echoes. Other kinds of echoes came from stationary objects, aircraft and precipitation, all easily distinguished by their relative size and speed. Polaroid photographs made of the PPI once or twice each day, from May 9 to July 9, allowed an immediate assessment of the numbers, directions and locations of migrating birds. The time-lapse films show that the radar detected bird migration along the Yukon coast and the North Slope, south over the British Mountains, 25 to 55 km or more inland, and offshore over the Beaufort Sea to 74 km. Most of the data came from the time-lapse films of the PPI display.

A scale value of zero was arbitrarily chosen to represent no migration; four represented a migration of moderate density, such as a typical shorebird or waterfowl flight over southern Canada, and seven represented a migration as dense, for example, as a typical movement of passerines over southern Canada during a night of favourable weather. This method proved better than counting echoes because is was quicker and, in certain situations, more accurate. Its disadvantage was that it provided no absolute numbers directly; hence, standard parametric statistical procedures are inapplicable unless their assumptions are carefully checked.

Standardization overcame the limitations of the ordinal scale in this study. The Migration Traffic Rate, that is, the number of birds

passing a 10 km "line" in one hour was established for some, but not all of the sampling periods; this rate was compared to the ordinal scale. On most days, an attempt was made every six hours to count the number of echoes involved in the movements of the birds, in various directions, in each of the three sampling areas - inland, coastal and offshore.

The time-lapse film allowed an estimate to be made, to the nearest 10°, of the flight direction of the birds involved. While the moving film displayed the bird echoes on a screen, the viewer traced the path of an echo on a sheet of transparent plastic placed over the screen. The same segment of film was viewed repeatedly until enough echo paths had been traced to provide a significant sample. The duration of each path traced was measured with a stop-watch to give data on the speed of flight.

The density of the birds moving along the coast and up to the maximum distance offshore at which they were detectable by radar, was recorded. Also noted were signs of unusual flight, that is, curving courses, movements far inland, echoes of great intensity, movements breaking away from or joining a concentrated stream of migrants along the shoreline, concentrations near the foothills rather than along the shores, flight patterns near areas of precipitation, and rapid changes in numbers aloft.

5.6 Migration Watches, 1975.

Migration watches were conducted from May 9 to July 9, 1975 at Komakuk Beach, Y. T., a DEW-line radar station, and at Clarence Lagoon, 23 km west of Komakuk. At each site, two observers shared a daily schedule of watches. The distance at which birds could be identified varied with weather, the size and behaviour of each species and the skill of each observer. The majority of birds reported were those passing within 1.4 km of the observation posts. The data from each site were divided into ten-day periods. Tabulations for each period showed how many birds of each species passed the observation site per hour, at each period of the day, how high they were flying, how far they were from shore, how large were their flocks, and in what direction they were moving.

5.7 Aerial Surveys, 1975

Seven aerial surveys were conducted over the Beaufort Sea in 1975 - namely, on May 14, May 28, June 26, July 3 and July 9. A DeHavilland Twin Otter was used for each survey, usually flying at an altitude of 30 to 46 m and at a speed of 114 to 192 km per hour.

During each survey flight, the plane flew northward from the shore at Komakuk for a distance of 280 km. Whenever possible, the flight followed open water. The purpose of these surveys was to locate

concentrations of birds rather than to systematically survey a definite portion of the Beaufort Sea. Hence, the observations cannot be used as a basis for total estimates of density or of absolute numbers of seabirds in areas other than those surveyed.

The survey techniques were similar to those used in the spring of 1974. Each survey route was selected after consideration of 7 to 10 day old ERTS satellite photographs of ice conditions in the Beaufort Sea, and from reports of ice conditions obtained from Komakuk radar operators and British Airways pilots flying the Beaufort Sea route.

6. RESULTS

6.1 Offshore Distribution and Numbers of Birds in 1974

The total numbers of each bird species, or species group, observed during the aerial surveys are summarized in Table 3 and in Figures 3 to 7. The distribution of the major species and of species groups as a function of sea ice conditions is outlined below :

6.1.1 Loons

The few loons observed offshore between May 27 and September 27 were broadly distributed over the southeastern Beaufort Sea. They were usually seen in small open-water leads with less than 80 per cent ice cover and showed little preference for extensive areas of open water, even after mid-July when some open water had appeared along the southern coast of the Beaufort Sea.

6.1.2 Geese and Diving Ducks

Of the 1,803 geese sighted during offshore aerial surveys, 1265 or 70 per cent were snow geese. In early June, geese were observed flying over 100 per cent ice cover but, during autumn, most were scattered along coastal staging areas with little or no ice cover.

The 1974 aerial surveys first reported open water in the Beaufort Sea between May 13 and 15. Diving ducks were not seen until May 21 when approximately 50,000 eiders, 17,000 oldsquaws and 200 scoters were observed in a large lead near Cape Dalhousie, and in a small lead off the west coast of Banks Island (Figure 3). When these leads closed again between May 20 and 31, fewer birds were in evidence and the oldsquaws and eiders had scattered widely. The aerial surveys from June 6 to July 18 found their numbers still low. Open water reappeared along the shoreline in mid-July, and remained open until freeze-up in mid-September; nevertheless, the numbers of oldsquaws and eiders continued to decline to near zero by July 24. By this date, nesting had begun and male eiders had finished their molt migration to the Chukchi Sea.

TABLE 3. NUMBERS OF THE MOST COMMON SEABIRDS OBSERVED OFFSHORE DURING 1974 AERIAL SURVEYS OF THE SOUTHEASTERN BEAUFORT SEA (Summarized from Searing *et al*, 1975).

SPECIES	MAY			JUNE			JULY			AUGUST		SEPT.		OCT.	
	13-15	21-27	29-31	6-8	20-23	25-26	3-7	15-18	23-24	13-22	25-30	10	26-28	6	14-18
Loons	0	19	0	34	11	12	17	24	5	22	22	8	1	0	0
Snow Geese	0	0	0	360	0	0	0	0	0	400	430	75	0	0	0
Scaup spp.	0	152	0	0	0	4	100	0	4	0	0	0	0	0	0
Oldsquaw	0	17454	11353	586	563	43	478	86	8	9	14	46	0	0	0
Common Eiders	0	56280	1950	267	0	141	408	0	2	0	0	0	0	0	0
King Eiders	0	10	140	433	66	634	249	141	40	0	0	75	0	0	0
Eiders, including unidentified birds	0	57301	7977	4844	101	815	721	201	42	15	1	75	60	212	0
Scoters	0	240	28	11	155	0	36	94	46	7	3	0	0	20	0
Diving Ducks (total)	0	87233	40336	9285	1416	1602	2195	1124	763	605	224	654	375	240	37
Sandpipers	0	0	0	0	0	0	0	0	4	0	29	101	0	0	0
Jaegers	0	0	0	16	5	1	22	6	8	3	1	0	0	0	0
Glaucous Gulls	15	190	60	39	25	7	67	267	31	37	69	52	42	0	0
Arctic Terns	0	0	0	1	1	0	0	0	0	19	7	0	0	0	0

