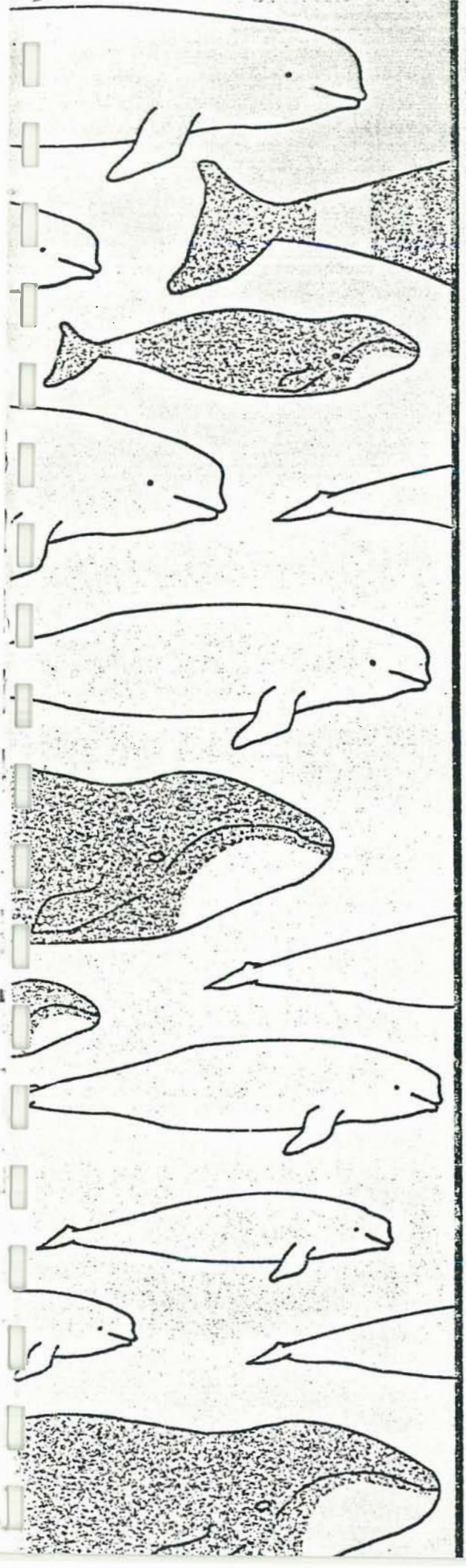

THE 1978 WHALE MONITORING PROGRAM MACKENZIE ESTUARY, N.W.T

A

ESSO RESOURCES CANADA LIMITED

Calgary, Alberta

DECEMBER 1978

F.F. SLANEY & COMPANY LIMITED

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ENVIRONMENTAL RESOURCE CONSULTANTS

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15 December 1978
File: VI846

Mr. George Greene
Esso Resources Canada Limited
500 - 6th Avenue S.W.
Calgary, Alberta
T2P 0S1

Dear Mr. Greene:

We take pleasure in submitting the report of *The 1978 Whale Monitoring Program, Mackenzie Estuary, N.W.T.*

This report presents the findings of the 1978 field research and an assessment of the effects upon white whales arising from Esso's 1978 summer offshore operations in the Mackenzie Estuary region. To date, on the basis of seven years of monitoring, there is no evidence that logistics traffic or the artificial islands have had any serious effects on whales or whale hunting.The information gathered will be of considerable value in understanding the implications of future offshore activities, and can aid in the environmentally sound design and scheduling of future operations.

We have appreciated working with you during this interesting and worthwhile project, and we extend our thanks for your helpful cooperation and that of Esso field personnel throughout the study.

Yours very truly,
F. F. SLANEY & COMPANY LIMITED

Mark A. Fraker
Biologist/Project Manager

Dr. Tarek Jandali
Regional Manager

THE 1978 WHALE MONITORING PROGRAM MACKENZIE ESTUARY, N.W.T.

by

MARK A. FRAKER

for

ESSO RESOURCES CANADA LIMITED
Calgary, Alberta

DECEMBER 1978

F.F. SLANEY & COMPANY LIMITED
VANCOUVER, BRITISH COLUMBIA, CANADA

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Many persons made important contributions to the success of the 1978 Whale Monitoring Program. Within Esso Resources Canada Limited, Mr. Tom Watmore, Mr. George Green, and Field Service personnel greatly aided the study by arranging camp accommodations and logistics. Mr. Jim Riley, Mr. Bill Fink, and Mr. Jim Fink encouraged the study and provided information about operations. Mr. Jim Gladstone forwarded whale sighting forms completed by industry personnel and provided logistical help. Pilots Tommy Gordon and Doug Mackinnon of Esso served both as pilots and observers on the offshore survey flights. We are grateful to the individuals who took time in the course of their work to record valuable observations of whales; these persons are identified where their observations are presented.

Mr. Andrew Erigaktoak of Aklavik, N.W.T., for the fourth year, served very ably as an observer on survey flights and provided liaison during visits to whaling camps. Pilot Dave Cotten of the Aklavik Flying Service was most helpful in flying the aerial surveys.

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The following F. F. Slaney Company Limited personnel contributed to this project: Ms. Carole Tizzard typed and helped assemble drafts of the report. Ms. Sharon Galenzoski drafted the maps and figures. Dr. Wayne Duval edited this report. Ms. Pamela Fraker conducted aerial surveys and collected biological data from harvested whales. Mr. Russel Fraker assisted with the collection of data from harvested whales.

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SUMMARY

Large numbers of white whales (*Delphinapterus leucas*) migrate to the Mackenzie River Estuary each summer where they are hunted by native persons from Aklavik, Inuvik, and Tuktoyaktuk. The whale hunt and resulting whale products play a very important role in the local culture and economy, and from the outset of hydrocarbon exploration in the Beaufort Sea, concern has been expressed about possible major adverse effects on this resource. In recognition of this concern, Essso Resources Canada Limited (formerly Imperial Oil Limited) has supported studies of white whales for the past seven years. A major focus of all studies has been to detect potential interference by exploration activities with whale movements and native hunting, and to communicate any concerns to Esso for immediate mitigative actions. Since 1976, as operations have moved further offshore, bowhead whales (*Balaena mysticetus*) have been included in the studies.

The arrival of white whales in the Mackenzie Estuary in 1978 was significantly affected by the late break-up of the landfast ice. The whales congregated offshore in West Mackenzie Bay in an area influenced by river water which was flowing beneath the ice. This observation supports the hypothesis that whales arriving in the Mackenzie region before break-up use the presence of river water to guide them to areas where the landfast ice barrier is likely to fracture early.

The whales were observed to gather offshore only in West Mackenzie Bay. As an apparent result, about 95% (6368) of the whales used the Niakunak concentration area in early July, while only 5% (236) used Kugmallit Bay. Subsequently, there appeared to be a movement from Niakunak to Kugmallit Bay, although the peak estimated number in Kugmallit Bay (about 800) was substantially lower than the peaks of approximately 2000 and 2500 estimated for 1977 and 1976, respectively. The total number of whales in the Estuary may be as high as 6000.

Surveys in late July revealed the presence of substantial numbers of white whales north of the Estuary in offshore waters of the Beaufort Sea. It is suspected that these whales were feeding in these waters or were moving to feeding areas, possibly near the edge of the permanent ice pack.

The total 1978 harvest in the Estuary was 121 which is low in comparison with the mean of 141.1 for the previous six years. This low harvest was attributed to generally windy weather which limited the number of days which were suitable for hunting. In Kugmallit Bay, the early departure of the whales, which itself may have been caused by disturbance from hunting activities, which were concentrated into four brief periods, further reduced the opportunities for hunting. In one case, the whales were observed making a mass

movement from the Hendrickson concentration area in apparent response to intensive hunting.

Island construction activities had no detectable effect on whale distribution or the pattern of use of the Estuary. Because of the current concentration of industrial activity and the relatively intensive hunting of whales in Kugmallit Bay, the potential for adverse effects on whales is greater there than elsewhere in the Mackenzie Estuary.

A smaller number of bowhead whales were observed in 1978 compared to 1976 and 1977. The reasons for this are unknown but may be related to the distribution of food organisms.

PART 1

THE 1978 WHALE MONITORING PROGRAM MACKENZIE ESTUARY, N.W.T.

1.1 INTRODUCTION

Large numbers of white whales (*Delphinapterus leucas)* migrate to the estuary of the Mackenzie River each summer. The period spent in the warm estuary is of key importance in their life history, and while they are there, the whales are hunted by Inuit from Aklavik, Inuvik, and Tuktoyaktuk. The whale hunt and resulting whale products are important to the local culture and economy, and from the outset of offshore exploration for oil and gas, concern has been expressed about possible adverse effects to white whales and whale hunting. In recognition of this concern, Esso Resources Canada Limited (formerly Imperial Oil Limited) has supported studies of white whales for the past seven years. Since 1976, as operations have moved further offshore, bowhead whales (*Balaena mysticetus)* have also been included in the studies.

This report presents and discusses the findings of the 1978 whale monitoring program. For a more general and comprehensive treatment of the biology of whales in the Beaufort Sea, the reader is referred to *The 1977 Whale Monitoring Program, Mackenzie Estuary, N.W.T.* (Fraker 1977b), and to Beaufort Sea Project Technical Report No. 4, *Bowhead and White Whales in the Southern Beaufort Sea*, (Fraker *et al.* 1978), both of which present relatively complete reviews of knowledge of both bowhead and white whales in the study region.

The study area lies immediately offshore of the outflow channels of the Mackenzie River (Map 1). Adjacent terrestrial areas are mainly of deltaic or glacial origin. The warm, fresh, turbid discharge water from the Mackenzie River strongly influence the character of the Estuary. Until recently, the region was relatively removed from human activity, except for native hunting, trapping, and fishing.

Because of the Mackenzie discharge, water throughout all but the most seaward areas is fresh in summer. The basic pattern of currents is determined by the river outflow which joins the eastward coastal flow resulting from the Coriolis force. This generally northeastward movement is sometimes temporarily modified by winds. Further offshore in the Beaufort Sea gyre, there is a wind-generated, clockwise circulation.

Esso's summer offshore exploration activities in the Mackenzie Estuary region centre around the construction and operation of artificial islands which are used as platforms for exploration drilling. Artificial island construction requires the use of dredges for excavating granular fill for the islands, and tugs, barges, and boats for transporting personnel, equipment, and materials. When the excavation site is distant from the island location, barges are required to transport the fill material; where the excavation site is adjacent to the island location, fill is pumped directly from the dredge. In some cases, the material comes from both near the site and from a distance.

Construction of the first artificial island, Immerk, began in summer 1972 and was finished the next year. Since Immerk, 14 other artificial islands have been constructed by Esso Resources Canada Limited (Map 1). In 1978, during the period when whales are numerous in the Estuary (late June through early August), activities of Esso centered around the construction of the base of Issungnak O-61, an artificial island located about 20 mi. (32 km) north of Pullen Island (Map 1).

Most of the material for Issungnak was excavated by the dredge *Beaver Mackenzie* operating near the site, although additional material was transported from Tuft Point where it was excavated by the dredge *Arctic Northern* (Map 1). Activities at Tuft Point commenced on 17 July and the *Beaver Mackenzie* was on location at the Issungnak site on 24 July 1978.

Personnel involved in these operations were housed in nearby camp barges (Map 1) and were transported to the work site by boat. There were also air and water logistics traffic between the barge camps, work sites, and base camp at Tuktoyaktuk.

1.2 PURPOSE

The main purposes of the 1978 whale monitoring program were to:

1. Document the distribution and abundance of white whales in the Mackenzie Estuary and the success of Inuit hunters in relation to Esso exploration activities and
2. Provide on-location advice to Esso supervisors regarding the concentrations and movements of white whales in relation to the timing and location of operations in order to minimize potential adverse effects on whales or whale hunting.

1.3 OBJECTIVES

The primary objectives of the 1978 study were to:

1. Monitor white whale movements and concentrations in the Mackenzie Estuary;
2. Prevent potential interactions between white whales and Esso offshore island-building and island clean-up activities through on-location advice;
3. Determine the Inuit utilization of white whales; and
4. Prevent potential interference with the hunt resulting from Esso activities.

Secondary objectives were to:

1. Expand the existing data base on white whales in the Mackenzie Estuary through continued estimation of whale numbers and observation of distribution and movements;
2. Gain additional insights into the biology of the whales in the Estuary through the collection of samples and measurements from animals harvested by hunters;
3. Document and describe encounters between industrial traffic and whales to gain a better understanding of the behavioural reactions of white whales to this type of disturbance.
4. Obtain additional information on the pattern and timing of white whale arrival and departure;
5. Study the effects of Inuit hunting on the distribution and behaviour of white whales;
6. Observe the distribution and abundance of white whales in offshore waters north of the Mackenzie Estuary study area; and
7. Document the occurrence and movements of bowhead whales in the Mackenzie Estuary region.

1.4 SCOPE OF WORK

The 1978 Esso whale study field program began on 21 June and continued to 13 August. Most of the investigation was focused on the white whales in Kugmallit Bay (Map 1), since the study was designed to intensively examine the main area of 1978 Esso operations. The movement of whales in relation to Esso activities was also monitored in the Tuft Point/Tuktoyaktuk Peninsula region. The whales in Niakunak Bay were studied to determine their distribution and abundance and their response to Inuit hunting. Bowhead and white whales were studied in waters north of the Mackenzie Estuary study area during four offshore surveys and from sightings made by industrial personnel.

The Mackenzie Estuary has been operationally defined, for the purpose of whale studies (Fraker 1976, 1977a, b.; Fraker *et al.* 1978, in prep.), as the area extending from the mouths of outflow channels to the outer perimeter of the area which has been included in regular, systematic surveys (Map 1). It does not coincide exactly with the area which would be defined biologically or oceanographically as an estuary, and it is used here as a convenient geographical term.

To facilitate the discussion of the whale data, the Mackenzie Estuary study area has been subdivided into six areas:

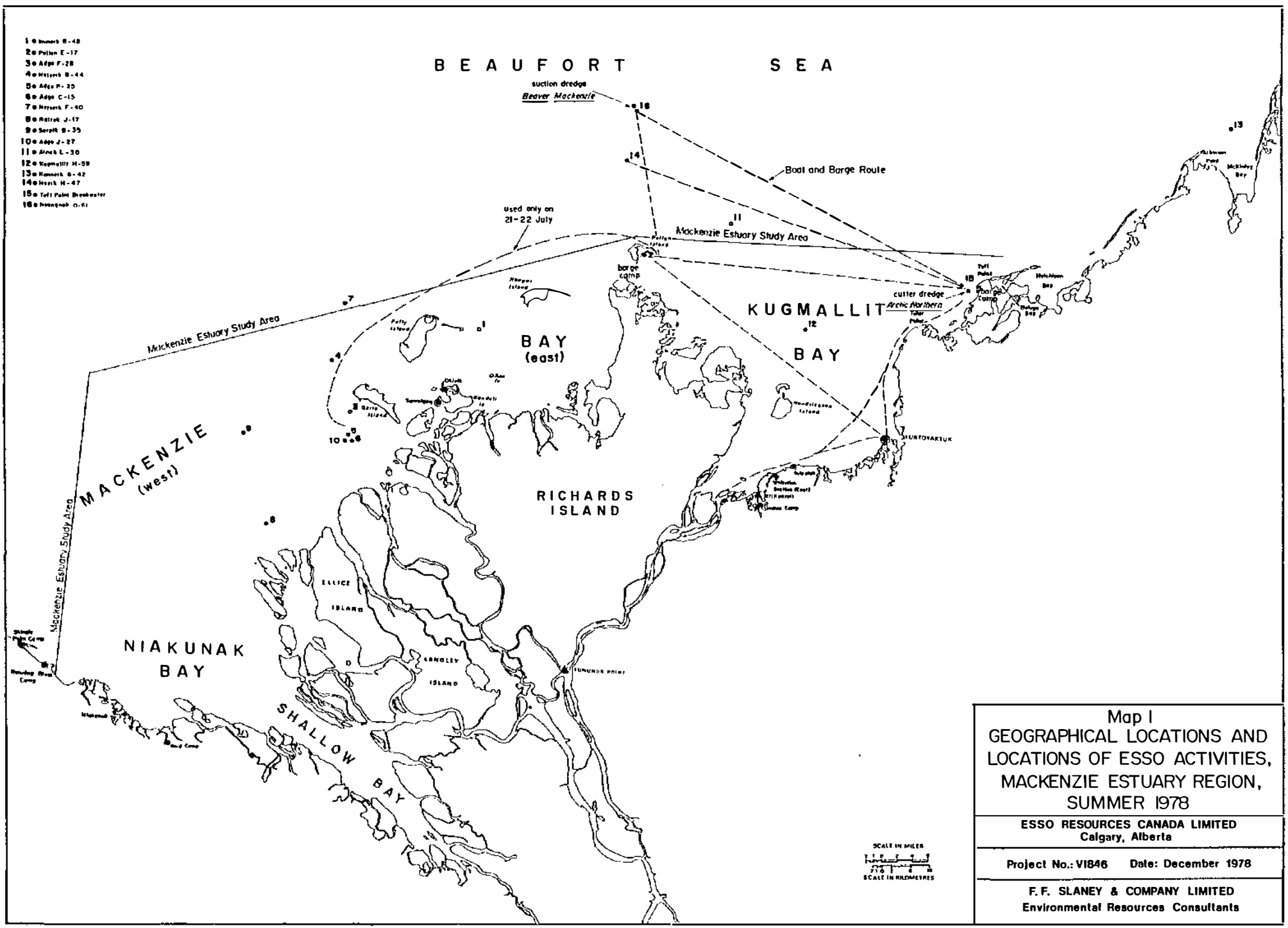
1. *Shallow Bay* — the seaward boundary being between the mouth of West Channel and the southern tip of the Olivier Islands;
2. *Niakunak Bay*[1] — the portion of West Mackenzie Bay lying north of Shallow Bay with the seaward boundary defined by a line running from Shingle Point to the outermost part of the Olivier Islands;
3. *West Mackenzie Bay* — the seaward boundary defined by the outer perimeter of the Estuary study area, the eastern boundary defined by Garry Island and a line running north of the western tip of Garry Island to the study area perimeter;
4. *East Mackenzie Bay* — mainly the area inside the Barrier Islands but extending to the study area perimeter;
5. *Barrier Islands* — Garry, Pelly, Hooper, and Pullen Islands; and
6. *Kugmallit Bay* — the seaward boundary extending approximately between Pullen Island and Warren Point.

In this report, frequent mention is made of results from previous years' studies, although the reports supporting these statements are not always cited. Results of the 1972 - 1974 seasons are described in Slaney (1973, 1974, and 1975, respectively) and results from 1975 - 1977 are described in Fraker (1976, 1977a, and 1977b, respectively).

1.5 METHODS

Methods used during the 1978 whale program were similar to those of previous years and included intensive systematic aerial surveys, reconnaissance aerial surveys, and frequent visits to hunting camps and the communities where hunters reside. A tape recorder was used to record survey data, and the tapes usually were transcribed shortly after each

[1]The name "Niakunak Bay" is not an officially recognized geographic name. For the purpose of this report, this bay has been delimited from West Mackenzie Bay because of its importance to whales and has been given the local Inuit name "Niakunak" (nee-AK-oo-nak), which refers specifically to the WestWhitefish Station locality. In Slaney reports prepared before 1977, this area was considered part of Shallow Bay.



Map I
GEOGRAPHICAL LOCATIONS AND LOCATIONS OF ESSO ACTIVITIES, MACKENZIE ESTUARY REGION, SUMMER 1978

ESSO RESOURCES CANADA LIMITED
Calgary, Alberta

Project No.: V1846 Date: December 1978

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flight. Biological data on whales were collected when possible. An Inuit observer, Andrew Erigaktoak, participated in the 1978 program by acting as a second observer on flights and providing liaison during camp visits. The study was carried out under a permit granted by the Fisheries and Marine Service.

