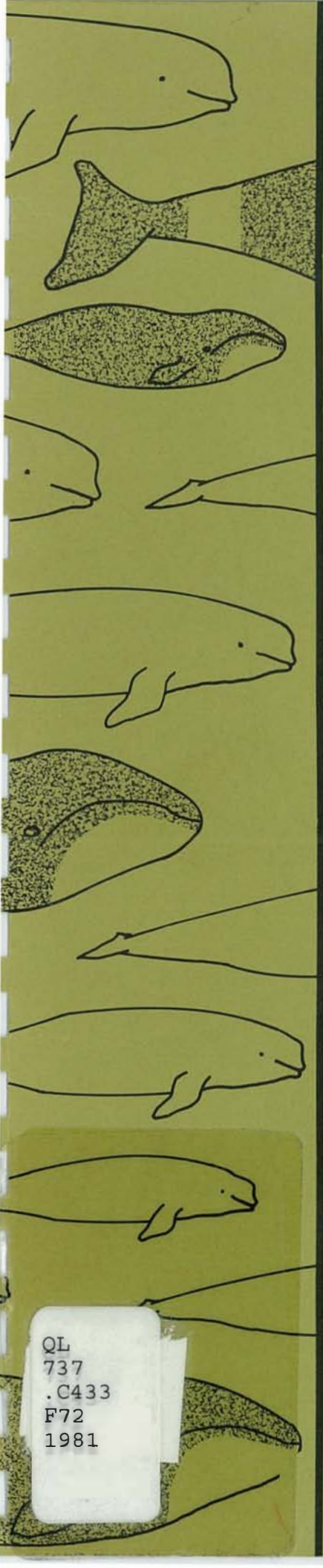

THE 1981 WHITE WHALE MONITORING PROGRAM MACKENZIE ESTUARY

by

LGL LIMITED
environmental research associates
Sidney, British Columbia

for

ESSO RESOURCES CANADA LIMITED
DOME PETROLEUM LIMITED
GULF CANADA RESOURCES INC.

CALGARY, ALBERTA

THE 1981

WHITE WHALE MONITORING PROGRAM,

MACKENZIE ESTUARY

by

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Calgary, Alberta

April 1982

Errata Sheet for THE 1981 WHITE WHALE MONITORING PROGRAM, MACKENZIE ESTUARY.

Page(s)	Correction
8, 2nd para., 1st sent.	'Out study area....' should read 'Our study area....'
15-18, legend	Dashes indicating edge of coverage for ice information should be in black rather than in red.
25	On the map Oliver Islands should read Olivier Islands.
46, Observations column, 23 July	'whales closest ~46 m to vessel founded...' should read 'whales ~46 m from vessel sounded...'

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April 1982

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

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Mr. Bill Cockney, Jr. served very ably as second observer on the aerial surveys, helped with the transcribing, accumulating and plotting of information and provided liaison during visits to the whaling camps as well as supplying thought-provoking ideas about the problems we noted. John Raddi was third observer on the aerial surveys and provided liaison with Tuktoyaktuk for the first half of the field season.

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We are grateful to the many families who provided generous hospitality during our visits to their camps; in particular Mr. and Mrs. Elijah Allen, Mr. and Mrs. George Allen, Mr. and Mrs. Jacob Archie, Mr. and Mrs. Bill Cockney, Sr. and Mr. and Mrs. Andy Kayotuk.

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We thank Dr. Rolph A. Davis (LGL Limited) for his rigorous review of this report. Ms E. White and Mrs. M. Hickey typed the report. Custom Drafting, Victoria, B.C., prepared the illustrations.

SUMMARY

Vessel traffic and other activities associated with hydrocarbon exploration in the Mackenzie estuary and offshore regions have the potential to adversely affect white whales and Inuit whale hunting. To ensure that negative interactions are minimized, a monitoring program was started in 1972; this is the tenth yearly report and is concerned primarily with activities occurring during the 1981 field season. Unlike previous reports, no information on bowhead whales is included; bowheads were the subject of separate studies of the offshore areas of the Beaufort Sea in 1981.

The landfast ice barrier across the Mackenzie estuary was first breached on 15 June in 1981, the earliest date recorded in ten years of study. The break was located about 25 km northwest of Shingle Point. The ice across Kugmallit Bay probably broke on 27 June. A survey along the landfast ice edge on 15 June revealed a small number of white whales, indicating migration to the estuary had already begun. Surveys from 18 to 26 June detected large numbers of migrating whales. No whales were observed migrating westward on the 4 July survey.

Whales were first reported in Niakunak Bay on 19 June, although some probably arrived on 17 June, and in Kugmallit Bay on 27 June. Maximum numbers were seen in both concentration areas on 6 July (2464 animals in Niakunak Bay and 1040 in Kugmallit Bay). The maximum estimated number of whales using the estuary on one day in 1981 was 3500. Very probably this estimate is well below the actual maximum because no productive flights could be made from 27 June to 5 July, which was the time when maximum numbers were expected to occur. There have been year-to-year variations in the estimated maximum, probably because of poor survey conditions when peak numbers were present. However, the 1981 figure was the lowest recorded since 1976, when the survey method was standardized.

During the ten years of study there have been major variations in the distribution of whales within the estuary. These variations appear to have been primarily the result of the timing of the ice break-up in the two concentration areas relative to the timing of the whale migration.

Most of the 1981 field effort focused on Kugmallit Bay -- the area which had most of the industry traffic and which sustained much of the whale harvest. No correlation was found between the number of whales landed by hunters from Tuktoyaktuk and the Kugmallit Bay camps and the number of vessel movements through Kugmallit Bay. The 1981 catch of 149 whales was the largest harvest since 1976 and was well above the nine year average of 131.

The 1981 harvest consisted of 61 males, 58 females, and 30 animals of unknown sex. There were significant geographical and temporal differences in the sex ratio of the catch. Since 1979 Kendall Island hunters have consistently landed a greater percentage of females than hunters from the Niakunak Bay camps. The sex ratio of the animals in this year's catch (1.05 males : 1 female) was statistically different from the sex ratio of animals taken in 1975, 1976 and 1978.

Of the 58 females landed, 10 were accompanied by newborns. Although firm data are lacking, this number is apparently greater than in previous years; the reasons for this are unknown.

No geographical or seasonal differences in mean lengths of landed males or landed females were observed. Year-to-year variations in the mean lengths of landed females were statistically significant but there was no trend. Year-to-year differences in lengths of harvested males were not significant.

Year-to-year, geographical, or seasonal differences have been observed in the sex ratio of the whale harvest and the mean lengths of landed males or landed females each year the results have been analyzed. However, the significant differences have not been consistent.

There were five situations in which concerns were expressed about possible industry interference with whales and/or whaling in 1981. Mitigative actions were taken by industry and to our knowledge none of the situations produced any lasting effects on the whales. One situation near Kendall Island may have resulted in a slightly lower harvest for that area in 1981; however, weather interfered with the ability of industry to take immediate effective mitigative action.

INTRODUCTION

Oil and gas exploration of the Mackenzie estuary and offshore areas began in 1972. This exploration has involved areas used by large numbers of white whales (*Delphinapterus leucas*) during part of the open-water season, particularly mid-June to early August. While in the estuary, the whales are the subject of a subsistence hunt by Inuit from Aklavik, Inuvik and Tuktoyaktuk. Because of the possibility for adverse effects, a long-term program to monitor whales and whale hunting was initiated when exploration began. From the beginning, a major emphasis of the study has been to collect baseline information on the whale population and the whale hunt. By 1981 nine years of data had been collected and the importance of gathering biological data was lessening. The emphasis of the 1981 whale monitoring program was to detect and mediate any adverse effects by industry; sufficient data on the number and distribution of whales and the success of the whale hunt were gathered to permit comparison with past years. (For more details on the biology of white whales, readers are referred to other reports: Fraker 1977a, 1977b; Fraker and Fraker 1979, 1981; Fraker *et al.* 1979.) The organization of this report reflects the change in emphasis: effects of industrial activities are presented throughout the discussion.

Since 1976, when oil and gas exploration began in the deeper offshore waters, the whale monitoring program has included bowhead (*Balaena mysticetus*) as well as white whales. In 1981 the importance of the far offshore activities increased to the extent that a separate bowhead whale study was funded by Dome Petroleum Limited, Esso Resources Canada Limited and Gulf Canada Resources Inc. Concurrently, in the same general area, bowhead projects were carried out for a consortium of Alaskan oil companies and the State of Alaska and for the U.S. Bureau of Land Management. Readers are referred to the reports of these studies for information on bowhead whales.

The first white whales arrive in the Mackenzie estuary from mid- to late June. The migration takes place over a two week time span and by late June-early July maximum numbers have gathered in the warm, shallow (<2 m) waters. For the next several weeks, large numbers of whales are found in specific and relatively small areas, termed 'concentration areas', although small groups of whales are also seen travelling toward and away from the estuary during

this time. By early to mid-August enough whales have left that low numbers of whales are found in the estuary at any one time. Starting in August the fall westward migration to wintering grounds in the Bering Sea begins.

The importance of the estuary is evident; however, its function for the white whales is not clear. Because whales are seldom seen feeding while in the shallow water, it seems more likely they are there to take advantage of the warm temperature and/or freshwater. Some calving may occur in the estuary, although females with newborn calves have been observed in areas east of the Mackenzie estuary. In the eastern Arctic, Finley and Johnston (1977) found one estuary, Coningham Bay, to be used primarily after the main period of calving. This suggests that the warm waters may be a good environment for neonates. The presence of adult males and females without calves suggests the estuary may also benefit adults. Finley *et al.* (1982) have suggested that immersion in freshwater may assist with moulting old skin.

While in the Mackenzie estuary the whales are hunted by Inuit from Aklavik, Inuvik and Tuktoyaktuk. A quarter to a third of the Inuit from Aklavik and Inuvik travel to traditional whaling camps, where they stay for anywhere from a few days to several weeks. Members of about 60 percent of the families in Tuktoyaktuk take part in excursions to the concentration area to get whales. These are usually one-day trips. The whale products are often traded and/or given to people who cannot participate in the hunt; thus the benefits of the white whale hunt are enjoyed by a large percentage of the Inuit in the Mackenzie Delta region.

Oil and Gas Activities

Currently three oil companies are active operators in the Mackenzie estuary region -- Esso Resources Canada Limited, Dome Petroleum Limited and Gulf Canada Resources Inc. Although some of the oil exploration and logistics occurred far offshore of the estuary in 1981, only industrial activities in areas less than 30 km from shore are relevant to this study. The study area included the white whale concentration areas and well-defined travel routes and the area with the highest density of industrial activity; thus we surveyed the areas with the greatest potential for adverse effects.

In 1981 Gulf's operations either commenced after the termination of the field portion of this program or were contracted to Canmar, a subsidiary of Dome, and are included in Dome's activities. Relevant activities of Esso and Dome involved the construction and maintenance of artificial islands, which are used as drilling platforms, and logistics for the work on the artificial islands and exploratory activities of drillships. In the study area in 1981 most dredging for fill material was done adjacent to the island sites. Barge camps provided housing close to most construction locations. Tugs, barges, other boats, helicopters and fixed-wing aircraft were used to transport personnel, supplies and equipment to the industrial sites. Seismic and coring programs were undertaken to define ocean floor topography and composition.

During the whale program (15 June to 7 August 1981), Esso completed dredging on one artificial island, Alerk P-23, and started on another, Itiyok M-17 (Fig. 1). A barge camp, 'Arctic Breaker', arrived at Alerk P-23 on 21 July and remained there beyond 7 August. Several tugs and barges carried personnel, supplies and equipment between Tuktoyaktuk and Alerk and Itiyok (Table 1). All traffic through Kugmallit Bay went by way of the sea buoy except for traffic between Tuktoyaktuk and Pullen Island (Fig. 1). A clean-up program at Ikattok J-17 and Adgo C-15 (Fig. 1) was carried out from 10 to 26 July. This operation involved four tugs, several barges and one barge camp which was anchored just west of Garry Island. The vessels involved in the clean-up operation were moved to Pullen Island for the period 27 to 31 July. A coring and seismic program was carried out around Itiyok and Isserk from 15 to 28 July and around Isserk and Issungnak from 4 to 11 August (Fig. 1).

Dome's 1981 exploration activities during the study period involved drilling from four drillships and construction of one artificial island, Tarsiut N-44. The drillships left their overwintering site in McKinley Bay during the period from late June to early July. Some of the drillships and support vessels initially anchored in leads seaward of the landfast ice until ice conditions allowed them to proceed to their drill sites farther offshore. Two of the drillships, which anchored offshore of Kugmallit Bay, were of concern to this study. Part of the dredging for Tarsiut N-44 occurred within the area of interest to this study at the South Tarsiut Borrow Site, which was located about 23 km northwest of Pelly Island (Fig. 1). The cutter

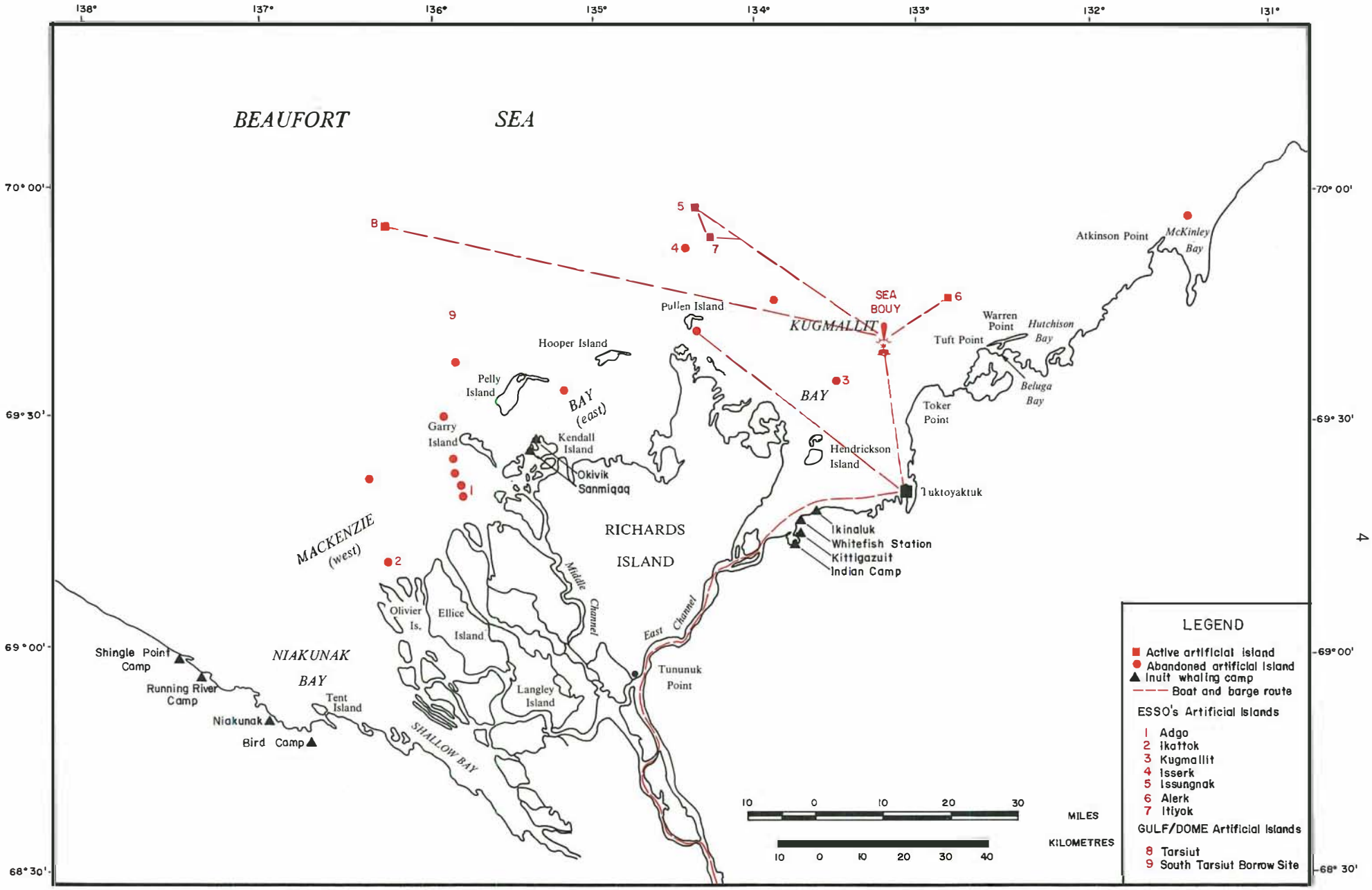


Figure 1. Location of activities relevant to this study, Mackenzie estuary region, summer 1981. (Only artificial island sites referred to in text are numbered.)

Table 1. Number of one-way passes of vessels through Kugmallit Bay, by company, 1981. (No information on traffic between Tuktoyaktuk and Inuvik is included.)

		Tuktoyaktuk - sea buoy			Tuktoyaktuk - Pullen Island
		Dome	Esso	Total	Esso
June	21	2	0	2	0
	22	1	0	1	0
	23	1	0	1	0
	24	2	0	2	0
	25	0	0	0	0
	26	1	0	1	0
	27	1	0	1	0
	28	9	0	9	0
	29	1	0	1	0
	30	3	0	3	0
July	1	4	0	4	0
	2	3	0	3	0
	3	3	0	3	0
	4	0	0	0	0
	5	1	0	1	0
	6	3	0	3	0
	7	4	0	4	0
	8	2	2	4	0
	9	3	0	3	0
	10	7	0	7	0
	11	3	1	4	0
	12	2	1	3	0
	13	4	2	6	2
	14	1	2	3	1
	15	3	2	5	0
	16	6	2	8	1
	17	1	2	3	0
	18	6	2	8	2
	19	3	3	6	0
	20	3	4	7	0
	21	2	10	12	0
	22	4	10	14	0
	23	4	10	14	2
	24	2	7	9	0
	25	5	7	12	0
	26	3	8	11	1
	27	2	7	9	1
	28	3	3	6	3
	29	0	2	2	3
	30	3	5	8	5
	31	1	6	7	2
August	1	5	7	12	2
	2	2	2	4	0
	3	3	1	4	0
	4	2	9	11	2
	5	6	8	14	0
	6	6	2	8	0

suction dredge 'Aquarius' operated at this site from 12 July to 12 August. Five split hopper barges transported dredged material from the borrow site to the Tarsiut island site. The dredging operation required a barge camp, Camp 208, near Pelly Island (Fig. 1) from 18 July to 12 August. The 16.1 m crew boat, 'Imperial Adgo', was used to carry personnel and supplies between Camp 208 and the South Tarsiut Borrow Site; at least two round trips per day were made. There was frequent traffic from Tuktoyaktuk harbour to the sea buoy and then offshore, in support of the operations at the Tarsiut island site and on the drillships. The only relevant Dome seismic surveys in near-shore areas were conducted immediately adjacent to the northeast corner of Herschel Island (see Fig. 3) for one week in the middle of July.

