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Distribution of Bowhead Whales in the Beaufort Sea, Summer 1983.

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DISTRIBUTION OF BOWHEAD WHALES AND OTHER MARINE MAMMALS IN THE SOUTHEAST BEAUFORT SEA, AUGUST-SEPTEMBER 1983

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SUMMARY

Systematic aerial surveys were conducted in the southeast Beaufort Sea on 19-24 August and 6-11 September 1983 to document the numbers and distributions of bowhead whales and of other marine mammals. The study area extended from 141°W (Alaska-Yukon border) eastward to 128°40'W (near Cape Bathurst), and from the 2-m depth contour northward to about 25 km north of the 100-m depth contour, except between 141°W and 138°W where the northern boundary was at 70°20'N. The northernmost 25-km sections east of 138°W also extended beyond the 200-m depth contour, and thus included the steep shelf break beyond the shallow continental shelf.

As before, the study area was divided into three survey-blocks - namely the Yukon Zone, the Delta Zone, and the Tuktoyaktuk Peninsula (Tuk. Pen.) Zone and a systematic grid of 24 north-south survey lines, was established, with survey lines spaced at 20-km intervals, so that each zone included eight survey lines. The survey altitude was 152 m (500 ft.) above sea level (ASL), the transect width was 2 km, and the survey coverage was 10%. On 22 August, two additional transects were flown at distances of 1 km and 3 km from the Yukon coast between Shingle Point and Stokes Point to document the presence of a large concentration of bowhead whales in that area.

BOWHEAD WHALE

A total of 56 bowhead whales were observed during the surveys on 19-24 August; an additional 86 bowheads were recorded during the survey along the Yukon coast on 22 August. Extrapolation and correction of these counts suggest that an estimated 1,487-1,880 bowheads were present in the study area in late August, including 430-823 bowheads in an area 37 x 10 km along the Yukon coast centred on King Point. Most of the remainder were in offshore waters at least 20 km from the coastline; an estimated 660 animals were in the Tuktoyaktuk Peninsula Zone and about 400 animals in the Yukon and Delta zones. During this survey, little evidence of migration was noted.

During the survey on 6-11 September, 50 whales were counted and extrapolation and correction of this count resulted in an estimate of 1,751 bowheads then present in the study area. All bowheads seen were offshore and all but three of the animals

counted were in the eastern half of the study area. Most were in a 55-km wide band between 70°40'N and 71°10'N. Unlike the August survey, no bowheads were seen along the Yukon coast. An estimated 1,080 bowheads were present in the Tuk. Pen. Zone, but only 56 bowheads were estimated to have been present in the Yukon Zone. Many of the bowheads seen were swimming rapidly to the southwest, indicating that fall migration was beginning.

The observed distribution of bowhead whales did not suggest that the animals were concentrated at the shelf break beyond the continental shelf; however, during the 6-11 September survey, bowheads may have been concentrated in waters 50-100 m in depth. Although no relationship between bowhead distribution and degree of ice cover was apparent, close pack ice west of Herschel Island on 6-11 September may have been responsible for the low numbers of whales in the Yukon Zone during that survey. Only one bowhead calf was observed during the surveys.

Comparison of the 1983 results with those from the previous three years indicates that the distribution of bowhead whales in the southeast Beaufort Sea varies substantially, both within and between years. In late August 1980, bowheads were common in shallow waters (< 50 m in depth) off the eastern Mackenzie Delta and Tuktoyaktuk Peninsula, with only small numbers present further west. In 1981, bowheads were generally distributed evenly throughout the study area, although they were most common in deeper waters (> 100 m in depth) north and northwest of the delta. In 1982, they were most numerous north and northeast of Herschel Island, particularly at the shelf break, with smaller numbers far offshore of the Tuktoyaktuk Peninsula. In none of these years were bowheads seen along the Yukon coast. In early September 1980, numbers of bowheads off the Tuktoyaktuk Peninsula were much lower than in August and the whales were somewhat further offshore, whereas their numbers near Herschel Island had increased. In 1981, bowheads had moved closer to shore off the Tuktoyaktuk Peninsula than they had been in August and they had become numerous around Herschel Island. In 1982, the largest concentrations were north and northeast of Herschel Island, with small numbers elsewhere in the study area.

The distribution of bowhead whales in the southeast Beaufort Sea is influenced by an array of factors, including ice conditions and the availability of food. Heavy ice may exclude bowheads from a specific region. In open water areas, the distribution of zooplankton concentrations may be an important determinant in the distribution of bowheads. But, there is little information about the availability of zooplankton in the Beaufort Sea. In the absence of such

information, it is not possible to evaluate if offshore oil exploration is affecting the distribution of bowheads in the southeast Beaufort Sea.

WHITE WHALE

Fifty white whales were recorded during the systematic survey on 19-24 August, most of which were either in the shallow coastal and estuarine waters or far offshore in waters exceeding 200 m in depth. Of more than 850 white whales recorded during the survey on 6-11 September, most (750 animals) were in one large group about 95 km north of Mackenzie Bay. The remainder were all far offshore, mostly in waters more than 200 m deep. The highly non-random distribution of the animals and the lack of data on surface and subsurface times of white whales in deep non-estuarine waters preclude the determination of the numbers of whales in the study area during the surveys.

SEALS

Ringed seals and bearded seals were observed regularly during the survey on 6-11 September, mostly in the eastern half of the study area. The densities of both species were higher in the Tuk. Pen. Zone than in either of the other two zones. Ringed seals appeared to avoid water exceeding 100 m in depth and many of the larger herds (up to 30 animals) were along or near, the 50-m depth contour. Several groups of ringed seals were associated with flocks of seabirds. Most bearded seals seen in the Delta and Tuk. Pen. zones were at least 100 km offshore, whereas most seen in the Yukon Zone were within 30 km of the coast. Many were hauled out on ice pans in waters greater than 50 m in depth.

RÉSUMÉ

Des levés aériens effectués de façon systématique dans le secteur sud-est de la mer de Beaufort afin de dénombrer les baleines et autres mammifères marins et d'en étudier la répartition, ont été réalisés du 19 au 24 août 1983 et du 6 au 11 septembre 1983. La région à l'étude s'étendait de 141°O. (frontière Alaska-Yukon) vers l'est jusqu'à 128°40' O. (près du cap Bathurst), et de l'isobathe de 2 m vers le nord jusqu'à environ 25 km au nord de l'isobathe de 100 m, à l'exception de la zone située entre 141° O. et 138° O., où la limite boréale se trouvait à 70°20' N. Les sections de 25 km les plus au nord, à l'est du 138° O., s'étendaient aussi au-delà de l'isobathe de 200 m et comprenaient par conséquent l'accore escarpé au-delà du plateau continental peu profond.

Suivant la méthodologie établie au cours des années précédentes, la région à l'étude était divisée en trois zones (zone du Yukon, zone du Delta et zone de la péninsule de Tuktoyaktuk). Pour ce faire, on a dressé une grille systématique de 24 lignes orientées nord-sud et espacées de 20 km chacune; chaque zone comprenait 8 lignes. Les levés ont été réalisés à une altitude de 152 m au-dessus du niveau de la mer, et la largeur des transects était de 2 km. On a couvert 10 pour-cent de la superficie à l'étude. En plus de levés systématiques, on a survolé, le 22 août, deux transects à une distance de 1 km et de 3 km du littoral, entre la pointe Shingle et la pointe Stokes (Yukon), pour recueillir des données sur la présence de baleines boréales, rassemblées en grand nombre dans cet endroit.

BALEINE BORÉALE

On a observé au total 56 baleines boréales au cours du levé systématique exécuté du 19 au 24 août; et le 22 août, 86 autres baleines boréales ont été dénombrées au cours d'un levé le long de la côte du Yukon. Après avoir extrapolé et corrigé ces chiffres, on estime qu'il y avait de 1,487 à 1,880 baleines boréales dans la région à l'étude à la fin d'août, dont de 430 à 823 étaient regroupées dans une zone de 37 x 10 km, surtout près de la pointe King le long du littoral. La plupart des autres baleines se trouvaient au large des côtes, à 20 km au moins de la côte; on estime que 660 se trouvaient dans la zone de la péninsule de Tuktoyaktuk et 400 dans les zones du Yukon et du Delta. Au cours de ce levé, aucun signe de migration n'a été remarqué.

Cinquante baleines ont été comptées au cours du levé effectué du 6 au 11 septembre. Après avoir extrapolé et corrigé ce chiffre, on estime à 1,751 le nombre de baleines boréales trouvées à l'intérieure de la région à l'étude. Toutes les baleines, sauf trois, ont été vues au large des côtes dans la moitié est de la région à l'étude. Elles étaient regroupées, pour la plupart, dans une bande de 55 km de large, comprise entre 70°40' N. et 71°10' N. Contrairement au levé fait en août, on n'a observé aucune baleine boréale le long du littoral du Yukon. Le nombre de baleines boréales a été estimé à 1,080 dans la zone de la péninsule de Tuktoyaktuk, mais à 56 seulement dans la zone du Yukon. Un grand nombre d'entre elles se déplaçaient rapidement vers le sud-ouest signe du début de la migration d'automne.

D'après l'évaluation de la répartition observée des baleines boréales, rien n'indique que ces mammifères s'étaient regroupés le long de l'accore se trouvant au-delà du plateau continental peu profond; il se pourrait toutefois que les baleines se soient rassemblées dans les eaux de 50 à 100 m de profondeur au moment du levé exécuté du 6 au 11 septembre. Bien qu'il n'y ait, semble-t-il, aucune relation entre la répartition des baleines et l'épaisseur de la glace, la présence d'une banquise épaisse à l'ouest de l'île Herschel entre le 6 et le 11 septembre pourrait expliquer le nombre peu élevé de baleines observé à cette date-là dans la zone du Yukon. Un seul baleineau a été remarqué au cours des levés.

En comparant les résultats des levés aériens réalisés en 1983 avec ceux des trois années précédentes, on constate que la répartition des baleines boréales dans le secteur sud-est de la mer de Beaufort varie énormément, d'une époque de l'année à l'autre et d'une année à l'autre. A la fin d'août 1980, les baleines boréales étaient nombreuses dans les eaux peu profondes (50 m) au large de la partie est du delta du Mackenzie et de la péninsule de Tuktoyaktuk mais elles étaient plus rares à l'ouest.

En 1981, elles étaient réparties à peu près également dans la région à l'étude, bien que plus nombreuses en eaux profondes (> 100 m) au nord et au nord-ouest du Delta. En 1982, on en comptait davantage au nord et au nord-est de l'île Herschel, particulièrement le long de l'accore et elles étaient beaucoup moins nombreuses, plus loin au large de la péninsule de Tuktoyaktuk. Au cours de cette même période, aucune baleine boréale n'a été aperçue le long du littoral du Yukon. Au début de septembre 1980, on en remarquait moins dans les environs de la péninsule de Tuktoyaktuk. Ces mammifères étaient un peu plus éloignés de la côte qu'en août; cependant ils étaient aussi plus nombreux près de l'île Herschel. En 1981, les

baleines s'étaient rapprochées de la péninsule par rapport à leur position au mois d'août et leur nombre avait augmenté autour de l'île Herschel. En 1982, les concentrations les plus grandes ont été observées au nord et au nord-est de l'île Herschel, alors qu'elles étaient faibles partout ailleurs dans la région à l'étude.

La répartition des baleines boréales dans le sud-est de la mer de Beaufort dépend de divers facteurs, notamment l'état des glaces et les réserves de norriture. Une glace épaisse peut en effet interdire l'accès d'une région aux baleines boréales; par ailleurs, la répartition des baleines reste liée à la présence de zooplancton. Mais comme on possède peu de renseignements sur les réserves de zooplancton dans la mer de Beaufort, il reste difficile d'évaluer l'influence de l'exploration pétrolière sur la répartition de ces mammifères marins dans le sud-est de la mer de Beaufort.

BÉLUGA

Cinquante bélugas ont été dénombrés au cours du levé systématique exécuté du 19 au 24 août. Ils se trouvaient pour la plupart dans les eaux côtières et estuariennes peu profondes ou, loin au large, dans les eaux dont la profondeur dépasse 200 m. Plus de 850 bélugas ont été comptés entre le 6 et 11 septembre, mais la plupart de ces mammifères (soit 750) formaient un seul groupe se déplaçant à environ 95 km au nord de la baie Mackenzie. Les autres restaient loin au large, dans les eaux de plus de 200 m de profondeur. A cause de la répartition inégale des bélugas et de l'absence de données sur la durée de leur émersion et de leur immersion en eaux profondes non estuariennes, il a été très difficile de les dénombrer.

PHOQUE

On a régulièrement aperçu des phoques annelés et des phoques barbus entre le 6 et le 11 septembre. La plupart d'entre eux étaient massés dans la moitié est de la région à l'étude; la densité de ces deux groupes était plus élevée dans

la zone de la péninsule de Tuktoyaktuk que dans les deux autres zones. Les phoques annelés semblaient éviter les endroits où la profondeur de l'eau dépaissait 100 m et de nombreux groupes, comptant au moins 30 animaux, se trouvaient à proximité ou au-delà de l'isobathe de 50 m. Plusieurs groupes de phoques annelés ont été associés à des volées d'oiseaux de mer. La plupart des phoques barbus observés dans les zones du Delta et de la péninsule de Tuktoyaktuk se trouvaient au moins à 100 km de la côte alors que ceux de la zone du Yukon ont été repérés à moins de 30 km de la côte. Un grand nombre d'entre eux s'étaient hissés sur la glace flottante dans des eaux de plus de 50 m de profondeur.

INTRODUCTION

The ongoing presence of industrial activity, including hydrocarbon exploration, in the southeast Beaufort Sea has raised concerns about the potential for disturbance of marine mammals in the region, especially the bowhead whale (Balaena mysticetus). In response to these concerns, the oil industry has been sponsoring research on the marine mammals that inhabit the area. Since 1980, systematic aerial surveys have been conducted annually in August and September in the southeast Beaufort Sea to document the distributions and numbers of bowhead whales and other marine mammals. The results of the surveys from 1980 to 1982 have been presented in Renaud and Davis (1981), Davis et al. (1982), and Harwood and Ford (1983). The present report gives the results of surveys conducted in late August and early September 1983.

The bowhead whale is a large baleen whale that inhabits cold northern waters. Historically, there were five substantial populations - Western Arctic, Davis Strait-Baffin Bay, Hudson Bay, Okhotsk Sea, and Spitzbergen (Marquette 1977; Mitchell and Reeves 1981) - but intense exploitation by commercial whalers seriously reduced the numbers of all populations. The Western Arctic population (or Bering Sea stock) is the focus of the present study. It is the largest remaining population but is considered to be 'endangered' under the U.S. Endangered Species Act, and is also considered to be endangered in Canada.[1]

Breiwick et al. (1980) estimated that the original stock size of the Western Arctic population of bowhead whales ranged between 14,000 and 26,000 animals; recent estimates of the minimum size of the population include 3,114-3,987 animals, based on spring counts at Barrow (Dronenburg and Carroll 1983), and 2,983-3,842 animals, based on aerial surveys of summering areas in the Canadian Beaufort Sea in 1981 (Davis et al. 1982). The Scientific Committee of the International Whaling Commission considers 3,871 (standard error, s.e. $\pm$ 254) to be the best estimate of present population size.[2]

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1 Committee on the Status of Endangered Wildlife in Canada.

2 International Whaling Commission, in preparation.

The Western Arctic bowheads winter in the Bering Sea. In spring, they enter the Canadian Beaufort Sea through recurring leads that are far offshore. Some animals then move south along the coast of Banks Island into Amundsen Gulf in June and early July (Fraker 1979; Braham et al. 1980). In late July and early August, there is a westward movement of bowheads out of Amundsen Gulf and a southward movement out of the northern Beaufort Sea into the southeast Beaufort Sea (Fraker 1979; Davis et al. 1982). During August and the first half of September, animals are present in waters north of the Mackenzie Delta and the Tuktoyaktuk Peninsula (Renaud and Davis 1981; Davis et al. 1982; Harwood and Ford 1983). Westward migration from Canadian waters into the Alaskan Beaufort Sea occurs during the last half of September and early October.

Several other species of marine mammals are present in the southeast Beaufort Sea in summer. The Mackenzie estuary stock of the white whale (Delphinapterus leucas) summers in the Canadian Beaufort Sea region, especially in the estuary of the Mackenzie River (Fraker and Fraker 1979, 1981, 1982). These animals leave the estuary in late July and early August and move offshore to join other animals that summer in the offshore pack ice or in Amundsen Gulf (Davis and Evans 1982). Westward migration from the Beaufort Sea to wintering areas in the Bering Sea is mostly through offshore waters remote from the coast. Ringed seals (Phoca hispida) and bearded seals (Erignathus barbatus) are year-round residents in the Canadian Beaufort Sea, although some individuals migrate out of the area in fall. Both species prefer areas with moderate to heavy ice cover; their distribution during the open water season is incompletely understood. Polar bears (Ursus maritimus) and walruses (Odobenus rosmarus) have also been reported in the study area in summer (Harwood and Ford 1983). The distribution of each of these species, as indicated by sightings in summer 1983, is summarized in the following sections.