1.5.1 Systematic Surveys

Systematic aerial surveys were designed to obtain data on the distribution, relative abundance, and movement pattern of white whales in Kugmallit and Niakunak Bays. Transect lines across the survey areas were established at two-mile[2] (3.2 km) intervals except for the "loop" extending into Shallow Bay (Map 2). A standard flight track was also established for the Tuft Point/Tuktoyaktuk Peninsula region (Map 2). This systematic survey pattern is the standard design used since 1976 in studies conducted for both Esso (Fraker 1977 a, b) and the federal Fisheries and Marine Service (Fraker *et al.* 1978, in prep.).

A float-equipped Cessna 185 aircraft was used for the whale surveys conducted in the Estuary. Flights were made as often as weather permitted, and as many transect lines as possible were flown on each occasion. An altitude of 1000 ft (305 m) and an airspeed of 120 mph (193 km/h) were maintained on all flights. Times were recorded to the closest 15 sec at the start and finish of each line and at landmarks along the way; total numbers of whales observed were recorded during each 15 sec interval so that sightings could be plotted to within approximately 0.5 mi. (0.8 km). The survey flights were timed so that the sun was either in front or behind the aircraft to minimize interference from glare on the water to observers looking out the sides. Observation conditions on each survey were rated according to the following scheme:

EXCELLENT: no glare or water disturbance to interfere with whale observations.

GOOD: small amount of glare and/or a few whitecaps which cause a minor amount of visual interference.

FAIR: glare and/or whitecaps which cause significant visual interference.

POOR: severe winds generate rough water; there may be glare, and air turbulence may interfere with both navigation and whale observation.

The visibility conditions which prevailed during each survey were taken into account in interpreting the results. Generally, estimates of numbers mentioned in the text derive from surveys conducted under excellent or good visibility conditions, unless otherwise noted. However, surveys flown under fair or poor conditions still provided valuable data on distribution, movement, and behaviour.

From an altitude of 1000 ft (305 m) it is possible to see whales up to two or three km away under favourable wind and light conditions. To keep the surveys consistent, only those whales within a 0.5 mi. (0.8 km) wide strip along either side of the aircraft were counted. In order to be able to confine counts to the 0.5 mi. (0.8 km) strip, the aircraft was flown over a 0.5 mi. (0.8 km) aircraft runway, and the struts were marked so that the projected area on the water viewed between the floats and the strut marks at 1000 ft (305 m) altitude was 0.5 mi. (0.8 km) wide.

The two observers, one on each side of the aircraft, used Seiko Liquid Quartz digital watches which were synchronized before each survey. Because the aircraft flew at an airspeed of 120 mph (192 km/h), approximately 0.5 mi. (0.8 km) was covered during each 15 sec. Cassette tape recorders were used to record the above data as well as observations on direction of movement and behaviour. Shortly after each survey the tapes were transcribed onto a standard form, and data on distribution, abundance, behaviour, and direction of travel were plotted onto individual maps for each survey.

Four systematic aerial surveys were also conducted north of the Mackenzie Estuary in offshore waters of the Beaufort Sea. North-south flight lines were located at five-mile (8 km) intervals from Hooper Island to Warren Point and extended approximately 40 mi. (64 km) into the Beaufort Sea to cover an area which had not previously been studied during the open-water period. These surveys were flown in a twin-engine DeHavilland Twin-Otter aircraft operating at altitudes of 1000 - 2000 ft (305 - 610 m) and an air speed of 140 kt (260 km/h).

1.5.2 Reconnaissance Surveys

Reconnaissance aerial surveys were used to answer questions about the presence or absence of whales in a given area, to concentrate attention on a particular area or activity, or to rapidly survey a large area where a systematic survey would have been impractical. These surveys were flown at altitudes of 1000 - 2000 ft (305 - 610 m).

1.5.3 Counting and Estimating Numbers of White Whales

Submerged white whales cannot be seen in the highly turbid water which usually occurs over most of the Mackenzie Estuary, and consequently, it is possible to count only those whales which are at the water's surface. An accurate estimate depends on knowing what proportion of the total number of

[2]Aircraft measurements, which are calibrated in the English system of measurement, were used for field measurements and thus, the resulting discussion is presented in English units with the metric conversion in parentheses.

whales in the area is at the surface; unfortunately this is not known.

Sergeant (1973) watched whales from a cliff near Churchill, Manitoba, and observed that they spent about one-third of the time at the surface, and thus he applied a visibility factor of three to his counts to arrive at an estimate of total numbers. Sergeant's visibility factor assumes that only an instantaneous count of whales in any given area is made. However, as the period of observation increases, a greater number of whales will be seen as they come to the surface. If the counts had been restricted in the present study to a narrow band across the transect strip, which would have approximated an instantaneous count, whales would have been recorded as absent from areas where they occurred in low density. This procedure would have been unacceptable because distribution was just as important as abundance in this study. By viewing objects while flying over land under survey conditions, Fraker (1976) determined that any given point is in view for about 15 sec under the standard observation technique used in the present and previous studies (Fraker 1976, 1977a, b; Fraker *et al.* 1978, in prep.). To compensate for the fact that the assumption of an instantaneous count of whales was not met, the visibility factor was reduced from three to two, and this factor has been applied consistently in whale studies in this area since 1975 (Fraker 1976, 1977 a, b). Although this factor probably results in conservative estimates of total whale numbers, it must be emphasized that the resulting figures should be treated as relative indices rather than estimates of absolute abundance. The most important feature of such surveys is that the methods be consistent so that results are comparable within and between years.

The transect lines in Kugmallit and Niakunak Bays are two miles (3.2 km) apart, and because the two observers, one on each side of the aircraft, survey 0.5 mi. (0.8 km) wide strips, one-half of the water surface area is viewed on each survey. Therefore, an extrapolation coefficient of two is applied to the survey results to allow for the whales which are assumed to be present in the remaining one-half of the area which was not actually viewed.

1.5.4 Camp Visitations

Whaling camps were visited frequently to monitor hunting effort and success and to detect possible interference by exploration activities.

1.5.5 Biological Data Collection

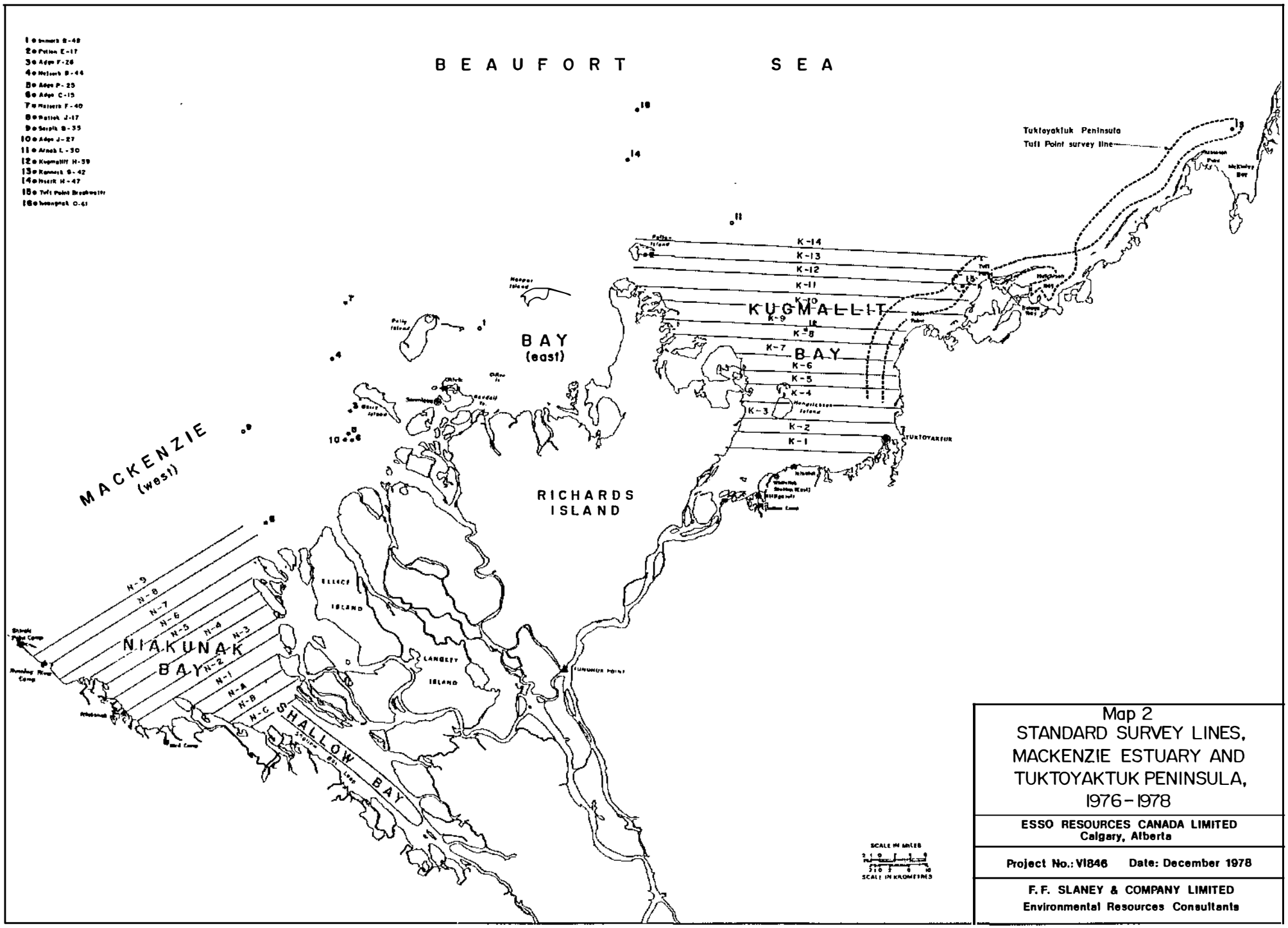
Occasionally, it was possible to obtain samples and measurements from whale carcasses. Because butchering occurs promptly after the kill, only a few carcasses can be examined. In many cases, even a minimal set of observations (consisting of total length, sex, and tooth samples) was difficult to obtain. Length was measured in a straight line from the tip of the snout to the tail notch. Stomach contents were examined in the field, and teeth collected in 1978 have been stored for future age determinations, if required.

1.5.6 Study of Spring Ice Conditions

The movement of white whales to the Mackenzie Estuary region were studied in relation to ice conditions. Images from the NOAA-5 (U.S. National Oceanic and Atmospheric Administration) satellite were used to examine temporal changes in ice cover within the southern Beaufort Sea.

1.5.7 Observations by Industry Personnel

Important observations were made by various persons operating on boats and aircraft in the region. These observations were recorded on standard forms and were submitted at the end of the field season. Data recorded included species and numbers of whales, location, date and time, direction of movement, distance from and reaction to vessels, and remarks on feeding or other behaviour.



Map 2
STANDARD SURVEY LINES, MACKENZIE ESTUARY AND TUKTOYAKTUK PENINSULA, 1976 - 1978

ESSO RESOURCES CANADA LIMITED
Calgary, Alberta

Project No.: V1846 Date: December 1978

F. F. SLANEY & COMPANY LIMITED
Environmental Resources Consultants

PART 2

WHITE WHALE MOVEMENTS, DISTRIBUTION ABUNDANCE, AND BIOLOGY

2.1 WHITE WHALE MOVEMENTS AND DISTRIBUTION

2.1.1 Spring Migration and Arrival of the Whales at the Mackenzie Estuary

The movement of the white whales to the Mackenzie region and their entry into the Estuary in 1978 was consistent with the basic pattern described previously (Fraker 1977b, in prep.). However, ice conditions and break-up in the Mackenzie region were substantially different from those seen in other years. The apparent result was a significant difference in details of the distribution and movement of the white whales within the Estuary.

In mid-June 1978, as in previous years (Fraker 1977 b, in prep.; Fraker *et al.* 1978), white whales were concentrated in Amundsen Gulf (Andriashek and Calvert, pers. comm.). On 25 June, when the first survey of this study was flown, eight whales were seen moving south-westward along the edge of the landfast ice northwest of Garry Island, and six were seen moving southeastward amongst large pans of ice north of the landfast ice along the Yukon coast. Although fog precluded surveying further east, more whales were probably moving toward the Estuary from Amundsen Gulf at this time. On 26 June, only a small number of whales again were seen northwest and west of Garry Island and three whales were seen proceeding west along the ice edge north of Pullen Island. Probably many more whales were in this area at this time, but their location is not known. The possibility that the whales were near large ice floes or nearer the edge of the transition zone ice (Marko 1975) was investigated briefly, but this could not be substantiated.

In contrast to the usual late-June situation, when there is a large open lead north of Kugmallit Bay and the Tuktoyaktuk Peninsula, in 1978 the transition zone ice had been forced against the landfast ice east of Pullen Island (Photo 1). The sighting on 26 June of a group of three white whales emerging from beneath the ice north of Pullen Island was significant because they had just come from the east where there was 7/8 ice cover. Thus the whales do not require this open nearshore lead in order to successfully travel from Amundsen Gulf. Over 100 whales were seen on 29 June (Map 3). Most of these were west of Garry Island, and many north of the Barrier Islands were moving westward. Two larger, stationary groups were seen in openings in the 7+/8 transition-zone ice north of Kugmallit Bay, further confirming that the whales indeed were travelling through this ice-congested area (Photo 2).

The landfast ice in West Mackenzie Bay decayed much more quickly than did that in Kugmallit Bay (Photo 1, 3). Thus in late June, when considerable amounts of turbid Mackenzie River water were flowing beneath the landfast ice in West Mackenzie Bay, none was flowing under the landfast ice in Kugmallit Bay. An apparent consequence of this was that the whales migrating to the Estuary gathered in relatively large numbers in West Mackenzie Bay in the region where the river water was flowing out from beneath the landfast ice, but none congregated north of Kugmallit Bay. Normally the whales arrive near the Estuary after the landfast ice has fractured, but a pattern similar to that seen this year was also observed in 1973 (Slaney 1974). However, river water flowing from under the ice was apparent at two locations in 1973, one in West Mackenzie Bay and one north of Kugmallit Bay, and whales congregated in both areas (Fraker in prep; Fraker *et al.* 1977; Slaney 1974). Thus, as suggested by Fraker (1977 b, in prep.), it appears that whales, arriving in the Estuary region before the landfast ice breaks, congregate in areas where river water is present offshore of the ice. It is likely that the ice at these locations will fracture first and provide the earliest access to the Estuary. This hypothesis is supported by the observation this year that the whales gathered only in West Mackenzie Bay, the sole area offshore of the landfast ice where there was river water present.

On 5 July, very strong southerly winds served to increase the rate of erosion of the landfast ice in West Mackenzie Bay, and on the morning of 6 July, whales were seen entering the Estuary through two large fractures near the area where the whales had been previously congregating (Photo 3). Large numbers of whales rapidly moved into Niakunak Bay, and nearly 3800 were estimated to be present there on 7 July (Fig. 1, Table 1).

Conditions in Kugmallit Bay were in striking contrast to those in Niakunak Bay. In early July ice extended for approximately 40 km from near Hendrickson Island to the edge of the landfast ice (Photo 1). On 5 July, an ice-breaking tug operated by Canadian Marine Drilling Ltd. succeeded in breaking a path through the ice from Kugmallit Bay to the outer edge of the landfast ice. But on 8 July there was only an estimated 236 whales in Kugmallit Bay - only about

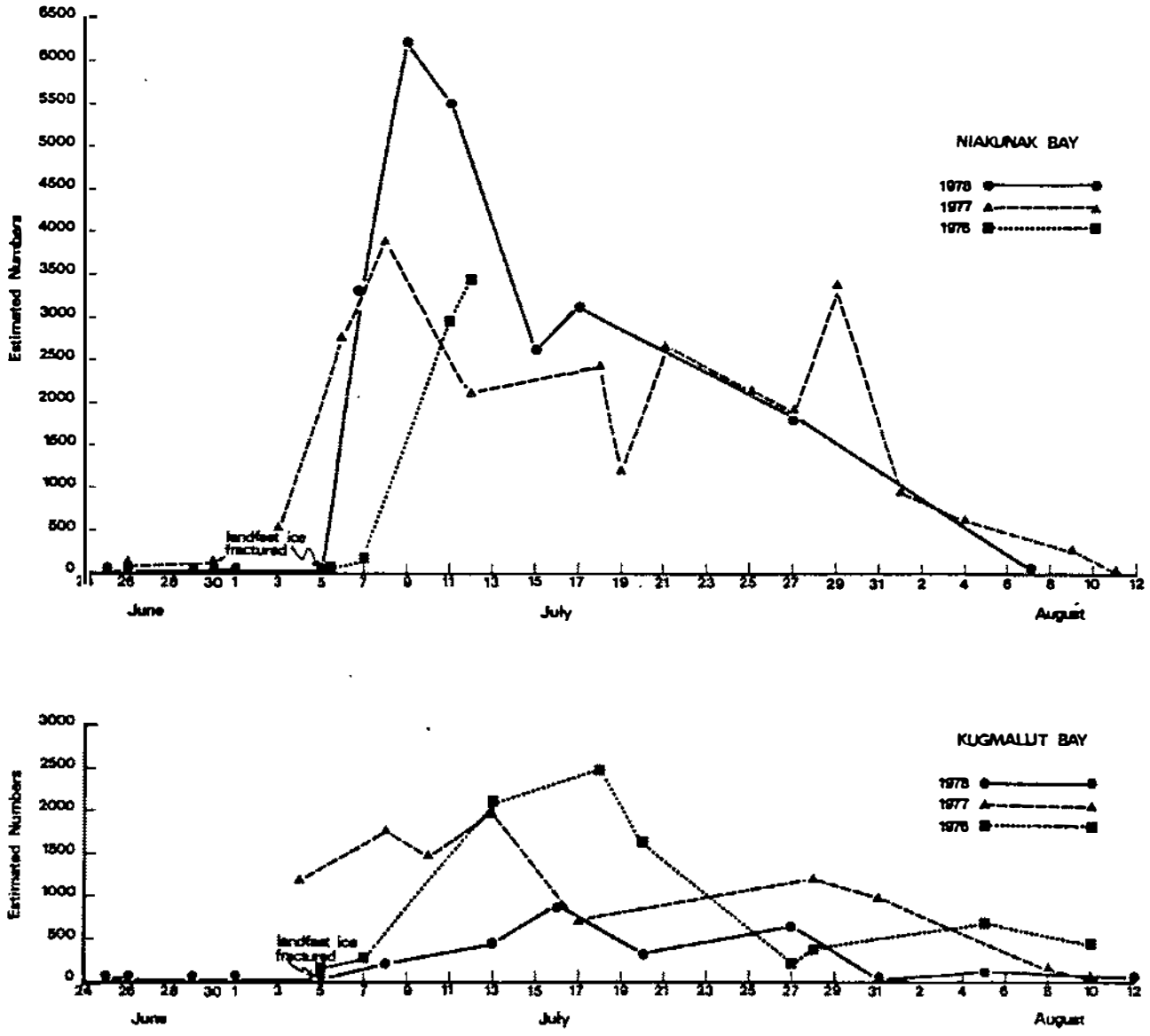


Figure 1.

Seasonal changes in abundance of white whales in Niakunak and Kugmallit Bays, 1976-1978.

five percent of the estimated total number in the Estuary at that time (Fig. 1; Table 1). Normally at this point in the season, large numbers of whales can be expected in both locations. For example, in 1977, on 8 July there was an estimated 3820 (69%) whales in Niakunak Bay (Fraker *et al.* in prep.) and 1748 (31%) in Kugmallit Bay (Fraker 1977b). This unusual distribution pattern seems to have been caused by an abnormally large amount of landfast ice in and north of Kugmallit Bay which prevented Mackenzie River water from reaching the Beaufort Sea, and thus no whales gathered in this area.