Esso, Dome, Gulf and at least five other companies used the barge route between Tuktoyaktuk and Inuvik in 1981. This traffic passes through the southernmost part of the white whale concentration area around Hendrickson Island (see Fig. 6). However, the 1981 frequency of use of this vessel route is not included because of the difficulty in obtaining complete information regarding vessel movements between Tuktoyaktuk and Inuvik. Also, whale hunters have not raised complaints about interference of whale movements by this traffic.

Objectives

The overall purpose of the whale monitoring program is to prevent adverse interactions between activities by Esso, Dome and Gulf and white whales and Inuit whale hunting. To achieve this, information is required on white whale distribution, movements, abundance and reaction to human activities. The specific objectives of the 1981 study were:

1. to determine the timing of the whale migration to the estuary relative to the timing and pattern of ice break-up;
2. to determine the distribution and abundance in, and movements between, various parts of the estuary;
3. to maintain good communication with Inuit hunters through camp visits so possible interferences with hunting could be detected early and appropriate responses made;

4. to document the size of the Inuit whale harvest and gather statistics on length and sex of landed animals;
5. to monitor various exploration-related activities in order to be able to identify possible problem areas;
6. to estimate the maximum number of whales using the estuary; and
7. to record incidental sightings of the reactions of whales to any human activity.

METHODS

The 1981 field program began on 15 June and continued to 7 August. Reconnaissance and systematic aerial surveys and interviews with hunters provided most of the data. The intensity of survey effort in each of the whale concentration areas in the estuary has varied from year-to-year, depending on the location of industry activities and gaps in basic white whale information. In 1981, initially most effort was expended determining the timing and location of the whale migration relative to the timing and location of breachings in the landfast ice that blocks access to the estuary. Subsequent investigations focused on Kugmallit Bay and adjacent nearshore areas of the Tuktoyaktuk Peninsula to McKinley Bay, the areas with most of the industry traffic. Some surveys were carried out in Niakunak Bay to obtain a more complete estimate of the maximum number of whales using the estuary in 1981. Plans for surveying East and West Mackenzie bays during late June-early July, to increase the completeness of the maximum estimate, were not carried out due to poor weather. East Mackenzie Bay was surveyed only once, late in the season, when there were questions about whales in relation to the location of a barge camp. No surveys were conducted this year in West Mackenzie Bay. Unlike previous years, in 1981 offshore areas were not systematically surveyed after the ice retreated; these surveys were conducted as part of an extensive program funded by Esso, Dome and Gulf.

Study Area

Our study area is defined as that area included in systematic surveys (Fig. 2); additional areas are covered during the spring migration reconnaissance surveys. To facilitate discussion of the 1981 data, five sub-areas have been specified. These are:

1. Niakunak Bay - the portion of West Mackenzie Bay lying north of a line running between the mouth of West Channel and the northern tip of the southernmost Olivier Islands and south of a line running from Shingle Point to the outermost part of the Olivier Islands;
2. Barrier Islands - Garry, Pelly, Hooper and Pullen islands;
3. East Mackenzie Bay - the area landward of the Barrier Islands;

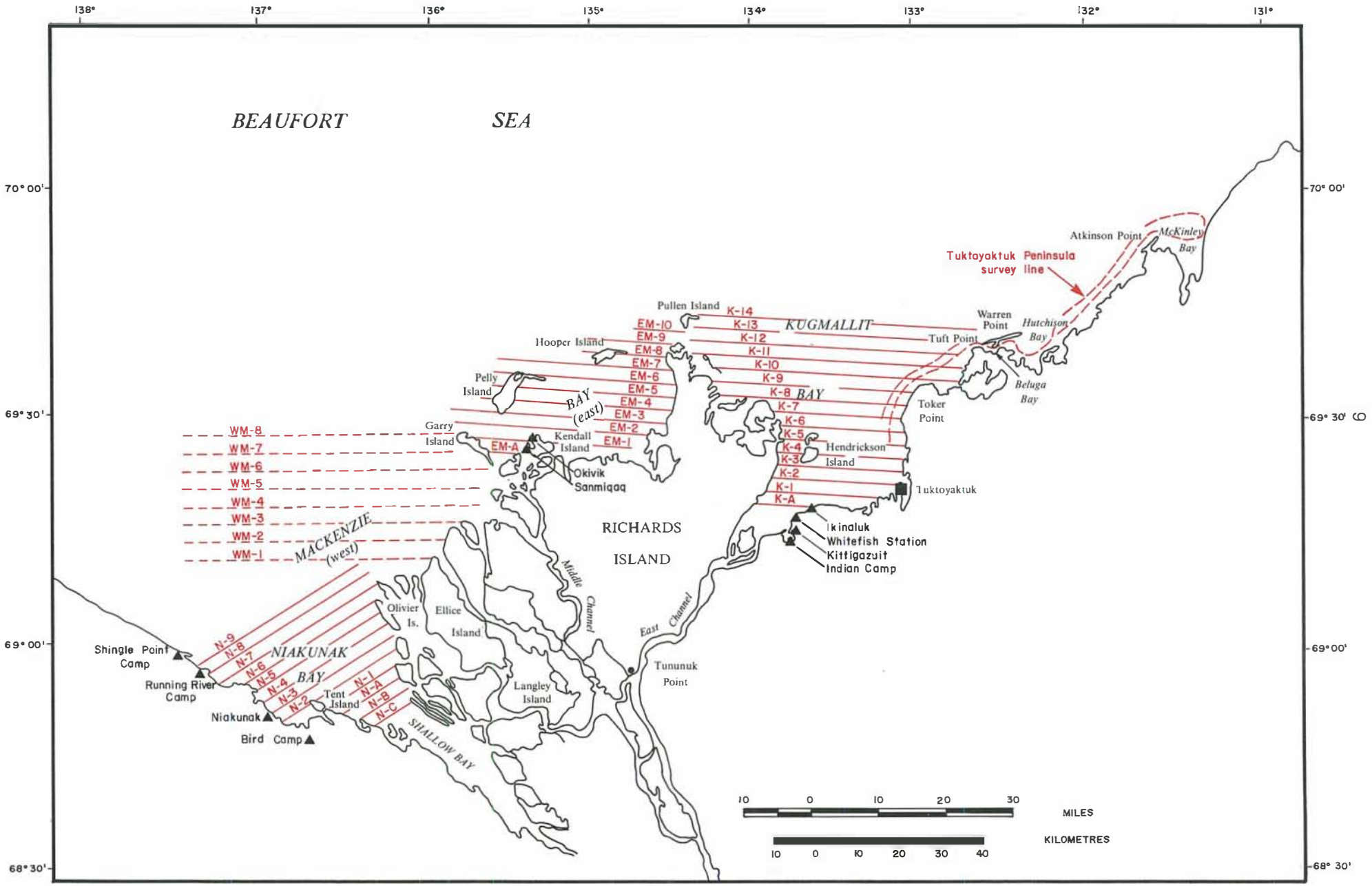


Figure 2. Standard survey lines, Mackenzie estuary and Tuktoyaktuk Peninsula, 1976-1981. (Dashed lines indicate West Mackenzie Bay survey area; this area was not surveyed during the 1981 program.)

4. Kugmallit Bay - the seaward boundary extending between approximately Pullen Island and Warren Point; and

5. Tuktoyaktuk Peninsula coastal area - the nearshore area along the Tuktoyaktuk Peninsula extending seaward for approximately 10 km.

Systematic Surveys

Systematic aerial surveys were conducted to obtain data on the distribution, relative abundance, behaviour, and movement patterns of whales. Transect lines across the areas surveyed in 1981, Niakunak Bay, Kugmallit Bay and East Mackenzie Bay, were spaced at 3.2-km intervals (Fig. 2). A standard flight track was flown along the Tuktoyaktuk Peninsula. The standard survey lines were first established in Kugmallit and Niakunak bays and off the Tuktoyaktuk Peninsula in 1976, and in East Mackenzie Bay in 1977.

A float-equipped Cessna 185 aircraft was used for all surveys. An altitude of 305 m and an airspeed of 193 km/h were maintained on all flights. The two observers, one in the right front seat and the other in the left rear, used digital watches that were synchronized before each survey. Times were recorded to the closest 15 s at the start and finish of each line and at landmarks along the way; total numbers of whales observed during each 15-s interval were recorded so that sightings could be plotted to within approximately 0.8 km. Surveys were conducted as often as weather allowed. Because of changes in weather, it was not always possible to complete each survey on each attempt, and therefore, the actual area surveyed was variable. The survey flights were timed so that the sun was either in front of or behind the aircraft in order to minimize glare on the water for 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 which generate rough water; there may be glare, and air turbulence may interfere with both navigation and whale observation.

Visibility conditions were taken into account in interpreting the results of each survey. Estimates of whale numbers are from surveys conducted under good or excellent visibility conditions, unless otherwise noted. Surveys flown under fair or poor conditions may also provide valuable data on distribution, movements, and behaviour.

From an altitude of 305 m it is possible to see whales up to 2 or 3 km away under favourable conditions. To keep the surveys consistent, only those whales seen within a 0.8 km-wide strip along each side of the aircraft were used to calculate estimates of numbers. In order for each observer to accurately determine the outer limit of the 0.8 km strip at the water surface, trigonometry was used to calculate the appropriate angle of view, taking into consideration the area obstructed by the float. Using an inclinometer the upper limit of this angle was marked with tape on the strut. Cassette tape recorders were used to record all data. Data were transcribed onto standard forms and plotted onto maps.

Reconnaissance Surveys

Reconnaissance aerial surveys were used to examine large areas during the spring migration period. These surveys were flown in a twin-engine Britten-Norman Islander, generally at an altitude of 457 m and an airspeed of 193 km/h. If we circled a group of whales, the altitude was increased to 610 m. Procedures during reconnaissance flights were similar to those during systematic surveys. During reconnaissance flights the extent of the ice cover was mapped. This information was modified and expanded using satellite imagery and ice maps prepared by the Beaufort Weather and Ice Office in Tuktoyaktuk.

Estimation Procedures

Because white whales are invisible beneath just a few centimetres of the highly turbid Mackenzie water, an accurate estimate of the number of whales present depends on knowing what proportion is at the surface at any one time. Unfortunately, this proportion is not precisely known and undoubt-

edly varies with the whales' activity. Sergeant (1973) watched white whales from a cliff near Churchill, Manitoba, and observed that they spend about one third of the time at the surface; thus, he applied a visibility factor of three to his counts to arrive at an estimate of total numbers. Sergeant's visibility factor assumes an instantaneous count of whales for any given area. As the period of observation increases, a greater number of whales will be seen as they come to the surface. If we had restricted our observations to approximate 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 information on distribution was an important objective of this study. By viewing objects while flying over land, Fraker (1976) determined that any given point is in view for about 15 sec using the standard observation technique. To compensate for the fact that the assumption of an instantaneous count of whales was not met, Sergeant's visibility factor was reduced from three to two, and this factor has been applied consistently in whale studies in this area since 1975. It must be emphasized that the resulting figures should be treated as relative indices rather than unbiased estimates of abundance. Calves are not included in the estimates because the dark calves are not reliably detectable in the turbid water, even when they are at the surface.

Usually individual whales are continually surfacing and then submerging out of sight. In a few instances, however, most whales have been observed to remain at the surface, and apparently few have been below the surface where they could not be seen. When a larger-than-normal proportion of the whales was at the surface, the numbers of whales observed have been strikingly larger than the numbers usually seen. In such cases, no visibility factor has been applied.

The transect lines in Kugmallit, Niakunak, and East Mackenzie bays are 3.2 km apart and the transect width is 1.6 km or 50% of the total area. Thus, an extrapolation coefficient of two was applied to the total number of whales actually observed to allow for whales assumed to have been present in the unsurveyed area. For the few surveys with only one observer present, the extrapolation coefficient was doubled to allow for the additional unsurveyed area.

Estimates of the number of white whales in the Mackenzie estuary may be affected by variables other than the proportion of whales at the surface. Different observers and the use of different aircraft could also affect the number of whales counted. These sources of variation have been reduced as much as possible. The same seats of the same type of aircraft have been used for surveys during the period when the highest numbers have been recorded. The same two observers conducted the surveys when the highest numbers were recorded in 1976 to 1980; two different observers conducted the surveys in 1981.

Visits to Hunting Camps

We visited all occupied whaling camps every two to four days to ascertain hunting effort and success and to learn of any possible interference with hunting by exploration activities. If landed whale carcasses were present, we obtained at least a minimal set of observations (consisting of total length and sex). Length was measured in a straight line from the tip of the snout to the tail notch. Canada Fisheries and Marine Service hired six local persons who were stationed in the various hunting camps to assist in collecting data related to the harvest. We co-operated and exchanged information with these observers.

Observations by Industry and Other Personnel

Important observations were made by various persons on boats, in aircraft, or on the barge camps. These observations were recorded on standard forms and were submitted at the end of the field season. Data recorded included location and numbers of whales, date and time, direction of movement, distance from and reaction to vessels, and remarks on feeding or other behaviour. These observations often covered geographical areas and/or time periods not included in our field program or when we were grounded by weather.

RESULTS

Ice Break-up and Spring Migration

The Mackenzie white whale stock winters in the Bering Sea (Fraker 1979). Beginning in April, these whales migrate north and northeast along the northwest coast of Alaska to Point Barrow; from there they follow leads far offshore to Amundsen Gulf and/or the section of the Beaufort Sea west of Banks Island (Braham and Krogman 1977; Fraker 1979). In middle to late June the southwest migration to the Mackenzie estuary begins. Late-migrating whales may travel more or less directly to the estuary from Point Barrow, without first travelling farther east. The timing of all phases of the migration appears to be determined principally by the timing of lead formation and ice break-up.

White whale access to the Mackenzie estuary is prevented by the sheet of landfast ice that extends across the outer part of the estuary. In 1981 this ice was first breached in West Mackenzie Bay, about 25 km northwest of Shingle Point, between 2130 and 2230 on 15 June (Fig. 3A). At that time the narrowest point in the band of ice stretching across Kugmallit Bay was 31 km wide. Although the entire length of the edge of the landfast ice, from Komakuk to Baillie Islands, was flown on 15 June, only 31 white whales were observed, indicating that the migration was not yet fully underway. No whales were observed landward of the break in the landfast ice.

The direction the 31 whales were travelling indicated they were coming from Amundsen Gulf. Assuming an average speed of 8 km/h, a conservative estimate of rate of movement in the eastern arctic (Koski and Davis 1979) that is within the limits defined by Kleinenberg *et al.* (1964), and a straight-line distance of 308 km between Baillie Islands and the most westerly whales observed, the migration must have started at least 38 hours before the time of the survey of 15 June. This means that the white whale migration out of Amundsen Gulf - southeastern Beaufort Sea area probably was underway by 14 June in 1981.

By 18 June whales had easy access to Niakunak Bay; however, Kugmallit Bay was still ice-bound (Fig. 3B). North of the estuary we observed a total of 75 white whales heading westward, although fog prevented surveying the ice edge farther east than Kugmallit Bay.

