Bowhead and White Whales in the Southern Beaufort Sea

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Technical Report No. 4

Beaufort Sea Project

Frontispiece. Tom Elanik, oldest active whale hunter in the Mackenzie Delta region at Ugurukuvik (Bird Camp), July, 1976. (B. Milsom photo).

BOWHEAD AND WHITE WHALES IN THE SOUTHERN BEAUFORT SEA

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TABLE OF CONTENTS

LIST OF MAPS

LIST OF MAPS (Continued)

LIST OF PHOTOS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. SUMMARY

(1) White whales migrate annually from their wintering area in the Bering Sea to the southeast Beaufort Sea and Amundsen Gulf, in May and June. They probably travel in the far offshore series of leads between Point Barrow, Alaska, and Banks Island. A local westward movement to the Mackenzie estuary takes place in late June and early July using the nearshore lead along the landfast ice. Probably the majority of white whales in the southeast Beaufort Sea congregate in the Mackenzie estuary from late June to early August. Some leave the estuary shortly after they arrive; others may spend the summer east of the estuary, in and near Amundsen Gulf. Smaller numbers also inhabit the Eskimo Lakes. A westward fall migration to wintering grounds takes place in August and September.

(2) High-use areas of white whales in the Mackenzie estuary are classified as: *concentration areas*, which are used consistently by large numbers of whales year after year; *intermittent-use areas*, which are used occasionally by large numbers of whales in some years; and *travel routes*.

(3) The main attraction of concentration areas appears to be the warm water, up to 18°C, which is probably important to all whales but especially to newborn calves.

(4) At least 4,000 white whales occur in the southeast Beaufort Sea, but numbers may be as high as 6,000. Annual production of calves is probably between 600 and 700; many calves are likely to be born in or near the concentration areas.

(5) Feeding by white whales appears to be low within the Mackenzie estuary, although considerable feeding probably occurs in other parts of the Beaufort Sea/Amundsen Gulf region.

(6) Hunting of white whales is an important summer activity for native persons from the Mackenzie delta region. In addition to supplying some winter provisions, the annual whale hunt offers a change from regular community life and an opportunity for native people to maintain an important part of their cultural identity.

(7) The annual kill of white whales amounts to about 225; of these, 150 animals are landed and butchered, and the remainder are wounded and not recovered. The current harvests are probably less than those of the late 1800's.

(8) Traditional whaling camps are located in major whale concentration areas in Mackenzie and Kugmallit Bays. Hunters from Tuktoyaktuk usually make brief hunting excursions from their homes.

(9) Inuit of the Mackenzie delta region hunt white whales in fast, outboard-powered boats and canoes. They shoot with rifles to wound and slow the animal, so that it can be harpooned. After the harpoon, which is attached to a marker-float by a rope, has been secured to the whale, the animal is killed.

(10) The spring migration of bowhead whales, from their wintering ground in the Bering Sea to the Southeast Beaufort Sea, occurs in May and June, probably in the offshore leads. They over-summer and feed mainly in Amundsen Gulf. During their westward migration in late August and September, bowhead whales probably pass close to the Canadian Arctic coast.

(11) The International Whaling Commission does not allow commercial harvesting of bowhead whales, although native persons are permitted to take this species. Recently, the Alaskan harvest has amounted to between 20 and 50 animals each year. Western Canadian Inuit have not killed bowheads for many years.

(12) Offshore petroleum exploration in the Beaufort Sea could potentially have serious adverse effects on bowhead and white whales. White whales, congregated in an estuarine concentration area, react by avoiding boat and barge traffic within approximately 2.5 km (1.5 miles). Boat traffic crossing white whale travel routes may hinder and delay the whales' passage for several hours. The presence of hovercraft and artificial-island construction machinery may locally affect the whales' movements, in some circumstances. Stationary activities, such as operational artificial islands, cause minor and local disturbances to white whales in the Mackenzie estuary. To date, the overall pattern of whale distribution and migration, and the Inuit harvest within the estuary, have not been adversely affected by current levels of industrial activity. Native hunting activities, themselves, are probably the greatest source of disruption to these whales.

(13) An offshore oil-spill or oilwell blowout would potentially threaten bowhead and white whales. In the short-term, both species could be affected by direct toxic effects and by hampering normal migratory movements, and in the long-term by effects on food organisms.

2. INTRODUCTION

Each year, thousands of beluga or white whales (*Delphinapterus leucas*) and hundreds of bowhead whales (*Balaena mysticetus*) migrate to the southern Beaufort Sea and Amundsen Gulf during the open-water season (Photos 1 and 2). Since 1972, oil and gas exploration has been taking place in these same offshore areas. Imperial Oil Limited has drilled exploratory wells from artificial islands, constructed in the shallow, nearshore waters of the Mackenzie estuary (Photo 3). Sun Oil Company Limited has conducted similar, but less extensive operations. In 1976, the first drillships, belonging to Canadian Marine Drilling Limited (a subsidiary of Dome Petroleum Limited) made their appearance (Photo 4). If sufficient reserves of oil and gas are found in the offshore waters of the Beaufort Sea, activities will increase to include step-out drilling and production facilities.

Offshore exploration and subsequent development involves certain environmental risks, of which an oil blowout is the prime and immediate concern. In the Beaufort Sea, which is ice-covered for most of the year, the hazards of such an accident are amplified.

White whales constitute an important renewable resource for the Inuit who hunt them. Each summer, in the Mackenzie delta region, several hundred native people move from the towns to the whale hunting camps. This hunt for white whales provides them with an opportunity to maintain an important part of their cultural identity, in addition to providing part of their food supply for the winter. A small number of white whales is also taken by Alaskan Inuit. However, in Alaska, the hunting emphasis is on bowhead whales, of which 20 to 50 are harvested each year.

2.1 Purpose

The purpose of this report is to describe the biology of bowhead and white whales of the southeast Beaufort Sea and to assess the possible effects of oil and gas exploration on the whales.

2.2 Objectives

The specific objectives are:

(1) to review the life histories of bowhead and white whales, including meristic characteristics, distribution and abundance, migration, preferred habitats, growth and reproduction;

(2) to compare the ecology of white whales within the Mackenzie estuary with the ecology of those in nearby offshore waters;

(3) to identify known and suspected critical habitats used for calving, feeding and travel;

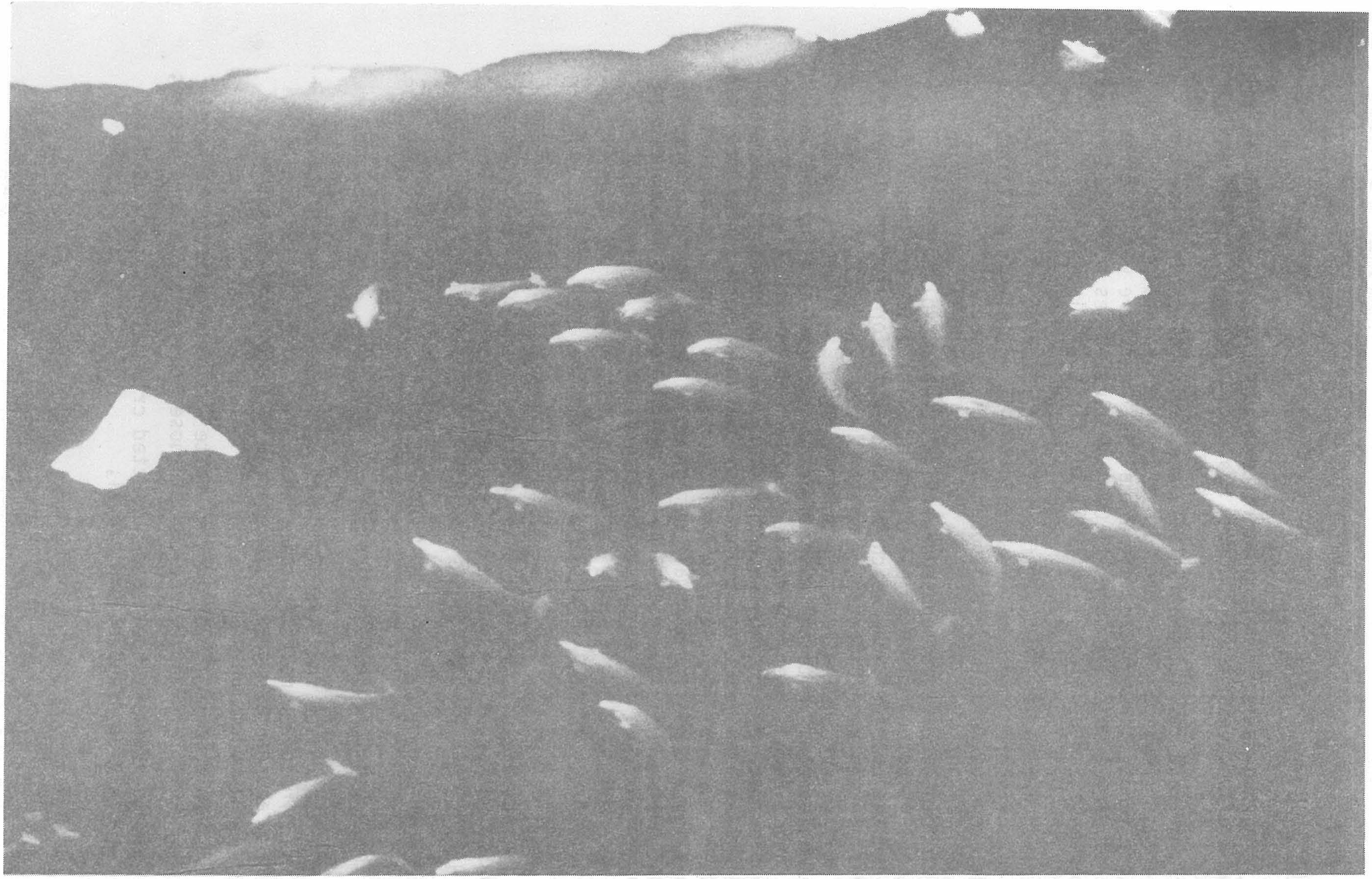

Photo 1. White whales in the ice north of the Mackenzie estuary, July 1974. On their spring migration, the white whales travel through leads in the ice. In 1974, severe ice conditions delayed the whales arrival at the Mackenzie estuary by about two weeks. (M. Robinson photo).

Photo 2. Bowhead whale in Franklin Bay, July 1973. The bowhead whale was much sought after by whalers in the late 19th and early 20th century. (W. Hoek photo)

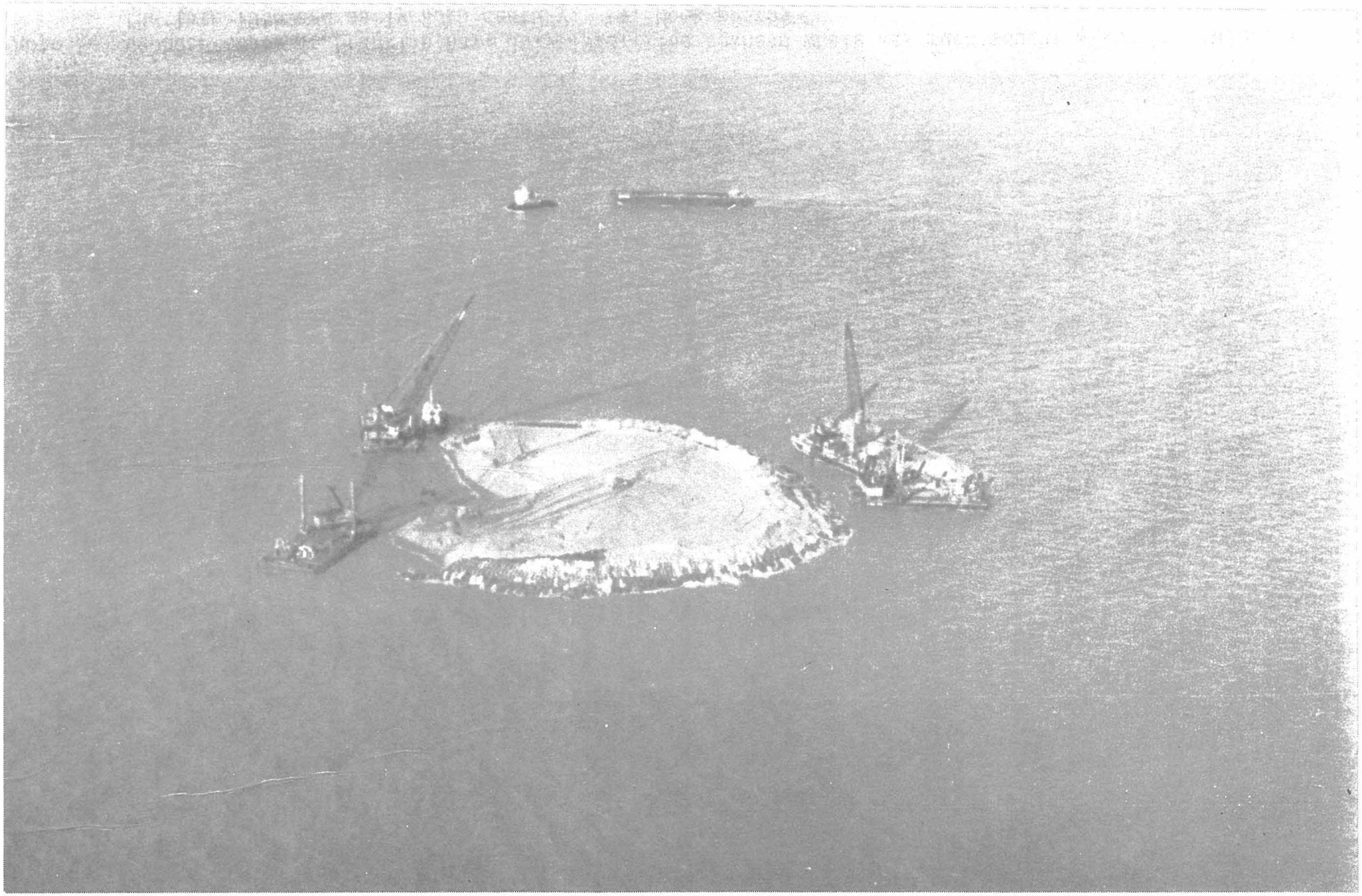

Photo 3. Artificial island under construction in Kugmallit Bay, July 1976. Imperial Oil and Sun Oil have used artificial islands as platforms for exploratory drilling rigs in the shallow waters of the Mackenzie estuary. (M. Fraker photo)

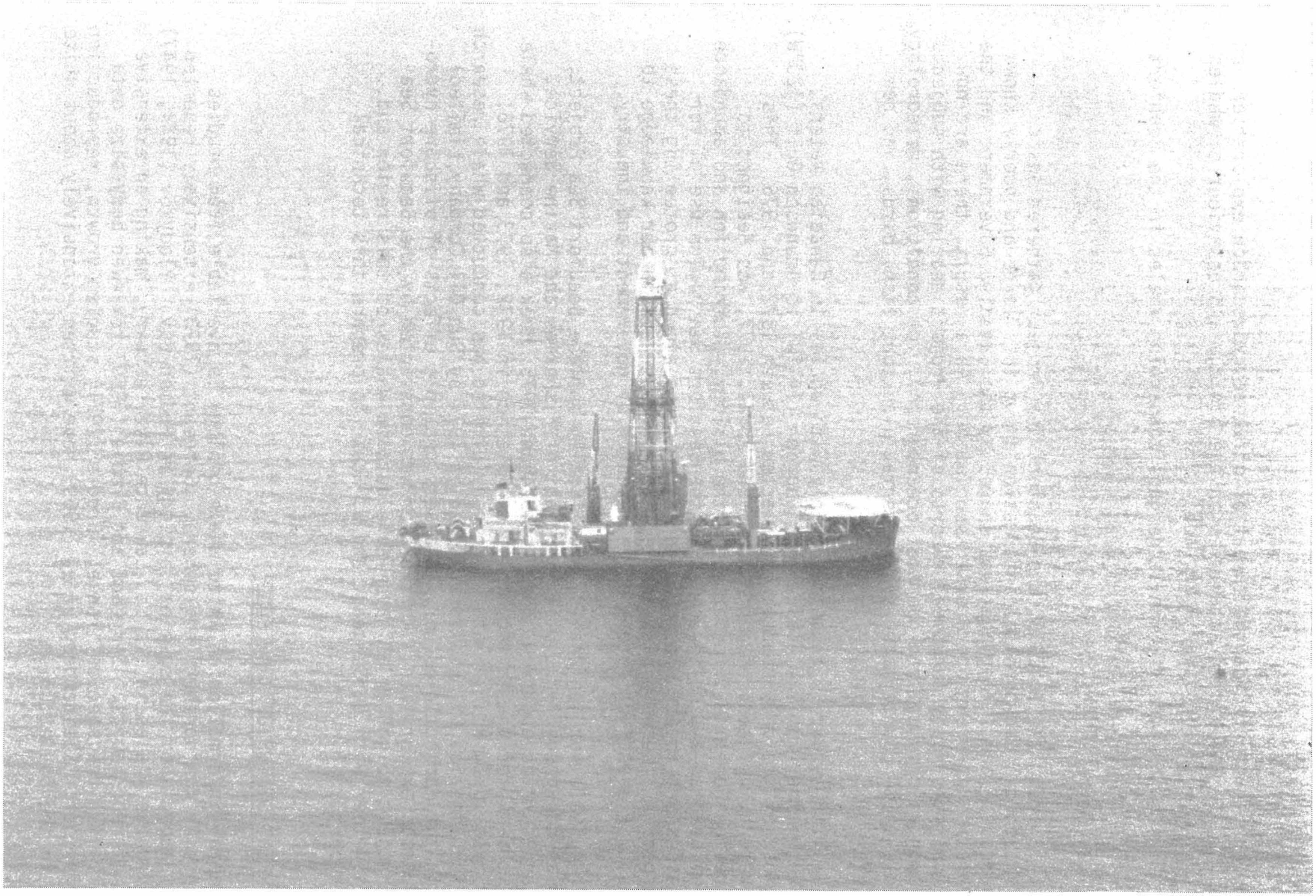

Photo 4. Canmar drillship on location in the Beaufort Sea, August 1976. Offshore exploratory drilling from ships commenced in 1976. (M. Fraker photo)

(4) to predict the threat of offshore hydrocarbon exploration and associated activities on the biology and behaviour of whales in the study area; and

(5) to identify knowledge gaps concerning whales in the Beaufort Sea.

2.3 Scope

From 1974 to 1976, the Beaufort Sea Project gathered basic biological and physical information about this large and poorly known area. Financial support was shared by the Canadian Government and the Arctic Petroleum Operators' Association. As a result, there are now more than forty technical reports of the Project dealing with subjects such as physical and chemical oceanography, ice conditions, meteorology, oil spill countermeasures, bacteria, plankton, fish, birds, and now whales.

This study is concerned mainly with whales in Canadian waters, extending from the Alaska-Yukon border (141°W) to Amundsen Gulf (120°W). Most of the data used were collected between 1972 and 1976. This report, written between January and April, 1977, was designed to review baseline information on the biology, distribution and abundance of bowhead and white whales in the Beaufort Sea region useful for assessing impact and for planning measures aimed at protecting these species. We have also identified important gaps in our knowledge to aid in directing future whale research by government and industry.

Field work on whales, specifically for the Beaufort Sea Project, was designed by Dr. D. E. Sergeant of Fisheries and Marine Service, and carried out by W. Hoek in 1974 and 1975. Hoek also conducted whale studies for the Arctic Biological Station in 1972, 1973 and 1976. Since 1972, F. F. Slaney & Company Limited has conducted whale research for Imperial Oil Limited (joined in 1974 by Sun Oil Company Limited) in the Mackenzie estuary to assess possible effects of offshore hydrocarbon exploration. Mark Fraker was contracted by the Beaufort Sea Project to gather all available data on whales of this region and, together with D. Sergeant and W. Hoek, to prepare this technical report.

3. CURRENT STATUS OF KNOWLEDGE

General information on white whale biology is available from studies elsewhere in the northern hemisphere. Sergeant (1973) extensively reported on most aspects of the species' biology in Hudson Bay. Vladykov (1944, 1947) studied white whales in the St. Lawrence River estuary, making an extensive survey of food habits. Sergeant and Brodie (1969) reviewed body-size data from all over the species' range; Brodie (1971) studied growth, reproduction and behaviour. Kleinenberg *et al* (1969) have written extensively about white whales in the Soviet Union.

Sergeant (1962) dealt briefly with the Mackenzie whale herd. Sergeant and Brodie (1969) reported on body size, and Sergeant (1973) deduced the length-age relationship of whales from the Inuit harvest in the Mackenzie delta region. The most recent publications dealing with white whales of the Beaufort Sea were prepared by F. F. Slaney & Company Limited, dealing mainly with animals of the Mackenzie estuary and the effects of hydrocarbon exploration (Slaney, 1973, 1974, 1975; Fraker 1976, 1977). Seasonal distribution was addressed by Sergeant and Hoek (1974).

Information on the bowhead whale is extremely scarce. Sources of historic information are Scoresby (1820) on food items of whales taken near Greenland; Scammon (1874) on aspects of the natural history of North Pacific whales, including those occupying the Beaufort Sea in summer; and Cook (1926) on commercial hunting of bowheads in the Beaufort Sea near the turn of the century. More recent studies deal with movements and the native harvest of bowheads in Alaska (Fiscus and Marquette, 1975; Marquette, 1976), and seasonal distribution and numbers in the Beaufort Sea (Sergeant and Hoek, 1974; Fraker, 1977).

4. THE STUDY AREA

The study area encompasses the southern Beaufort Sea and Amundsen Gulf lying between 141°W (the Canada/U.S. boundary) and 121°W. Most of the bowhead and white whales in the western Canadian Arctic appear to use this area during the five-month period, May to September. The following sections briefly describe the general physical and biological features of this region as they affect whales. Readers wishing greater detail should consult other Beaufort Sea Project Technical Reports cited in this section.

To facilitate the discussion of the whale data, the region near the Mackenzie delta has been subdivided into several areas :

(1) Mackenzie estuary (the area inside the boundary of intensive studies by F. F. Slaney & Company Ltd; see Map 6);

(2) Niakunak Bay*;

(3) West Mackenzie Bay;

(4) East Mackenzie Bay;

(5) Kugmallit Bay.

4.1 Physical Setting

The movements of bowhead and white whales are governed, to a very large extent, by ice. This section summarizes the general pattern of ice conditions and some of the physical forces affecting the formation and break-up of sea ice.

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* The name "Niakunak Bay" is not an officially recognized geographic name. However, because of its importance to whales, Fraker (1977) delineated this area from West Mackenzie Bay and gave it the local Inuit name "Niakunak" (nee-ak-oo-nak), which refers specifically to the West Whitefish Station locality.

Three general ice zones (Map 1) are defined for the southern Beaufort Sea (Marko, 1975) : *Landfast ice,* a continuous sheet of typically smooth new ice, stretching from the shore out to grounded pressure ridges or ice island fragments at about the 18-20 m depth contour; *Transition Zone Ice,* a zone of rapidly deforming, heavily-ridged and highly irregular ice along the boundary between circulating ice of the Beaufort Gyre and the landfast ice; and *Gyral Pack Ice,* multi-year floes extending from the transition zone out into the Arctic Basin and moving in a clockwise gyre.

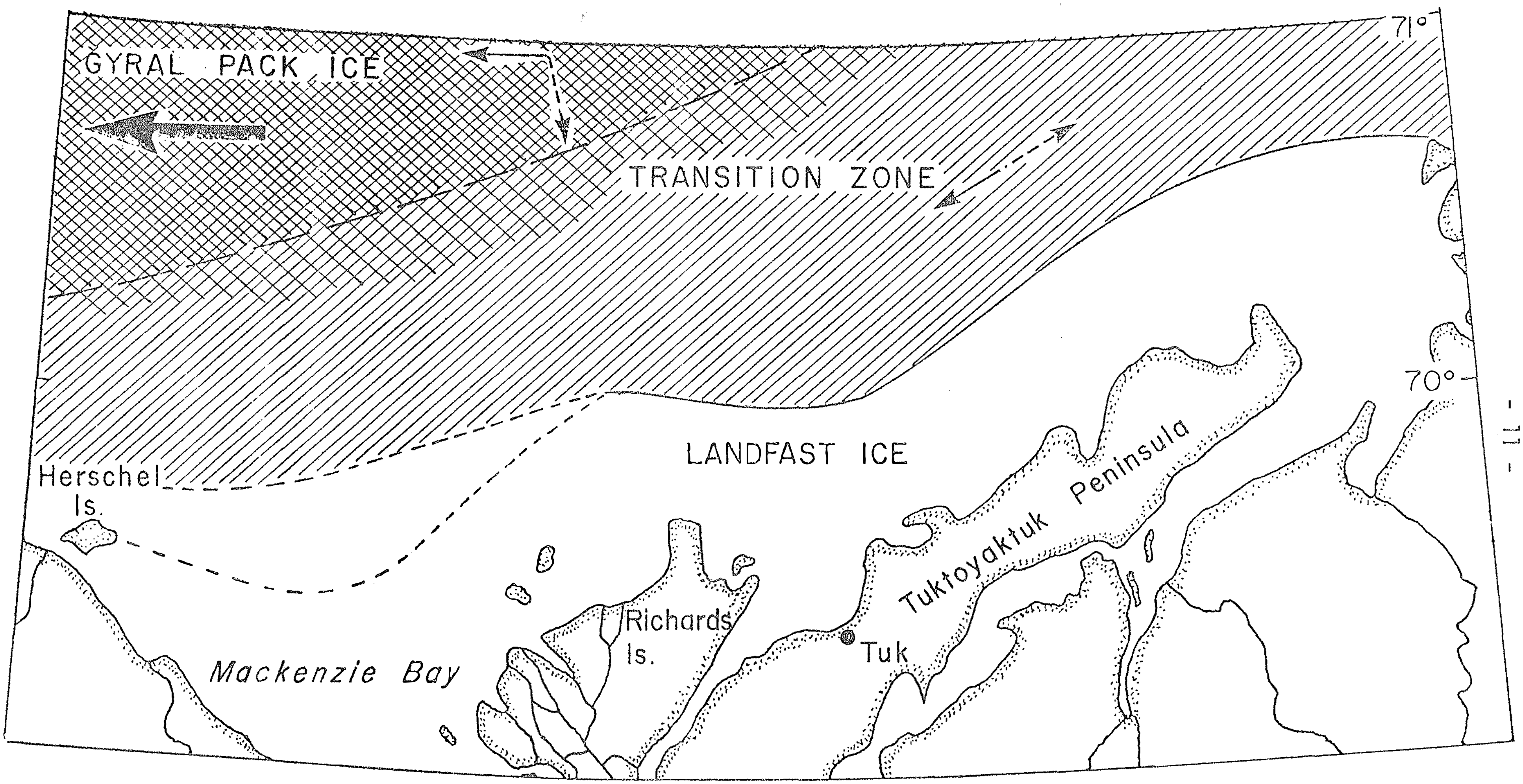
4.1.1 Break-up and Summer Conditions

The Arctic Maritime Climate dominates the study area from break-up in late spring to freeze-up in early fall. During this period, coastal temperatures usually range between 2° and 15°C and precipitation rates and amounts are the highest. Annual total amounts are relatively small, about 15 cm/year (Burns, 1974).

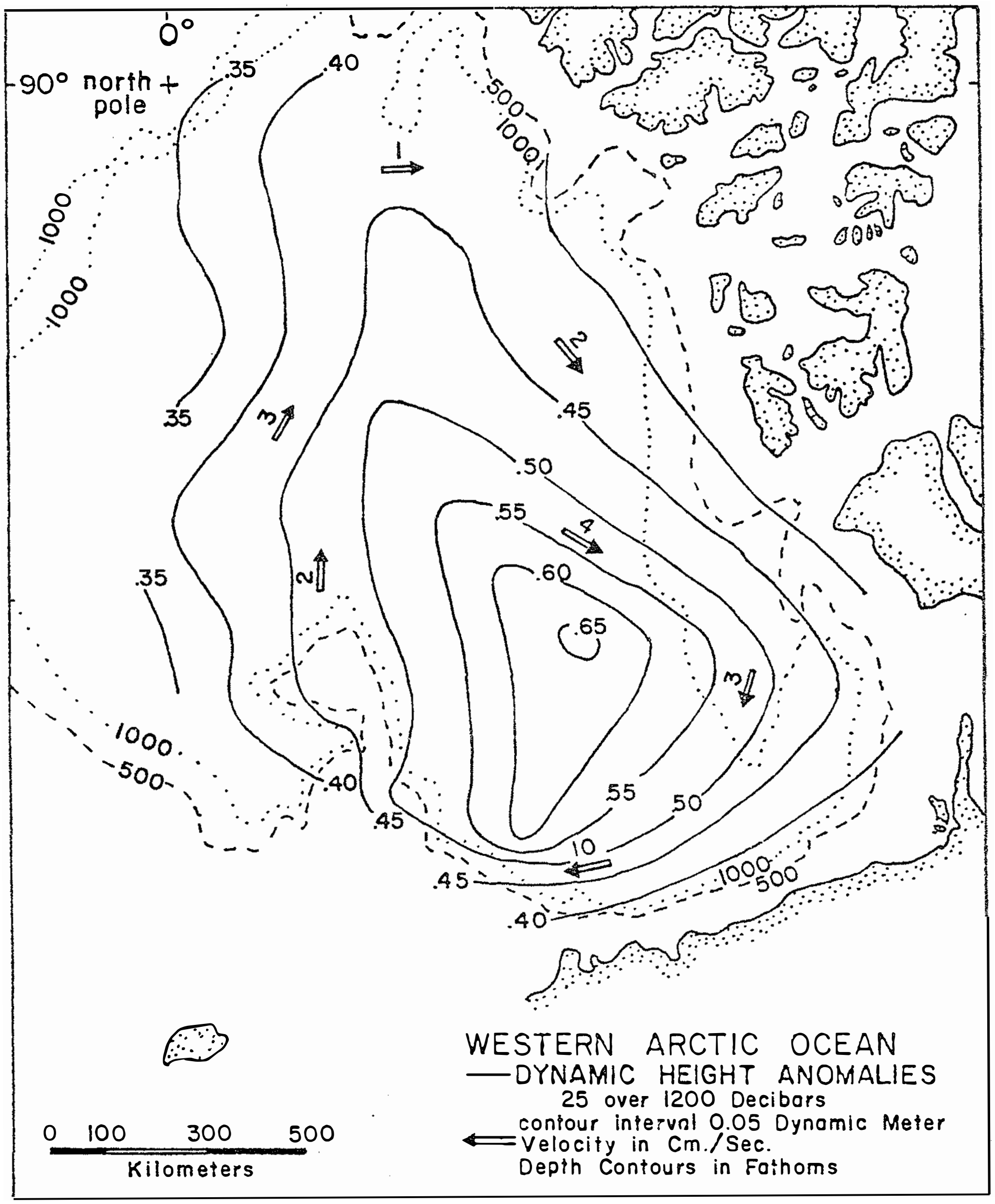
The wind regime is the major factor in influencing the extent of ice build-up, movement and break-up. The clockwise water circulation of the Beaufort Gyre (Map 2) has mean velocities of about 4 cm/sec (Herlinveaux and de Lange Boom, 1975), but can approach speeds of 30 cm/sec for short periods in the spring.

Usually, early spring winds are easterly in the southern Beaufort Sea, resulting in a westward movement of the ice cover. By April, a large polynya (open-water area) begins to develop near Amundsen Gulf, and a fracture zone of varying extent is often observed from Point Barrow to the Banks Island region (Photo 5). During May and June, the polynya usually expands in all directions as the Beaufort Sea Gyre causes a net drift of ice away from the Cape Bathurst area. Two important leads develop : one is north of the landfast ice along the coasts of the Yukon and the Tuktoyaktuk Peninsula, the other beyond the landfast ice west of Banks Island (Photo 6). The ice in Amundsen Gulf also begins to fracture at this time. The rising temperatures, the increased solar radiation (24-hour daylight), and the intrusion of warm, turbid Mackenzie River water causes rapid disintegration of the ice along the coast of the southeast Beaufort Sea. Kugmallit and Mackenzie Bays are usually ice-free by early to mid-July. Open-water conditions in Liverpool Bay and elsewhere along the Arctic coast are usually delayed until late July.

In August of a typical year, the pack ice has retreated to about 100 to 200 km from the Alaskan coast and 200 to 1,000 km from the Canadian mainland, but it usually remains close (0 to 100 km) to Banks Island from Cape Kellett to Cape Prince Alfred (Canadian Hydrographic Service, 1970). Prevailing winds control the large-scale ice movements. If southeasterly winds prevail, the pack can be carried as far as 74° North by August and September. If north-westerly winds prevail, the pack is continually pushed toward nearshore areas where floe concentrations can become heavy, such as in the summer of 1974 and the autumn of 1975.



MAP 1. A schematic representation of the different ice zones of the southeastern Beaufort Sea. The large solid arrow indicates the direction of the prevailing average gyral motion. The lesser solid and broken-line arrows represent the direction of the dominant motion in the winter-spring, and summer-fall periods, respectively. The variable positioning of the landfast ice in western Mackenzie Bay is indicated by the broken-line boundaries merging at Herschel Island (from Marko, 1975).



MAP 2. A compilation by Newton (1974) of dynamic height anomaly data for the Canada Basin of the Arctic Ocean. The corresponding near-geostrophic velocities are indicated by the labelled arrows (from Marko, 1975).