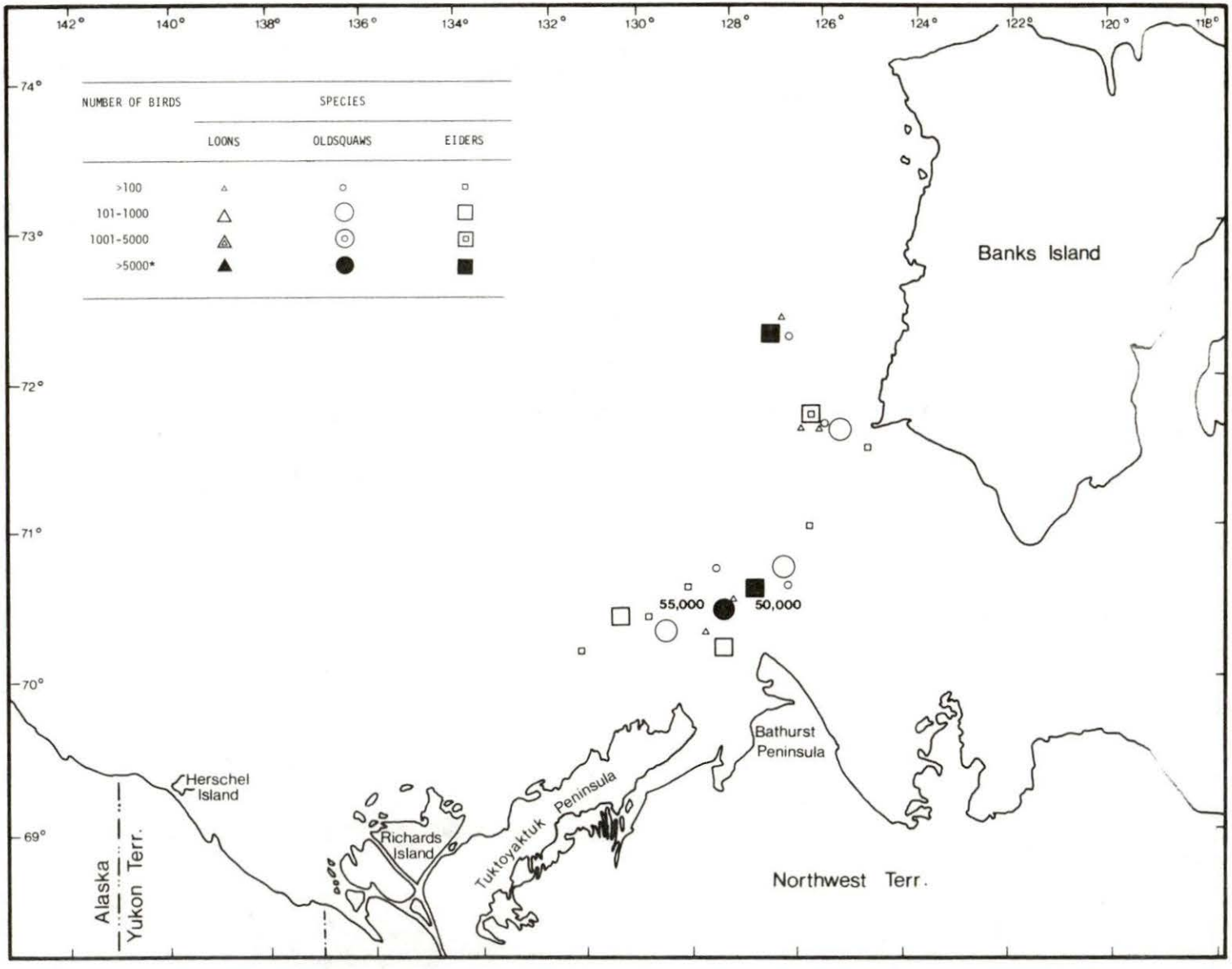

FIGURE 3. Distribution and numbers of loons, old squaws and eiders on the Beaufort Sea from aerial surveys in May, 1974.

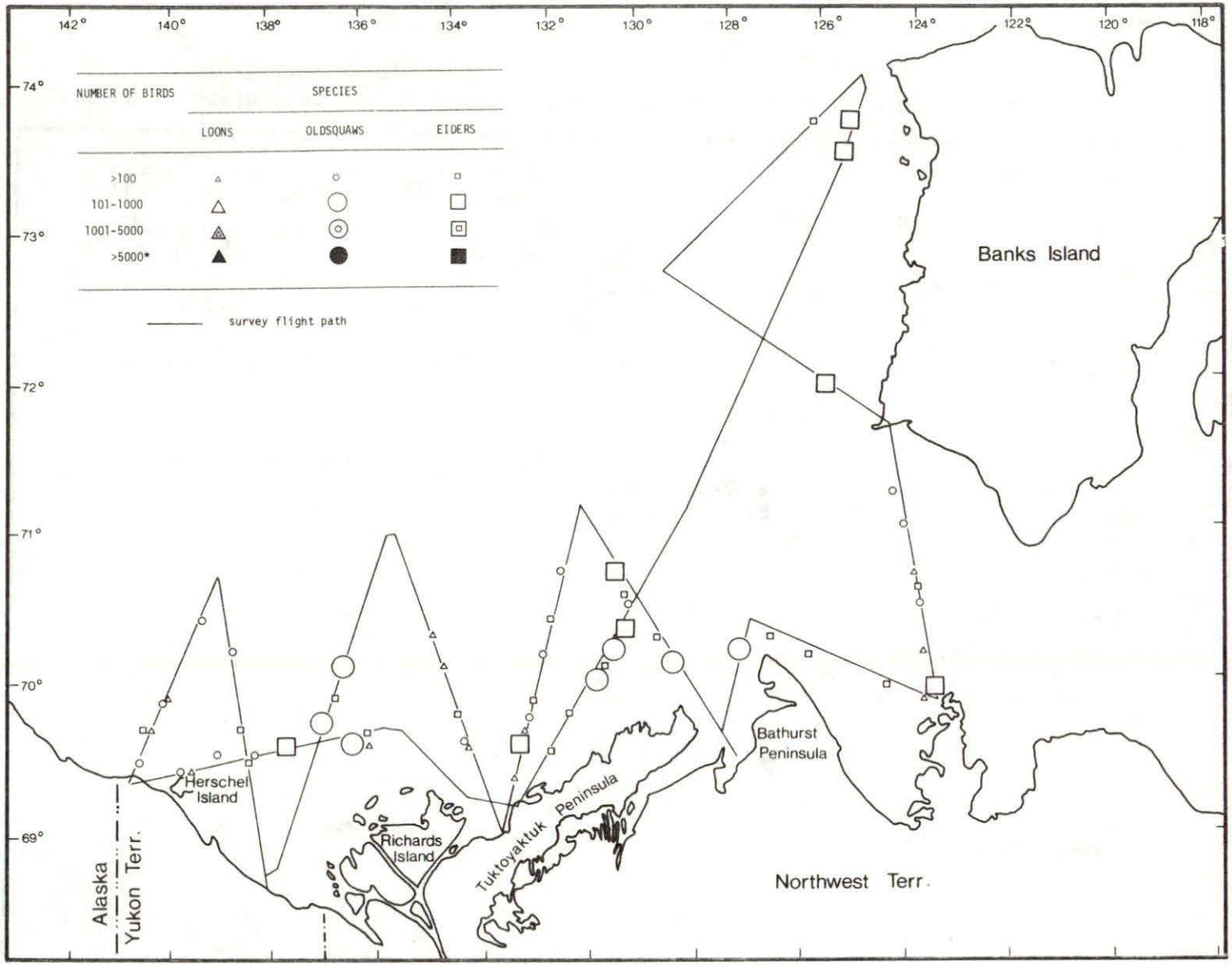

FIGURE 4. Distribution and numbers of loons, old squaws and eiders on the Beaufort Sea from aerial surveys in June, 1974.

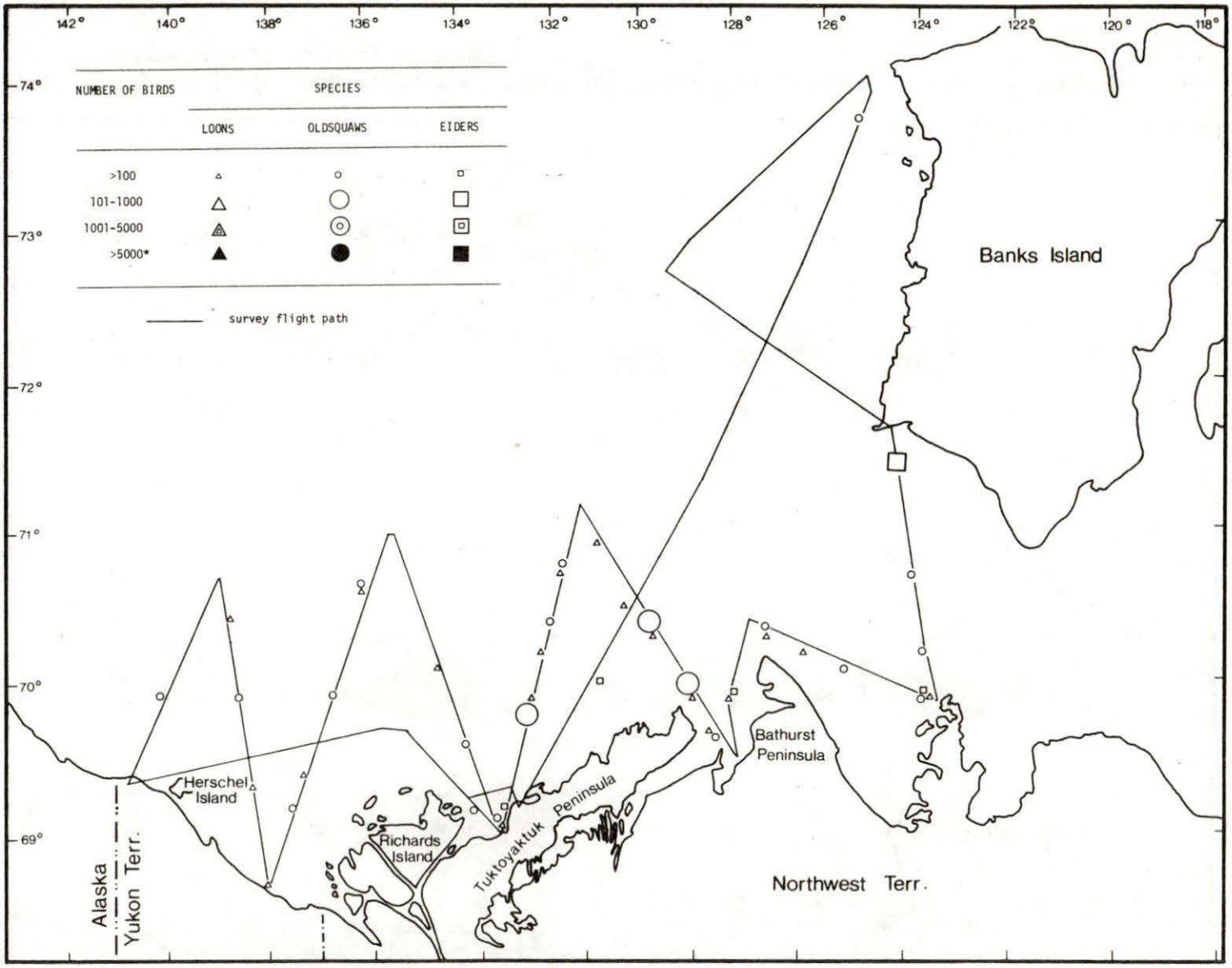

FIGURE 5. Distribution and numbers of loons, old squaws and eiders on the Beaufort Sea from aerial surveys in July, 1974.