METHODS

TIMING AND PATTERN OF SURVEYS

Systematic aerial surveys were conducted on 19-24 August 1983 and on 6-11 September 1983. The study area extended from 141°W (Alaska-Yukon border) east to 128°40'W (near Cape Bathurst), and from the 2-m depth contour north to about 25 km north of the 100-m depth contour, except between 141°W and 138°W where the northern boundary was 70°20'N. The northernmost 25-km sections east of 138°W also extended beyond the 200-m depth contour, and thus included the steep shelf break beyond the shallow continental shelf. Recent studies have suggested that bowheads concentrate over, and slightly offshore of, the 'shelf break' (Davis et al. 1982; Richardson et al. 1983). With the exception of these areas north of the 100-m depth contour, this area was the same as that was surveyed in 1982 (Harwood and Ford 1983), and included all of the 1980 study area (Renaud and Davis 1981) and part of the 1981 study area (Davis et al. 1982).

In conformity with previous surveys (Davis et al. 1982; Harwood and Ford 1983), the study area was divided into three survey-blocks (Fig. 1). A grid of 24 north-south survey lines was established, with survey lines spaced at 20-km intervals, so that each survey-block included eight survey lines. Survey coverage was 10%, based on a transect width of 2 km (see Survey Techniques). Information pertaining to the survey lines is presented in Appendix 1.

The first survey was conducted on five days from 19-24 August 1983. All lines were surveyed, with the exception of the easternmost line (along 128°42'W). In addition to these lines, on 22 August two transects were flown at distances of 1 and 3 km from the Yukon coast between Shingle Point and Stokes Point to document the presence of a large concentration of bowhead whales in the area.

The second survey was conducted on four days from 6-11 September 1983, during which time all survey lines were flown. Both surveys were begun in the westernmost part of the study area, and, with the exception of one day during the first survey, progressed from west to east. On some occasions the start and end points (latitudes) of transects were altered because of local fog or undercast conditions (see Appendix 1).

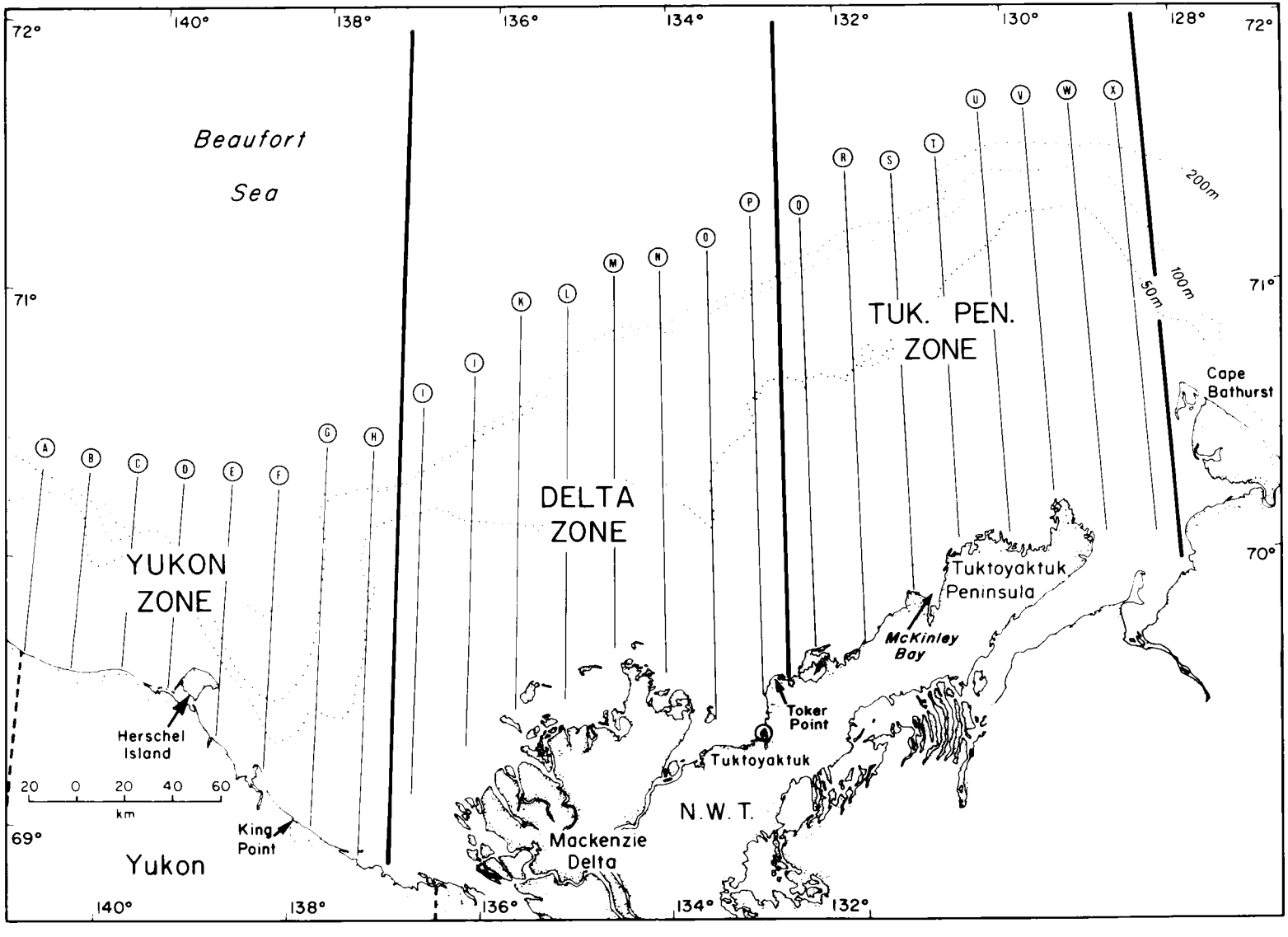

Fig. 1. Transect lines and zones of the study area.

SURVEY TECHNIQUES

Aerial surveys were flown in a deHavilland Twin Otter (Series 300), operated by Kenn Borek Air Ltd., Inuvik, Northwest Territories. The aircraft was equipped with a radar altimeter for precise maintenance of survey altitude and a Collins LRN-70 (VLF Omega) navigation system for accurate navigation. An automatic pilot was also used. As well, the aircraft was equipped with two bubble windows on the left side, one located two seats behind the pilot and the other at the rearmost seat behind the passenger door. The bubble window provided the left side observer with enhanced forward and vertical visibility.

All surveys were conducted at an altitude of 152 m (500 ft) ASL. Although it was originally intended to conduct the surveys at an altitude of 305 m (1,000 ft), low cloud ceilings necessitated the use of the lower altitude to complete the surveys in a sufficiently short period to avoid biases resulting from major population movements. Even on the few transects when conditions would have allowed higher survey altitudes, the same 152-m altitude was maintained. It was felt that this uniformity of flight altitudes would provide the most consistent results for both the whale surveys and water colour studies.

The surveys were conducted at a ground speed of about 185 km per hour or 100 knots (kts). Although speeds of up to 240 km/h have been used in previous surveys (Renaud and Davis 1981; Harwood and Ford 1983), the slower ground speed provides the observers with a longer time to find and count whales. This extra time is important when surveys are conducted over moderately rough waters.

The transect width used during the surveys was 2 km, consisting of two strips extending from 100 to 1,100 m from the flight line on each side of the aircraft. The strip of 0 to 100 m on each side of the aircraft has reduced visibility from both the front right and left side (bubble window) seats and thus was not considered as part of the transect. The results of the 1981 surveys (Davis et al. 1982) indicated that the optimum transect strip for bowhead surveys at an altitude of 152 m was 100 to 1100 m on each side of the aircraft.

SURVEY PROCEDURES

All surveys were conducted using two observers. One occupied the front right (co-pilot's) seat whereas the other occupied a seat on the left side of the aircraft. During the first survey, the left-side observer occupied the second left seat behind the pilot, whereas during the second survey, the left-side observer was in the rearmost seat, behind the passenger door. As stated above, both of these seats were equipped with bubble windows. Communication between observers was maintained by means of an intercom system.

Both observers recorded into portable tape recorders all sightings of marine mammals. Each sighting included information on species, numbers, presence of calves (if detectable), group type, direction of movement or orientation, behaviour, sighting cue, and general and specific ice conditions. In addition, the lateral distance from the transect line of each bowhead seen was determined using a Suunto PM-5/360S inclinometer. The geographic location of the sighting was determined using an interval timing system with signals every 2 min and digital watches, which compared the time of the sighting with the start and end times of the transect lines. This position was checked by noting the location of the aircraft as indicated on the Collins LRN-70. At every 2-min interval along the transect, the ice cover, sea state, and observation conditions were also recorded.

SURVEY CONDITIONS

WEATHER CONDITIONS

Previous surveys in the Beaufort Sea have indicated that weather conditions play an important role in the ability of observers to detect marine mammals. Surveys can only be conducted when the ceiling is sufficiently high (at least 152 m for the surveys flown in 1983, see Methods), when there is no heavy precipitation, and when surface fog is absent. As well, when skies are clear, low sun angles can often produce severe glare conditions. During the survey on 19-24 August, one or more of these conditions rendered observation impossible for 196.2 km^2 (or 2.9%) of the 6,811.2 km^2 of transect lines surveyed. During the survey on 6-11 September, impossible observation conditions were encountered for 682.2 km^2 (or 9.4%) of the 7,281.4 km^2 of transect lines surveyed. Areas where impossible observation conditions were encountered are denoted on the distribution maps in the Species Accounts.

SEA STATE

Previous surveys of bowhead whales in the Beaufort Sea also showed that the state of the sea affects the ability of observers to detect marine mammals. Davis et al. (1982) quantified this effect: they found that in 1981 there was a generally declining trend in bowhead whale densities as sea state increased. They concluded that sea states of two or less on the Beaufort Scale resulted in optimal surveying conditions, and that, as much as possible, surveys should not be attempted in sea states of five or higher. The sea conditions encountered during the aerial surveys in 1983 are summarized in Table 1. Conditions were much less favourable for observing animals during the first survey on 19-24 August - when less than 50% of the transect segments surveyed were in a sea state of two or less - than during the second survey on 6-11 September - when more than 82% of the transect segments surveyed had a sea state of two or less. An evaluation of the effects of sea state on detectability of bowhead whales during the surveys in 1983 is presented in Appendix 2.

TABLE 1

Sea surface conditions (Beaufort Sea) encountered during aerials urveys in the southeast Beaufort Sea, August-September 1983

Sea State (Beaufort Scale)	19-24 Aug. 1983 Area of Survey (km^2)	(%)	6-11 Sept. 1983 Area of survey (km^2)	(%)
0	13.8	0.2	1,127.2	17.1
1	540.6	8.2	2,420.4	36.7
2	2,631.6	39.7	1,890.6	28.6
3	2,246.8	34.0	877.8	13.3
4	926.0	14.0	270.0	4.1
5	256.2	3.9	13.3	0.2

ICE CONDITIONS

Information on ice conditions during the surveys in 1983 was available from three sources. First, NOAA satellite imagery was available when satellite passes coincided with clear weather conditions. Secondly, information was available from aircraft patrols conducted by the Atmospheric Environment Service. Thirdly, data on ice conditions during the surveys were routinely recorded every 2-min by the observers in the aircraft; these observers recorded the average ice cover during the preceding 2-min period.

Figure 2 is a NOAA image showing the ice conditions in the eastern Beaufort Sea on 22 August 1983. Ice conditions based on the percentage of ice cover recorded by the observers during each of the two surveys are presented in Figures 3 and 4. During the survey on 19-24 August, the pack ice remained to the north of the study area, although some open pack ice was present in the north-central portion of the area (see Fig. 3). By the time of the second survey on 6-11 September, however, substantial amounts of ice had moved into the study area. Much of the western third of the study area (Yukon Zone) was covered by pack ice exceeding 75% cover (see Fig. 4). Ice was also present in the northeasternmost portion of the study area, including close pack ice (> 90%) north of 71°35'N. As well, small pieces of brash ice were present in much of the waters north of 70°40'N.

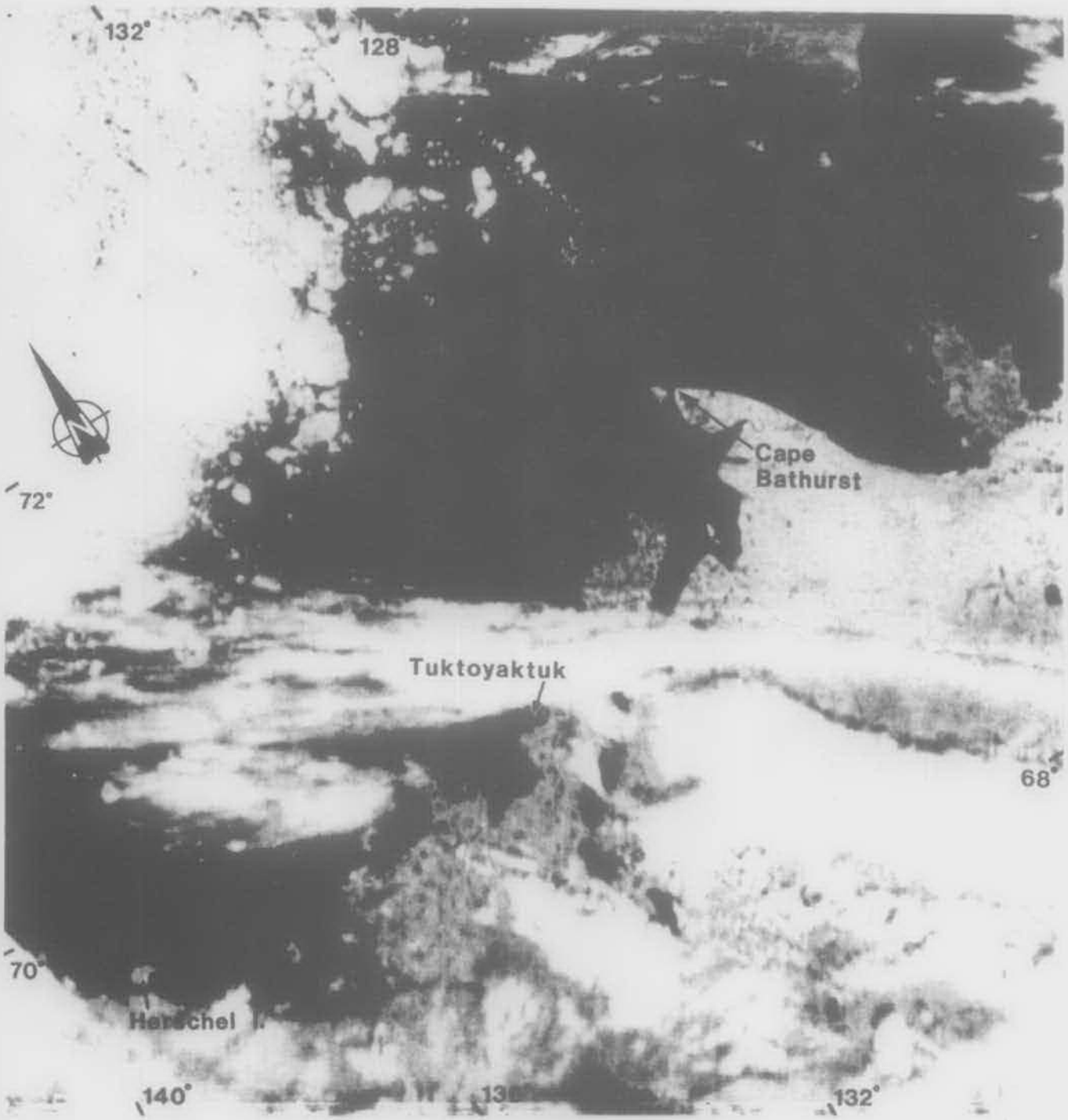

Fig. 2. Ice conditions in the southeastern Beaufort Sea, 22 August 1983 (NOAA satellite image).