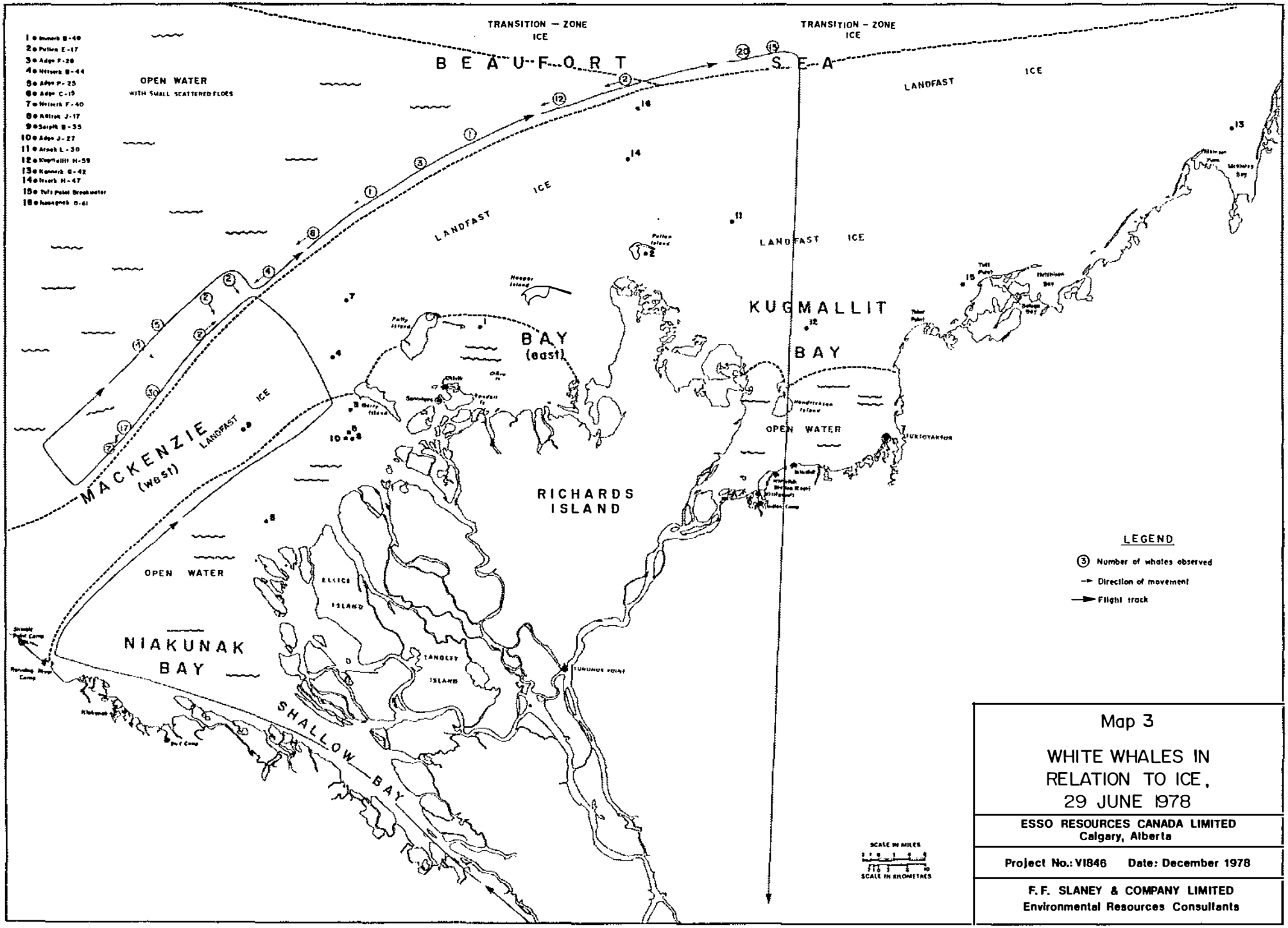
2.1.2 Distribution and Abundance of Whales within the Mackenzie Estuary

2.1.2.1 Niakunak Bay

The pattern of increase in whale abundance within Niakunak Bay in 1978 was similar to that seen in 1976 and 1977 (Fig.1). However, this year the estimated numbers grew to nearly 6400 - more than had previously been estimated for this area or even the entire Estuary. It is very unlikely that this increased estimate reflects any significant change in

Photo 1.
NOAA satellite image of ice conditions in the Mackenzie Estuary region of the southern Beaufort Sea, 30 June 1978. Note the large extent of ice in and north of Kugmallit Bay (approx. 45 km) compared to that in West Mackenzie Bay (approx. 10 km). At the time of the photo, turbid river water could be seen flowing out from beneath the landfast ice in West Mackenzie Bay but not north of Kugmallit Bay. In late June 1978, whales congregated offshore of West Mackenzie Bay but not offshore Kugmallit Bay; in contrast, in 1973 whales congregated in both areas.

Photo 2.
Transition-zone ice north of Kugmallit Bay, 29 June 1978. Instead of the usual lead extending along the Tuktoyaktuk Peninsula, transition-zone ice was forced southward against the landfast ice. Whales were observed moving through this area of 7+/8 ice.



Map 3

WHITE WHALES IN RELATION TO ICE, 29 JUNE 1978

ESSO RESOURCES CANADA LIMITED
Calgary, Alberta

Project No.: V1846 Date: December 1978

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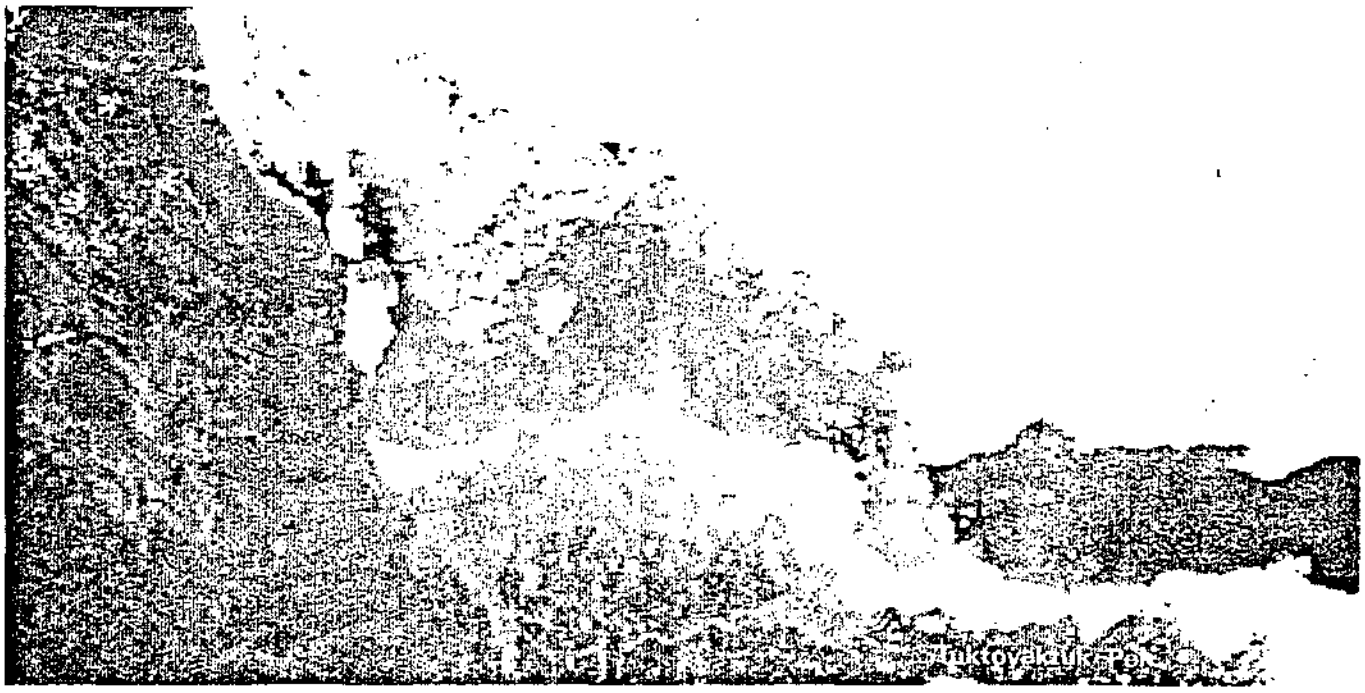


Photo 3.
NOAA satellite image of ice conditions in the Mackenzie Estuary region of the southern Beaufort Sea, 5 July 1978. The barrier of landfast ice in West Mackenzie Bay has fractured, allowing whales to enter the Estuary. North of Kugmallit Bay, a large piece of landfast ice has broken away and turbid water can be seen beyond the north edge. The ice in Kugmallit Bay broke-up later on 5 or 6 July.

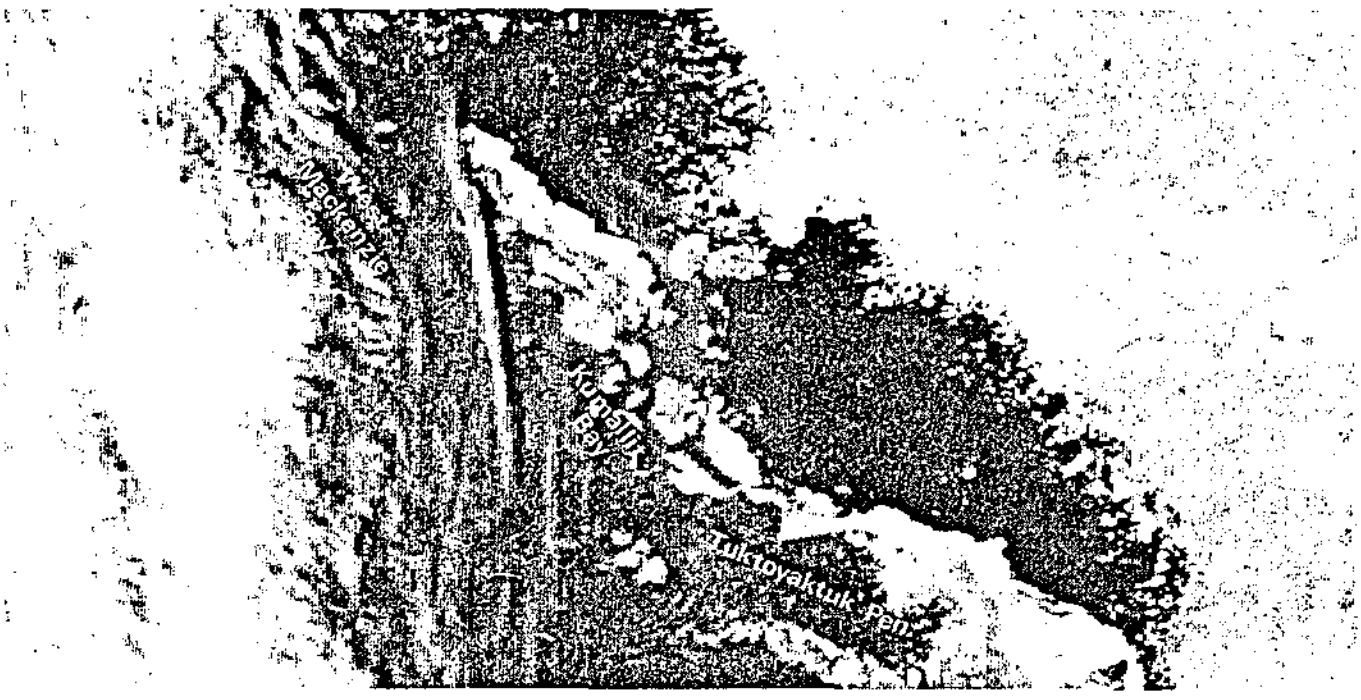


Photo 4.
NOAA satellite image of ice conditions in the Mackenzie Estuary region of the southern Beaufort Sea, 10 July 1978. On this date, ice still congested the waters near Pullen and northern Richards Island. Whales were first observed moving through East Mackenzie Bay and into Kugmallit Bay on 13 July, although small numbers were observed in Kugmallit Bay on 8 July.

Table 1. Summary of systematic whale surveys in Kugmallit and Niakunak Bays, 1978.

Kugmallit Bay

Date	Lines Flown	Observation Conditions	Whales Observed	Extrapolation Coefficient	Visibility Factor	Estimated Numbers
25 June	reconnaissance	Good	0	-	-	0
26 June	reconnaissance	Good	0	-	-	0
29 June	reconnaissance	Good	0	-	-	0
1 July	reconnaissance	Good	0	-	-	0
8 July	K1-K8	Good K1-K7 Excellent K8	59	2	2	236
12 July	K1-K5	Poor	43	2	2	172
13 July	K1-K7	Fair K1, K4-K7 Good K2-K3	105	2	2	420
16 July	K1-K10	Good	195	2	2	780
20 July	K1-K10	Good	73	2	2	292
24 July	K1-K7	Fair	75	2	2	300
27 July	K1-K13	Excellent	157	2	2	628
30 July	K1-K4	Poor	0	2	2	0
31 July	K1-K8	Good	0	2	2	0
3 August	K1-K12	Good	32	2	2	128
5 August	K1-K13	Good K1-K6 Fair K7-K9 Poor K10-K13	28	2	2	112
12 August	K1-K14	Excellent K1-K8 Good K9-K14	30	2	2	120

abundance of whales in the Estuary. Instead there may have been a difference in the behaviour of the whales at the time of the survey (9 July) as well as an extraordinary distribution with about 95% of the whales in Niakunak Bay.

After the initial period of very high numbers, there was a decline after which both the numbers and the temporal pattern of change approximated those seen in 1977 (Fig. 1). There may have been periods when the whales moved out of Niakunak Bay and sub sequently returned (Fraker 1976, 1977 b; Fraker *et al.* in prep.), but the 1978 survey coverage of this area was insufficient to describe the numerical changes in detail (Table 1).

An extraordinarily dense concentration of whales occupied the western half of Shoalwater Bay from early on 7 July to late on 8 July (Map 4, Photo 5). Mr. Jacob Archie (pers. comm.), who regularly hunts

Table 1, Continued

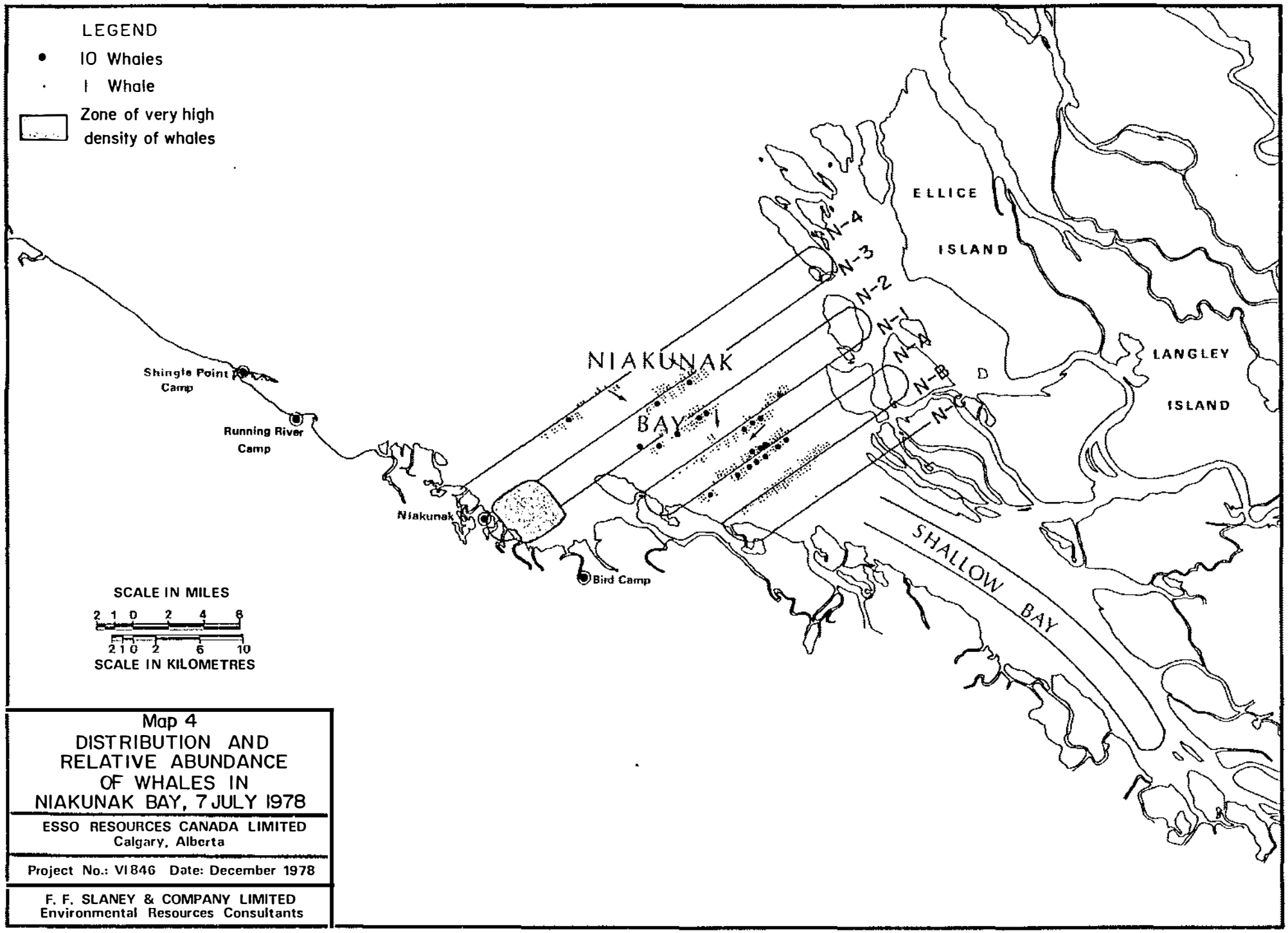
Niakunak Bay

Date	Lines Flown	Observation Conditions	Whales Observed	Extrapolation Coefficient	Visibility Factor	Estimated Numbers
25 June	reconnaissance	Good	0	-	-	0
26 June	reconnaissance	Good	0	-	-	0
29 June	reconnaissance	Good	0	-	-	0
30 June	SB Loop-N8	Good	0	2	2	0
1 July	SB Loop-N7	Good	0	2	2	0
7 July (I)	SB Loop-N8	Good	625 est. 1250[1]	2 0	2 0	2500 1250 2750[1]
7 July (II)	SB Loop-N4	Excellent	632 est. 1250[1]	2 0	2 0	2528 1250[1] 3778
9 July	SB Loop-N9	Good	1592	2	2	6368
11 July	SB Loop-N9	Good	1381	2	2	5520
15 July	SB Loop-N9	Excellent SB Loop-NA Good NB-N9	671	2	2	2684
17 July	SB Loop-N10	Excellent SB Loop-N2 Good N3-N10	799	2	2	3196
27 July	SB Loop-N6	Good	449	2	2	1796
1 August	SB Loop-N8	Fair	48	2	2	192
7 August	SB Loop-N9	Excellent SB Loop-N3 Good N4-N9	30	2	2	120

[1]On 7 July 1978 the whales in the western half of Shoalwater Bay were too densely congregated to be counted accurately. A visual estimate of 1000 - 1500 was made, and a working figure of 1250 has been used.

whales in this region said that he had seen a similar concentration in this area six years previously (1972), and the maps in Slaney (1973) also indicate that a concentration of whales was present in Shoalwater Bay during early July of that year.