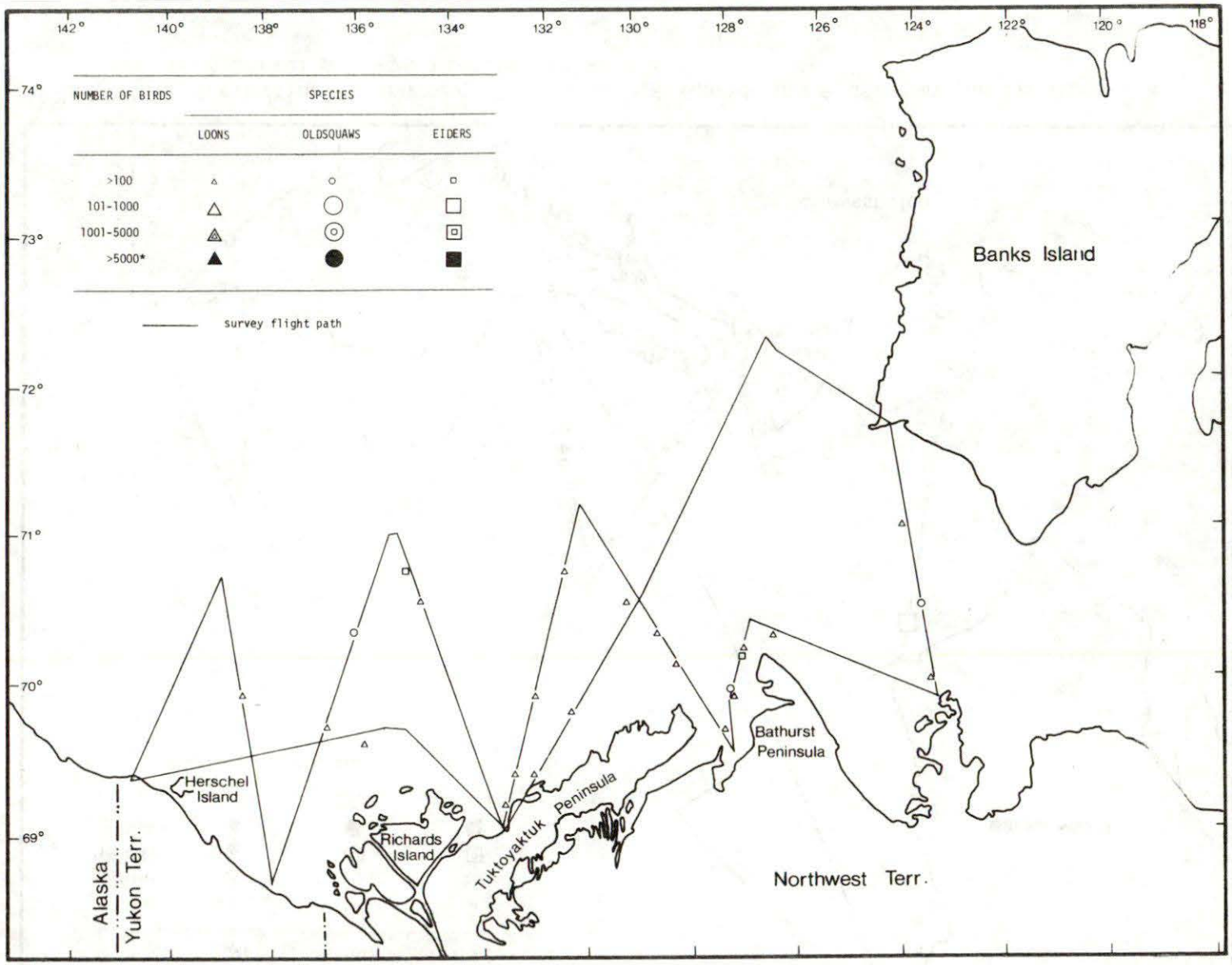

FIGURE 6. Distribution and numbers of loons, old squaws and eiders on the Beaufort Sea from aerial surveys in August, 1974.

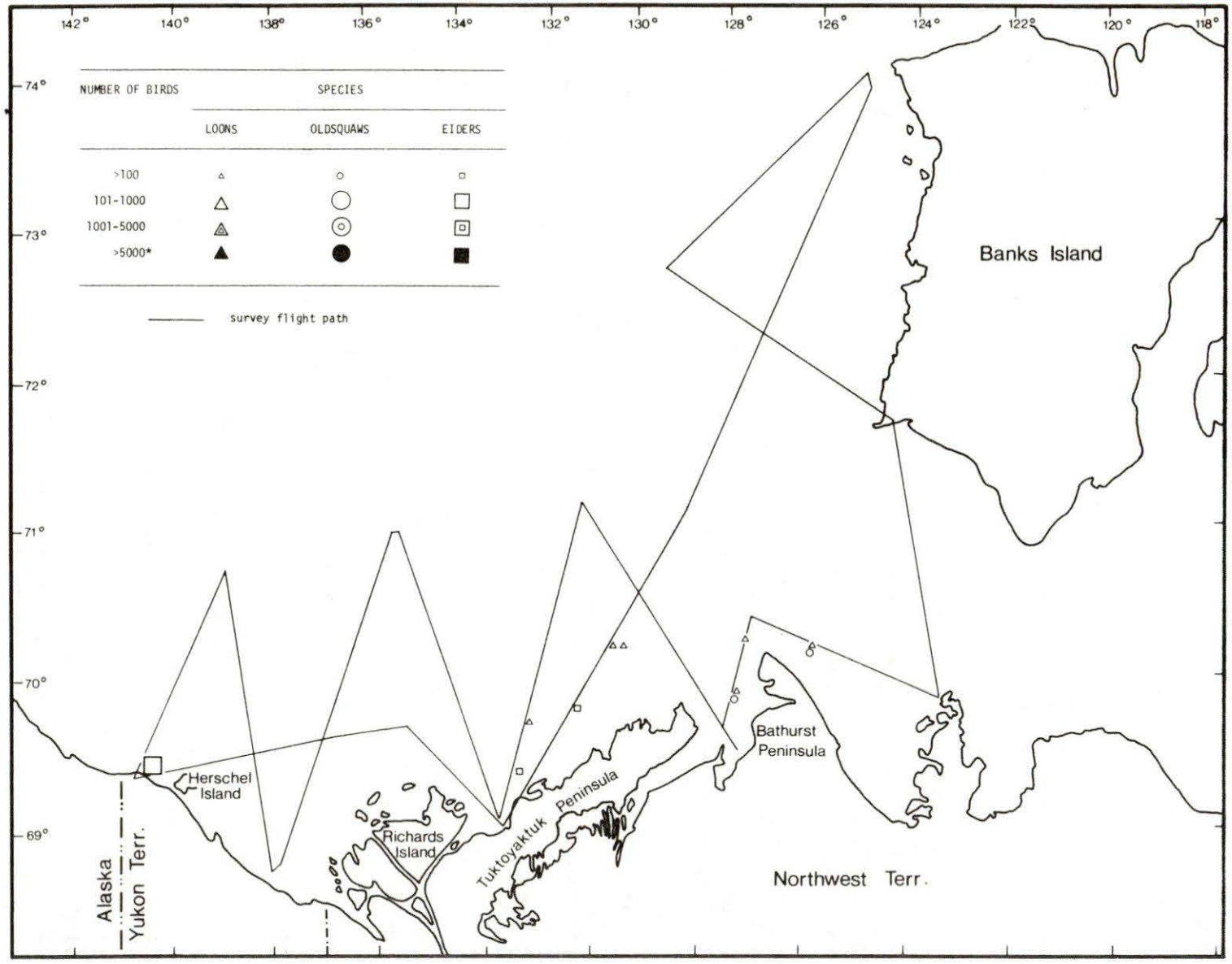

FIGURE 7. Distribution and numbers of loons, old squaws and eiders on the Beaufort Sea from aerial surveys in September, 1974.

No large numbers of scoters were seen during any survey month. Most sightings were in the large bays of open water along the coast. Few scoters were seen after the end of July, when their annual molt was completed.

6.1.3 Jaegers, Glaucous Gulls and Arctic Terns

The offshore distribution of jaegers only related to seasonal ice conditions during June and again in mid-August. At these times, more than 50 per cent of the jaegers observed were more than 100 km offshore in areas of little ice; the rest of the birds were sighted between 5 and 70 km from the coast.

In contrast, sea ice cover influenced the movements of glaucous gulls throughout the study period. The gulls were widely distributed across the southeastern Beaufort Sea - usually near open water. They concentrated in a large lead off Cape Dalhousie late in May and, similar to diving ducks, they dispersed during June with the return of heavy ice cover. At this time, the gulls frequented the ice-covered sea, sometimes more than 200 km from shore. During July, nearly all sightings of glaucous gulls were in the extensive system of leads along the mainland coast of the Beaufort Sea. The last gull sighted during offshore surveys in 1974 was in late September, in Kugmallit Bay; the bay had already begun to freeze.