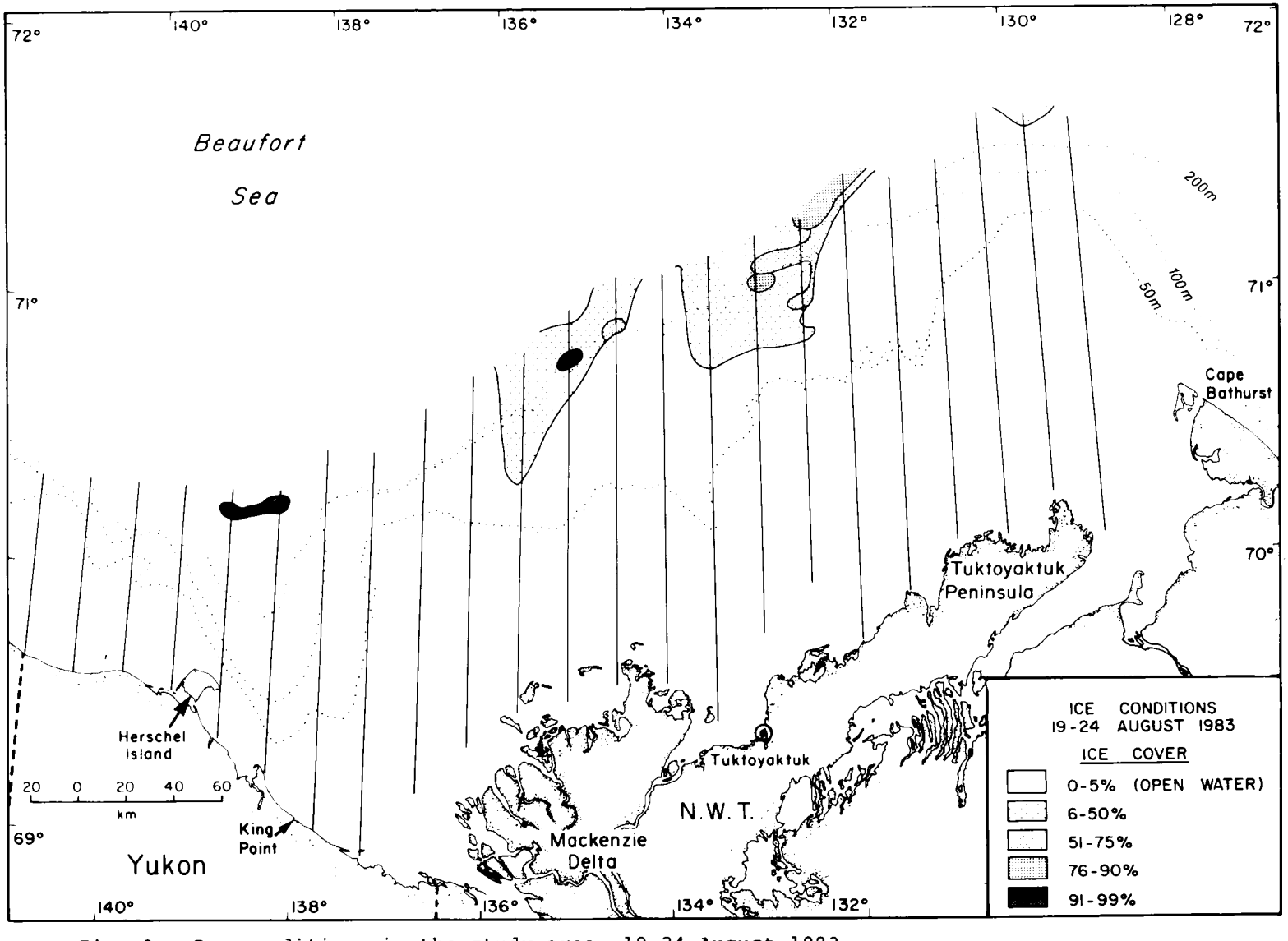

Fig. 3. Ice conditions in the study area, 19-24 August 1983.

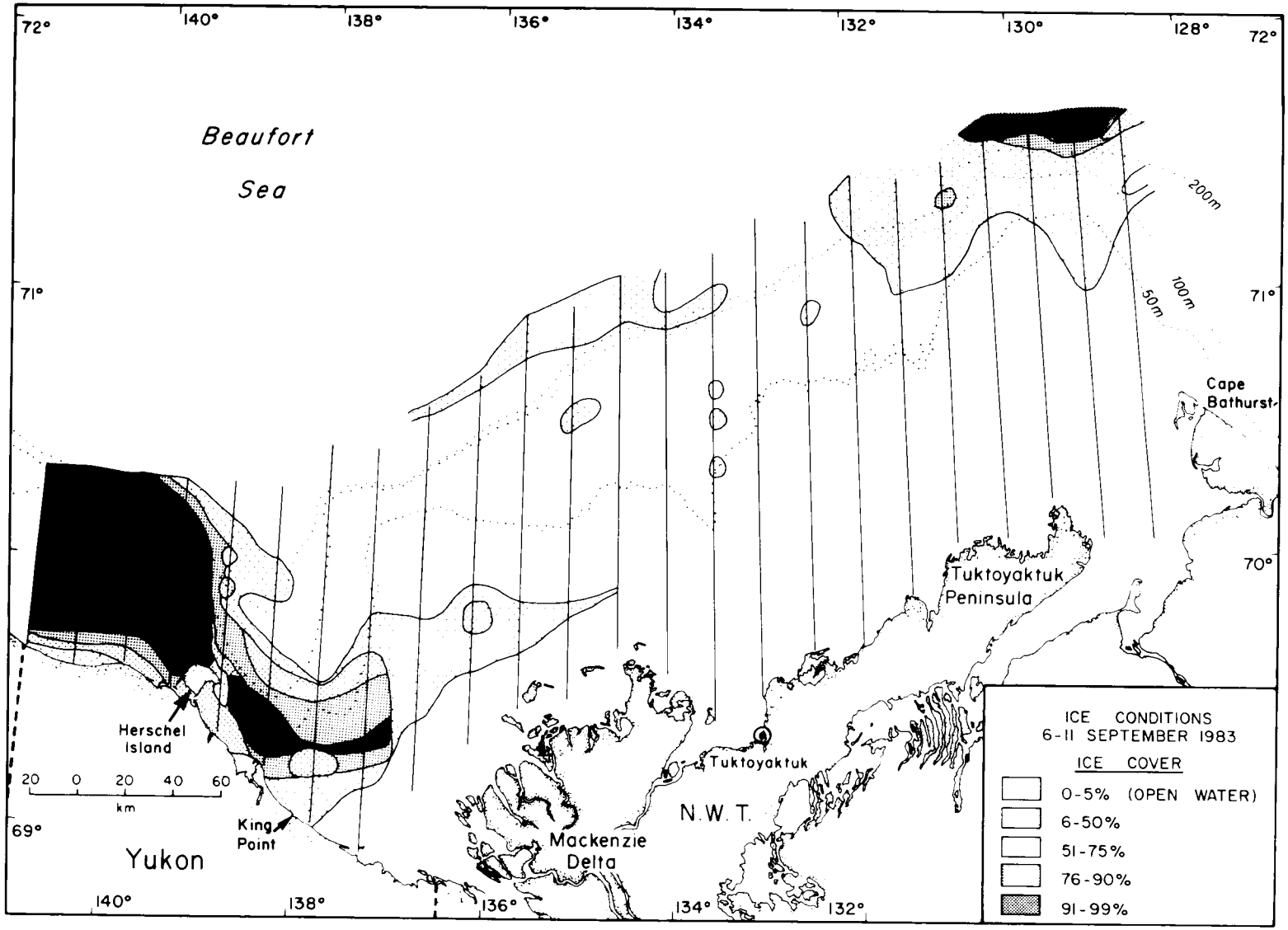

Fig. 4. Ice conditions in the study area, 6-11 September 1983.

SPECIES ACCOUNTS

BOWHEAD WHALE

Distribution and Movements

19-24 August 1983. A total of 56 bowhead whales were observed during this survey of which 39 were within the 2-km wide transect strip (i.e., they were on-transect). Bowheads were distributed widely throughout the study area, from Herschel Island in the west to the easternmost survey line (129°14'W) in the east (Fig. 5). However, 24 of these animals, including 22 on-transect, were seen during one 2-min transect segment near King Point, Yukon Territory, and were part of a large group of bowheads present along the Yukon coast in late August. Most of the remainder were seen in offshore waters at least 20 km from the coastline, from 69°50'N in the south to 71°30'N in the north. Including the 22 animals seen in nearshore waters near King Point, the density of bowhead whales during the survey on 19-24 August was 5.9 whales per 1,000 km^2; excluding the nearshore concentration, the density was 2.6 whales/1,000 km^2.

With one exception, all sightings of bowhead whales seen in offshore waters during the survey on 19-24 August were of single animals. On 24 August, a group of three animals was seen off-transect at 71°16'N, 130°15'W. No calves were seen during the survey.

None of the 24 bowheads seen during the nearshore transect segment off the Yukon coast exhibited any directional movement. Of the remainder, the direction of movement, if any, of 15 animals was recorded. Eight were stationary, including all five animals seen within 30 km of the Yukon coast north of Shingle Point. The direction of movement of the remaining seven animals is listed in Table 2. The distribution of directions of the moving whales during the survey was random (Rayleigh test, $r = 0.143$, $z = 0.143$, $n = 7$, $p > 0.05$).

6-11 September 1983. A total of 50 bowhead whales were seen during this survey of which 29 were on-transect. The density was 4.4 whales/1,000 km^2. However, bowheads were not distributed evenly throughout the study area during this survey. All but three animals (i.e., 47) were recorded in the eastern half of the study area, east of 135°W (Fig. 6). West of that longitude, the density was 0.3 whales/1,000 km^2; east of 135°W, the density was 7.7 whales/1,000 km^2. Unlike the August survey, no animals were seen along the coast of the

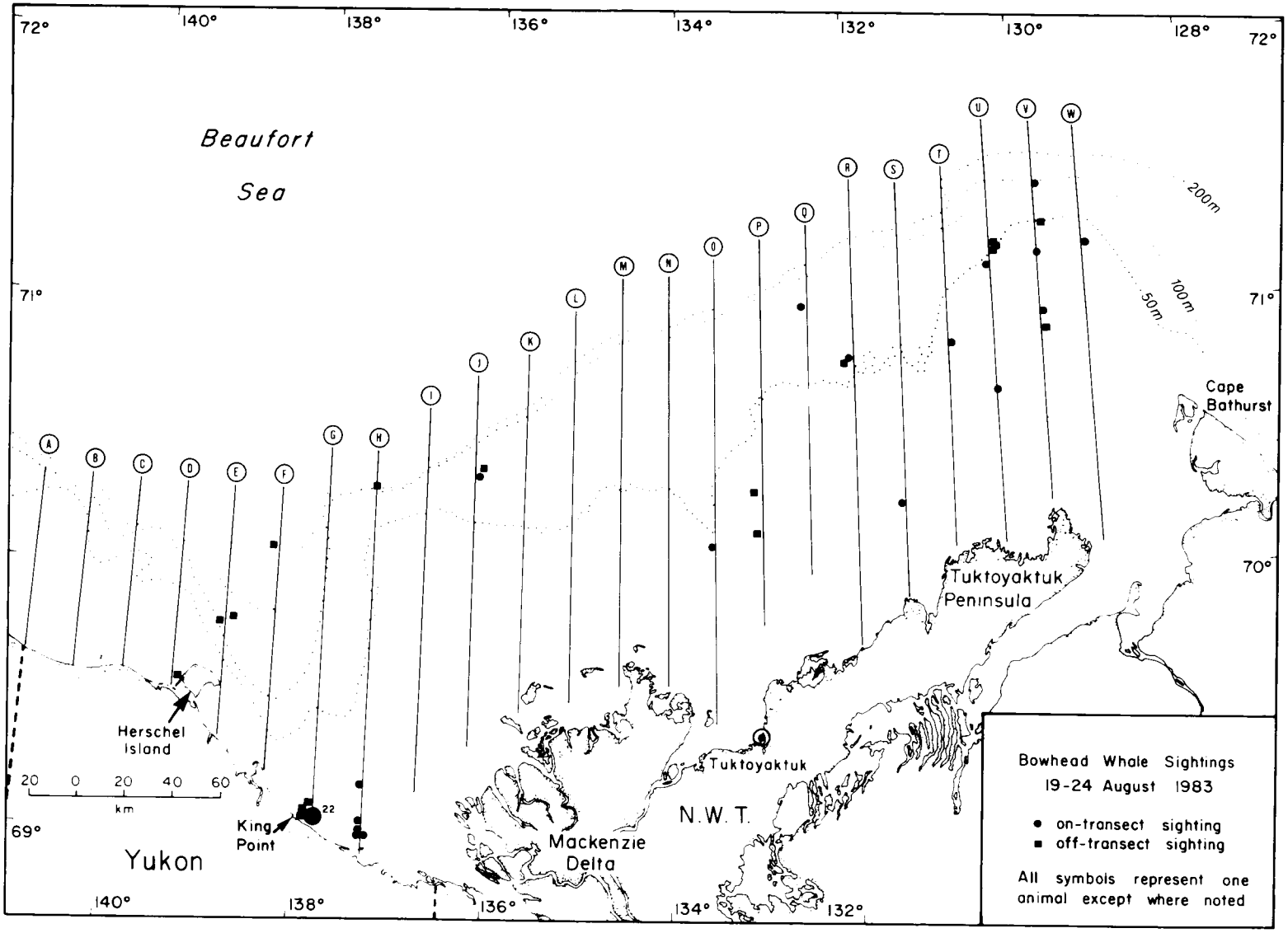

Fig. 5. Bowhead whale sightings in the study area, 19-24 August 1983.

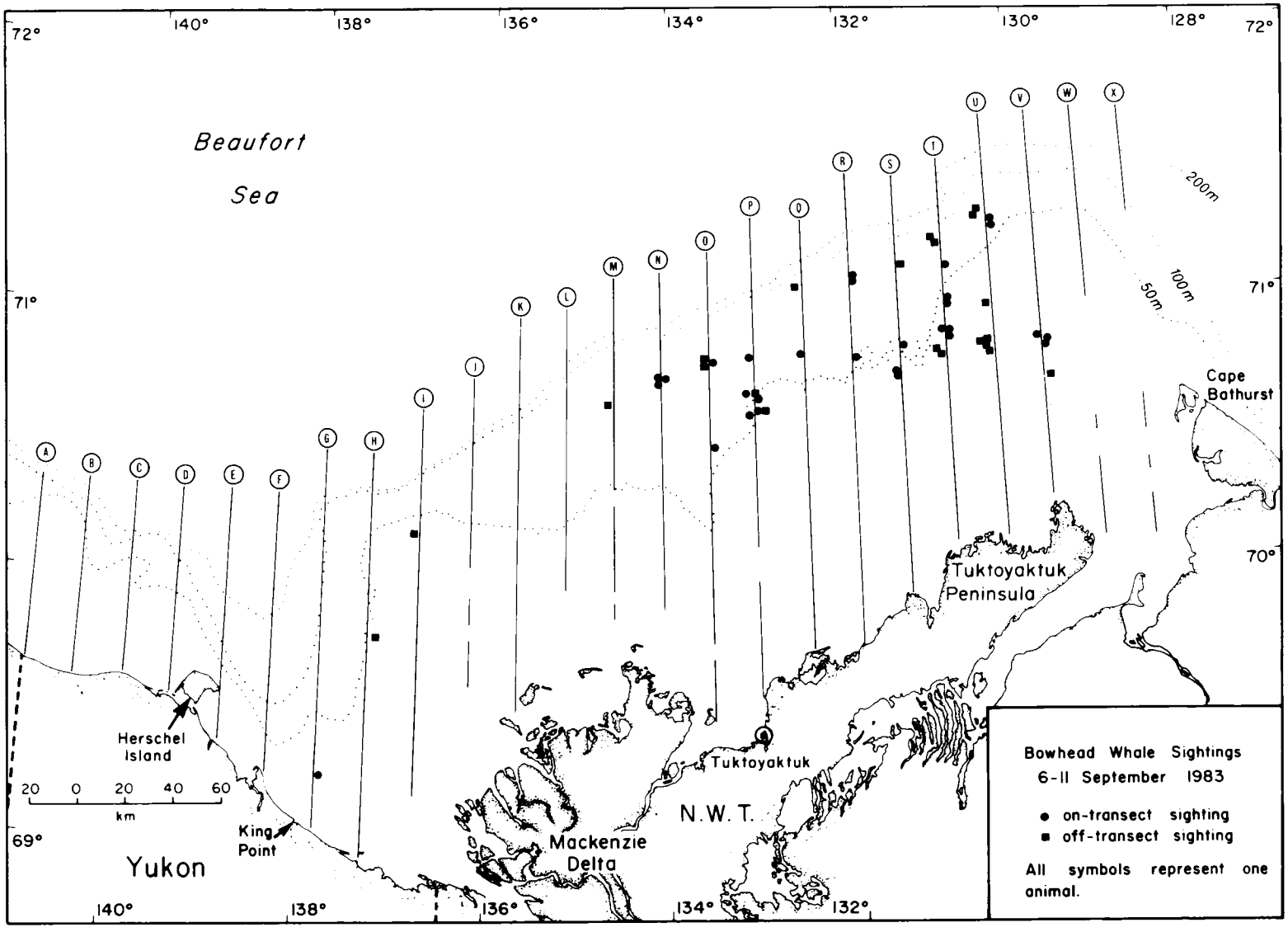

Fig. 6. Bowhead whale sightings in the study area, 6-11 September 1983.

Yukon Territory. All the whales seen in the eastern half of the study area were north of 70°30'N and 40 of the 47 were seen in a 55-km wide band from 70°40'N to 71°10'N (see Fig. 6). All were single animals except for eight groups of two whales. One of these couples included an adult and a calf.

TABLE 2

Direction of movement of bowhead whales recorded during aerial surveys in the southeast Beaufort Sea

Direction	19-24 Aug. 1983		6-11 Sept. 1983	
	No. whales	%	No. whales	%
N	1	6.7	4	14.8
NE	0	-	0	-
E	1	6.7	0	-
SE	2	13.3	0	-
S	1	6.7	2	7.4
SW	0	-	13	48.1
W	1	6.7	1	3.7
NW	1	6.7	0	-
No movement	8	53.3	7	25.9

The direction of movement, if any, was recorded for 27 bowheads. Although seven of the bowheads were stationary, most of the remainder exhibited a southwesterly movement (Table 2). The distribution of directions during this survey was non-random (Rayleigh test, $r = 0.624$, $z = 7.78$, $n = 20$, $p < 0.01$). The movements seemed to be more rapid and purposeful than those exhibited by bowheads during the August survey which often appeared to be slow and leisurely. The September observations suggest that the fall migration was beginning.