The areal extent of the Niakunak concentration area as seen in 1978 (Map 5) was within the bounds described previously (Fraker 1977 a, b; Fraker *et al.* in prep.). Unlike the pattern seen in 1977, when the first whales in Niakunak Bay occupied only a very small small area, in 1978 they used most of the bay (Map 4). Possibly this year, because of the late date of arrival of the whales, the water in the concentration area



Map 4
DISTRIBUTION AND RELATIVE ABUNDANCE OF WHALES IN NIAKUNAK BAY, 7 JULY 1978

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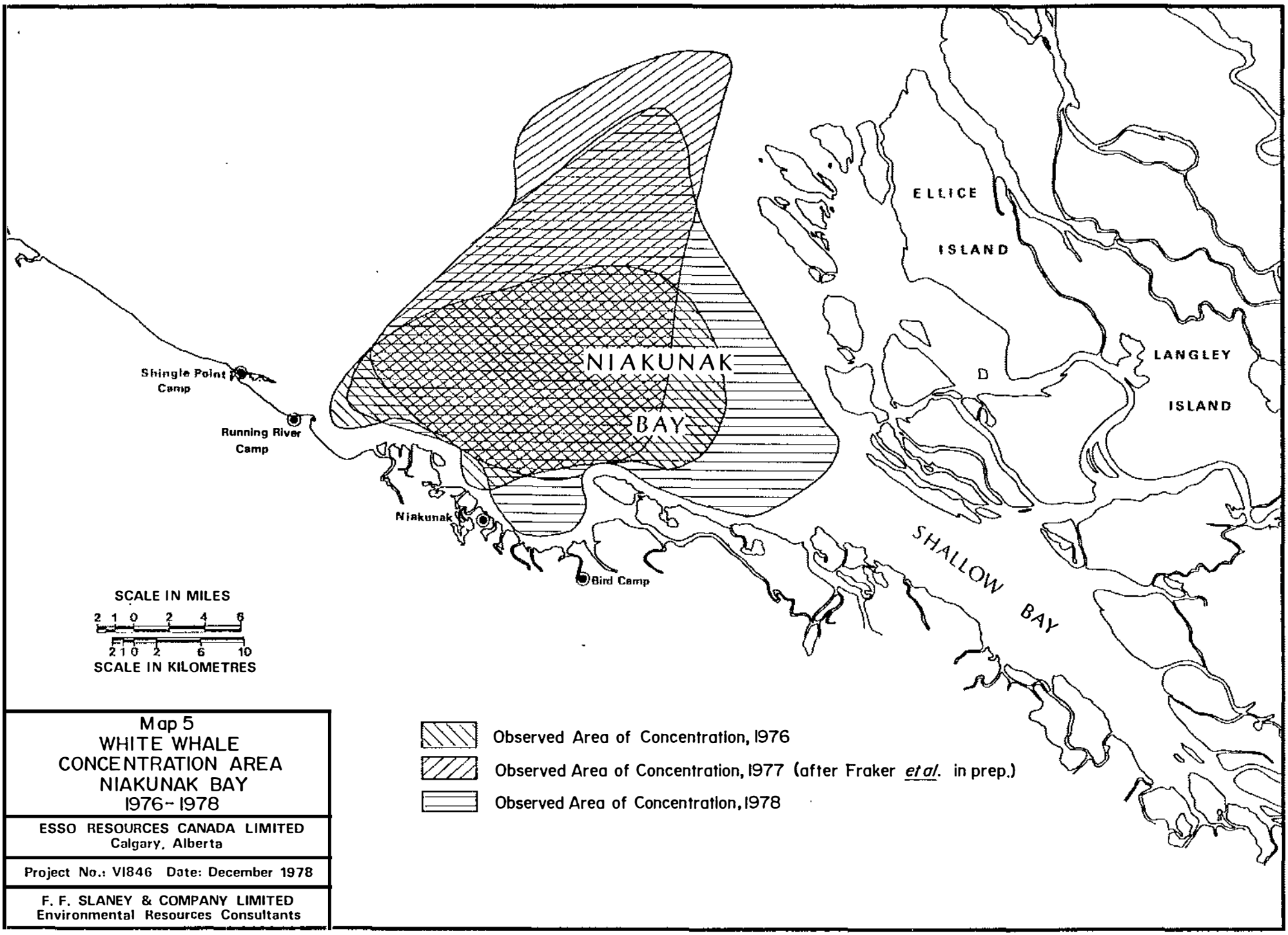

Map 5
WHITE WHALE
CONCENTRATION AREA
NIAKUNAK BAY
1976-1978

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may have been generally warmer than it was in 1977, and the whales may have found suitable conditions over a broader area.

2.1.2.2. Kugmallit Bay

In contrast to 1976 and 1977, the number of whales in Kugmallit Bay this year increased slowly and failed to attain normal levels of abundance (Fig. 1, Table 1). On 8 July, three days after the landfast ice barrier had been breached there was only an estimated 236 whales there. Four days later the estimated number was 172. Although the observation conditions on 12 July were poor, it was clear that there were not large numbers of whales in Kugmallit Bay. Although Kugmallit Bay was open to the Beaufort Sea, landfast ice blocked access from East Mackenzie Bay until about 12 July (Photo 4), and thus it appears that few whales entered Kugmallit Bay directly from offshore. On 13 July a systematic survey revealed an increasing number of whales in the Hendrickson Island area and a reconnaissance survey that day revealed an apparent movement of whales through West and East Mackenzie Bays toward Kugmallit Bay (Map 6). Because no whales were seen seaward of Garry or Hooper Islands, the whales appeared to have passed landward of these two islands. Eastward-moving whales were again seen in the Hooper and Pullen areas on 16 July. Whale numbers in Kugmallit Bay continued to increase slowly, during the first half of July. A peak estimate of 780 was recorded on 16 July (Table 1), but this is less than half the peak estimates of 1976 and 1977 (Fig. 1).

The number of whales in Kugmallit Bay remained at a moderate level until the end of July when numbers dropped nearly to zero (Table 1, Fig. 1). Consequently in 1978, the number of whales in Kugmallit Bay amounted to only about 50% of the levels reported in 1976 and 1977. As well, the whales vacated this area about 7-10 days earlier than in previous years (Fig. 1). The low numbers can be most readily explained by the apparent influence of early ice conditions, while the early departure will be discussed in section 2.1.2.3.

The distribution of the whales in Kugmallit Bay was within the spatial pattern previously described (Fraker 1977 b), and there was no change in the interpretation of the use or in the areal extent of high-use areas (Map 7).

The apparent movement of whales from Niakunak Bay to Kugmallit Bay poses several questions about the factors which govern the way in which the whales distribute themselves within the Mackenzie Estuary. It is not known whether there is a tendency for whales to return to the same concentration area year after year, but possibly the movement of animals from Niakunak to Kugmallit Bay is a manifestation of some degree of site fidelity. A further possible indication of site fidelity was seen in 1972 when it appeared that all of the whales which used Kugmallit Bay came from Niakunak Bay in mid-June, after the ice in the Pullen Island area broke-up (Slaney 1973). Alternatively, the whales which left Niakunak Bay may have been responding to social pressure associated with a high density of whales. The individuals which departed Niakunak Bay might also have been those which were most affected by disturbance from hunting. Further research is necessary to understand the factors which can affect the distribution and movement of these animals.

2.1.2.3. Response of White Whales to Hunting

It has been apparent for some years that white whales react to the activities of the hunters, but detailed observations of the whales' behaviour under these circumstances have been beyond the scope of previous studies. However, in 1978 an effort was made to describe the behaviour and reaction of whales being pursued by hunters.

In Niakunak Bay, hunting commenced shortly after the first whales arrived, and the hunters took advantage of the extraordinarily dense aggregation of whales in the western half of Shoalwater Bay (Map 4, Photo 5). Three hunting parties went out on 7 July and secured four whales. The first hunt took place in the morning, and the second in the evening between 2130 and 2200 hr. Observations were made only during the evening period.

The high density of whales was present in the evening as it had been in the morning, and the hunters were able to quickly locate a suitable whale to pursue (Photo 6). Whales within 0.5 mi. (0.8 km) responded to the disturbance by moving away from the hunters, but whales beyond that distance were not visibly disturbed. Fraker (1977 a) made detailed observations of the response of whales to tug boat with a barge tow which passed through Niakunak Bay in the first half of July 1976. Whales up to 1.5 mi. (2.4 km) responded by moving away from the barge tow. The reasons for the lesser response of the whales to hunting activity may owe to the smaller amount of sound produced by the outboard motors of the hunting boats compared to that produced by larger engines of the tugs.

The whales in the exceptionally dense aggregation were subjected to hunting disturbance twice on 7 July without any large-scale effects; only the whales within 0.5 mi. (0.8 km) responded noticeably, albeit vigourously. However, the aggregation was no longer present a day later (at 2300 hr on 8 July) when a reconnaissance flight was flown to investigate the aggregation. One of the residents of Bird Camp put the time of departure of these whales at an hour or two before the reconnaissance flight (2100 to 2200

hr). The role of the disturbance from hunting in the departure of the whales from Shoalwater Bay is not clear. However, it is apparent that the whales accommodated some hunting disturbance without vacating the area.

In the Hendrickson Island area of Kugmallit Bay, hunting did not commence until late on 16 July because of strong winds before this date (Fig. 2). These winds persisted throughout July and restricted the opportunities when whale hunting could be undertaken. The largest number of whale kills, and therefore the greatest amount of hunting effort[3] was concentrated in four periods: 17 July, 22 July, 24 July, and 27 - 29 July. Although there are no firm data on the temporal pattern of hunting in previous years, the activity in 1978 was certainly concentrated into fewer days than normal.

Detailed observations of the general response of whales to hunting activities in Kugmallit Bay were made on 22 July. An abbreviated systematic survey of the area near Hendrickson Island was conducted between 1112 and 1150 hr (Map 11), and less than 200 whales were estimated to be in this area. However, there were very large numbers of whales north of the surveyed area. Five parties of hunters (probably from Tuktoyaktuk) were present in the area during the survey period, and some hunting had taken place earlier. The total whale kill on 22 July is known to have been at least 10 (Fig. 2).

A group of at least 400 whales could be seen moving rapidly north-westward, away from the concentration area, and several smaller groups of whales were observed headed westward near Hooper and Pullen Islands.

Mr. Vince Steen (pers. comm.) of the boat *Pressure Ridge* noted that substantial numbers had moved past the Pullen Island area during the morning of 22 July, and he suggested that this probably was a response to disturbance from hunting. Mr. Bill Fink also observed part of this movement away from Kugmallit Bay (Table 2). The movement of white whales out of Kugmallit Bay on 22 July was almost certainly a response to disturbance from hunting in the concentration area near Hendrickson Island.

While most whales were moving away from the Hendrickson Island area, some were heading in at the same time. Two groups of about 100 and another of 20 were headed southwestward (Map 8). Whether these whales had earlier left the area because of disturbance and were subsequently returning, or whether they were arriving from outside the Estuary is unknown.

There was an early decline in the number of whales in Kugmallit Bay in 1978, compared with 1976 and 1977 (Fig. 1). This early disappearance may have been a result of the episodes of concentrated hunting which may have caused greater disturbance to the whales than is usual. This hypothesis requires testing with data from future studies.

In most years, there is probably a peak of about 2,000 whales in the Hendrickson area, but in 1978 the peak estimate was less than 800 (Fig. 1). Approximately 10% (81) of this number were landed by hunters, and based on loss rates from other years, (Fraker 1977 b), an additional 20 - 27 whales were probably lost during hunting. In contrast, in Niakunak Bay fewer hunters took only 30 whales from a population which may have peaked at approximately 6000. Thus, the total kill in Niakunak Bay, including losses, may have been on the order of only one percent of the whales there.

The whales in Kugmallit Bay are probably subjected to much more disturbance from hunting in most years than are those in Niakunak Bay. There are three main reasons for this: First, the whales are hunted throughout all of the Hendrickson concentration area. The Niakunak Bay concentration area is much larger and less sheltered, and the hunters can safely hunt only part of it (Fraker 1977; Fraker *et al.* 1978). Thus whales in Niakunak Bay may be able to find a disturbance-free area while those near Hendrickson Island may often be forced to flee outside of the concentration area in order to avoid disturbance. Second, the whales in this area are pursued by hunters from both Kugmallit Bay camps and from Tuktoyaktuk. Over the past seven years an average of about 100 whales has been taken from this area - nearly three-quarters of the total harvest in the Estuary while only about one-fifth of the harvest is taken from Niakunak Bay (see Part 3). Third, typically there are one-and-a-half to two times as many whales in Niakunak Bay as there are in Kugmallit Bay. Thus, because there are fewer whales, and a larger number of hunters operating throughout the entire Hendrickson concentration area, the whales in Kugmallit Bay are probably subject to a greater amount of disturbance from hunting than are those in Niakunak Bay.

2.1.3 Distribution of White Whales Outside of the Mackenzie Estuary

The summer movements and distribution of white whales outside of the Mackenzie Estuary are very poorly known, and an objective of the 1978 whale monitoring program was to increase the data available from this previously unsurveyed region. Offshore surveys were flown on 26 and 29 July and on 2 and 8 August. Substantial numbers of whales

[3] The number of whale kills and the amount of disturbance to which the whales are subjected are assumed to be directly related. While this relationship may be oversimplified, it is probably largely correct.

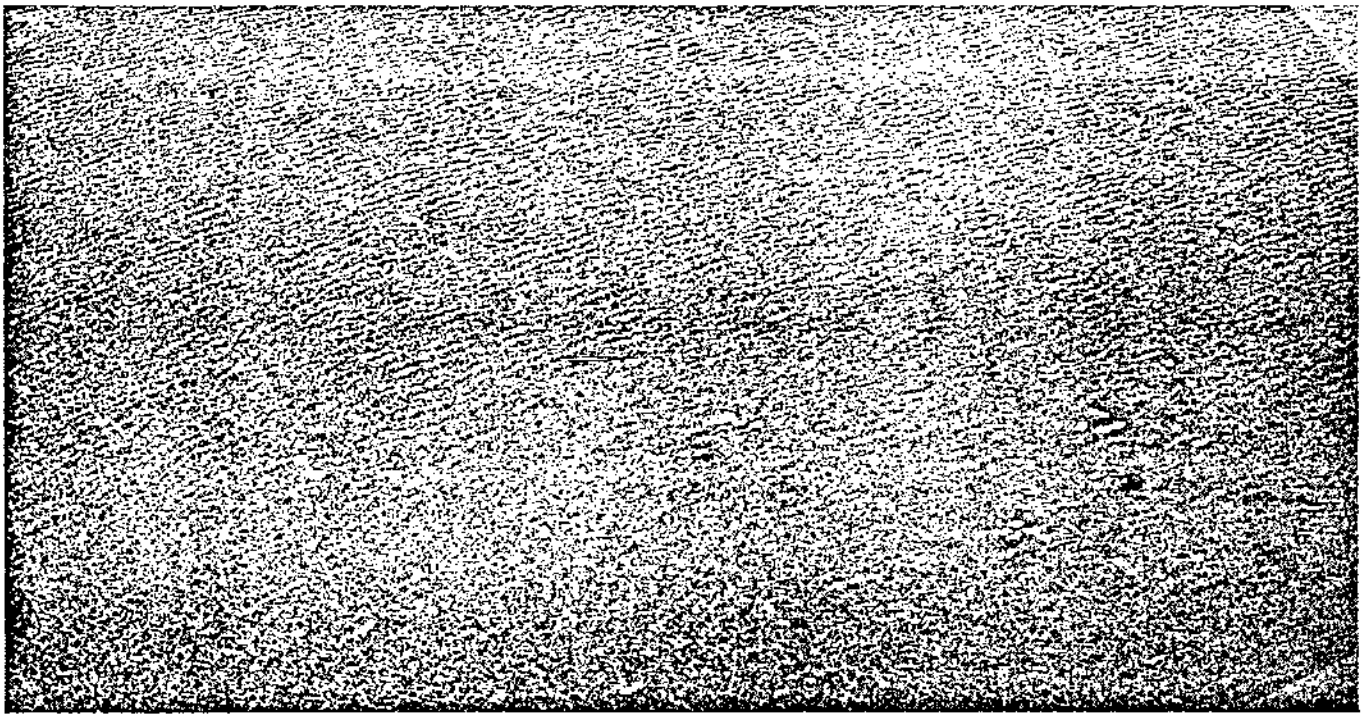


Photo 5.
An extraordinarily dense concentration of whales, Niakunak Bay, 7 July 1978. This grouping of whales was present from early on 7 July to late on 8 July. Calves, which were not present on the morning of 7 July, were common by evening.

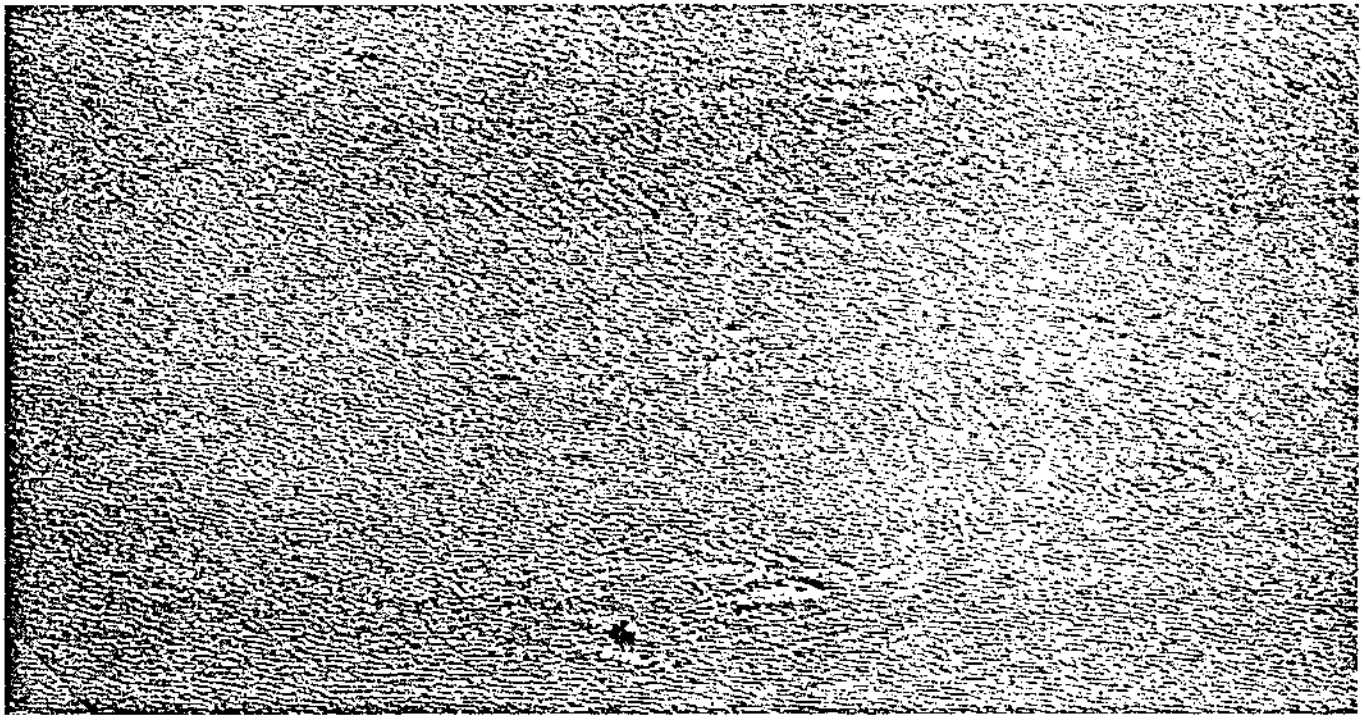
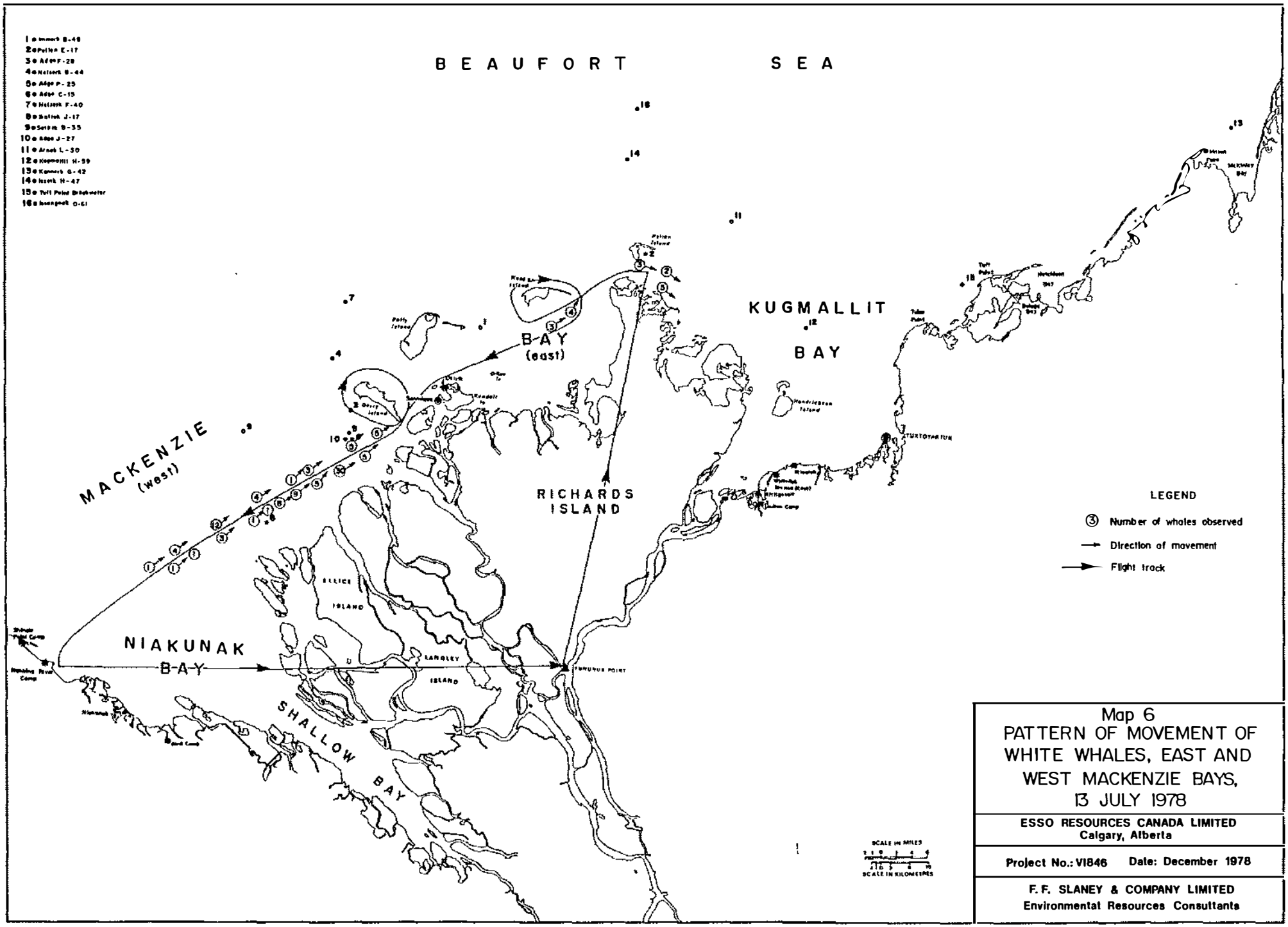


Photo 6.
Whales being pursued by hunters in boats, Niakunak Bay, 7 July 1978. The hunters are following two or three whales while another three or four can be seen nearby. A larger number of whales can be seen in the background moving away from the source of the disturbance.