Arctic terns were rarely observed offshore. Thus, it is difficult to evaluate the degree to which sea ice governs their movements and distribution. It is not known whether their relative scarcity over the Beaufort Sea was a result of the heavy ice conditions in 1974. Most of the Arctic terns observed were near the beaches - even in August when nearshore leads had developed.

The highest offshore density of seabirds was about 5 birds per square kilometre, in June, more than five times their density at any other time up to October (Figure 8). These birds probably represented migrating or newly arrived birds waiting for the snow to clear from their nesting sites. The likely shift of these ducks to shore sites in the breeding and molting season probably explains the rapid decrease in their densities offshore during late June and July.

6.2 Ice leads used as Seabird Migration Routes

Birds can migrate considerable distances in a short time. For example, eiders can migrate from the Bering Sea to the Beaufort Sea within two days. Birds are traditional and must rely on average weather conditions ahead, on their migration route. Snow geese that copulate on the sand-bars of the Mackenzie River, at Fort Good Hope, must anticipate the snow to clear from nest sites on Banks Island, 960 km away, one week later. Eiders leaving the edge of the ice in the Chukchi or Bering Sea rely on finding an open water lead off Baillie Island two days later. Such expectations are usually correct; open water, food and resting places are normally available. Subsequently, the birds have established a

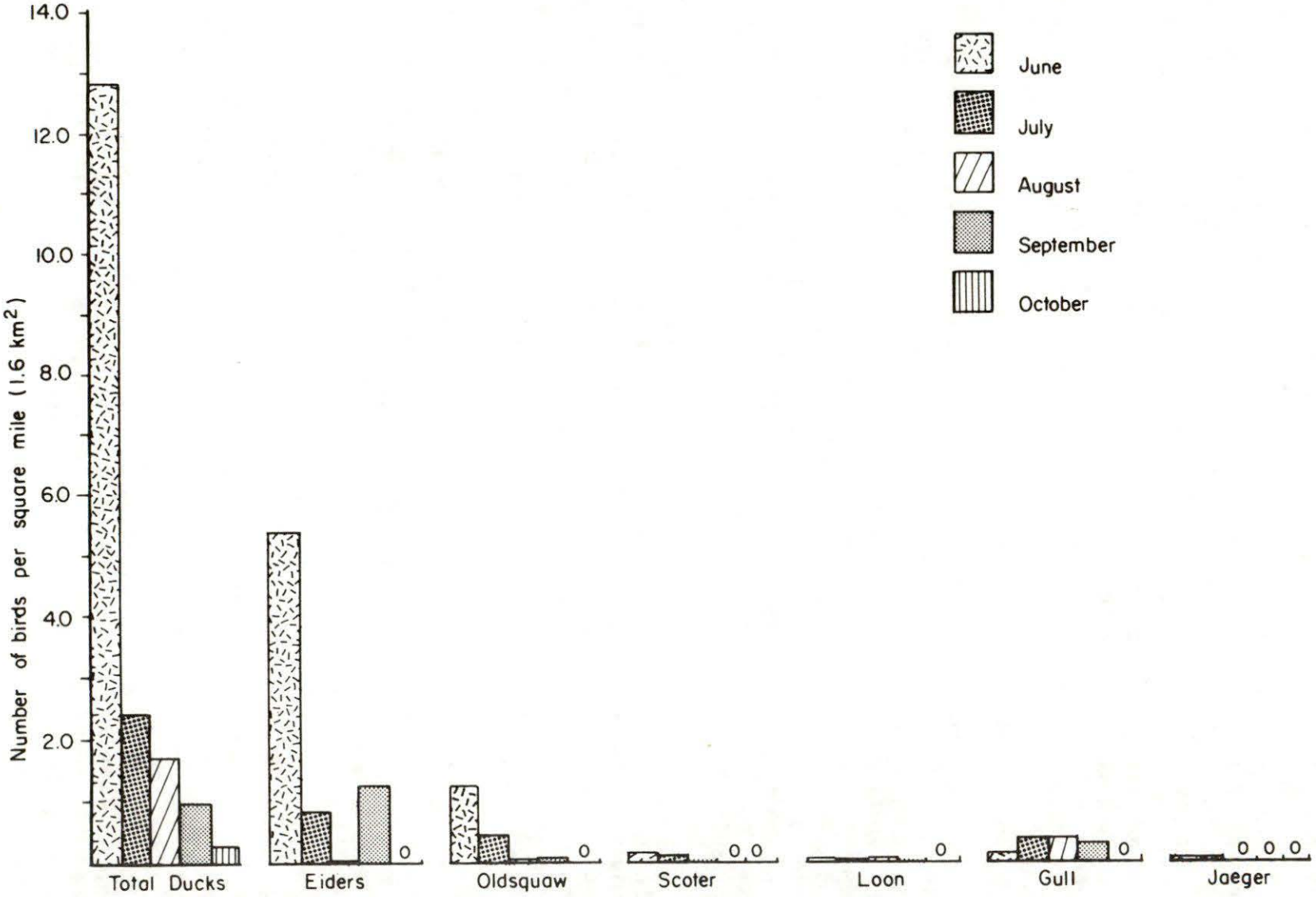

FIGURE 8. Observed Densities of waterfowl based on offshore aerial surveys of the southeastern Beaufort Sea in the summer of 1974.

traditional, if not instinctive, migration route from lead to lead.

Three leads, or polynyas, have formed in the Beaufort Sea at springtime in 17 of the past 18 years. As the season progresses, these leads widen, lengthen and usually join together before the shorefast ice moves seaward (Figure 9). The westernmost lead, usually the narrowest, forms near Herschel Island and curves to the northeast. The second lead forms off Cape Dalhousie, curves to the northeast past Baillie Island and then hooks towards Sachs Harbour, Banks Island. The third lead parallels the west coast of Banks Island; in some years, it extends southwestward to join the Herschel Island lead. The width of the leads is largely determined by wind. The prevailing polar easterlies assure lead formations nearly every year.

The only time that a lead did not form during the past 18 years was in the spring of 1964 - a late season marked with persistent onshore winds. From early April until late June there was no open sea water from west of Point Barrow, Alaska to Prince Patrick Island, and south to Coppermine. In other words, the entire Beaufort Sea and Amundsen Gulf had no open water. By May 20, starving eiders, loons and murres were reported on the ice and along the coast at Point Barrow, Mould Bay, Sachs Harbour. Holman Island, Anderson River, Tuktoyaktuk and Herschel Island. I estimated that 100,000 eiders and other marine birds died of starvation as a result of the complete ice cover.

Of the three leads in the Beaufort Sea, the Herschel Island lead is the least important to sea birds. It overlies water which is too deep for diving ducks to feed on the bottom. The Cape Dalhousie - Baillie Island lead and the Banks Island lead are shallow enough to permit bottom-feeding, and are also on direct routes to the nesting grounds further east and northeast. A comparison of bird densities (Figures 3 to 7) especially in May and June, illustrates the relative importance of the three leads.

A polynya, known to exist off Cape Parry from at least 1959 until 1970 (the author's personal observations), has not reappeared again. It may be that this once-regular patch of open water has shifted to become a part of the Baillie Island lead off Cape Bathurst. If this condition persists, it may affect future nesting success of the small colony of thick-billed murres at Cape Parry.

6.3 Coastal Movements, Distribution, and Numbers of Birds in 1974

Post-breeding activities of birds include molt migration, molting, staging and southbound migration. Depending upon the species, age and sex of the birds, these activities begin at different times. The lakes, bays and lagoons behind the barrier beaches of the Beaufort Sea coast are the locations for molting, brood-rearing and fall staging. Multiple regression techniques were applied to the results of bird surveys on the coastal tundra, lakes and other bodies of water in order to analyze the habitat requirements of birds nesting on the coastal plain. These analyses showed