Yukon Coast, 22 August 1983. On 22 August, two survey lines were flown off the Yukon coast between Shingle Point and Stokes Point (Fig. 7). One line was flown northwest along the coast between these two points at a distance of about 1,100 m from the coastline. A second line extended from Stokes Point southeast to 137°42'W and was located about 3,300 m off the coastline. Thus, a section of water 4 km in width extending out from the coastline was surveyed. The total distance surveyed along these two lines was 144.2 km covering an area of 288.2 km^2.

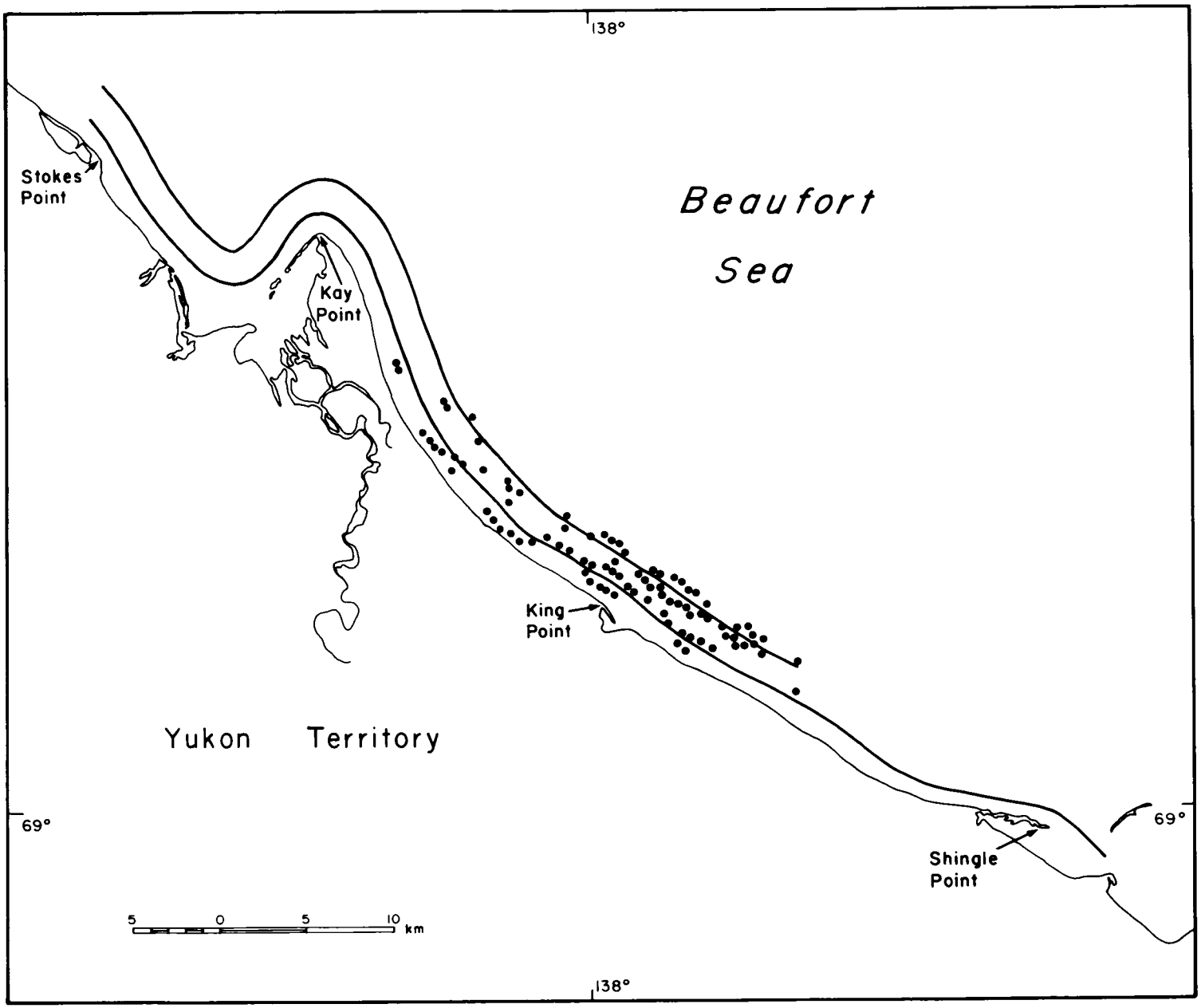

Fig. 7. Distribution of bowhead whale sightings along the coast of Yukon Territory from Shingle Point to Stokes Point, 22 August 1983. Solid line denotes path of survey. (•) denotes location of one bowhead whale sighting.

A total of 110 bowhead whales were counted during this survey. If it is assumed conservatively that the animals seen off-transect (i.e., more than 1,100 m from the aircraft) by the right observer along the line 1,100 m from the coast were recorded on-transect by the right observer along the line 3,300 m from the coast (and vice-versa), then a total of 86 bowheads were counted on-transect. All animals seen were counted along a 37.1-km stretch of water (148.4 km^2) centred at about King Point (see Fig. 7). The density of whales in this area was 0.579 whales/km^2 (579.5 whales/1,000 km^2). Although these surveys extended only 4,400 m from the coast, biologists conducting behavioural studies of bowheads in the region at the same time noted that bowheads were present to 10 km offshore.[1]

None of the bowhead whales seen along the Yukon coast displayed any directional movement. Those seen were either stationary at the surface of the water or were diving or surfacing. No calves were seen in the turbid water of the area.

Estimates of Numbers of Surfaced Animals

Surveys of marine mammals count only those animals that are at, or near, the surface of the water. Animals below the surface are not seen and must be estimated indirectly. Estimates of numbers of bowheads at the surface in the study area were calculated using the ratio estimation method (Cochran 1977; Eberhardt et al. 1979). Separate ratio estimates were obtained for each of the three survey-blocks or strata (Yukon, Delta, and Tuk. Pen. zones). These stratum estimates were combined to provide a total estimate of the number present and its standard error, which was done following the procedure described by Caughley and Grigg (1981).

The average densities of bowhead whales recorded in each survey zone during the two surveys are presented in Table 3. The estimates of numbers of bowhead whales in each zone and in the total area are also presented. The calculations for the survey on 19-24 August do not include the 22 whales seen on-transect near King Point; the numbers in this area are calculated separately in the next section. During both systematic surveys, estimated numbers of bowhead whales were highest in the Tuk. Pen. Zone (118 and 193). During the first survey (19-24 August), estimated numbers of surfaced bowheads

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[1] W.J. Richardson, LGL Ltd., pers. comm.

were higher in the Yukon Zone (50) than in the Delta Zone (21) to the east. However, all five animals seen on-transect in the Yukon Zone during that survey were seen along a 22-km stretch of transect within 30 km of the coast at Shingle Point (see Figure 5). These animals may have been part of the large concentration of whales present along the Yukon coast in late August. Excluding those five animals, estimated numbers of bowheads present in offshore waters decreased from east to west during both surveys.

TABLE 3

Estimates of numbers of bowhead whales at the water surface in the Beaufort Sea, August--September, 1983

Survey block	Total area (km^2)	Area surveyed (km^2)	(%)	No. transects	No. whales seen[a]	Density[b] (/km^2) (s.e.)	Est.[b c] number (s.e.)
19-24 August 1983							
Yukon[d] Zone	16,500	1,680.8	(10.2)	10	5	0.0030 (0.0027)	50 (44.7)
Delta Zone	26,200	2,662.2	(10.2)	16	2	0.0008 (0.0005)	21 (12.2)
Yuk. Pen. Zone	26,750	2,257.4	(8.4)	14	10	0.0044 (0.0010)	118 (27.1)
Total	69,450	6,600.4	(9.5)	40	17	189	(53.7)
6-11 Sept. 1983							
Yukon Zone	16,500	1,754.8	(10.6)	10	1	0.0006 (0.0005)	1 (8.7)
Delta Zone	26,200	2,360.2	(9.0)	16	10	0.0042 (0.0017)	110 (45.2)
Yuk. Pen. Zone	26,750	2,484.2	(9.3)	16	18	0.0072 (0.0021)	193 (55.5)
Total	69,450	6,599.2	(9.5)	42	29	313	(72.1)

a Includes on-transect sightings only.
b Densities and estimated numbers and their standard errors are based on the ratio estimation method.
c Estimates are not corrected to account for animals at the surface but unseen and for submerged animals.
d Calculations for Yukon Zone do not include the 22 bowhead whales seen on-transect within 7 km of shore near King Point.

About 67% more surfaced bowheads were estimated to have been present in the study area during the September survey (313) than during the August survey (189). This difference is not statistically significant (Mann-Whitney z = 0.28, p = 0.4), although the small number of animals seen during the surveys reduces confidence in the statistical test.

Yukon Coast, 22 August. During the survey along the Yukon coast from Shingle Point to Stokes Point on 22 August, whales were recorded up to 4.4 km from the coastline. The recorded density in the 37.1-km stretch of nearshore waters in which bowheads were seen was 0.579 whales/km^2. However, whales were also common (22 whales seen) along the entire length (7.3 km) of the first 2-min transect segment in the north - south transect line near King Point (line G, see Figure 5) that crossed this region. Moreover, personnel conducting behavioural studies of bowheads in this area observed many bowheads up to 10 km from the coast on 22 August.[1] Thus, bowheads were present in an area of at least 371 km^2 and the authors feel that it is logical to assume that the recorded density of bowheads within 4.4 km of the coastline was representative of the entire 371 km^2 area. Extrapolation of the recorded density (0.579/km^2) of surfaced bowheads to this area indicates that a minimum of 215 whales were present off the Yukon coast on 22 August.

Estimates of Actual Abundance

None of the above estimates of numbers of bowheads present in the study area has been corrected to account for animals undetected below the surface and for animals that were at the surface but not seen. These biases must be corrected to provide an estimate of the actual number of animals present within the study area. Such an attempt is useful in that it provides an estimate of the proportion of the total Western Arctic bowhead population that was present in the study area during the periods of the surveys, and permits comparisons with results obtained from the same area in previous years.

Davis et al. (1982) calculated that during aerial surveys of the Beaufort Sea in 1981, only 68.5% of the bowhead whales on the surface were actually counted. They cautioned that this value was specific to their surveys only and that it was not necessarily applicable to surveys in other areas or in other years. Davis et al. (1982) believed that environmental conditions, especially sea state, were very important factors

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[1] W.J. Richardson, LGL Ltd., pers. comm.

affecting the detectability of surfaced bowheads. Although sea states were quite different between the two surveys in 1983, the percentages recorded for various sea states during the 1983 surveys were remarkably similar to those recorded during the four surveys in 1981 (Table 4).

TABLE 4

Comparison of sea state during surveys in 1981 and 1983

Sea state (Beaufort Scale)	Percentage of total survey distance (%)	
	1981[a]	1983
0	6.2	8.6
1	22.2	22.4
2	31.2	34.2
3	22.3	23.7
4	14.9	9.1
5	3.2	2.0

[a] Adapted from Davis et al. (1982).

Because most of the other potential causes of non-detection of surfaced bowheads were common to the surveys in 1981 and 1983 (e.g., observer ability, aircraft type, and seat position), it is reasonable to apply the correction factor of 1/0.685 (Davis et al. 1982) to the surveys conducted in 1983. Because of the differences in sea conditions between the two surveys in 1983, the general application of this correction factor may result in a modest underestimate of the numbers present during the August survey, when sea conditions were rougher than average, and an overestimate of the numbers present during the September survey, when sea conditions were smoother than average.

Davis et al. (1982) evaluated the diving behaviour of bowhead whales in the Beaufort Sea in 1981. They determined that bowheads could be seen at the surface of the water only 26.1% of the time in 1981. They applied a correction factor of 1/0.261 to account for animals below the surface and not seen. Again, Davis et al. (1982) cautioned that this factor was specific to the surveys in 1981 and was not necessarily applicable to other areas or to other years. Würsig et al. (1983) calculated that without calves bowheads northeast of Herschel Island in August 1982 could be seen from the air 24% of the time, a value remarkably similar to that calculated by

Davis et al. (1982). Thus, for purposes of this report, a correction factor of 1/0.261 was used to account for submerged animals on the systematic surveys.

The correction factors used on the data from the systematic surveys are not directly applicable to the concentration of bowheads present along the Yukon coast on 22 August (see Figure 7). These animals were in relatively shallow water ranging from 10 to 30 m in depth. Consequently, dive times may have been shorter than those of animals in deeper water that formed the basis of the correction factor for submerged animals. Thus, the applicability of the submerged animal correction factor to the Yukon coastal waters is unknown. In addition, the waters along the Yukon coast were turbid and animals that were just below the surface were not visible to the surveyors. In the clearer waters farther offshore, some of these animals would have been detectable. Thus, the correction factor for unseen animals that were present at, or near, the surface was not applicable in these turbid waters. During the two transects along the Yukon coast on 22 August, the survey conditions were extremely good, with excellent lighting and low sea states (mostly Beaufort Scale 1). Under these conditions it is likely that few, if any, surfaced animals were missed, although some just below the surface may not have been detected.

In the absence of a verified correction factor for the Yukon coastal waters, two values were chosen arbitrarily that represent the probable range of realistic factors. The correction factor for unseen animals in the study area is 3.83 (1/0.261), which represents those animals that are visible at, or near, the surface for 26.1% of the time. It seems unlikely that the bowheads in the shallow waters along the Yukon coast spent less time at the surface than did the animals in the deeper offshore waters. On the other hand, it seems unlikely that whales which were apparently feeding (see Discussion) spent more than 50% of their time at the surface. This figure was selected to represent the low end of the range of correction factors for submerged animals. Even if the whales averaged more time at the surface, this would likely have been compensated by the fact that some of the animals near the surface could not be seen in the turbid waters.

Thus, the range of correction factors that seems most appropriate extends from 3.83 to 2.0 (1/0.50). Application of these factors to the uncorrected estimate of 215 animals suggests that, on 22 August 1983, 430 to 823 bowheads were actually present in the 37 x 10 km section of Yukon coastal waters centred on King Point.

Table 5 presents the estimated numbers of bowhead whales actually present in the study area during the surveys in August and September 1983, including those at the surface but not seen and those that were undetectable below the surface. The values of 1,487 to 1,880 animals for 19-24 August and 1,751 bowheads for 6-11 September represent 38-49% and 45%, respectively, of the estimated current Western Arctic population of 3,871 animals.

TABLE 5

Estimated numbers of bowhead whales present in the southeast Beaufort Sea, August-September 1983 (adjusted to account for animals at the surface but not seen, and for undetectable animals beneath the surface)

	19-24 August		6-11 September	
Survey Zone	uncorrected[a] estimate	corrected estimate	uncorrected[a] estimate	corrected[b] estimate
Yukon Zone	50[a, c]	280[b]	10	56
Yukon Coast	215	430-823[d]	-	-
Delta Zone	21[a]	117[b]	110	615
Tuk. Pen. Zone	118[a]	660[b]	193	1,080
Total		1,487-1,880		1,751

[a] From Table 3.

[b] Uncorrected estimates: ÷ 0.685 (correction for undetected animals) ÷ 0.261 (correction for submerged animals).

[c] Does not include animals seen within 10 km of the Yukon coast.

[d] See text for correction factors.

Estimates of Calf Production

Bowhead calves in the company of adults are very difficult to detect, as they are often partially or completely hidden beneath, or on the offside of, the adult. Thus, in general, only when a very good look at a bowhead is obtained can an accompanying calf be observed. Davis et al. (1983) showed that the zone of highest detectability of calves is

restricted to the inner portion of a 1,000-m wide transect strip. Harwood and Ford (1983) suggested that detectability of calves was even across an 800-m wide transect strip, but their data, in fact, support the conclusion of Davis et al. (1982).

During the surveys, only nine sightings, totalling 14 whales, were made in which it could be determined with certainty whether a calf was present or absent. One of the 14 animals was a calf; on this basis, the proportion of calves in the population in 1983 was 7.1%. However, this sample size is considered to be too small to be meaningful. Most other workers have not accounted for the difficulty of seeing calves and they have presented estimates of calf production based on the numbers of calves and adults seen over the entire transect width (see Cubbage and Rugh 1982 for a summary). Davis et al. (1983) and Ljungblad et al. (1983) have shown that this approach seriously underestimates the actual calf production. Therefore, this type of data is not presented here.

Distribution in Relation to Water Depth

Aerial surveys in 1981 (Davis et al. 1982) and studies of bowhead whale behaviour in 1980-1982 (Richardson et al. 1983) suggested that bowheads may concentrate over, and slightly offshore of, the shelf break in the Beaufort Sea, where water depths increase rapidly from 100 m over distances of as little as a few kilometres. Survey lines in 1983 were extended about 25 km north of the 100-m depth contour in an attempt to examine this relationship.