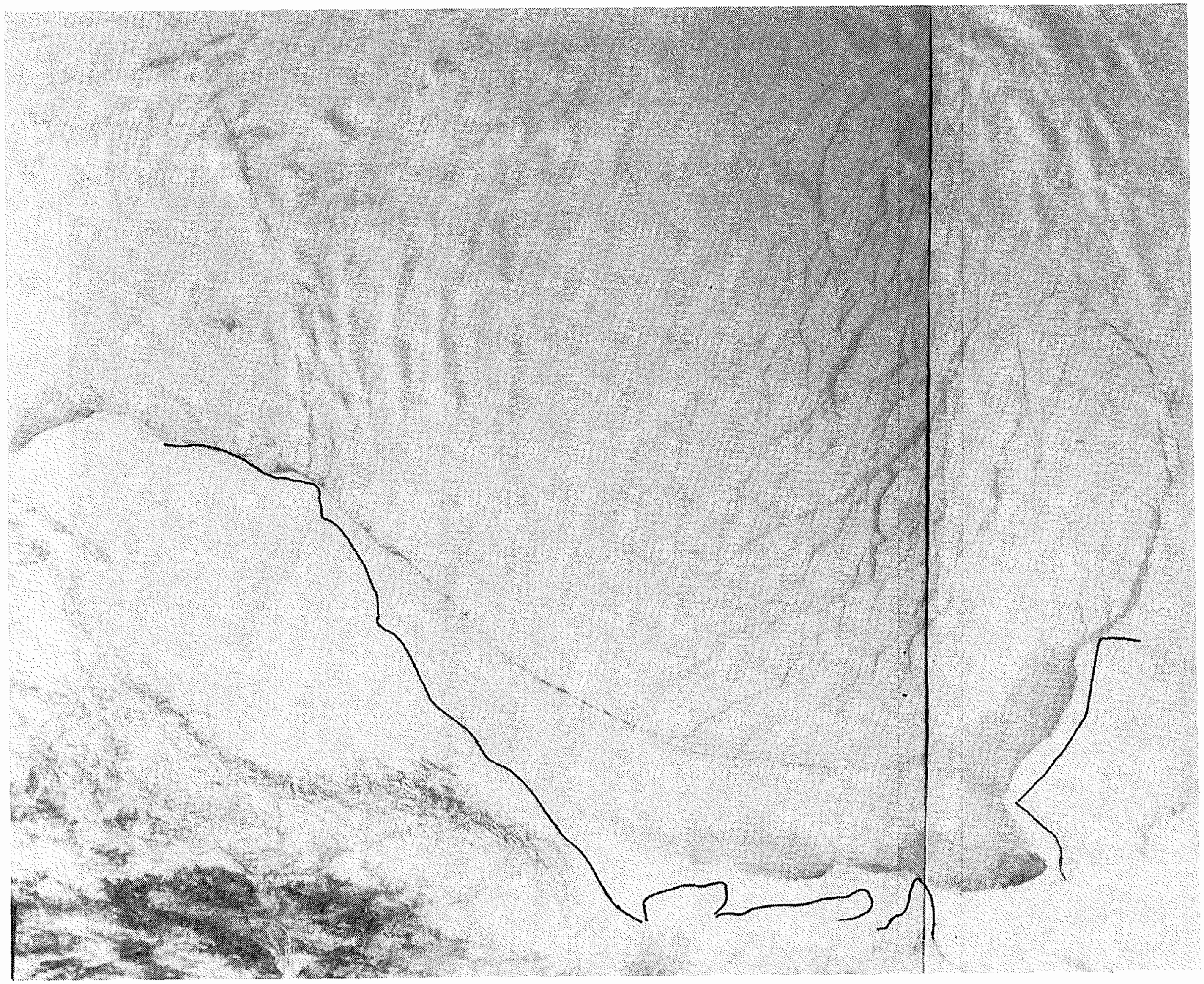


Photo 5. NOAA satellite image of Canada Basin, 26 March 1975. As early as March, a major lead between Point Barrow, Alaska, and the Banks Island region has begun to develop, as have many leads in the polar pack ice to the north.

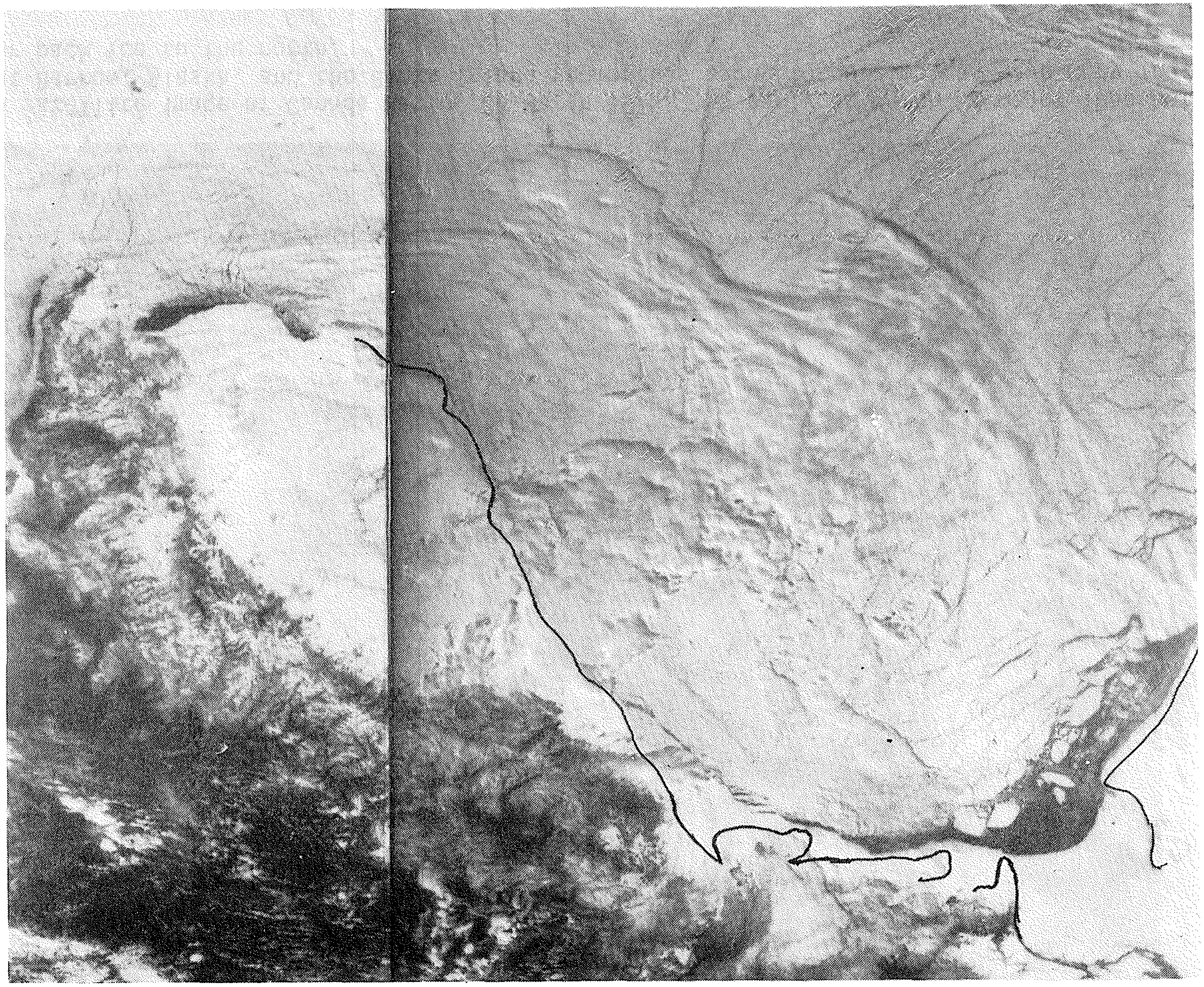


Photo 6. NOAA satellite image of the Canada Basin, 20 May 1973. The large lead west of Banks Island and the nearshore lead north of the Tuktoyaktuk Peninsula were well developed by this time. Although there were whales present in Amundsen Gulf at this time, no whales were observed west of Cape Dalhousie until 19 June, after which large numbers were observed travelling mainly from the east.

4.1.2 Freeze-up and Winter Conditions

Freeze-up in the Beaufort Sea usually occurs in the second week of October, but this can vary from late September in a congested season to early November, if the pack ice has remained well offshore during summer (Canadian Hydrographic Service, 1970). Initial ice formation begins amongst old pack ice and in the brackish, shallow areas near the shoreline. The Beaufort Sea anti-cyclone dominates the weather picture in late September, moving the polar pack shoreward. Eventually, the edge of the polar pack and new shore ice converge about 16 to 32 km offshore. Twenty to twenty-five days elapse between first occurrence of first-year ice and the time of complete freeze-over (Burns, 1974). The Cape Parry area is the last area to freeze-up - usually about mid-November.

During the winter months, a ridge of high pressure usually extends from Siberia across the Chukchi and Beaufort Seas to the Mackenzie Valley. Resulting winds in the Beaufort Sea are generally onshore, keeping the pack ice tightly in place along the coast. Winter maximum temperatures may fall below -40°C. Precipitation is light but prevailing winds cause deep drifting and compacting of snow around pressure ridges and any exposed land masses.

4.2 Biological Setting

The presence of sea ice greatly influences the biological productivity in arctic waters. Under winter snow cover, only small amounts of light penetrate beneath the ice and little photosynthesis occurs. However, a spring plant community develops on the underside of the ice and contributes significantly to the year's primary food production.

The Mackenzie River has a tremendous influence in the southern Beaufort Sea by transporting nutrients and enormous quantities of silt. The extreme turbidity of the river water restricts the penetration of light to a few centimetres and, within the plume of turbid water, productivity is limited mainly by light, not by nutrients (Grainger, 1975).

Grainger (1975), in a survey from Cape Dalhousie to Herschel Island, found the greatest primary productivity near Herschel Island. Relatively high values were also recorded offshore of Richards Island and the Tuktoyaktuk Peninsula, outside the influence of the Mackenzie outflow. Productivity in the southern Beaufort Sea ranks low by northern coastal marine standards (Grainger, 1975). The situation north of Cape Bathurst and in Amundsen Gulf is unknown. The area in which the polynya (open-water area) develops early each year may be quite productive, if for no other reason than that the presence of open water, for a longer period of time, exposes the water to a greater amount of sunlight.

The greatest diversity of zooplankton species was found near Herschel Island and offshore of Richards Island and the Tuktoyaktuk Peninsula.

The numbers of plankton individuals showed a substantially different picture (Grainger, 1975); the highest numbers occurred nearshore, in two bays off Kugmallit Bay (Mason Bay and Tuktoyaktuk Harbour) and in Liverpool Bay. Intermediate numbers were found offshore of the Tuktoyaktuk Peninsula, Richards and the nearby Barrier Islands, the Yukon coast, and north of Herschel Island. The lowest numbers were found in the areas under the greatest influence of the Mackenzie River.

Wacasey (1975) found a similar trend in zoobenthos (bottom-dwelling animals) distribution throughout the same region. The greatest diversity of species was again in areas least influenced by the Mackenzie River - near Herschel Island, north of Cape Dalhousie, and in Liverpool Bay. The greatest biomass values were found north of Cape Dalhousie, intermediate values occurred near Herschel Island and in Liverpool Bay, while low numbers were found in Kugmallit and Mackenzie Bays. The productivity of zoobenthos is lower than that found in eastern Arctic locations, by a factor of 5 to 10 (Wacasey, 1975).

There is no information on productivity in Amundsen Gulf. This is unfortunate, because bowhead whales concentrate in this region from June to August, and white whales occur here during much of June. Whether or not there is abundant food for these marine mammals in this area is unknown.

5. METHODS

This report is based on work from the following sources :

(1) Reports of research conducted on white whales from 1972 to 1976 by F. F. Slaney & Company Limited on behalf of Imperial Oil Limited;

(2) Reconnaissance observations by W. Hoek of the Arctic Biological Station from 1972 to 1976;

(3) Systematic observations during aerial surveys by biologists working on other studies of the Beaufort Sea Project in 1974 and 1975;

(4) Casual observations by geologists, oceanographers, biologists, boat captains, pilots, and others travelling in the Beaufort Sea region.

5.1 Studies by F. F. Slaney & Company Limited, Vancouver

The principal methods of study by F. F. Slaney & Company Limited were systematic aerial surveys, reconnaissance aerial surveys, hunter interviews, and examination of whale carcasses.

5.1.1 Systematic Surveys

Systematic surveys were comprised of flying a set of predetermined flight lines at a constant altitude (1,000 feet, 304 m) and a constant airspeed (120 mph, 194 km/hr). Only those whales within a half-mile (0.8 km) wide strip along either side of the aircraft were counted. The aircraft was flown over a half-mile aircraft runway and the struts were marked so that the projected area on the water viewed between the floats and the strut marks at an altitude of 1,000 feet was a half-mile (0.8 km) wide.

As submerged whales cannot be seen in the turbid water of the Mackenzie estuary, it is impossible to count all whales along a transect line. Based on Sergeant's (1973) observations, a visibility factor of three was applied in 1973 and 1974; a factor of two was applied in 1975 and 1976 (Appendix 7). Because of the calves' dark colour, they are difficult to spot, and no estimate of their numbers was made. Survey periods are shown in Table 1.

TABLE 1. White Whale Survey Periods, F. F. Slaney & Co., Ltd.

1972	June 30	-	August 5
1973	May 26	-	August 11
1974	June 19	-	September 8
1975	June 23	-	August 7
1976	June 27	-	August 17

In 1973 and 1976, regular flight lines, spaced two miles (3.2 km) apart, were used to survey selected areas of the estuary (Map 3). Irregular flight lines were used in 1974 and 1975 to survey the entire estuary area (Map 4). Because of the large size of the study area and the lack of prominent landmarks, the flight lines took advantage of radio beacons from drilling rigs, DEW-line stations and the few useful landmarks which do exist.

5.1.2 Reconnaissance Surveys

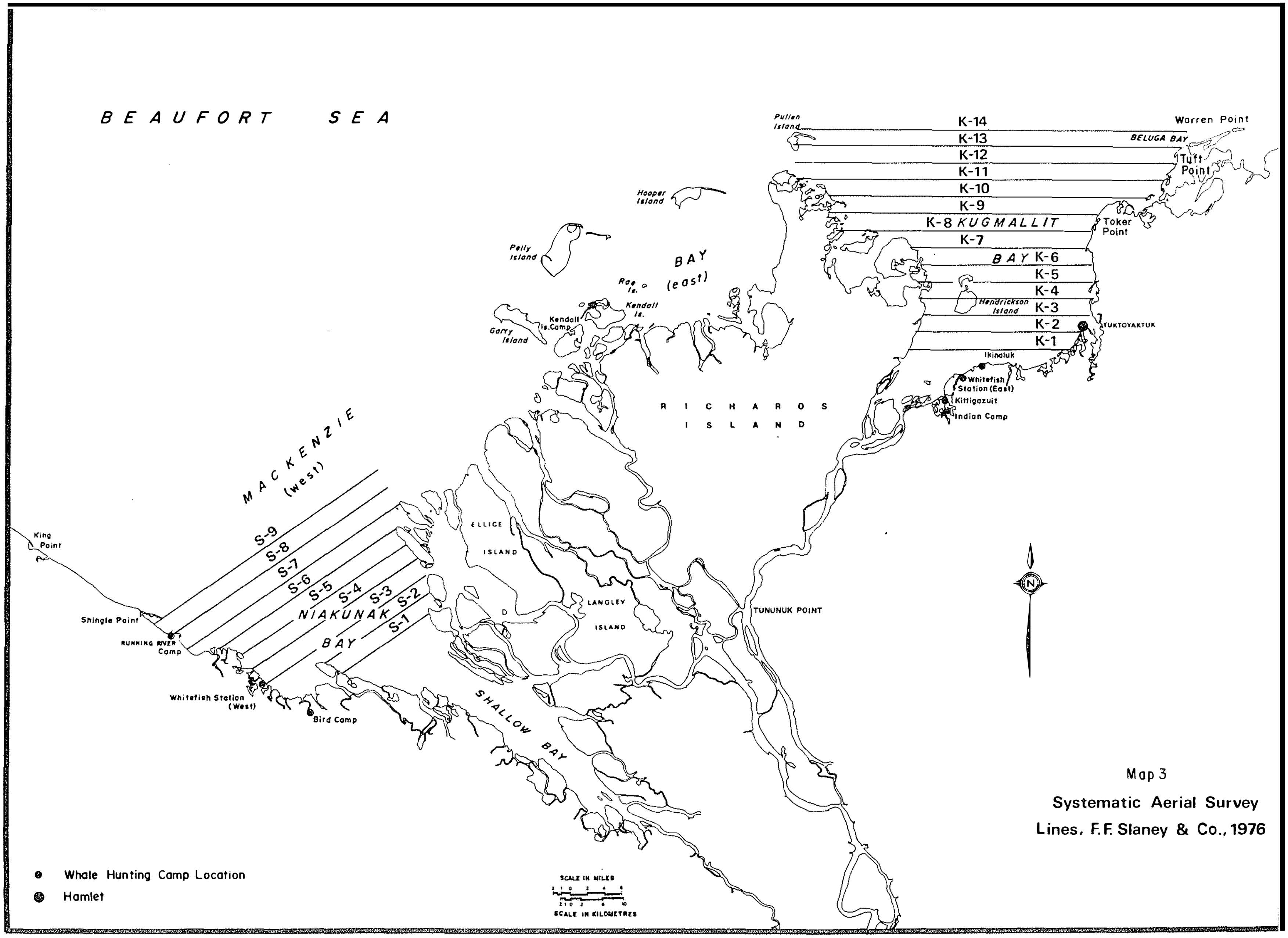
Aerial reconnaissance surveys provided information about the presence or absence of whales in a particular area, or an extensive area, such as the coast of Tuktoyaktuk Peninsula. These surveys were flown at 1,000 feet (304 m); times were recorded at various landmarks and when whales were sighted. Observations were not limited to a half-mile strip along either side of the aircraft, and all sighted whales were recorded. In 1972, all surveys were of a reconnaissance nature.

5.1.3 Camp Visitations

Each year, frequent visits were made to the whaling camps in order to follow the progress of the hunt and to learn of possible interference of the hunt by exploration activities.

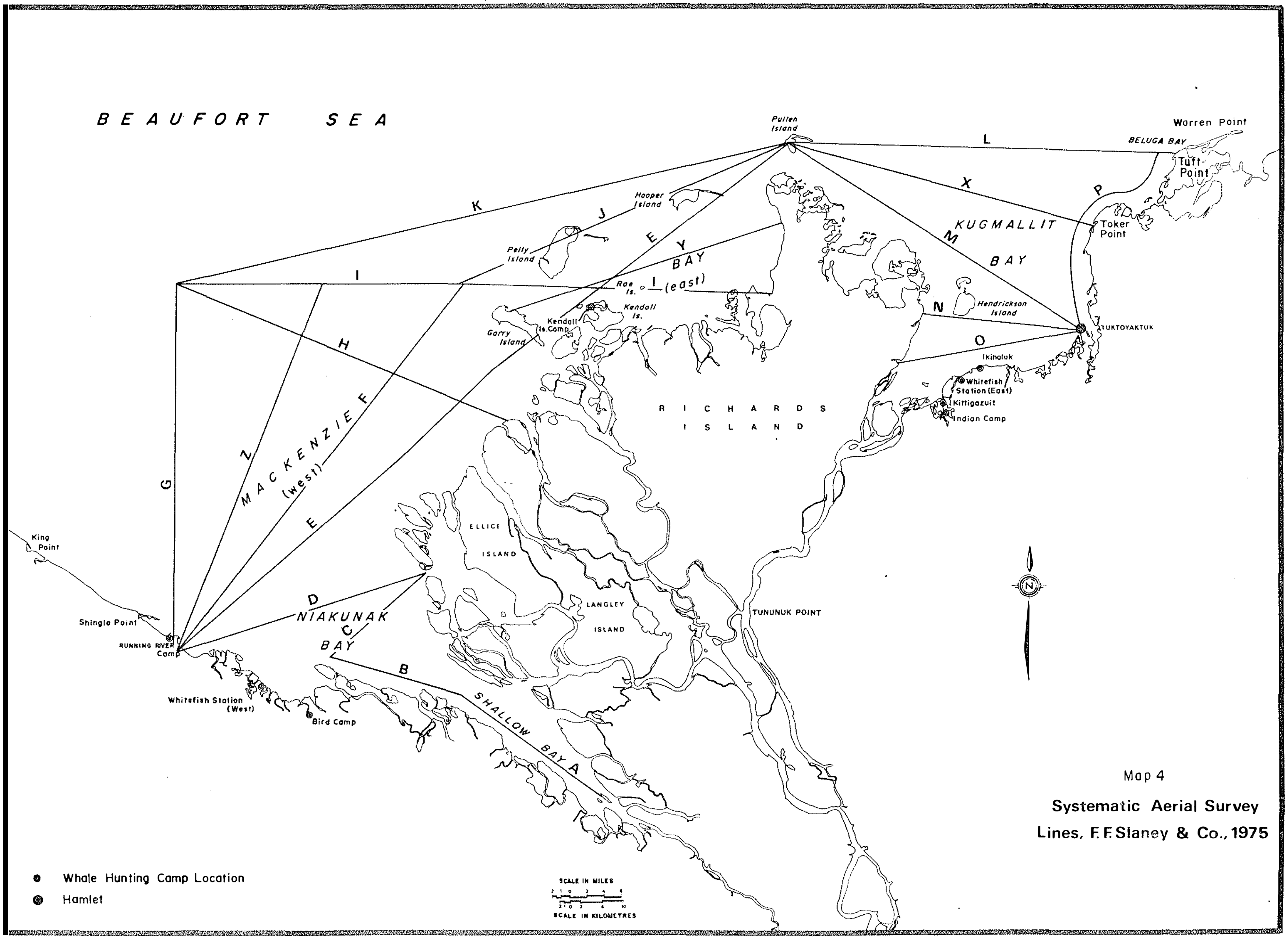
5.1.4 Biological Data Collection

Occasionally, samples of teeth and ovaries, and measurements from whale carcasses were obtained. The carcasses examined were mainly



Map 3

Systematic Aerial Survey Lines, F.F. Slaney & Co., 1976



Map 4

Systematic Aerial Survey Lines, F.F.Slaney & Co., 1975 those landed at a camp or butchering site. Because butchering occurs promptly after the whale is landed, only a few carcasses were examined. In addition, a small number of carcasses of whales which had not been retrieved, but had subsequently washed ashore, were examined.

Length measurements were taken in a straight line from the tip of the snout to the tail-notch. Teeth were removed and later sectioned longitudinally for age determination (Sergeant, 1973). Stomach contents were examined in the field.

5.1.5 Bowhead Harvest Analysis

To determine historic bowhead whale abundance and distribution, and to assess the effects of commercial bowhead hunting, the data compiled by Townsend (1935) were analysed. These data consisted of the catch statistics from all available log books of American whaling vessels, many of which had pursued bowheads in the western Arctic. Most of the vessels which operated in the eastern Beaufort Sea during the 1890's and 1900's were included.

Two assumptions were made in using these data :

(1) All ships which obtained bowheads expended the same effort to kill these whales. The harvest of sailing vessels was compiled separately from that of steamships, to compensate for the differences in technology;

(2) For any given vessel, the whales were taken equally in each year of a particular voyage. Townsend listed the whale harvest during voyages which lasted up to four seasons. For the purposes of analysis, the number of whales killed were averaged for the years of the voyage.

Based on the total whale harvest, and the total number of ships which killed bowheads, a measure of catch per unit effort and the number of whales taken per ship, per year, was computed from 1841 to 1911.

5.2 Studies by the Arctic Biological Station, Ste-Anne de Bellevue

Reconnaissance surveys were made by W. Hoek during the summers, 1972 to 1976. These surveys spanned various portions of the open-water season and covered nearshore and coastal areas, mainly from Herschel Island to Cape Parry. Helicopters (*Bell 205* and *206*) and light fixed-wing aircraft (*Cessna 185* and *337*, and *Twin Otter*) were used. In September, 1972, Hoek conducted a fall flight, utilizing an *Argus* aircraft; this flight went as far west as about 100 miles (160 km) east of Point Barrow, Alaska. In September, 1973, he made a flight north of the Delta and as far west as Herschel Island, using a helicopter, and observed migrating bowheads.

5.3 Studies by Other Biologists of the Beaufort Sea Project

Incidental observations of whales in the course of aerial surveys for seabirds, seals and polar bears provided important supplemental data.

5.3.1 Studies by Canadian Wildlife Service, Edmonton

Sightings of bowhead and white whales were recorded during aerial surveys by Canadian Wildlife Service (CWS) biologists studying seals and polar bears in 1974 and 1975. These surveys were flown from mid- to late June, using a *Cessna 337* flying at 500 feet (152 m). The transect lines seaward from the southern Beaufort Sea coast ran north and south; those along the west coast of Banks Island ran east and west (Map 7). Generally, these lines were 100 miles (160 km) long and five miles apart. Using a random numbers table, approximately 60 per cent of the lines were selected. Animal sightings were usually concentrated in a quarter-mile (0.4 km) strip along each side of the aircraft, although all whales observed off transect were recorded. The aircraft's ground-speed varied from about 150 mph to 180 mph (240 km/hr to 288 km/hr). The two survey periods were 19 - 28 June, 1974 and 12 - 20 June, 1975. The whale observations are plotted on Maps 7 and 8. The whole of the area was surveyed in 1974. In 1975, surveys extended for only a few miles beyond the landfast ice; there was extensive open water between 136°W and 126°W and west of Banks Island, and surveying areas of open water for seals was pointless. (Stirling *et al.* 1975).

5.3.2 Studies by L.G.L. Ltd., Edmonton

In 1975, L.G.L. Ltd. conducted seven aerial surveys of seabirds during the period 14 May to 5 July, mainly north of the Yukon coast; the 9 July survey extended east to Richards Island. These flights followed different tracks each time and concentrated along leads in the ice. The flights were usually conducted at an altitude of 30 - 46 m and an airspeed of 114 - 192 km/hr. The observers reported all birds (and whales) seen, both 'on' and 'off' a 400 m-wide transect strip. Observations are listed in Appendix 4, and details can be found in Richardson *et al.*(1975).

5.3.3 Studies by Renewable Resources Consulting Services Ltd., Edmonton.

In 1974, Renewable Resources Consulting Services Limited conducted three monthly seabird surveys of the southeast Beaufort Sea, from June to August. In addition, one survey was flown in April, four in May, and two in both September and October. Prior to June, the flights were designed to detect the presence of birds in offshore leads; later surveys followed the flight lines shown on Map 9. The surveys were flown at an airspeed of 100 mph (160 km/hr) and at an altitude of 150 feet (38 m). Incidental observations of whales are shown on Maps 9 and 17. Details of surveys can be found in Searing *et al.*(1975).

5.4 Observations by Other Persons

More than 80 whale observations were contributed by other biologists, aircraft pilots, boat captains, and others. Some of this information was passed on verbally or in letters; some was forwarded on self-addressed, postage-paid, arctic whale sighting cards supplied by the Arctic Biological Station.

6. RESULTS AND DISCUSSION

6.1 White Whales

6.1.1 Movements and Distribution

White whales migrate from their wintering area in the Bering Sea to the southeast Beaufort Sea/Amundsen Gulf region in May and early June, using a far offshore complex of leads which develop between Point Barrow, Alaska, and Banks Island. Their westward movement into the Mackenzie estuary usually takes place in the last half of June through the nearshore lead which lies off landfast ice north of the Tuktoyaktuk Peninsula. The majority of the whales in the southeast Beaufort Sea congregate in the Mackenzie estuary from late June to early August although some animals leave the estuary shortly after they arrive. A substantial number of white whales spend the summer east of the estuary, in and near Amundsen Gulf; a smaller number summer in the Eskimo Lakes. A westward migration to the wintering grounds occurs in late August and September.

6.1.1.1 Spring Migration

Since Mackenzie estuary whales probably spend the winter in the Bering Sea (Section 6.1.1.9), the spring observations of white whales swimming generally in a northeast direction past Point Hope in northwestern Alaska, are of particular interest (Table 2). These observations by biologists of the U. S. National Marine Fisheries Service, and by Alaskan natives, were limited to those animals which pass along the lead adjacent to the landfast ice. Any whales migrating farther offshore could not be seen.

The peak movement of white whales past Point Hope occurs in the first two weeks of May, but a few pass in late April and late May (Table 2). There is no direct proof that these animals eventually travel to the southeast Beaufort Sea in the summer, but their direction of movement is consistent with this assumption. The Alaskan observation of about 2,000 white whales in early May, 1974 is consistent with the size of the Mackenzie herd; no summer whale concentration areas are known from northern Alaska.

TABLE 2. The Spring Movement of White Whales past Point Hope, Alaska, 1974 and 1975. (Whales sighted)

Date	1974[1]	1975[2]
Prior to April 30	n/a[3]	1
April 30	n/a	100
May 1	60	n/a
April 30 to May 2	n/a	1
May 2	2,000	7
May 3	300	-
May 4	18 to 19	-
May 5	-	-
May 6	-	-
May 7	25 to 35	-
May 8	22 to 27	-
May 9	-	-
May 10	-	25
May 11	-	-
May 12	200	-
May 13	-	30
May 14	-	20
May 15	4 or 5	11
May 16	25 to 35	-
May 17	-	-
May 18	-	-
May 19	-	-
May 20	-	-
May 21	n/a	-
May 22	n/a	15
May 23	n/a	12
May 24	n/a	-
May 25	n/a	-
May 26	n/a	15
May 27	n/a	7

[1] From Fiscus and Marquette (1974)
[2] From Marquette (1976)
[3] n/a = not applicable

The earliest sightings of white whales in the eastern Beaufort Sea are in mid-May. Stefansson (1922) and his party,camped along the ice edge west of Banks Island, were awakened by the barking of their dogs during the night of May 21, 1914. The cause of this disturbance was the blowing of white whales, and "thousands" were seen during the next two or three weeks. Recently, white whales were observed in the southeast Beaufort Sea (May 27, 1974) by biologists conducting bird surveys. Although they had seen no white whales two weeks earlier, bowhead whales were spotted, indicating that travel to this area was possible during early May.

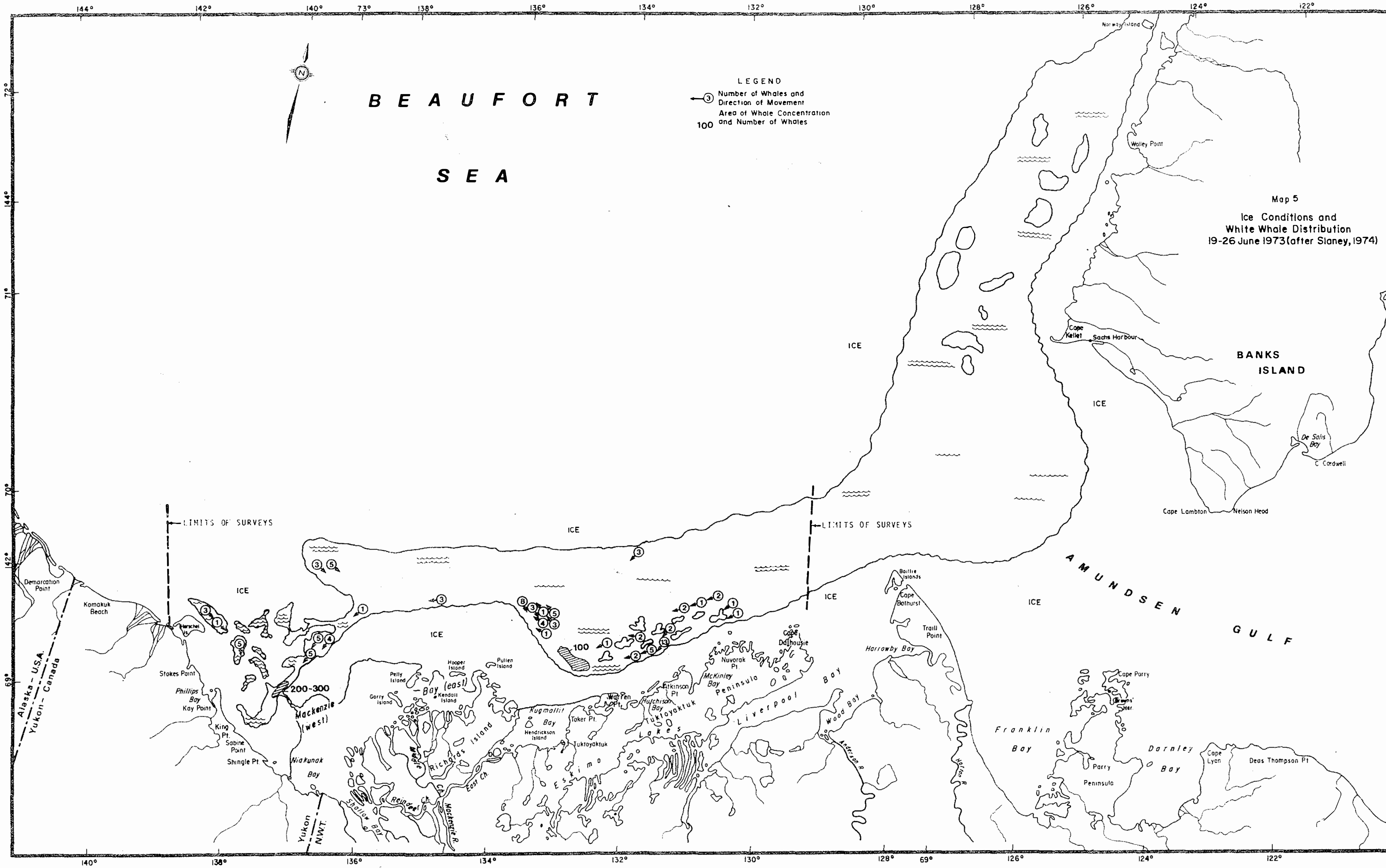
In 1973, a large nearshore lead was present, extending west from the Amundsen Gulf region nearly to Herschel Island (Photo 6); however, no white whales were observed from May 26 to June 19. During the period June 19 to 26, many whales were present seaward of landfast ice from Herschel Island to Cape Dalhousie (Map 5); most whales were arriving from the east and travelling along landfast ice of the Tuktoyaktuk Peninsula. On June 8 and 9, nearly 200 whales were seen in Amundsen Gulf by D. Andriashek (Map 6; Appendix 2).