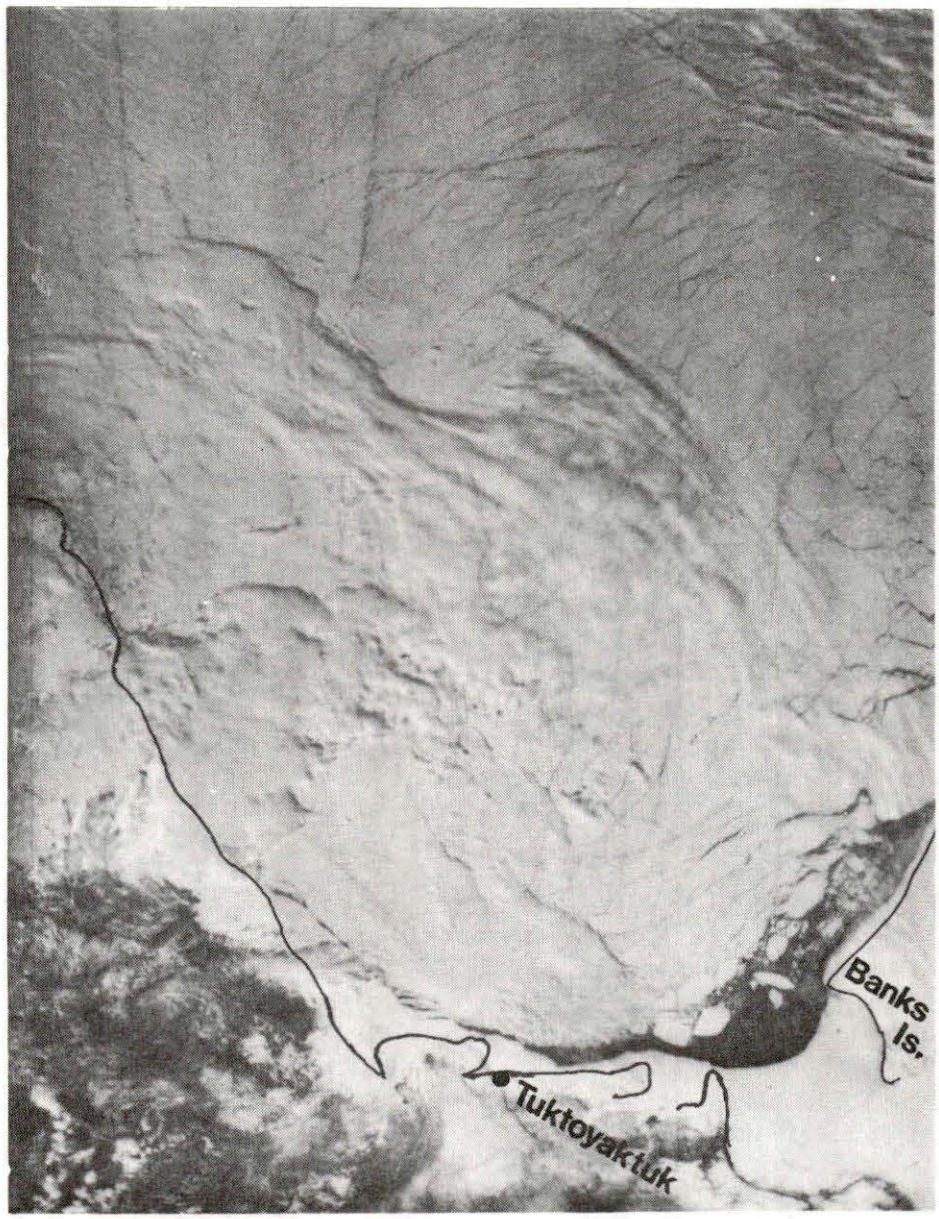

FIGURE 9. NOAA Satellite photograph of the Canada Basin on May 20, 1973.
Notice the dark area along the coastline and Banks Island. This is the extensive open water of polynyas and leads which persist during the spring of most years. (Source: Marko, J. 1975. Satellite Observations of the Beaufort Sea Ice Cover. Beaufort Sea Project Technical Report #34, 137 pp.)

that the numbers of red-throated loons, whistling swans and glaucous gulls found on the coastal water increased slightly during July, but declined thereafter. The numbers of arctic loons and oldsquaws frequenting the Beaufort coastal waters did not change significantly. All five species were more numerous on the larger lakes and lagoons than on the smaller ones.

Arctic loons and whistling swans appeared more frequently on fresh-water lakes than on other kinds of water. Swans also occurred in greater numbers in coastal bays than they did near beaches or islands. Fewer red-throated loons and glaucous gulls were seen near islands than in bays or near the shore. Oldsquaws were more often concentrated near beaches and in bays than on lakes.

Larger numbers of red-throated loons and glaucous gulls frequented the lakes near the sea than those further inland. The reverse was true for arctic loons and whistling swans. Arctic loons nest on the shores of larger, deeper lakes than red-throated loons and hence have a more stable food supply. Most ponds used by red-throated loons freeze to the bottom; for that reason, they must feed on fish at sea.

6.4 Species Richness of Seabirds in Coastal Water-bodies.

It is well known that the nature and diversity of a habitat affects the number of species that occupy it. Species richness (the number of different species found) is one measure of the importance of an area to wildlife. Changes in the numbers of species from year to year may reflect changes, whether from natural or artificial causes, in habitat quality.

In this study, 90 lakes and lagoons were classified as either fresh-water or marine. All lakes which were connected to the ocean by streams only were considered fresh water lakes. The species richness of each body of water is clearly related to the presence or absence of a connection to the ocean. The mean species richness was greater on lakes and lagoons with ocean access than on those that were land-locked. The average number of bird species per salt water lake was 6.80 ± 2.85 ($n = 286$), while the average number of species per fresh water lake was 4.91 ± 2.00 ($n = 245$).

The number of species on a body of water near the Beaufort Sea is related to its size. The number of species on the lakes tended to increase slightly during the early part of the survey period, but decreased substantially near the end of the surveys. This change is probably the result of migrations of male seabirds to the bays and beaches for their annual molt.

6.5 Species Composition and Associations of Seabirds in Coastal Water-bodies

The changing composition of the avian population in the Beaufort Sea during and after the breeding season reflects the seasonal requirements of the various species and, thus, the places and times during which

these species may be susceptible to the effects of environmental disruptions. For each category of lake or lagoon, and for lakes at varying distances from the coastal shoreline, the relative numbers of individual birds of different species, or species groups, were calculated. Gulls, dabbling ducks, diving ducks, geese and swans of the family *Anatidae* constituted more than 75% of the birds sighted.

Different species of birds frequently require, and seek out, similar habitats, resulting in strong correlations between the numbers of species present on different bodies of water. Such correlations can be assessed only after accounting for variables such as the date of observation and the characteristics of the water-bodies. For example, if two species did not happen to prefer similar habitats, both might occur in large numbers on large lakes solely because the size of the lake attracts greater numbers of birds.

Generally, the numbers of closely-related birds, such as geese and swans occurring at the same place, showed a high degree of correlation. Gulls were often sighted with terns. Most species of diving ducks were found with other diving ducks and with loons; the strongest correlation was between oldsquaws and scaup.

6.6 Critical Coastal Areas

The coastal surveys confirm what local Eskimos know, that is, that certain barrier beaches, bays, islands and lakes are more attractive to waterfowl than are others. The food habits, habitat requirements and behaviour of each species were not studied at each site. However, the fact that species richness declines inland from the barrier beaches indicates that the edge of the sea (the littoral zone) provides a habitat-mix suitable to a larger variety of species.

Other coastal areas examined during the coastal surveys were the littoral flats and marshes in river deltas. These places are intensively used for nesting, feeding, rearing young, and for autumn staging. Snow geese, brant, white-fronted geese, swans, dabbling ducks and many species of shorebirds concentrate in these flats and marshes, and represent what is probably the densest population of birds to be found in any Arctic habitat, except those on the bird cliffs of the eastern Arctic.

Specifically, the critical coastal areas are summarized in Table 4. Many major nesting areas are, of course, also used for molting, feeding and the rearing of young. The sites used primarily for molting are frequented by male ducks and geese which are too young to breed. Geese normally do not nest until they are three years old; the non-nesters gather in large flocks at traditional molting grounds. Male oldsquaws, scoters and scaup abandon the females once nesting has begun in the ponds inland; they migrate to larger lakes and coastal lagoons for their annual molt.

Beginning in early July, male king eiders and most male common eiders migrate westward to the Chukchi Sea for their annual molt. Female

eiders molt close to where they nest and rear their young.

6.7 Coastal migration of Seabirds, 1972

The 1972 migration watch was primarily intended to determine the extent of coastal migration. From only one point of observation near the sea, it was impossible to see the breadth of the stream of migrating birds. However, aircraft flights across the path of migration gave some rough estimates. The chance of seeing a single bird, or flock, varies with the size of the species and conditions of visibility. In this study, birds seen flying beyond the 0.8 km markers on the ice purposely were not counted or recorded.

TABLE 4. CRITICAL WATERFOWL AREAS OF THE COASTAL BEAUFORT SEA

Location	Major Species	Major Activity	Dates
Nunaluk Spit and coastal waters south of Herschel Island	Glaucous Gull	Nesting	June - Sept.
	Common Eider	Nesting	June - Sept.
	Scoter	Molting	July - August
	Oldsquaw	Molting	July - August
	Black Guillemot	Molting	June - Sept.
Phillips Bay	Glaucous Gull	Nesting	June - Sept.
	Whistling Swan	Nesting	June - Sept.
	Brant	Staging	September
	Arctic Tern	Nesting	June - August
Escape Reef	Glaucous Gull	Nesting	June - Sept.
	Arctic Tern	Nesting	June - August
Shoalwater Bay (Blow River Delta & Moose Channel Flats)	Whistling Swan	Nesting	June - Sept.
	Dabbling Ducks	Nesting	June - Sept.
	Shorebirds	Nesting	June - Sept.
	Snow Goose	Staging	September
	White-fronted Goose	Staging	September
	Brant	Staging	September
Pelly Island	Whistling Swan	Nesting	June - Sept.
	Glaucous Gull	Nesting	June - Sept.
	Brant	Nesting	June - Sept.
Kendall Island Migratory Bird Sanctuary	Snow Goose	Nesting	June - Sept.
	Brant	Nesting	June - Sept.
	Whistling Swan	Nesting	June - Sept.