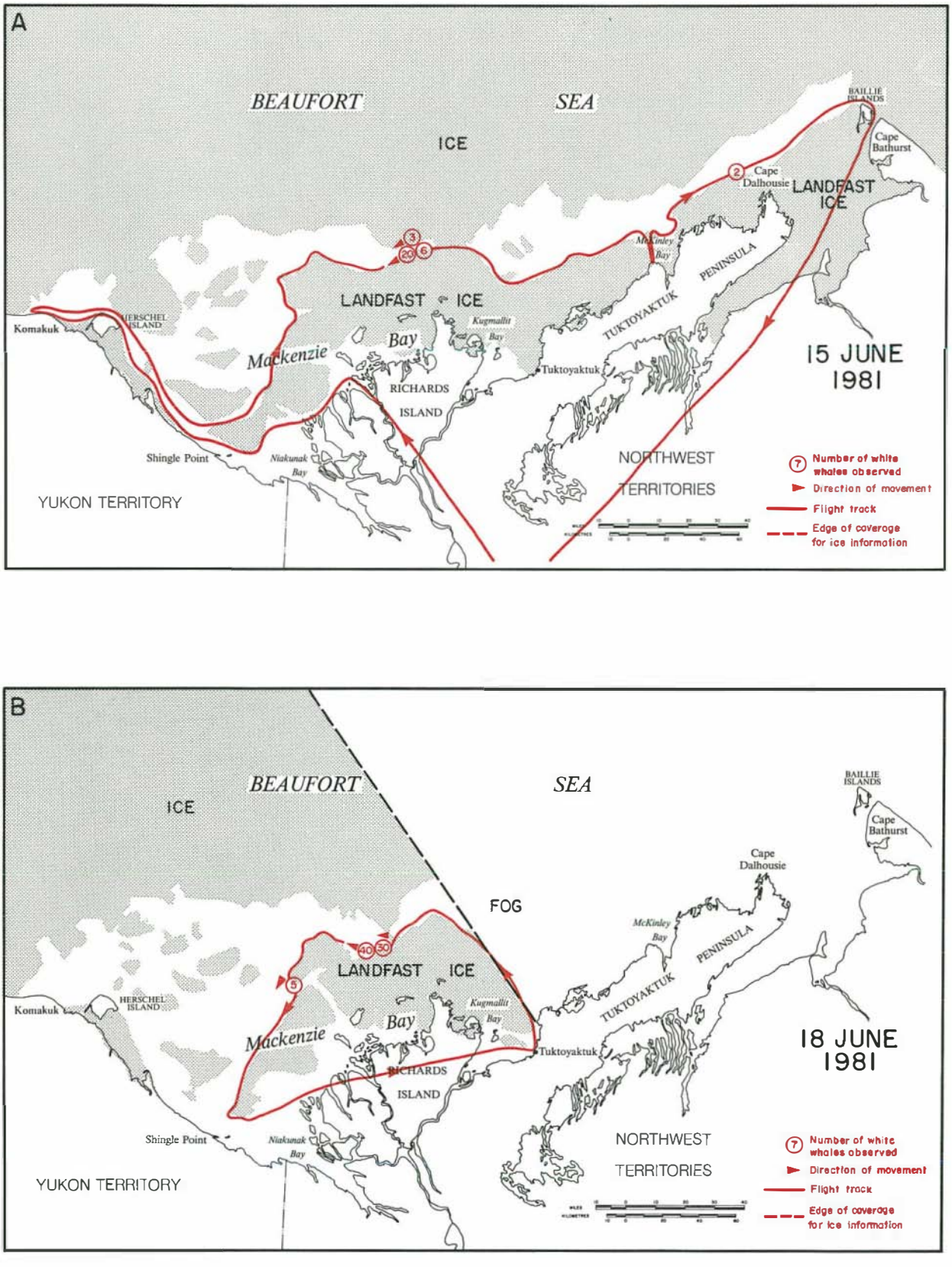
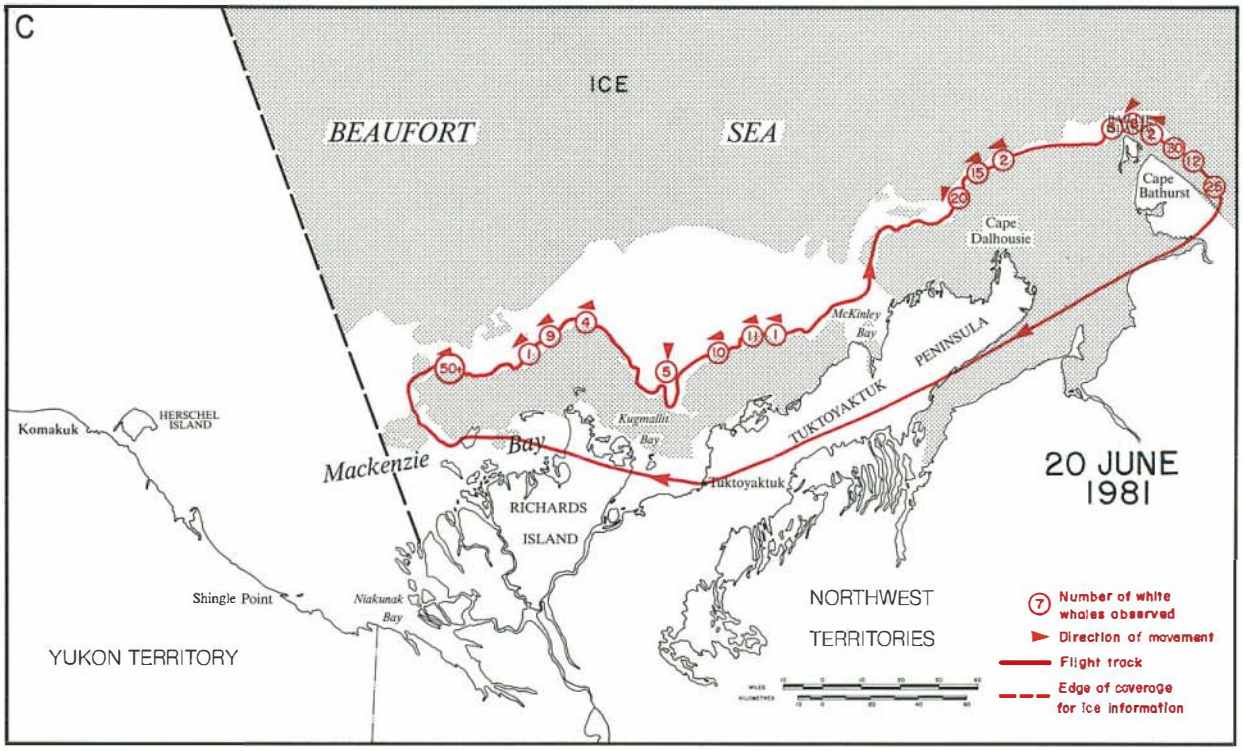


Figure 3. Results of spring migration surveys, 1981.



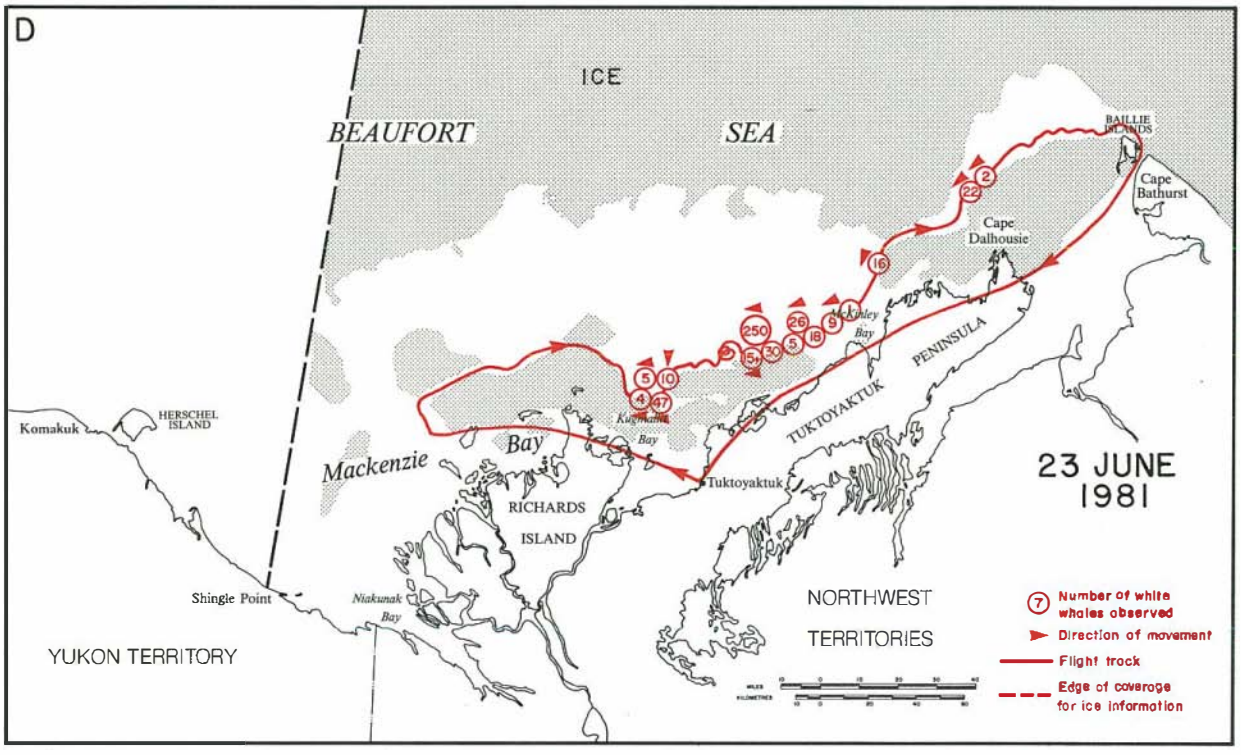
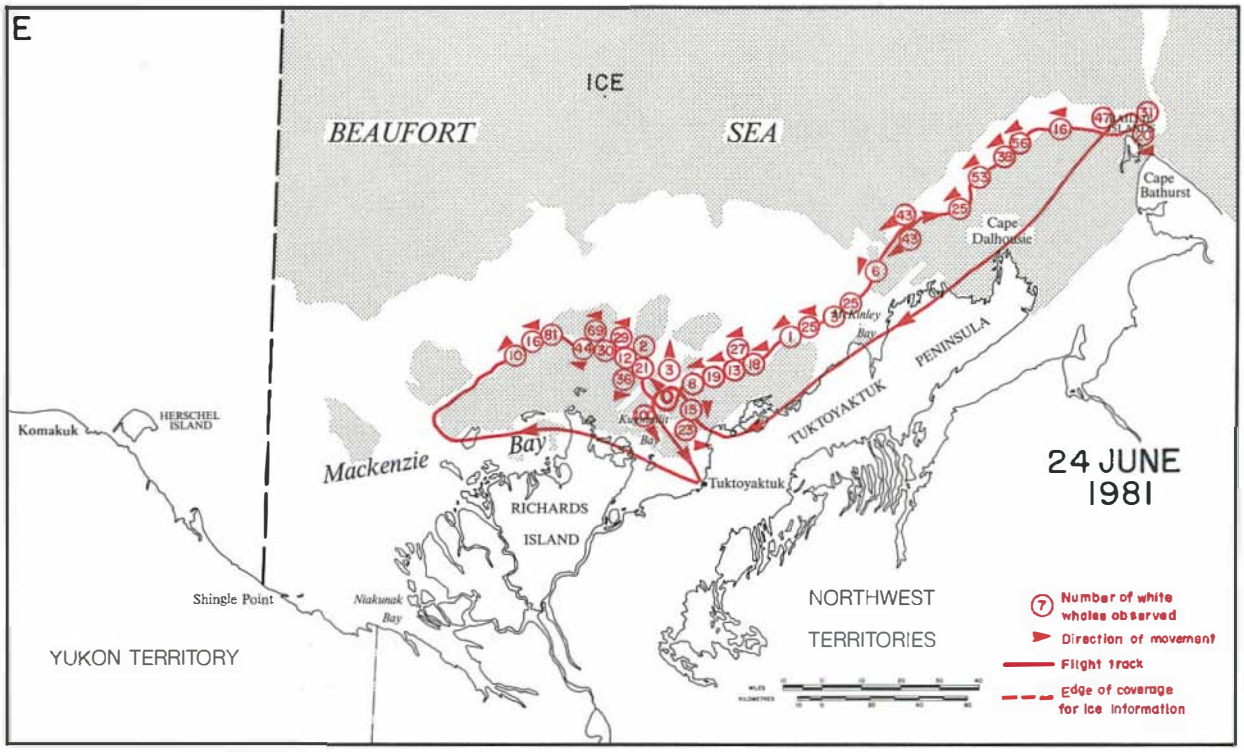
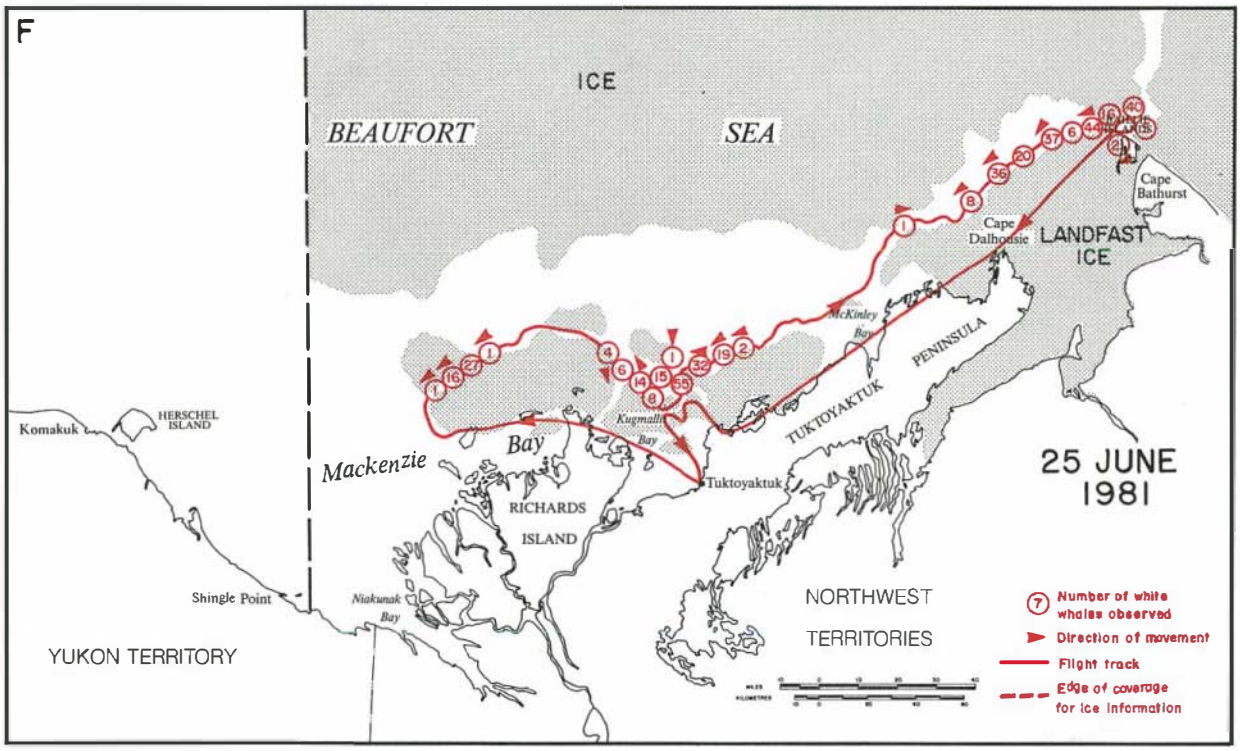


Figure 3. Continued





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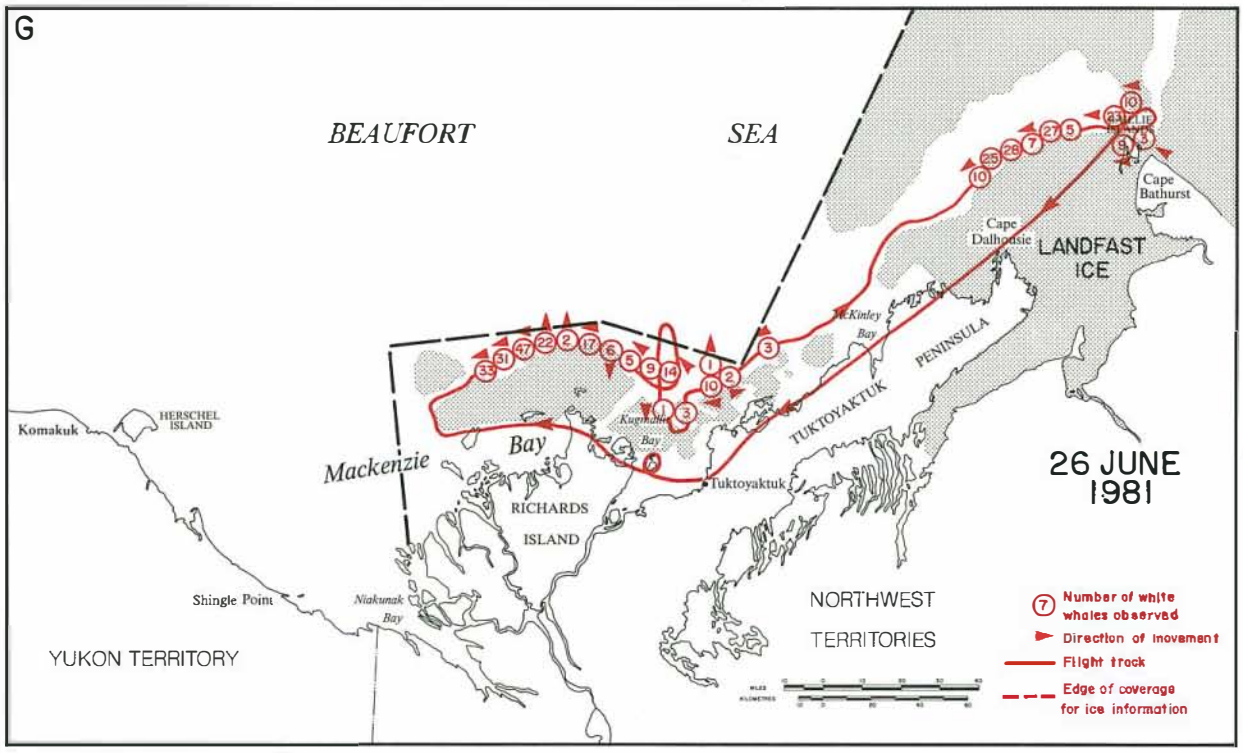


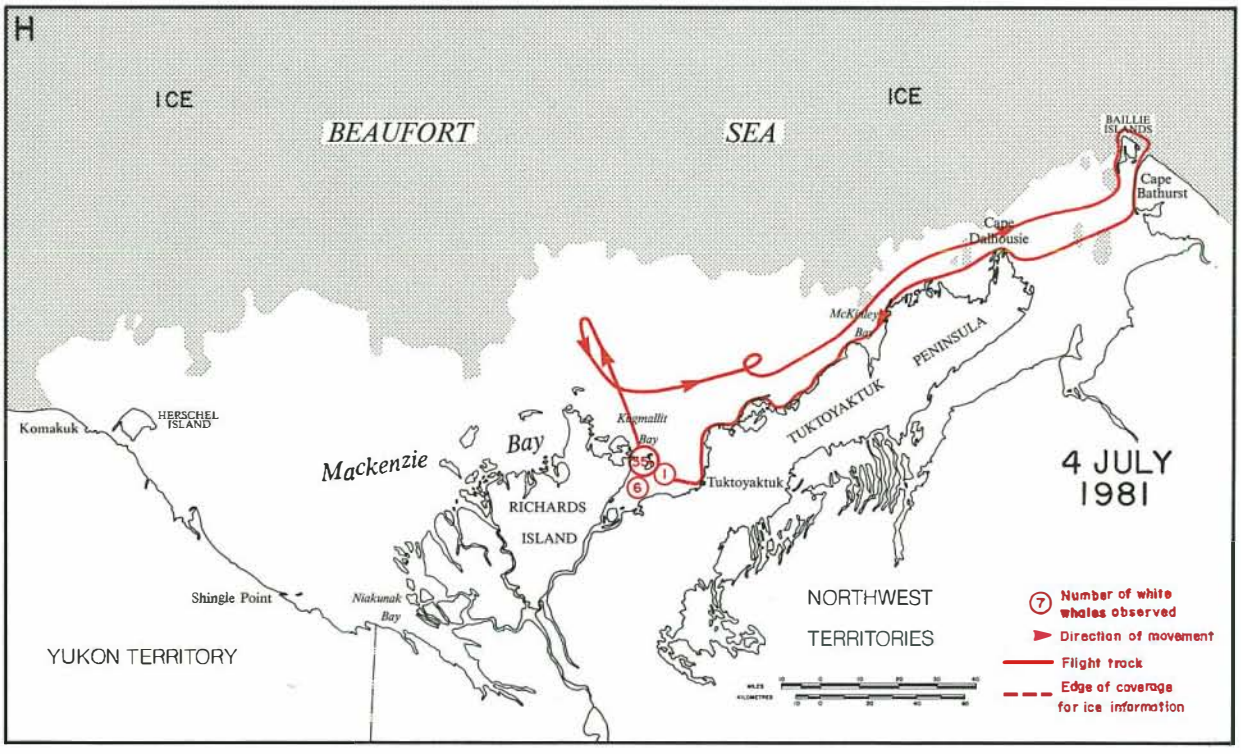


Figure 3. Continued

More whales were seen on 20 June when 220 animals were sighted from north of Pelly Island to southeast of Cape Bathurst (Fig. 3C). Many whales were sighted in openings in the ice on the southeast side of Cape Bathurst. Most were travelling toward the estuary along the ice edge.