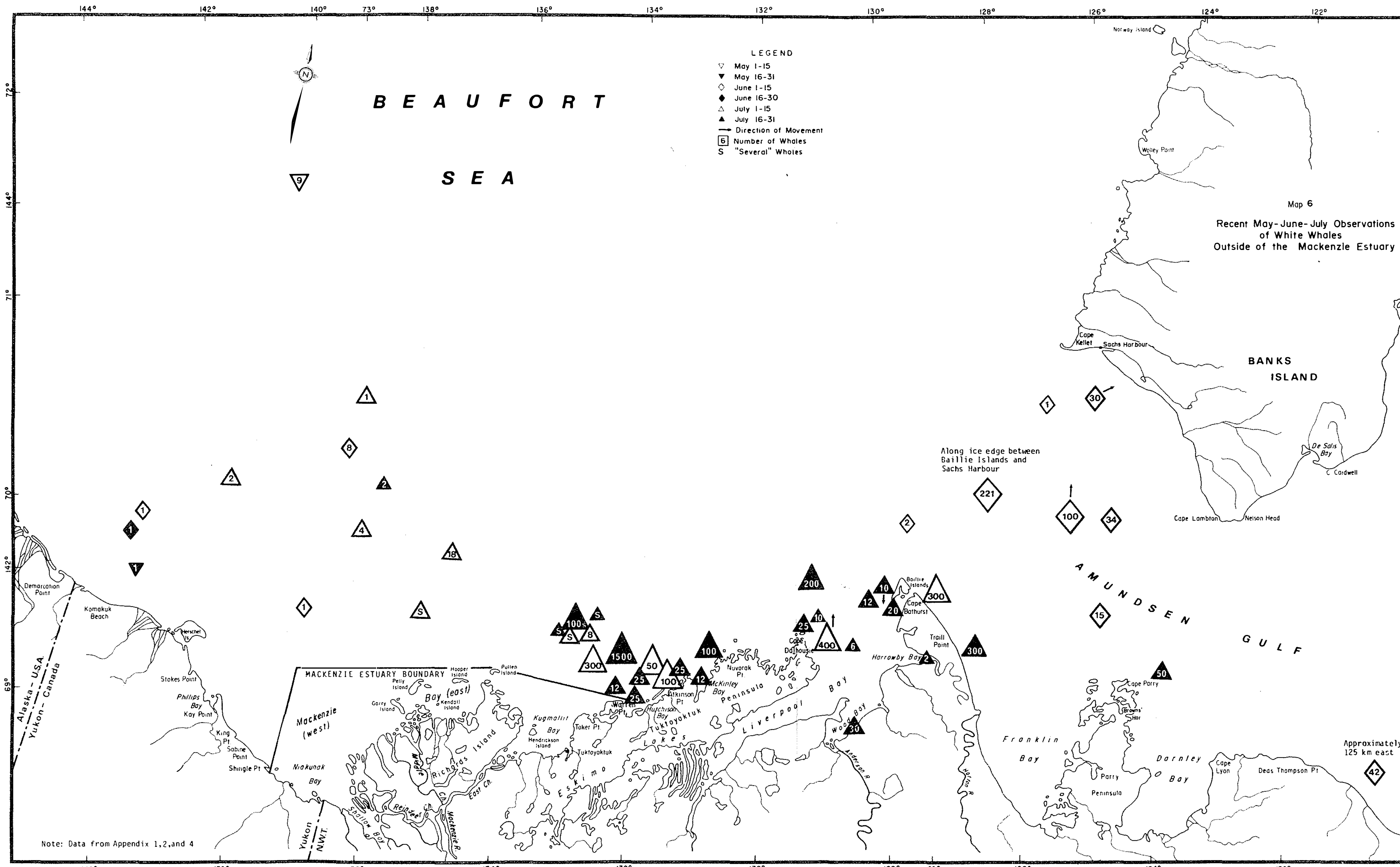
In 1974, a year of severe ice conditions in the southeast Beaufort Sea, most white whales also arrived in the Mackenzie estuary from the east (Slaney, 1975). Whale surveys on June 19 and 28, 1974 revealed that most whales were in Amundsen Gulf. The smaller number of white whales west of Banks Island were headed south, perhaps towards the estuary (Map 7).

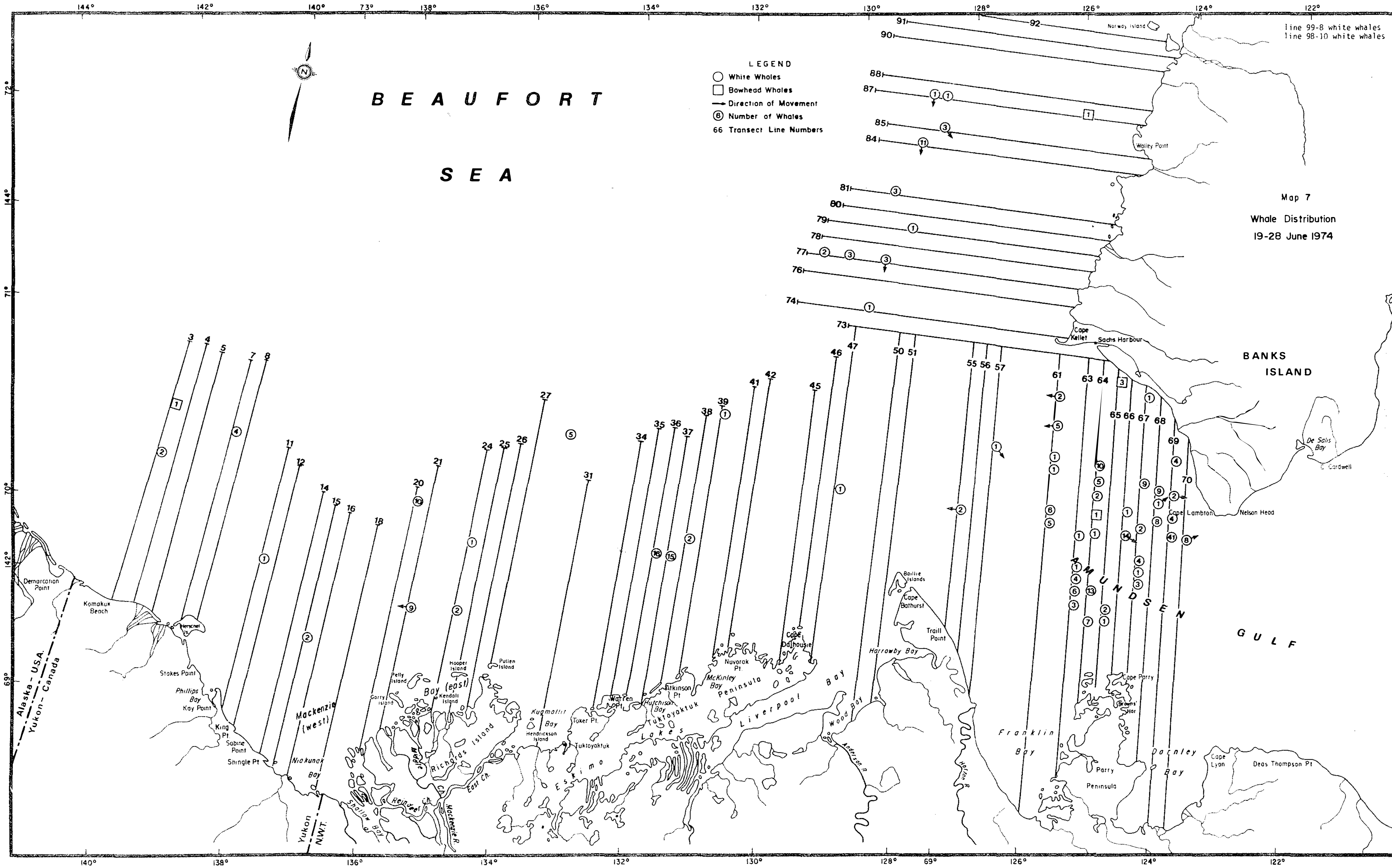
In 1975, the mid-June pattern of whale distribution was similar to that of the previous year (Map 8). Numerous whales were present within the pack ice of Amundsen Gulf, with lesser numbers found in ice-infested waters north of Mackenzie Bay. The area beyond the landfast ice along the Tuktoyaktuk Peninsula and the west coast of Banks Island was largely ice-free but the presence or absence of whales in this region was not determined. On June 23, white whales were seen moving in a southwest direction, parallel to the Tuktoyaktuk Peninsula. However, small numbers of whales were also observed swimming east near Herschel Island and Demarcation Point. Thus, it appeared that most whales entered the estuary from the east.

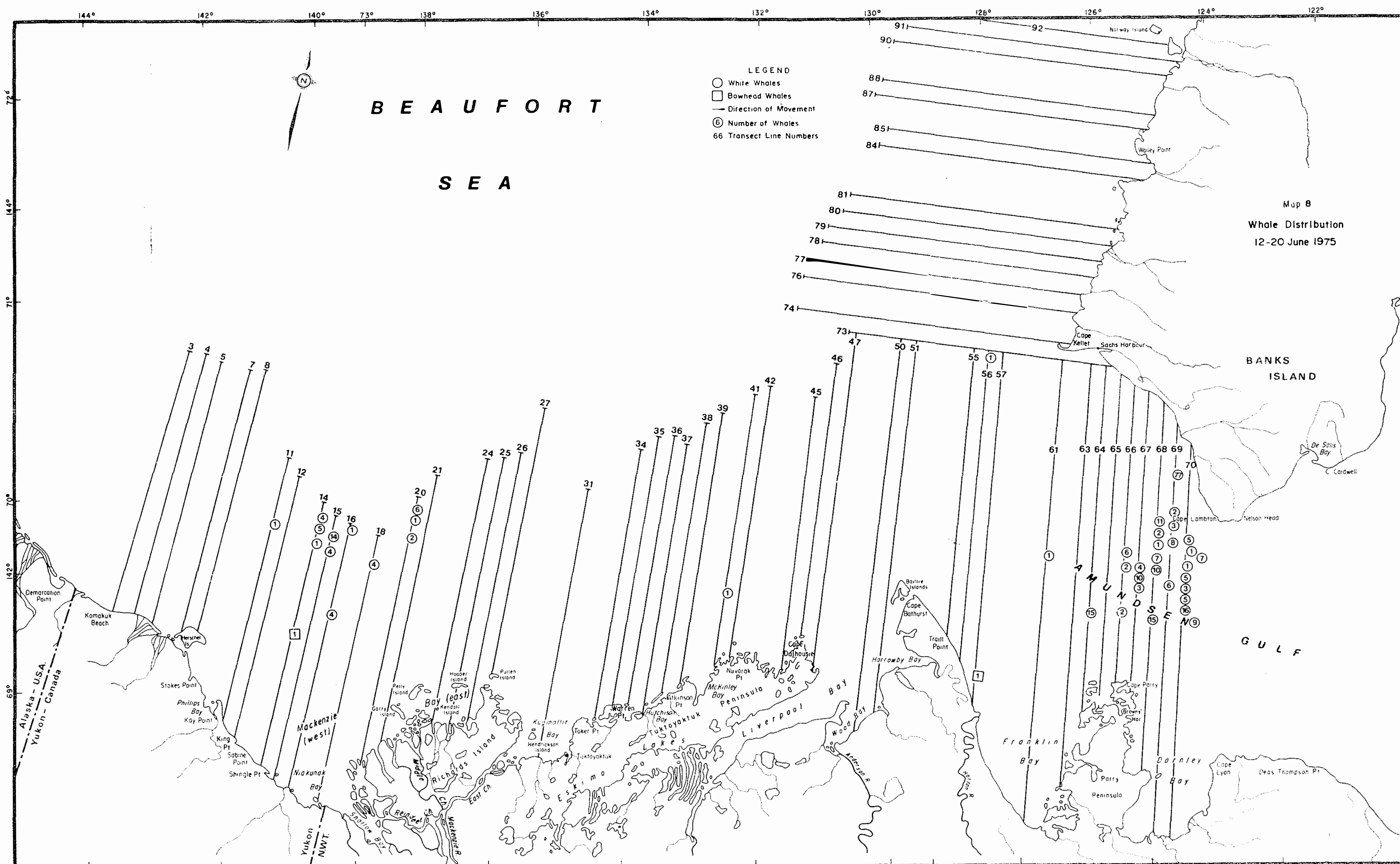
We hypothesize that far offshore leads which extend generally from Point Barrow, Alaska, to the vicinity of Banks Island are used by most white whales migrating from their wintering area in the spring. This route need not be used by all whales nor in all years, although it seems to offer the best explanation for the appearance of whales in the Amundsen Gulf area in May and June.

Evidence strongly indicates that the majority of white whales come to the Mackenzie delta region from the east; some also arrive from the west. For example, pods of 22 and 4 were seen swimming east of Herschel Island, and near the Alaska/Yukon border, respectively, on June 29, 1975 (Fraker, 1976). There are also several observations of white whales north and west of the estuary


BEAUFORT
SEA
LEGEND
Number of Whales and Direction of Movement
Area of Whale Concentration and Number of Whales
Map 5
Ice Conditions and White Whale Distribution
19-26 June 1973 (after Slaney, 1974)
BANKS ISLAND
AMUNDSEN GULF
LIMITS OF SURVEYS
ICE
200-300
Mackenzie (west)
Bay (east)
Richards Island
Tuktoyaktuk Peninsula
Liverpool Bay
Franklin Bay
Darnley Bay
Parry Peninsula
Eskimo Lakes
Herschel
Demarcation Point
Komakuk Beach
Stokes Point
Phillips Bay
Kay Point
King Pt
Sabine Point
Shingle Pt
Niakunak Bay
Shallow Bay
Yukon NWT
Alaska - U.S.A.
Yukon - Canada
Pelly Island
Garry Island
Hooper Island
Pullen Island
Kendall Island
Kugmallit Bay
Hendrickson Island
Toker Pt
Tuktoyaktuk
Warren Pt
Atkinson Pt
Hutchison Bay
McKinley Bay
Nuvorak Pt
Cape Dalhousie
Wood Bay
Harrowby Bay
Baillie Islands
Cape Bathurst
Traill Point
Cape Parry
Cape Lyon
Deas Thompson Pt
Cape Lambton
Nelson Head
C Cardwell
De Salis Bay
Cape Kellet
Sachs Harbour
Norway Island
Walley Point
East Ch
Mackenzie R.
Anderson R.
Horton R.


BEAUFORT SEA
LEGEND
May 1-15
May 16-31
June 1-15
June 16-30
July 1-15
July 16-31
Direction of Movement
Number of Whales
S "Several" Whales
Map 6
Recent May-June-July Observations of White Whales Outside of the Mackenzie Estuary
BANKS ISLAND
AMUNDSEN GULF
Along ice edge between Baillie Islands and Sachs Harbour
Approximately 125 km east
MACKENZIE ESTUARY BOUNDARY
Mackenzie Bay (west)
Bay (east)
Alaska - USA
Yukon - Canada
Yukon
N.W.T.
Franklin Bay
Darnley Bay
Liverpool Bay
Eskimo Lakes
Sachs Harbour
Cape Kellet
De Salis Bay
C. Cardwell
Cape Lambton
Nelson Head
Cape Parry
Parry Peninsula
Cape Lyon
Deas Thompson Pt
Cape Bathurst
Baillie Islands
Harrowby Bay
Trail Point
Cape Dalhousie
Nuvorak Pt
McKinley Bay
Tuktoyaktuk
Kugmallit Bay
Richards Island
Pelly Island
Hooper Island
Pullen Island
Garry Island
Kendall Island
Shingle Pt
Stokes Point
Phillips Bay
Kay Point
King Pt
Sabine Point
Komakuk Beach
Demarcation Point
Herschel
Niakunak Bay
Shallow Bay
East Ch.
Mackenzie R.
Note: Data from Appendix 1,2,and 4


line 99-8 white whales
line 98-10 white whales
LEGEND
White Whales
Bowhead Whales
Direction of Movement
Number of Whales
66 Transect Line Numbers
BEAUFORT
SEA
Map 7
Whale Distribution
19-28 June 1974
BANKS
ISLAND
AMUNDSEN
GULF
Sachs Harbour
Cape Kellet
Nelson Head
Cape Lambton
De Salis Bay
Cape Parry
Parry Peninsula
Franklin Bay
Darnley Bay
Cape Lyon
Deas Thompson Pt
Cape Bathurst
Baillie Islands
Harrowby Bay
Liverpool Bay
Wood Bay
Cape Dalhousie
Nuvorak Pt
McKinley Bay
Tuktoyaktuk Peninsula
Eskimo Lakes
Tuktoyaktuk
Kugmallit Bay
Hendrickson Island
Pullen Island
Hooper Island
Pelly Island
Garry Island
Kendall Island
Richards Island
Mackenzie Bay (east)
Mackenzie Bay (west)
Niakunak Bay
Shallow Bay
Shingle Pt
King Pt
Sabine Point
Kay Point
Phillips Bay
Stokes Point
Herschel
Komakuk Beach
Demarcation Point
Alaska - U.S.A.
Yukon - Canada
Yukon
N.W.T.


BEAUFORT
SEA
LEGEND
White Whales
Bowhead Whales
Direction of Movement
Number of Whales
66 Transect Line Numbers
Map 8
Whale Distribution
12-20 June 1975
BANKS
ISLAND
AMUNDSEN
GULF
Cape Kellet
Sachs Harbour
De Salis Bay
Cardwell
Cape Lambton
Nelson Head
Norway Island
Mackenzie (west)
Bay (east)
Richards Island
Eskimo Lakes
Tuktoyaktuk
Liverpool Bay
Franklin Bay
Darnley Bay
Parry Peninsula
Cape Parry
Cape Bathurst
Cape Dalhousie
Harrowby Bay
Wood Bay
Baillie Islands
Trail Point
Cape Lyon
Pearce Point
Herschel Is.
Komakuk Beach
Demarcation Point
Stokes Point
Phillips Bay
Kay Point
King Pt
Sabine Point
Shingle Pt
Niakunak Bay
Shallow Bay
Pelly Island
Garry Island
Hooper Island
Kendall Island
Pullen Island
East Ch.
Kugmallit Bay
Hendrickson Island
Toker Pt
Warren Pt
Atkinson Pt
Hutchison Bay
McKinley Bay
Nuvorak Pt
Alaska - USA
Yukon - Canada
Yukon
N.W.T.
Mackenzie R.
Anderson R.
Horton R.
Browns Har.

in May and June (Maps 6 and 9). These may be animals which made their way early from the Amundsen Gulf region, coming east by some route other than the offshore route hypothesized earlier, or which deviated, at some point, from the far offshore route to follow smaller leads into the western part of the study area.

6.1.1.2 Arrival at the Mackenzie Estuary

Whether whales enter from east or west, they usually arrive at the Mackenzie estuary in the last week of June, when landfast ice fractures across Mackenzie and Kugmallit Bays (Map 5). The exact timing of arrival is very much dependent on this ice condition, (see Table 3).

TABLE 3. Arrival of White Whales at the Mackenzie Estuary

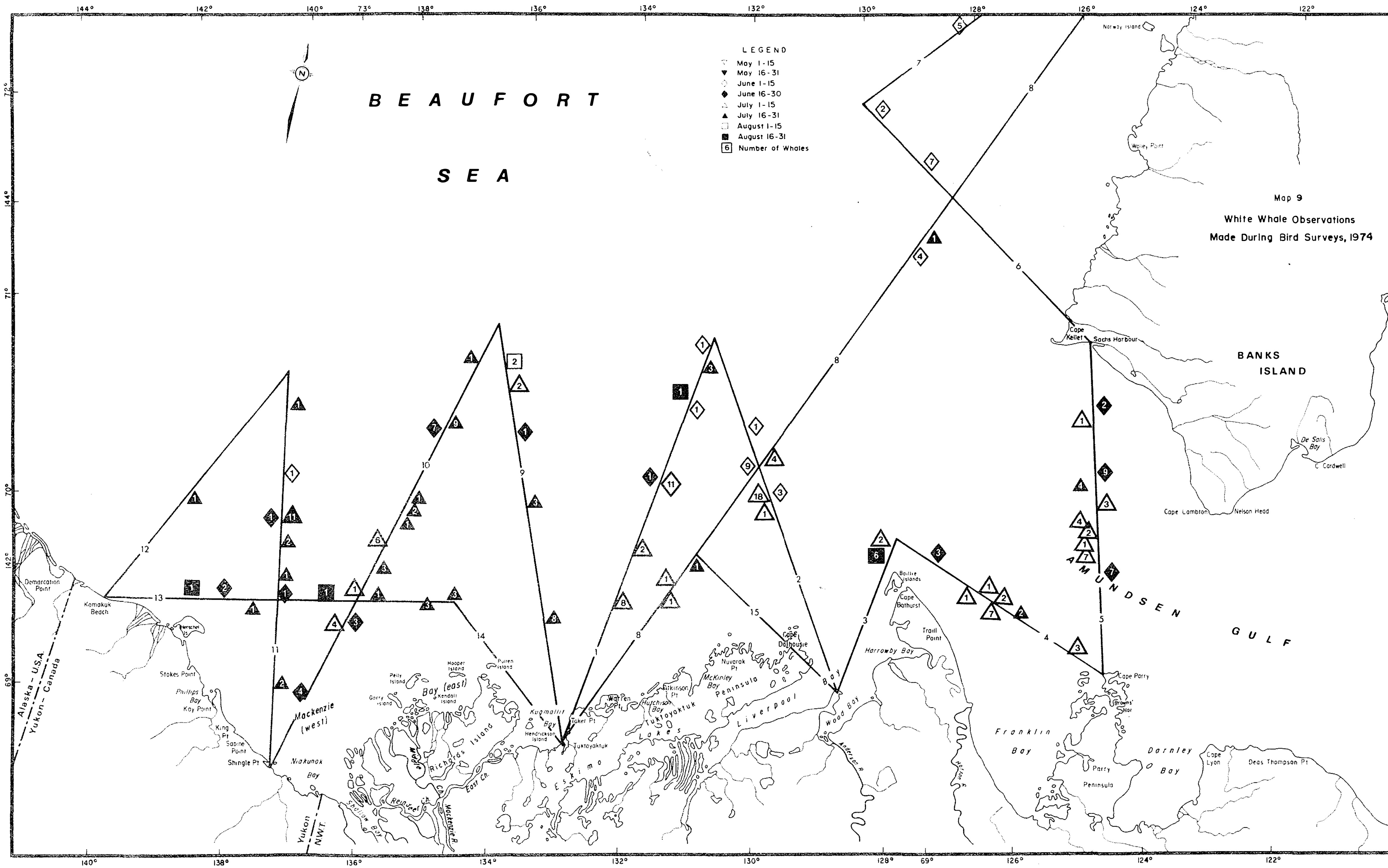
Year		Time of Arrival
1972	... ...	late June
1973	... ...	June 26
1974	... ...	July 11
1975	... ...	June 26
1976	... ...	July 1

Factors other than ice conditions influence the whales' movement to the Mackenzie region. Surveys of the lead lying just beyond the landfast ice were conducted regularly from May 26, 1973, but no whales were observed until June 19 (Slaney, 1974). Examination of NOAA satellite photographs during this period (Photo 6) leaves little doubt that it was possible for whales to move west from the Amundsen Gulf region. However, no whales were observed in this area until two days before the ice fractured. Possibly, whales do not arrive until the landfast ice is ready to fracture, and when passage is assured into the delta area.

The severe ice conditions of 1974 illustrate the variability in the time of arrival; no whales were observed in the Mackenzie estuary until July 11 - about two weeks later than usual. Slaney (1975) estimated that about half the usual number of whales actually entered the estuary in 1974, because the ice conditions severely hampered movements.

6.1.1.3 High-use Areas

White whales do not distribute themselves evenly throughout the Mackenzie estuary, but tend to use some areas more than others. Based on five years' data, Fraker (1977) identified three distinct kinds of high-use areas, founded on the type and degree of utilization :


BEAUFORT SEA
LEGEND
May 1-15
May 16-31
June 1-15
June 16-30
July 1-15
July 16-31
August 1-15
August 16-31
6 Number of Whales
Map 9
White Whale Observations
Made During Bird Surveys, 1974
BANKS ISLAND
AMUNDSEN GULF
Cape Kellet
Sachs Harbour
De Salis Bay
C Cardwell
Cape Lambton
Nelson Head
Demarcation Point
Komakuk Beach
Herschel Is.
Stokes Point
Phillips Bay
Kay Point
King Pt
Sabine Point
Shingle Pt
Niakunak Bay
Mackenzie (west)
Bay (east)
Pelly Island
Garry Island
Hooper Island
Kendall Island
Pullen Island
Richards Island
East Ch.
Mackenzie R.
Kugmallit Bay
Hendrickson Island
Tuktoyaktuk
Toker Pt
Warren Pt
Hutchison Bay
Atkinson Pt
Eskimo Lakes
Tuktoyaktuk Peninsula
McKinley Bay
Nuvorak Pt
Liverpool Bay
Cape Dalhousie
Wood Bay
Anderson R.
Harrowby Bay
Baillie Islands
Cape Bathurst
Trail Point
Horton R.
Franklin Bay
Parry Peninsula
Cape Parry
Darnley Bay
Cape Lyon
Deas Thompson Pt
Norway Island
Alaska - USA
Yukon - Canada
Yukon
NWT

CONCENTRATION AREA : An area where relatively large numbers of whales congregate consistently during much of the summer (open-water) season, year after year.

INTERMITTENT-USE AREA : An area where relatively large numbers of whales have occasionally been observed, but where large numbers of whales usually do not persist for more than a few days. Large numbers of whales may not be observed at all in these areas in some years.

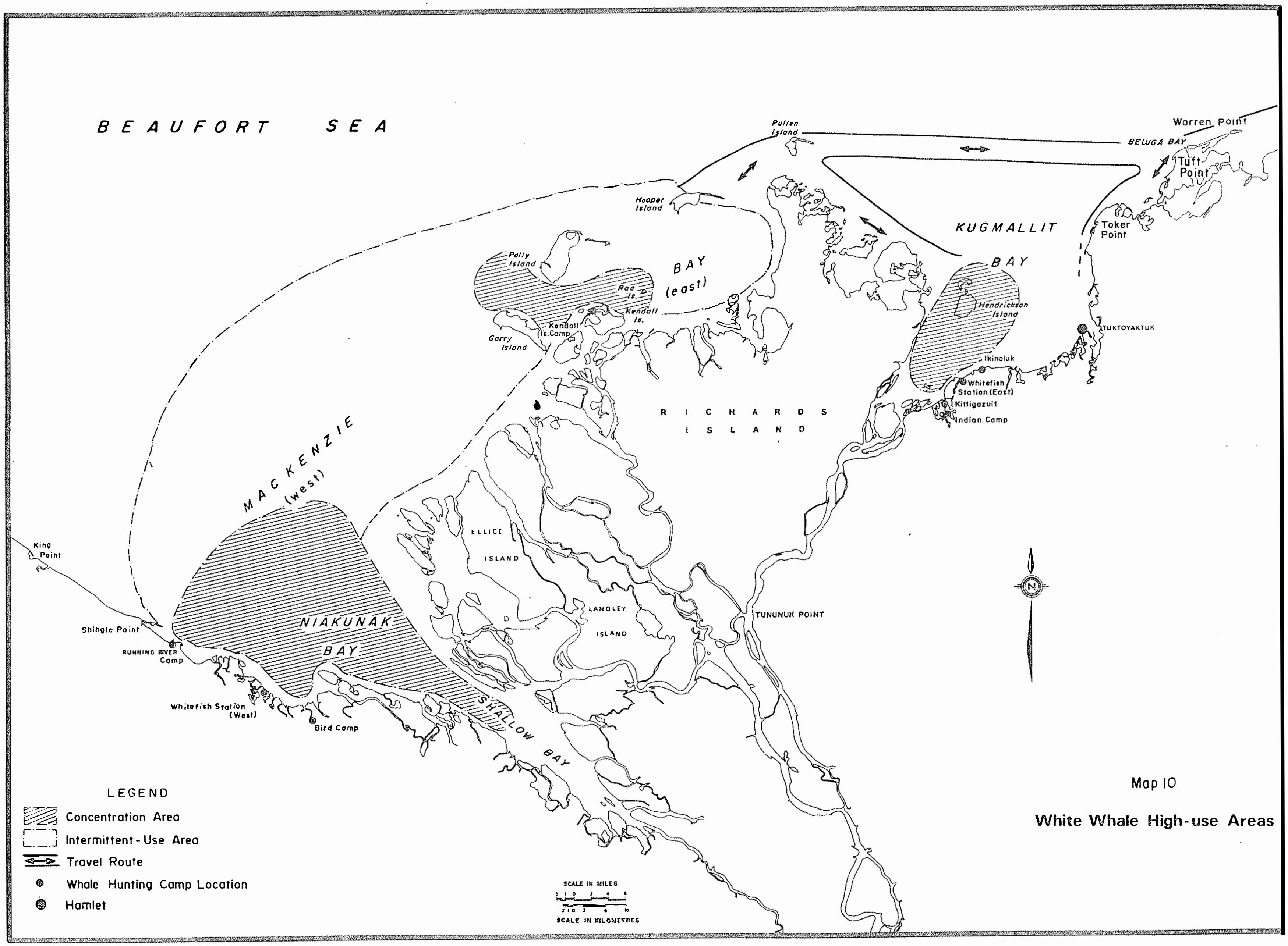
TRAVEL ROUTE : An area where whales, in insignificant numbers, are normally observed travelling and are rarely observed in other activities, such as resting or feeding.

The geographical extent of these high-use areas has been plotted on Map 10. The boundaries are based on several years of study, but further refinement is desirable as more data become available. This pattern of use by whales is maintained from late June until early August. There is a considerable amount of movement between concentration areas and other areas; a detailed description of these movements can be found in Fraker (1977).