The relationship of water depth to the distribution of bowhead whales recorded during the 1983 surveys is listed in Table 6.

During the first survey on 19-24 August, bowhead whales were seen in waters that ranged from a few metres in depth to waters > 200 m in depth (see Fig. 5). Excluding the nearshore concentration of 24 animals centred at King Point, the distribution did not vary significantly from expected, given the relative survey distances over areas of 0-50 m, 50-100 m and 100+ m water depth (chi-square = 1.17, df = 2, $p > 0.05$). All four of the whales in waters greater than 100 m in depth were seen in the Yukon Zone, where the 100-m depth contour is much closer to shore than in areas to the east. Two of those whales were seen within 30 km of Herschel Island. There was no indication that bowheads were concentrated at the shelf break.

TABLE 6

Relationship of water depth to distribution of bowhead whales

Distribution factors	Water depth (m)		
	0-50	51-100	100
19-24 August			
No. km of survey	1,895.2	760.7	651.6
% of total survey	57.3	23.0	19.7
No. of bowheads recorded	18	10	4
% of total bowheads	56.3	31.3	12.5
6-11 September			
No. km of survey	1,913.8	712.7	673.1
% of total survey	58.0	21.6	20.4
No. of bowheads recorded	24	26	0
% of total bowheads	48.0	52.0	0

Similarly, there was no indication that bowheads were concentrated near the shelf break during the survey on 6-11 September (see Fig. 6). In fact, none of the bowheads recorded during this survey were in waters greater than 100 m in depth. Twenty-four bowheads were seen in waters 0-50 m in depth and 26 were in waters 50-100 m in depth. This distribution was significantly different from the expected distribution (chi-square = 31.3, df = 2, $p < 0.001$). Twenty-one of the 47 bowheads seen in the eastern half of the study area were over, or within 10 km of, the 50-m depth contour.

Distribution in Relation to Ice

During the survey on 19-24 August, open pack ice was present in the study area only in the north-central portion (see Survey Conditions). One bowhead whale was seen in this region, in 51-75% ice cover. All other whales seen during the survey were seen in ice-free water. During the second survey on 6-11 September, ice covered much of the Yukon Zone, and was also present across much of the northernmost portion of the study area. One bowhead whale was seen in the pack ice in the Yukon Zone (ice cover was 6-50%) and six individuals were seen in 6-50% ice cover in the northeastern part of the study area. All others were recorded in ice-free waters. This distribution did not differ significantly from expected, given the relative survey distances flown over open water, water with 6-50% ice cover, and water with 51-75% ice cover (chi-square = 1.03, df = 2, $p > 0.05$).

Distribution in Relation to Industrial Activity

Sightings during aerial surveys. The location of offshore hydrocarbon exploration activities associated with the 1983 drilling program in the southeast Beaufort Sea are plotted on Figures 8 and 9, along with the locations of the bowhead whale sightings during the surveys. The sites plotted include only those that were active during the period of the surveys. Shipping routes and corridors are not plotted.

During the survey on 19-24 August, most bowheads were seen in the northeast portion of the study area or in the nearshore waters of the Yukon coast. Both of these areas were well away from the region of industrial activity. The nearest distance that bowheads were seen to any of the five drillships was 25 km - two animals west of Explorer 3 (Arluk: 70°19'N, 135°26'W) and one animal east of Explorer 1 (Aiverk: 70°24'N, 133°42'W). In addition, one animal was seen 13 km northwest of Ukalerk (70°08'N, 123°42'W), an active borrow site.

As in the August survey, most whales seen during the survey on 6-11 September were in the northeast portion of the study area (see Fig. 9). The nearest sighting of a bowhead to a site of industrial activity was one animal 15 km northeast of the drillship Explorer 1 at Aiverk. One bowhead seen north of Mackenzie Bay was 20 km southwest of the drillsite Pitsiulak (69°54'N, 136°42'W) and a second animal north of Mackenzie Bay was 20 km northeast of the drillship Explorer 2 (Natiak: 70°04'N, 137°13'W).

Sightings by industrial personnel. Sixteen sightings of bowhead whales, totalling 23 animals, were recorded by industry personnel on board drillships and support vessels in the study area. Animals were seen as early as 13 July and as late as 16 September, but 18 of the 23 animals were seen during the period 18 August-12 September. All were seen south of 70°30'N and between 131°20'W and 135°30'W. Only one bowhead was seen from a drillship. Most sightings were of animals at least 2-3 km from the sighting platform. Some of the sightings may have been of the same individual on different occasions. Most of the sightings were of single animals, but two groups of four bowheads and one group of two bowheads were seen. Because watches for marine mammals were not done on a systematic basis and there was undoubtedly much variation among the abilities and interest of the observers on the various ships, it is difficult to interpret these results. It is clear that at least a few whales were present during the summer in the region of industrial activity.

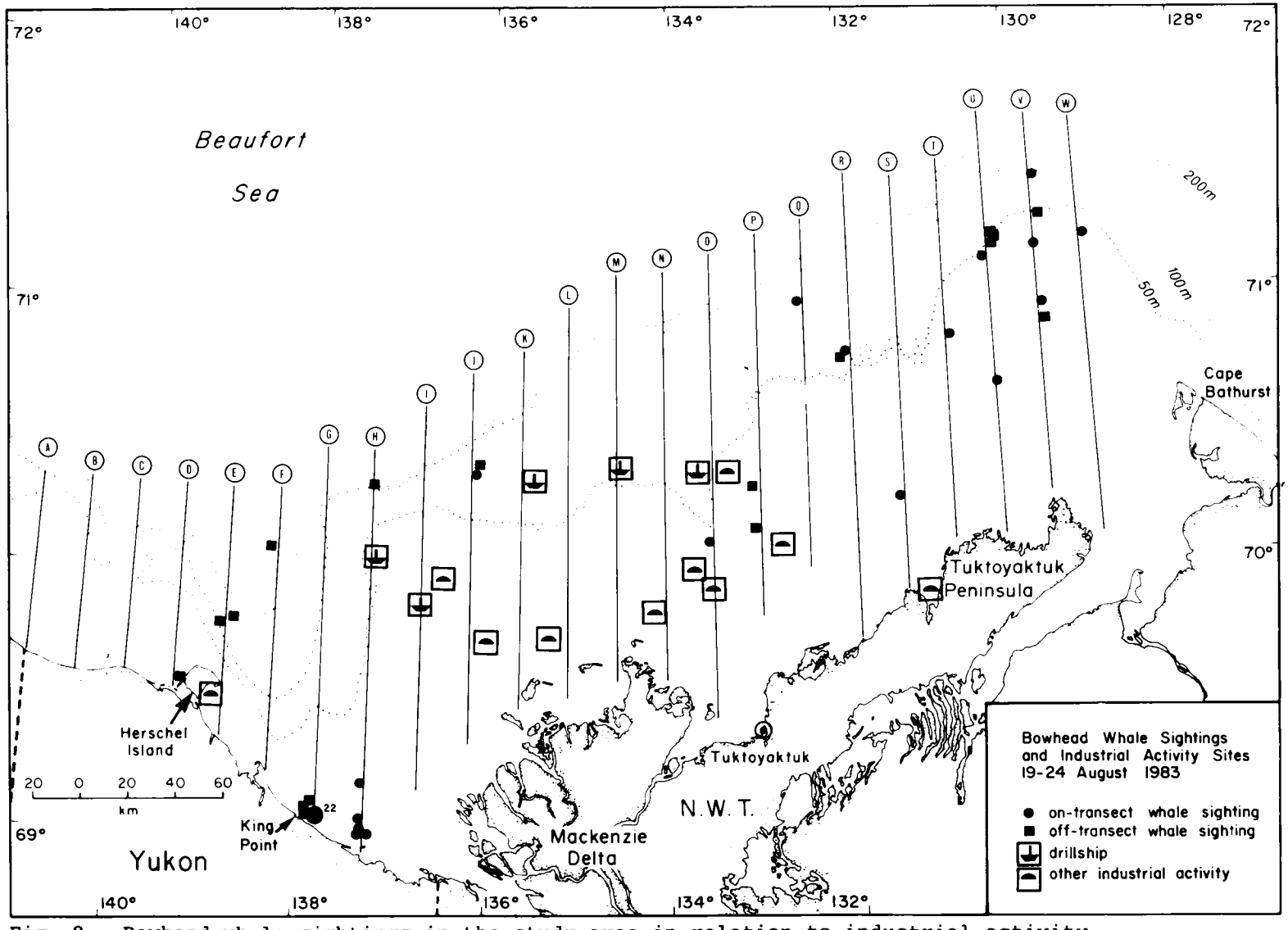

Fig. 8. Bowhead whale sightings in the study area in relation to industrial activity, 19-24 August 1983.

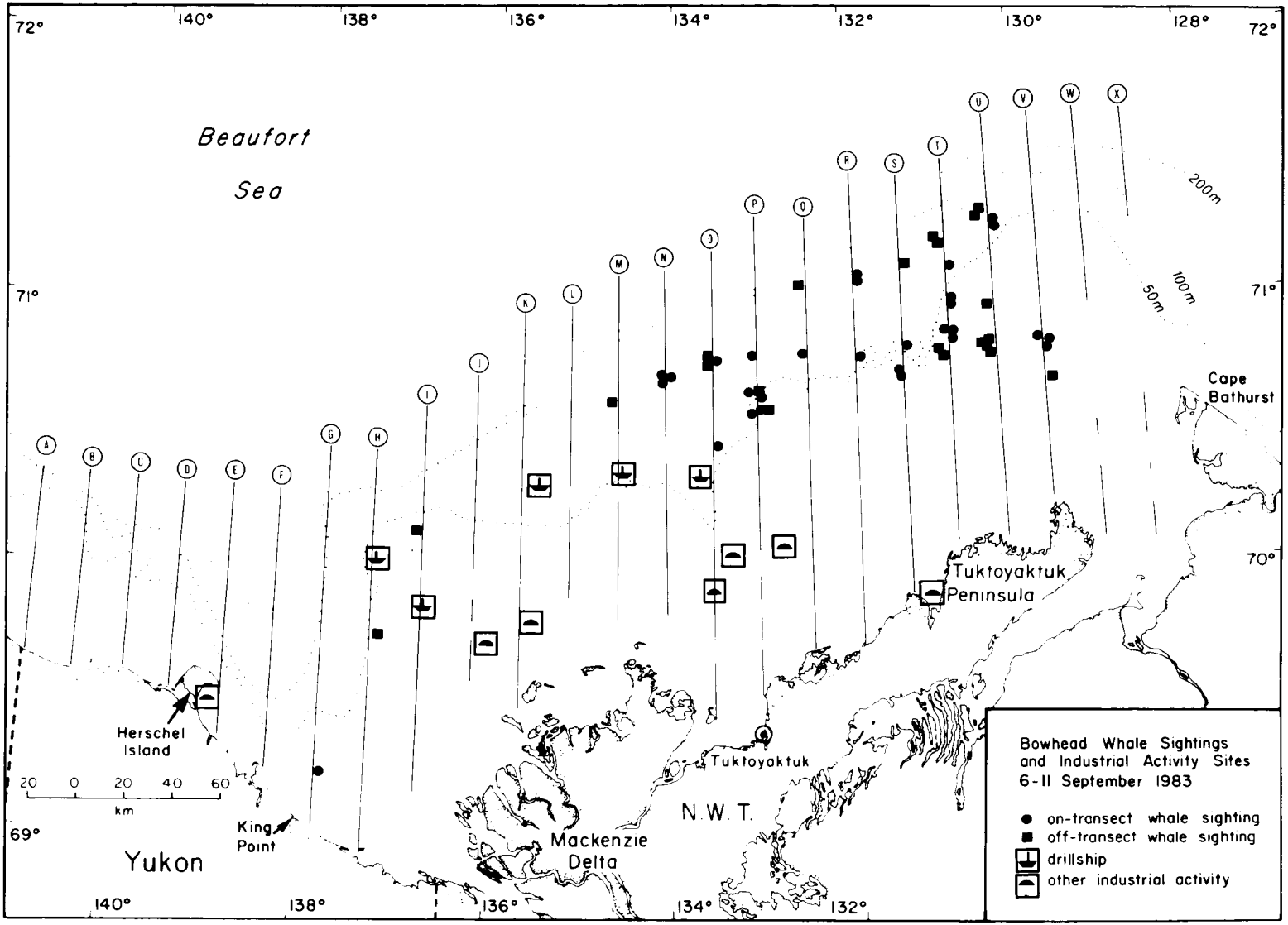

Fig. 9. Bowhead whale sightings in the study area in relation to industrial activity, 6-11 September 1983.

Discussion

The year 1983 was the fourth consecutive year that bowhead whale distribution in the southeast Beaufort Sea has been documented. There are some clear differences in the observed distributions among these years (1980-1983), although some caution is necessary in comparing and interpreting the results because of differences in survey effort. In all four years, systematic aerial surveys were conducted on similar dates in late August and in early September. However, in 1980, these surveys were restricted to the Tuk. Pen. Zone and extended offshore only as far as the 50-m depth contour. Although surveys in 1981-1983 all covered the area from 141°W to 129°W, there were differences in the northern extent of the study area. In 1982, the surveys extended north to the 100-m depth contour; in 1983, they extended about 25 km past this contour, and in 1981, several lines extended north to 72°N. The densities of bowheads recorded in the three survey-blocks of the study area in the four years are presented in Table 7. Although there are broad confidence intervals associated with several of the densities that make detailed comparisons questionable, they do provide a basis for examination of differences and similarities in distribution among the four years.

Richardson et al. (1983) examined and summarized both the results of the systematic surveys in 1980-1982 (Renaud and Davis 1981; Davis et al. 1982; Harwood and Ford 1983) and of non-systematically obtained sightings in those three years (Fraker et al. 1982; Hobbs and Goebel 1982; Ljungblad et al. 1983). They found that the distribution in 1980 differed substantially from those observed in 1981 and 1982. In late August 1980, very large numbers of bowheads were observed in shallow waters (< 50 m in depth) off the Mackenzie Delta and particularly the western Tuktoyaktuk Peninsula (53.8/1,000 km^2). Smaller numbers were seen north of Herschel Island. In early September, fewer whales were seen off the Tuktoyaktuk Peninsula and they were farther offshore but still in less than 50 m of water. As well, numbers off the Mackenzie Delta were much reduced, but more were present near Herschel Island.

TABLE 7

Densities (no. whales/1,000 km^2) of bowhead whales recorded during aerial surveys in the southeast Beaufort Sea in late August and early September, 1980-1983[a]

Time of survey	Yukon Zone	Delta Zone	Tuk. Pen. Zone
late August			
1980	-	-	53.8
1981	4.6	6.6	4.4
1982	26.4	3.2	5.2
1983	3.0	0.8	4.4
early September			
1980	-	-	11.9
1981	3.0	2.7	5.6
1982	21.5	1.9	1.6
1983	0.6	4.2	7.3

[a] Data from Renaud and Davis (1981); Davis et al. (1982); Harwood and Ford (1983); present study.

In late August 1981, bowhead whales were common and generally evenly distributed in all zones of the study area (4.4 to 6.6/1,000 km^2). Bowheads were present in waters off the Mackenzie Delta, as in 1980, but most animals were seen in deeper waters (100 m in depth), especially north and northwest of the delta. In early September, many of those far offshore of the Tuktoyaktuk Peninsula had apparently moved closer to shore. Smaller numbers and densities were present off the delta but bowheads had become numerous around Herschel Island.

In late August 1982, many bowheads were concentrated off Herschel Island (26.4/1,000 km^2), but others were found east to Cape Bathurst. They were particularly numerous at the shelf break north of the Mackenzie Delta, in the same area that animals were seen in late August 1981. On the other hand, few were recorded in shallow waters. In early September, most animals were seen in the Yukon Zone, particularly north and east of Herschel Island; lower densities were recorded elsewhere in the study area. Thus, in a general sense, late August distributions were similar in 1981 and 1982 and very

different from 1980. Similarities in early September distributions among years were less apparent, with the exception of the common presence of bowheads off Herschel Island in all three years.

In 1983, the observed distribution in late August was dissimilar to that observed in each of the previous years. The most striking feature was the large concentration of bowheads along the Yukon coast between Shingle Point and Kay Point. The density of surfaced animals in this area (371 km^2) was extremely high (579.5/1,000 km^2). This density is an order of magitude higher than the 53.8/1,000 km^2 recorded in the much larger southern Tuk. Pen. Zone (13,820 km^2) in 1980. Between 430 and 823 bowheads were estimated to be present along the Yukon coast in August 1983, which represents 11 to 21% of the total estimated population of 3,871 bowheads.

The concentration of bowheads along the Yukon coast was present in the area from at least 14-28 August.[1] The animals were apparently feeding in these shallow waters (10-30 m) throughout this period. Feeding activity was indicated by the presence of glaucous gulls (Larus hyperboreus) and black-legged kittiwakes (Rissa tridactyla) in the area. The waters used by these bowheads were very turbid but the turbid layer was underlain by clear water. During the surveys, several circular 'holes' of clear water were noted in the turbid layer where bowheads had dived or surfaced through the turbid water. Concentrations of bowheads along the Yukon coast were not observed in the 1980 to 1982 period. However, 33 bowheads were seen within a few kilometres of the shore between Shingle Point and Kay Point on 13 September 1976.[2]

In early September 1983, the distribution of bowheads was substantially different from previous years in that no animals were seen in the Herschel Island area; however, the distribution elsewhere was similar to that noted in 1980 when large numbers were present far offshore of the Tuktoyaktuk Peninsula. Substantial numbers were also present off the peninsula in September 1981.