Map 6
PATTERN OF MOVEMENT OF WHITE WHALES, EAST AND WEST MACKENZIE BAYS, 13 JULY 1978

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Map 7

WHITE WHALE HIGH USE AREAS, KUGMALLIT BAY, 1976-1978

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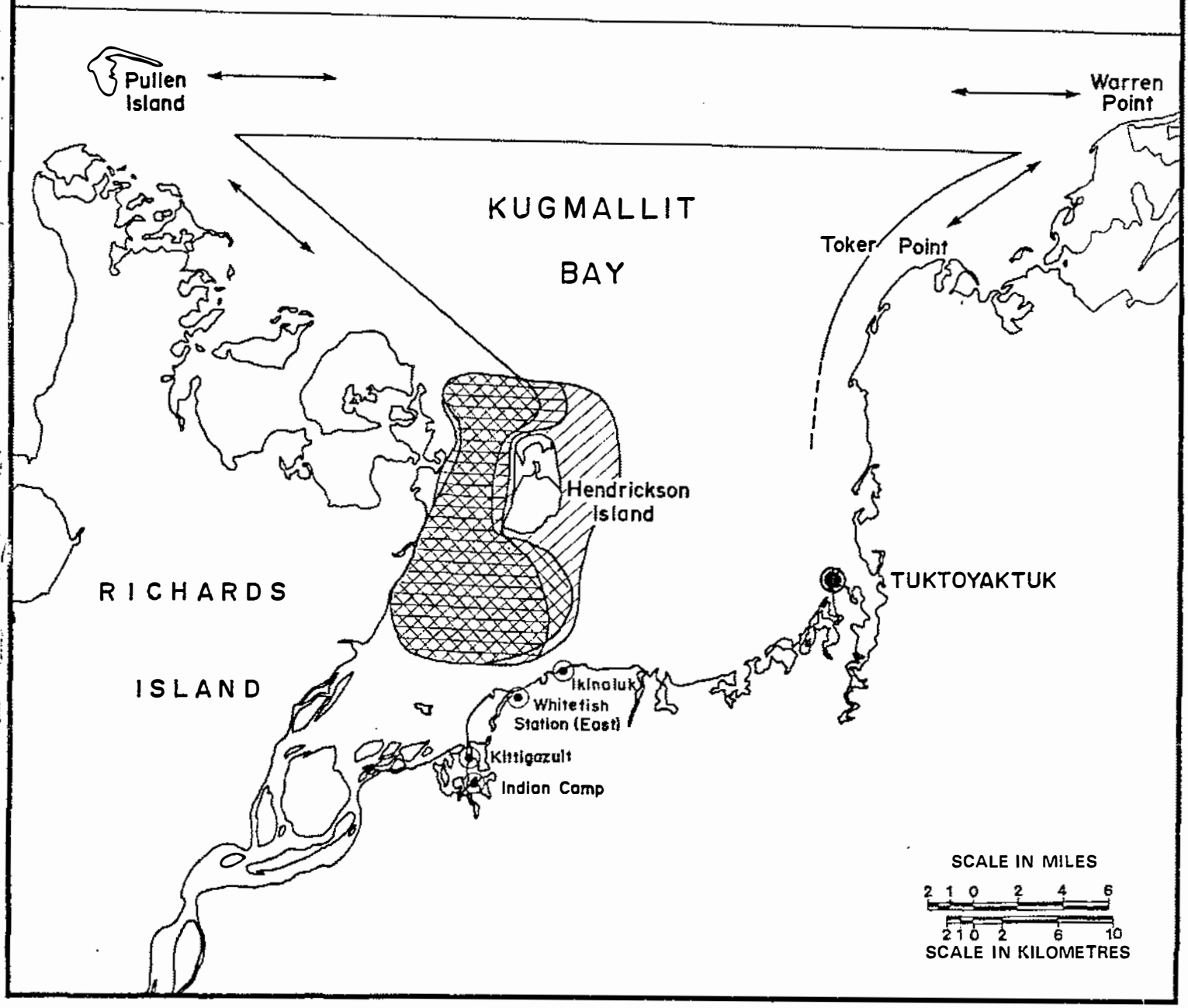
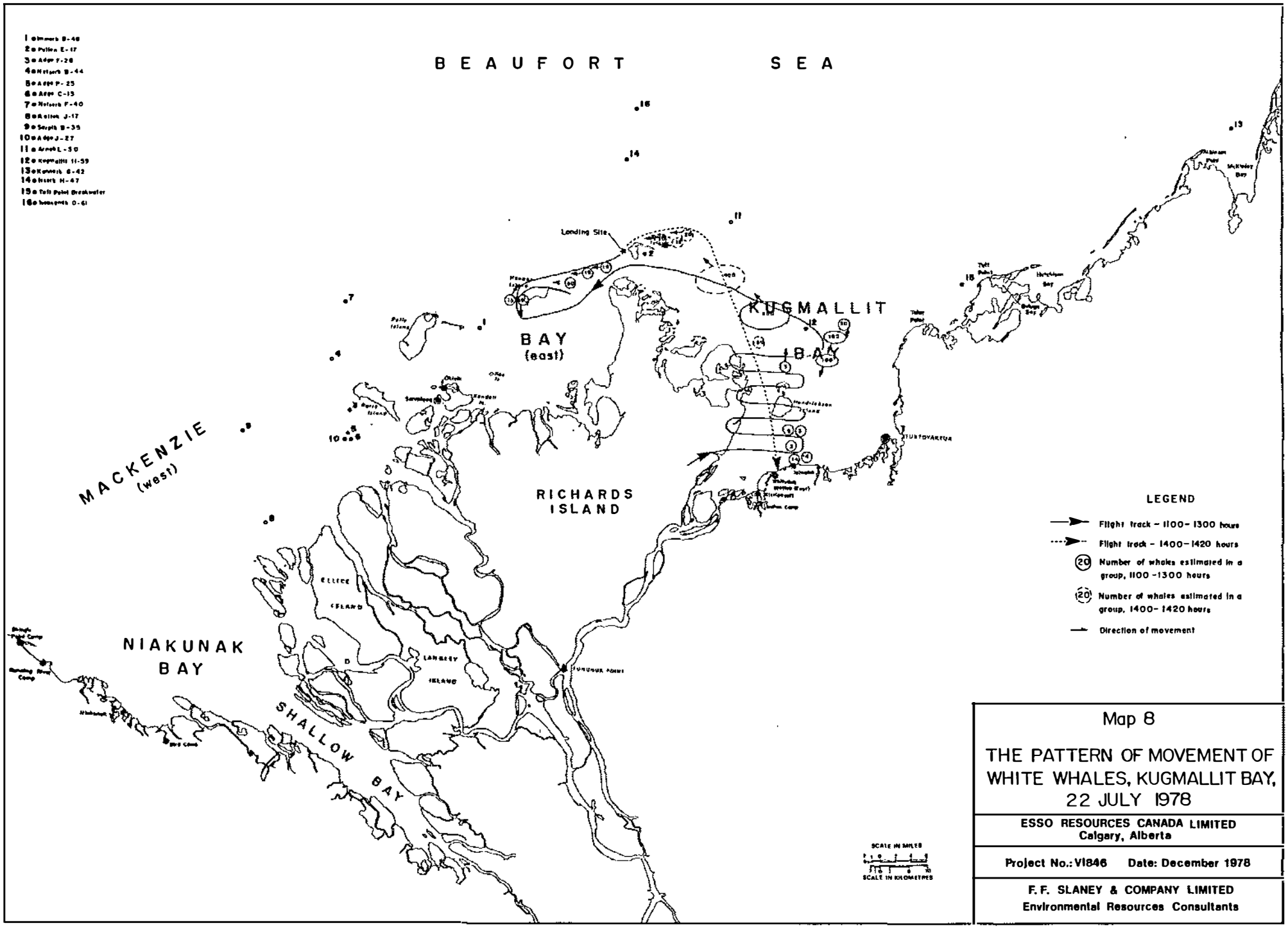
LEGEND

- Travel Route
- Observed Area of Concentration, 1976
- Observed Area of Concentration, 1977
- Observed Area of Concentration, 1978





Map 8

THE PATTERN OF MOVEMENT OF WHITE WHALES, KUGMALLIT BAY, 22 JULY 1978

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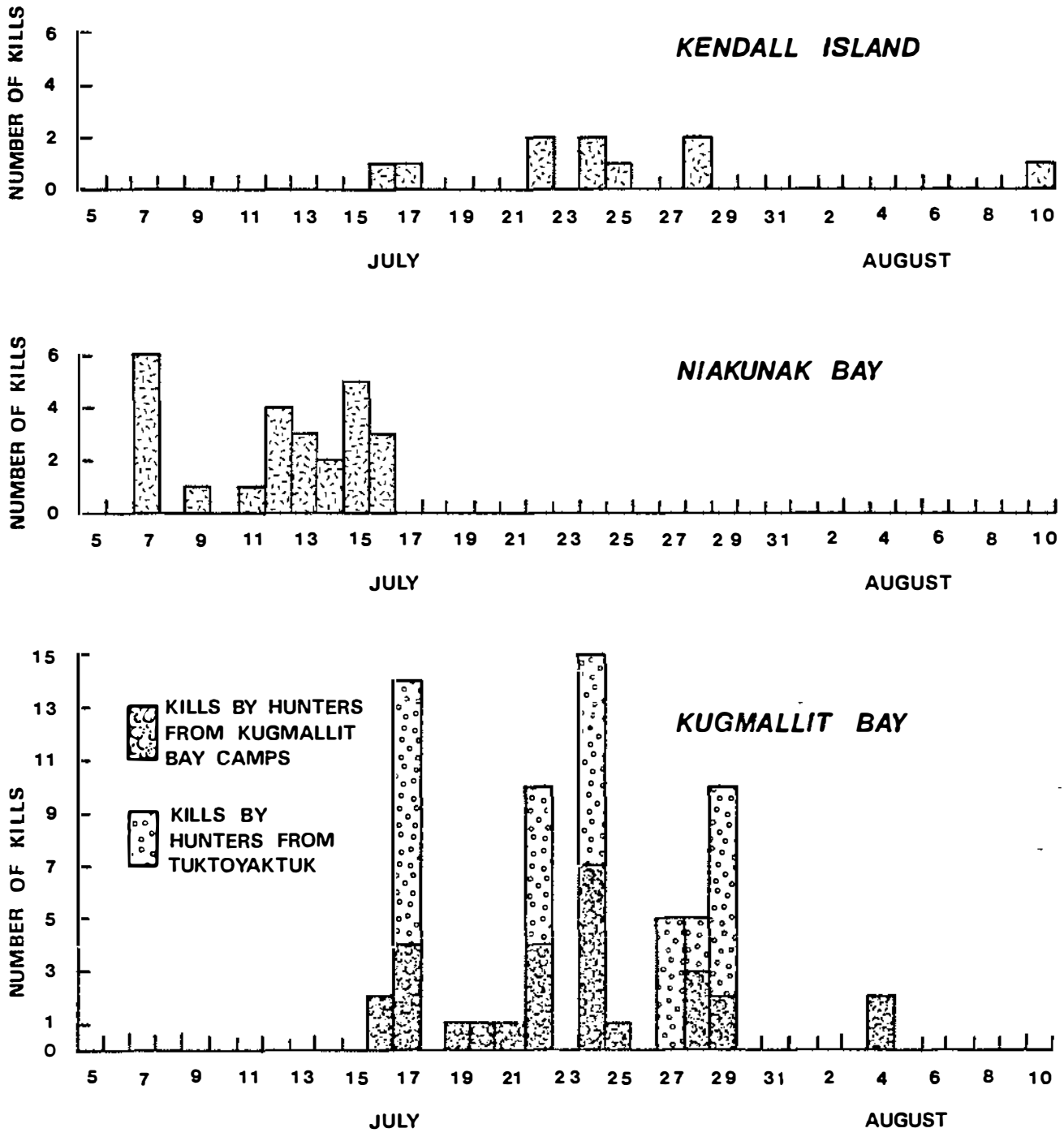

Figure 2. Known dates of whale kills in the Mackenzie Estuary, 1978.

were seen on the July surveys (Maps 9, 10), but except for small numbers near Hooper and Pullen Islands on the outer fringe of the Estuary, none were observed during the August surveys.

On 26 July, two large groups were sighted north of Kugmallit Bay (Map 9). One, with about 100 whales, was headed southward toward the Estuary, and another of about 50 whales was apparently not moving at the time, and because they were observed diving, they may have been feeding. On 29 July, several small groups of whales ranging in size from 1 to 6 were observed (Map 10). Several of the groups far north on the two most easterly lines were moving southeastward toward the Tuktoyaktuk Peninsula, while those further south were headed southwest-

Table 2.
Observations of white whales made by industry personnel, 1978.

Date Time	Location	Numbers	Direction of Movement	Observations	Observer
19 July 0800-0900	0.25 mi. (0.4 km) N of Pullen Spit	12	E	Water depth 8 ft (2.4 m).	Mr. Ron Huckfield Northern Construction Co. Ltd.
22 July 1100	10 mi. (16 km) NE of Hendrickson Island	75	NW	Travelling; water depth 25 ft (7.6 m).	Mr. Bill Fink, Esso
22 July 1120	4 mi. (6.7 km) W of Pullen Island	15	W	Travelling; water depth 10 ft (3.0 m).	Mr. Bill Fink, Esso
22 July 1140	5 mi. (8.2 km) N of Hooper Island	20	W	3-4 calves; travelling; water depth 12 ft (3.7 km).	Mr. Bill Fink, Esso
22 July 1150	off W Pelly spit	27	W	Travelling, accompanied by at least 12 young-of-the-year calves.	Mr. Bill Fink, Esso
23 July 2320	8 mi. (13.3 km) NW of Tuktoyaktuk Harbour	20-30	NNW	Apparently moved E, away from the vessel, which was approx. 0.25 mi. (0.4 km) away.	Mr. James I. Macpherson. Arctic Transportation Co. Ltd.
02 August 0740	S of Pullen spit	60-80 in small groups	N	whales moved in apparent reaction to vessel which was 1-2 mi. (1.6-3.2 km) distant; several calves were present.	Mr. Robert Coleman. Okanagan Helicopters
05 August	16 mi. (26.2 km) N of Pullen Island	10-12	NW	Moving slowly NW; no apparent reaction to helicopter (Bell 212, 800 ft ASL); water depth 40-50 ft (12.2-15.2 m).	Mr. Robert Coleman Okanagan Helicopters
09 August 1645	between Arnak and Issunnak artificial island	10-12	NW	Moving NNW in groups of 2-5 whales; water depth approx. 45 ft (13.7 m); no apparent reaction to helicopter (Bell 212, 600 ft ASL).	Mr Robert Coleman Okanagan Helicopters
09 August 1945	N of Pullen Island	9	NW	Tended to dive in apparent response to Bell 212 helicopter at 400 ft ASL.	Mr. Robert Coleman Okanagan Helicopters
20 August 1900-2000	0.25 mi. (0.4 km) S of Pullen spit	20	—	No apparent reaction to vessel which passed about 400 yd (366 m) from the whales; numerous gulls "wheeling" in the area suggested feeding; water depth 8-10 ft (2.4-3.0 m).	Mr. Ron Huckfield Northern Construction Co. Ltd.
31 August 1030-1600	Pullen Island area	large	W	The whales appeared to be spread out over 2-3 mi. (3.2-4.8 km); gulls were present near the whales indicating possible feeding; water depth 4 m; approx. 1 mi. (1.6 km) distant from vessel.	Mr. J. W. Kavanagh McGregor & Johanson Contracting Ltd.
04 September	Tuft Point	40-50	S	Travelled between Tuft Point and the breakwater; gulls nearby suggested feeding; water depth 4-6 m.	Mr. Dennis Eaton McGregor & Johanson Contracting Ltd.
08 September	Pullen spit	large	W	The whales appeared to be spread out over 4-4.5 mi. (6.4-7.2 km); gulls were present near the whales indicating possible feeding; water depth 4 m; no apparent reaction to vessel which was approx. 1 mi. (1.6 km) distant.	Mr. J. W. Kavanagh McGregor & Johanson Contracting Ltd.
13 September	Tuft Point	8-10	—	The whales were about 50 m offshore of Tuft Point spit; water depth 8-15 ft (2.4-4.6 m); gulls nearby indicated possible feeding.	Mr. Ron Huckfield Northern Construction Co. Ltd.