TABLE 4 (Continued). CRITICAL WATERFOWL AREAS OF THE COASTAL BEAUFORT SEA

Location	Major Species	Major Activity	Dates
Harry Channel & Swan Channel	Whistling Swan	Nesting	June - Sept.
	White-fronted Goose	Nesting	June - Sept.
	Sandhill Crane	Nesting	June - Sept.
	Shorebirds	Nesting	June - Sept.
Kidluit Bay	Glaucous Gull	Nesting	June - Sept.
Hutchison Bay to Atkinson Point	Glaucous Gull	Nesting	June - Sept.
	Brant	Nesting	June - Sept.
	White-fronted Goose	Nesting	June - Sept.
	Oldsquaw	Molting	July - August
	Scoter	Molting	July - August
McKinley Bay	Whistling Swan	Nesting	June - Sept.
	White-fronted Goose	Molting	July
	Oldsquaw	Molting	July - August
	Scaup	Molting	July - August
	Scoter	Molting	July - August
Cape Dalhousie	Sabine's Gull (occasionally)	Nesting	June - August
	Arctic Tern (occasionally)	Nesting	June - August
Smoke, Moose and Kugaluk Rivers	Canada Goose	Molting	July
	White-fronted Goose	Molting	July
	Whistling Swan	Molting	July - August
	Oldsquaw	Molting	July - August
	Scaup	Molting	July - August
	Merganser	Molting	July - August
	Scoter	Molting	July - August
Anderson River Delta Migratory Bird Sanctuary	Snow Goose	Nesting	June - Sept.
	Brant	Nesting	June - Sept.
	White-fronted Goose	Nesting	June - Sept.
	Whistling Swan	Nesting	June - Sept.
	Shorebirds	Nesting	June - August
	Scaup	Molting	July - August
	Oldsquaw	Molting	July - August
	Scoter	Molting	July - August
	Glaucous Gull	Nesting	June - Sept.
	Parasitic Jaeger	Nesting	June - Sept.

TABLE 4 (Cont). CRITICAL WATERFOWL AREAS OF THE COASTAL BEAUFORT SEA

Location	Major Species	Major Activity	Dates
Mason River Delta	White-fronted Goose	Molting	July
	Whistling Swan	Molting	July - Sept.
Ikpisugyuk Point	Glaucous Gull	Nesting	June - Sept.
	Common Eider	Molting	July - August
	Scoter	Molting	July - August
	Oldsquaw	Molting	July - August
	White-fronted Goose	Molting	July
Harrowby Bay (Old Horton Riverbed)	Canada Goose	Molting	July
	White-fronted Goose	Molting	July
Langton Bay	Canada Goose	Molting	July
Cape Parry Migratory Bird Sanctuary	Murre	Nesting	June - Sept.
	Eider	Staging	May - June
Banks Island Migratory Bird Sanctuary # 1 (Kellett, Lennie & Big River deltas and bays)	Eider	Staging	May - June
	Oldsquaw	Molting	July- August

In spite of such observational limitations, the numbers of the more common species were roughly estimated from sightings at Cape Dalhousie between May 29 and June 16, 1972 (Table 5).

TABLE 5. SUMMARY OF BIRD OBSERVATIONS AT CAPE DALHOUSIE, MAY & JUNE, 1972.

Species	Numbers estimated from ground observations
Yellow-billed Loon	4,500
Arctic Loon	9,000
Red-throated Loon	200
Unidentified Loons	24,150
Pomarine Jaeger	6,200
Parasitic Jaeger	5,300
Long-tailed Jaeger	7,700
Glaucous Gull	35,400
Sabine's Gull	6,400
Arctic Tern	2,300
Oldsquaw	1,130,250
Common Eider	549,120
King Eider	695,115
White-fronted Goose	1,100
Canada Goose	9,350
Pacific Brant	21,885
Plover	6,400

6.8 Coastal Migration of Seabirds, 1975

Observations from May 12 to July 9, 1975 indicate that the spring migration along the Yukon Beaufort Sea coast occurs in two principal directions - eastward and westward. The radar confirmed that most seabird migrants move, more or less, parallel to the coast. However, there is a third group of migrants, namely, those moving northeast across the British Mountains and the North Slope of the Yukon, and then out over the Beaufort Sea. This third direction of movement usually involved far fewer flocks than did the eastward or westward flights.

6.8.1 Eastward Migration

The radar at Komakuk Beach detected eastward migrations of birds during almost every day of the study period, i.e. May 12 to July 9. At times, over one thousand eastbound groups of birds were detected. However, fewer birds moved east during mid-May than later in the season. The most intense and most prolonged eastward movement occurred between July 3 and 8. When observations ended on July 9, the volume of this eastward migration, as detected by radar, still seemed to be increasing.

Quite different seasonal patterns of migration were recorded by the ground observers at Clarence Lagoon and Komakuk.

Prior to May 27, the maximum rate of eastward migration during any one half-day period, at either Clarence Lagoon or Komakuk, was 12.5 birds per hour, as counted during the afternoon of May 23 at Komakuk. These were mostly unidentified shorebirds. More often, no birds were seen. At both Clarence Lagoon and Komakuk, eastward migration peaked during the period May 27 to June 13. More than 100 birds per hour were observed during seven half-day periods between May 29 and June 11. The most common birds sighted were brant, oldsquaw and pomarine jaeger.

The highest rate of movement observed, visually, during any one half-day period was 486 birds per hour; this was at Clarence Lagoon during the afternoon of June 7. At the same time, birds were passing Komakuk at the rate of 332 per hour. Again, brant, oldsquaw and pomerine jaeger were the most abundant migrants. After June 13, the eastbound migration rate at either site never exceeded 26 birds per hour. This maximum rate occurred at Komakuk during the afternoon of July 1. Most of the birds observed were oldsquaws and unidentified shorebirds.

The sharp decline of the eastward migration, detected by ground observers during the latter part of the study, was not supported by any similar decline in the numbers of birds detected by radar, either along the coast, over North Slope, or over the sea ice. Because of the limitations of visual observations, only an incomplete and biased picture of the eastward flow of migrants is possible.

6.8.1.1 Broad-front Movements

The radar showed large numbers of unidentified birds moving eastward, more or less parallel to the sea coast, along the shoreline, over the entire North Slope, and offshore to the 74 km limits of the radar's range. Often, smaller numbers of birds moved eastward over the British Mountains and their foothills.

The relative numbers of eastbound migrants detectable at different points varied considerably from time to time. Sometimes, the numbers of birds flying along the coast were not much greater than those flying at various distances offshore. At other times, eastward migrating birds along the shore numbered many more than those offshore. More commonly, however, there were fewer flocks inland.

The eastward movement of birds 20 km offshore occasionally equalled, but seldom exceeded migration along the coast. However, because of the greater breadth of the offshore movement, relative to the narrower coastal movement, the total number of flocks - and presumably the numbers of individual birds - were likely much greater over the sea than over the land and along the shore.

6.8.1.2 Species Composition

Aerial and ground observations were most useful in estimating the species composition of migrant flocks. The radar rarely indicated even

related groups of species. The species groups involved in the eastward migration are mostly seabirds and shorebirds that winter in the Pacific Ocean. Their route to nesting grounds in the Canadian Arctic is through the Bering Straits, around Alaska, and eastward to the Arctic Islands and along the mainland coast (Figure 10).

Glaucous gulls were the only species moving east in significant numbers between May 9 and 20; they passed ground observers at an average rate of 0.37 birds per hour. The absence of king eiders, during this period, is surprising. From their dates of departure, in an east/northeast direction, from Point Barrow, Alaska and across the Beaufort Sea, one would expect them to be moving eastward at the same time as the gulls. Aerial surveys on May 14 did not encounter eiders in small leads as far as 280 km north of Herschel Island. The eastward migrations detected by radar during this period probably consisted, largely, of glaucous gulls - a species reported to migrate over land as well as long the shoreline and over the sea.

From May 20 to 31, the predominant species moving east were brant (28.2 birds per hour), oldsquaw (10.7 per hour), glaucous gull (3.6 per hour) and pomarine jaeger (1.1 per hour). Shorebird movements commenced during this period, averaging 3.5 birds per hour: only the pectoral sandpiper was identified in significant numbers. Many birds were sighted during the last three days of May.

The dominant species involved in the late May migration eastward tend to fly close to the ground or ice. Because shorebirds migrate at moderate to high altitudes, they were more likely detected by radar.

Heavier eastward migration was recorded both by the observers on shore and by radar during the first ten days of June. Again, the most abundant species were brant (86.7 birds per hour), oldsquaw (22.3 birds per hour), Pomarine jaeger (9.4 birds per hour) and glaucous gull (4.7 birds per hour). Arctic and red-throated loons were also moving eastward at the rate of about 1.8 birds per hour. About one common eider, arctic tern and red phalarope passed each hour. Other species of shorebirds also occurred in significant numbers. Because shorebirds are relatively inconspicuous in size and colour, they may have been more common than visual observations would suggest.

An aerial survey over the Beaufort Sea on June 5 encountered more birds than in six subsequent aerial surveys, combined. Oldsquaws were by far the most common species, with a total of 4,274 counted. There were also 723 common eiders, 115 king eiders and 194 brant. Most birds observed from the aircraft were flying east.