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1 W.J. Richardson, LGL Ltd., pers. comm.

2 W.R. Koski, LGL Ltd., pers. comm.

Substantial differences exist in the distributions of bowhead whales in the southeast Beaufort Sea, both within, and between, years. Because of this variation, an accurate model of bowhead distribution cannot be constructed from data from only four years. The distribution is influenced by an array of factors, including ice conditions and the availability of food. Presumably, the complete absence of bowhead whales in the Herschel Island area in early September 1983 (whales were common there in each of the previous years) was due to the presence of very heavy pack ice with little or no open water. Why they were not present there in late August, however, as they were in other years, in unclear. Similarly, the periodic occurrence (1976, 1983) of large concentrations of bowheads along the Yukon coast is unexplained. Changes in distribution are probably related to variations in the distribution and availability of the zooplankton on which bowheads feed. However, there is little quantitative information about zooplankton distribution in the southeast Beaufort Sea, and no data at all on year-to-year variations in its abundance in different parts of the study area.

In the absence of such information, it is not possible to interpret the observed distributions of bowhead whales in the southeast Beaufort Sea in relation to the area of industrial activity. The trend towards fewer bowheads in the industrial area noted in Richardson et al. (1983) continued in 1983, although some animals were observed in the area by industry personnel. The significance, if any, of this trend is not known.

Between 1,487 and 1,880 bowhead whales were estimated to be present in the southeast Beaufort Sea in late August and early September 1983. These figures represent 38% and 49% of the estimated present size of the Western Arctic population of bowheads. Davis et al. (1982) estimated that slightly higher numbers of bowheads were present in the three survey-blocks during aerial surveys in late August and early September 1981 (2,079 and 1,834 bowheads, respectively), but their study area was somewhat larger, extending north to 72°N. Virtually the entire population of the Western Arctic bowhead is believed to summer in the Canadian Beaufort Sea and in Amundsen Gulf to the east. If the estimates derived from this study are accurate, it thus appears that somewhat more than half of the bowhead population was in waters to the east or north of the study area in late August and early September. Some of these animals would have been expected to pass through the study area during their westward migration in late September and early October.

WHITE WHALE

Distribution and Movements

A total of 45 white whales were recorded during the systematic surveys of the Beaufort Sea on 19--24 August of which 43 were on-transect. Five others were seen incidental to the survey, including three animals near Shingle Point during a special survey along the Yukon coast on 22 August. In addition, about two dozen white whales were seen by Dome personnel southwest of McKinley Bay, on the Tuktoyaktuk Peninsula, during the week prior to the surveys, but these animals were not observed during the period of the survey. The locations of all white whales recorded during the period of the survey (19-24 August) are plotted on Figure 10.

White whales were not distributed widely throughout the study area during the 19-24 August survey. Twenty-eight of the 50 animals were seen in the shallow (less than 10 m deep) waters of Mackenzie Bay and another 11 were counted in the shallow estuarine waters along the north side of Richards Island, at the mouth of the Mackenzie River. A single animal was seen in coastal waters at Cape Dalhousie, at the eastern tip of the Tuktoyaktuk Peninsula. Only 10 animals were seen in the deep waters offshore, nine of which were at the northernmost part of the survey area, in waters exceeding 200 m in depth. These animals were in open (6-50% ice cover) pack ice. A single white whale was seen in ice-free water 50 km north of Richards Island.

The relative ages of 40 of the 50 white whales were determined based on body colour: 32 were white adults, 7 were grey subadults, and 1 was a neonate. The neonate was in the nearshore waters to Mackenzie Bay. Few of the animals seen exhibited any directional movement; there was no obvious pattern among those that were moving. Twenty-nine of the animals seen were single individuals; there were nine groups of two and one group of three animals.

A total of 826 white whales were recorded during the survey on 6-11 September (Fig. 11). An additional 28 animals were seen incidental to the survey. Most of the white whales seen on this survey were recorded in one large group, estimated at 750 animals. This group was swimming northeast in open pack ice (6-50% ice cover) in about 50 m of water about 95 km north of the coastline of Mackenzie Bay. Unlike the August surveys, no white whales were seen in Mackenzie Bay. The remainder of the white whales seen during the survey period were all far offshore in the northern portion of the study area. Most (85

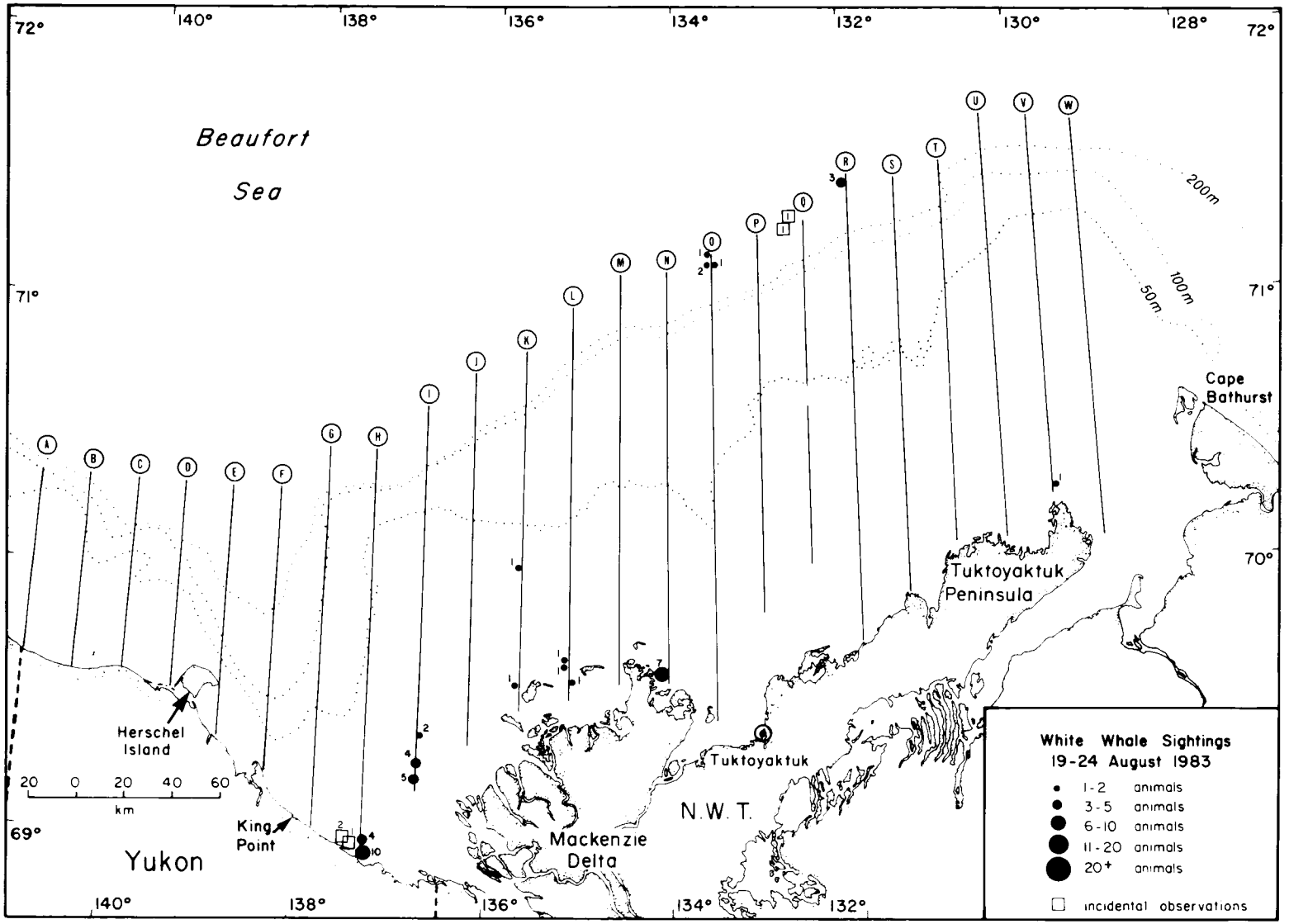

Fig. 10. White whale sightings in the study area, 19-24 August 1983.

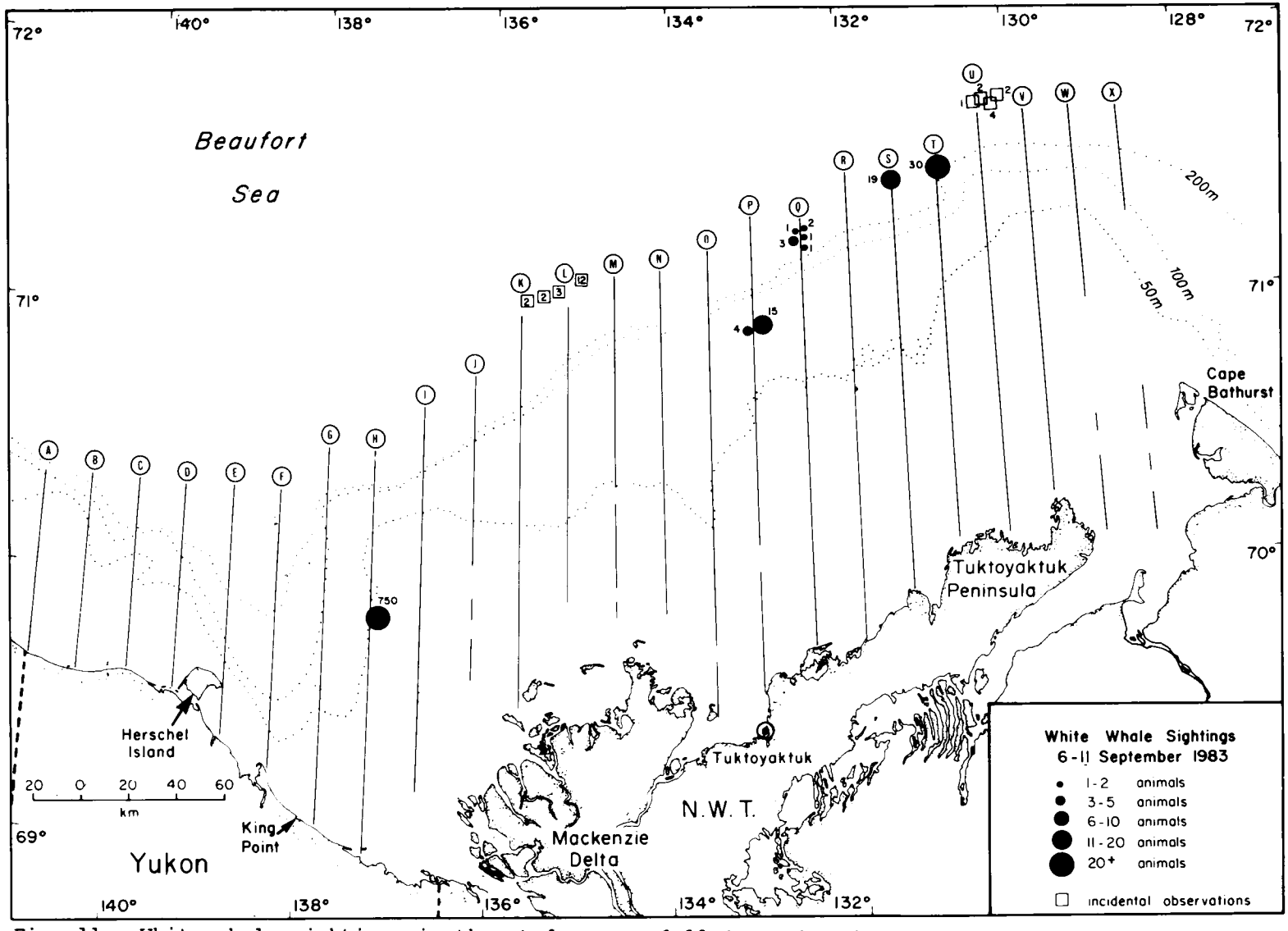

Fig. 11. White whale sightings in the study area, 6-11 September 1983.

of 104 animals) were in waters deeper than 200 m. The more southerly sightings during the survey were in waters pieces of brash ice (<5% ice cover), whereas those beyond the 200-m depth contour were in waters with 6-50% ice cover. Those white whales seen incidental to the survey (due north of the Mackenzie Delta, see Figure 11) were in pack ice with 51-75% ice cover.

As well as the concentration of 750 white whales, a group of 19 animals due north of Tuktoyaktuk was swimming north or northeast. The remainder of the animals, all seen north of the 200-m depth contour, were swimming strongly to the west or southwest. The age structure of the concentration of 750 whales north of Mackenzie Bay was not determined. However, 56 of the remaining 104 animals were aged: 37 were white adults, 12 were subadults, and 7 were neonates.

The highly non-random distribution of the white whales precludes the use of a statistical extrapolation procedure to determine the numbers of whales in the study area. As well, there are no data on the proportion of time that white whales spend at, or near, the water surface in deep non-estuarine waters.

Sightings by Industry Personnel

Four sightings of white whales, totalling 12 animals, were recorded by personnel on board drillships and support vessels in the study area. In mid-July, groups of two and six animals were seen along the coast of the Tuktoyaktuk Peninsula at Toker Point and McKinley Bay, respectively. In late July, a single animal was seen about 50 km northwest of McKinley Bay, in late August, a group of three white whales was seen about 70 km offshore, near 70°10'N, 135°45'W. Direction of movement was not recorded for any of the observations.

Discussion

During the surveys in 1983, white whales were seen in two more or less discrete regions of the study area. In mid-to-late August most white whales seen were in shallow waters along, or near the coast, especially in the estuary of the Mackenzie River. These were presumably remnants of the estimated 7,000 white whales that enter the estuary in late June and early July and leave in late July and August (Fraker 1980; Fraker and Fraker 1981, 1982). Results of the 1983 study of white whales in the Mackenzie estuary are not yet available, and it is not known if the timing of the movements into, and out of, the estuary in 1983 is comparable with that of other years. However, it seems that in all years, some white whales

remain in the estuary throughout August. In 1981 and 1982, small numbers of white whales were also recorded in the Mackenzie estuary in late August (Davis and Evans 1982; Harwood and Ford 1983), although in both those years, more animals were recorded offshore of the estuary than in 1983. After leaving the Mackenzie estuary in August, white whales apparently move northward to the deep offshore waters near the edge of the pack ice (Davis and Evans 1982). A pod of 750 white whales observed swimming northeast about 95 km north of Mackenzie Bay presumably represented this movement.

Excluding the pod of 750 animals, all of the white whales seen during the September 1983 survey were in the northernmost portions of the study area, particularly north of the Tuktoyaktuk Peninsula. This distribution is similar to that observed in early September 1981 when all white whales seen in the southeast Beaufort Sea were in the northern Tuk. Pen. Zone. In both years, virtually all the animals seen were beyond the 200-m depth contour and were moving strongly in a westerly direction. Harwood and Ford (1983) recorded no white whales in the northern Tuk. Pen. Zone during surveys in early September 1982; however, their survey lines extended northward only to the 100-m depth contour in that region and thus any animals present in the areas where they were seen in 1981 and 1983 could not have been detected. The results of the surveys in 1983 substantiate the findings of Davis and Evans (1982) that the majority of the white whale population migrates west in the fall through offshore waters remote from the coast.

Davis and Evans (1982) estimated that the population of white whales that entered the eastern Beaufort Sea in the summer exceeded 11,500 animals. The results from 1983 indicate that only a small fraction of the population was present in the study area in late August and early September 1983.

SEALS

Ringed Seal

Distribution. Fifteen ringed seals were recorded during the survey on 19-24 August (Fig. 12). These animals were seen in five sightings, including three individuals, a group of two and a group of 10 animals. All were seen east of 136°W. Ringed seals were seen both in nearshore waters as shallow as 2 m in depth within 1 km of the coast, and in waters 150 km offshore and over 200 m in depth. The two northern sightings (see Fig. 12) were swimming among open pack ice (6-50% ice cover), whereas the three southernmost sightings, including the group of 10 animals, were in ice-free water.