By 23 June, the whale migration was well underway; 460 whales were sighted during our survey (Fig. 3D). The observed peak of the migration occurred on 24 June when over 1000 whales were seen between Pelly Island and Baillie Islands (Fig. 3E; Table 2). Fewer animals were sighted during surveys on 25 June (Fig. 3F) and 26 June (Fig. 3G). Poor weather precluded surveys from 27 June to 3 July. We saw no whales during the survey on 4 July (Fig. 3H), indicating that the migration to the Mackenzie estuary was essentially complete.

The ice across Kugmallit Bay most likely broke on 27 June; cloud cover interfered with the satellite imagery on 26 to 28 June, but at 2100 26 June, we observed that the band of ice across Kugmallit Bay was still intact. This ice was well fractured by 29 June (L.G. Spedding, Esso Resources Canada Limited, pers. comm.). Whales were first reported in Kugmallit Bay on 27 June (B. Cockney, Sr., pers. comm.) indicating the ice had broken by that time. Clearly the migration was well underway by the time Kugmallit Bay became accessible to whales in 1981.

The 1981 whale migration spanned at least 14 days. The migration probably did not start much before 14 June and continued through to at least 27 June. By 4 July the migration appeared to be over.

Breaching of the fast ice barrier across the Mackenzie estuary occurred earlier in 1981 than in any year from 1972 to 1980 (Table 3); no information is available prior to 1972. The known date of first break-up has ranged from 15 June (1981) to 10-11 July (1974). In general, 1973, 1977, 1979 and 1981 were early years for ice break-up while 1974, 1978 and probably 1976 were late years. During most years, whales have had access to Niakunak and Kugmallit bays at about the same time, but in 1972, 1979 and 1981 Niakunak Bay was accessible long before Kugmallit Bay opened.

When the fast ice barrier broke on 15 June, we found a small number of whales moving toward the estuary (Fig. 3A). The 29 animals seen north of

Table 2. Number of white whales sighted along the landfast ice edge during aerial reconnaissance surveys, June-July 1981.

Date	Number of whales sighted
15 June	31
18 June	75
20 June	220
23 June	460
24 June	1008
25 June	435
26 June	353
4 July	0

Table 3. Approximate dates when ice barrier was breached, first white whales arrived, and 'many' whales arrived, Mackenzie Bay and Kugmallit Bay, 1972-1981.

	Date ice barrier was breached		Date first whales arrived		Date of survey when 'many' whales arrived**	
	Mackenzie Bay	Kugmallit Bay	Mackenzie Bay	Kugmallit Bay	Mackenzie Bay	Kugmallit Bay
1972	NA*	NA*	late June	15 July	NA	NA
1973	22-23 June	27 June	26 June	27 June	NA	NA
1974	10-11 July	10-11 July	11 July	11 July	NA	NA
1975	late June	late June	26 June	30 June	NA	NA
1976	NA	NA	3 July	1 July	11 July	13 July
1977	17 June	NA	30 June	4 July	6 July	4 July
1978	5 July	5-6 July	6 July	8 July	7 July	13 July
1979	19 June	1 July	19-20 June	2 July	23 June	10 July
1980	27 June	30 June	27-28 June	4 July	30 June	***
1981	15 June	27 June	16 June	27 June	6 July	6 July

* NA means that insufficient data were collected to determine even an approximate date.
** The date of the first survey when more than 50% of the maximum for that area that year were estimated is the date when 'many' whales arrived.
*** Too few whales used this area to ascertain a date when 'many' whales arrived.

Hooper Island probably reached the breach in the ice and entered the estuary on 17 June. Thus, whales probably arrived at the estuary earlier in 1981 than in any other year of study (Table 3). Generally, 'many' whales (defined as over 50% of the maximum estimated in that area that year) arrive within a week of the time of arrival of the first whales. The increase in numbers can be very rapid, e.g., 1978 in Niakunak Bay (Fig. 4).

Generally whales enter Niakunak Bay before Kugmallit Bay because the west side of the estuary usually becomes accessible before the east side. The only known exception occurred in 1976 when whales were first recorded in Kugmallit Bay on 1 July, while none were reported in Niakunak Bay until 3 July.

Survey Areas

Niakunak Bay

In 1981, surveys of Niakunak Bay were designed to estimate peak numbers of whales in the estuary and thus were restricted to the late June-early July period. Fog and wind limited the number of surveys.

No whales were observed landward of the break in the landfast ice on the 15 June reconnaissance survey. However, during that survey westward-migrating whales were observed 197 km (distance along ice edge) east of the break in the ice (Fig. 3A). Assuming an average speed of 8 km per hour, the first whales could have arrived in Niakunak Bay on 17 June. An estimated 164 whales were present in Niakunak Bay during our first systematic survey on 19 June (Table 4; Appendix 1). Survey conditions on 21 and 29 June were too poor to allow numerical estimates; however, there was an obvious increase in numbers between 21 and 29 June. The peak estimate for Niakunak Bay in 1981, 2464 animals, was obtained on 6 July. After this date, there was an apparent decrease and by 11 July, an estimated 1864 white whales remained.

The 1981 Niakunak Bay whale concentration area was, for the most part, within the area used by white whales during 1976 to 1980 (Fig. 5); however, in 1981 whales utilized slightly more of the area just west of the Olivier Islands than in previous years. Year-to-year differences in the specific areas utilized are common.

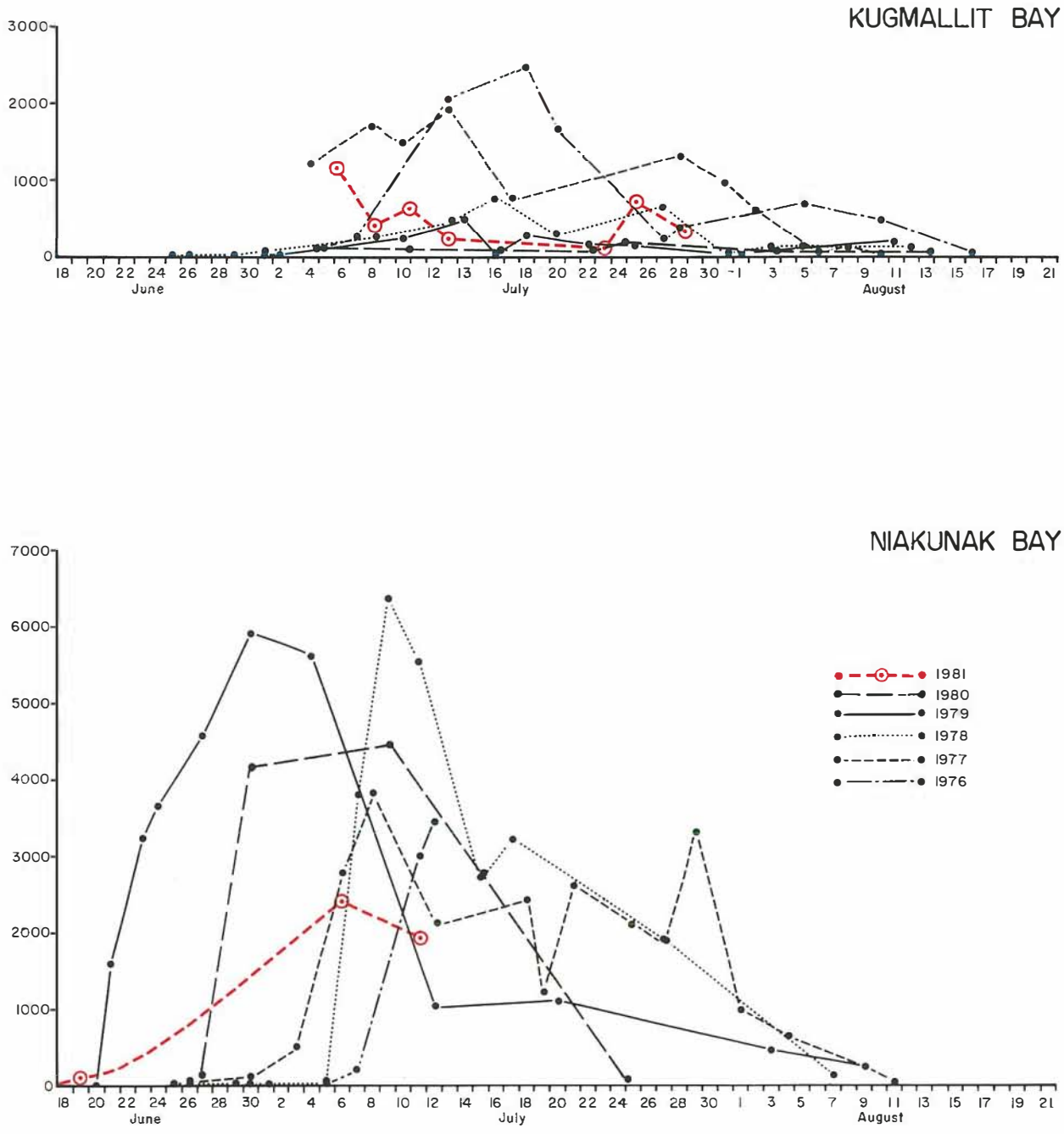


Figure 4. Estimated numbers of white whales in Kugmallit Bay and Niakunak Bay, 1976-1981.

Table 4. Results of systematic whale surveys in Niakunak Bay, 1981.

Date	Lines flown	Observation conditions	Whales observed	Extrapolation coefficient*	Visibility factor**	Estimated numbers
19 June	N-C to N-7	Excellent (N-C to N-5) Good (N-6 to N-7)	41	2	2	164
21 June	N-C to N-7	Good (N-C to N-4) Fair (N-5 to N-7)	11	-***	-	-
29 June	N-C to N-8	Fair (N-C to N-5) Poor (N-6 to N-8)	420	-***	-	-
6 July	N-C to N-9	Excellent	616	2	2	2464
11 July	N-A to N-9	Excellent	466	2	2	1864

* An extrapolation coefficient of two was used to account for the unsurveyed area between transect lines.

** A visibility factor of two was used to account for whales unseen beneath the water surface.

*** No population estimate calculated.

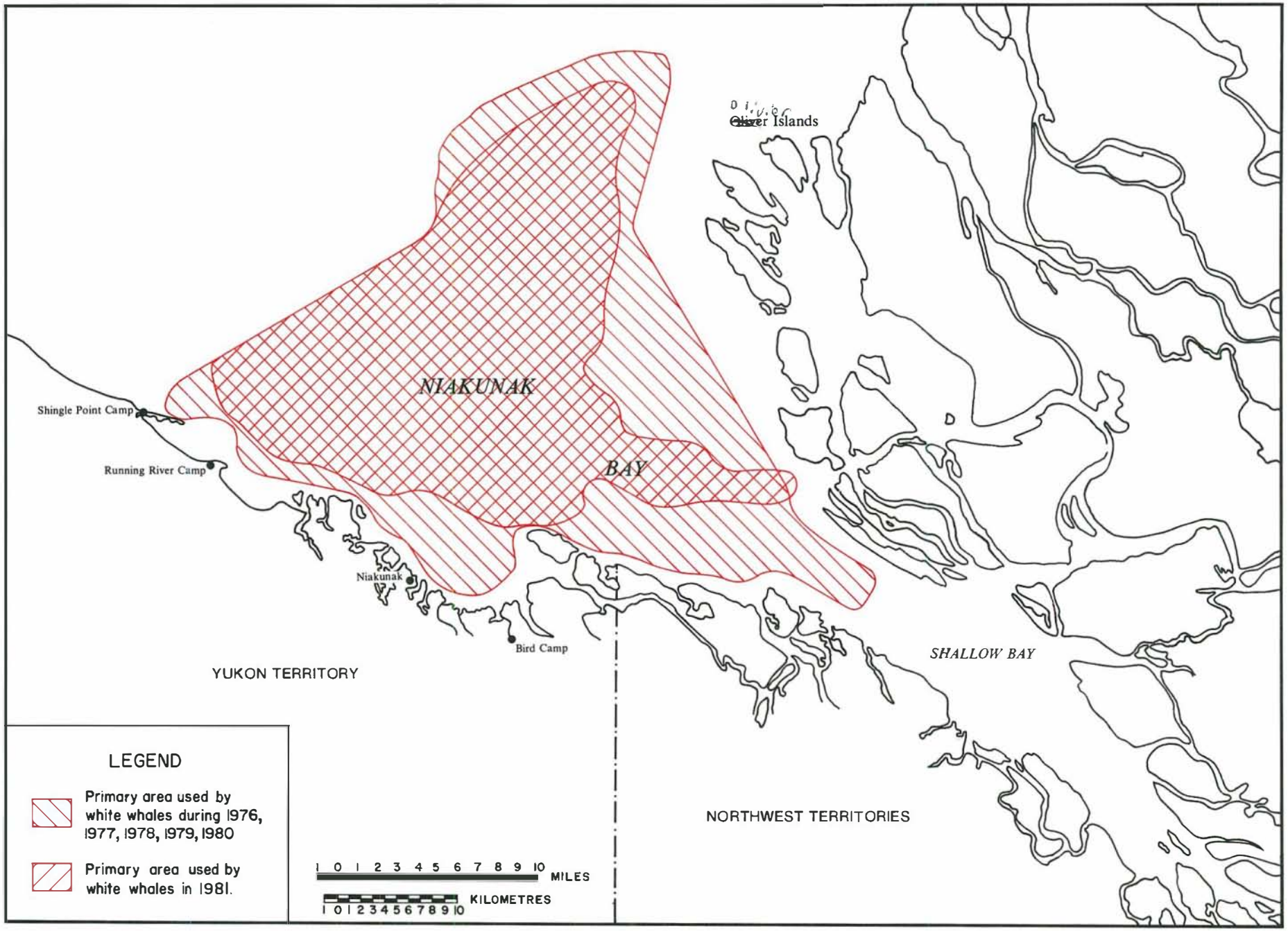


Figure 5. The extent of the Niakunak Bay white whale concentration area, 1976-1981.

The peak estimate of number of whales in Niakunak Bay was lower in 1981 than in 1976 to 1980 (Fig. 4). Given the general pattern of a fairly rapid increase in numbers, it is probable that the peak number of whales using Niakunak Bay in 1981 was missed during a period of poor weather and therefore was underestimated. From 1977 to 1979, Niakunak Bay was surveyed frequently during the initial period whales were in the estuary. The time between the arrival of the first whales and the survey which produced the peak estimate varied from three days (1978) to 11 days (1979) (Table 5). Peak numbers in Niakunak Bay in 1981 then would have been expected on or before 28 June. A large number of whales (420) were observed in Niakunak Bay on 29 June, when visibility was seriously impaired by whitecaps. Other researchers have observed that wind speed and sea state (= whitecaps) affect marine mammal censusing and have suggested a partial solution would be to reduce the transect width (Eberhardt *et al.* 1979). If the effective transect width was reduced because of the sea state on 29 June, it is very likely more whales were in Niakunak Bay on 29 June than on 6 July. Therefore, the observed peak number of whales using Niakunak Bay on 6 July 1981 was probably an underestimate.

Kugmallit Bay

Because Kugmallit Bay has most of the industry vessel traffic, the greatest potential for adverse interactions between exploration and whales and whaling exists there. This area normally sustains much of the whale harvest. In addition, the harvest here was poor in 1980, and there was widespread concern that this was a consequence of industry activities. For these reasons Kugmallit Bay was frequently surveyed in 1981 -- by reconnaissance surveys before 27 June and by systematic surveys after 5 July. Poor weather precluded surveys from 27 June to 5 July.

No whales were seen in Kugmallit Bay before the ice barrier broke on 27 June. We first observed whales in this area on 29 June. The maximum number of whales was seen during the first systematic survey on 6 July when 1040 were estimated (Table 6; Fig. 5; Appendix 1). Subsequent estimates of whale numbers fluctuated and by the beginning of August very few whales were in the concentration area.

Table 5. The date whales first arrived and the date of the survey with the maximum estimate of whales, Niakunak Bay, 1977-1981.

Year	Date whales first arrived	Date of survey with maximum estimate	Number of days between dates
1977	30 June	8 July	8
1978	6 July	9 July	3
1979	19-20 June	30 June	11
1980*	27-28 June	9 July	12
1981*	17 June	6 July	19

*Weather prevented surveys during period when peak numbers of whales were likely to occur.