Oldsquaws were the most common eastbound migrants between June 11 and 20, passing coastal sites at the rate of 12.3 birds per hour. Almost all the pomarine jaegers were seen before June 12, migrating east, at a rate of 4.1 birds per hour. Glaucous gulls continued to migrate at the rate of 3.3 birds per hour, eiders (mostly common) at 3.1 birds per hour, arctic terns at 1.5 birds per hour, brant at 1.5 birds per hour and loons at 1.4

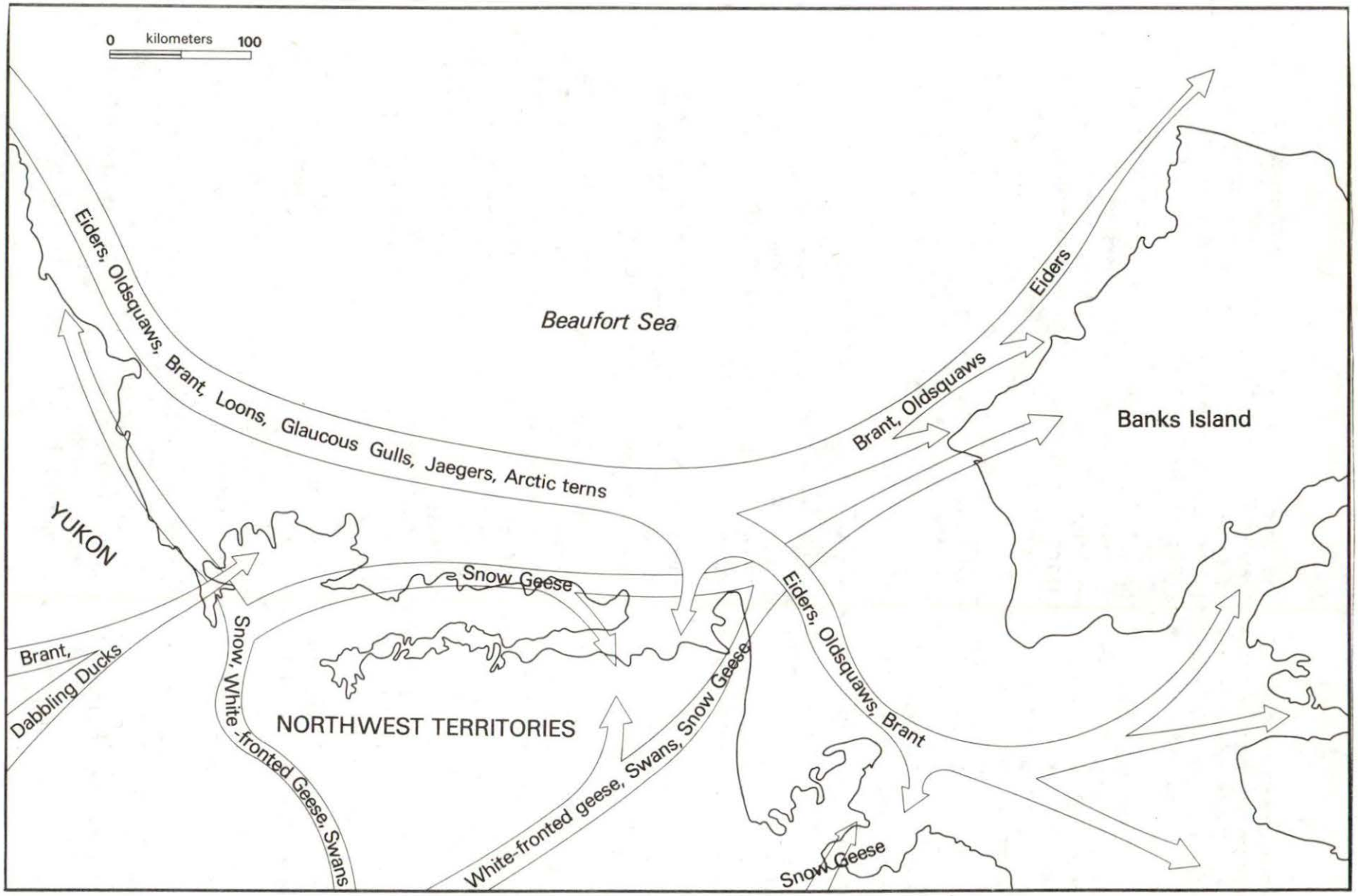

FIGURE 10. Inland and coastal routes of waterfowl spring migration in the Beaufort Sea.

birds per hour.

From June 21 to 30, field observers saw many fewer birds than they had seen during the three previous periods. The glaucous gull was the only species to pass at the rate of more than one bird per hour. However, the radar detected large numbers of unidentified birds migrating eastward during the same period. It is unlikely that they were glaucous gulls because these unidentified birds were travelling at moderate or high speeds and at altitudes of at least 100 m.

The oldsquaws were most abundant of the seabirds observed during the offshore aerial survey of June 26. The survey also reported a significant number of scoters, but most of them were westbound.

From July 1 to 9, small numbers of oldsquaws, glaucous gulls and brant were moving east. Their numbers were few compared with the eastward broad-front migration detected by radar over the Beaufort Sea and Yukon coast.

6.8.1.3 Migrant Flight Characteristics

Most of the migrating birds observed from shore moved parallel to the the coast. The radar often showed a concentrated movement of birds migrating eastward within one or two kilometres of the coast, as well as a broad-front eastward migration of lower density across the Beaufort Sea and along the North Slope. The birds that followed the coastline frequently changed course, according to the irregularities of the shore. For example, on July 8, 1975, several flocks moving east-southeast about 25 to 40 km offshore suddenly shifted course to a track closer to shore; presumably they 'jogged' in response to the sight of open water in a lead lying off Komakuk. Those involved in the broadfront movement offshore, or inland, tended to maintain straight, direct tracks.

6.8.2 Westward Migration

Ground observers saw few birds moving west before the end of May, and it was not until mid-June that they reported westward migrants in large numbers. The peak of westward flights occurred on June 21 when birds passed the observers at the rate of 127 per hour; almost all of these birds were unidentified scoters.

The seasonal pattern of the westward migration, observed from the shore, did not coincide with the pattern recorded on radar. Radar monitoring detected westward, as well as eastward movement nearly every day of the study.

6.8.2.1 Broad-front Movements

The radar showed that many birds moved west, more or less parallel to the coast, not only along the shoreline but also over the entire North Slope, and offshore to the limit of visual or radar detectability. Much

smaller numbers were travelling northwest over the northern part of the British Mountains south of Komakuk. As was the case with eastward migration, the radar indicated that large numbers of birds were moving west far beyond the vision of observers on the shore.

6.8.2.2 Species Composition

The species involved in the westward migration are those that winter in interior North and South America. Their migration route follows the Great Plains and the Mackenzie River Valley to the Beaufort Sea coast, thence west to nesting grounds in Alaska (Figure 10). Scoters and oldsquaws undertake a molt migration to Alaska, or to coastal lagoons.

Between May 9 and 20, almost no birds were seen moving west. Westbound migration increased considerably by the end of May, although the numbers of birds moving in a westerly direction were still much less than those moving east. Whistling swans, passing at the rate of 1.7 birds per hour, and white-fronted geese (at 1.0 per hour), were the principal westward migrants during this period. There was also some shorebird migration.

During the first ten days of June, the westward movement of swans continued at the rate of 0.7 birds per hour. Pintails predominated, at the rate of 3.2 birds per hour. More shorebirds were seen.

From June 11 to 20, the westward migration of pintails increased to a rate of 2.8 birds per hour. Relatively few whistling swans moved west after June 17. Scoters began to move west (1.0 per hour). Fewer shorebirds were moving west than in early June.

The most conspicuous westward movement during mid-June was that of pomarine jaegers and unidentified jaegers. Prior to June 12, almost all jaegers were observed moving east. After that date, they began migrating west at the rate of 14.6 birds per hour. The low numbers of lemmings (the jaegers' food) at their nesting grounds on Banks Island and Victoria Island may have resulted in a complete nesting failure and, subsequently, this 'reverse migration'.

In the last week of June, the birds which dominated westward migration were scoters (5.4 per hour), unidentified ducks (3.6 per hour), and pintails (1.5 per hour). Although westward movement of jaegers continued, fewer were seen compared with mid-June.

The movement of pintails westward virtually ceased between July 1 and 9. Scoters, predominantly surf scoters, moved at the rate of 2.5 per hour, and oldsquaws at 1.9 birds per hour. The aerial survey of July 3 was the first flight over the Beaufort Sea during which large numbers of scoters were seen : white winged scoters, 137; surf scoters, 82; and unidentified scoters, 289.

6.8.3 Northeastward Migration

Intermittent northeastward movements of birds were detected by radar from May 12 until early July.

6.8.3.1 Broad-front Movements

Whether over land or sea, the northeastward movements of birds were always on a broad front. The birds arrived over the British Mountains and the Brooks Range, and were often detectable 55 km, or more, south and southwest of Komakuk. Usually, they continued across the Yukon North Slope and coast with no change in direction. Once offshore,most of them continued to fly northeast until they passed beyond radar range 45 to 75 km offshore or dropped below the radar horizon. Occasionally, the birds would change direction from northeast to east after they had moved out to sea. There, they joined birds flying east.

6.8.3.2 Species Composition

There is little direct evidence bearing on the identification of the species of birds making northeastward flights. Brant are known to move from the Yukon River Basin in Alaska, over the mountains to the Beaufort Sea. Oldsquaws are the most common ducks to move northward down the tributaries of the Colville River and migrate eastward along the coast in large numbers; we may surmise that there is also a broad-front, northeastward movement over the mountains and the Beaufort Sea towards Banks Island. Shorebirds may also be among the migrants flying toward the northeast; they migrate nonstop for long distances and at high altitudes, routinely.