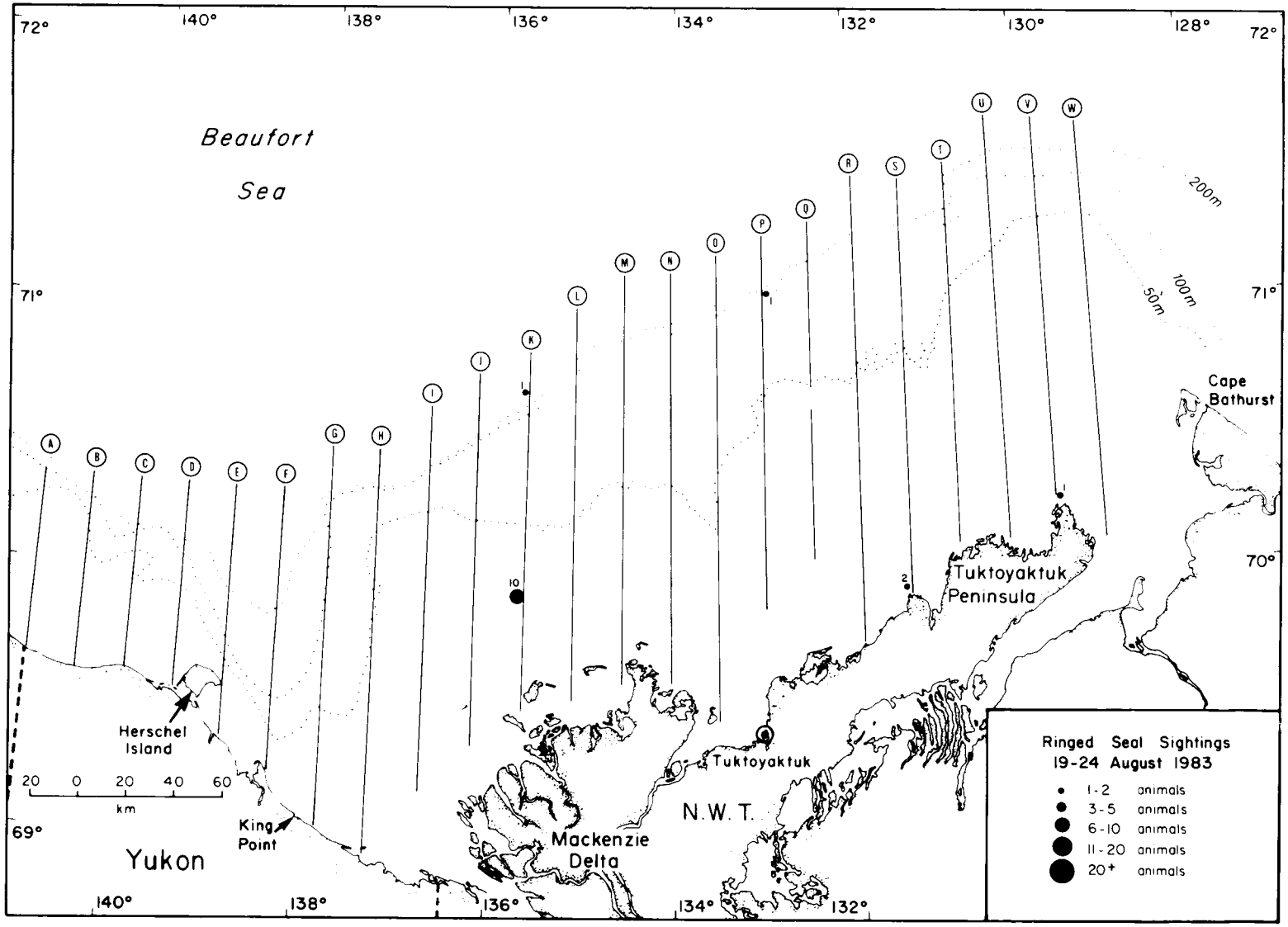

Fig. 12. Ringed seal sightings in the study area, 19-24 August 1983.

A total of 259 ringed seals were recorded during the survey on 6-11 September (Fig. 13) and all were on-transect. An additional six animals were seen during ferry flights between survey lines. Although ringed seals were recorded throughout the study area from east to west during this survey, the great majority (253 of 259 animals) were seen in the eastern half, and most of those were in the Tuk. Pen. Zone. Recorded densities in the Yukon, Delta, and Tuk. Pen. zones were 0.2, 1.7, and 8.7 seals/100 km^2, respectively. Most of the sightings were at least 70 km offshore, although in the westernmost part of the study area, individuals were present in the close pack ice within 10 km of the coast.

Only two of the ringed seals seen during the aerial surveys in early September were in waters greater than 100 m in depth (Table 8) although the six animals seen during ferry flights were also in such waters.

TABLE 8

Relationship of water depth to distribution of ringed seals

Distribution	Water depth (m)		
	0-50	51-100	100
No. km of survey	1,913.8	712.7	673.1
% of total survey	58.0	21.6	20.4
No. of ringed seals recorded	149	108	2
% of total ringed seals	57.5	41.7	0.8

This distribution is significantly different from that expected, given the relative distances surveyed over the three depth regimes (chi-square = 68.3, df = 2, $p < 0.001$). However, seal numbers did not differ significantly in waters 0-50 m in depth from those in waters deeper than 50 m (chi-square = 0.02, df = 1, $p > 0.05$). Thus, it appears that ringed seals avoided areas where water depths exceeded 100 m. Many of the large herds seen were at, or near, the 50-m depth contour.

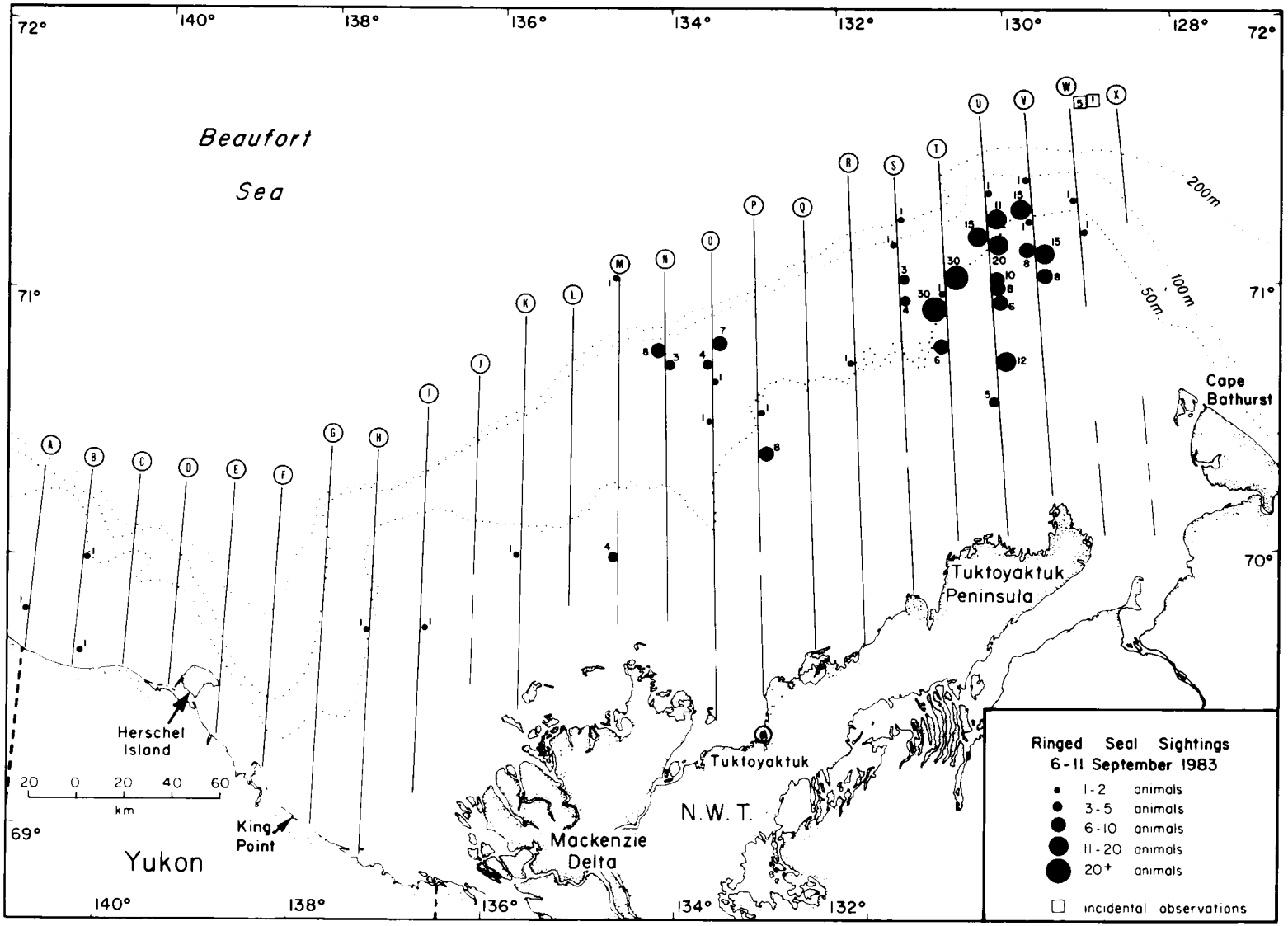

Fig. 13. Ringed seal sightings in the study area, 6-11 September 1983.

Ringed seal sightings comprised both solitary animals and groups of up to 30 animals. The number of sightings of various group sizes is listed in Table 9.

TABLE 9

Sightings of ringed seals by group size

Sighting	Group size										Mean group size
	1	2	3	4	5	6-10	11-15	16-20	21+	Total	
No. of sightings	20	0	2	3	2	9	4	1	2	44	6.0
% of sightings	45.5	0	4.6	6.8	4.6	20.5	11.46	2.3	4.6		

The mean number of seals per sighting was 6, although almost half of the sightings were of single animals. Excluding the sightings of single animals, the mean group size was 10.2 seals. Many of the groups of ringed seals were associated with flocks of seabirds, including black-legged kittiwakes, northern fulmars (Fulmarus glacialis), and glaucous gulls.

Most ringed seals (230 of 265) were seen in ice-free waters; 26 were recorded in open pack ice (6-50% ice cover), and 9 animals were seen in areas of close pack ice (90% ice cover). Seven of the nine animals in the close pack ice were hauled out on ice; all of the other seals recorded were swimming.

Bearded Seal

Distribution. A single bearded seal was recorded during the survey on 19-24 August; it was swimming in shallow ice-free water northeast of Mackenzie Bay (Fig. 14). A flock of 20 glaucous gulls was seen at the same time.

Of total 42 bearded seals recorded during the survey on 6-11 September, all were on-transect, 25 were swimming, and 17 were hauled out on ice pans. Bearded seals were observed throughout much of the study area, but most animals were seen in the eastern half (Fig. 15). Accordingly, recorded densities were much higher in the eastern portion of the study area than in the western portion: densities of the Yukon, Delta, and Tuk. Pen. zones were 0.28, 0.72, and 0.81 seals/100 km^2, respectively.

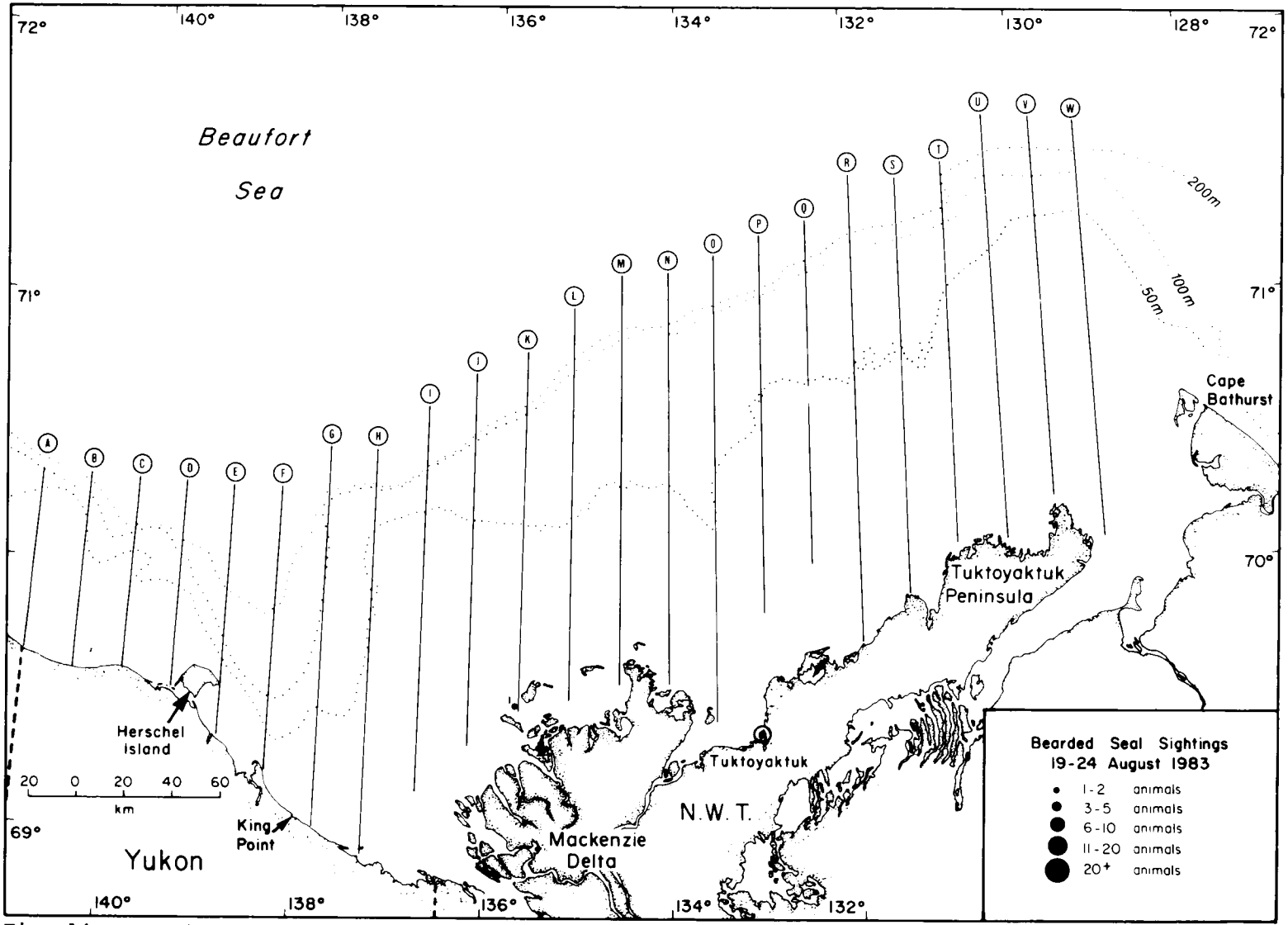

Fig. 14. Bearded seal sightings in the study area, 19-24 August 1983.

In the Delta and Tuk. Pen. zones, most of the bearded seals seen were at least 100 km offshore. However, in the Yukon Zone, where pack ice was present close to shore, most animals seen were within 30 km of the coast. Of the 42 seals seen, 11 were in waters less than 50 m in depth, 20 were in waters 51-100 m in depth, and 11 were in areas where waters exceeded 100 m in depth. This observed distribution differed significantly from that expected, given the relative distances surveyed over the three depth regimes (chi-square = 21.6 df = 2, $p<0.001$). The distribution suggests that bearded seals prefer waters 51-100 m in depth, and that they avoid water 0-50 m deep. However, most of the pack ice present in the eastern half of the study area was restricted to areas where water depths exceeded 50 m, and it is much easier to detect seals when hauled out on ice than when swimming in water. All 17 of the hauled-out bearded seals were beyond the 50-m depth contour.

Most bearded seals seen (29 to 42) were solitary individuals. There were also three groups of two animals and one group each of three and four animals. These last two groups were within 2 km of each other. Seven animals were seen swimming in ice-free waters, 30 were in open pack ice with 6-50% ice cover, and 5 animals were in pack ice with > 75% ice cover.

Sightings by Industry Personnel

Seals were commonly recorded by industry personnel on board drillships and support vessels in the study area. The majority of sightings were merely of 'seals' and, consequently, no distinction between ringed seal and bearded seal could be made in assessing the sightings.