Map 9

OFFSHORE OBSERVATIONS OF WHITE WHALES, 26 JULY 1978

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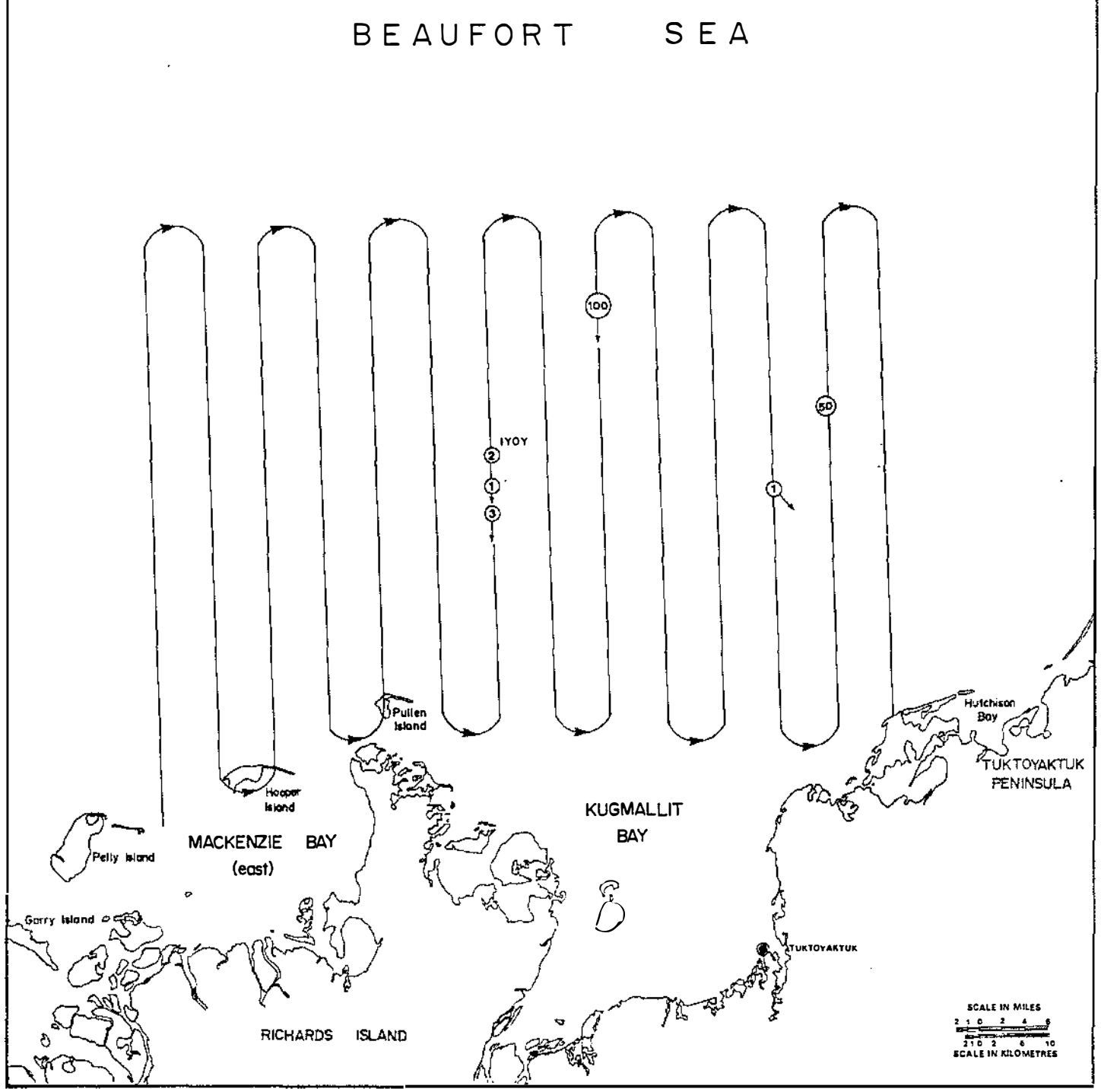
LEGEND
- (5) Whole Observation
- Direction of Movement
- Flight Track
- YOY Young-of-the-year



Map 10

OFFSHORE OBSERVATIONS OF WHITE WHALES, 29 JULY 1978

ESSO RESOURCES CANADA LIMITED
Calgary, Alberta

Project No.: VI846 **Date: December 1978**

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Environmental Resources Consultants

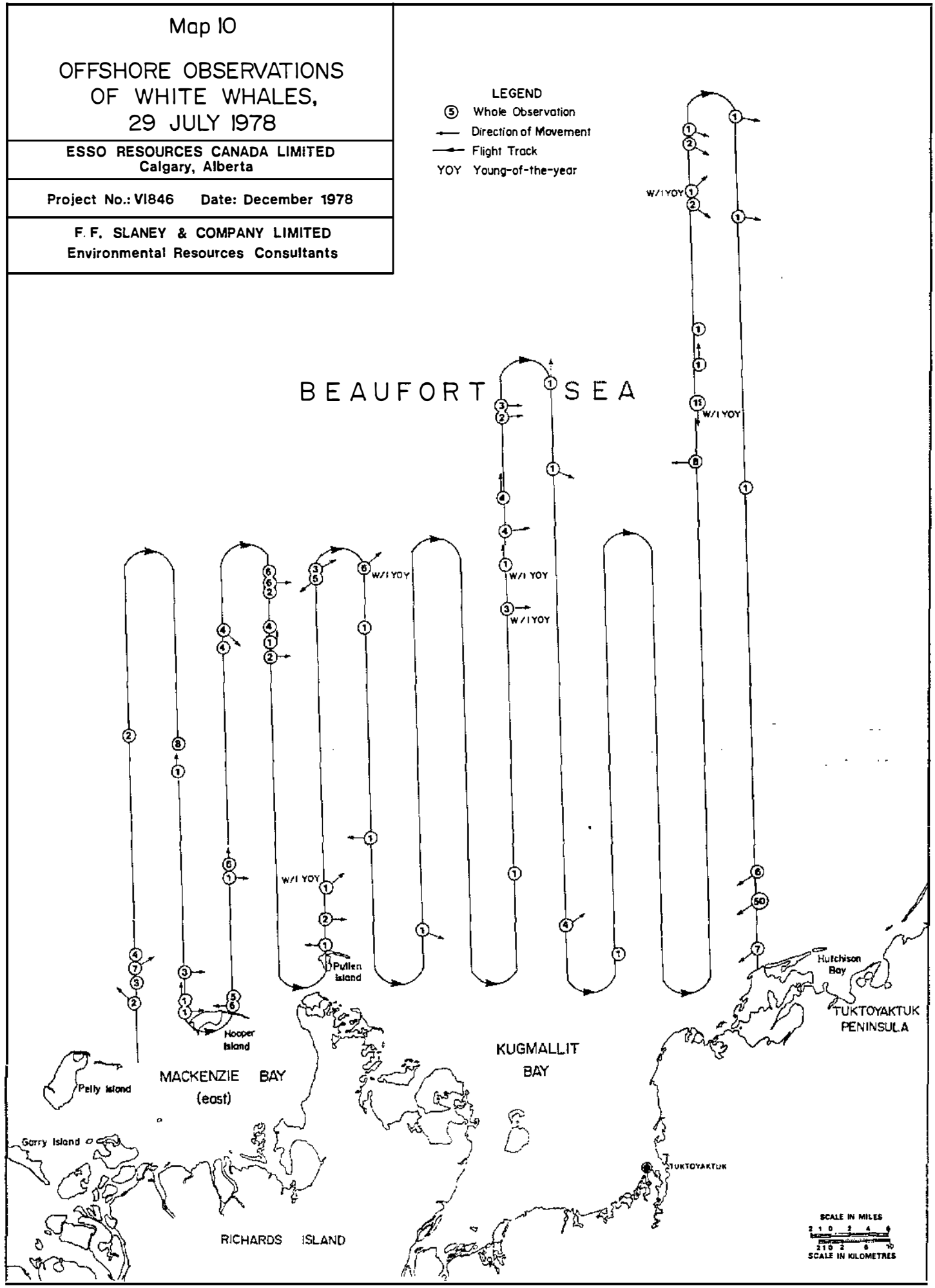


Table 3.

Results of surveys along the Tuktoyaktuk Peninsula to Kannerk artificial island.

Date	Observations
19 July	1 whale near Tuft Point headed NE; no whales observed in Beluga or Hutchison Bays; or along the Tuktoyakatuk Peninsula to Kannerk artificial island.
23 July	5 whales headed SW near mouth of Beluga Bay; 8 whales headed S near Toker Point; no whales in Beluga or Hutchison Bays, or along the Tuktoyaktuk Peninsula to Kannerk artificial island.
28 July	approx. 100 whales headed SW near Warren Point; no whales in Hutchison or Beluga Bays; 3 whales apparently feeding near bar SW of Atkinson Point.
31 July	approx. 70 whales headed SW around the Tuft Point activity site; a total of 24 (plus 2 young-of-the-year) whales headed SW, 25 (plus 2 young-of-the year) whales headed NE, plus 10 whales apparently feeding along the Tuktoyaktuk Peninsula.
1 August	7 whales (plus 1 young-of-the-year) headed SW near Toker Point; no whales near Tuft Point or in Beluga or Hutchison Bays.
3 August	12 whales apparently feeding off the breakwater at Tuft Point (dredge not operating at the time); approx. 100 whales 0.5-1.0 mi. (0.8-1.6 km) from the breakwater moving toward Kugmallit Bay.
4 August	4 whales headed S toward shore and 11 headed W near Warren Point, 12 whales headed SW and 10 whales apparently feeding near Warren Point.
7 August	2 whales headed SW near Tuft Point; 2 whales apparently feeding off Warren Point; 10 whales apparently feeding in Hutchison Bay; 4 whales (plus 4 young-of-the-year), 5 whales headed NE and 2 whales headed SW along the Tuktoyaktuk Peninsula.
10 August	No whales observed near Tuft Point, Beluga Bay, or Hutchison Bay.
11 August	23 whales near mouth of Beluga Bay and approx. 40 whales near Warren Point, all apparently feeding; no whales in Beluga or Hutchison Bays; 6 whales headed SW near Kannerk artificial island; 2 whales apparently feeding near Atkinson Point.

ward Kugmallit Bay. Although no whales were seen in offshore areas on the surveys of 2 and 8 August, white whales were reported by industrial personnel to be present offshore during this time. For example, on 5 and 9 August, industry personnel observed white whales in open water north and northeast of Pullen Island (Table 2).

The southwestward movement of white whales along the Tuktoyaktuk Peninsula in the latter part of July and in August (Map 11, Table 3) has been observed in this and previous studies (Fraker 1976, 1977 a, b; Fraker *et al.* 1978; Slaney 1974), but its significance has not been readily apparent. Two possible explanations have been offered: 1. these were whales just coming to the Estuary for the first time during the season, or 2. they were whales which had left the Estuary and were subsequently returning.

The second possibility has become more probable in light of the results of the offshore surveys. In 1973, Slaney (1974) observed that soon after entering the Estuary some whales left, and subsequently during July and August whales were often observed moving away from the Mackenzie region. Many of the whales observed this year during the offshore surveys were

also headed away from the Estuary (Map 10). Some whales, particularly those seen in the eastern half of the survey area on 29 August, were headed south and east, and it is possible that they may have eventually intercepted the Tuktoyaktuk Peninsula and returned toward the Estuary. During surveys in previous years which have continued east to Cape Dalhousie, there has been an apparent tendency for more whales to be present along the Tuktoyaktuk Peninsula closer to the Estuary. This would be expected if whales were intercepting the peninsula as they return from offshore. It is also possible that the young-of-the-year calves which were seen offshore in open water and along the Tuktoyaktuk Peninsula were born in the warm estuary water, and moved offshore with their mothers.

The most likely function of this offshore movement of whales is for feeding in oceanic waters and perhaps along the ice edge. In 1973, pilots reported that "hundreds" of whales were in floe ice about 200 mi. (320 km) north of the Estuary by the end of July (Slaney 1974). The ice edge is suspected to be an important feeding area for several species of arctic marine animals (Sekerak and Richardson 1978), and it may be that some whales also leave the Mackenzie Estuary to exploit fish and other marine organisms found near the ice edge. The fact that some of the whales observed in open water during this study were diving deeply lends support to this feeding hypothesis. On their return to the Mackenzie Estuary, some whales would appear to intercept the coastal zone off the Tuktoyaktuk Peninsula where they may spend some time feeding, probably on fish (Map 11). Further study is required to determine the spatial and temporal pattern and the function of the use of offshore areas by white whales.

Table 4.
Maximum Estimated Numbers of white whales In the Mackenzie Estuary, 1972-1978.

Year	Estimated Numbers
1972	1500 - 2000
1973	3500 - 4000
1974	3500 - 4000
1975	4000
1976	5500 - 6000
1977	5500
1978	6600

2.2 WHITE WHALE ABUNDANCE

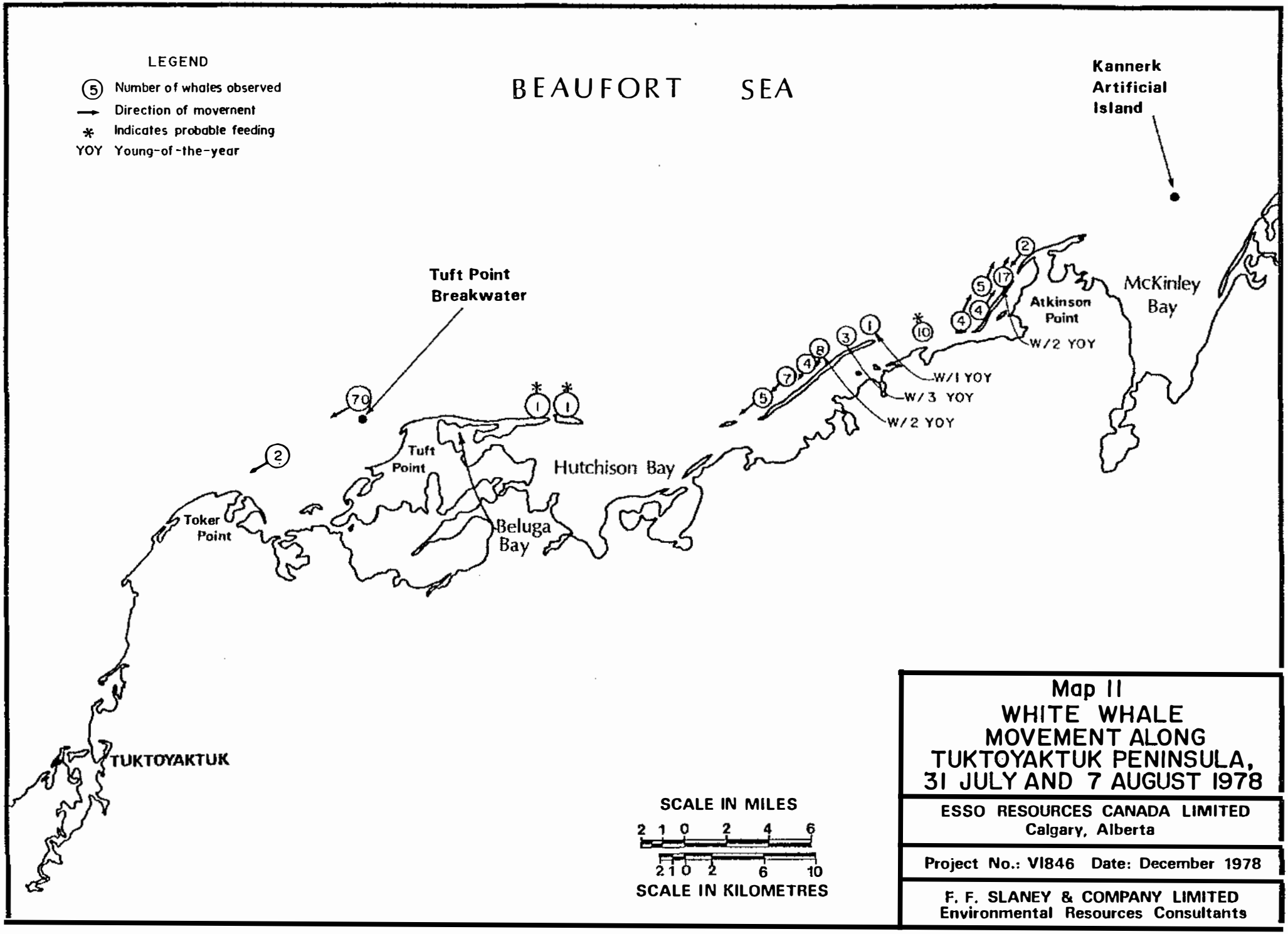
The maximum estimated number of whales present in the Mackenzie Estuary has varied substantially from year to year (Table 4). Some of the variation in the estimates is undoubtedly due to the inherent difficulties in counting whales in such a large expanse of turbid water. Another possible factor is that ice conditions in the Beaufort Sea may cause the whales to become more or less concentrated or may hamper their movement, thus altering the numbers present at any one time in the Estuary. Estimates of abundance made since 1976 are probably more reliable because the methodology has been standardized and attention focused on concentration areas which have been identified as the most intensively used parts of the Estuary.

In 1978, the majority of the whales congregated in Niakunak Bay where the maximum estimate was 6,368 on 9 July (Table 1). On the previous day, 236 whales were estimated in Kugmallit Bay. Thus the peak estimated number of whales in the Mackenzie Estuary was about 6,600, which is greater than the previous high estimate of 6,000 made in 1976 (Table 4). Although the 1978 maximum estimate is higher than any from previous years, it is very unlikely that there has been any real increase in the actual number of whales. Long-lived animals with a low birth rate, such as white whales, have limited capability to increase their numbers. Although there are undoubtedly fluctuations in the size of the Beaufort Sea white whale population, the survey technique is affected by the vagaries of the weather, ice conditions, and behaviour of the whales, and thus, variability in estimates is to be expected. The maximum number of white whales in the Mackenzie Estuary is probably at least 4,000 and may be as high as 6,000.

2.3 BIOLOGY OF WHITE WHALES IN THE MACKENZIE ESTUARY

2.3.1 Reproduction

A major question in the biology of white whales is the function of the annual visit to estuaries, both in the Beaufort Sea and elsewhere (Fraker 1977 b; Fraker *et al.* 1978, in prep.; Sergeant 1973). Sergeant (1973) was the first to point out that the visit to the estuaries was correlated with the appearance of large numbers of calves, and he hypothesized that the estuaries served as warm-water calving grounds. Newborn white whale calves, with a high surface-to-volume ratio and thin blubber layer, are probably quite suseptible to rapid heat loss in cold water. In warm water the calf could devote much of the nourishment from its mother's milk to growth and laying down fat stores instead of expending energy maintaining the body temperature. Thus, the possible



Map 11
WHITE WHALE MOVEMENT ALONG TUKTOYAKTUK PENINSULA, 31 JULY AND 7 AUGUST 1978

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Calgary, Alberta

Project No.: VI846 Date: December 1978

F. F. SLANEY & COMPANY LIMITED
Environmental Resources Consultants

advantages of a calf's being born and nursed for a period in the 10 - 15°C waters of an estuary compared to 0 - 2°C offshore sea water are apparent. Sergeant's hypothesis was subsequently modified by Fraker *et al.* (1978) to include whales of all age classes as potential benefactors of the warm water.

While estuaries may function, in part, as calving areas for white whales, there are several observations of whales with newborn calves in cold, offshore waters, and there are corollary predictions of the calving hypothesis which have not been fulfilled (Fraker 1977 b; Fraker *et al.* 1978). The function of the estuaries in the life history of white whales remains an open question.

The observations of Mr. Jacob Archie (pers. comm.) on 7 July lend support to the possibility that calving is a major reason for the whale's visit to the Estuary. Mr. Archie hunted the whale concentration in Shoalwater Bay twice on 7 July. In the morning, he observed no calves. However, in the evening Mr. Archie reported that calves were common. Thus it may be that the whales do make use of the concentration areas for calving. The apparently synchronous timing of the births, as observed by Mr. Archie, suggests that the whales may be able to exercise some control over the timing of parturition and that many births may be delayed until the whales actually arrive in the warm estuary water. The control of the timing of parturition and the use of concentration areas as calving grounds would be of very high biological significance, and these possibilities should be tested with observations from future studies in the Mackenzie Estuary and elsewhere.

The sighting of whales accompanied by young-of-the-year calves moving down the Tuktoyaktuk Peninsula in late July and in August suggested that these calves were born outside the estuary in cold offshore waters (Fraker 1977 b; Fraker *et al.* 1978). The observations made during the offshore surveys (sect. 2.1.3) offer another possible explanation: The newborn calves which are seen with their mothers and other whales moving southwestward along the Tuktoyaktuk Peninsula during this period may have been born in the Estuary, moved into offshore waters, and subsequently are returning to the Estuary. Additional data are required to determine what proportion of calves may be born outside the Estuary.