Table 6. Results of systematic whale surveys in Kugmallit Bay, 1981

Date	Line flown	Observation conditions	Whales observed	Extrapolation coefficient*	Visibility factor**	Estimated numbers
6 July	K-A to K-9	Excellent (K-A to K-7) Good (K-8 to K-9)	260	2	2	1040
8 July	K-A to K-11	Excellent (K-A to K-2) Good (K-3 to K-11)	80	2	2	320
10 July	K-A to K-13	Good	164	2	2	656
13 July	K-A to K-11	Excellent (K-A to K-8) Good (K-9 to K-11)	47	2	2	188
16 July	K-A to K-7	Poor	22	-***	-	-
18 July	K-A to K-10	Fair	6	-***	-	-
21 July	K-A to K-11	Good (K-A) Fair (K-1 to K-11)	16	-***	-	-
23 July	K-1 to K-11	Excellent	27	2	2	108
25 July	K-1 to K-8	Good	183	2	2	732
28 July	K-1 to K-14	Good	140	2	2	560
1 August	K-1 to K-9	Good (K-1 to K-3) Fair (K-4 to K-9)	9	-***	-	-
5 August	K-1 to K-10	Fair	0	-***	-	-

* An extrapolation coefficient of two was used to account for the unsurveyed areas between transects.

** A visibility factor of two was used to account for unseen whales beneath the water surface.

*** No population estimate was calculated.

We found the highest densities of whales in different parts of the concentration area on different days. Many of the areas used in 1981 were within the white whale concentration area defined in 1976-1978 (Fig. 6). (Too few whales were observed in Kugmallit Bay to allow any definition of a concentration area in 1979 or 1980.) However, during one survey in 1981, moderate numbers of whales were observed in an area east of the designated concentration area (Fig. 6). Because this distribution occurred for a short time (a survey two days after the first one found no whales in that area), we have not redefined the Kugmallit Bay concentration area.

The peak estimate for Kugmallit Bay in 1981 was greater than that found in 1978, 1979 or 1980 (Fig. 5). However, in 1976 and 1977, there were many more whales and they stayed for a longer period of time. Because no surveys were conducted from 27 June to 5 July, it is possible that more than 1040 whales used Kugmallit Bay in 1981, but were not detected.

Tuktoyaktuk Peninsula

Because vessels travel along the coast of the Tuktoyaktuk Peninsula, an area that is an important whale travel corridor, the nearshore areas of the peninsula from Tuft Point to and including McKinley Bay were surveyed frequently in 1981. Sightings of 318 white whales were made during the eight surveys in 1981 (Table 7). The majority of the animals seen (288 whales or 91%) were travelling. Most (272 or 94% of those travelling) were moving toward the estuary (southwest or west). Surveys conducted before 5 August detected no whales moving away from the estuary. Most of the whales moving into the estuary were in small groups, with short distances (<2 km) between the groups. Generally non-travelling whales were in smaller groups, diving deeply with gulls flying overhead, which indicates that the whales were feeding.

In 1980 only 169 whales were observed during six surveys extending at least as far east as Atkinson Point. Fewer whales (126) were seen during the 10 similar surveys done in 1979.

East Mackenzie Bay

Because information was needed regarding the possible effects of Dome's Camp 208 on whale distribution (see Discussion), East Mackenzie Bay was

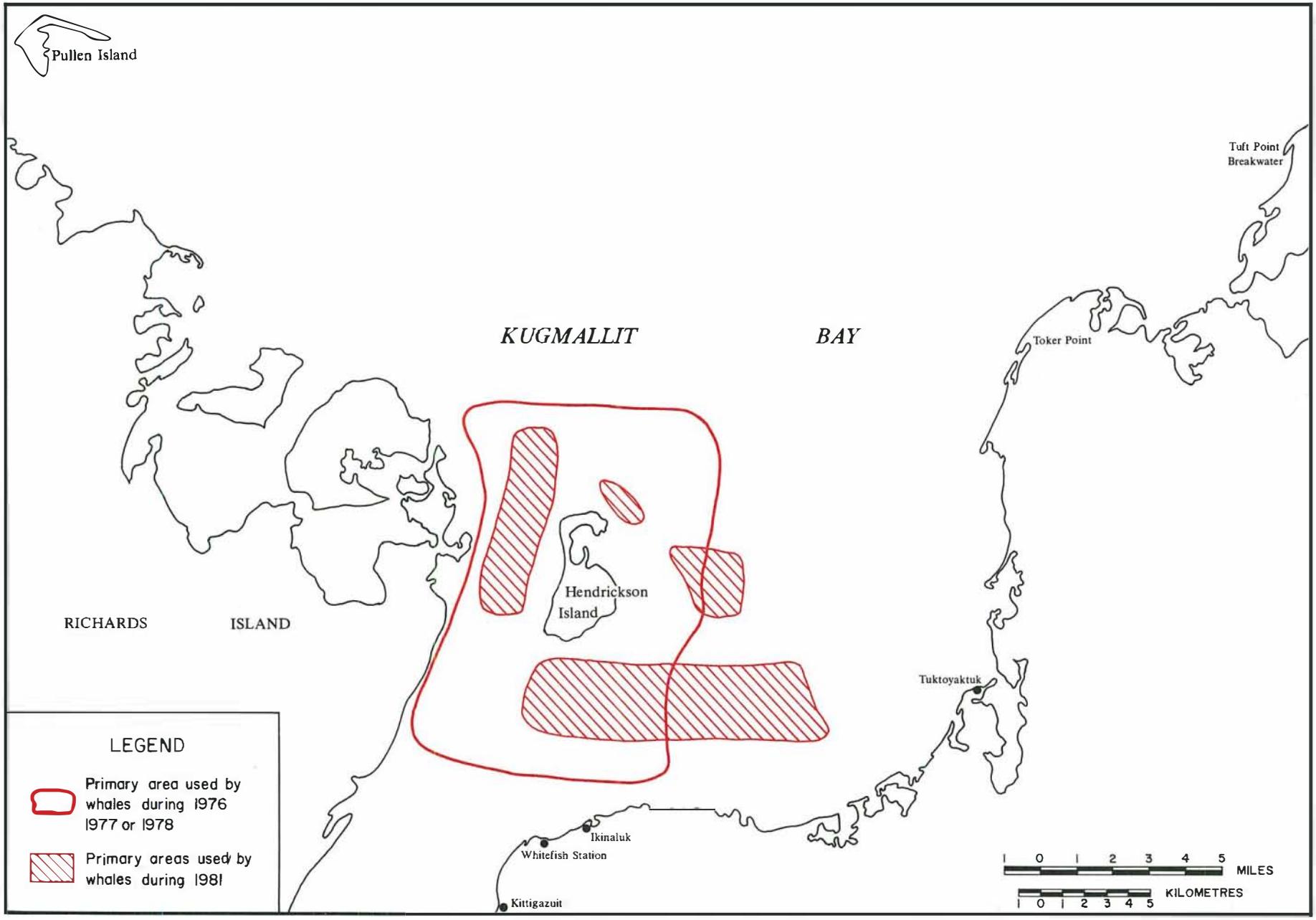


Figure 6. The general extent of the Kugmallit Bay white whale concentration area in 1976, 1977 or 1978 compared with 1981. (Too few whales used Kugmallit Bay in 1979 and 1980 to define a concentration area.)

Table 7. Results of systematic whale surveys from Tuft Point to McKinley Bay, 1981.

Date	Total number of whales seen during survey	Whales that are travelling		
		Number	Direction	Location
13 July	72	42	SW	north of Warren Pt.
		5	W	north of Hutchison Bay
		25	SW	north of Atkinson Pt.
16 July	11	1	SW	north of Toker Pt.
		2	W	north of Hutchison Bay
		8	SW	between Big Bar and Atkinson Pt.
19 July	21	14	SW	north of Atkinson Pt.
21 July	20	7	SW	seaward of Big Bar
		9	SW	north of Atkinson Pt.
23 July	156	86	SW	north of Warren Pt.
		9	SW	opposite Big Bar
		3	SW	between Big Bar and Atkinson Pt.
		45	SW	northwest of Atkinson Pt.
		2	W	north of McKinley Bay
27 July	3			northeast end of Hutchison Bay
31 July	15	3	SW	north of Tuft Pt.
		7	SW	north of Warren Pt.
		2	SW	opposite Big Bar
5 August	20	15	N-NE	north of Warren Pt.
		2	SW	opposite Big Bar
		1	NW	northwest of Atkinson Pt.

surveyed on 4 August. Conditions were excellent on that day; surveys on subsequent days were precluded by weather.

Only 14 whales were observed during the survey for a total estimate (extrapolation coefficient = 2; visibility factor = 2) of 56. Five of the 14 were travelling north of Hooper Island; the other nine were observed north of Pelly Island in an area frequently used by whales travelling to the concentration area near Garry, Pelly and Kendall islands (Fig. 7). No whales were seen in the concentration area on 4 August.

Whale Harvest

The whale harvest in the Mackenzie estuary has significant economic and cultural implications for the Inuit of Aklavik, Inuvik and Tuktoyaktuk. Roughly one-quarter to one-third of the Inuk families in Aklavik and Inuvik travel 90 to 150 km from their communities to established camp sites along the coast. Some remain in these camps just long enough to land and butcher a whale; others stay for a month or two, using the camps as a fishing base after whaling is over. About 60 percent of Tuktoyaktuk families participate in one-day whaling excursions. A few families take foster children out to the whaling camps so that more youngsters will appreciate their Inuk heritage. Questions regarding the effects of industrial activities on whale distribution and abundance have been asked at several recent Hunters and Trappers Association meetings. By examining the effects of both hunting and industrial activities on the whales, we gain a more complete understanding of changes in whale distribution and abundance.

Monitoring the harvest also allows us to quickly detect possible interference with hunting by industry activities. Mitigative measures can often be initiated before reductions in the harvest result. This *modus operandi* has been established over several years and has built up lines of communication between hunters, industry, government and the authors, which can be used in the future.

Timing of the Harvest

The timing of the arrival of the hunters to the whaling camps varies more than that of the arrival of the whales at the estuary. Families generally establish their camps as soon as school is over, unless weather delays

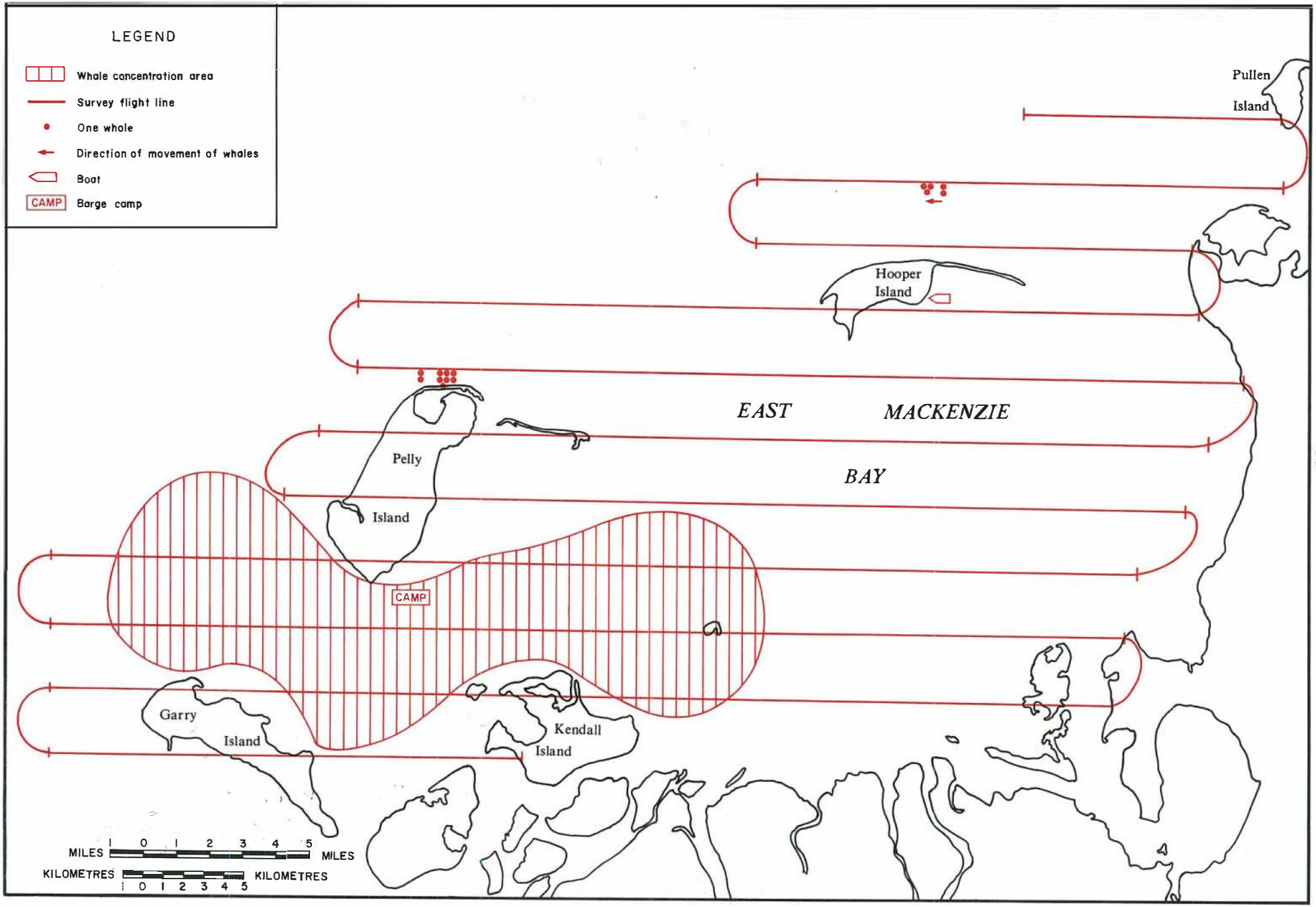


Figure 7. White whale distribution, abundance and normal concentration area and industrial support vessels, East Mackenzie Bay, 4 August 1981.

them. In 1981, the Niakunak Bay camps were first occupied on 26 June. Hunters arrived at Kendall Island on 1 July and at the Kugmallit Bay camps around 4 July. Windy weather delayed the arrival of hunters on the east side.

The date the first whale was taken was similar for each of the three concentration areas: 1 July for Kugmallit Bay and Niakunak Bay and 2 July around Kendall Island (Fig. 8). This synchronization of initial hunting success was the result of a short period with low winds after a spell of unfavourable weather. In all three areas hunting continued for approximately three and one-half weeks. Frequent fog and strong winds prolonged the hunting period throughout the estuary. For Kugmallit Bay and Niakunak Bay, hunting stopped because of declining interest. At Kendall Island declining interest, unfavourable weather, and a feeling that whales would not come into the shallow-water area while the barge camp was close to the southern shore of Pelly Island combined to end hunting there.

The start and conclusion of the 1981 hunt generally was within the range observed from 1978 to 1980 (Fig. 8). An exception was the landing of the first whale at Kendall Island two days earlier than in previous years. In general the timing of the harvest was earlier in 1979 and 1981 than in 1978 and 1980 (Fig. 8).

Hunting Camps

All of the traditional whaling camps, as well as several occasional ones, were utilized in 1981 (Fig. 1). Aklavik people occupied Shingle Point, Running River, Niakunak and Bird Camp as well as a new unnamed location approximately 3 km west of Bird Camp. At Kendall Island just the two traditional sites, Okivik and Sanmiqaq, were used. Inuvik people occupied Indian Camp, Whitefish Station and Ikinaluk. Whaling was also undertaken from two additional sites along East Channel, just a few kilometres northeast of Tununuk Point. One family from Tuktoyaktuk used Kittigazuit. On occasion, Hendrickson Island was used as a temporary camp site by people from Tuktoyaktuk as well as people from the Kugmallit Bay camps. In general, there were more whaling camps with fewer people in each camp in 1981 than in previous years.