Concentration Areas

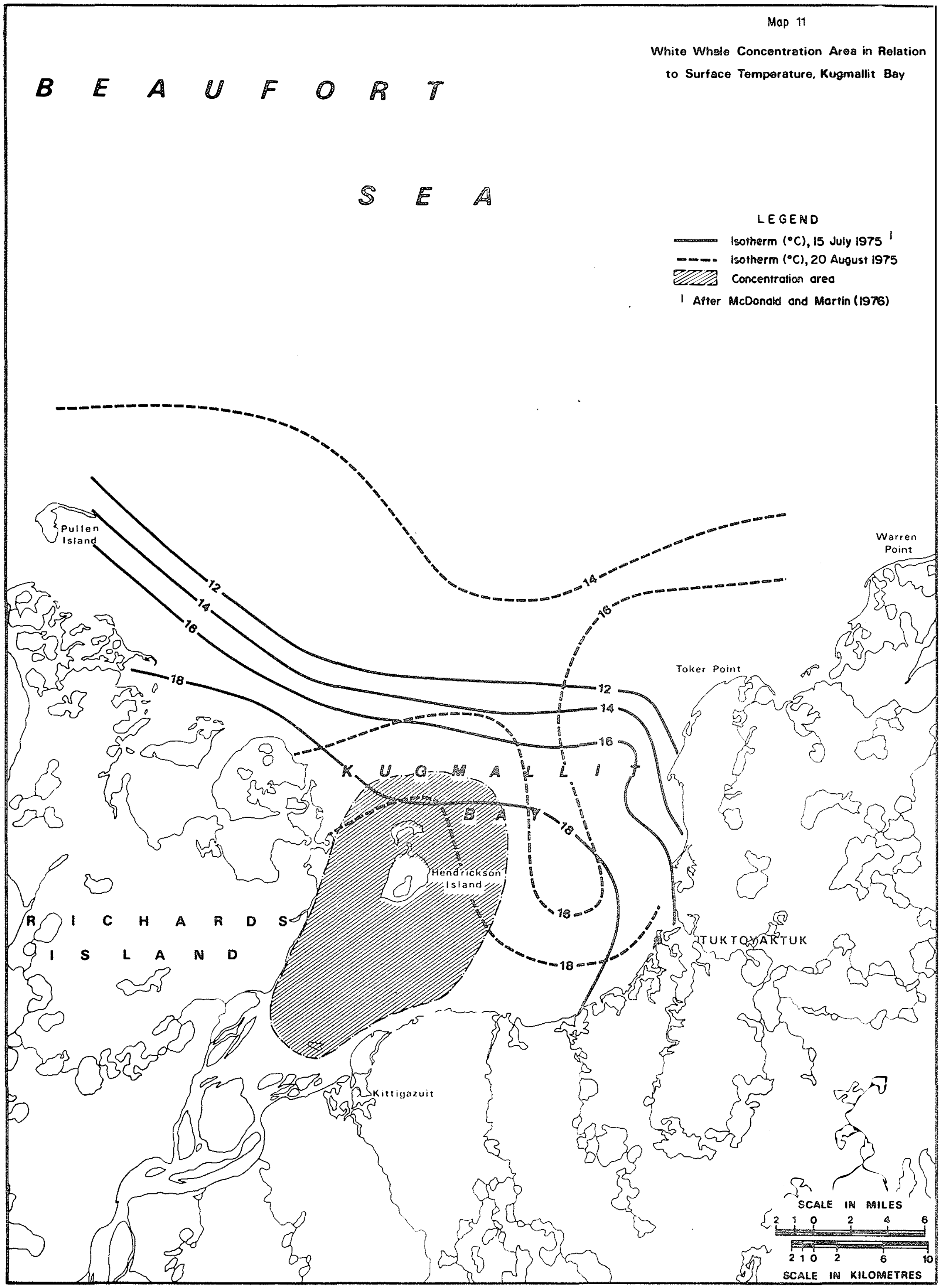
The concentration areas are all located near major outflows of the Mackenzie River, and they differ from adjacent parts of the estuary in several respects. At the time of their utilization by large numbers of whales, concentration areas tend to be warmer (up to 18°C), more turbid, less saline, and shallower than adjacent parts of the estuary. These characteristics are most pronounced in Kugmallit Bay and the Niakunak/Shallow Bay area. The Kendall Island concentration area, although near a major river outflow, is more subject to influence by the Beaufort Sea. Compared to other concentration areas, the Kendall Island area has deeper water (part of it is outside the two-metre isobath); and it experiences intrusions of cold, clear, saline water during storms coming from the north,

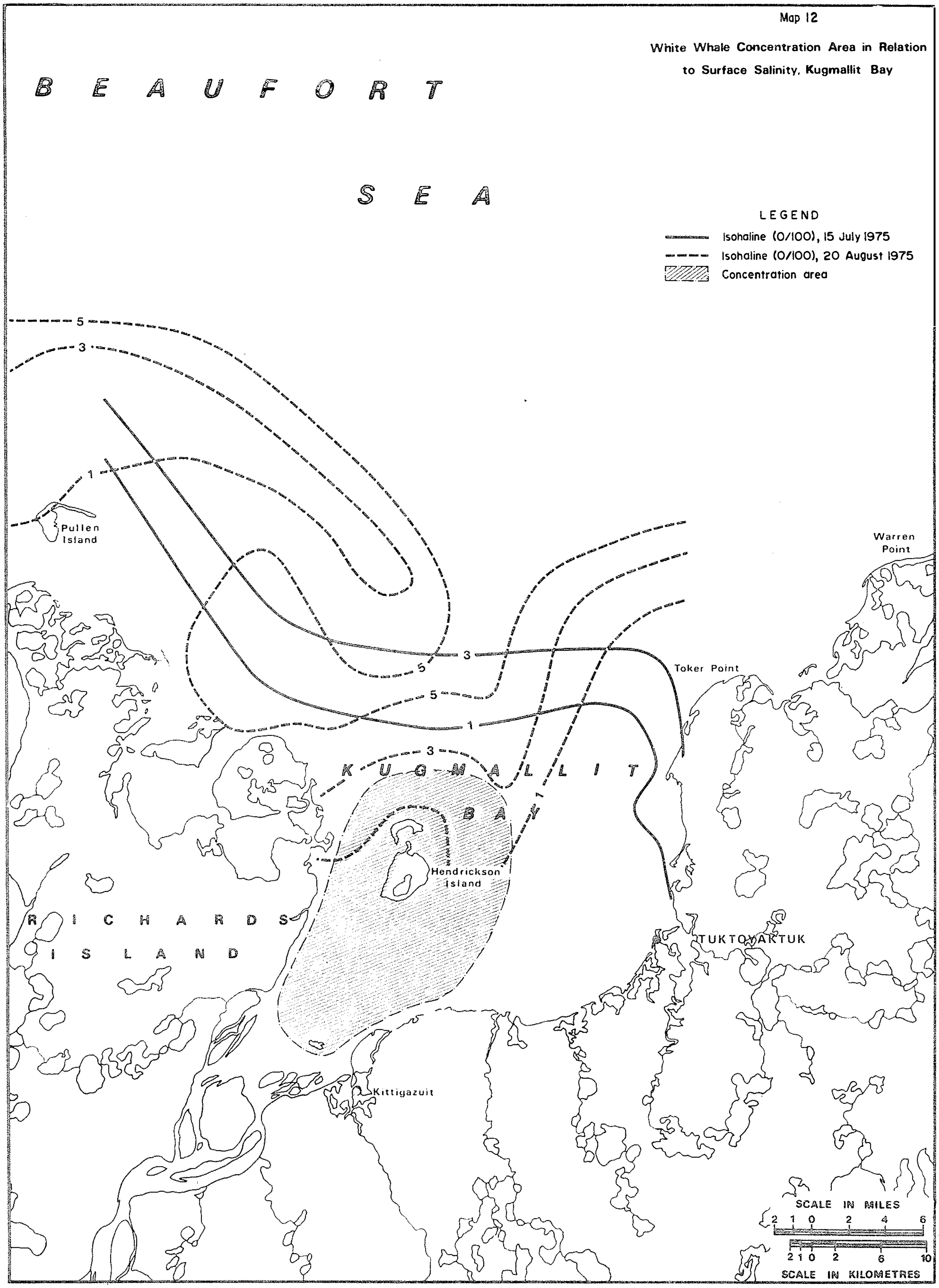
A relationship between water-body characteristics and whale concentration in Kugmallit Bay is discussed here because it is the best-studied region of the Mackenzie estuary. Maps 11, 12 and 13 show the relationship between the whale concentration area, and surface temperature, surface salinity, and surface turbidity, as measured by McDonald and Martin (1976) in 1975. The three variables show a roughly similar pattern, since they are all related to the water discharged from the East Channel of the Mackenzie River. Two relationships are apparent :

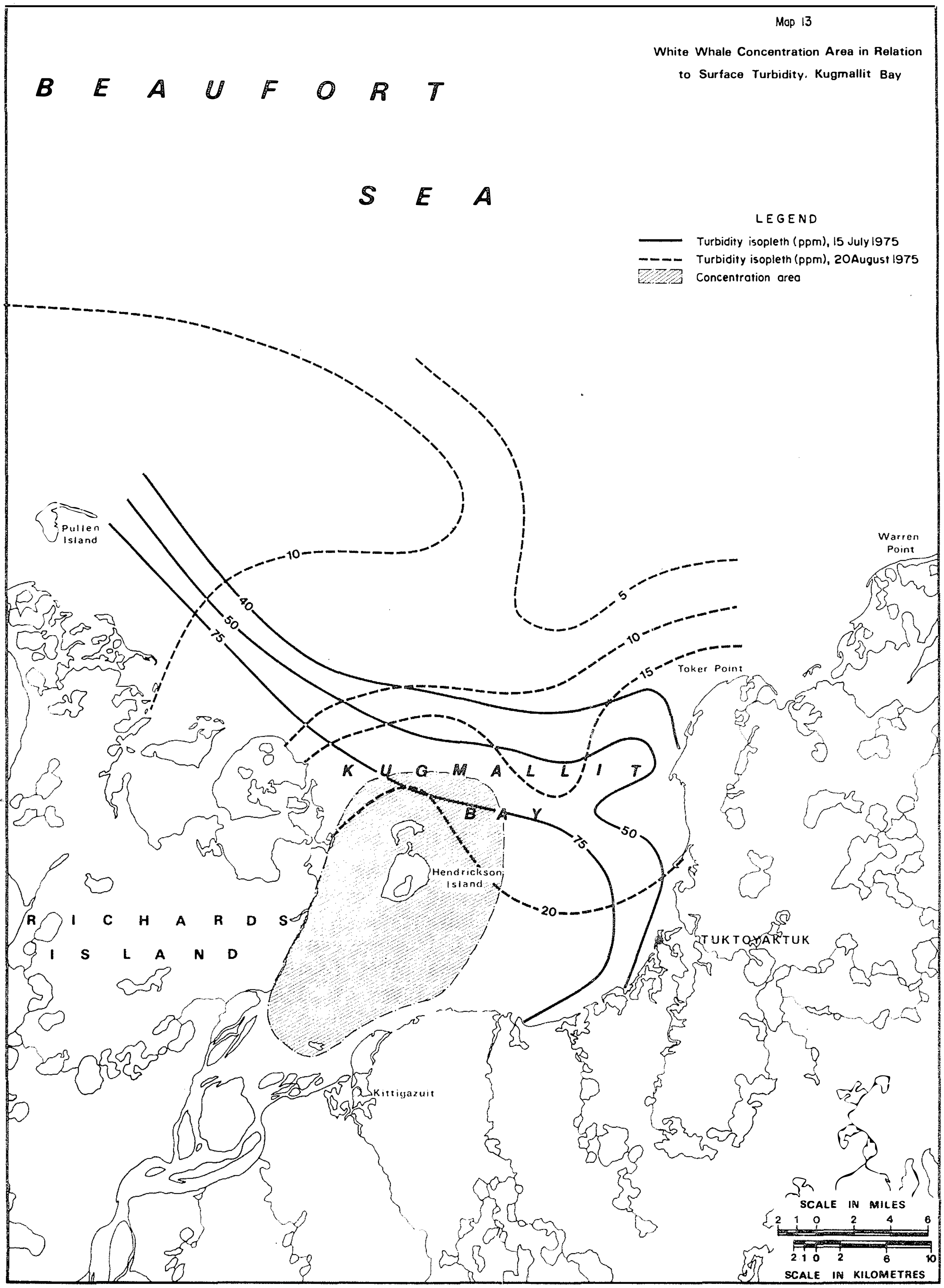


Map 10

White Whale High-use Areas


Map 11
White Whale Concentration Area in Relation to Surface Temperature, Kugmallit Bay
BEAUFORT SEA
LEGEND
Isotherm (°C), 15 July 1975 [1]
Isotherm (°C), 20 August 1975
Concentration area
[1] After McDonald and Martin (1976)
Pullen Island
Warren Point
Toker Point
12
14
16
18
KUGMALLIT BAY
Hendrickson Island
RICHARDS ISLAND
TUKTOYAKTUK
Kittigazuit
SCALE IN MILES
2 1 0 2 4 6
2 1 0 2 6 10
SCALE IN KILOMETRES


Map 12
White Whale Concentration Area in Relation to Surface Salinity, Kugmallit Bay
BEAUFORT SEA
LEGEND
Isohaline (0/100), 15 July 1975
Isohaline (0/100), 20 August 1975
Concentration area
Pullen Island
Warren Point
Toker Point
KUGMALLIT BAY
Hendrickson Island
RICHARDS ISLAND
TUKTOYAKTUK
Kittigazuit
SCALE IN MILES
2 1 0 2 4 6
2 1 0 2 6 10
SCALE IN KILOMETRES


Map 13
White Whale Concentration Area in Relation to Surface Turbidity, Kugmallit Bay
BEAUFORT SEA
LEGEND
Turbidity isopleth (ppm), 15 July 1975
Turbidity isopleth (ppm), 20 August 1975
Concentration area
Pullen Island
Warren Point
Toker Point
KUGMALLIT BAY
Hendrickson Island
RICHARDS ISLAND
TUKTOYAKTUK
Kittigazuit
SCALE IN MILES
SCALE IN KILOMETRES

(1) The Kugmallit Bay concentration area falls within the zone most constantly under the influence of the Mackenzie River, and

(2) The whales, which practically vacate the estuary by mid-August, leave before the temperature and salinity of the concentration area have changed from summer conditions. Turbidities measured on July 15 were substantially higher than those measured on August 20.

The warmer water of the concentration areas is the most obvious feature which whales may be seeking. There is no apparent reason why they should seek more turbid water, since many of the estuarine areas used by whales in the eastern Arctic have clear water (Sergeant and Brodie, 1975). Whales in the eastern Arctic make use of the estuaries of relatively warm rivers draining plateaus (Sergeant and Brodie, 1975), but not those of cold, glacial-meltwater rivers. Similarly, there are no known concentrations of white whales in the southern Beaufort Sea region other than at the mouth of the Mackenzie River, which probably has the warmest outflow of any river in the western Arctic.

Food is another possible reason for the whales' concentrating in estuaries. However, most of the animals examined from the native whale harvest in the Mackenzie estuary have empty stomachs, and little feeding behaviour has been observed in these areas. Thus, feeding is probably not a major factor for the whales' congregating here.

Concentration areas may also afford protection from storms. During periods of high winds, white whales have been observed to orient themselves into the wind (Fraker, 1976; Slaney, 1974), suggesting that wind can force the whales to modify their behaviour. Calves are probably more vulnerable than adults to the effects of wind, and shelter from storms may be important.

Sergeant and Brodie (1975) and Sergeant (1973) hypothesized that white whales congregate in estuaries to give birth to their calves. It is assumed that there is an advantage to the births taking place in warm river outflow (up to 18°C in the case of the Mackenzie River) compared with the nearby sea-water (about 0°C). The new-born calves are small, have a thin layer of blubber and a relatively large surface-to-volume ratio, all of which may result in rapid heat loss. By spending the first few weeks of their lives in warm water, the calves probably grow quickly and acquire a layer of blubber which serves as an energy store and insulation. However, this hypothesis does not account for the presence of animals other than calves and calving females in concentration areas. Evidence from the harvest-catches and aerial observations (section 6.1.3) shows that adult males, lactating females, post-partem females, pregnant females and dark-coloured juveniles are all present.

We hypothesize that white whales congregate in estuaries in the summer, primarily for the thermal advantage to all classes of whales, including newborn calves. Secondarily, these concentration areas may afford shelter from storms. This pattern is exhibited by many other whale species which migrate *en masse* to warmer calving waters. In addition, social factors may influence the aggregation of whales.

Intermittent-use Areas

Large numbers of whales are seen, occasionally, in the intermittent-use areas (Map 10) - at times when nearby concentration areas may be practically vacant. Hay and McClung (1976) observed similar behaviour by whales in Cunningham Inlet, Somerset Island, and hypothesized that such behaviour was related to feeding. Some whales in the intermittent-use areas in the Mackenzie estuary have been observed diving and, probably, feeding (Fraker, 1977).

Travel Routes

Most whales use definite travel routes (Map 10) between concentration areas. During such travel, nearly all of the whales are oriented in the same direction and are moving relatively rapidly. Feeding is also apparent along travel routes; for example, at Tuft Point and North Head, small groups of diving whales were observed in association with gulls.

The actual travel routes are dictated by local geography, such as the east shore of Richards Island, North Head and Tuktoyaktuk Peninsula. Another travel route probably lies along the north coast of the Yukon. The only travel route, not adjacent to land, extends across the outer reaches of Kugmallit Bay; this is the shortest distance between the Pullen Island area and the Tuktoyaktuk Peninsula. These travel routes exist only during the open-water period; whales travelling through ice-infested waters must utilize any routes of opportunity.

6.1.1.4 White Whales outside the Mackenzie Estuary in Summer

Although the majority of white whales in the western Arctic appear to congregate in the Mackenzie estuary from late June to early August, some are present elsewhere in the southeast Beaufort Sea/ Amundsen Gulf region. Unfortunately, information is limited in this region because no systematic surveys have been conducted to determine distribution and abundance of whales. It appears that these animals may travel north, as far as the north coast of Banks Island, east to Prince of Wales Strait (between Banks Island and Victoria Island) and possibly into western Dolphin and Union Strait (between the mainland and southwest Victoria Island).

Some white whales leave the estuary shortly after they arrive and it is not known whether they return. Slaney (1974) reported that whales " . . . were noted heading northeast in open water as early as July 11 (1973). . . . By July 15, commercial pilots reported 'large' numbers o whales in the Eskimo Lakes and 'hundreds' in floe-ice about 200 miles north, toward the end of the month."

In August 1952, Manning and Macpherson (1958) observed white whales along the north coast of Banks Island. On August 12, they saw a group of 50-100 swimming westward off Cape Crozier, and on August 23, they saw several hundred pass Castel Bay, moving westward amongst the ice floes. They also cited a record of a whale shot near Holman Island, off the west coast of Victoria Island, on August 1, 1949. One group of 25 whales was observed swimming southward past Johnson Point, Banks Island, through Prince of Wales Strait in late August, 1975 (Map 14). Near the western entrance to Dolphin and Union Strait, 42 white whales were reported in late June, 1973. In early August, 1975, two whales were observed headed south about 30 miles south of Holman Island.

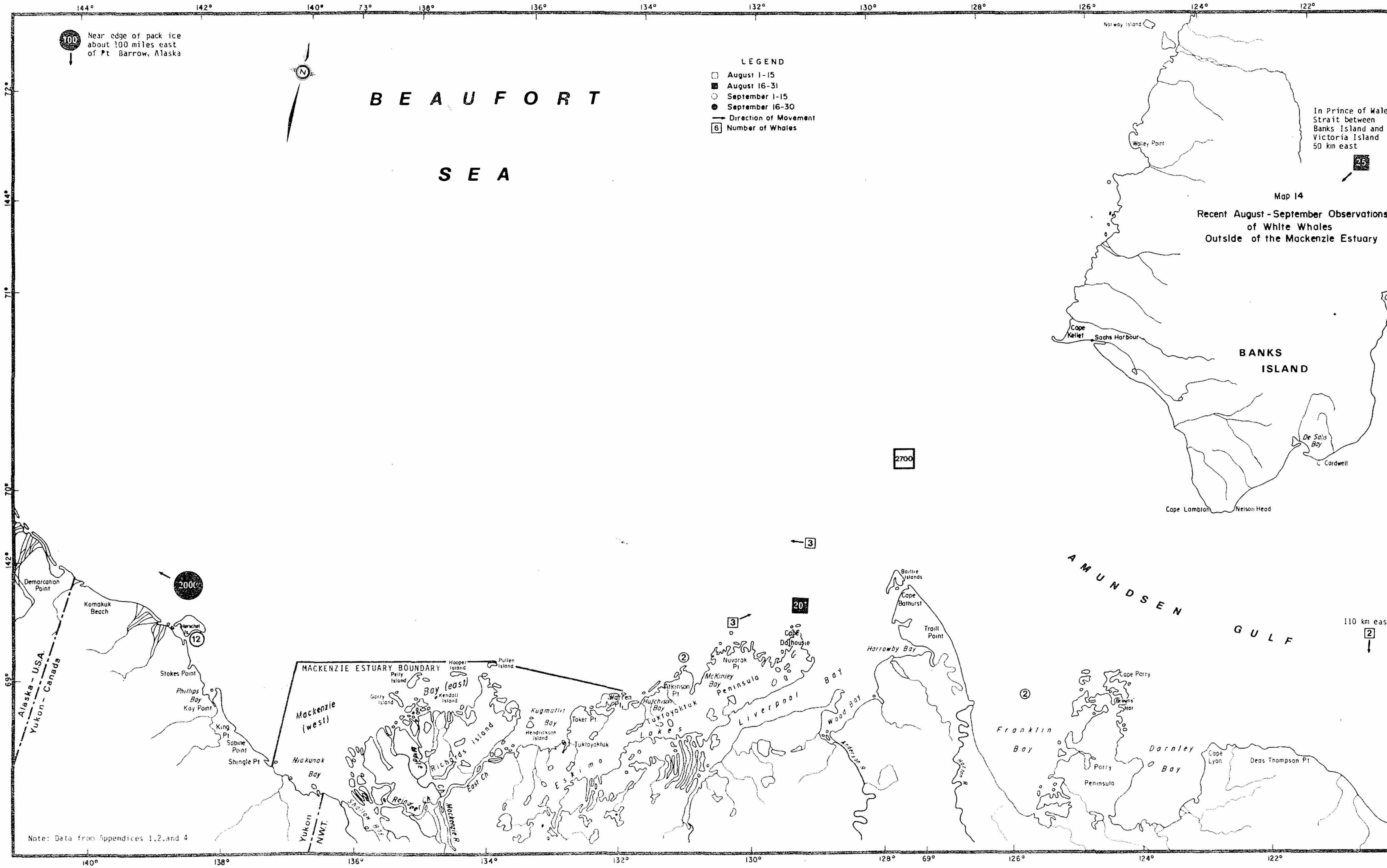
A substantial number of whales are in Amundsen Gulf from late May to late August; at least a few animals remain until September (Maps 6, 9 & 14). On August 12, 1970, Dr. T. W. Barry (pers. comm.) observed a spectacular concentration of 2,700 to 3,000 whales in Amundsen Gulf, north of Baillie Islands (Map 14); these animals were diving and, possibly, feeding. The latest observation of whales from this area was that of two white whales seen on September 11, 1974 in Franklin Bay (Map 14).

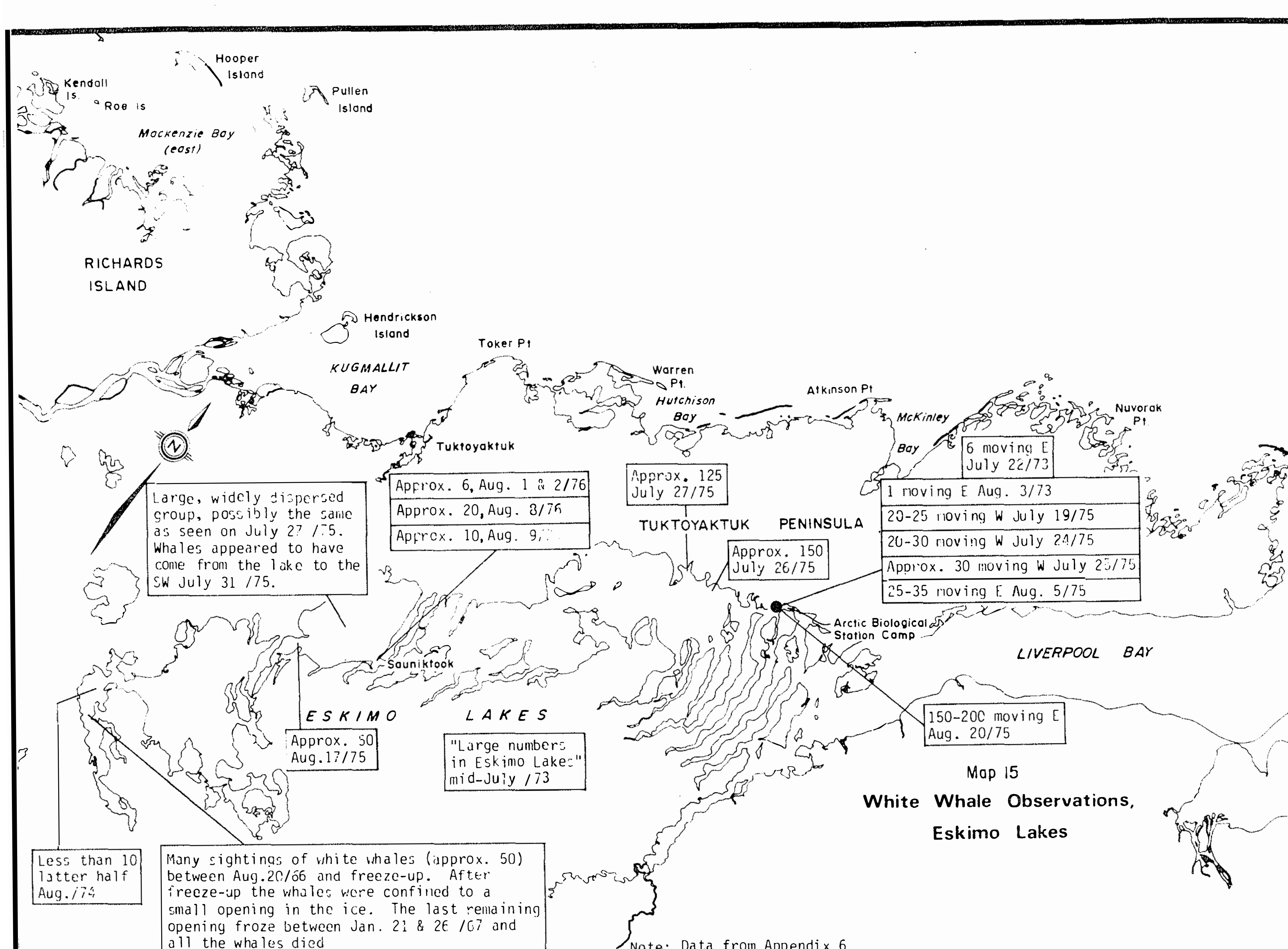
In late July and August, whales frequently move into Liverpool Bay. Occasionally, they penetrate into Wood Bay near the mouth of the Anderson River, but this was observed only twice by Dr. T. W. Barry (pers. comm.) who has studied birds in this area for the past 20 years.

White whales regularly enter the Eskimo Lakes during the summer (Map 15). In the winter of 1966-67, about 50 whales became stranded in the Lakes, where they eventually perished (Hill, 1967). In 1973, commercial pilots reported "large" numbers to be present in mid-July (Slaney, 1974). Smiley (pers. comm.) observed about ten whales here in mid-August, 1974.

In 1975, 125 to 250 whales were present in Eskimo Lakes (Map 15). On July 27, a large group of approximately 125 whales was observed in Eskimo Lakes, west of the easternmost set of "fingers". Mr. James Walbridge (pers. comm.), stationed at the Arctic Biological Station camp on Eskimo Lakes, reported two to three dozen whales on August 5, and 150 to 200 on August 20; they were swimming past the camp toward Liverpool Bay.

Few whales were seen in 1976; two residents of Tuktoyaktuk reported about six near Sauniktook on August 1 and 2, and another 20 on August 8.


Map 14
Recent August - September Observations of White Whales Outside of the Mackenzie Estuary
LEGEND
August 1-15
August 16-31
September 1-15
September 16-30
Direction of Movement
Number of Whales
BEAUFORT SEA
AMUNDSEN GULF
BANKS ISLAND
Near edge of pack ice about 100 miles east of Pt. Barrow, Alaska
In Prince of Wales Strait between Banks Island and Victoria Island 50 km east
110 km east
MACKENZIE ESTUARY BOUNDARY
Mackenzie (west)
Bay (east)
Richards Island
Liverpool Bay
Franklin Bay
Darnley Bay
Parry Peninsula
Tuktoyaktuk Peninsula
Eskimo Lakes
Sachs Harbour
Cape Kellet
De Salis Bay
Cape Lambton
Nelson Head
Demarcation Point
Komakuk Beach
Herschel Is.
Stokes Point
Phillips Bay
Kay Point
King Pt.
Sabine Point
Shingle Pt.
Shallow Bay
Kugmallit Bay
Tuktoyaktuk
Toker Pt.
Atkinson Pt.
McKinley Bay
Nuvorak Pt.
Cape Dalhousie
Baillie Islands
Cape Bathurst
Harrowby Bay
Wood Bay
Cape Parry
Cape Lyon
Deas Thompson Pt.
Alaska - USA
Yukon - Canada
Yukon
N.W.T.
Note: Data from Appendices 1, 2, and 4
100
2000
2700
25
20
12
3
2



Map 15
White Whale Observations, Eskimo Lakes

The role of the Eskimo Lakes, Liverpool Bay and Amundsen Gulf in the ecology of the white whales is not known. Whales may travel to these areas to feed. There are relatively large numbers of fish in the Eskimo Lakes (Poulin and Martin, 1976). Dr. T. W. Barry (pers. comm.) suspects that white whales may follow runs of herring into the Lakes. Bowhead whales also tend to concentrate in Amundsen Gulf during most of the open water season, suggesting that this area may be a productive feeding ground; this may explain, in part, why large numbers of white whales spend about one month in this region in the spring.

6.1.1.5 Fall Migration

Little is known about the fall outmigration of white whales from the Beaufort Sea to their wintering grounds. This movement probably takes place in late August and September and probably occurs toward the west. The main supporting data are :

(1) The paucity of whale sightings,in the Beaufort Sea, during late August and September (Maps 9 and 14) - possibly a result of decreased abundance;

(2) The record of 2,000 westward-moving whales near Herschel Island in September, 1972 (Map 14);

(3) Approximately 100 whales, near the edge of the pack ice east of Point Barrow, which probably arrived from the east in September, 1972 (Map 14); and

(4) The lack of fall observations of whales east of the Beaufort Sea and Amundsen Gulf.

Whether the fall migration takes place along the coast or offshore - possibly along the pack ice - is not known.

6.1.1.6 Wintering Area of the White Whales

With the exception of animals which may inadvertently stay in the Beaufort Sea, white whales do not overwinter in this area. The Bering Sea is the closest region to the Beaufort Sea where large areas of open water exist during winter and where Beaufort Sea white whales most likely overwinter. This conclusion is supported by the observations of eastward-migrating whales passing Northwest Alaska each spring (see 6.1.1.1), and of westward-moving whales in the fall - especially the report of approximately 2,000 near the Alaska-Yukon border in September, 1972 (Map 14). However, our knowledge of these migrations is tentative because large numbers of white whales in the Bering Sea have never been observed.

6.1.2 White Whale Abundance

The estimated number of white whales in the Mackenzie estuary varies significantly from year to year (Table 4). One possible reason is the inherent difficulty of counting whales in the large expanses of turbid water. Ice conditions cause the whales to become more or less concentrated, or hamper the movement of whales to the estuary. The maximum number, at any one time, is at least 4,000, and may be as high as 6,000. These estimates do not include whales outside the Mackenzie estuary or the dark-coloured juveniles, which are difficult to detect.

TABLE 4. Maximum Estimated Numbers of White Whales in the Mackenzie Estuary, 1972 - 1976 (from Fraker, 1977).

Year		Estimated numbers
1972	... ...	1,500 - 2,000
1973	... ...	3,500 - 4,000
1974	... ...	3,500 - 4,000
1975	... ...	4,000
1976	... .	5,500 - 6,000

The number of white whales in the Niakunak concentration area is usually equal to or greater than that in the Hendrickson area. For example, in 1973, the number estimated in the Niakunak area was 2,500 (July 2); five days later, the same number was observed in the Hendrickson area (Slaney, 1974). In 1976, there was an estimated 3,500 whales in the Niakunak area on July 12, and an estimated 2,000 present in the Hendrickson area on July 13 (Fraker, 1977). The Kendall area appears to be used by 1,000 whales, or less, in most years (Fraker, 1976).

6.1.3 White Whale Biology

6.1.3.1 Reproduction

The annual arrival of white whales in river estuaries coincides with the appearance of large numbers of newborn calves (Finley, 1976; Fraker, 1977; Sergeant, 1973). In the clear water of Creswell Bay, Somerset Island, in the eastern Arctic, K. Finley recorded the increase in numbers of neonatal calves from late July to mid-August, 1975; the proportion of calves in the population increased from

4 per cent (July 24) to 17 per cent (August 21). A similar pattern probably occurs in the Mackenzie estuary from late June to early August; however, the extremely turbid water precludes aerial survey counts of the dark-coloured neonates and classified counts[1] from aerial photographs.

It has been thought that the warm water of the estuaries was important, if not essential, to the survival of the newborn calves. But new evidence suggests that the concentration areas may not be critical to successful calving. Finley (1976) has observed neonates in Barrow Strait in the eastern Arctic; some of these sightings were offshore and preceded the arrival of whales at concentration areas. Similar, but tentative observations have been made in the western Arctic (Andriashek and Calvert, pers. comm.; Fraker, in preparation) and Alaska (Braham, pers. comm.). How frequently calving occurs outside of estuarine concentration areas and whether or not calves born in cold water suffer an increased rate of mortality are unanswered questions.

The native harvest is composed of about 20 per cent females (30 animals per year). Female whales, pregnant with term calves, are extremely uncommon in the Inuit whale harvest in the Mackenzie estuary. In 1976, one hunter from Tuktoyaktuk killed a female which carried a full-term foetus; this was the only such happening within the memories of the hunters from Tuktoyaktuk (Fraker, 1977). If calving occurs regularly in the concentration areas, where most of the hunting takes place, one would expect that the harvest would include a significant number of females carrying a full-term foetus.

The above information notwithstanding, newborn calves are seen in the concentration areas, and females which have recently given birth do appear in the Inuit harvest. During 1974, the majority of calves were sighted in the Niakunak Bay area, and there was some indirect evidence of calving in Kugmallit Bay (Slaney, 1975). Of ten females examined from Kugmallit Bay on July 26, 1974, three had recently given birth. Afterbirths, including several umbilical cords, were present in the uteri, and there was evidence of lactation in the mammae. In 1976, a female containing an afterbirth was killed in Niakunak Bay (Fraker, 1977).

After reaching sexual maturity at the age of five years, females normally produce a calf every three years (Brodie, 1971). The number of calving females is small, compared with total herd size. Assuming a 50 : 50 ratio of mature animals, an annual birth rate of 165 per thousand is theoretically possible. However, based on reproductive data collected from whales in Hudson Bay, Sergeant (1973) computed a birth rate of about 130 per thousand. This predicted figure checked

---

[1] A classified count is a determination of both numbers and age composition of a group of animals.

well against classified counts (120 per thousand) for a nearby estuarine concentration area. Classified counts made by Finley (1976) at Creswell Bay yielded a similar figure.

The bias of the native harvest toward males may affect white whale reproduction. Assuming that a 50 : 50 sex ratio is not necessary for successful reproduction, the tendency to harvest males should help maintain the herd's productivity. Although there is no information on the mating behaviour of white whales, limited data from other species of toothed whales suggest that one male may inseminate several females. Sergeant (1962a) found that "herd bull" pilot whales (*Globicephala melaena*) maintained a harem of females and excluded other males, at least seasonally, thereby implying that there is no strong bond between any one male and female. Because the gestation period is about 14.5 months (Brodie, 1971) and because delayed implantation is unknown in cetaceans, mating probably precedes the whales' arrival at the estuary by about two months. Thus any man-made disruption of the white whales' pair-bonding and social structure within the Mackenzie estuary would have about ten months for readjustment; this amount of time is probably adequate. It is likely that the predominantly male harvest leads to a high level of reproduction in the Mackenzie herd being maintained, by leaving more females than males in the herd.