7. DISCUSSION

Birds are the most mobile of animals, and those found in the Arctic are truly "here today, gone tomorrow". Snow geese departing from the Mackenzie Delta on a September storm can be in Alberta the next day. Arctic terns travel from the Antarctic to the Arctic, and back again, in the course of a single year. Instinctively and without parental guidance, a young golden plover migrates from the shores of the Beaufort Sea to the east coast of Labrador, and thence over the Atlantic to Brazil and Argentina.

The mobility of the birds is deceptive. Despite their speed and their great range over the globe, they are vulnerable to disaster. Because the life history, distribution, physiology and behaviour are different for each species found in the Beaufort Sea, their vulnerability occurs at different places and different times.

The birds are most vulnerable during migration, nesting, and the rearing of young. Certain species have unique characteristics which bring them into peril. Swans and cranes, among other waterfowl, molt all at once; their flightlessness is dangerous. The loon, scarcely adapted to life on land, cannot escape from enemies unless he takes off from water.

The general tendency of almost all the birds of the Beaufort Sea to gather in flocks for particular activities, such as copulation and courtship, nesting, feeding, molting, and in preparation for migration, leaves them open to mass destruction from agencies as diverse as weather and pollution.

Because of the vast differences in the points of vulnerability, an oil spill or an oil blowout can affect birds of the Beaufort Sea in a multitude of ways, as outlined below :

7.1 Migration

Most of the true seabirds of the Beaufort Sea arrive in mid-May and in June, flying offshore from lead to lead, eastward and northeastward, around northern Alaska, Yukon Territory and Northwest Territory. These species are the yellow-billed loon, Arctic loon, red-throated loon, oldsquaw, king eider, common eider, Pacific brant, guillemot, murre, glaucous gull, Sabine's gull, Arctic tern, parasitic jeager, long-tailed jaeger, pomarine jaeger, and various shorebirds. Some nest on the edge of the Beaufort Sea or further inland to the south; others continue on as far as the Queen Maud Gulf or the high Arctic Islands before nesting.

Of these birds, only the loons,oldsquaw, eider, guillemot, murre and glaucous gull are regularly encountered in the open leads offshore. The others, such as the shorebirds, more commonly migrate from river delta to river delta where the spring run-off water first occurs, or fly over the seascape directly to the Arctic Islands.

The birds using the leads, however, account for approximately two million individuals. In 1964, when there were no open leads, 100,000 eiders starved. On one day in May, 1974, 175,000 oldsquaws, eiders and loons were massed in the open water off Cape Dalhousie and Baillie Island.

Oil trapped in the leads would be as disastrous to these birds as were the closed leads of 1964 for the eiders. Since few king eiders nest south of the Beaufort Sea, virtually the entire western population of that species could be adversely affected by an oil spill in the offshore leads. At the same time, the only population of murres that nest in western Canada - those migrating to Cape Parry - would be decimated.

The birds that migrate down the Mackenzie River and then westward to nesting grounds in Alaska are not commonly found in open leads. Whistling swans, white-fronted geese, pintail ducks and shorebirds rest and feed on the tundra, or in the coastal lagoons. They would be endangered only if an oil spill or oil blowout occurred in the fall, fouling the beaches and lagoons before freeze-up.

7.2. Nesting

Brant, snow geese, shorebirds and eiders that happen to nest in

the littoral zone of the Beaufort Sea - a zone marked by the line of driftwood - risk being flooded out by a storm tide before the eggs hatch or the young can swim or fly. Although storm tides rarely occur before the young hatch, nesting in this zone is always a gamble. If an oil spill or oil blowout occurred in August or September - the usual period of storm tides - onshore winds would push oil over the entire littoral zone, spoiling it for nesting throughout the following seasons. The species that would be the most seriously affected by pollution of beaches, lagoons and tidal marshes are :

(1) Pacific brant. The nests of all the mainland birds are found within inches of the normal tide-line, and the young are raised, and molt, within the littoral zone.

(2) Snow goose. Two of the three major nesting colonies in the western Arctic, Anderson River and Kendall Island which, between them, accommodate up to 16,000 nesting birds annually, are in littoral zones subjected to storm tides nearly every year. Their nesting grounds could hardly escape contamination by an oil spill dispersed by fall storms.

(3) Glaucous gull. Approximately half of the population nests and raises its young on barrier beaches and islands.

(4) Arctic tern. About 75% of the population nests on barrier beaches, islands and delta marshes.

(5) Parasitic jaeger. At least half of the birds along the Beaufort Sea coast nest within the littoral zone.

In addition to the foregoing species, about a quarter of the population of oldsquaws, numerous shorebird species, dabbling ducks and passerines nest in the marshes of river deltas where grasses and sedges would trap any large quantities of oil. A few common eiders nest on barrier beaches near Herschel Island, Baillie Island and Cape Parry and thus are vulnerable to such pollution.

7.3 Molting

Waterbirds that molt their entire flight feathers at one time risk mass destruction from oil contamination. During the flightless period, they gather in large flocks in the coastal lagoons. Molting scaup, oldsquaws and scoters, numbering in some years up to 600,000, have been found in the coastal waters of Tuktoyaktuk Peninsula and the Yukon, where the brackish lagoons are rich in vertebrate food species.

White-fronted geese, snow geese, Pacific brant and Canada geese that are too young to nest, gather in large flocks to molt on the lush littoral marshes of the river deltas and bays. The grasses and sedges, which is their food supply, could be easily contaminated by oil deposited onshore by storm surges.

7.4 Autumn Staging Areas

Up to 500,000 snow geese, white-fronted geese and brant gather simultaneously on the flats of the outer Mackenzie Delta, between Richards Island and the Blow River. They arrive in late August and remain throughout much of September. This country is critical in the birds' preparation for their southward migration. The young geese feed almost continuously, gaining about one-quarter of their body weight, and becoming strong on the wing. The adults regain weight which was lost during the incubation and annual molt. About every four years, storm tides innundate much of the outer Mackenzie Delta, and any residue of oil resulting from such storm tides could destroy the vegetation on which the geese feed, as well as many of the birds themselves.

8. CONCLUSIONS

About 100 species of birds use the Beaufort Sea and its littoral zone. Their patterns of migration, feeding, resting and nesting are complex. As species, they range in numbers from the ubiquitous oldsquaw and eiders to the rare ivory gull. Observations made over the years have established that some birds arrive in the Beaufort Sea as early as April, and some depart as late as December. This means that the region is habitable by migratory birds for up to three-quarters of the year.

In the spring, about ten major species of seabirds, numbering over 2 million individuals, use the open leads between the landfast ice and the pack ice. In addition, radar studies reveal that uncounted numbers migrate on a broad front at high elevations, overflying the Beaufort Sea.

Loons and other species, which cannot take off from land and are dependent upon water for food, are attracted to any open water in the ice. Seabirds traditionally use open leads which currents and winds usually cause to appear each spring. The lead which forms nearly every year off Herschel Island is used for resting. The shallower lead off Cape Dalhousie and Baillie Island is used both for feeding and resting; large numbers of eiders, oldsquaws and loons concentrate there.

Important places for the rearing of broods and the annual molt of adults are protected bays and lagoons behind barrier beaches, such as those adjacent to McKinley Bay on Tuktoyaktuk Peninsula. These sites are especially favoured by scaup, white-wing scoters, surf scoters and oldsquaws. The littoral zone of Ellice and Olivier Islands, Moose Channel flats, Anderson River Delta and Harrowby Bay flats are heavily used for nesting, feeding, rearing young and autumn staging.

9. RECOMMENDATIONS

Apart from the obvious precautions of taking care and enforcing tidiness in oil operations, and of avoiding certain times and places for activities that might endanger the birds and their habitat, there are a few remedies that might be tried in the event of an oil spill or oil blowout which pollutes the leads and the littoral zone of the Beaufort Sea:

(1) Masking foams might be used to cover polluted leads and local areas of beaches, in order to discourage birds from using their traditional places whilst they are still contaminated.

(2) Scaring devices might keep birds away from contaminated places where they would normally congregate.

(3) Clean-up of barrier beaches and lagoons might be successful, to a degree, if the work takes advantage of land formations and known water currents and tide. For example, at Atkinson Point, a storm tide washes over the sandspit into Louth and McKinley Bays. The bays are shallow (less than 2 metres), but the receding tide flows through a network of tidal channels. Craft designed to remove oil might be successful in these areas under favourable conditions.

(4) Since "de-oiling" of birds has never been successful in any climate - and in the Arctic would be expensive and futile - contaminated birds should be killed promptly to end their misery.

10. FURTHER STUDY

(1) A study of inshore and littoral zone tidal currents in critical bird habitat should prove useful for the deployment of clean-up equipment. Since most of the critical areas are somewhat protected from heavy seas, a clean-up can begin while a storm is still in progress. Shallow-draft vessels (1 metre or less) and barges would be required.

(2) It would be desirable to study precisely the use which seabirds make of the leads during the spring. Such a study would require a camp on the edge of the ice, and expensive logistical support.