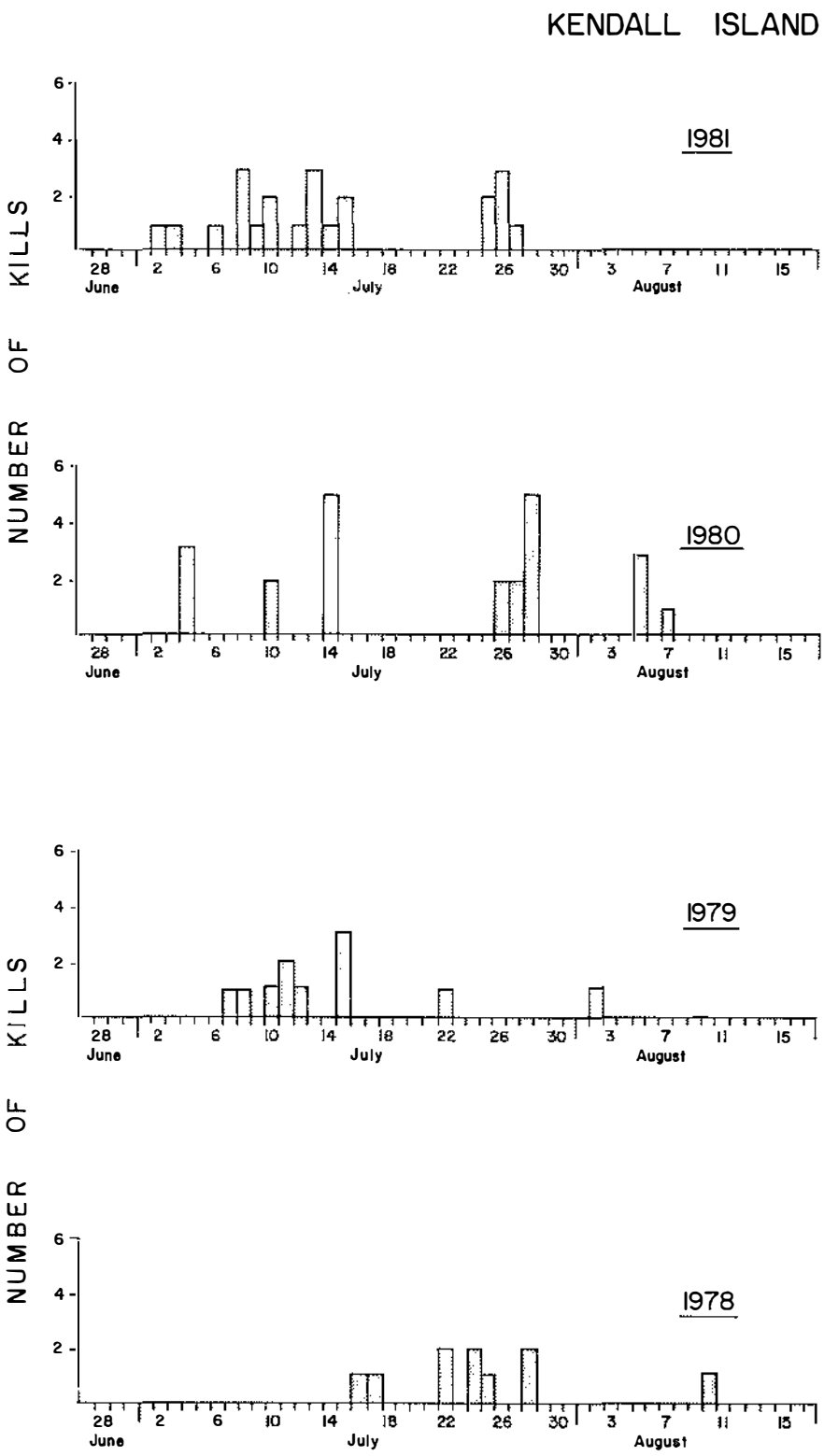
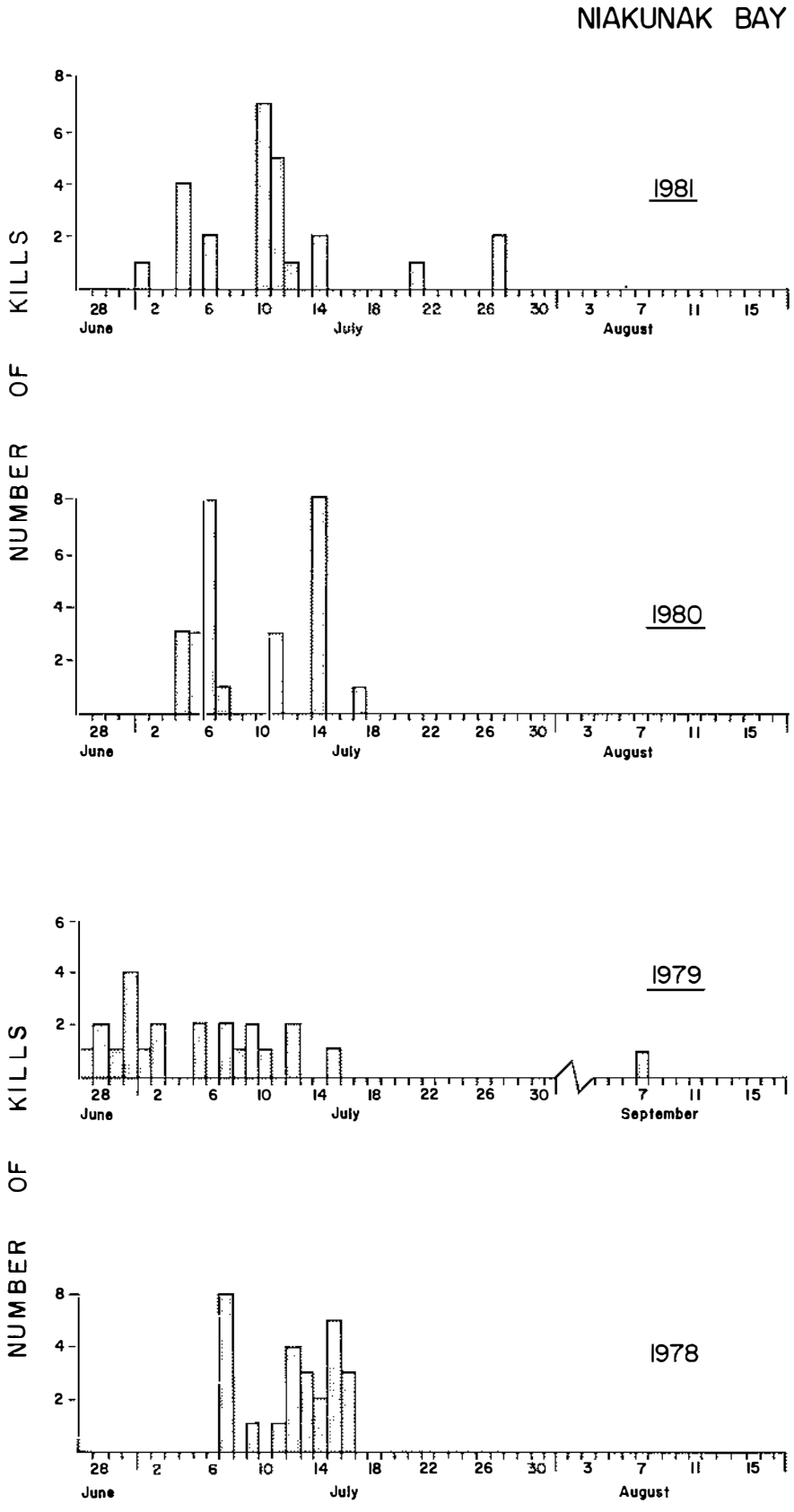


Figure 8. Known dates of white whale kills, Mackenzie estuary, 1978-1981.



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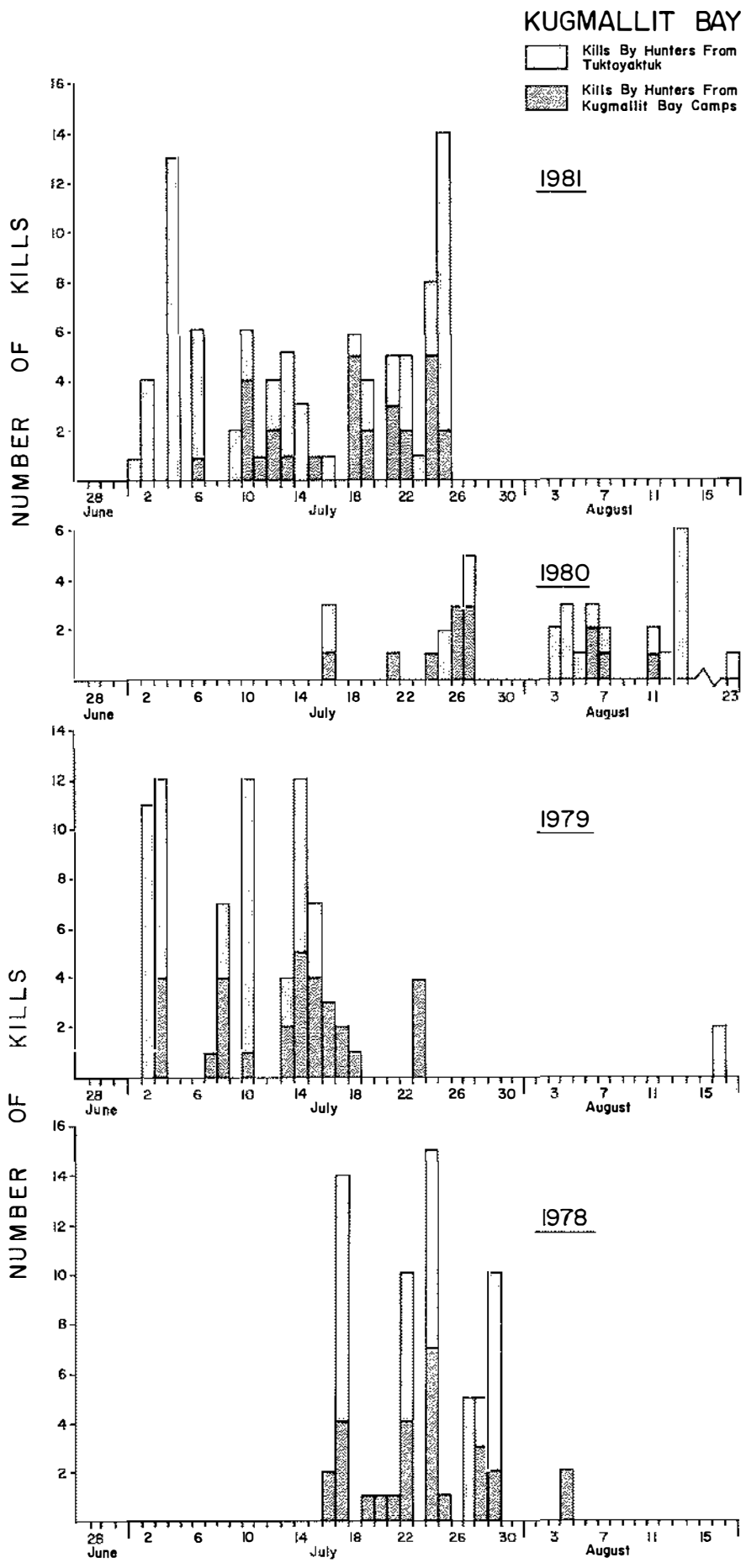


Figure 8. Continued.

Most Tuktoyaktuk hunters continued their practice of making one-day excursions to the concentration area.

Four families from Holman Island stayed at Bird Camp for a little over a week starting at the beginning of July. Their visit was arranged by the Committee of Original Peoples Entitlement (COPE). The Holman Island people went whaling with hunters from Aklavik.

Hunting Success

The 1981 harvest of 149 whales was well above the nine-year (1972-1980) average of 131 (Table 8); it was the third largest harvest recorded in ten years of study. More whales were taken in 1981 than in any year since 1976, when 154 whales were taken. Tuktoyaktuk hamlet, Kendall Island camps, and Niakunak Bay camps landed more than their usual number of whales. Only Kugmallit Bay camps landed fewer whales than usual. Combining the catch for the Kugmallit Bay camps and Kendall Island camps results in a harvest of 52 animals for Inuvik hunters (average = 52.5 whales). Aklavik hunters (with hunters from Holman Island) landed 35 whales and Tuktoyaktuk hunters landed 62.

Precise data for 1981 on the number of active hunters and the amount of time spent hunting are not available. However, the general impression is more effort was expended hunting white whales in 1981 than in 1980 (DFO 1981). Holman Island people did not hunt white whales during 1972 to 1980; this year they utilized 15 of the whales landed on the west side.

Sex Composition of the Harvest

The 1981 harvest consisted of 61 males, 58 females, and 30 animals of unknown sex, for a ratio of 1.05 males per female. Differences in sex ratio of landed whales were noted between concentration areas and between the first and latter half of the hunting season. The sex ratio of whales harvested in Kugmallit Bay (38 males:35 females) was not significantly different from the sex ratio of whales landed in Niakunak Bay (17 males:7 females; Yates corrected $\chi^2 = 1.87$, df = 1, $p<0.25$) or at Kendall Island (6 males:16 females; Yates corrected $\chi^2 = 3.24$, df = 1, $p<0.1$). However, there was a significant difference between the sex ratio of whales landed in Niakunak Bay and Kendall Island (Yates corrected $\chi^2 = 7.06$, df = 1, $p<0.01$).

Table 8. Number of white whales harvested in the Mackenzie estuary, 1972-1981. The percentage of the total harvest attributed to each area is indicated in parentheses.

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	Mean harvest 1972-1980
Tuktoyaktuk Hamlet	45(40)	87(49)	40(33)	50(35)	51(33)	54(39)	53(44)	49(41)	23(26)	62(42)	50.2(38)
Kugmallit Bay Camps	31(27)	63(36)	50(41)	60(42)	59(38)	32(23)	28(23)	31(26)	14(16)	30(20)	40.9(31)
Kendall Island Camps	4(4)	7(4)	2(2)	3(2)	12(8)	30(21)	10(8)	12(10)	24(27)	22(15)	11.6(9)
Niakunak Bay Camps	33(29)	20(11)	30(25)	29(20)	32(21)	24(17)	30(25)	28(23)	29(32)*	35(23)**	28.3(22)
	113	177	122	142	154	140	121	120	90	149	131.0

* Includes eight whales taken near Aklavik.

** Includes 13-15 whales taken by Holman Island families with help from Aklavik hunters.

To test for seasonal differences in the sex ratio of landed whales, the hunting interval was divided into two periods of equal length: 30 June-13 July and 14-27 July. Data of whales for which sex but not date were determined were not included in the analyses. During the early period the harvest was primarily males (71% of 69) whereas in the latter half of July it was mainly females (76% of 46). This difference was statistically significant ($\chi^2 = 24.54$, df = 1, $p<0.005$).

Of the 58 females landed in 1981, ten (17%) were accompanied by newborns; two of the newborns were struck and landed. Another seven of the 58 (12%) were carrying a fetus. The lengths of the fetuses ranged from 12 to 165 cm.

Although sample sizes were small, there were differences between the concentration areas in terms of the proportions of females with neonates and fetuses. None of the seven females taken in Niakunak Bay was accompanied by a calf or was pregnant. In Kugmallit Bay, 6% of the 35 females were accompanied by neonates and a further 14% were pregnant whereas fully 50% of the 16 females at Kendall Island had neonates and 13% were pregnant.

The sex ratio of landed whales has varied greatly from year to year (Table 9). Prior to 1980 the harvest had been composed consistently of more males than females; however sex was determined for a lower percentage of the harvest prior to 1979. The sex ratio of the harvest in 1980 and 1981 approached unity.

The sex ratio of whales from the different concentration areas has varied significantly over the past three years (Table 10). Differences between areas were not examined prior to 1979 because there were too few data. Females comprised a significantly greater percentage of the harvest from the Kendall Island area than from Niakunak Bay. The sex ratio of the harvest from Kugmallit Bay relative to the other two concentration areas has not been consistent.

Length Composition of the Harvest

Changes in the length of animals comprising the harvest could reflect changes in the size (= age) composition of the population, and therefore, the status of the population. Because there are sexual differences in length, data on males and females must be analyzed separately. Data on the

Table 9. Sex ratio of landed catch of white whales in the Mackenzie estuary, 1974-1981.

	Number of males landed	Number of females landed	Males/ female	Percent of harvest for which sex was determined
1974	16	7	2.29	19
1975	13	4	3.25	12
1976	36	7	5.14	28
1977	13	8	1.62	15
1978	35	7	5.00	35
1979	36	23	1.57	49
1980	42	44	0.95	96
1981	61	58	1.05	80

Table 10. Sex ratio (males:female) of landed catch of white whales by concentration area, 1979-1981.

	Kugmallit Bay	Kendall Island	Niakunak Bay
1979	1.89	0.22	3.40
1980	0.50	1.00	5.67
1981	1.09	0.38	2.43

two landed newborn calves were not included in the 1981 analyses. The mean length of males landed in the Mackenzie estuary in 1981 was 423.0 ± 41.88 cm; for landed females the mean length was 365.3 ± 32.57 cm.

There were no apparent geographical differences in lengths of harvested animals. Mean lengths of harvested males were 415.1 cm, 426.3 cm, and 438.1 cm (n = 33, 6 and 16) for Kugmallit Bay, Kendall Island and Niakunak Bay, respectively ($F = 1.65$; $df = 2, 52$, $p>0.2$). Differences in average lengths of harvested females (362.8 cm, n = 30; 379.8 cm, n = 15; and 344.9 cm, n = 7, for Kugmallit Bay, Kendall Island and Niakunak Bay, respectively) were not statistically significant ($F = 3.17$; $df = 2, 49$; $p\simeq0.10$).

To test for temporal differences in length, the hunting period was divided into two equal intervals: 30 June-13 July and 14-27 July. No significant temporal differences in lengths of harvested males (425.7 cm vs. 412.4 cm; $t = 0.942$, $df = 53$, $p>0.3$) or of harvested females (370.6 cm vs. 348.4 cm; $t = 0.946$, $df = 49$, $p>0.3$) were noted.

Lengths of harvested males and females have varied from year-to-year (Table 11; Fig. 9). No significant annual differences were found in lengths of harvested males ($F = 0.71$; $df = 7, 208$; $p>0.2$). The differences in lengths of harvested females were statistically significant ($F = 3.56$; $df = 7, 128$; $p<0.01$), but no trend is obvious (Table 11).

Observations by Industry Personnel

Industry personnel frequently report observations of white whale distribution, abundance and behaviour. This information is useful because it often covers areas and/or time periods that we could not cover. In 1981, 15 sightings of about 540 whales were recorded by others (Table 12). Six sightings of about 200 whales were made around the Barrier Islands during July. Five sightings of about 100 whales were made in the area around Issungnak 0-61 on 24-26 June. Whales were reported seaward of the ice northwest of Niakunak Bay on 19 June.

Mitigative Measures

An important objective of the 1981 white whale monitoring program, as with previous programs, was to detect any interference by industrial activities with whales or whaling. If interference or potential interference

Table 11. Mean lengths and standard deviations of harvested whales according to sex, Mackenzie estuary, 1974-1981.