By adjusting Sergeant's (1973) birth rate from 130 per thousand (which assumes a sex ratio of 56 males : 44 females) to 120 per thousand (which assumes a 50 : 50 sex ratio), the minimum number of calves produced each year in the Mackenzie estuary is 480, based on a population of 4,000. Because the whale harvest is strongly biased toward males, the sex ratio has probably shifted in favour of females. For this reason, the annual calf crop may be greater than 480. By assuming a sex ratio of 60 females : 40 males and a population-size of 6,000, 864 calves could be born, in theory, each year, in or near the Mackenzie estuary (Table 5). The actual production of calves is probably somewhere between 600 and 700 each year,

TABLE 5

Possible Annual Rates of Calf Production of White Whales in the Mackenzie Estuary

Population size		Sex Ratio Females : Males	Annual Calf Production
4,000	...	50 : 50	480
5,000	...	50 : 50	600
6,000	...	50 : 50	720
4,000	...	60 : 40	576
5,000	...	60 : 40	720
6,000	...	60 : 40	864

6.1.3.2 Age and Growth

Teeth were collected, for aging purposes, from whales harvested between 1974 and 1976 (Fraker, 1977). The largest number of dentinal layers counted was 68. Because two dentinal layers are laid down each year (Brodie, 1969), the maximum age is 34 years. However, some layers of the teeth from older individuals have worn away, and a more realistic estimate of maximum life-span of Beaufort Sea white whales is about 50 years.

Growth rates and age composition of the harvest reflect the general condition of the whale herd. The relationship between age and length is plotted in Figure 1. Most of this variation is probably a function of different rates of tooth wear. For example, teeth from the same individual can show differences of at least ten growth layers. Unless there is standardization in the selection of teeth for age determination. or refinement in the aging techniques, the use of teeth for age structure and growth studies is limited.

On the basis of the age/length relationship for females (Figure 1), all females in the harvest were mature. The largest male was an estimated 18.8 feet (5.8 m) in length, and was 25 years old, or more.

An analysis of variance of the data from 1974 to 1976 indicates no statistically significant *change* in the size of the males or females harvested ($F = 0.16$, $n = 60$: $F = 5.38$, $n = 25$, respectively) (Figure 2). However, a t-test indicates a statistically significant *difference* between the lengths of harvested males and females ($t = 4.10$, $p < 0.001$). Sergeant and Brodie (1969) compared the lengths of harvested white whales from twelve areas in the northern hemisphere; Mackenzie delta whales are intermediate in the range (Table 6).

TABLE 6

Comparison of Mean Lengths of White Whales harvested from Different Areas

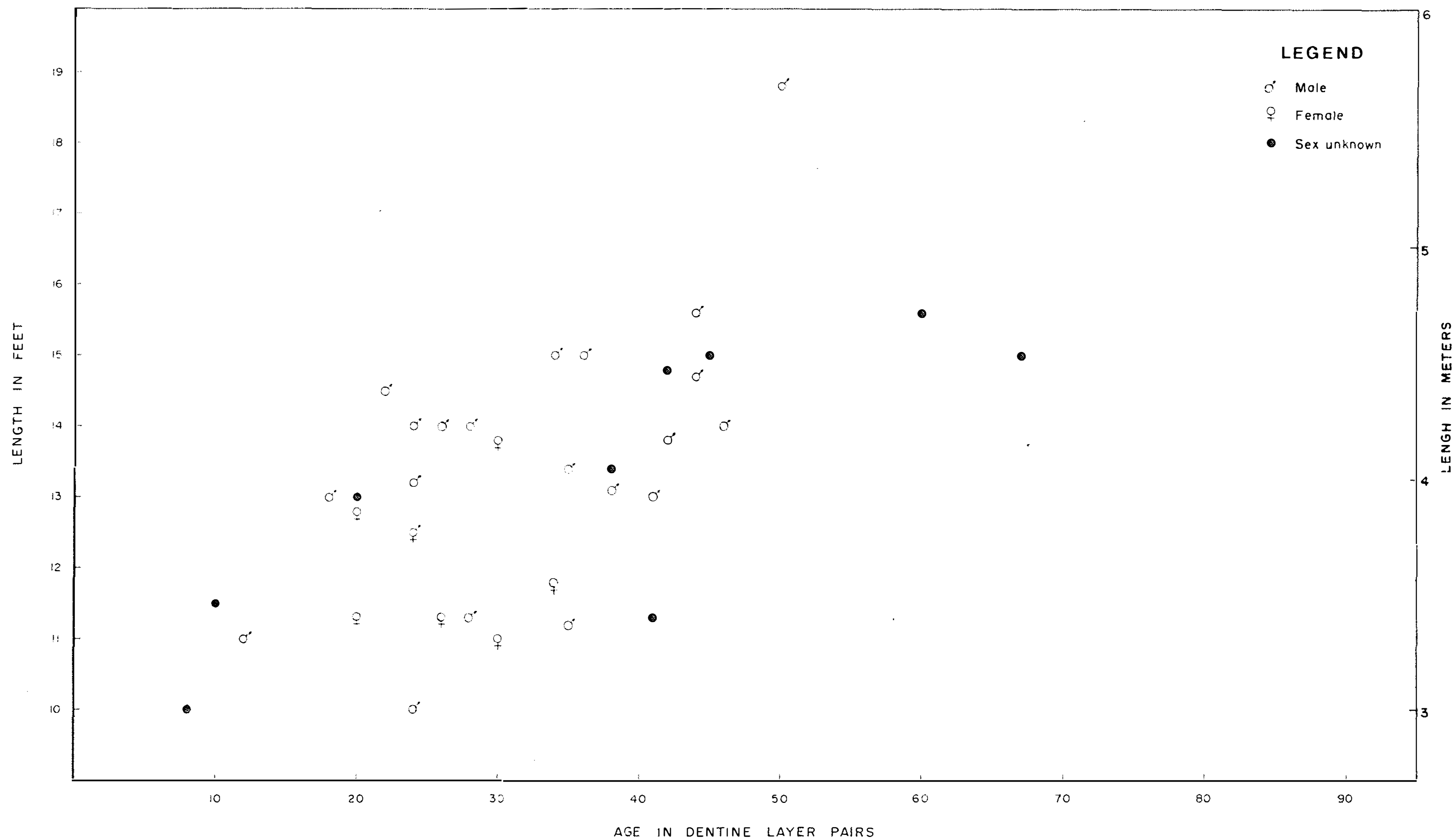
Area	Mean Lengths: Males Feet (Metres)		Mean Lengths: Females Feet (Metres)
Hudson Bay[1]	11.5 (3.5)	...	10.2 (3.1)
Mackenzie region[1]	13.4 (4.1)	...	11.8 (3.6)
Mackenzie region[2]	14.1 (4.3)	...	12.7 (3.9)
Sakhalin (USSR)[1]	14.9 (4.6)	...	13.1 (4.0)

[1] Sergeant and Brodie, 1969
[2] Fraker, 1977.

FIGURE 1

Growth Curve for White Whales Taken in The Inuit Harvest, Mackenzie Estuary, 1974-1976

(from Fraker, 1977)

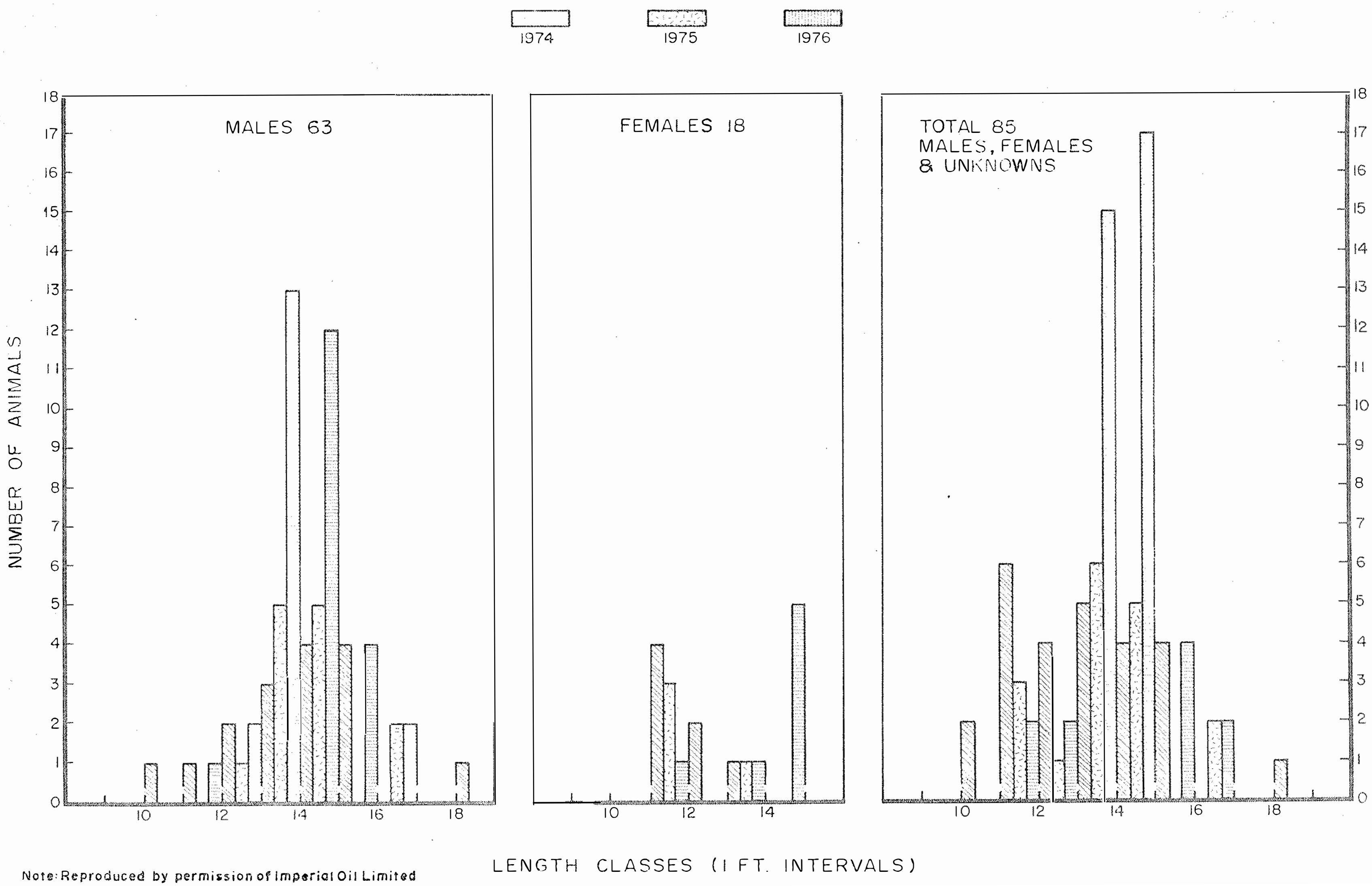


Note: Reproduced by permission of Imperial Oil Limited

FIGURE 2

Length Frequencies of Beaufort Sea White Whales, 1974, 1975 and 1976

(from Fraker, 1977)



Note: Reproduced by permission of Imperial Oil Limited

6.1.3.3 Food and Feeding Habits

White whales probably eat almost any type of aquatic or marine animal of appropriate size. Food items as small as shrimp and as large as 10 lb cod have been found in stomachs of white whales, along with a variety of other fish and invertebrates. However, in the Mackenzie estuary region, feeding does not appear to be an important activity.

Perhaps the most comprehensive food study of white whales was done by Vladykov (1947). He found that their diet, in the St. Lawrence River, consisted of at least 50 different kinds of fish and invertebrates, including capelin, cod, sturgeon, sand-lance, plaice, marine worms, shrimp, octopus and squid.

In Hudson Bay, capelin are the most common food item (Sergeant, 1973). Other fish eaten include pike, sand-lance, Greenland cod, arctic char, and two species of cisco. Marine worms, squids, and crustacea, such as the spider crab and several species of shrimp, are also found in the stomachs of white whales. Sergeant observed considerable quantities of mud, grit and stones in the stomachs, which indicates bottom-feeding habits.

Examination of the stomachs of whales killed during the native hunt, in the summer, indicates that the frequency of feeding is low in the Mackenzie estuary, at least in adult animals (Fraker, 1977). However, this is not conclusive evidence, for two reasons : first, some hunters feel that whales, taken by hunting, may often expel stomach contents during the chase. Secondly, whales may feed in areas removed from the hunting areas, such as in the intermittent-use areas, and the food may pass through the animals' digestive systems before they are killed.

The food of white whales in the offshore Beaufort Sea area and in Amundsen Gulf is probably composed of squid and fish. In August, 1973, a survey of the marine organisms between Cape Parry and Cape Lambton was made from the C.S.S. *Parizeau* by Mr. D. St. Aubin (pers. comm.), using a high-speed Isaacs-Kidd research trawl. The only fish larvae taken in abundance were those of polar cod (*Boreogadus saida*); thus, we suspect that polar cod is probably a major food offshore. Some of the squid beaks found in the stomachs of whales, taken in the native harvest, have been those of *Gonatus fabricii*, a typical offshore species. (The chitinous squid beaks persist much longer in whales' stomachs than do fish-bones which are probably dissolved quickly by acidic stomach juices).

Fish were found in the stomachs of only three whales, examined over the past five years in the Mackenzie delta (Fraker, 1977): two whales examined in 1974 contained remains of boreal smelt (*Osmerus eperlanus*) and saffron cod (*Eleginus navaga*), while, in 1976, one whale was found to have consumed several large loche or burbot

(*Lota lota*). In the 1950's, Dr. J. G. Hunter (pers. comm.) examined one whale stomach containing what probably were the remains of whitefish. All fish species are common locally, and their consumption indicates some feeding by whales in the estuary.

Whales frequently travel along the Tuktoyaktuk Peninsula in summer. They may be moving to and from feeding areas, or actually feeding in small inlets and bays along the Peninsula. Some animals also move north of the Mackenzie delta, possibly to feed in open water or along the edge of the ice.

6.1.4 Hunting and Utilization of White Whales

For as long as there have been white whales and people in the Mackenzie delta region, there has probably been an annual whale hunt. When Alexander Mackenzie reached the mouth of the river in mid-July, 1789, the Inuit were ". . . gone to where they fish for whales . . . ." And the archaeological studies by McGhee (1974) have demonstrated that whaling has taken place at the mouth of East Channel of the Mackenzie River for at least 500 years.

Today, hunting white whales is still an important summer activity for a significant number of native persons. About 100 families are involved in the harvesting and processing of whale products. These products contribute to the winter food supply, and are often shared with, or sold to people unable to hunt. Whaling, together with fishing, berry gathering,and caribou- and moose-hunting, are the main summer activities for a large proportion of the people who live temporarily at the whaling camps. Besides supplying some winter provisions, the annual whale hunt offers a change from regular community life and an opportunity for native people to maintain their cultural identity.

The arrival of the whales in late June/early July is quickly followed by the arrival of the hunters. Hunting activity is intense for about three weeks and then begins to decline, becoming more opportunistic. By early August, most people have returned to their communities or have moved to fishing camps. Some people remain at the whale camps to fish.

It is difficult to place a value on the whale harvest. In terms of dollars, the domestic value of a processed whale has been placed at $233 (Brakel, 1977); thus, the value of the average annual catch of about 150 whales would be $35,000. But whale hunting is much more than dollars or food supply. The hunt is a very important component of the local culture.

6.1.4.1 The Hunting Period

Typically, whaling in the Mackenzie estuary begins in late June, soon after the whales arrive. The hunt peaks in the first half of July, and dwindles by early August. For example, in 1975, the whales' arrival was reported in west Mackenzie Bay on June 26; by June 29, hunting had begun in Niakunak Bay. By July 20, these hunters, having taken a sufficient number of whales to meet their needs, had either moved to their fishing camps or returned to Aklavik.

Unfavourable weather and ice conditions can alter the hunting period. In 1974, many hunters had moved to their camps before the whales' arrival at the concentration areas; severe ice conditions had prevented the whales from entering the estuary until July 11 - nearly two weeks later than usual. In 1976, spring break-up on the Mackenzie River was about two weeks earlier than normal. Some hunters thought that the early break-up would mean an early arrival of the whales. They established their camps in mid-June but waited three weeks before substantial numbers of whales arrived.

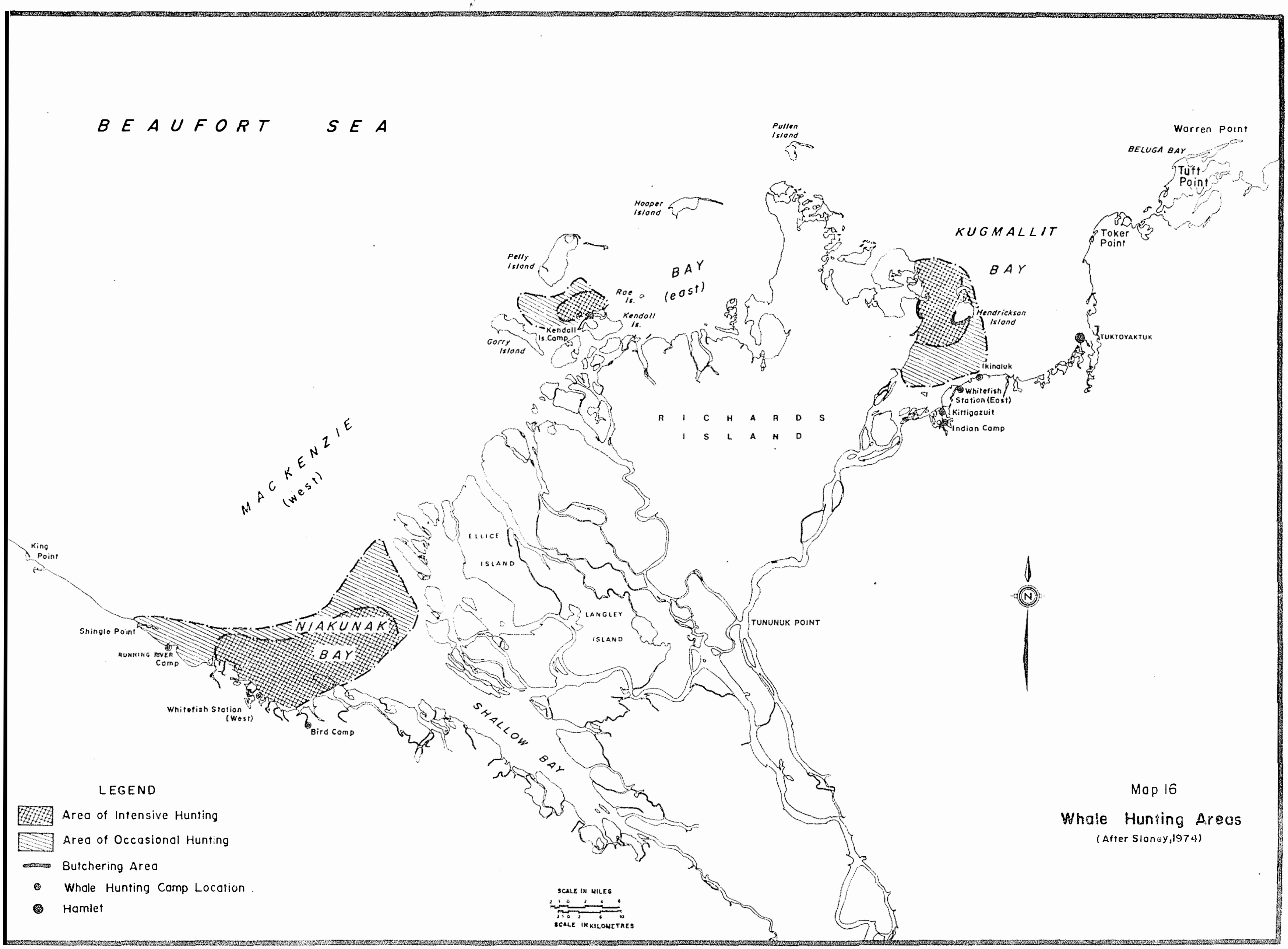
Although most of the hunting has finished by early August (when whale numbers decline), whales are sometimes taken in September by Tuktoyaktuk residents who pursue whales which happen to swim past the hamlet.

6.1.4.2 The Hunting Camp

Most hunting camp-sites have been used for many years. These sites are close to whale concentration areas (Map 16), have relatively well-protected harbours or beach areas for boat storage and whale butchering, and are safe from high-water levels generated by summer storms. There is an abundant supply of drift-wood nearby for fuel, and fresh water can be obtained from streams and lakes in the vicinity. The camps have permanent stages or drying racks which are used for processing whale meat and muktuk, and for drying fish. The camps are situated where breezes usually blow, to reduce the insect harassment.

During the past five years, the two largest camps were "Bird Camp" on Niakunak Bay, used mainly by persons from Aklavik, and "Indian Camp", on Kugmallit Bay, used mainly by Inuvik residents. Both camps were supplied, in part, by the Northwest Territories Game Management Division, with some food, equipment and gasoline. Game officers assisted in transporting widows and persons on welfare, so that they could participate in the hunt and the processing of whale products. Other smaller camps were used by one to nine families.

Most hunters from Inuvik camp near the mouth of East Channel, although some select Kendall Island. Camps in the Niakunak Bay area are used almost exclusively by Aklavik hunters. Hunters from Tuktoyaktuk seldom establish hunting camps. Instead, they take advantage of the mobility afforded by power boats to make day-trips from their home to the hunting area near Hendrickson Island.


BEAUFORT SEA
MACKENZIE (west)
BAY (east)
KUGMALLIT BAY
NIAKUNAK BAY
SHALLOW BAY
RICHARDS ISLAND
ELLICE ISLAND
LANGLEY ISLAND
Pullen Island
Hooper Island
Pelly Island
Garry Island
Roe Is.
Kendall Is.
Kendall Is. Camp
Warren Point
BELUGA BAY
Tuft Point
Toker Point
Hendrickson Island
TUKTOYAKTUK
Ikinaluk
Whitefish Station (East)
Kittigazuit
Indian Camp
TUNUNUK POINT
King Point
Shingle Point
RUNNING RIVER Camp
Whitefish Station (West)
Bird Camp
N
LEGEND
Area of Intensive Hunting
Area of Occasional Hunting
Butchering Area
Whale Hunting Camp Location
Hamlet
SCALE IN MILES
SCALE IN KILOMETRES
Map 16
Whale Hunting Areas
(After Sloney, 1974)

There were more families at Kendall Island in 1976 than in previous years; this was reflected in an increased harvest. They chose Kendall Island because the other hunting areas were becoming too crowded.

The distances from Inuvik and Aklavik to the hunting areas usually preclude day-trips but some hunters, often because of job demands, travel to the whaling areas for two- or three-day hunts. These hunters use friends' camps or carry a light camp outfit. The whales taken by these hunters often are not processed immediately; instead, the muktuk and some meat are taken back to the community for freezing. Cooking may take place long after the kill.

A hunting camp requires a considerable expenditure of time, effort and money. A camp outfit, consisting of a tent, tent-floor, stove, sleeping bags, cooking and eating utensils, axes, saws and so on, is transported by boat or canoe to the camp site. Outboard motors are purchased and maintained in working order. In addition, fuel and adequate food supplies are bought and transported. And, of course, the families must travel from town. The camp outfit, dried meat, muktuk, blubber and whale-oil, dried fish, berries - and the family - must all be moved back to town after the hunt.

6.1.4.3 The Whaling Areas

Practically all whale hunting takes place in the whale concentration areas near the hunting camps (Map 16). The water must be shallow enough so that a wounded animal's swimming beneath the surface will cause a turbulence which is visible to the hunter.

The entire Hendrickson concentration area is hunted, since it is relatively well protected from northerly storms and offers comparatively convenient access to shelter on Hendrickson Island and in Kidluit Bay. In contrast, about half of the Niakunak and Kendall concentration areas fall within the Inuit's usual hunting areas.

6.1.4.4 Hunting Methods

In the Mackenzie region, sailboats, canoes and kayaks have all been used in the past to closely approach and harpoon the whales. Whales have also been captured with large, stout nets. Today, nearly all the whales are pursued by hunters in boats or freighter canoes, powered by large outboard motors. Because the whales are frightened by the motors, rifles are used to wound and slow the whales so that they can be harpooned more easily (Photo 7).

As recently as the turn of the century,kayaks were still used in whale-hunting, and such hunts still remain within the memories of the oldest living residents of the Mackenzie delta (Fraker, 1977).

Photo 7. Whale hunting implements, Kendall Island, July 1977. A large canoe or small boat, an outboard motor, a rifle, and a harpoon with a line and float are the basic tools of the trade for whale hunters in the Mackenzie Delta region. (M. Fraker photo)

Nuligak (1966) gives a clear account of whale hunting near the mouth of East Channel toward the end of the nineteenth century :

> "The very first among my early memories is of the white whale hunt. In the spring, families from all the surrounding camps came to Kitigariuit[1] for the hunt. Lots of people - lots of kayaks. I was too young to be able to count them; I only know the long sandbank of the Kitigariuit beach was hardly large enough for all the kayaks drawn up there. And the beach was a good eight or nine hundred yards long. The sight of all those kayaks putting out to sea was a spectacle we children never tired of.
>
> The kayak paddles bore designs in red, and the hunters' weapons were red as well. Each kayak was furnished with two harpoons of very slender wood, eight or nine feet long. To one of the harpoons was attached a kind of skin bottle, rather small and inflated with air. A long string was tied to the end of the second harpoon. A wooden disc, *illiviark*, was fastened to the middle of the string and, at the end, was another skin bag, larger than that of the first harpoon, and embellished by eagle feathers. The kayak itself was sixteen to eighteen feet long, eighteen or nineteen inches wide and about fourteen inches deep. The two harpoons were in their place on the foredeck.
>
> When the kayak fleet first assembled, a file leader was chosen by the hunters. The file leader was singled out, whatever his age, by yelling his name. He it was who launched the first kayak in pursuit of the whales once they were among the shoals. The chosen hunter's kayak would be followed by a second, a third, and the others in succession. At the great whale hunts, I remember there was such a large number of kayaks that when the first had long disappeared from view, more and more were just setting out.
>
> During the season of the whale hunt, the men of Kitigariuit were always on the watch. They rose early, observing signs of fair weather and consulting over them. Some would stay on watch, eyes turned to the open sea until they discovered the belugas approaching the sandbars and shallows. Once the whales had disappeared among the shoals, the sentinels awoke their companions. Immediately, a swarm of kayaks was launched. The hunters, paddling with all their might, drove their craft in pursuit of the whales.
>
> Then, on the seaward side of the shallows, they faced the belugas and paddled forward all abreast. With loud shouts, they struck the water with their paddles, splashing it in great cascades. Panic-stricken at the noise, the whales threw themselves on the sandbanks in their efforts to flee. The largest soon had but two feet of water beneath them, and found

[1] Kitigariuit = Kittigazuit

it impossible to escape. The Inuit called, then, at the top of their voices, the name of the oldest hunter. The first shot was reserved for him. The old man chose a very large beluga, snatched a harpoon from its place on the foredeck of the kayak, and hurled it at his prey. Then all the hunters joined the slaughter. The trapped whales thrashed and lunged in the shallows, hurling spray that often nearly blinded the men in the kayaks.

When the hunt was over, the men recovered their weapons. Each harpoon bore a special mark, recognized by every hunter. Clever hunters might have killed five, seven belugas, while others had taken but one. To haul the whales back to camp, a sort of pipe was driven into their bodies or necks, and air was blown into the carcasses so they would float. A single man often had as many as five belugas in tow behind his kayak.

After a hunt, the shore was covered with whale carcasses. For myself, I did not count them, but I know there were a great many. Once I heard the elders say that three hundred whales had been taken. At other times, there were but one hundred and fifty of them. There are not many belugas any more. The Inuit scarcely see any during their expeditions - the Inuit eat white man's food nowadays."

Today, two or three hunters go out in each hunting boat or canoe, powered by large outboard motors (20 to 80 hp) (Photo 8). One hunter stays in the bow while the other operates the motor. The man in the bow is armed with a rifle and a harpoon attached by several feet of line to a float - often a 10-gallon metal fuel keg. When the boat comes to within about 20 to 30 yards of a whale, the bowman shoots to wound and slow, but not to kill the animal; a dead whale sinks and may be lost in the turbid water. As soon as the boat can approach the wounded whale, the hunter throws his harpoon. When the harpoon and float are secured to the animal, the hunter shoots to kill. If the hunters want more whales, they temporarily abandon the kill, which is marked by the float attached to the harpoon-line, and pursue other animals.

There are certain locations from which hunters spot whales. Often, such as on Hendrickson Island, a teepee-shaped structure, made from driftwood, serves as a lookout in this region of very low relief. The hunters wait for periods of relatively calm weather before setting out on a hunt. Calm conditions make spotting of whales easier, as well as facilitating shooting, harpooning, and recovering the animals. In rough weather, waves may break over the stern of a slow-moving boat towing a whale, forcing the hunters to abandon their kill.

The rifle calibre of their choice is relatively large and slow, so that the bullets will pass through the thick blubber to penetrate vital areas. The .303 British and .30/30 Winchester are popular

Photo 8. Hunters waiting for the kill, Kugmallit Bay, July 1974. The hunters have wounded a whale with rifle fire and have harpooned it; now they are waiting for it to surface so that the fatal shot can be delivered. (W. Vogl photo)

and effective calibres. In contrast, light, fast bullets tend to fragment and lodge in the blubber, inflicting relatively minor wounds which may only injure or later kill the animal.

An estimated one-third of the whales shot or wounded are not retrieved (Table 7). Some of the wounded probably recover, but others eventually die. Thus, for every two whales which are landed, another is shot. Lethally-wounded animals tend to sink, and many are lost because of the difficulty of locating them in turbid water. The proportion of the animals which are shot, and later die of their wounds, is not known.

TABLE 7. Number of Whales Shot and Retrieved in 1973, based on Interviews with Hunters (from Slaney, 1974).

Total shot per hunter or camp	Number Retrieved	Number lost
2	2	0
17	9	8
9	5	4
6	5	1
3	2	1
22	16	6
6	2	4
5	3	2
4	3	1
4	3	1
44	34	10
11	7	4
133	91	42

Hunt (1977) identified eight factors which contribute to the high loss rate :

(1) The concentration of Beluga, at times, is great. Therefore, there is confusion when trying to follow the whale which was initially wounded;

(2) The excitement of the hunt causes hunters to shoot indiscriminately, wounding more than one animal;

(3) The obvious abundance of Beluga tends to lessen the desire to obtain those initially shot, if they are difficult to find;

(4) The sudden occurrence of storms necessitates cutting loose dead Beluga, in tow, in order to prevent swamping. (In the traditional method, the whales were towed from the beach along the shoreline. In the modern technique, the Beluga are chased and sometimes secured far from shore.);

(5) Some mortally-wounded Beluga dive, and die on the sea bottom;

(6) The natural instinct of the wounded Beluga causes it to head for deep water in order to avoid capture. If the whale reaches deep water, it can easily escape and perhaps subsequently die, depending on the severity of its wounds;

(7) The disorientation of young whales, separated from the mother during the chase, causes stress and perhaps mortality;

(8) The inexperience of hunters who are anxious to make a kill but are negligent about retrieving the whale.

Unretrieved dead whales tend to bloat and wash up on shore (Fraker, 1977). Of four such whales examined in 1974 on Garry and Hendrickson Islands, two were mature males, two were mature females, and all had been shot. Six dead whales were observed floating in the estuary area in 1975, but none was examined. Twelve carcasses were observed floating in Kugmallit Bay in 1976; the four examined were all males. The number of dead whales seen floating represents only part of the actual numbers lost - the outflow of the Mackenzie tending to carry the dead whales out to sea.

In the past few years, the degree of cooperation between hunters, during the hunt, has declined. Historically, cooperation was necessary to drive the whales into shallow water. Today, hunters in their own boats act almost independently and avoid interfering with one another.

6.1.4.5 Hunting Success

The harvest of white whales varies considerably from year to year (Table 8), depending on the number of hunters, the number of "whale processors", the weather, and the number of whales and the length of their stay in the estuary. Weather is, perhaps, the main factor accounting for the variable harvests over the past five years. Stormy weather makes observation, shooting and retrieval of whales more difficult, and causes hazardous boating. Niakunak Bay is particularly vulnerable to storms from the north and northwest, but Kugmallit Bay is sheltered somewhat by Richards and Hendrickson Islands. If stormy periods coincide with weekends, "weekend hunters", coming from Aklavik, Inuvik and, to a lesser extent, Tuktoyaktuk, are often less successful. In 1974, ice conditions greatly hampered the migration of whales, resulting in their late arrival and short stay in the estuary; in addition, part of the herd never did arrive.

TABLE 8. White Whale Harvest in the Mackenzie Delta Area, 1954 to 1976

Year	Niakunak Bay Camps	Kendall Island	Kugmallit Bay Camps	Tuktoyaktuk	Total	Source*
1954	68	24) 26)	94	14	200) 210-225)	6 5
1959	7	17	30	nd**	145	1
1960	17	nd	nd	nd	nd	3
1961	20	52	16	nd	nd	2
1962	1	33	11	30	75) 85)	1) 3)
1963	nd	94	nd	33	nd	1
1964	nd	nd	15	30	nd	1
1965	6	21	8	35	70	1
1966	9	14	13	56	96	1
1970	30	nd	nd	75	nd	4
1971	30	nd	49	3	82	4
1972	33	4	31	45	113	7
1973	20	7	63	87	177	7
1974	30	2	50	40	122	7
1975	29	3	60	50	142	7
1976	32	12	59	49	152	7

* Source : 1. Bissett, 1967
2. Bogart, 1962
3. Currie, 1964
4. W. J. Hunt, pers. comm.
5. McEwen, 1955
6. Rees, 1955
7. Fraker, 1977.

** nd = no data.

Theoretically, a larger harvest is feasible during a period of favourable weather; however, more whales are not killed because the women processors and processing facilities become overworked.