2.3.2 Feeding

Probable feeding behaviour was previously observed at several locations within the Mackenzie Estuary (Fraker 1977 b; Fraker *et al.* in prep.). In 1978, as in other years, apparent feeding was observed frequently in the area between Richards and Pullen Islands, along the spit running east of Pullen Island, and along the Tuktoyaktuk Peninsula (Map 11).

As in previous years, whales which were observed diving actively and deeply were suspected to have been feeding. Often such behaviour was seen along coastlines and near spits and islands where fish are known to migrate. Glaucous Gulls (*Larus hyperboreus*) frequently were nearby either on the water or in the air (Photo 7). It is possible that the gulls stay close to the whales in order to take advantage of fragments of food which may result or to pursue fish and other organisms which may come near the surface as a consequence of the whales' activities.

2.3.3 Length and Sex of Harvested Whales

Significant differences in the size and/or sex composition of the whales harvested in the Mackenzie Estuary could indicate significant changes in the status of the herd. Therefore, an effort has been made each year to examine as many harvested whales as possible

The mean length of male whales measured over each of the past five years has varied from 423.3 to 436.6 cm (13.9 to 14.3 ft) (Table 5). There is no trend in the annual differences in lengths (Fig. 3), and an analysis of variance indicates no statistically significant difference ($F = 0.280$; $df = 4, 80$; $p << 0.10$).

The mean length of female whales measured during the same period has ranged from 358.8 to 414.0 cm (11.8 to 13.6 ft). An analysis of variance indicates a statistically significant difference in the lengths at the 0.95 level ($F = 4.15$; $df = 4, 20$). The source of the statistically significant variation is the data from 1976 when the mean was exceptionally large compared to those of other four years. The other means fall within a range of only 10 cm (358.8 - 368.6 cm). The very small number of measurements of females is, of course, likely to result in a lot of chance variation, and the differences between the mean lengths of whales harvested in different years do not appear biologically significant.

The sex composition of the harvest from 1974 to 1978 has been heavily weighted toward males, with a ratio of 3.45:1, based on a sample of 100 males to 29 females. This ratio is very significantly differnt from 1:1 ($x^2 = 20.16$, $df = 1$, $p << 0.005$), which would be expected at birth, and there has been no statistically significant change in the proportions of the two sexes in the harvest during the past five years ($x^2 = 3.97$, $df = 4$, $p < 0.90$).

The sex ratio of animals taken in the harvest is important because the tendency to take males probably serves to conserve the reproductive

Table 5. Means and standard deviations of lengths of harvested whales taken in the Mackenzie Estuary, 1974-1978.

FEMALES				MALES			
Year	Mean Length (cm)	Standard Deviation	n	Year	Mean Length (cm)	Standard Deviation	n
1974	368.6	± 28.364	7	1974	423.3	± 58.936	16
1975	366.8	±17.283	4	1975	429.9	± 34.197	13
1976	414.0	± 28.521	7	1976	429.8	± 29.351	35
1977	365.0	± 18.055	3	1977	436.6	± 31.698	12
1978	358.8	± 16.976	4	1978	424.8	± 23.078	18

potential of the herd. On the other hand, at some point the sex ratio in the herd could become so distorted that mating, and therefore reproduction, could be adversely affected.

It is not entirely clear how the bias toward males comes about. Many hunters are selective of the animals which they harvest, choosing larger animals, which tend to be males. However, estimating the size of a whale which is largely submerged in the turbid Mackenzie discharge water is not easy, and it is difficult to understand how such selectivity could be reliable enough to continually maintain the observed sex composition of the harvest. Perhaps there is a spatial separation of the whales which also contributes to this bias toward harvesting males.

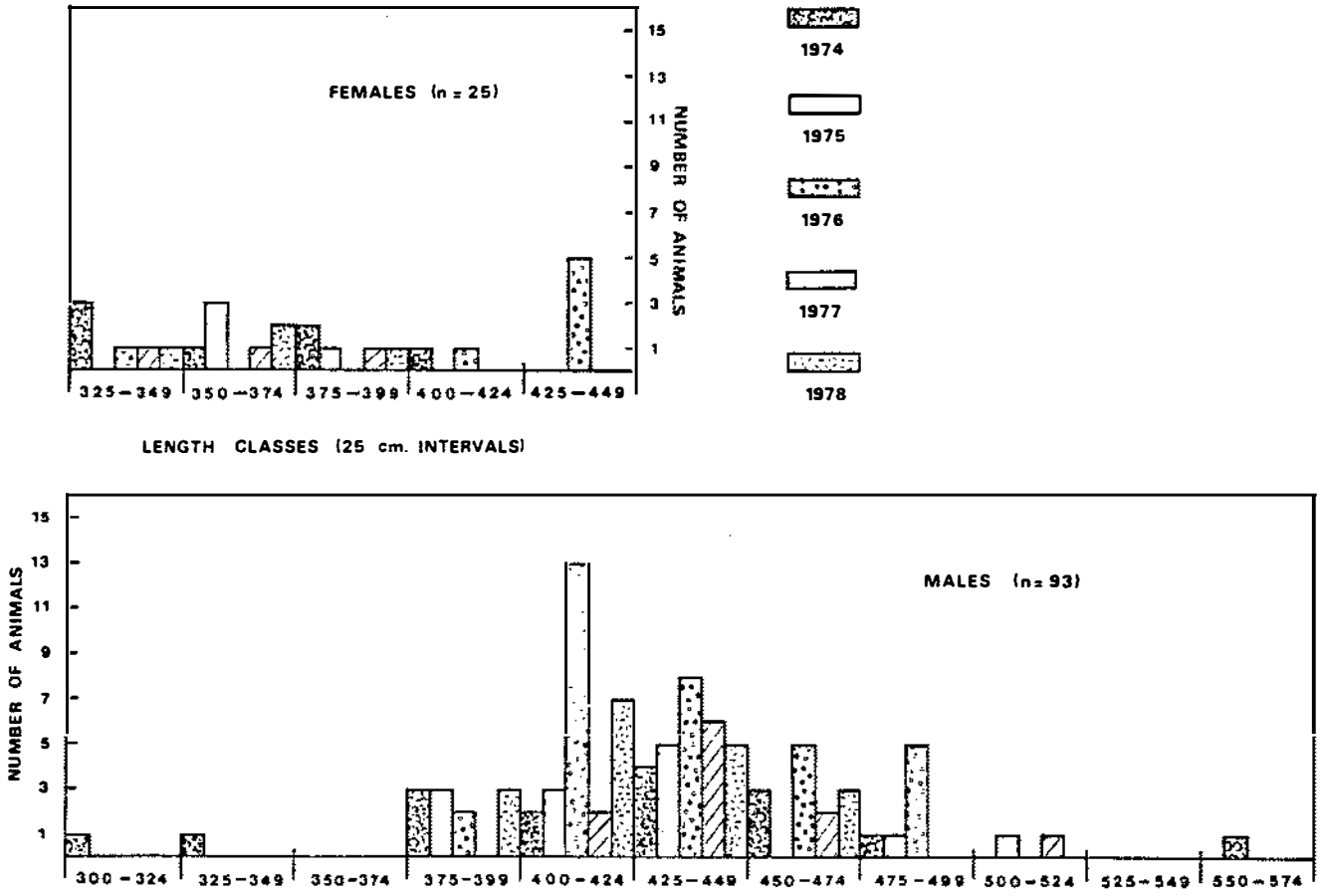

Figure 3. Length frequencies of whales harvested in the Mackenzie Estuary, 1974-1978.

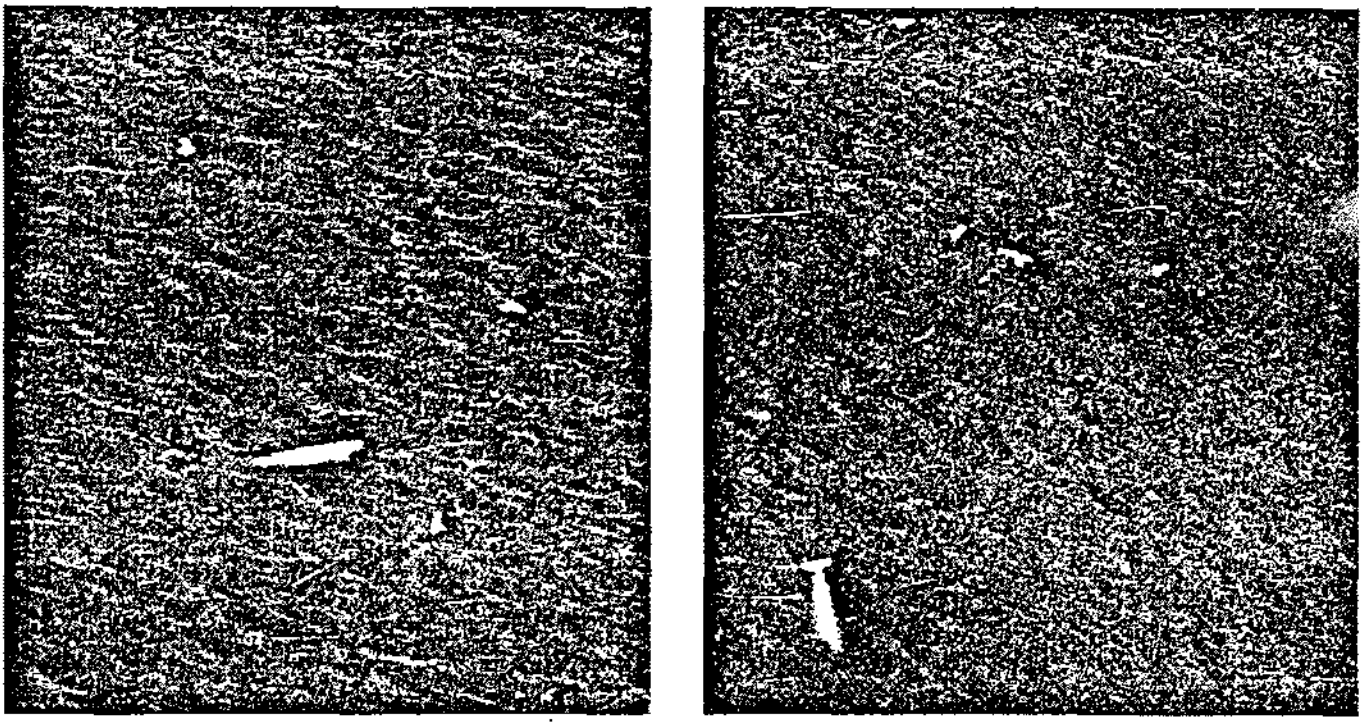

Photo 7.

White whales feeding along the Tuktoyaktuk Peninsula, July, 1978. Whales such as these which were observed diving, often in the proximity of gulls, were believed to have been feeding.

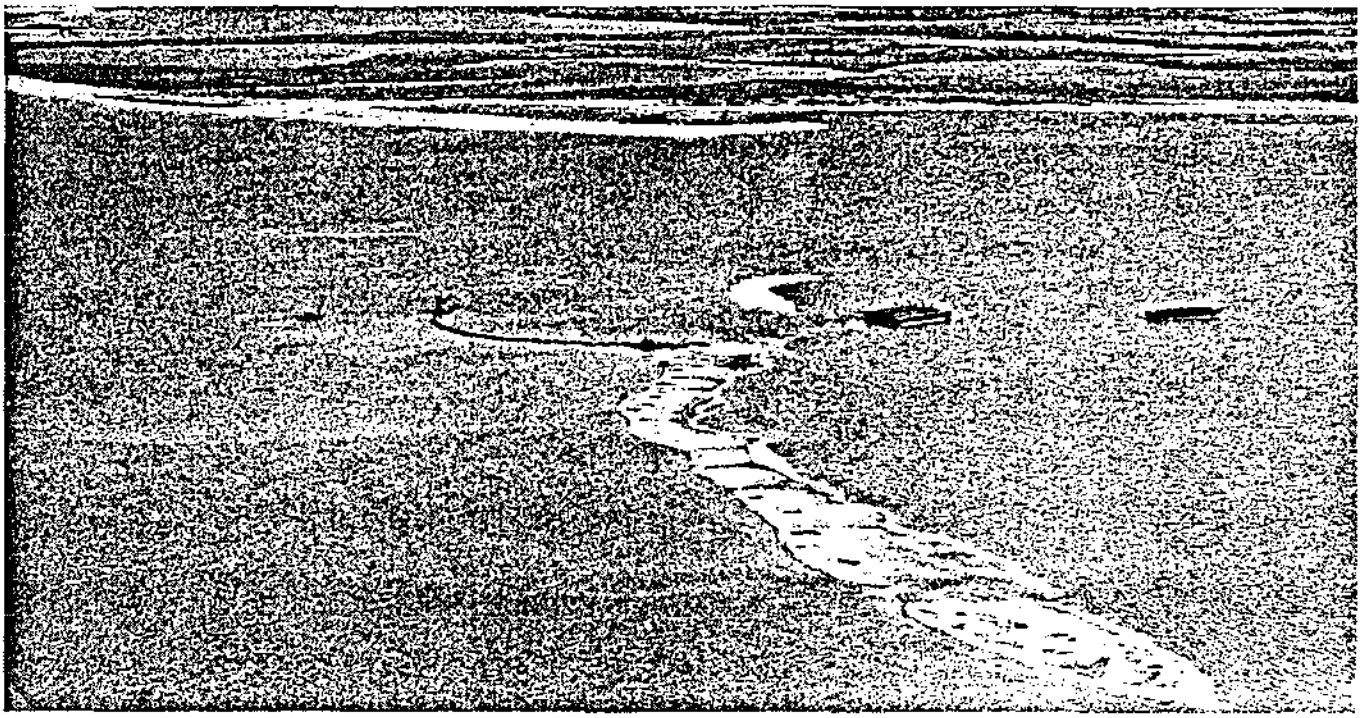

Photo 8.

Tuft Point underwater borrow operations, 31 July 1978. At the time of the photograph the dredge Arctic Northern was operating on the seaward side of the artificial breakwater to repair it. Usually the dredge operated landward of the breakwater where it filled barges to carry material to the site of Issungnak artificial island.

PART 3

HUNTING AND UTILIZATION OF WHITE WHALES

3.1 THE HUNTING PERIOD

In 1978, the first hunters from Aklavik established camps on Niakunak Bay on 6 July. The first hunters from Inuvik established camps on Kugmallit Bay on 8 July and at Kendall Island on about 15 July. The arrival of hunters at camps on Niakunak and Kugmallit Bay was a few days later than usual, while hunters reached Kendall Island at about the usual time.

Most of the whales taken in Niakunak Bay were landed in the second week of July, in contrast to the latter half of July in both Kugmallit Bay and the Kendall Island area (Fig. 2). Normally, the hunting activity in Niakunak and Kugmallit Bays is greatest during the first two weeks of July, although it often continues with reduced intensity into early August (Fraker 1977 b). In 1978 in Niakunak Bay hunting activity was concentrated in the second week of July, immediately after the whales arrived, although a greater amount of hunting would probably have taken place later had there been less wind. In Kugmallit Bay, winds prevented any hunting until the night of 16-17 July, and because of persistently windy conditions, most additional hunting was concentrated into five additional days (Fig. 2) when the water was sufficiently calm. Consequently, there was more hunting activity than usual in Kugmallit Bay in the latter half of July.

The timing of hunting activity in the Kendall Island area of East Mackenzie Bay is more variable than elsewhere and it tends to start later; the 1978 pattern was not unusual. In this area as well, hunting was greatly hampered by strong winds in the latter half of July and early August.

3.2 HUNTING SUCCESS

The harvest of white whales in the Mackenzie Estuary varies considerably from year to year (Table 6) owing to several factors, including the number of hunters, the number of "whale processors", the weather, and the number and length of stay of whales in the Estuary. Over the past six years, the total annual harvest in the Mackenzie Estuary has ranged from 113 to 177, with a mean of 141.4. The 1978 harvest of 121 was below average.

Weather was undoubtedly a major factor contributing to the lowered harvest in 1978. Hunters in all areas spent considerable time waiting for suitable conditions. The late arrival of the whales in the Estuary was another factor, and in Kugmallit Bay, the early departure of the whales also contributed to the lowered harvest. But in spite of these factors, hunters from Tuktoyaktuk and Aklavik (using Niakunak Bay) landed nearly average numbers of whales (Table 6). The hunters in Kugmallit Bay took nearly 20 fewer whales in 1978 than average. Part of this reduction was due to weather, while most was probably a result of the shift to Kendall Island of several Inuvik hunters who formerly hunted in Kugmallit Bay. This shift in location first occured in 1977, and the 1977 and 1978 harvests in Kugmallit Bay are similar. The reduction of the Kendall Island harvest from 30 in 1977 to 10 in 1978 was partly due to unfavourable weather and possibly to fewer hunters.

Table 6.

White whale harvest statistics, Mackenzie Estuary, 1972-1978.

	1972	1973	1974	1975	1976	1977	1978	Mean Harvest 1972-77
Niakunak Bay Camps	33	20	30	29	32	24	30	28.0
Kugmallit Bay Camps	31	63	50	60	59	32	28	49.2
Tuktoyaktuk Community	45	87	40	50	51	54	53	54.5
Kendall Island	4	7	2	3	12	30	10	9.7
	113	177	122	142	154	140	121	141.4

3.3 HUNTING CAMPS

All of the hunting camps used in 1977 were again occupied during the 1978 whale hunt (Map 1). Ikinaluk, which had been occupied each summer until 1976; was not used in 1977 or in 1978. Both the north (Okivik) and south (Sanmiqaq) camps on Kendall Island were utilized this year.

PART 4

THE IMPACT OF EXPLORATION ACTIVITIES ON WHALES AND WHALE HUNTING

The possible effects on white whales of recent activities related to offshore exploration by Esso (formerly Imperial Oil Limited) in the Mackenzie Estuary region have been the subject of seven years (1972-1978) of investigation by F. F. Slaney & Company. Throughout these studies, a basic objective has been to detect potential interference by exploration activities with white whales and Inuit hunting activities, and to communicate any concerns to Esso supervisors.

Throughout its operations in the Mackenzie Estuary, Esso has utilized the information gained from previous and ongoing whale monitoring programs and has taken into consideration possible concerns related to whales and whale hunting in locating and scheduling specific logistic and exploration activities. In a number of instances, operational plans and schedules have been adjusted to prevent possible adverse effects. Readers are referred to previous reports (Fraker 1976, 1977 a, b; Slaney 1973, 1974, 1975) for details of previous operations.

The 1978 monitoring of Esso operations focused on the underwater borrow operations and associated marine traffic at Tuft Point and on operations in Kugmallit Bay where most of the activity in the Estuary took place.

4.1 TUFT POINT MONITORING

In July 1976, approximately 150 white whales were discovered to be present in Beluga Bay shortly after the start-up of operations at Tuft Point (Fraker 1977 a, b). The timing of the appearance and the subsequent departure of these whales appeared to be related to the frequency of barge traffic in the area, and consequently, the 1977 and 1978 whale monitoring programs have focused considerable attention on this area. This year, as in 1977, no significant interference with the movement of whales through the Tuft Point area was observed. Whales were observed moving along the adjacent Tuktoyaktuk Peninsula during frequent surveys (Table 3), and industry personnel reported white whales near Tuft Point twice in September (Table 2).

On 28 July, at 1956 hr, a group estimated at approximately 100 whales (plus 10-20 young-of-the-year calves) was observed near Warren Point and was headed toward Kugmallit Bay. Beluga and Hutchison Bays, and the Tuft Point area were again surveyed between 2315 and 2345 hr, but no whales were seen, indicating that the whales had passed through this area unhindered.

On 31 July, approximately 70 whales were observed moving around the operations at Tuft Point. At 1342 hr, the whales were sighted north of the artificial breakwater which was being repaired by the dredge *Arctic Northern* operating on the seaward side (Photo 8). These whales were observed again at 1359 and 1417 hr, at which time they had passed the activity site. During the observation period they maintained a distance of 2.5 mi. (4.0 km) from the operations being conducted at the breakwater.