Year	Males			Females		
	Mean length (cm)	Standard deviation	Sample size	Mean length (cm)	Standard deviation	Sample size
1974	423.3	58.94	16	368.8	28.36	7
1975	429.9	34.20	13	366.8	17.28	4
1976	429.8	29.35	35	414.0	28.52	7
1977	436.6	31.70	12	365.0	18.06	3
1978	424.8	23.08	18	358.8	17.00	4
1979	423.7	26.64	25	374.9	32.70	17
1980	438.2	50.14	42	393.6	42.77	42
1981	423.0	41.88	55	365.3	32.57	54

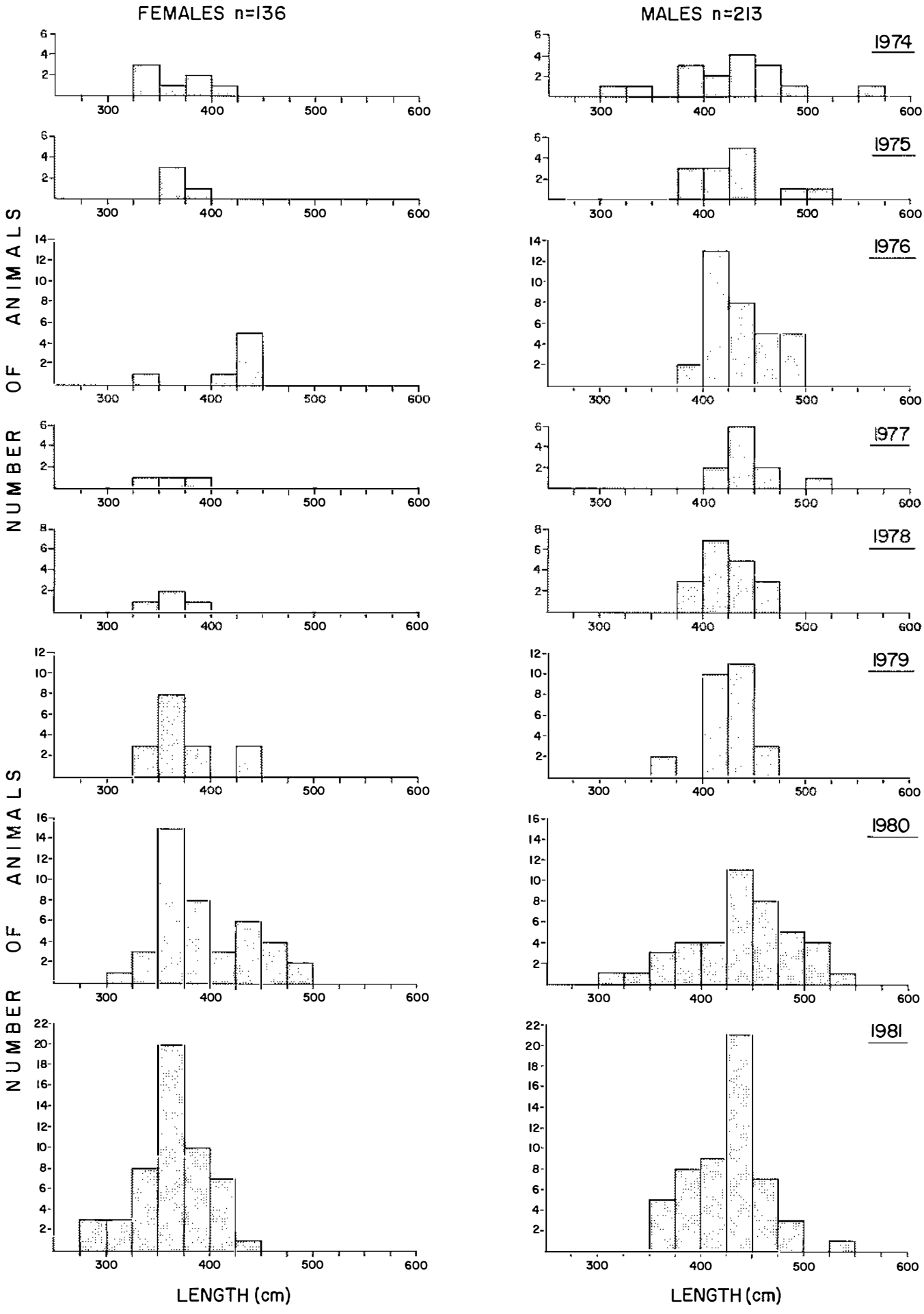


Figure 9. Length frequencies of white whales harvested in Mackenzie estuary, 1974-1981.

Table 12. Observations of white whales by industry personnel, 1981.

Date Time	Location	Number of whales	Direction of movement	Observations	Observer Company
19 June 1830	N69°34' W137°40'	5	-	whales appeared to be "playing around"	B. MacKenzie BFS*
24 June 1500	N69°58' W134°10'	5 and 7	W	whales in leads in the ice	J. Cutler OH*
24 June 1700	N70°30' W121°00'	~200	E	-	K.B. Whiteside AFS*
24 June 1730	N70°01' W134°08'	25			J. Hessberger OH
25 June	N69°58' W134°10'	3	W	-	J. Cutler OH
26 June 1630	N69°59' W134°13'	7	E	no apparent reaction to Sikorsky 612 helicopter at altitude of 305 m	J. Cutler OH
26 June 1830	N69°58' W134°14'	50+	E	2 or 3 young in group; no apparent reaction to Sikorsky 612 helicopter at altitude of 183 m; whales were lying still	J. Cutler OH
8 July 1700	N69°35' W135°45'	10	W	no apparent reaction to tug *Cecilia Hall* 805 to 1609 m away	G. Fawcett NCC*
10 July 1700	N69°27' W135°53'	60-70	S	whales directly ahead dove; rest of pod showed no apparent reaction to boat 229 to 1609 m away; at least 10 cow/calf pairs were further from *Cecilia Hall*	G. Fawcett NCC
20 July 1630	N69°35' W135°42'	10	SE	Time between surfacing increased although speed, direction and pod shape did not change when 457 to 1207 m away from vessel; whales dove when *Cecilia Hall* accelerated	G. Fawcett NCC

Table 12 (Cont'd)

Date Time	Location	Number of whales	Direction of movement	Observations	Observer Company
22 July 1400-1445	N69°29' W135°46'	30-35	variable, then S-SW	whales were feeding and did not react to *Cecilia Hall* 209 m away when tug was silent	G. Fawcett NCC
22 July 2000	N69°41' W135°01'	50 or more	SE	no apparent reaction to vessel G.S.I. *Mariner* 1609 m away	D. Weston GSI *
23 July 0145-0210	N69°32' W135°35'	30-40	towards Pelly Is.	whales closest ~46 m From ~~to~~ vessel founded and changed direction but most continued to stay further (~1609 m) away	G. Fawcett NCC
24 July	N69°46' W134°19'	~25	-	-	Camp 6 ERCL
30 July	N69°34' W133°01'	10-15	SW	whales sounded when vessel *Imperial Sarpik* approached	D. Hood

* Abbreviations used for company names are as follows:

BFS = Beaufort Flying Service
AFS = Aklavik Flying Service
OH = Okanagan Helicopters
NCC = Northern Construction Company
GSI = Geophysical Services Inc.
ERCL = Esso Resources Canada Limited

occurred, we notified the appropriate industrial personnel of the interference and recommended feasible mitigative measures. When appropriate, information was relayed to local people who may or may not have been affected by the interference. Esso has been involved in the whale monitoring program since its inception in 1972; on several occasions Esso has altered its plans and/or schedules to minimize actual or potential interference. Readers are referred to previous reports for details of specific instances (Slaney 1973, 1974, 1975; Fraker 1976, 1977a, 1977b, 1978; Fraker and Fraker 1979, 1981). Dome and Gulf were first directly involved in the white whale program in 1981.

There were five situations involving mitigation by the whale monitoring team in 1981. Each case will be discussed separately, in chronological order.

Case One: Canmar Vessels in Leads Offshore of Kugmallit Bay

During the reconnaissance survey on 23 June, white whales were observed moving west in the main lead seaward of the landfast ice north of Kugmallit Bay (Fig. 3D). In the same lead, west of the migrating animals, two Canmar drillships were anchored, waiting for improved ice conditions to allow them to proceed out to the drill sites, and three supply vessels were standing by (Fig. 10A). We watched as a group of approximately 250 whales, spread out over several km, approached the drillship, 'Explorer II', directly in their path (Fig. 10A). When the first whales were within about 1 km of the drillship, they milled briefly and then turned toward the landfast ice (Fig. 10A). The whales proceeded past the 'Explorer II' midway between the drillship and the ice edge (Fig. 10B). After several whales had passed by, the animals abruptly headed into the ice and proceeded past the 'Explorer II' travelling under the ice, coming up in openings in the ice (Fig. 10C, D). This abrupt change in the movement of the whales coincided with the initiation of movement of the supply vessel, 'Supplier I', which was just northwest of the 'Explorer II'. The whales continued moving west under the ice even though this route brought them within 100 m of the 'Supplier III' which was standing by in an indentation in the ice (Fig. 10D).

Because the whale migration appeared to be proceeding without interruption by these vessels, it was decided not to take any mitigative action but to carefully monitor the situation.

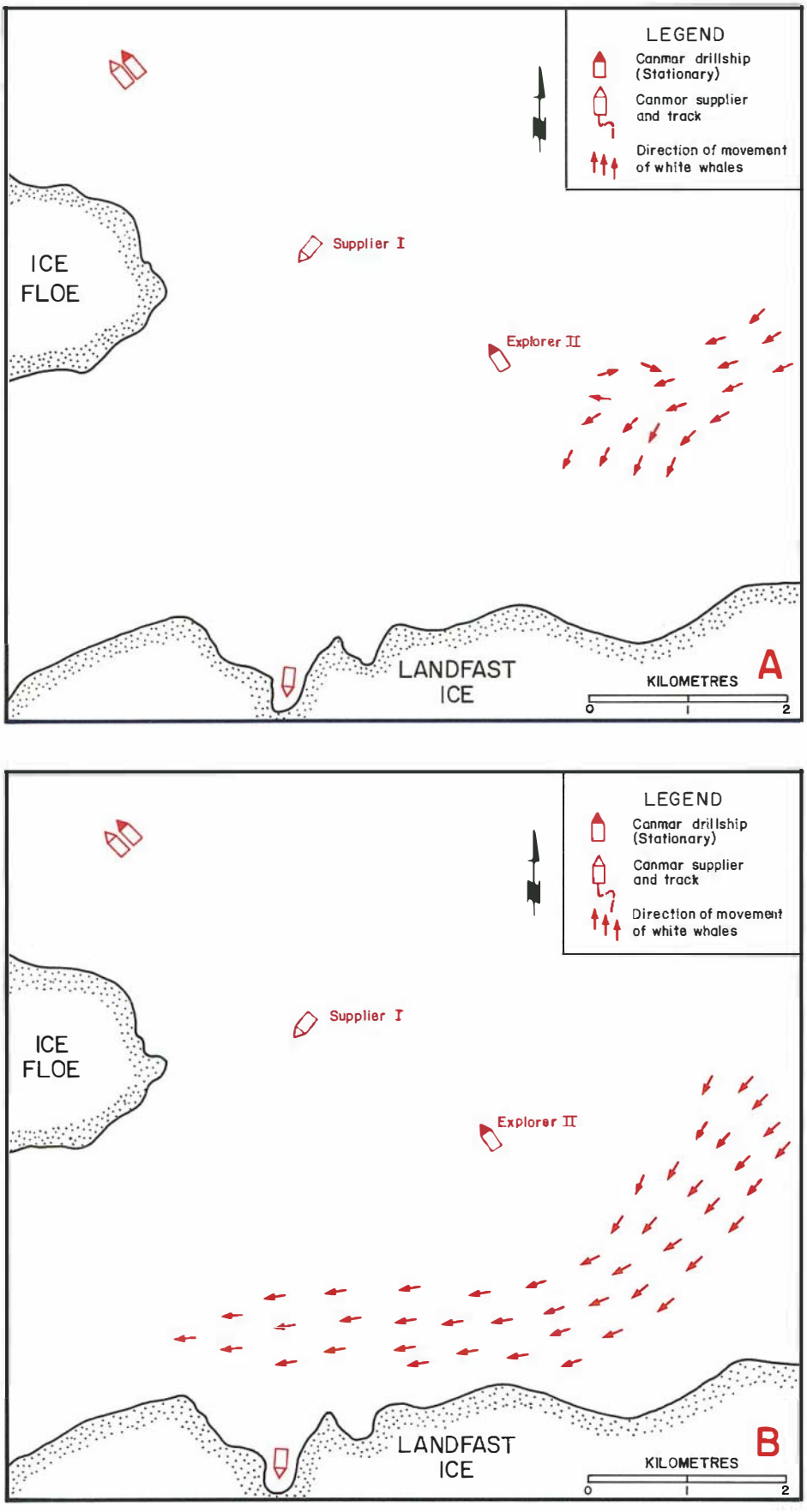
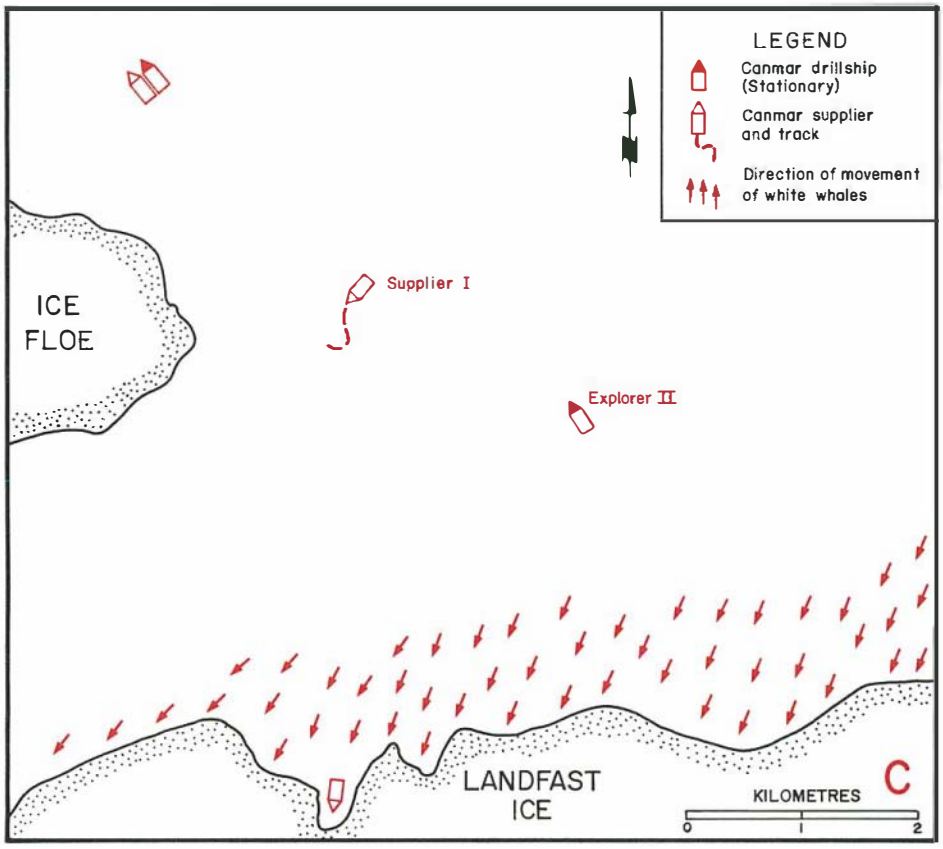


Figure 10. Location and movements of industrial vessels and movements of white whales in lead north of Kugmallit Bay, 23 June 1981.



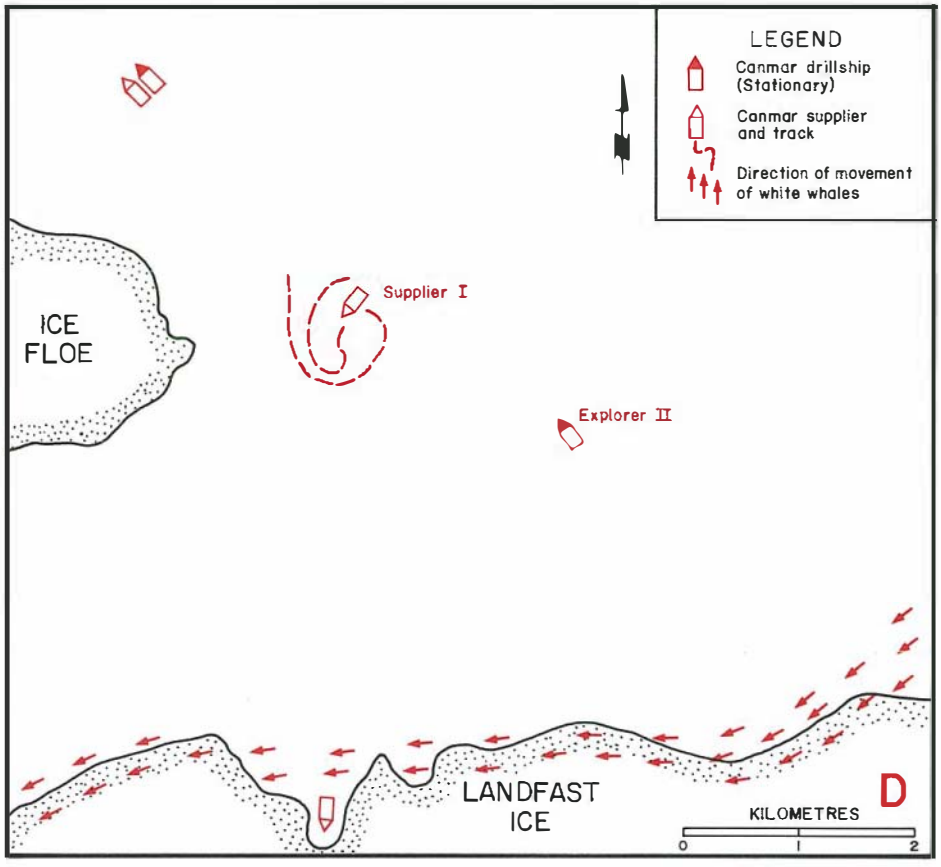


Figure 10. Continued.

During a survey of the same area on 24 June, we observed whales milling around in several leads, including the main one, seaward of the landfast ice. The two drillships had not moved, but only one supply vessel and one ice breaker were now in the area. 'Supplier IV' was proceeding northward through a lead in the landfast ice, when it made an S-shaped movement that took it 1-2 km from 25-30 whales (Fig. 11A). These animals started moving rapidly away from the vessel. The 'Supplier IV' straightened its course; the whales in the lead continued to move away from the vessel and several headed away from the estuary (Fig. 11B). The 'Supplier IV' turned eastward toward the two drillships and the icebreaker, which were anchored in the main lead (Fig. 11C), and caused another group of 7-10 animals to take evasive action.