The number of hunters varies according to the attractiveness of wage employment, motivation and the amount of money available for gasoline, tents, canoes, engines, guns and ammunition. Hunting success is also affected by boat traffic disturbances of industry, Government, private persons and the hunters themselves. In 1975, some hunters complained that over-eager, inexperienced hunters, in speed-boats, were trying to kill whales in the deeper water north of Hendrickson Island and were thereby discouraging the whales from entering shallower water where they could be more effectively hunted by a larger number of people.

The long-term trend in the harvest is not clear. During the 1960's, the harvest for the entire Mackenzie delta region was about 100; twice this number was taken in 1954 (Table 8). The harvest over the past five years averaged about 150 annually. Whether or not these differences represent actual changes in hunting interest or effort, or are merely a reflection of changes in methods of recording statistics is unknown. Hunting effort during the past five years has remained approximately the same.

How does the current level of harvest compare with that of many years ago? Nuligak (1966), quoted in Section 6.1.4.4, indicates that very large numbers of hunters gathered at Kittigazuit each summer for the whale hunt: as many as 300 whales may have been killed during a good day's hunt. This is more than the current *annual* harvest (150) plus the maximum estimated loss (75) for the entire delta region. The annual harvest at Kittigazuit may have been as large as 500 to 600 whales, not including whales taken in Niakunak Bay and near Kendall Island. Thus, current levels of harvest, including losses, are likely less than the levels imposed on the Mackenzie whale herd in the late 19th Century.

6.1.4.6 Processing and Utilization

As soon as the whale is brought to the camp, the women quickly cut the skin and blubber into strips with their unique curved knives, called *ulus* (Photo 9). The flippers and tail flukes are also removed. The large "tenderloin" muscle along the back is usually removed and made into dried meat. Often the heart and kidneys are eaten, and sometimes the stomach and oesophagus are used as containers. Bones, lungs, liver, reproductive tract, intestines and head are usually discarded. Several persons have recently displayed some interest in the teeth for the purposes of commercial Eskimo art.

The strips of skin and blubber are cut into a 'chain' of diamond-shaped pieces, and are hung on the stage to cure (Photo 10). After about two days, the muktuk is boiled until it feels tender when poked with a long-handled fork. It is then placed on logs to cool, after which it is ready to eat. Cooked muktuk is placed in barrels or pails for storage. Fresk muktuk from the flippers and flukes is often eaten raw.

Photo 9. Women preparing muktuk and dried meat, Bird Camp, July 1976. The white skin (muktuk) hanging on the stage will be cooked after curing for 2-3 days and then will be stored for winter use. The meat which the women are cutting with their *ulus*, will be cut into strips and dried for human and dog food. Uncooked blubber renders an edible oil. (M. Fraker photo)

Photo 10. Muktuk and drying meat hanging from a stage, Bird Camp, July 1977. (M. Fraker photo)

Muktuk has a unique and strong flavour, and an oily, rubbery texture. Fresh, raw muktuk from the flippers or flukes is milder and less oily. After aging, cooked muktuk becomes more tender and develops a flavour similar to that of a strong cheese.

Whale meat is cut into thin strips, ready for hanging on the drying-stage. Usually a small, smoldering fire is maintained beneath the stage, in order to smoke the meat as it dries. The dried meat is practically black, but quite palatable. The kidneys, heart and tenderloin are sometimes cooked and eaten fresh; the two last-mentioned meats make excellent eating.

If the stomach is needed as a container, the women carefully remove it from the animal. It is then turned inside out, scraped clean, inflated and tied shut. Once dried, the stomach makes a suitable container for berries or dried meats.

At most whaling camps, the utilization of whales is relatively complete. However, in 1974 and 1975, at the butchering site on Hendrickson Island, only the muktuk and a small amount of meat were processed; this was probably because of the lack of women on Hendrickson Island. Dragging a dead whale behind a boat is a slow process; this is an important reason for cutting up the whales near the place where they are killed.

Although all commercial whaling in Canada ceased after December, 1972, the Federal Government allows trade in white whale products by Inuit (Hunt, 1976). Some unprocessed whales and whale products are now sold locally to persons unable to hunt. Muktuk is shipped to points, such as Sachs Harbour and Holman Island. The annual Northern Games of the Northwest Territories provide a substantial market for muktuk each summer.

6.1.4.7 Tourism

In recent years, a few tourists have hired aircraft and boats in order to view the white whales. In 1976, at least one party of tourists took a charter boat from Tuktoyaktuk, and another party of two kayakers travelled down the Mackenzie; their purpose, in part, was to see the white whales. In other years, tourists have stopped at the native whaling camps, where they are generally not welcomed by the Inuit.

6.2 Bowhead Whales

The bowhead, a large "whalebone" or baleen whale, inhabiting Arctic waters, is a member of the right whale group, so called by the whalingmen because their slow swimming and generally placid behaviour made them the "right" whales to pursue. During the 19th Century and the first few years of the 20th Century, this whale was much sought for its whalebone, or baleen plates. The baleen plates are suspended from the whale's upper jaw and are used to filter small food items from the water. Baleen is not composed of bone, but of a horny material.

Because the easily-taken bowhead yielded valuable whalebone and oil, this whale was nearly driven to extinction over most of its range. The bowheads of the western North American Arctic were the last to be exploited. Although the stocks were very much reduced, the decline of the whalebone market saved them from further depletion.

Bowhead whales were afforded complete protection by an International Convention on Whaling in 1935 (Goodwin and Holloway, 1972), and this policy has continued under the International Whaling Commission since the late 1940's (Marquette, 1976). The International Union for Conservation of Nature consider this species to be endangered, although the bowhead population occupying the Beaufort Sea may be recovering (Goodwin and Holloway, 1972).

6.2.1 Movements and Distribution

The spring and fall migration of bowhead whales in the Beaufort Sea region probably follows the same general pattern as that of white whales : they migrate from the wintering area in the Bering Sea by way of far offshore leads in May and June, returning in August and September by a coastal route. Most bowheads spend late spring and summer in Amundsen Gulf.

6.2.1.1 Spring Migration

In April and May, as leads develop in the ice of the Chukchi and Beaufort Seas, bowheads begin to migrate from their Bering Sea wintering grounds toward their summering areas (Cook, 1926; Scammon, 1874). The migration begins in mid-April, peaks in May and continues into June (Table 9). The whales pass Point Hope and Point Barrow; beyond Point Barrow, the eastward migration has not been observed. Some animals, passing Point Hope, may summer in the Chukchi Sea to the west; those whales passing Point Barrow probably continue east until they reach the eastern Beaufort Sea and Amundsen Gulf. Bowheads and white whales have been observed swimming together through the same leads off western Alaska. We suspect that the bowheads use the same route hypothesized for the white whales in Section 6.1.1.1.

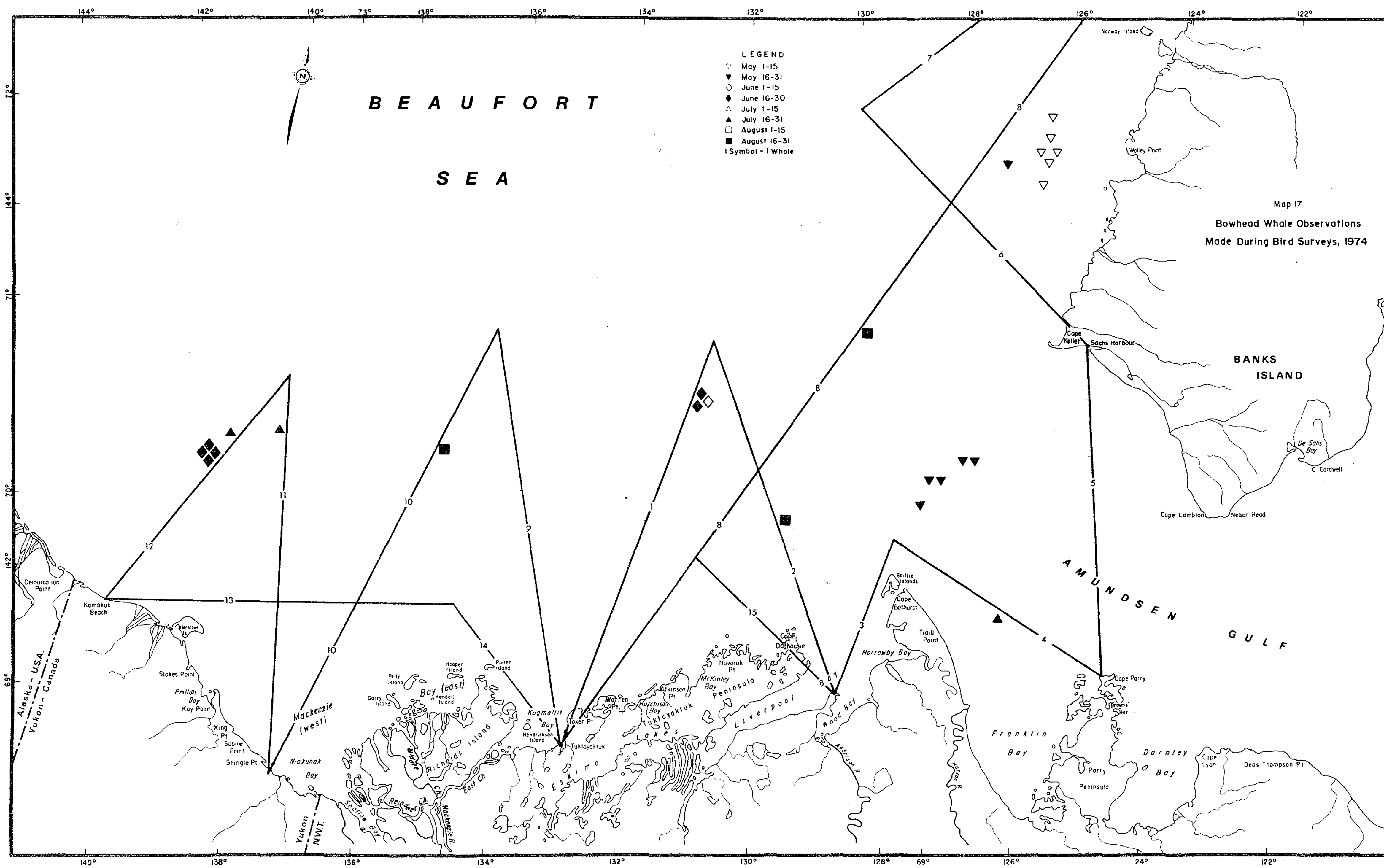
The Inuit of Point Hope and Point Barrow recognize three distinct influxes, or 'waves' of whales during spring migration (Marquette, 1976). The whales comprising the first two 'waves' are usually small animals of both sexes, many of which may be yearlings. The third 'wave' is made up of males and females with calves. It is not yet known how well defined and consistent this pattern is.

The earliest observation of bowheads in the study area is May 14, recorded west of Banks Island during the 1974 bird surveys conducted for the Beaufort Sea Project (Map 17). Subsequent

TABLE 9. The Spring Movement of Bowhead Whales past Point Hope and Point Barrow, Alaska, 1974 and 1975.

Date	1974[1]	1975[2]	
	Point Hope	Point Hope	Point Barrow
	Number of whales sighted	Number of whales sighted	Number of whales sighted
April 20-26	n/a[3]	27	11
21	3	n/a	n/a
27	n/a	0	0
28	n/a	0	0
29	n/a	0	0
30	3	4	0
May 1	0	0	0
2	2	2	0
3	0	0	0
4	3	0	0
5	14[4]	0	3
6	7	1	1
7	0	0	15
8	0	0	0
9	n/d[5]	7	3
10	n/d	22	1
11	1	1	0
12	0	0	0
13	n/d	0	3
14	1	18	1
15	0	2	6
16	4	12	6
17	n/d	15	0
18	n/d	3	3
19	n/d	2	0
20	0	1	1
21	0	0	3
22	1	0	0
23	0	0	6
24	0	4	0
25	9	1	0
26	0	5	0
27	5	1	0
28	0	3	0
29	0	0	0
30	6	0	0
31	n/a	1	0
Totals :	59	132	63

[1] From Fiscus & Marquette, 1975.
[2] From Marquette, 1976.
[3] n/a = not applicable
[4] An additional 12 whales were seen from an aircraft flying over an open lead west of the village.
[5] n/d = no data, because the closing lead prevented observations.


LEGEND
May 1-15
May 16-31
June 1-15
June 16-30
July 1-15
July 16-31
August 1-15
August 16-31
1 Symbol = 1 Whale
Map 17
Bowhead Whale Observations
Made During Bird Surveys, 1974
B E A U F O R T
S E A
BANKS
ISLAND
A M U N D S E N
G U L F
Cape Kellet
Sachs Harbour
Cape Lambton
Nelson Head
De Salis Bay
C. Cardwell
Norway Island
Cape Parry
Cape Bathurst
Baillie Islands
Cape Dalhousie
Harrowby Bay
Franklin Bay
Darnley Bay
Parry Peninsula
Cape Lyon
Deas Thompson Pt
Liverpool Bay
Wood Bay
Tuktoyaktuk
Tuktoyaktuk Peninsula
Eskimo Lakes
Kugmallit Bay
Mackenzie Bay (east)
Mackenzie (west)
Richards Island
Niakunak Bay
Shallow Bay
Shingle Pt
King Pt
Sabine Point
Kay Point
Phillips Bay
Stokes Point
Herschel
Komakuk Beach
Demarcation Point
Alaska - U.S.A.
Yukon - Canada
Yukon
N.W.T.

observations were made north of Cape Bathurst and west of Banks Island. No whales were seen on the surveys conducted between April 12 - 24 and May 1 - 5.

In June, bowheads have been sighted far north of the Beaufort Sea coast, in Amundsen Gulf, and west of Banks Island. Nine were observed north of Herschel Island and Tuktoyaktuk Peninsula, mainly in the latter half of the month (Maps 7, 8 & 17). Only five whales have been reported from Amundsen Gulf (Maps 7, 8 & 18), although coverage of this area is less than that of the Beaufort Sea.

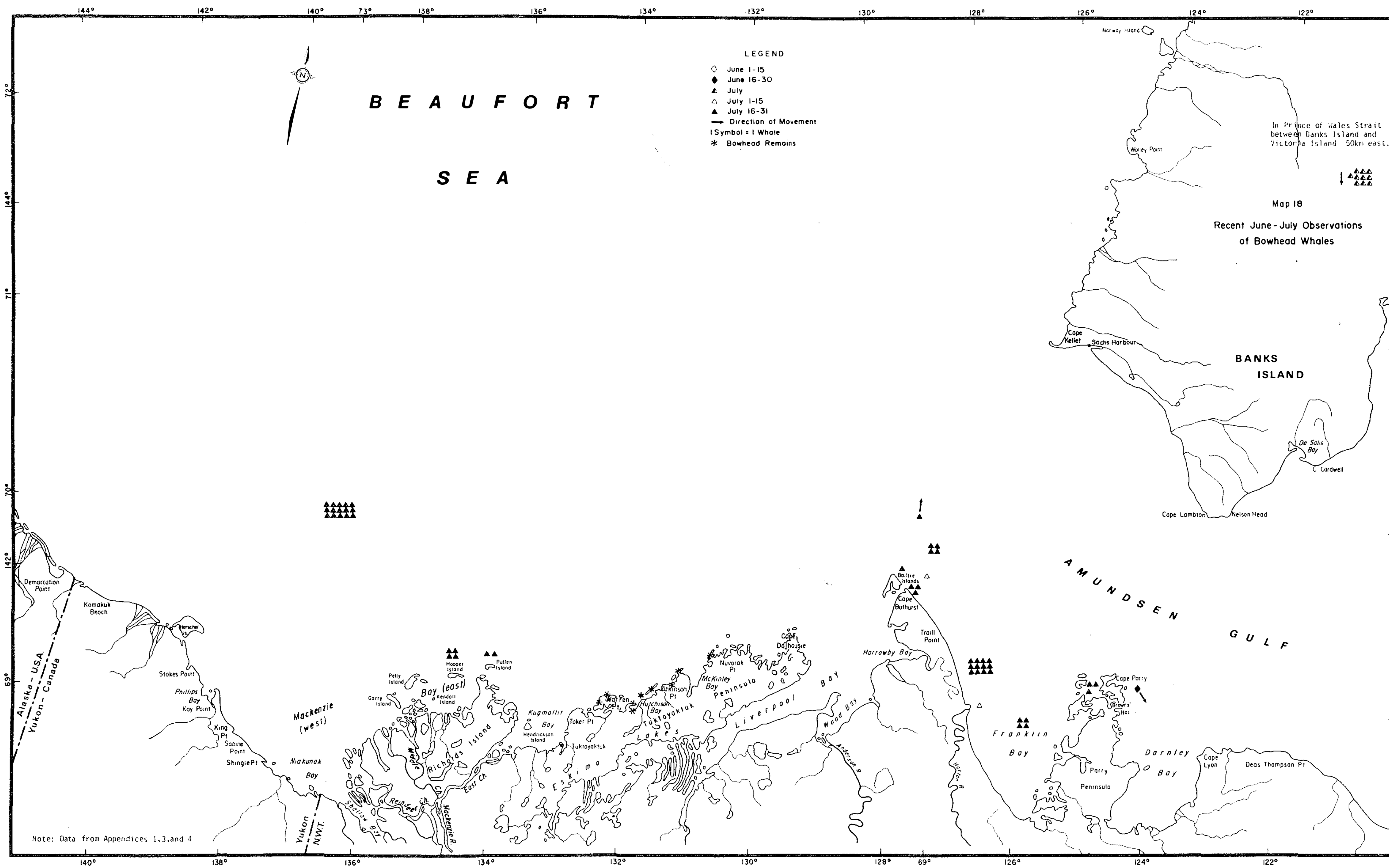
6.2.1.2 Summering Area

The best information on summer bowhead distribution and relative abundance in the eastern Beaufort Sea comes from Cook's 1926 book on Arctic whaling. He mentions the date and location of many bowhead whale sightings made on voyages between 1893 and 1905. These sightings are plotted for two-week intervals on Map 19. (Accounts of 'several' whales were arbitrarily considered to be five, for the purpose of this report). One must realize that the searches made by whalers were not random but were concentrated on areas where whales were thought to be most common. However, the whalers covered a large area in their search for whales.

Whalers, overwintering at Herschel Island, usually began operations during early July, although ice restricted their movements for the first few weeks. Based on Cook's information, the whales quickly made their way eastward to the vicinity of Cape Bathurst and Amundsen Gulf. Nearly all of his July observations were concentrated here. The whales were not observed on their eastward migration, since they would have completed the journey before ice conditions allowed the ships to move. Cook and the other whalers quickly made their way from winter quarters on Herschel Island to Cape Bathurst and Amundsen Gulf. Experience led them to call this region "the whaling ground". In fact, some whalers even overwintered at Baillie Islands - although the facilities were poor - in order to gain early access to the best whaling area.

Recent observations show a somewhat different summering pattern from that of historical accounts (Map 18). The observations north of the Mackenzie delta region were made during 1974, a very severe ice-year in the southern Beaufort Sea; ice conditions may account for this apparently unusual distribution. The sighting of ten bowheads heading south in Prince of Wales Strait, between Banks and Victoria Islands, in July, leads us to believe that some may range north into M'Clure Strait and Viscount Melville Sound.

August sightings of bowheads are scattered throughout the southern portion of the study area. During the first half of August, Cook's observations were all east of Kugmallit Bay but observations


BEAUFORT
SEA
LEGEND
June 1-15
June 16-30
July
July 1-15
July 16-31
Direction of Movement
1 Symbol = 1 Whale
Bowhead Remains
In Prince of Wales Strait between Banks Island and Victoria Island 50km east.
Map 18
Recent June-July Observations of Bowhead Whales
BANKS ISLAND
Sachs Harbour
Cape Kellet
De Salis Bay
C Cardwell
Cape Lambton
Nelson Head
AMUNDSEN GULF
Norway Island
Demarcation Point
Komakuk Beach
Stokes Point
Phillips Bay
Kay Point
King Pt
Sabine Point
Shingle Pt
Mackenzie (west)
Niakunak Bay
Bay (east)
Richards Island
Hooper Island
Pullen Island
Pelly Island
Garry Island
Kendall Island
East Ch.
Kugmallit Bay
Hendrickson Island
Toker Pt
Tuktoyaktuk
Eskimo Lakes
Hutchison Bay
Atkinson Pt
McKinley Bay
Nuvorak Pt
Tuktoyaktuk Peninsula
Cape Dalhousie
Liverpool Bay
Wood Bay
Anderson R.
Harrowby Bay
Baillie Islands
Cape Bathurst
Traill Point
Horton R.
Franklin Bay
Cape Parry
Parry Peninsula
Darnley Bay
Cape Lyon
Deas Thompson Pt
Alaska - USA
Yukon - Canada
Yukon
N.W.T.
Mackenzie R.
Note: Data from Appendices 1,3,and 4

during the latter half of the month extended west to near the international boundary, suggesting a tendency for these animals to move westward toward the end of summer (Map 19). Map 20 presents a similar picture from recent information, although the sightings are mainly in the Mackenzie delta region where a relatively large number of persons have researched in the past few years. Presumably, a substantial number of whales has also been present, but unobserved, in Amundsen Gulf.

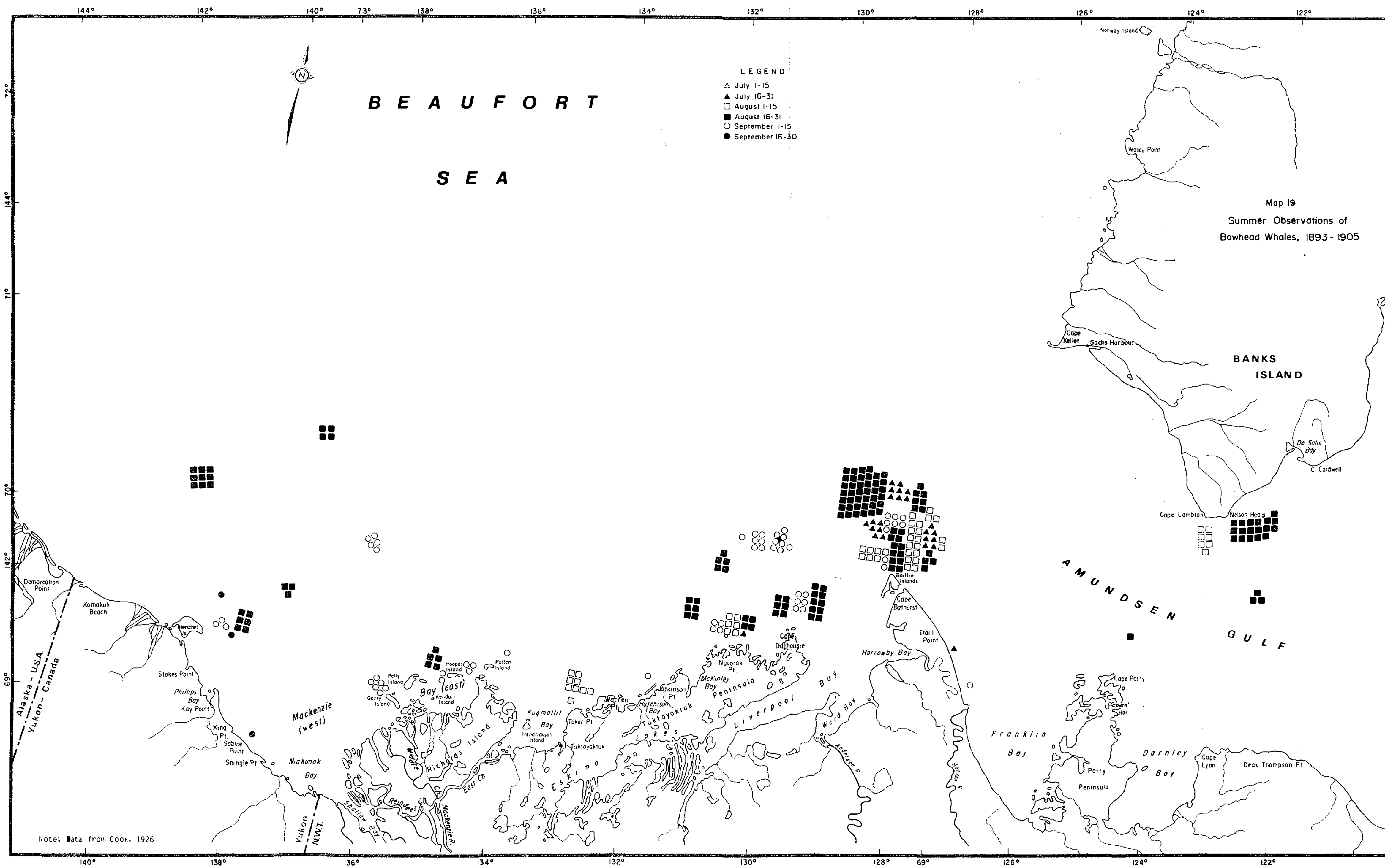
In early August, 1976, unusual sightings of bowheads were made in Kugmallit Bay and along the nearby Tuktoyaktuk coast (Map 20). In the previous four years of study, in the same region, by F. F. Slaney & Company Limited, no bowheads were sighted in the same areas at the same time of the year. Since most of the whales were headed in an easterly direction, they may have been delayed on their eastward migration by severe ice conditions, and have followed the nearshore lead along the Alaskan coast.

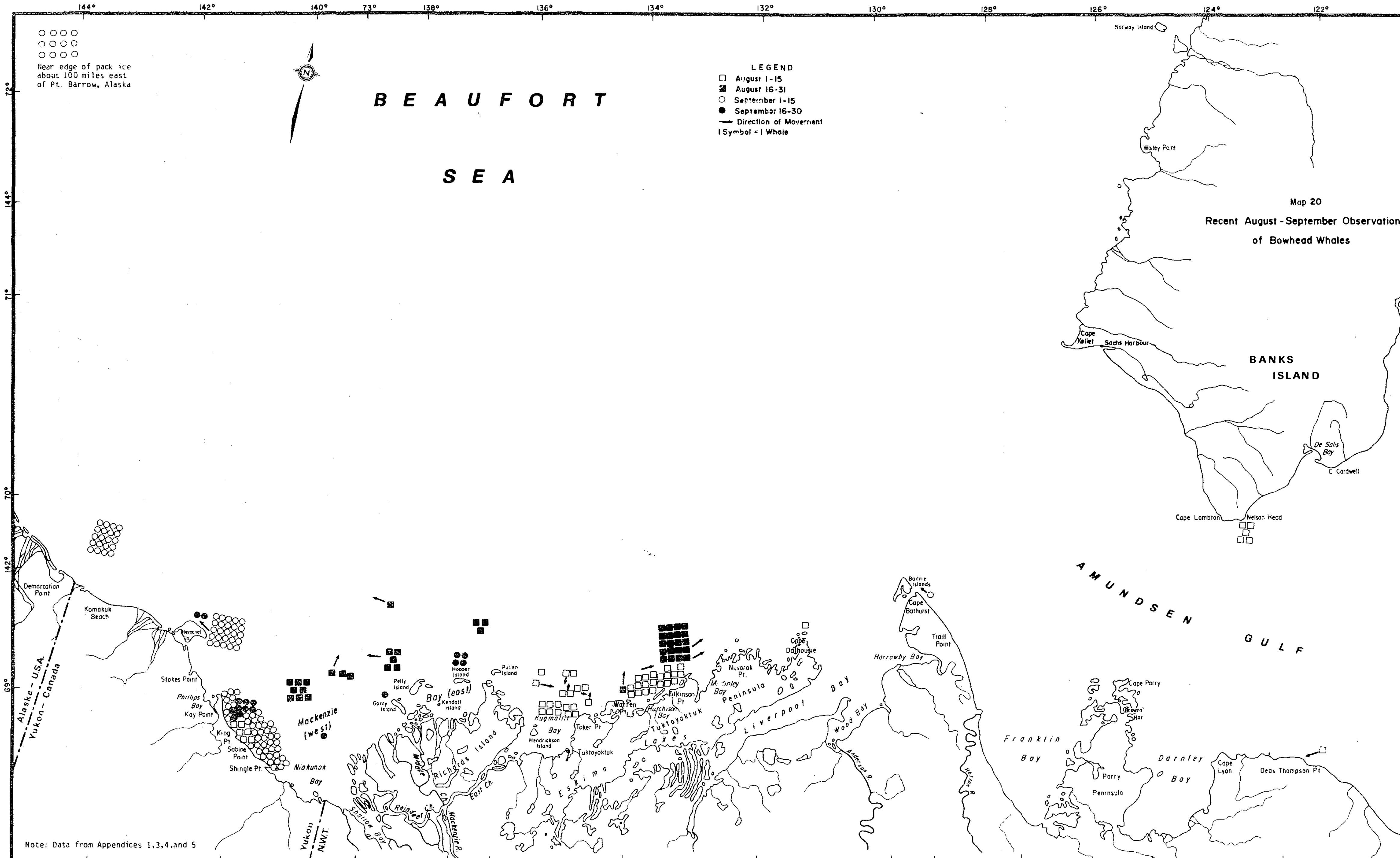
6.2.1.3 Fall Migration

Historically, whalers who did not intend to overwinter in the Arctic, pursued the whales westward during September (Cook, 1926). Most whales were west of Cape Bathurst by early September and had completely left the area by mid-month (Map 19). Recent bowhead observations reinforce this generalization (Map 20). The fall whale-hunt at Kaktovik (Barter Island, Alaska) takes place in September, while the hunt at Point Barrow continues into the second week of October (Fiscus and Marquette, 1975) - further support to the conclusion that most of the outmigration from Canadian waters occurs by mid-September.

The pace of westward migration seems leisurely. McWatt (pers. comm.), on about September 1, 1975, saw a small number of bowheads moving slowly in a southeast direction between Shingle Point and Sabine Point, on the Yukon coast (Map 20). They were swimming at the rate of a man walking slowly along the beach and were observed for about one hour, during which they made several dives of 10 to 15 minutes in duration. Possibly, the animals were feeding.

Koski (pers. comm.), who has engaged in bird studies in the Beaufort Sea area for several years, has frequently seen bowheads in the vicinity of Shingle Point in late summer (Map 20). In late August and between September 7 and 15, 1973, he made three or four sightings; in the following year, two sightings were made in the first half of September. Hoek, on a helicopter flight from Tuktoyaktuk on September 20, 1973, saw four bowheads north of Hooper Island, and one northwest of Garry Island. Fifteen km north of King Point, he located six bowheads, and two more about 2 km north of Herschel Island. A large number of sightings were made along the Yukon coast between September 15 and 19, 1976, with at least 33 seen on September 13. We suspect that bowheads feed along the Yukon coast, betwen Shingle Point and Kay Point, on their westerly fall migration.


BEAUFORT SEA
LEGEND
July 1-15
July 16-31
August 1-15
August 16-31
September 1-15
September 16-30
Map 19
Summer Observations of
Bowhead Whales, 1893-1905
BANKS ISLAND
AMUNDSEN GULF
Norway Island
Wolley Point
Cape Kellet
Sachs Harbour
De Salis Bay
C. Cardwell
Cape Lambton
Nelson Head
Baillie Islands
Cape Bathurst
Traill Point
Harrowby Bay
Cape Dalhousie
Nuvorak Pt.
McKinley Bay
Atkinson Pt
Hutchison Bay
Tuktoyaktuk Peninsula
Liverpool Bay
Wood Bay
Eskimo Lakes
Warren Pt
Toker Pt
Tuktoyaktuk
Kugmallit Bay
Hendrickson Island
Pullen Island
Hooper Island
Pelly Island
Garry Island
Kendall Island
Mackenzie Bay (east)
Mackenzie (west)
Richards Island
East Ch.
Reindeer Ch.
Mackenzie R.
Shallow Bay
Niakunak Bay
Shingle Pt
Sabine Point
King Pt
Kay Point
Phillips Bay
Stokes Point
Herschel
Komakuk Beach
Demarcation Point
Alaska - USA
Yukon - Canada
Yukon
N.W.T.
Franklin Bay
Parry Peninsula
Cape Parry
Browns' Har
Darnley Bay
Cape Lyon
Deas Thompson Pt
Note: Data from Cook, 1926


BEAUFORT
SEA
LEGEND
August 1-15
August 16-31
September 1-15
September 16-30
Direction of Movement
1 Symbol = 1 Whale
Near edge of pack ice about 100 miles east of Pt. Barrow, Alaska
Map 20
Recent August - September Observations of Bowhead Whales
BANKS ISLAND
AMUNDSEN GULF
Norway Island
Walley Point
Cape Kellet
Sachs Harbour
De Salis Bay
C. Cardwell
Cape Lambton
Nelson Head
Baillie Islands
Cape Bathurst
Trail Point
Harrowby Bay
Franklin Bay
Cape Parry
Parry Peninsula
Darnley Bay
Cape Lyon
Deas Thompson Pt
Demarcation Point
Komakuk Beach
Herschel Is.
Stokes Point
Philips Bay
Kay Point
King Pt.
Sabine Point
Shingle Pt.
Niakunak Bay
Mackenzie (west)
Pelly Island
Garry Island
Kendall Island
Hooper Island
Pullen Island
Bay (east)
Richards Island
Hendrickson Island
Kugmallit Bay
Toker Pt
Tuktoyaktuk
Warren Pt.
Atkinson Pt.
Hutchison Bay
Nuvorak Pt.
McKinley Bay
Cape Dalhousie
Liverpool Bay
Wood Bay
Eskimo Lakes
Tuktoyaktuk Peninsula
Shallow Bay
Reindeer Ch.
East Ch.
Mackenzie R.
Alaska - U.S.A.
Yukon - Canada
Yukon
N.W.T.
Note: Data from Appendices 1,3,4,and 5

Whether the fall migration takes place along the coast and also along the pack ice is unknown. Several observations, shown on Map 20, were of animals moving near the coast, on which the hunt at Kaktovik (Barter Island, Alaska) traditionally relies. On the other hand, 12 animals seen along the pack ice, 100 miles east of Point Barrow, suggest that some travel offshore.