Seals were observed from 3 July to 20 October. In total, 1,506 seals were recorded in 369 sightings (4.1 seals per sighting). However, over 70% (260 sightings) of the sightings were of single animals; the average group size, excluding single animals, was 11.4 seals. Groups ranged in number from 2 to 170 animals. Seals were observed throughout late July, August, and September at all drillsites and from support and supply vessels moving between the drillsites and shorebases at Tuktoyaktuk and McKinley Bay. Animals were regularly observed within a few metres of the drillships. There were 94 sightings, totalling 155 animals (1.6 animals per sighting) from the stationary drillships, and 275 sightings, totalling 1,354 seals (4.9 seals per sighting) from moving supply and support vessels. The presence of animals at many locations

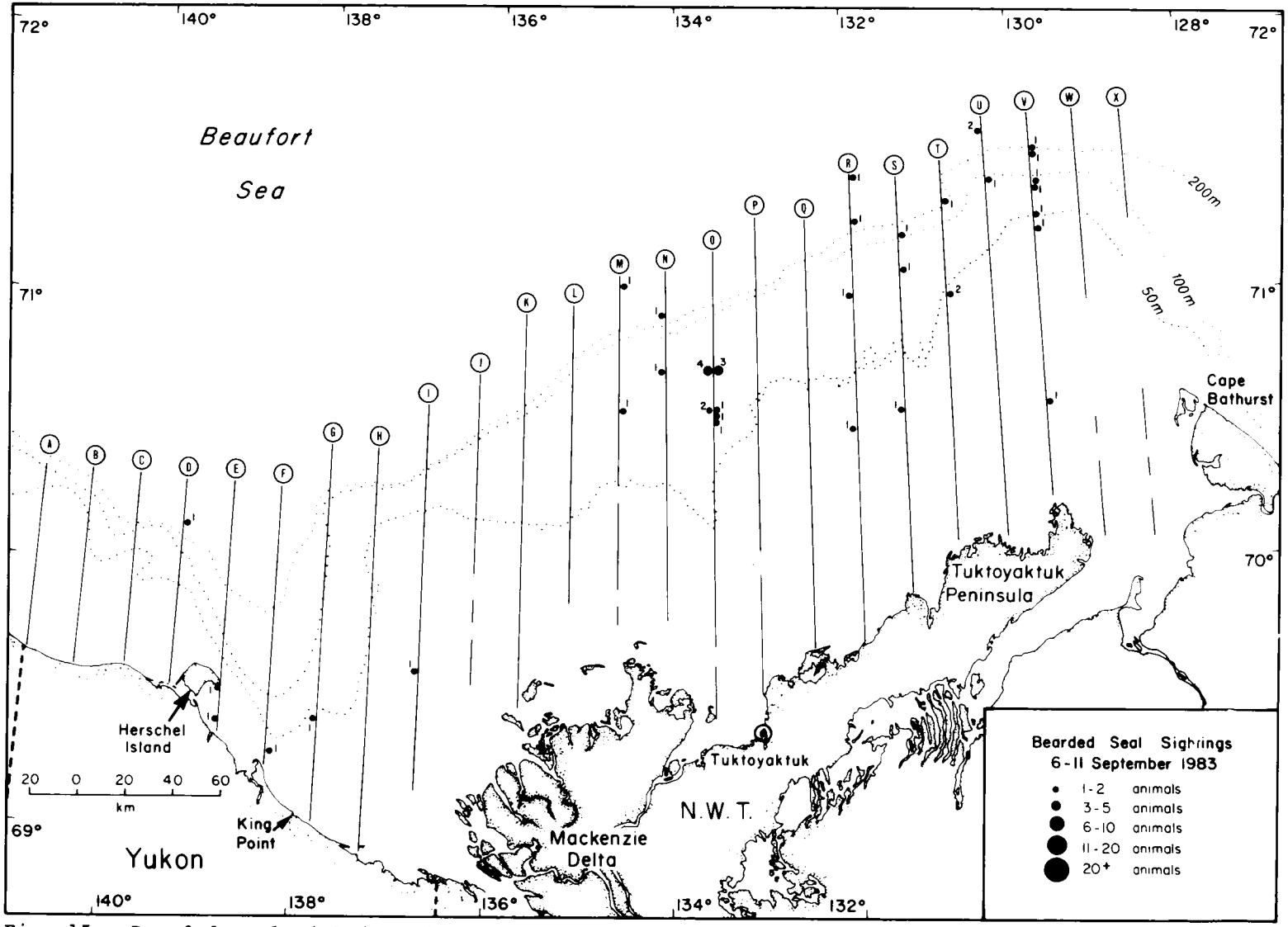

Fig. 15. Bearded seal sightings in the study area, 6-11 September 1983.

indicates that seals were widespread throughout the area of industrial activity (see Bowhead Whale section for locations of industrial activity).

(d) Discussion

At first glance, the results of the aerial surveys indicate that the numbers of ringed seals and bearded seals present in the study area were substantially higher during the survey in early September than during the survey in August. These results are, in general, opposite to the findings of Renaud and Davis (1981) and Harwood and Ford (1983), both of whom recorded higher seal densities in August than in September. However, to a large extent, the detectability of seals in ice-free offshore waters is a function of sea state: it becomes increasingly difficult to detect seals as the sea state increases. Harwood and Ford (1983) noted that less than 1% of the seals seen during their surveys of the Beaufort Sea in August and September 1982 were recorded in sea states greater than 2 on the Beaufort Scale. Renaud and Davis (1981) also noted the difficulty of observing seals in rough waters. In 1983, sea states were substantially higher during the August survey (53% over sea state 2) than during the September survey (18% over sea state 2). Accordingly, the low numbers of seals seen during the August survey were probably an indication of lower detectability rather than an indication of low numbers in the region. Consequently, it is important not to make comparisons between the August and September surveys. Few substantial comments can be made about seal distribution in the southeast Beaufort Sea in late August 1983, except that seals were seen regularly during August by industry personnel on board the drillships and support vessels in the southeast Beaufort Sea.

During the September surveys, recorded densities of both ringed seals and bearded seals increased from west to east; these findings may reflect real differences in distribution within the study area. Harwood and Ford (1983) also noted that densities of both species of seals were highest in 1982 in the Tuk. Pen. Zone. Reasons for such a distribution are not immediately apparent. Ringed seals apparently prefer waters less than 100 m in depth; such areas constitute the greatest portion of the Tuk. Pen. Zone. As well, they avoided areas where pack ice was present; such areas were predominant in the western half of the study area. However, whether these two factors control, or merely reflect, the distribution of the ringed seal in the Beaufort Sea is not known. Food, probably zooplankton (Eley and Lowry 1978), may be a more important

determinant. However, there is little information about zooplankton distribution in the southeast Beaufort Sea or about the feeding habits of ringed seals in the area during the open water period.

Results of the surveys indicated that bearded seals occur in significantly larger number in waters 51-100 m deep than in waters 0-50 m or waters >100 m in depth. As stated previously, however, this observed distribution may in part be a function of the greater visibility of seals hauled out on ice than of swimming seals. Most of the hauled out seals were seen in 51-100 m of water and little ice was present in waters less than 50 m deep. Conversely, the seals may prefer areas where ice is available for hauling out but where water depths are sufficiently shallow that they can feed. Bearded seals are benthic feeders and generally require waters less than about 200 m in depth (Braham et al. 1977). There are, however, few studies of the benthic fauna in offshore waters of the southeast Beaufort Sea and none of the food eaten by bearded seals in this region during the late summer.

Several groups of ringed seals were seen simultaneously with flocks of seabirds but, although associations between seabirds and cetaceans are well known (Evans 1982), pelagic associations between seabirds and seals have received little attention, possibly because of the difficulty in detecting seals in offshore waters. Evans (1982) believed that most seabird-cetacean associations were opportunistic or incidental, as a result of a local concentration of shared prey. Such may have been the case in the seabird-seal associations that were observed. The birds were frequently seen sitting on the water (i.e., possibly feeding) and were in flocks of up of 150 birds. Likely prey items included crustaceans such as euphausiids and amphipods. These foods were found in ringed seal stomachs taken in the western (American) Beaufort Sea in August (Eley and Lowry 1978) and are common prey of fulmars and kittiwakes.

OTHER SPECIES

Industry personnel made 21 sightings of polar bears, totalling 37 animals. Several of the sightings were of animals seen at one site on consecutive days and may have represented the same animal or animals. Polar bears were recorded from 22 July to 16 October, but almost half of them were seen in late September and October (10 sightings, 16 bears), when ice was extensive. Most sightings were of animals on pack ice; there were eight sightings of females with cubs or yearlings. Polar bears were seen throughout the area of industrial activity, from 137°W in the west to 132°13'W in the east.

One walrus was recorded by industry personnel. It was swimming at Nerlerk (70°26'N, 133°20'W) on 25 August 1983.

APPENDIX 1

TABLE A-1. Locations of survey lines and survey dates, 19-24 August 1983

Transect line	Date flown	Co-ordinates South end Lat. (N)	South end Long. (W)	North end Lat. (N)	North end Long. (W)	Length (km)	Direction flown
A	19 Aug	69°39'	140°58'	70°20'	140°58'	75.9	North
B	19 Aug	69°36'	140°26'	70°20'	140°26'	81.4	South
C	19 Aug	69°37'	139°54'	70°20'	139°54'	79.6	North
D	19 Aug	69°33'	139°22'	70°20'	139°22'	87.0	South
E	19 Aug	69°23'	139°50'	70°20'	138°50'	105.5	North
F	19 Aug	69°15'	138°18'	70°20'	138°18'	120.3	South
G	22 Aug	69°05'	137°46'	70°30'	137°46'	157.3	North
H	22 Aug	68°58'	137°14'	70°30'	137°14'	170.2	South
I	22 Aug	69°13'	136°42'	70°40'	136°42'	160.9	North
J	22 Aug	69°23'	136°10'	70°48'	136°10'	157.3	South
K	22 Aug	69°32'	135°38'	70°52'	135°38'	148.0	North
L	22 Aug	69°34'	135°06'	71°03'	135°06'	164.7	South
M	23 Aug	69°38'	134°34'	71°10'	134°34'	170.2	North
N	23 Aug	69°40'	134°02'	71°11'	134°02'	168.4	South
O	20 Aug	69°29'	133°30'	71°15'	133°30'	196.2	North
P	20 Aug	69°49'	132°58'	71°20'	132°58'	168.4	South
Q	20 Aug	70°00'	132°26'	71°22'	132°26'	151.7	North
R	23 Aug	69°46'	131°54'	71°32'	131°54'	196.1	North
S	23 Aug	69°57'	131°22'	71°31'	131°22'	174.0	South
T	24 Aug	70°08'	130°50'	71°34'	130°50'	159.1	North
U	24 Aug	70°08'	130°18'	71°44'	130°18'	177.6	South
V	24 Aug	70°17'	129°46'	71°43'	129°46'	159.2	North
W	24 Aug	70°07'	129°14'	71°42'	129°14'	175.8	South

APPENDIX 1

TABLE A-2. Locations of survey lines and survey dates, 6-11 September 1983

Transect line	Date flown	Co-ordinates South end Lat. (N)	South end Long. (W)	North end Lat. (N)	North end Long. (W)	Length (km)	Direction flown
A	6 Sep	69°39'	140°58'	70°20'	140°58'	75.9	North
B	6 Sep	69°36'	140°26'	70°20'	140°26'	81.4	South
C	6 Sep	69°37'	139°54'	70°20'	139°54'	79.6	North
D	6 Sep	69°33'	139°22'	70°20'	139°22'	87.0	South
E	6 Sep	69°23'	139°50'	70°20'	138°50'	105.5	North
F	6 Sep	69°15'	138°18'	70°20'	138°18'	120.3	South
G	6 Sep	69°05'	137°46'	70°30'	137°46'	157.3	North
H	6 Sep	68°58'	137°14'	70°30'	137°14'	170.2	South
I	6,8 Sep	69°13'	136°42'	70°40'	136°42'	160.9	North
J	8 Sep	69°23'	136°10'	70°48'	136°10'	157.3	South
K	8 Sep	69°32'	135°38'	71°01'	135°38'	164.1	North
L	8 Sep	69°34'	135°06'	71°03'	135°06'	164.7	North
M	8 Sep	69°46'	134°34'	71°10'	134°34'	151.7	South
N	8 Sep	69°40'	134°02'	71°11'	134°02'	168.4	North
O	8 Sep	69°29'	133°30'	71°15'	133°30'	196.2	South
P	8 Sep	69°34'	133°01'	71°23'	133°01'	201.6	South
Q	9 Sep	69°45'	132°26'	71°22'	132°26'	179.0	North
R	9 Sep	69°46'	131°54'	71°32'	131°54'	196.1	South
S	9 Sep	69°57'	131°22'	71°31'	131°22'	174.0	North
T	9 Sep	70°08'	130°50'	71°34'	130°50'	159.1	South
U	9 Sep	70°08'	130°18'	71°44'	130°18'	177.6	North
V	9 Sep	70°17'	129°46'	71°43'	129°46'	159.2	South
W	11 Sep	70°07'	129°14'	71°42'	129°14'	175.8	North
X	11 Sep	70°06'	128°42'	71°42'	128°42'	177.6	South

APPENDIX 2
EFFECTS OF SEA STATE ON DETECTABILITY OF BOWHEAD WHALES

Davis et al. (1982) tentatively concluded that the population densities of bowhead whales recorded during aerial surveys decreased as sea state (Beaufort Scale) increased. In this section the observed distribution of bowhead whales during the surveys in 1983 are related to the sea conditions encountered during the surveys, and the effects of sea state on the numbers of bowhead whales recorded in 1983 are listed in Table A-3.

TABLE A-3

Relationship between sea state (Beaufort Scale) and numbers of bowhead whales recorded during surveys in the Beaufort Sea, August-September 1983

Sea state (Beaufort Scale)	No. of km surveyed	No. whales recorded	No. recorded/ 1,000 km	No. whales on-transect	Density (no./1,000 km^2)
19-24 August					
0	6.9	0	0	0	0
1	270.3	1	3.70	1	1.85
2	1,315.8	15	11.40	7	2.66
3	1,123.4	7	6.23	3	1.34
4	463.0	9	19.44	6	6.48
5+	128.1	0	0	0	0
	3,307.5	32	9.68	17	2.57
6-11 September					
0	563.6	7	12.42	2	1.77
1	1,210.2	23	19.00	16	6.61
2	945.3	16	16.93	8	4.23
3	438.9	4	9.11	3	3.42
4	135.0	0	0	0	0
5+	6.6	0	0	0	0
	3,299.6	50	15.15	29	4.39
Total					
0	570.5	7	12.27	2	1.75
1	1,480.5	24	16.21	17	5.74
2	2,261.1	31	13.71	15	3.32
3	1,562.3	11	7.04	6	1.92
4	598.0	9	15.05	6	5.02
5+	134.7	0	0	0	0
	6,607.1	82	12.41	46	3.48

The results are in general agreement with the findings of Davis et al. (1982). The relatively high density recorded in sea state 4 and the low density recorded in sea state 0 are likely functions of low sample sizes rather than accurate reflections of actual detectability.

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Please insert the attached Errata sheet in your copy of ESRF Report #001.

ERRATA

Environmental Studies Revolving Funds Report No. 001 (McLaren, P.L. and R.A. Davis. 1985. Distribution of bowhead whales and other marine mammals in the southeast Beaufort Sea, August - September 1983) regrettably contains a number of errors and recipients are asked to make the following corrections:

Page (i) correct mailing address is
LGL LIMITED
environmental research associates
P.O. Box 280
King City, Ontario, Canada
L0G 1K0

Page (ii) - correct citation should read
MacLaren, P.L. and R.A. Davis. 1985. Distribution of bowhead whales and other marine mammals in the southeast Beaufort Sea, August-September 1983. Environmental Studies Revolving Funds, Report No. 001. Ottawa. 62 p.

Page 1 - text lines 23-24 should read: "... 56 bowhead whales were observed during the systematic survey on 19-24 August ...".

Page 11 - text lines 13-14 should read: "... this area was the same as that which was surveyed in 1982 ...".

Page 13 - text lines 21-22 should read: "... this uniformity of flight altitudes would provide the most consistent results for the whale surveys .".

- text line 26, delete reference to "Harwood and Ford 1983".

Page 15 - text lines 13-15 should read: "Areas where impossible observation conditions were encountered are denoted by gaps in the survey lines on the distribution maps ...".

- text line 17, "state of the sea" should read: "sea state".

Page 16 - Table 1 title, should read: "Sea surface conditions (Beaufort Scale) encountered during aerial surveys of the southeast Beaufort Sea, August-September 1983".

Page 26 - Table 3. (a): The survey block named "Yuk. Pen Zone" should read: "Tuk. Pen Zone".
(b): The values of 189 and 313 are placed in the wrong column. The total estimated number of bowheads for the 19-24 August survey is 189 (s.e. 53.7); that for the 6-11 September survey is 313 (s.e. 72.1).

Page 27 - text lines 18-19, should read: "... bowheads were present in an area of at least 371 km^2 and it is logical to assume ...".

Page 28 - text lines 25-26 should read: "Würsig et al. (1983) calculated that non-calf bowheads northeast of Herschel Island ...".

Page 32 - Table 6. (a): delete the heading "Distribution factors".
(b): categories of water depth (m) should read 0-50, 51-100 and >100.

Page 33 - text line 1 should read: "The locations of offshore hydrocarbon exploration activities ...".

- text line 16: the longitude of Ukalerk is 132°42'W.

Page 37 - text lines 4-5 should read: "... animals were seen in deeper waters (>100 m in depth) ...".

Page 39 - text lines 15-16 should read: "... variations in the distribution and availability of zooplankton concentrations on which bowheads feed.".

Page 39 - text line 28, add the sentence: "Observations in future years may well reverse the trend".

Page 43 - text line 2 should read: "sightings during the survey were in waters with pieces of brash ice ...".

Page 44 - text lines 24-25 should read: "The results of the surveys in 1983 tend to substantiate the findings of Davis and Evans (1982) ...".

Page 46 - Table 8. Delete the heading "Distribution".

Page 48 - Table 9. Delete the heading "Sighting".

Page 48 - text lines 20-22 should read: "A total of 42 bearded seals were recorded during the survey on 6-11 September; all were on-transect. Twenty-five were swimming and 17 were hauled out on ice pans.".

Page 50 - text lines 11-12 should read: "... and that they tend to avoid waters 0-50 m deep.".

Page 52 - text lines 39-40 should read: "As well, they tended to avoid areas where pack ice was present;".

Page 53 - text lines 20-21 should read: "... seals were seen simultaneously with flocks of seabirds. Although associations between seabirds and cetaceans ...".

Page 57 - text lines 1-2 should read: "Davis et al. (1982) tentatively concluded that the densities of bowhead whales ...".