On 3 August between 1142 and 1152 hr, approximately 100 whales moving toward Kugmallit Bay were observed near Tuft Point. At this time, the dredge, *Arctic Northern*, was inside the breakwater but not operating. Some of the whales were within 0.5 mi. (0.8 km) of the breakwater, while a few were apparently feeding within 200 - 300 m of the breakwater.

In 1976, the apparent interference with the movement of whales in the Tuft Point area was apparently related to the relatively intensive barge activity rather than the stationary dredging operation. During the latter part of July 1976, there were about 24 barge movements per day, while in 1977 there were only about 7. The frequency of barge movements this year was less than half that of 1977. No whale movements were observed to have been significantly interferred with in either 1977 or 1978.

The only apparent effect this year was a tendency for the whales to avoid coming close to the Tuft Point operations. As observed on 31 July, while the dredge was operating outside the breakwater, a group of whales moved past the area at a distance of approximately 2.5 mi. (4.0 km). This distance is greater than the theoretical range of audibility (1.8 km) which Ford (1977) calculated for the majority of sounds emanating from typical dredging operations at Tuft Point. However, Ford predicted that certain transient sounds could be perceived up to 4.0 km.

There may have been some differences in the sound production this year, while the dredge was operating on the seaward side of the breakwater, compared to that when Ford conducted his studies, or it may be that the whales observed on 31 July were staying outside the area affected by the transient sounds which may be audible to 4.0 km. The effect on the

whales which travelled a short distance seaward of the breakwater, apparently to avoid disturbance, probably was very small and insignificant.

At other times, such as on 3 August, the whales came close to the breakwater. As in 1976 and 1977, whales were also reported by industry personnel to be present between the breakwater and Tuft Point (Table 2). The presence of gulls near some of these whales, many of which were diving, suggested that feeding was taking place.

4.2 KUGMALLIT BAY

Whales using Kugmallit Bay in 1978 arrived late and in smaller-than-usual numbers apparently because of ice conditions (sect. 2.1.1), while their earlier-than-usual departure appears to have been a consequence of intensive hunting activity (sect. 2.1.2.3). During the 1978 study, whales were frequently seen by industry personnel (Table 2) and by observers during aerial surveys in the Pullen Island area, which was used as a base of operations for the island-building activities, and there was no indication of any important effect on movement or feeding behaviour of white whales in this area.

Two minor interactions between whales and traffic were reported by industry personnel (Table 2). On 23 July, a group of 20-30 white whales moved away from a vessel which approached then to within approximately 0.25 mi. (0.4 km). In contrast, on 20 August the tug *Dorothy Robinson* came within about 400 yd (366 m) of 20 whales which apparently were feeding near Pullen Island spit without causing any obvious alarm. On 2 August, some of the 60-80 whales present at that time south of Pullen spit moved away in apparent response to a vessel which was one to two miles (1.6-3.2 km) distant, while on other occasions vessels approached to within one mile (1.6 km) without the whales obviously responding.

As previously noted (Fraker 1976, 1977 a, b; Slaney 1974), the observed response of whales to boat traffic has varied, and this variation is probably the result of an interaction of a complex of factors including water depth, nearness of obstacles such as shallow water or land, boat type, boat speed, traffic intensity, recent experience of the whales, and whether or not any of the whales are pregnant or are accompanied by calves. Several of the sightings near Tuft Point and Pullen Island involved whales which appeared to be feeding, annd it is possible that whales which are feeding are less sensitive to disturbance than they are at other times.

In early August, Mr. Robert Coleman made three observations of white whales while flying north of Pullen Island in a Bell 212 helicopter (Table 2). On two occasions when the helicopter was operating as low as 600 ft (183 m) the whales which were overflown were apparently unperturbed. However, at 400 ft (122 m) the whales responded weakly and tended to dive. Thus there appears to be some potential for low-flying helicopters to disturb whales, although any effects are probably insignificant except where the whales are present in high density, such as in concentration areas.

Although there was no apparently significant effects of Esso activities on whales in Kugmallit Bay, there are probably minor effects resulting from the inevitable interactions with marine traffic and even low-flying aircraft. Whale hunting undoubtedly has a much greater effect, and this was particularly evident this year. While there have been no detectable changes in the distribution or behaviour of whales in Kugmallit Bay which can be related to Esso operations, the combined activities of all industrial and government operators and Inuit hunters, if they remain at current levels, create a greater potential for possible effects in this area than elsewhere in the Mackenzie Estuary.

4.3 MONITORED BARGE MOVEMENTS

In 1976 and 1977, it was found that restricting and monitoring barge movements through potentially sensitive areas could minimize disturbance of whales and Inuit whale hunting activities (Fraker 1977a, b). Subsequently, a close liaison has been maintained between the whale biologist/monitor team and Esso field supervisors to coordinate such activities when required. In 1978, one barge movement through Niakunak Bay was planned for early July to take Barge Camp 205 from one of the Adgo artificial islands southwest of Garry Island to Tuktoyaktuk. This movement could not take place because of extremely low water.

The barge camp was finally retrieved on 21 - 22 July when the tug *Beverly Lambert* moved from Tuktoyaktuk to the Adgo Island, travelling north of the Barrier Islands (Map 1). When the whale biologist and monitor were consulted regarding this move, they anticipated no significant potential for adverse effects on whales or whale hunting if the vessels travelled on the seaward side of the Barrier Islands and not through East Mackenzie Bay. No monitoring of adjustment of the timing of this movement was recommended.

4.4 EFFECTS ON WHALE HUNTING

The 1978 whale harvest in the Mackenzie Estuary was lower than average largely because windy weather hampered hunting in all areas and because

ice conditions delayed the arrival of the whales. This resulted in a shorter period during which the whales were in the Estuary (Part 3).

In Kugmallit Bay, where nearly all the industrial activity took place, the 1978 harvest taken by hunters from Tuktoyaktuk was 53 whales which is very close to the average of 54.5 for the previous years (Table 6). However, the harvest taken by Inuvik hunters operating from camps near the mouth of East Channel was only 28, about 20 fewer than the mean of 49.2 from the preceding six years, although it is only four less than the number taken in 1977. The reduction from the average harvest taken by hunters from Kugmallit Bay was lower than average probably because of three factors: First, as in 1977, several Inuvik hunters shifted from Kugmallit Bay to the Kendall Island area. Second, windy weather hindered hunting. Third, the whales in Kugmallit Bay arrived late and left early and were, therefore, available to be hunted for a reduced amount of time. Thus, there has been a decrease in hunting effort in Kugmallit Bay which is reflected in lower harvests in 1977 and 1978 compared to previous years, except 1972 when overall harvests were low. The harvest of 30 taken in Niakunak Bay was slightly above six-year mean of 28.0. Hunters using Kendall Island as a base took only 10 whales, which is practically the same as the six-year mean of 9.7. However, because of the shift of many Inuvik hunters from Kugmallit Bay to the Kendall region, a larger harvest, as in 1977, would have been expected if the weather had been more favourable. Therefore, industrial activities had no detectable effect on the 1978 whale harvest in Kugmallit Bay or elsewhere in the Estuary.

PART 5

BOWHEAD WHALES

The bowhead whale (*Balaena mysticetus*) is a rare species of baleen whale which is confined to arctic waters. None were seen during whale monitoring studies up to 1975, but since 1976, as Esso operations have moved further offshore, bowheads have been seen more frequently. Seventeen incidents of bowhead sightings were reported in 1976, 28 in 1977, and 8 in 1978 (Table 7, Map 12), for a total of 53 observations over the past three years.

There are at least two possible reasons why the number of sightings has varied from year to year. First, most of the 1977 observations were made from vessels towing barges from Tuft Point to the site of Isserk artificial island, while in 1978 there were fewer movements to the Issungnak site. In 1976 the tows were to the Kugmallit artificial island site which is well inside Kugmallit Bay where fewer bowheads would be expected. Second, other factors, such as the availability and distribution of their planktonic food organisms, may affect the distribution of bowheads in the southeastern Beaufort Sea from year to year.

The status of the bowhead whale population in the western Arctic has been a focus of international concern over the past few years, and until recently the total population size had been placed at less than 1000 (Braham and Krogman 1977; Fraker *et al.* 1978). Intensive survey effort in 1978 has resulted in an increased and probably improved estimate range of 1783 to 2865, with a "best estimate" of 2,264 (Braham pers. comm.). Although recent estimates are higher, the number of bowheads is still too few to consider the population to be secure.

On the basis of sightings recorded in the logbooks of whaling vessels operating in the Beaufort Sea near

Table 7. Observations of bowhead whales, 1978.

Date Time	Location	Numbers	Direction of Movement	Observations	Observer
26 July 1624	030° T and 15 mi. (24 km) from 70° 09'N, 133° 42'W	2	NE	In open water; water depth 50 m	Mr. Mark Fraker F. F. Slaney and Co.
26 July 1952	343° T and 40 naut. mi. (74 km) from Tuktoyaktuk	2	NE	In open water; water depth 50 m.	Mr. Mark Fraker F. F Slaney and Co.
08 August	017° T and 64 naut. mi. (118 km) from Tuktoyaktuk	1	Unknown	Amongst ice floes. water depth 50 m	Mr. Tommy Gordon Esso
07 September 2000	350° T and 26 naut. mi. (48 km) from Tuktoyaktuk	6	N	Whales were spread over an area approx. 1 mi. (1.6 km) in diameter; they appeared to avoid vessel; water depth 50 ft (15.2 m).	Mr. James Derby Arctic Transportation Ltd.
08 September 0800	3 mi. (4.8 km) NE of James Shoal	16	NE	Whales sounded (dove) when vessel came within 500 ft (152 m); approx. 5 were smaller than others and may have been calves; water depth 40 ft (12.2 m).	Mr. James MacPherson Arctic Transportation Ltd.
09 September 1000	2 mi. (3.2 km) NE of James Shoal	30-	E	Whales were approx. 0.25 - 2 mi. (0.4-3.2 km) from vessel; water depth 35 ft (10.7 m).	Mr. James Derby Arctic Transportation Ltd.
10 September 2115	28 naut. mi. (52 km) NNW of Tuktoyaktuk	4	W	Water depth 60 ft (18.3 m).	Mr. James MacPherson Arctic Transportation Ltd.
14 September 1430	69° 51' N, 133° 04' W	2	310°T (NW)	Water depth 36 ft (11.0 m).	Mr. A. Michaelsen, Arctic Transportation Ltd.

Map 12

SIGHTINGS OF BOWHEAD WHALES, 1978

ESSO RESOURCES CANADA LIMITED
Calgary, Alberta

Project No.: VI846 **Date: December 1978**

F. F. SLANEY & COMPANY LIMITED
Environmental Resources Consultants

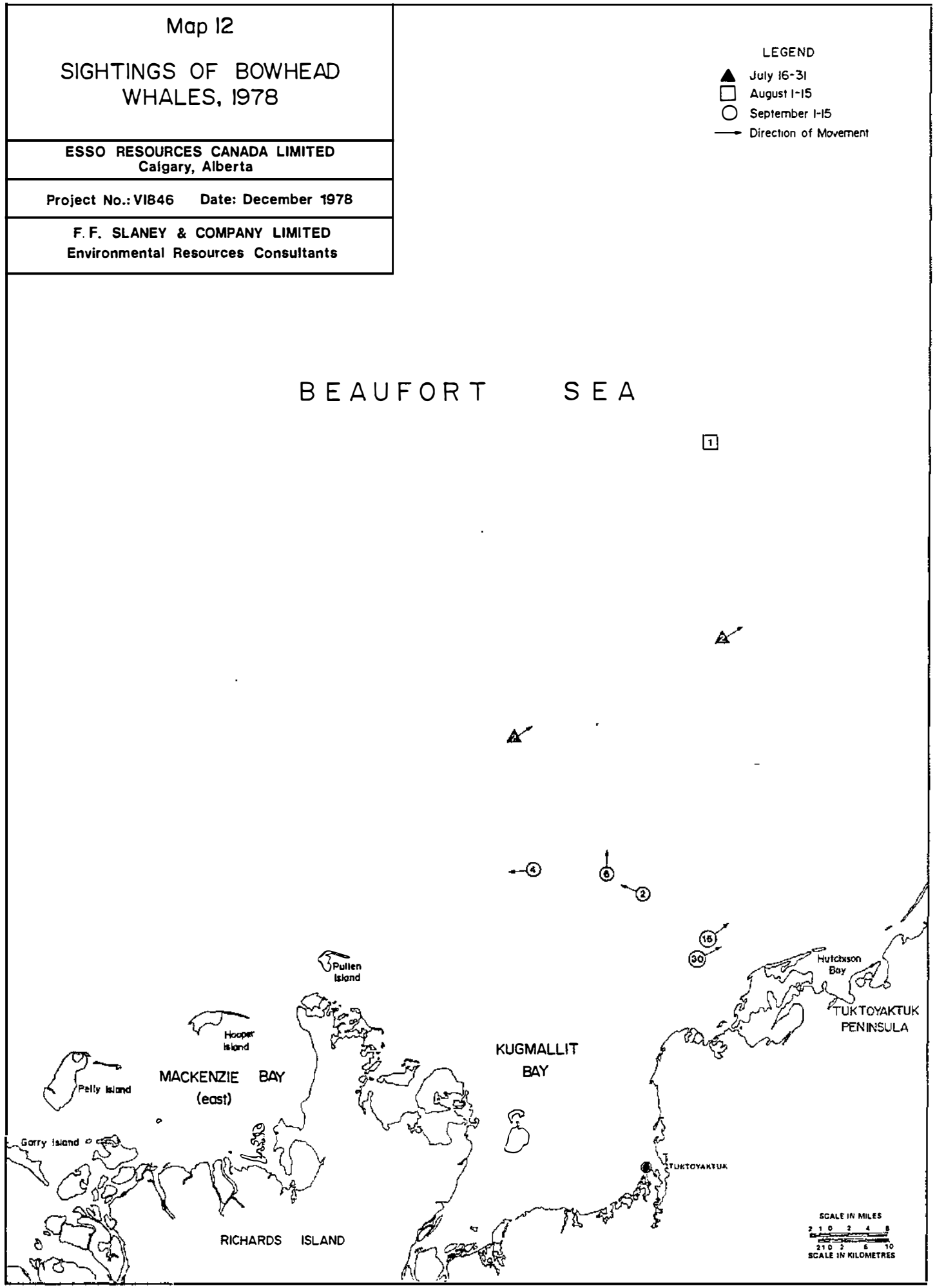

Table 8. Direction of movement and time period of sightings of bowhead whales, Mackenzie Estuary region, 1976-1978.

Time Period	Direction of Movement			
	W-NNW	N-ENE	E-SSE	S-WSW
16 - 31 July	2	4	2	0
1 - 15 August	0	1	3	1
16 - 31 August	3	7	1	2
1 - 15 September	5	2	1	0
16 - 30 September	4	0	0	0

the turn of the century, Bockstoce (1977, pers. comm.) has identified the region from Atkinson Point (at the eastern edge of the area covered in this study) to Cape Bathurst out to a depth of about 50 m as part of the primary summer range of bowheads. This is also an area of relatively high biological productivity as a result of the mixing of Mackenzie River discharge and oceanic water (Grainger 1975; Hsaio 1975; Fenco and Slaney 1978).

The bowheads observed in the past three years have been moving in a variety of directions (Table 8). Most sightings during July and August have been of bowheads heading east, while most sighted during September have been moving west. There are two possible explanations for the larger proportion of eastward moving whales in July and August. First, these may be late-migrating individuals which are just arriving in the eastern Beaufort Sea. Or these may be whales which have moved westward in offshore waters north of the Estuary, possibly to feed, and are returning eastward through nearshore waters. The westward-moving whales observed in late August and in September probably are migrating toward their wintering area in the Bering Sea.

PART 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

1. Landfast ice delayed the arrival of white whales at the Mackenzie Estuary in 1978 and apparently resulted in an unusual pattern of distribution. Approximately 95% of the whales were in Niakunak Bay and only about 5% in Kugmallit Bay after the whales first entered the Estuary. Once the water in the Estuary became less ice congested, there was apparently a movement of whales from Niakunak to Kugmallit Bay. However, the peak estimated number in Kugmallit Bay was less than half of that estimated in 1976 and 1977.

2. The peak number of white whales in the Mackenzie Estuary in 1978 was as great as those observed in previous years and was estimated to be on the order of 6000.

3. The observed geographical extent of concentration areas seen in 1978 in Niakunak and Kugmallit Bays was unchanged from previous years.

4. Hunting camps were established in the first week of July in Niakunak and Kugmallit Bays. Hunting camps at Kendall Island were not established until mid-July.

5. The whale harvest in 1978 was 121 which was lower than the mean of 141 for the previous six years. Adverse weather significantly interfered with hunting and caused it to be concentrated on 6 days in Kugmallit Bay. The resulting disturbance may have caused the whales to leave Kugmallit Bay earlier than usual.

6. Whales observed near various activities related to island-building operations did not show any significant adverse reaction. Similarily, the 1978 island-building operations had no detectable adverse effects on white whales in the Mackenzie Estuary.

7. Because of intensive hunting activity in the Hendrickson Island area of Kugmallit Bay, whales there are subjected to substantially more disturbance than are those in other areas of the Estuary. Currently, industrial activity is also greatest in Kugmallit Bay. Thus, the potential for adverse effects from hunting and/or industrial activities is currently greater in Kugmallit Bay than elsewhere in the Mackenzie Estuary.

6.2 RECOMMENDATIONS

These following recommendations derive directly from the 1978 studies. More comprehensive recommendations can be found in Fraker (1977 b).

1. The white whale monitoring program should be continued each year during the period when whales are present as long as offshore exploration continues. As with previous programs, future studies should include the following aspects:

   a. Because of the great influence which ice can have on the distribution and relative abundance of whales in the Mackenzie Estuary, ice conditions and the movement of whales to the Mackenzie region should receive continued attention.

   b. Aerial surveys of the major concentration areas in Kugmallit and Niakunak Bays during the first half of July in order to maintain a continuous series of comparable data on population size.

   c. Advantage should be taken of opportunities to gain more data related to the reproduction of white whales and to the possible biological significance of the concentration areas and other parts of the Estuary.

   d. All offshore exploration activities that could potentially affect white whales should be monitored in order to prevent adverse interactions between whales and Esso activities.

   e. The native hunt should be monitored in order to document the harvest, and to prevent interactions with Esso activities which might adversely affect the hunt.

   f. To further improve the understanding of the relative importance of disturbance of whales by Esso activities, further studies of the reactions of whales to native hunting should be conducted.

   g. In order to facilitate rapid communication between the whale biologist and Esso supervisors, the biologist should be provided with a radio using the same frequencies as the Esso network.

h. A native observer should be employed to serve as a second observer on whale surveys and to provide liaison at the whale hunting camps.

i. If marine traffic more intensive than that of 1977 or 1978 operates in the Tuft Point region, activities in this area should be monitored carefully.

2. A close liaison should be maintained with all other industry and Government whale research programs in the Beaufort Sea region to ensure data compatability, maximum information exchange, and cost effectiveness of programs.

3. Because bowhead whales have been observed in the vicinity of Esso operations in the deeper offshore waters in the Beaufort Sea in 1976, 1977, and 1978, possible effects of exploration on this endangered species should be studied. Many valuable data can be gathered from vessels and aircraft operating offshore, and personnel should be provided with whale sighting forms to ensure a systematic record of sightings of both bowhead and white whales. The data gathered by industry personnel should be supplemented by offshore aerial surveys of the region where Esso is operating and of adjacent areas.

4. Seven years of uninterrupted white whale data have been collected during Esso programs. If Esso is considering a long-term presence in the Mackenzie Estuary region, the following parameters should continue to be monitored on an annual basis.

   a. Length of whales taken in the harvest.
   b. Age of whales taken in the harvest.
   c. Reproductive data (ovaries and reproductive condition) from female whales taken in harvest.

   The purpose for collecting the above data is to be able to detect changes in the status of the herd which may result from industrial activities and/or the native hunt.

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