6.2.1.4 Wintering Area

Bowheads overwinter near the ice edge in the Bering Sea (Allen, 1973; Cook, 1926; Scammon, 1874). Here, the whales were always encountered in the early spring by the whalers. It is unlikely that the whales overwinter in the eastern Beaufort Sea.

6.2.2 Whale Population Status and Abundance

The bowhead was almost driven to extinction over most of its range, but the North Pacific stock (including those whales using the Beaufort Sea) was least affected. Rice (1974) has expressed some doubt as to whether or not the North Pacific stock was over-exploited. Harvest (per ship, per year) increased from 1841 to the early 1850's, followed by a slight decline (Figure 3). The catch-rate remained relatively constant for sailing vessels until 1870, when there was another decline, followed by another period of relative stability, lasting until 1880. Steam vessels were, clearly, more efficient, catching whales from 1881 to 1911 at roughly twice the rate of the sailing vessels.

Annual catches remained relatively high for the steamers during the 1890's but declined in the early 1900's. To illustrate this, the mean annual catch, per steamship, for the years 1891 to 1899 (9.2) can be compared with the figure the the years 1900 to 1911 (5.9). (The year 1908 was excluded from consideration as no ships whose log-books were examined took bowheads in that year).

Whaling was most intense in the eastern Beaufort Sea from 1890 to the 1900's (Stevenson, 1969, 1968 a & b). Nearly all vessels listed by Townsend are also mentioned by Cook (1926) as operational in this region during this period. Thus, the pattern shown in Figure 3 specifically reflects bowhead whaling in the eastern Beaufort Sea.

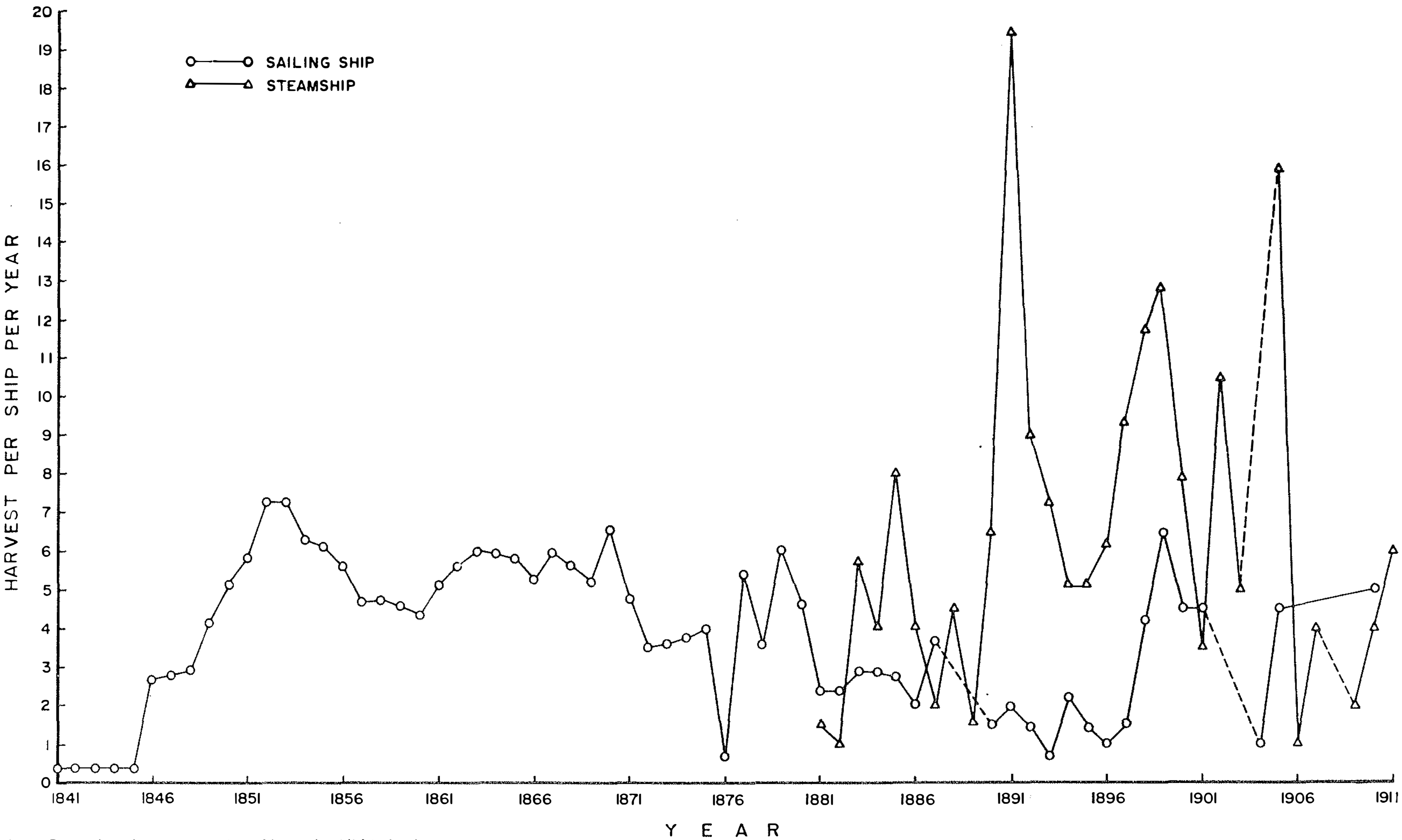
The large fluctuations in the 1890 - 1911 harvest statistics were normal. The vagaries of ice conditions and weather made Arctic whaling a chancy operation, at best, and the bowheads themselves were sometimes very difficult to locate and approach (Allen, 1973; Cook, 1926). Some fluctuations shown in Figure 3 are the result of a small data base from only a few ships.

The bowheads of the North Pacific region were exploited until the catch-per-unit-effort (annual catch per vessel), fell by about one-third. However, the stocks were not depleted such that commercial whaling was no longer feasible. In fact, the annual catch per vessel increased during the last three years of whaling (Figure 3). The drop in demand for whalebone led to the end of whaling for bowheads (Cook, 1926).

FIGURE 3

Bowhead Whale Harvest per Ship per Year, 1841-1911

(from Fraker, 1977)



Note: Reproduced by permission of Imperial Oil Limited

Since the catch of bowhead whales for the period 1868 to 1884 was relatively constant, Rice (1974) assumed that the North Pacific population sustained a mortality not exceeding five per cent. He estimated that the population numbered between 4,000 and 5,000 at that time. The proportion of the North Pacific population held by Beaufort Sea animals is unknown.

A current population estimate is very difficult for bowhead whales because relatively small numbers are dispersed over a very large area. A preliminary estimate of 800 passed Point Barrow, Alaska in the spring of 1976 (Marquette, 1977); practically all of these animals are members of the North Pacific stock and probably summer in the western Canadian Arctic. Some North Pacific bowheads also summer in the Chukchi Sea. Marquette places total numbers at between 1,000 and 3,000, based on very limited data. The present lack of adequate data on bowhead numbers and distribution is a serious knowledge gap.

6.2.3 Biology of Bowhead Whales

6.2.3.1 Reproduction

Very little is known about reproduction in the bowhead species. Tomalin (1957) cites evidence that birth takes place between February and May. Gestation is thought to be about 9.5 months (Goodwin and Holloway, 1972). Unlike many other species of whales, bowheads do not seek warmer water in which to calve.

6.2.3.2 Food and Feeding

Although the bowheads are very large animals, their food consists of relatively small pelagic organisms. Based on Scoresby's (1820) drawings of organisms frequently found in the same waters as the bowhead, Hjort and Ruud (1929) show pteropod molluscs, ctenophores and crustaceans as bowhead food. Scoresby observed only "shrimps" in the whales' stomachs, but assumed a more diverse diet. Johnson *et al* (1966) have made the only recent observations on bowhead food published to date; in the stomach of one whale, remains of polychaete worms, gastropod molluscs, echinoidean echinoderms and crustaceans were found. Lowry *et al* (1978) analyzed the stomach contents of two bowhead whales taken near Point Barrow, Alaska in September, 1972. They found 90% euphausiids, 7% gammarids, and 3% hyperiids, by volume.

Nineteenth-century whaling captains described abundant planktonic organisms, such as copepods, amphipods and euphausiids, in bowhead-frequented waters (Allen, 1973). Between Cape Lambton and Cape Parry, in August 1973, the most abundant organisms caught by fine-meshed nets in the Isaacs-Kidd pelagic trawl were the copepod, *Calanus hyperboreus*, the hyperiid amphipod, *Parathemisto libellula*, and euphausiids, *Thysanoessa inermis* and *T. raschi*. (St. Aubin, pers. comm.). These are probably important summer foods of bowhead whales. Food is unlikely to limit bowhead numbers.

The baleen plates function to filter the small marine organisms from the water. As described by Slijper (1962) : "Right whales seem to swim through thick masses of krill with almost constantly open mouths. The water streams into the mouth and through the openings between the baleen plates, while the krill is kept back by the hairy fringe (of the baleen). A little later, the mouth is closed for a brief interval, the tongue is brought up and the krill is pushed towards the throat in a way not yet fully understood."

6.2.4 Bowhead Whale Harvest

The regulations of the International Whaling Commission prohibit a commercial harvest of bowheads, but permit a harvest by or for natives. Bowheads have not been harvested in the western Canadian Arctic since the days of the Yankee whalers, although Alaskan natives have killed between 50 and 100 each year (Table 10). Some bowhead remains, along the Tuktoyaktuk Peninsula (Map 18), may be of whales which were wounded in Alaska but died in Canadian waters.

TABLE 10. Alaskan Bowhead Whale Harvest from 1974 to 1976

Year	Number landed	Number killed and lost	Number struck and lost	Totals
1974[1]	20	3	28	51
1975[2]	15	2	26	43
1976[3]	48	8	35	91

1 Fiscus and Marquette, 1975
2 Marquette, 1976
3 Marquette (pers. communication)

A short while ago, it was necessary for Canadian Inuit to obtain a permit to kill bowheads, but this requirement was withdrawn in 1976. A few bowheads have been killed in the eastern Arctic but none have been taken recently in the western Arctic. However, several persons from the Mackenzie delta region have recently shown an interest in bowhead hunting. Such a hunt would require hunting gear not now available in the region.

7. CONCERNS AND RECOMMENDATIONS

From the outset of offshore oil and gas exploration in the Beaufort Sea, Government and native persons have expressed concern about possible adverse effects on whales, especially on white whales. Recognition of the importance of this resource to local Inuit, and concern for the well-being of the Beaufort Sea white whales was forcefully stated in the Mackenzie Valley

Pipeline Inquiry (Berger, 1977). While the bowhead has received less attention, it is an endangered species and an important resource for Alaskan Inuit. Furthermore, both species constitute international resources shared by Canada, the United States and the U.S.S.R.

In our discussion of concerns and possible effects, the following factors must be considered :

- Much of the current knowledge of whales of the western Arctic is based on observations obtained from monitoring the effects of offshore hydrocarbon exploration (Fraker, 1977). To date, there has been very little scientific research directed toward studying basic whale behaviour and biology.

- Observations have conclusively demonstrated that whales can be disturbed by offshore exploration activities, such as logistics traffic (Fraker, 1977).

- Monitoring and flexible operational planning have proven effective in ensuring that effects to whales of offshore activities at existing levels have been minimal (Fraker, 1977).

- Full-scale production of oil and gas reserves would present different features, including step-out wells, gathering systems, and associated logistics and infrastructure. Hence, the assessment of potential concerns, such as increased industrial activity, acoustic barriers and large oil spills is speculative.

Much remains to be learned about whales and their relationship to the Beaufort Sea ecosystem. We cannot say for certain why whales are where they are, when they are. This makes it very difficult to predict possible effects related to specific industrial activities and events.

7.1 Effects of Current Oil and Gas Exploration in the Southeast Beaufort Sea

7.1.1 Logistics Traffic

Logistics traffic is defined as barges, boats, hovercraft and aircraft associated with the various facets of offshore exploration. Barges are self-propelled or moved by tug, and are used to transport large pieces of equipment and granular fill-material for artificial islands. Boats, hovercraft, helicopters and fixed-wing aircraft transport smaller equipment, supplies and personnel. This section deals, primarily, with the observed effects of such traffic on white whales, and is based on 5 years of monitoring of information in the Mackenzie estuary.

7.1.1.1 Boats and Barges

Boat and barge traffic is a potential source of disturbance to whales. Such traffic can affect whales by creating a disturbance in a whale-occupied area and also by blocking or impeding their movement and travel.

There are specific known instances where such disturbance has, and has not occurred. On July 11 and 12, 1976, Fraker (1977) made a detailed examination of the reaction of whales to a towed barge which passed through the Niakunak Bay concentration area. Aerial observations showed that the whales, up to approximately 1.5 miles (2,400 m) from the barge, swam rapidly away from the disturbance; very few whales remained within 0.5 miles (800 m) of the barge. Whales within a corridor about three miles (4,800) wide were affected. The scattering effect on their distribution was obvious three hours after the passage of the barge. Thirty hours later, the whales had returned to near-original distribution.

The estimated distance of 1.5 miles (2,400 m) at which the whales obviously responded is considerably less than the white whales' range of sound detection. Ford (1977) recorded the noise of a tug-boat involved in the Niakunak Bay barge-tow and calculated the probable range of perception as 3,300 m. This suggests that the mere presence of a foreign sound does not necessarily cause a whale avoidance-reaction; the reaction may depend on sound pressure level, to a large extent.

In the east Mackenzie delta, whales are frequently affected by boat traffic moving through the southern part of the Hendrickson concentration area, between the mouth of East Channel and Tuktoyaktuk. Slaney (1974) reported that :

> "During aerial surveys of July 2 and 7 (1973), whales reacted to boats moving in the shipping lane between the mouth of East Channel and Tuktoyaktuk. On July 2, whales moved *en masse* from the south end of Kugmallit Bay toward the north end of Hendrickson Island as a boat emerged from the East Channel headed toward Tuktoyaktuk. A similar reaction was noted on July 7, probably caused by a boat moving from Tuktoyaktuk toward the south end of Hendrickson Island."

Boat traffic also affected whales, to a lesser degree, in the Kendall concentration area. The number of whales in this location is relatively low, and the animals utilizing this area of deeper water may be less disturbed by boat traffic. In both 1974 and 1975, whales behaving in an undisturbed manner were observed near tugs operating in east Mackenzie Bay (Slaney, 1975a, 1975b).

Heavy traffic of barges can block or, at least,impede whale movement. In 1975, Fraker (1976) observed that whales appeared shoreward of a heavily used barge route when barge traffic stopped.

In 1976, Imperial Oil Limited used an area near Tuft Point as a source of island-building material. The main pieces of equipment operating in this area were a suction dredge, which excavated material, and barges and tugs, which carried the material to the island site. At the start of operations, an artificial breakwater was constructed to protect the site from storms. Shortly after operations began, white whales appeared in Beluga Bay*, 4 km east of Tuft Point (Table 11); from July 20 to August 4, 100 to 150 whales were present. As the barge traffic declined, the whales gradually left the Beluga Bay area. Three direct observations of interactions between whales and barges were made by Fraker (1977). However, only one incident which occurred on August 1, 1976 is quoted here as an illustrative example :

> "At 1200 hours, no whales were seen in Beluga Bay, although a large group of whales extended from near the mouth of Beluga Bay to near the Tuft Point artificial breakwater. It appeared as though these whales may have left Beluga Bay sometime earlier in the day. The whales were concentrated in the vicinity of the Tuft Point activity site, with a few others trailing off toward Beluga Bay.
>
> At 1211 hours, many whales were proceeding to go round the breakwater. At 1231 hours, many had crossed the barge route - some coming as close as a quarter of a mile off the end of the breakwater, or less than half a mile off the dredge. During this period, the dredge was operating and filling a barge. While the whales were passing the breakwater, a tug began pushing a loaded barge toward the whales. The whales swam rapidly away from the approaching barge, with the result that they split into two groups : approximately 100 animals headed north, 50 south.
>
> These whales did not appear to be affected by the noise from the stationary dredge; it was operational at the time and would have been plainly audible to the whales after they had passed the end of the breakwater, if not before (Ford, 1977). Not until the tug began pushing the barge toward the whales, did they respond."

Potentially serious disturbance to white whales of the Mackenzie estuary could result from exploration-related boat traffic, unless adequate protection planning and monitoring are implemented. Thus far, the effects of boat traffic have been minimal. Imperial Oil Limited, the main offshore operator, has attempted to adjust the location and timing of operations in order to avoid sensitive areas. By far the greatest source of current disturbance to whales comes from native whale-hunting activities in the concentration areas, when the whales are frequently chased and shot at from boats and canoes powered by outboard motors.

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* Beluga Bay is not an officially recognized geographical name. It was named by Fraker (1977) in order to conveniently discuss this previously unnamed bay.

TABLE 11. Whale/Barge Interactions near Tuft Point, July - August, 1976

Date	Detailed Events
July 13 & 16	No whales in Beluga Bay.
" 17 & 18	Dredging operations begin at Tuft Point borrow area. Barges begin hauling material to the site of an artificial island.
" 20	100-150 white whales present in Beluga Bay.
" 21	Large number of whales present in Beluga Bay. Approximately 50 whales milling around along the coast of Tuktoyaktuk Peninsula, near the north entrance to Beluga Bay; whales observed moving in and out of Beluga Bay through north entrance. Ten whales moving toward Beluga Bay from Hutchison Bay.
" 28	Large number of whales observed coming from Beluga Bay toward the Tuft Point activity site at 1100 hours. Main group of whales approached to within 1.5 miles of activity site; some individuals left the main group and approached the activity site more closely, as if to investigate conditions (1200 hours). Whales still present along the shore between Tuft Point and Beluga Bay (1500 hours). No whales along coast; 100 to 150 whales present in Beluga Bay (2320 hours).
" 28	Group of 100 to 150 whales southwest of Tuft Point observed swimming rapidly ahead of a barge moving toward the Point (2204 - 2219 hours). The barge appeared to force the whales closer to shore. The whales changed direction, swimming toward Toker Point in the direction from which they had come (2219 - 2234 hours). The whales then oriented in every direction but with a tendency to move southwest (2324 - 2341 hours).
" 29	Approximately 100 whales present in Beluga Bay, 30 animals in west arm of Hutchison Bay, possibly arriving from Beluga Bay. 20 whales moving S.W. along the coast near Warren Point. Approximately 50 animals near north entrance to Beluga Bay; some whales moving into the Bay, others moving out.
" 31	No whales seen in Beluga Bay or Hutchison Bay; approximately 100 whales present along adjacent coast.
Aug. 1	A large number of whales present from entrance of Beluga Bay to near the Tuft Point activity site (1200 hrs). Several whales moved past the artificial breakwater (1211 hrs). Many whales passed the breakwater and crossed barge route (1231 hrs). The whales split into 2 groups as a tug, pushing a loaded barge, approached them (1237 hrs).

Aug. 3	Approximately 100 whales present in the west arm of Hutchison Bay; may have come from Beluga Bay.
" 4	Last date when large numbers of whales seen in Beluga Bay area; approximately 75 were in the west arm of Hutchison Bay, and 20 along adjacent coast.
Aug. 5,6,7,8, 10, 15 & 16.	Few or no whales in Beluga Bay and adjacent areas.

7.1.1.2 Hovercraft

We have never observed an encounter between a hovercraft and whales. However, hovercraft pilots and other witnesses of such encounters report no adverse reactions by the whales. On the other hand, Vogl (*in litt.* to G. R. Douglas, Fisheries and Marine Service) cites the following incident :

> "On July 29 (1974), we accompanied a hunting party to Hendrickson Island . . . The Inuit decided to wait in Kidluit Bay until the beluga returned from deep water. Just as the animals were observed coming around the point, a hovercraft, moving north, traversed the water between Hendrickson and Richards Islands. The beluga vacated the area and were not seen until the following morning. The hunters were understandably upset since they had waited for at least 8 hours for favourable whaling conditions and were then required to wait further."

An advantage of hovercraft over boats is their ability to travel over shallow water and mudflats. Thus, they offer the potential of avoiding whale concentration areas. This could be particularly advantageous in the west Mackenzie Bay area, where barges must travel through the whale concentration area in channels which are deep enough to accommodate such traffic.

7.1.1.3 Aircraft

No study has specifically addressed the effects of aircraft on whales. However, Fraker (unpubl.), while conducting aerial surveys in a Cessna 185, at an altitude of 1,000 feet, observed that whales look skyward, apparently at the aircraft. Seemingly, the animals were not frightened. Helicopters are probably as disturbing as fixed-wing aircraft - if not more so.

In August, 1976, Smiley (pers. comm.), from a *Twin Otter* flying at 1,000 feet, observed a substantial reaction by white whales which were congregating in the very shallow, clear water of Cunningham Inlet, Prince of Wales Island. Great clouds of silt followed the whales' hurried retreat into deeper water. Possibly, whales in clear water are more easily disturbed by aircraft than are whales in turbid water. In the Mackenzie estuary, submerged whales become invisible when only a few centimetres below the surface.

Providing that aircraft maintain an altitude of 1,000 feet or more above the Mackenzie estuary (except when poor weather necessitates lower flying), there would probably be minimal effects on whales and whale-hunting.

7.1.2 Artificial Islands and Borrow Operations

At the outset of offshore exploration in the Mackenzie estuary, in 1972, concern was expressed about the possible effects of artificial islands on whales. The physical presence of the artificial islands, and associated activities, may have a limited influence on whale distribution but, to date, this has not occurred to any significant degree. Slaney (1973) reported that, "Migration movements (within the estuary) and timing may have been slightly modified by the presence of operating machinery at Rae Island and the Immerk site, in that the main herd paused outside of Garry Island from approximately July 15 to July 17 (1972), while only small pods ventured into east Mackenzie Bay." Similar operations the following year had no noticeable effect (Slaney, 1974).

In 1975, substantial numbers of whales were seen through much of the summer near Netserk South, an operational artificial island (Fraker, 1976). Some animals within 100 metres were observed by workers on the island.

Between July 31 and August 4, 1976, Mr. D. McWatt (pers. comm.), in charge of clean-up operations on Netserk South, had several opportunities of observing white whales close to the island. McWatt reported that :

> "During calm weather, the whales came closest to the island. The numbers present within about 100 yards were from 2 up to 40. Many other animals could be seen further out. They were present both as individuals and pods. So long as the water was relatively calm and noise was low on the island, the whales would approach to within a few feet. If the water became rough, or noise was generated on the island (e.g. from a Case Uniloader or a violently-burning fire), the whales would stay further away. The animals apparently were not using the island for shelter, as there was no suggestion that they were moving to the lee side of the island during rough weather. Sometimes, when the water was quiet, the whales would lie still at the surface. On occasion, they were seen "standing head-first" in the water, with their tail flukes extended above the surface

(as bowheads sometimes do).

On about three occasions, mothers were seen suckling their calves. The mother would swim on her side, with her belly toward the outside of the circle. She often had her upper flipper partially out of the water, as did the calf occasionally."

Borrow operations, which supply fill material for artificial islands, or other facilities, probably are perceived by whales as a focus of sound production, similar to that of operational artificial islands. The apparent reaction of the whales to such operations is to avoid the immediate area near the site.

Ford (1977) studied the sounds produced from the two borrow sites in Kugmallit Bay. By relating the sound attenuation rates and probable auditory sensitivity of the white whales, he calculated that the whales probably could hear average sounds from the operation at a range of 2,900 m. In addition, there were occasional transient sounds which might be perceived at a range of 4,000 m.

While logistic boat traffic and sounds associated with operational islands may have a small effect on whale distribution and movements, it is unlikely that the islands themselves would have any appreciable effect. White whales must negotiate ice conditions which vary greatly from year to year and it seems unlikely that artificial islands, if scattered in the estuary, would affect whales. Sound from an operational island probably causes the whales to give such an island a wider berth. The noise emanating from an operational island would be less than that from a dredge site, such as Tuft Point. However, a number of closely-spaced, operational artificial islands might create a physical barrier to whales, and possibly preclude their travel to an important area.

7.2 Effects of an Offshore Oil Blowout

An oil blowout, although an unlikely occurrence, is probably the most serious potential threat to bowhead and white whales. A direct threat is the contact with toxic oil, resulting in injury or death. Indirect threats include possible contamination of food, and the whales' avoidance of oil-contaminated waters which might block migration and/or prevent the whales' use of required habitat. The potential severity of these effects depends largely on the fate of the oil spread by currents and winds, the volumes of oil released and ice conditions, and also on rates of biodegradation and routes of transfer through the food chain.

In this report, it is assumed that the area affected by a hypothetical oil blowout are the waters offshore of the Tuktoyaktuk Peninsula and Yukon coast. Depending on winds and currents, the oil could be carried onshore, to foul beaches and lagoons, or offshore where it would spread out in the clockwise Beaufort Gyre. Amundsen Gulf probably would not be affected. For a more detailed consideration of this blowout scenario, the reader is referred to Milne and Smiley (1976).

7.2.1 Direct Impacts of Oil on Whales

Observations on the direct effects of oil on whales and porpoises do not exist. However, Smith and Geraci (1975) have studied the effects of oil on ringed seals; their observations, with some qualifications, will be extrapolated to whales.

Like ringed seals, whales do not rely on hair to insulate themselves from the cold. In contrast to muskrats, otters and fur-seals, whales' contact with oil should not result in an increased rate of heat loss and thermoregulatory problems.

A surface oil-slick is likely to affect the eyes and blowhole of bowhead and white whales. Smith and Geraci (1975) reported appreciable damage to the eyes of ringed seals after 24 hours of contact with fresh, crude oil. They also noted that the persons engaged in the research experienced eye irritation from the pungent fumes of the crude oil: the same volatile fractions of the oil were responsible for, at least, some of the eye damage to seals. The seals' eye inflammation soon subsided after they were returned to clean water,but prolonged exposure could lead to permanent damage or blindness. For acoustically-oriented whales, such as white whales, blindness might not be an insurmountable handicap.

When experimental seals ingest crude oil, there is liver damage, as evidenced by the presence of liver enzymes in the blood (Smith and Geraci, 1975). The kidney, however, seems to be a more sensitive target organ.

White whales, like seals, feed on relatively large, individual prey animals, and probably would not ingest large amounts of oil. On the other hand, bowheads, which feed on small organisms filtered from the water, would also filter out suspended oil. In this way, bowheads could ingest damaging quantities of oil, unless the presence of oil caused them to cease feeding. Fortunately, neither species appears to feed heavily in the region of a potential blowout, although bowheads may feed, to some degree, during their migration through the area.

Both species of whale would probably try to avoid direct contact with oil from a blowout, especially fresh oil containing large amounts of the pungent, irritating fractions.

7.2.2. Indirect Effects of Oil on Whales

7.2.2.1 Whale Movements during Spring (May to early July).

From May to early July, bowheads and white whales undertake a spring migration from the Bering Sea. If the whales utilize the far offshore route in reaching the Amundsen Gulf region, as we have hypothesized in sections 6.1.1.1 and 6.2.1.1, they would probably not contact oil from an oilwell blowout in the current area of exploration - mainly north of the Mackenzie delta.

However, during the second phase of white whale migration, from Amundsen Gulf to the Mackenzie estuary, any oil which clogs leads in the ice could block or impede their travel.

Most white whales reach the Mackenzie estuary by swimming from the east, along the edge of the landfast ice; oil in this area would be very serious. White whales, sensitive to intensive boat traffic, might also be disturbed by oil clean-up activities.

Without clearly understanding the white whales' dependence on the Mackenzie estuary, it is hard to speculate on the outcome of denying them their access. If calving or calf-rearing is important here, there could be increased calf mortality. However, in a long-lived species, such as the white whale, the loss of a year's calf crop would probably be compensated by improved survivorship of animals born in succeeding years. Older animals probably would not be affected.

The most serious impact would be on the success of the native whale hunt. A delay in the whales' migration would shorten the hunting season and, possibly, reduce the harvest. Understandably, the hunters would be upset by any disruption of their usual harvest of whales.

7.2.2.2 Whale Movements during Summer (mid-July to mid-August)

During the summer, most white whales in the Beaufort Sea region are in the Mackenzie estuary - although some are further east. Throughout the summer, there is relatively heavy white whale traffic along the Tuktoyaktuk Peninsula. Most bowhead whales summer in the Amundsen Gulf region.

An oil blowout which pollutes the coastal waters of the Tuktoyaktuk Peninsula could be serious, even though most white whales reach the Mackenzie estuary by mid-July. Some white whales from the Mackenzie estuary would attempt to move east during July. Still others would probably move from the east, toward the delta region, throughout July and much of August. Many of these animals might encounter oil and also considerable clean-up and containment activities which might affect their movements. The consequences of delaying or preventing these animals from arriving at the Mackenzie estuary are unknown.

7.2.2.3 Whale Movements during Fall (mid-August to October).

In late August and September, both whale species are engaged in westward outmigration. Most fall migration probably occurs along the coast, and thus a blowout affecting coastal areas could be serious. During the open-water period, whales would be able to avoid oil-slicks and any water-borne traffic associated with clean-up and containment. It is likely that a significant proportion of the whales would successfully complete their out-migration, but some might be delayed long enough to become trapped in the ice.

7.2.3 Effects of Oil on Whales' Foods and Feeding

Available information suggests that white whales do not feed extensively in the Mackenzie delta region; this is a tentative statement which might be modified as more data become available. Thus, if for some reason, fish stocks were severely damaged - even given a long recovery time - the effect on whales would probably not be serious. However, if fish stocks utilized by the Inuit domestic fishery were severely damaged, there might be an increase in the annual take of whales to compensate for a reduced catch of fish. For a few years, at least, the whale harvest might probably be doubled, without seriously affecting the population (see sub-section 6.1.3.1 and 6.1.4.5).

Toxic petroleum fractions may be concentrated in the food chain, subjecting each higher trophic level to more highly concentrated toxic chemicals. White whales might be more vulnerable to such concentration because they feed on fish.

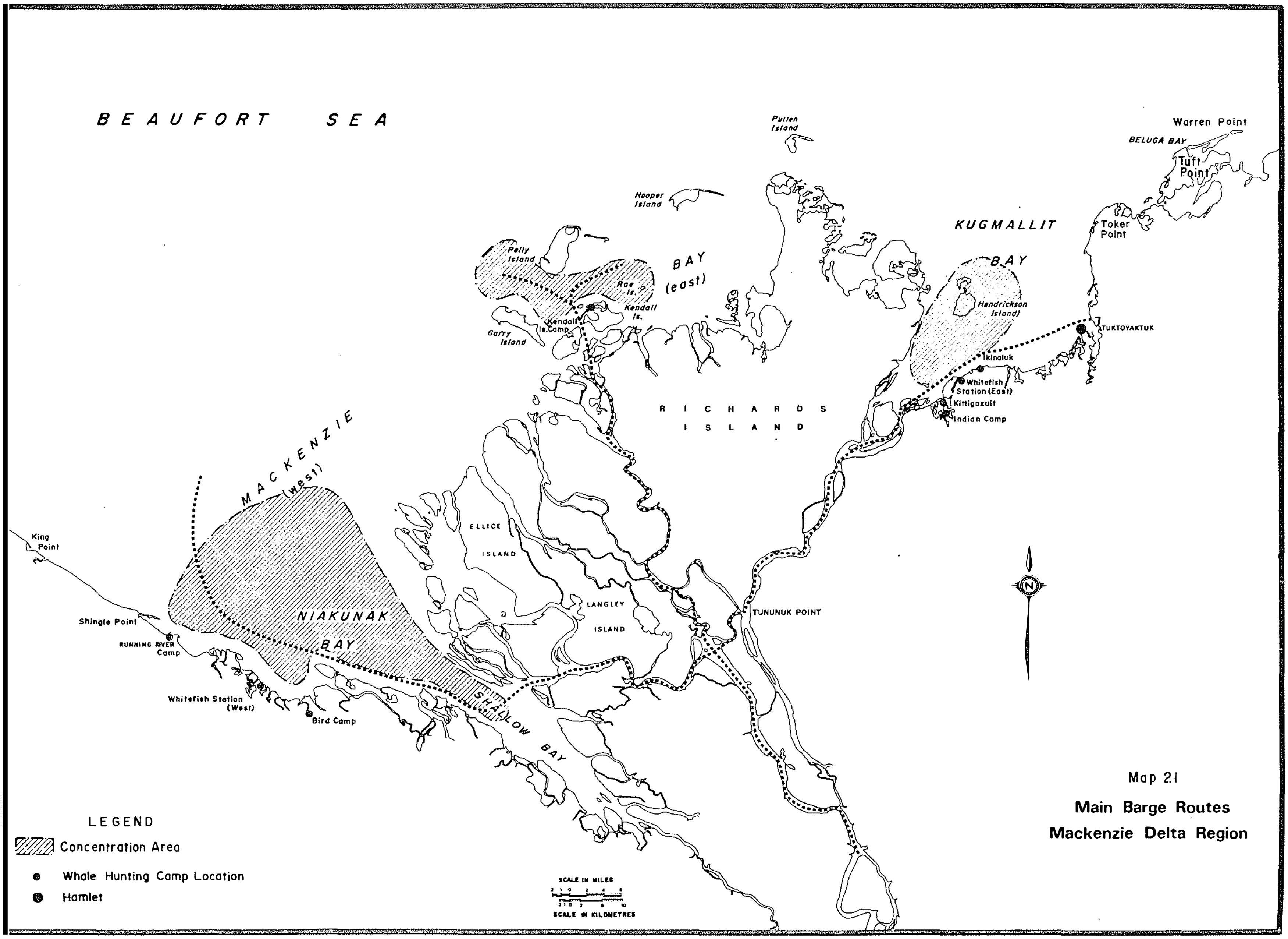
7.3 Recommendations

Although our knowledge of whales and possible impact of offshore exploration is limited, specific actions are recommended to protect whales in the study area. However, these recommendations may require modification in the light of new data.

7.3.1 Boat and Barge Traffic

All major barge routes pass through whale concentration areas (Map 21), but whales in some areas are more vulnerable than those in others. In Niakunak Bay, the only usable channel for boats runs through the centre of the concentration area, so traffic moving through this area, particularly in July, will unavoidably disturb whales, to some extent. The level of traffic over the past few years has been low, and little disturbance has resulted; however, the potential for significant impact in this area does exist. Sergeant and Hoek (1976) regarded the potential threat to whales in this area as serious enough to warrant the establishment of a disturbance-free sanctuary. This suggestion is a major recommendation of the Mackenzie Valley Pipeline Inquiry (Berger, 1977).

In Kugmallit Bay, most industrial boat-traffic skirts the southern extremity of the concentration area and the disturbance is confined to a small peripheral area. The areas south of Hendrickson Island, and between Hendrickson and Richards Islands, are currently used by whales, although old hunters' stories (Nuligak, 1966; Fraker, 1977) indicate that the whales once came much closer to the actual mouth of East Channel. This modified distribution is, probably, a consequence of disturbance by commercial boat-traffic between East Channel and Tuktoyaktuk, and by boats of Inuit hunters. The traffic pattern on the East Channel/Tuktoyaktuk route, used since the mid- 1930's, probably does not pose a significant threat to white whales. However, commercial traffic-disturbance could be minimized if the chosen route is as close as possible to the southern shore



Map 21
Main Barge Routes
Mackenzie Delta Region

of Kugmallit Bay (at the southernmost portion of the area used by whales and whale-hunters).

The potential disturbance in the Kendall Island concentration area is somewhat less, because whales in the deeper water of this area seem less perturbed by boats (Fraker, 1977). However, the avoidance reactions of whales in this area require more documentation to test the above-mentioned impressions. The Kendall Island area had fewer whales and fewer whale-hunters. However, hunting pressure was relatively high in 1976, and this may continue.

Apparently, sound is the main source of disturbance from boat-traffic. A means of reducing the boat-generated noise should be investigated. The ambient sea-noise increases during stormy periods; thus, boats passing during storms might be less noticeable to whales and, therefore, less disturbing.

Under some circumstances, it is possible to avoid disturbing whales in concentration areas (especially in Niakunak Bay) by scheduling barge movements when the whales are, periodically, absent. Aerial surveillance, flexible exploration operations and a better understanding of whale behaviour are necessary to accomplish this. Any operations along whale travel routes require close monitoring to detect and avoid migration interference. Although, at times, the disruption involves few whales (as occurred at Tuft Point in 1976), operators should be prepared to suspend operations, temporarily, in order to allow passage to the whales.

7.3.2 Hovercraft Traffic

Hovercraft should not be used in whale concentration areas and along travel routes when either whale hunters or substantial numbers of whales might be disturbed. The capability of these vehicles to travel over any flat, level surface allows them to operate in shallow waters outside areas of whale concentration.

7.3.3 Aircraft Traffic

Both fixed-wing aircraft and helicopters should maintain altitudes of, at least, 1,000 feet when flying over white whale concentration areas, during the open-water season, except during periods of inclement weather. At present, most pilots operate their craft within these guidelines - with the exception of some tourist flights.

7.3.4 Stationary Operations

As future industrial operations increase, there is the concern of possible disturbance from artificial island construction and operation. In the vicinity of such exploration sites, an area of about 8,000 m diameter may be influenced by industrial sounds, which the animals can and do perceive (Ford, 1977). Actual observations of whale avoidance suggest that the animals alter their swimming patterns within about 2,400 m (1.5 miles) of stationary dredging operations.

If several such activities (dredging, barge and boat traffic, active artificial islands, and drillships) are in close proximity to each other, an effective acoustic barrier to whale movements could result. Continuous aerial surveillance of whale concentration areas and intra-delta travel-routes, and the temporary suspension or re-routing of industrial activity would minimize this threat.

7.3.5 Blowout Clean-up

In the event of an oilwell blowout, clean-up operations, such as burning and boom deployment, could impede or halt whale movements. Boat and air traffic could effectively discourage the whales from entering oil-contaminated waters. Conversely, such oilspill counter-measures might serve to prevent the escape of whale-herds from polluted, coastal embayments and offshore leads. Whale distribution in the Mackenzie delta requires close monitoring and, in some cases, temporary suspension of operations, during any open-water clean-up attempts.

8. FURTHER STUDY REQUIREMENTS OF WHITE WHALES

8.1 Migration

Spring and fall migrations for bowhead and white whales are not adequately documented to predict the potential effects of exploration development. Studies are especially required to determine the routes and timing of whale migrations, and the possible relation to ice conditions[1].

8.2 Feeding

A major oil-spill has potential adverse implications to food-web organisms, such as fish, which whales depend on for food. Although feeding is considered as generally unimportant in the Mackenzie estuary, white whales apparently feed in the intermittent-use areas and travel routes. Whales should be sampled, in these areas, to determine their food habits and preferences. Feeding may also take place in Amundsen Gulf, in the spring, and whales in this area should also be sampled.

8.3 Intra-Estuary Movements

Over the past five years of aerial observations, general trends have been identified concerning the movements and distribution of whales within the Mackenzie estuary. To provide better protection to whales during oil and gas development, a more detailed understanding is necessary. Radio tracking of individual whales is required.

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1 A study of the spring migration of white whales was undertaken in 1977 by F. F. Slaney & Company Limited for Fisheries and Marine Service, Department of Fisheries and the Environment; a final report will be completed in early 1978.

8.4 Population Size

Population size is fundamental to management and protection. In contrast to clear water estuaries in the eastern Arctic, the silt-laden water of the Mackenzie River makes population estimates very difficult. Studies of whale behaviour in this estuary are necessary to determine the proportion of the whales at the surface during any given period of time; an accurate visibility factor can then be applied.

8.5 Reproduction

In any harvested or otherwise-affected population, changes in reproduction may reflect important trends in the population. A systematic and long-term program of collecting reproductive data from the native kills is required.

8.6 Value of Niakunak Bay

Niakunak Bay is a sensitive area for white whales during exploration and development activities. A detailed study of whales' use of this region, in relation to physical/chemical factors, could explain the basis for their selection of and preference for this area, and could further our understanding of the importance of other concentration areas to white whales.[2]

8.7 Summer Occurrence of Bowheads and White Whales in the South-eastern Beaufort Sea - Amundsen Gulf Region

Information on the distribution and abundance of bowhead and white whales in the south-eastern Beaufort Sea - Amundsen Gulf region is very limited. A combination of aerial surveys and a scheme for soliciting the observations of persons working in the area should be employed in a study of this region.

8.8 Acoustic Disturbance

The studies of underwater industrial noise and white whale vocalizations, conducted in 1976 (Ford, 1977), identified sounds which constitute the major source of disturbance to white whales. Further studies of industrial noise and possible ways of reducing it, should be undertaken.

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2 A study of whale distribution in relation to physical/chemical factors was undertaken in 1977 by F. F. Slaney & Company for Fisheries & Marine Service of the Department of Fisheries and the Environment. A final report will be completed in early 1978.

9. ACKNOWLEDGMENTS

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APPENDIX 1

RESULTS OF RECONNAISSANCE SURVEYS 1972 - 1976

W. HOEK

Date	Location	Observations
July 2, 1972	Middle of Shallow Bay to just N.E. of Shingle Point	1,000 white whales
" 2, 1972	15 miles W. of Olivier Island	25 white whales
" 2, 1972	10 miles N.W. of Pitt Island	100 white whales
" 2, 1972	Kendall/Garry/Pelly Islands region	25 white whales
" 16, 1972	near Kidluit Bay	30-50 white whales; 1 whale was tagged
" 18, 1972	East coast Richards Island, N. of Hendrickson Island	600 white whales headed N.W. toward Pullen Island.
Sept.21, 1972	near Herschel Island	2,000 white whales headed West
" 21, 1972	near Alaska/Yukon border	20 bowheads not oriented in any particular direction
" 21, 1972	near edge of pack, about 100 miles E of Point Barrow, Alaska, 72°05'N, 148°40'W	100 white whales headed S.
" 21, 1972	near edge of pack ice, E. of above location	12 bowheads not oriented in any particular direction
July 26, 1973	15 miles N of Cape Dalhousie	200-300 white whales
" 26, 1973	Liverpool Bay	6 white whales
" 26, 1973	Cape Dalhousie	25 white whales
" 26, 1973	near Baillie Island	10 white whales moving S.
" 26, 1973	10 miles N.E. Baillie Island	4 bowheads
" 26, 1973	N. of Cape Bathurst	3 bowheads
" 26, 1973	Franklin Bay, 10 miles N. of mouth of Horton River	12 bowheads
" 26, 1973	5 miles W.S.W. of Cape Parry	3 bowheads
" 26, 1973	Harrowby Bay	1 white whale adult with calf

APPENDIX 1 - Page 2.

Date	Location	Observations
July 26, 1973	Cape Dalhousie	10 white whales
" 26, 1973	Between Nuvorak Point and McKinley Bay	100 white whales
" 26, 1973	S. and W. of Hendrickson Island	1,000 white whales
" 26, 1973	near Hooper Island	200 white whales
" 26, 1973	6 miles N.N.E. Pelly Is.	200 white whales
" 26, 1973	Kendall/Garry/Pelly Island region	100 white whales
" 26, 1973	Between Garry and Ellice Islands	1,500 - 2,000 white whales
" 28, 1973	5 miles N. of Tuktoyaktuk, along coast	25 white whales
" 28, 1973	6 miles N. of Tuktoyaktuk, along coast	25 white whales
" 28, 1973	Between Toker Point and Warren Point	50 white whales
" 28, 1973	Warren Point	100 white whales
" 28, 1973	N. of Hutchison Bay	25 white whales
" 28, 1973	4 miles S.W. of Atkinson Point	25 white whales
Sept.19, 1973	69°44'N, 132°03'W	1 dead female bowhead, 32 feet long
" 20, 1973	N. of Hooper Island	4 bowheads
" 20, 1973	N.W. Garry Island	1 bowhead
" 20, 1973	10 miles N. King Point	6 bowheads
" 20, 1973	1 mile N. Herschel Is.	2 bowheads
July 15, 1974	Lead (20 miles long), 15 miles N. Toker Point	300 white whales
" 15, 1974	Leads N. of Pullen Island	Scattered white whales
" 15, 1974	Floe-ice between Garry Is. and Sabine Point	Scattered white whales
" 15, 1974	Midway between Olivier Is. and Garry Island	2,000 white whales
" 15, 1974	Between Shingle Point and middle of Shallow Bay	1,500 white whales

APPENDIX 1 - Page 3.

Date	Location	Observations
July 17, 1974	69°52'N, 131°35'W.	Remains of 1 bowhead
" 17, 1974	70°N, 131°02'W.	Vertebra of 1 bowhead
" 17, 1974	S. of Hendrickson Is.	300-400 white whales
" 17, 1974	Large lead 15 miles N. of Toker Point	1,500 white whales
" 23, 1974	1 mile N. of Kendall Is.	50 white whales
" 23, 1974	Between Pullen Island and Kidluit Bay	Few hundred white whales
" 23, 1974	Kendall/Garry/Pelly Islands region	250 white whales
" 26, 1974	Between Cape Bathurst & mouth of Horton River	300 white whales
" 28, 1974	near Hendrickson Island	300 white whales
" 28, 1974	3 miles N. of Pullen Is.	2 bowheads
" 28, 1974	95 miles N. of Shingle Point	15 adult bowheads, plus 2 calves; 10 white whales
" 29, 1974	Just N. of Kendall Is.	1 white whale
" 30, 1974	69°44'N, 132°03'W.	Carcass of 1 young bowhead
Sept.11, 1974	69°52'N, 131°35'W.	1 bowhead vertebra
" 11, 1974	Atkinson Point, DEW-line Station	1 bowhead skull
" 11, 1974	3 miles S.E. of Cape Bathurst	1 bowhead, approx. 50 feet long, headed N.W. in floe-ice
" 11, 1974	Middle of Franklin Bay, between mouth of Horton River & Cape Parry	2 white whales (1 adult, 1 immature)
" 13, 1974	69°45'N, 132°W.	1 bowhead - young male, 24 ft. 9in. long.
" 13, 1974	Between Tuktoyaktuk & 69°45'N, 132°W.	9 dead white whales
" 13, 1974	Tibjak Point	1 white whale - resting its head on the beach, but swam away when the helicopter appeared
July 12, 1975	Franklin Bay, near Horton River	1 bowhead, 35 white whales
" 14, 1975	69°42'N, 132°68'W.	Lower mandible of adult bowhead

APPENDIX 1 - Page 4.

Date	Location	Observations
July 14, 1975	69°43'N, 132°35'W.	Bowhead carcass
" 14, 1975	69°45'N, 132°03'W.	Bowhead skull
" 14, 1975	69°45'N, 132°W.	Bowhead carcass (Same as one found in 1974)
" 14, 1975	Bay E. of Toker Point	20-30 white whales
" 14, 1975	Between Toker Point and Atkinson Point	50 white whales
" 17, 1975	Kugmallit Bay	300-400 white whales
" 17, 1975	Hendrickson Island	18 butchered carcasses of white whales
" 18, 1975	Kendall/Garry/Pelly Islands region	200 white whales
" 18, 1975	near W. side Hooper Is.	25 white whales
" 18, 1975	10 miles N. of Shoal-water Bay	1,000 to 1,500 white whales
" 18, 1975	10 miles N. of Shingle Pt. DEW-line station	25 white whales
" 20, 1975	Franklin Bay	4 bowheads, 1 white whale
" 21, 1975	Mouth of Mason Bay	50 white whales
" 21, 1975	East Mackenzie Bay	200 white whales
" 22, 1975	N. of Shoalwater Bay	500 white whales
" 22, 1975	8 miles S.E. Hendrickson Island	50-100 white whales
" 23, 1975	Tibjak Point	25 whales
" 23, 1975	4 miles S.W. Warren Pt.	12 white whales
" 23, 1975	Warren Point	12 white whales
" 23, 1975	5 miles N.E. Warren Pt.	25 white whales
" 24, 1975	Lower Kugmallit Bay	200 white whales
" 24, 1975	3 miles S. Pullen Is.	10 white whales
" 24, 1975	1 mile S. Pullen Island	25 white whales
" 24, 1975	Along N. side Hooper Is.	50 white whales headed W & N.W.
" 24, 1975	Kendall/Garry/Pelly Islands region	200 white whales
" 24, 1975	Lower Mackenzie Bay (N. of Shingle Point)	1,500 white whales

APPENDIX 1 - Page 5.

Date	Location	Observations
July 26, 1975	Eskimo Lakes, 69°38'N, 131°05'W.	52 white whales
" 26, 1975	near N.E. side Baillie Island	1 bowhead, 50 white whales
" 26, 1975	Cape Bathurst	10 white whales
" 5, 1976	About 5 miles W. of Tuktoyaktuk runway	200 white whales
" 7, 1976	About 8 miles W. of Garry Island	12 white whales
" 7, 1976	N. of Shoalwater Bay and Tent Island	400 white whales
" 10, 1976	Franklin Bay, near Baillie Island	1 bowhead; about 300 white whales heading N.W.
" 14, 1976	Tibjak Point	150 white whales
" 14, 1976	69°38'N, 131°55'W.	100 white whales
" 14, 1976	5 miles W. of Warren Point	30 white whales
" 16, 1976	E. coast of Richards Is., from Hendrickson Is. to Pullen Island	Small groups of white whales
" 16, 1976	Hutchison Bay	Few white whales
" 16, 1976	McKinley Bay	12 white whales
" 16, 1976	10 miles E. Cape Parry	50 white whales, in ice
" 16, 1976	W.of Baillie Island	12 white whales
" 16, 1976	Cape Bathurst	A few white whales, scattered in 5/10ths ice
" 16, 1976	Kugmallit Bay	500 white whales within 1 mile of CCG ship, *Nahetic*

APPENDIX 2

INCIDENTAL OBSERVATIONS OF WHITE WHALES IN THE SOUTHEAST BEAUFORT SEA : 1970 - 1976

Date	Location	Observation	Observer
Aug. 12, 1970	35-50 miles N of Baillie Islands	Approx. 2,700-3,000 whales	Dr. T. W. Barry, CWS
Summer, 1971	near Holman Island	1 pod of unknown size	Dr. T. G. Smith, FMS
Aug. 26, 1971	Pauline Cove, Herschel Is.	26 whales	Mr. B. Beck, FMS
June 8, 1973	71°37'3"N,126°09'W	1 whale	Mr. D. Andriashek, CWS
" 8, 1973	70°34'N, 125°W	15 whales	Mr. D. Andriashek. CWS
" 8, 1973	71°N, 125°W	34 whales	Mr. D. Andriashek. CWS
" 8, 1973	71°N, 125°30'W	approx. 100 whales swimming in lead	Mr. D. Andriashek, CWS
" 9, 1973	20 miles S Sachs Harbour	30 whales swimming N.E. in large lead	Mr. D. Andriashek, CWS
" 9, 1973	20 miles N. Baillie Islands	2 whales swimming E in narrow lead	Mr. D. Andriashek, CWS
" 29, 1973	S of Cape Baring, Victoria Island, in E-W lead, 3-4 miles long by 200-400 yards wide, solid ice cover all round	approx. 42 whales	Dr. T.G. Smith, FMS
July 10, 1973	6 miles N.E. Campbell Is.	approx. 100 whales, including numerous calves of unknown age	Mr. J. Lovrity, FMS
" 11, 1973	near N.W. shore of Liverpool Bay	approx. 400 whales headed toward mouth of Bay	
Sept 13, 1973	near Herschel Island	12 whales	Dr. T. W. Barry, CWS
July 8, 1974	70°N, 133°W	8 whales	Mr. J. Goddard, FMS
" 13, 1974	69°50'N, 135°50'W	several whales	Mr. J. Goddard, FMS

APPENDIX 2 - Page 2

Date	Location	Observation	Observer
July 15, 1974	69°50'N, 133°05'W	several whales	Mr. J. Goddard, FMS
" 15, 1974	70°20'N, 137°W	4 whales	Mr. J. Goddard, FMS
" 16, 1974	69°50'N, 133°15'W	several whales	Mr. J. Goddard, FMS
" 17, 1974	69°50'N, 133°28'W	hundreds of whales	Mr. J. Goddard, FMS
" 17, 1974	70°10'N, 133°15'W	several whales	Mr. J. Goddard, FMS
" 28, 1974	1-4 miles S.E. Cape Bathurst	20-30 whales	
" 29, 1974	70°35'N, 136°50'W	2 whales	Mr. J. Goddard, FMS
Aug. 12, 1974	5 miles N.E. Cape Dalhousie	20+ whales	
July 13, 1975	N of Hooper Island	more than 500; took about 2 hours for the group to pass	Mr. J. S. Code
" 24, 1975	N.W. of Hooper Is	40 - 50 whales	Mr. J. S. Code
Aug. 4, 1975	W end Hooper Island	200 whales	Mr. J. S. Code
" 5, 1975	near Nuvorak Point 70°18'N, 130°30'W	3 whales moving N.E.	Mr. F.E. Stephenson, DOE
" 5, 1975	30 miles S of Holman Is., Victoria Island	2 whales moving S.	Mr. A. Benson, Klondike Helicopters
" 5, 1975	N side of Hooper Is.	30-50 whales	Mr. J. S. Code
" 5, 1975	30 miles N of Cape Dalhousie, 70°40'N, 129°45'W	3 whales moving N	Mr. F.E. Stephenson, DOE
" 6, 1975	Prince of Wales Strait, opp. Johnson Point, Banks Island	25 whales moving S.W.	Mr. D. Chamberlin

APPENDIX 2 - Page 3

Date	Location	Observation	Observer
Aug. 6, 1975	120 miles from Sachs Harbour on direct line to Tuktoyaktuk	6 whales (one a calf of unknown age)	Mr. A. Benson, Klondike Helicopters
" 15, 1975	Along the coast, near King Pt., Yukon, in 5-mile stretch centered on 69°04'N,137°48'W	approx. 80 whales headed N.W. Some appeared to be feeding or playing	Mr. F.E. Stephenson, DOE
" 16, 1975	50 miles N of Toker Point	6-8 whales	Mr. F.E. Stephenson, DOE
" 17, 1975	Brown's Harbour, Cape Parry	12-15 whales moving N, 400-500 yards offshore	Mr. D. St. Aubin, University of Guelph
" 20, 1975	Brown's Harbour, Cape Parry	1 whale caught in seal-net	Mr. D. St. Aubin, University of Guelph
" 22, 1975	20 miles N.W. Hooper Island	3 whales	Mr. A. Benson, Klondike Helicopters
Sept.9, 1975	near Atkinson Point 69°56'N, 131°21'W	2 whales	Mr. K. Pearson, Klondike Helicopters
June 7, 1976	Along edge of ice curving N.E. and N from Baillie Island to about 15 miles S.E. of Sachs Harbour	221 whales, moving E and S.E.	Dr. T. W. Barry, CWS.

APPENDIX 3

INCIDENTAL OBSERVATIONS OF BOWHEAD WHALES IN THE SOUTHEAST BEAUFORT SEA : 1973 - 1976

Date	Location	Observation	Observer
June 8, 1973	71°37'N,126°09'W	6 whales in 8/10ths ice, with large leads	Mr. D. Andriashek, CWS
July 14, 1973	35 miles WSW of Cape Parry DEW-line station	2 whales	Mr. D. Andriashek, CWS
" 29, 1974	Hooper Island	4 whales	Decca personnel
Sept.16, 1974	Mackenzie Bay	1 whale	Mr. J. Scott
June 30, 1975	Moore Island, S.E. of Cape Parry	1 whale headed SSE	Dr. T. W. Barry, CWS
July, 1975	Prince of Wales Strait between Banks Island & Victoria Island	10-15 whales headed S	Unknown, GSC
Aug. 5, 1975	5 miles S of Nelson Head, Banks Island	5 whales showing no directional interest	Mr. A. Benson, Klondike Helicopters
" 15, 1975 (1245 hrs)	near King Point, along Yukon coast, 1-2 miles offshore	Whales, moving SE	Mr. F. E. Stephenson, DOE
" 15, 1975 (1500 hrs)	near King Point, along Yukon coast, some very close to shore	7 whales, moving SE; some may have been part of group of 3 seen earlier in day	Mr. F. E. Stephenson, DOE, and Mr. A. Benson, Klondike Helicopters
" 22, 1975	20 miles NW of Hooper Island	3 whales	Mr. A. Benson, Klondike Helicopters
" 25, 1975	30 miles N of Shingle Pt.	Approx. 8 whales	Mr. J. Pearson, Klondike Helicopters
" 29, 1975	NW of Garry Island, 69°38'N, 136°08'W	5-10 whales swimming W	Mr. T. Drew, Bradley Air Service

APPENDIX 3 - Page 2

Date	Location	Observation	Observer
Aug. 29, 1975	35 miles N of Shingle Pt. 69°33'N, 136°47'W	2 whales resting motionless in water next to ice-floe	Mr. T. Drew, Bradley Air Service
" 31, 1975	35 miles NNW of Garry Is. 69°54'N, 136°20'W	1 whale moving W	Mr. T. Drew, Bradley Air Service
" 31, 1975	Between Shingle Pt. and Sabine Pt.	4 whales moving SE. They made several 10-15 minute dives - may have been feeding	Mr. D. McWatt
Sept. 2, 1975	8 miles N of Pelly Is., 69°47'N, 135°46'W	1 whale moving E	Mr. T. Drew, Bradley Air Service
" 2, 1975	15 miles N of Hooper Is., 69°50'N, 134°54'W	2 whales moving N	Mr. T. Drew, Bradley Air Service
" 6, 1975	Herschel Island	25-30 whales moving W	Mr. R. Mackenzie
" 9, 1975	40 miles NW of Hooper Is.	1 whale moving W	Mr. J. Pearson, Klondike Helicopters
" 8, 1975	15 miles N of Pullen Is., 69°57'N, 134°39'W	4 whales moving E	Mr. T. Drew, Bradley Air Service
July 19, 1976	30 miles N Cape Bathurst	1 whale moving N	Mr. K. Gay, NTCL
Aug. 6, 1975	3.5' (4 miles) N Deas Thompson Point	1 whale moving WSW	Mr. K. Gay, NTCL
Aug. 10, 1976	9 miles NE Hendrickson Island	6 whales	Mr. D. Broder, Okanagan Helicopters
" 19, 1976	3 miles NW Beluga Shoal (4 miles NW Warren Pt)	1 whale moving N	Mr. K. Gay, NTCL
" 30, 1976	near Atkinson Point, 5-8 miles from shore	About 40 whales headed NE	Mr. G. Bruinsma, FMS

APPENDIX 3 - Page 3

Date	Location	Observation	Observer
Sept. 2, 1976	Brown's Harbour, Cape Parry	1 whale headed N	Dr. T. G. Smith, FMS
" 16, 1976	10 miles NW Atkinson Point	1 whale moving NW	Mr. J. Cooper, IOL
late Aug. 1975	Stanton	10 whales moving past Stanton, headed toward Anderson River	Mr. Jorgen Elias
late July 1976	Stanton	30-40 whales moving past Stanton, headed toward Anderson River	Mr. Jorgen Elias

APPENDIX 4

OBSERVATIONS OF WHALES IN THE BEAUFORT SEA BY LGL LTD. (1974 - 1976)

Date	Location	Observation	Observer
Aug. 25, 1974	Near Cape Dalhousie	6 - 7 white whales headed W	W. Koski
Sept. 3, 1974	West of Shingle Point	2 bowhead whales	W. Koski
" 11, 1974	Along transect 23 (between Shingle Pt and Sabine Pt.	1 bowhead whale	W. Koski
May 14, 1975	280 km N of Herschel Is.	9 white whales in opening in the ice; could have travelled through small leads. No large amounts of open water	S. R. Johnson
" 28, 1975	20 km N of Komakuk Beach	1 white whale, interface between solid shorefast ice and pack ice containing small cracks and holes	S. R. Johnson
June 5, 1975	45 km NNE of Komakuk Beach	1 bowhead whale in large lead	S. R. Johnson
" 15, 1975	60 km N of Komakuk Beach	1 white whale in large lead in pack ice	S. R. Johnson
" 15, 1975	175 km N of Shingle Point	8 white whales milling about in a pod in a small area of open water	S. R. Johnson
" 15, 1975	90 km N of Shingle Point	1 white whale in large leads outside of shorefast ice	S. R. Johnson
" 26, 1975	50 km NNE of Komakuk Beach	1 white whale in open water between large pan and pack ice	S. R. Johnson
July 3, 1975	50 km N of Herschel Is.	2 white whales at pack ice/ open water interface	S. R. Johnson
" 9, 1975	210 km N of Shingle Pt.	1 white whale in open water with scattered pans	S. R. Johnson

APPENDIX 4 - Page 2.

Date	Location	Observation	Observer
July 9, 1975	70 km N. of Pelly Island	18 white whales in open water with small amounts of floating ice	S. R. Johnson
Sept. 5, 1976	2 miles E King Point, 1-1½ miles offshore	2 bowhead whales	W. Koski
" 5, 1976	3 miles E King Point, 1½-2 miles offshore	4 bowhead whales	W. Koski
" 5, 1976	2.5 miles E King Point, 1-1½ miles offshore	2 bowhead whales	W. Koski
" 6, 1976	2 miles W Shingle Point	1 bowhead whale	W. Koski
" 6, 1976	Between Clarence Lagoon and Komakuk Beach DEW-line Station, 1/8th mile offshore	1 bowhead whale	W. Koski
" 12, 1976	Middle of transect 31 (W. King Point)	2 bowhead whales	W. Koski
" 13, 1976	Between Shingle Point and Kay Point	33 bowhead whales	W. Koski & T. Watmore
" 19, 1976	1 mile W King Point	4 bowhead whales	W. Koski

APPENDIX 5

OBSERVATIONS OF BOWHEAD WHALES (1976) BY F. F. SLANEY & COMPANY LTD.

Date	Location	Number	Observer
August 3	8 miles NW of Toker Point	1	M. Fraker
" 5	20 miles E of Pullen Island	1	M. Fraker
" 7	9 miles NW of Toker Point	1	M. Fraker
	11 miles NW of Toker Point	2	M. Fraker
	9 miles N of Toker Point	1	M. Fraker
" 10	Between Warren Point and Atkinson Point	20 - 30	M. Fraker
	4 miles NW of Toker Point	4	M. Fraker
	9 miles N of Toker Point	1	M. Fraker
	9 miles NW of Toker Point	2	M. Fraker
	16 miles E of Pullen Island	1	M. Fraker
	18 miles E of Pullen Island	1	M. Fraker
" 15	Just off Cape Dalhousie	1	M. Fraker
" 31	North of Pullen Island	3	R. Olmsted

APPENDIX 6.

INCIDENTAL OBSERVATIONS OF WHITE WHALES IN ESKIMO LAKES, 1966-1967; 1973-1976.

Date	Location	Observation	Source
Fall and winter 1966-1967	Southwestern Eskimo Lakes	Many observations of up to 50 whales which eventually perished in the ice	Hill, 1967
mid-July 1973 approx.	Eskimo Lakes	Large numbers of whales	Slaney, 1974
July 22, 1973	Arctic Bio. Station Camp	6 whales headed E.	Mr. J. Lovrity, FMS
Aug. 3, 1973	3-4 miles W of Arctic Bio. Station Camp	1 whale headed E.	Mr. J. Lovrity, FMS
" 17, 1974	69°50'N, 133° 25'W	About 10 whales	Mr. B. Smiley, FMS
July 31, 1975	69°05'N, 132°45'W	Large group of whales, widely dispersed, possibly the same group seen on July 27	Fraker, 1976
July 27, 1975	7-8 miles W of Arctic Bio. Station Camp 69°34'N, 131°40'W	Approx. 125 whales	Fraker, 1976
" 24, 1975	Arctic Bio. Sta. Camp	20-30 whales moving W	Mr. M. Foy, FMS.
" 25, 1975	Arctic Bio. Sta. Camp 69°35'N, 131°15'W	Approx. 30 whales in two pods, moving W	Mr. J. Lovrity, FMS.
" 26, 1975	6 miles W of Arctic Bio. Sta. Camp 69°32'30"N, 131°39	Approx. 150 whales	Dr. J. A. Percy, FMS
Aug. 17, 1975	69°06'N, 132°50'W	Approx. 50 whales	Mr. F. E. Stephenson, DOE, & Mr. P. Sorenson, Aklavik Flying Service

APPENDIX 6 - Page 2

Date	Location	Observation	Source
July 19, 1975	Arctic Bio. Sta. Camp, 69°35'N, 131°15'W	20-25 whales moving W	Mr. J. Lovrity, FMS
Aug. 5, 1975	Arctic. Bio. Sta. Camp	25-35 whales moving E	Mr. J. Walbridge, FMS
" 20, 1975	Arctic Bio. Sta. Camp	150-200 whales moving E	Mr. J. Walbridge, FMS
" 9, 1976	69°10'N, 132°30'W	Approx. 10 whales, possibly 2 were calves of unknown age	Mr. D. Wood & Mr. M. Wood, Canadian Hydrographic Service
Aug. 1 & 2/76	Sauniktook	Approx. 6 whales	Fraker, 1977
" 8, 1976	Sauniktook	Approx. 20 whales	Fraker, 1977

APPENDIX 7

LIMITATIONS ASSOCIATED WITH ESTIMATING WHITE WHALE NUMBERS

The environment of the Mackenzie estuary and the behaviour of the the animals imposes certain constraints on efforts to estimate numbers of white whales. The following discussion identifies some of the difficulties, and the approaches which have been used to cope with them :

1. The very turbid water allows only those animals at the surface to be counted; animals beneath the surface are completely invisible. Sergeant's (1973) observations at Churchill, Manitoba, indicated that whales spent about one-third of their time at the surface and two-thirds below. Therefore, Sergeant applied a visibility factor of 3, by which the number of animals seen during aerial survey is multiplied to obtain an estimate of the total in the area covered. This visibility factor assumes that the behaviour of the whales in the Mackenzie estuary is similar to that of the whales observed at Churchill, and that the observer views any given area for only an instant. The degree of similarity of behaviour between whales in the Mackenzie estuary and that at Churchill is unknown but, without information to the contrary, it is reasonable to assume that it is similar. In order to gain a maximum amount of information on both distribution and abundance, as large an area as feasible, instead of a narrow strip, will be viewed from the aircraft - as has been the standard method in our previous studies (e.g. Fraker, 1977). Depending on weather conditions, any given area is viewed for approximately 10 to 15 seconds. The greater the period of observation, the greater the tendency toward over-estimation of whale numbers. To compensate for this tendency, the standard visibility factor has been reduced from 3 to 2 (Fraker, 1977).

2. Weather conditions, especially wind and fog, can greatly influence the ability to see whales. Whitecaps on the water, created by wind, are

APPENDIX 7 - Page 2.

particularly distracting. Rough water may also affect the behaviour of whales, and their visibility. Glare from bright sun can limit the observation area. Low cloud and fog sometimes preclude surveying some areas. Population estimates will be limited to those days when weather conditions do not impose serious limitations.

Fraker, M. A., 1977. The 1976 White Whale Monitoring Program, Mackenzie Estuary, N.W.T., prepared for Imperial Oil Limited, Calgary, Canada by F. F. Slaney & Company, Limited, Vancouver, Canada. 73 pp.

Sergeant, D. E., 1973. Biology of White Whales (*Delphinapterus leucas*) in Western Hudson Bay. J. Fish Res. Bd. Canada. 30: 1065-1090 pp.