Several people from Tuktoyaktuk were along on our flight. We conferred with them and decided to ask Dome (owner of the vessels) to:

1. have all vessels follow a straight course and avoid approaching whales;
2. move the drillships away from the edge of the landfast ice; and
3. suspend or reduce vessel traffic through Kugmallit Bay for a few days or inform us of vessel movements so we could monitor any effects.

These recommendations were made to ensure that whales milling northward of the ice in Kugmallit Bay would not be affected by industry traffic causing them to move farther westward to Niakunak Bay before Kugmallit Bay was accessible; if the whales bypassed Kugmallit Bay there might have been few whales available to be hunted by people from Tuktoyaktuk and Kugmallit Bay camps. We communicated the recommendations to Dr. John Ward of Dome on 25 June and the appropriate personnel immediately issued a notice requesting vessels to avoid approaching groups of whales. Within two days the two drillships were away from the edge of the landfast ice. It was not possible to suspend or reduce vessel traffic through Kugmallit Bay but Dome agreed to inform us of all arrivals and departures. We conducted two more surveys in this area, on 25 and 26 June, and on both dates we found some whales milling in leads in the landfast ice north of Kugmallit Bay (Figs. 3F and 3G).

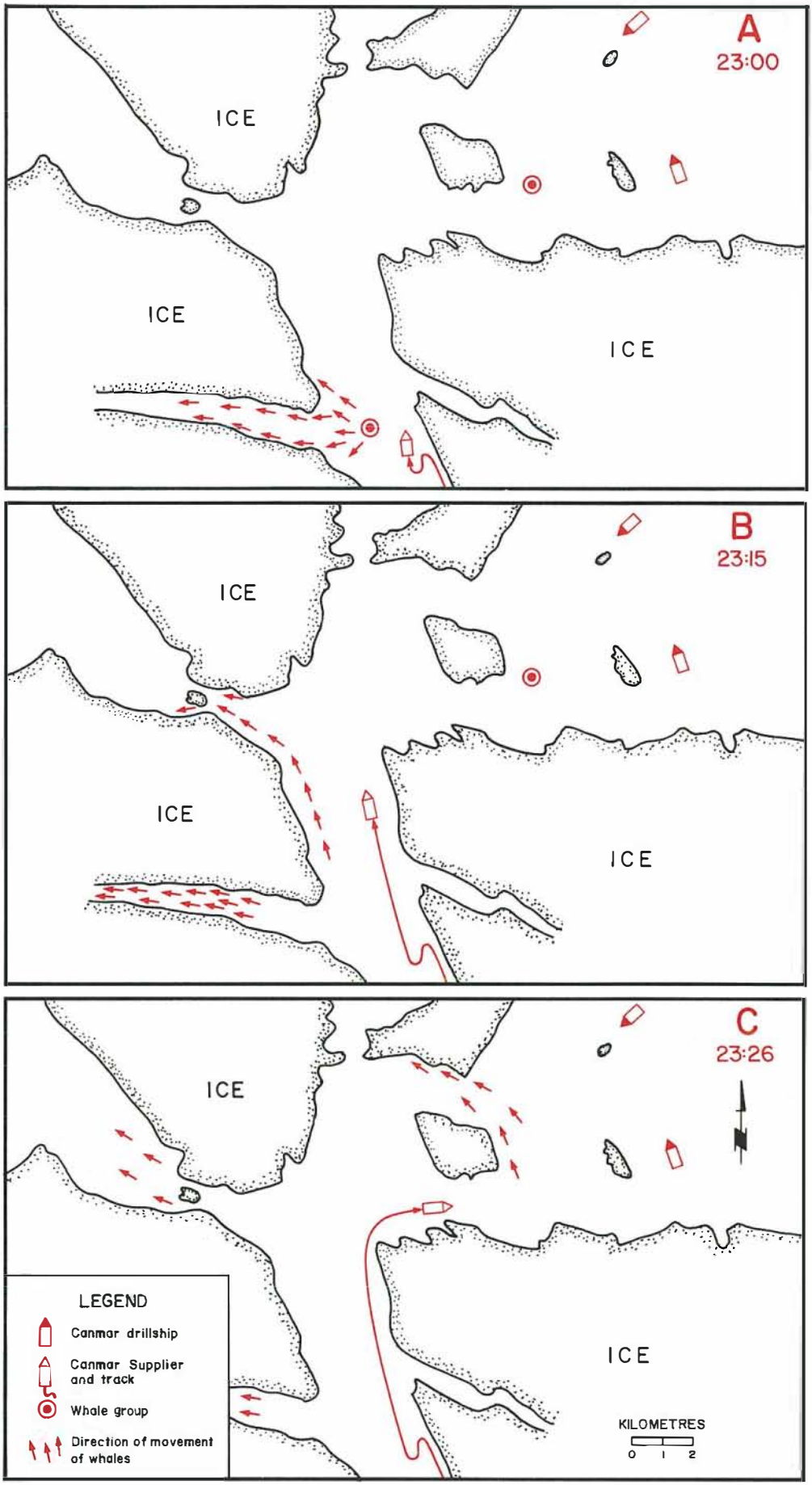


Figure 11. Movements of Supplier IV and white whales in lead north of Kugmallit Bay, 24 June 1981.

(Weather interfered with surveying from 27 June to 3 July.) For the next eight days an average of three vessels/day moved through Kugmallit Bay; there were nine movements by industry vessels on 28 June. By 4 July Kugmallit Bay was open and little ice remained.

It is unlikely any lasting effects on whale distribution and/or abundance resulted from the interactions on 23 and 24 June. More whales (over 1000) used Kugmallit Bay in 1981 than in 1978 (780 animals), 1979 (500) or 1980 (120). However, the incidents do point out that whales will take evasive action to moving vessels when the whales are migrating through small leads in the ice.

Case Two: Esso's Clean-up Operations around Garry Island

On 25 June we met with Reid Warne to discuss Esso's planned clean-up activities at Ikattok J-17 and Adgo C-15 in the area southwest of Garry Island (Fig. 1). The plans called for a barge camp anchored just west of Garry Island. We outlined the extent of the area used by whales and by whale hunters and it was agreed that Esso vessels would avoid the area. The clean-up operations proceeded without apparently interfering with whales or whale hunting.

Case Three: Helicopters over the Kugmallit Bay Concentration Area

On 5 July the two whale observers from Tuktoyaktuk working for Canada Fisheries and Marine Service, Joseph Avik and Jonah Carpenter, expressed concern regarding the low altitude that helicopters had been maintaining over the Kugmallit Bay whale concentration area. We recommended that helicopters either maintain an altitude of at least 457 m or avoid the concentration area (Fig. 6). This precautionary measure was recommended to Dr. John Ward of Dome on 6 July, to Mr. Mark Psutka of Esso on 7 July, and to Mr. Frank Hunt of the Polar Continental Shelf Project on 10 July. All parties readily agreed to the recommendation.

Case Four: Vessel Travelling along Yukon Coast

On 11 July several hunters at Bird Camp (Fig. 1) complained that a vessel travelling back and forth close to shore between Tent Island and Shingle Point was keeping whales out of the shallow-water area where they

are hunted. Inquiries at Esso, Dome, Gulf, Northern Transportation Company Limited (NTCL), Arctic Transportation Limited (ATL), Canada Fisheries and Marine Service, Geophysical Services Inc., Canada Coast Guard, and Polar Continental Shelf Project failed to produce any record of a vessel in the area of interest during early July. Further inquiries of the hunters did not yield a detailed description of the vessel sufficient to identify it.

In 1981, we observed whales in the hunting area close to the Yukon coast during June, before most of the hunters had arrived at the whaling camps. During the two systematic surveys in July the whales were farther out, beyond the area where most hunting occurs. Variations in the exact area utilized in Niakunak Bay have been observed from year-to-year. Given the yearly variations observed in the Niakunak Bay concentration area and the failure to find any record of a vessel in the area of concern at the appropriate time, we suspect that the absence of whales close to the Yukon coast in July 1981 was a normal variation in whale distribution unrelated to industry activities.

Case Five: Camp 208 near Pelly Island

On 23 July several hunters at Okivik reported that industrial activities were interfering with whaling around Kendall Island. The hunters were waiting for whales to come into the concentration area; they had seen animals travelling southwest along the shore of Pelly Island, approaching the shallow-water areas south of Pelly Island where hunting traditionally occurs. However, the whales turned around and retraced their route. The hunters suggested that the whales were being kept out of the shallow-water area by the movements of the 'Imperial Adgo', on contract to Dome to move men and supplies between Camp 208 and the South Tarsiut Borrow Site (Fig. 12). On 22 July the hunters requested that Camp 208 be moved to the west of Garry Island or, if that was not feasible, then to the west of Pelly Island, out of the travel corridor. On 23 July, Camp 208 moved west of Pelly Island.

On 23 July, G. Fawcett (Northern Construction Company, pers. comm.) observed 30 to 40 white whales between Pelly Island and Garry Island (Table 12). (He had observed whales outside of the hunting area on 20 and 22 July.) On 23 July, hunters at Okivik landed two whales, the first whales landed at that camp since 15 July. Three whales were landed on 24 July and one on 25 July.

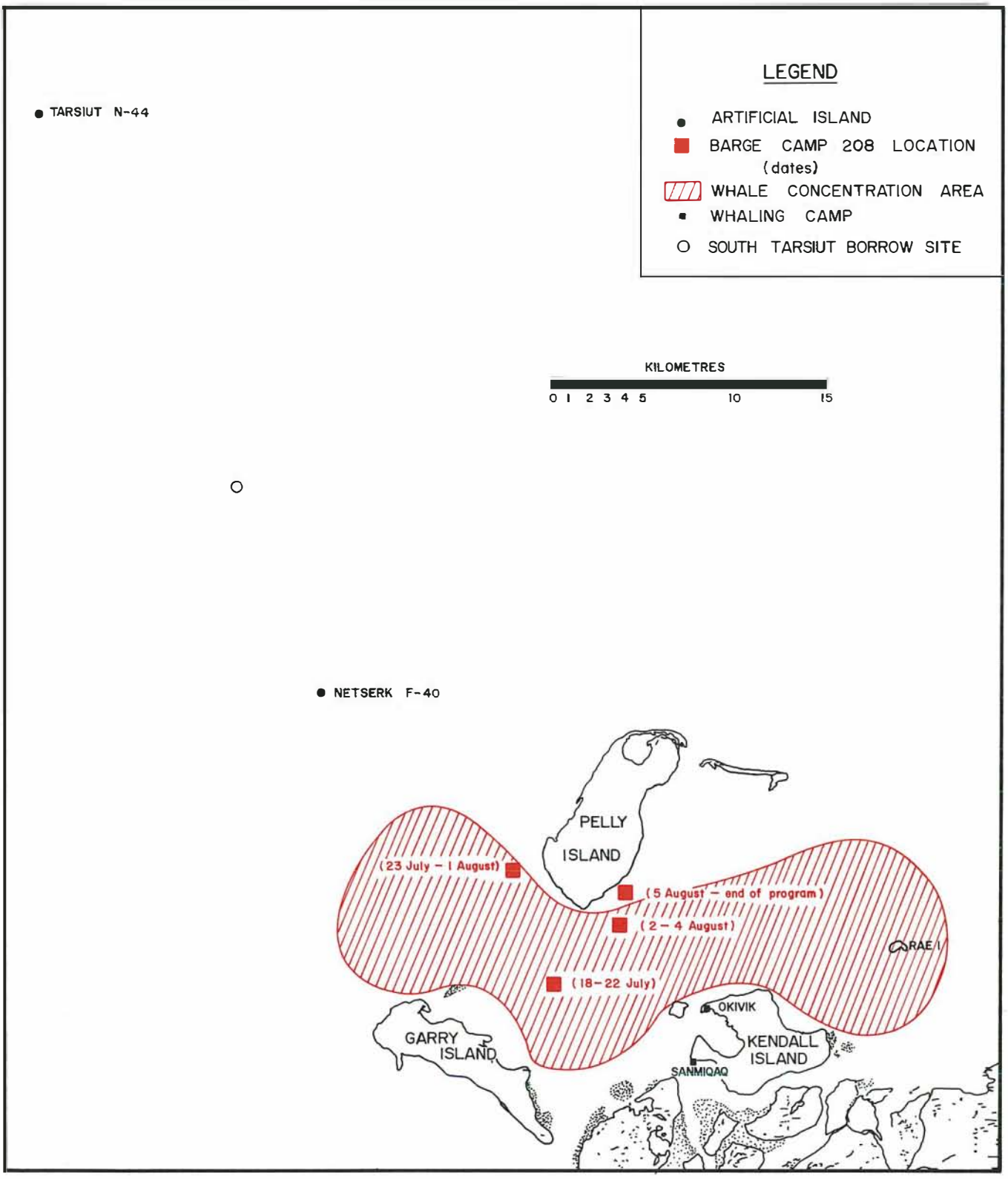


Figure 12. Locations of barge camp, Camp 208, East Mackenzie Bay,18 July - 7 August 1981.

The hunters remained at Okivik, hoping to land a few more whales. On 30 July we received a request from the hunters that Camp 208 move again as the whales were no longer coming into the hunting area. On 31 July, we passed this request along to Dome with the suggestion Camp 208 move either to the west of Garry Island or to the northeast end of Pelly Island. Several discussions with Dome personnel and with the hunters at Okivik were necessary to clarify the most feasible location for Camp 208. During the period when these interviews were occurring high seas necessitated the move of Camp 208 from its exposed location west of Pelly Island to the southeast end of Pelly Island (Fig. 12). During our 4 August survey we observed a few whales in the area immediately north of Pelly Island (Fig. 6), in the travel corridor, but none in the usual concentration area. Arrangements were made to move Camp 208 to the northeast end of Pelly Island, on 5 August, but before this could be done, high seas caused Camp 208 to drag anchor and go aground southeast of Pelly Island. Subsequently, Camp 208 was freed and moved out of the area on August 12. Meanwhile the Kendall Island hunters moved to a fishing camp south of Shell's Camp Farewell on Middle Channel. When we landed there to bring the hunters up-to-date, we found the camp set up but not occupied. It appeared everyone had gone into Inuvik. We presumed interest in whaling had declined and on 7 August the white whale program ended.

The observations of white whales in the shallow-water area and the hunting success on 23-25 July, after Camp 208 moved, but not on 20-22 July indicated that Camp 208 and the movements of the 'Imperial Adgo' between Camp 208 and the South Tarsiut Borrow Site may have been keeping whales away from the hunting area in mid-July.

DISCUSSION

Distribution of White Whales

The white whales have used the Mackenzie estuary in a relatively consistent pattern during the ten years of study, with certain important exceptions. Early in the open-water season, immediately after they arrive, the whales gather in specific, relatively small areas, the concentration areas, where they remain in large numbers for approximately two to three weeks (Fig. 4). The concentration areas in Niakunak and Kugmallit bays are the first to be used. Niakunak Bay has been used by large numbers of whales in each year since studies began in 1972. Kugmallit Bay has been used heavily in most years, but there have been exceptions -- particularly 1979 and 1980 -- when few whales were present. The third concentration area, which lies in the Garry-Pelly-Kendall islands area, is used by fewer whales, for a shorter time, and later in the season than the other two areas. However, it can be used early in some years (e.g., 1977, Fraker *et al.* 1979). The fact that most of the social behaviours that we have observed in the estuary have been in concentration areas strongly suggests these areas have a social function. In addition, Sergeant (1973) and Fraker *et al.* (1979) believe that the warm waters of the estuary may be important for calf rearing. The whales seldom feed in the concentration areas.

White whales travel throughout the estuary; however, the probability of sighting travelling whales is low in most areas. Specific areas, such as along the Tuktoyaktuk Peninsula, around Pullen Island, and seaward of Hooper, Pelly and Garry islands, are well-defined travel routes. After the initial migration to the estuary, there is usually a two-to-three week period when few travelling whales are seen. After this lull, whales frequently move from one place to another.

Whales feed frequently in only a few areas, e.g., around Pullen Island and off the coast of the Tuktoyaktuk Peninsula, particularly near points of land. At such places, migrating fish probably are concentrated, and we suspect that the whales are feeding on them.

During the ten years that the whale monitoring program has been carried out, exploration activities have varied greatly in intensity and location and during this same period there have been major variations in the

distribution of the whales. Although there have been minor and temporary changes in whale distribution that we believe have been caused by industry activities, the major variations appear to be the result of ice conditions (see 'Effect of Ice on Whale Distribution and Abundance').

Numbers of White Whales

An important purpose of the whale monitoring program is to determine if industry activities affect the number of white whales using the Mackenzie estuary. The estimated maximum number of whales found in the estuary on any one day is the measurement that we have used. In 1981, the maximum estimate was obtained on 6 July: 2464 animals in Niakunak Bay and 1040 in Kugmallit Bay, for a total of about 3500 animals.

The 1981 estimated maximum probably is well below the actual maximum for several reasons. First, East and West Mackenzie bays were not surveyed at the time the maximum counts were made. Hunters at Kendall Island reported seeing 50-100 whales in the small area they hunted during the first week in July (E. Allen, pers. comm.). Varying numbers of whales have been observed in East and West Mackenzie bays in previous years (Fig. 13). Because data from the two years when intensive surveying was done (1977 and 1979) show different patterns, it is not possible to generalize on the number of whales likely to be in these two areas in late June-early July. Second, given the pattern of changes in whale abundance in Niakunak Bay and Kugmallit Bay in previous years (Fig. 5), maximum numbers probably occurred during the two weeks after whales first entered the estuary. This was during the period when poor weather prohibited aerial surveys (29 June-4 July). Third, the Inuk observer on the survey during which maximum numbers were counted, was relatively inexperienced. (Andrew Erigaktoak, the Inuk observer from 1975 to 1980, died in 1980.) If data from just the experienced observer are used and the extrapolation coefficient increased to four to account for the additional unsurveyed area, then the 1981 maximum estimate for Niakunak and Kugmallit bays would be 4100.

Year-to-year variations in the maximum estimate have been observed (Table 13). (Only estimates derived using the current standard procedures are given.) Some of the variation undoubtedly results from differences in weather conditions that interfere with surveying (see section on Niakunak

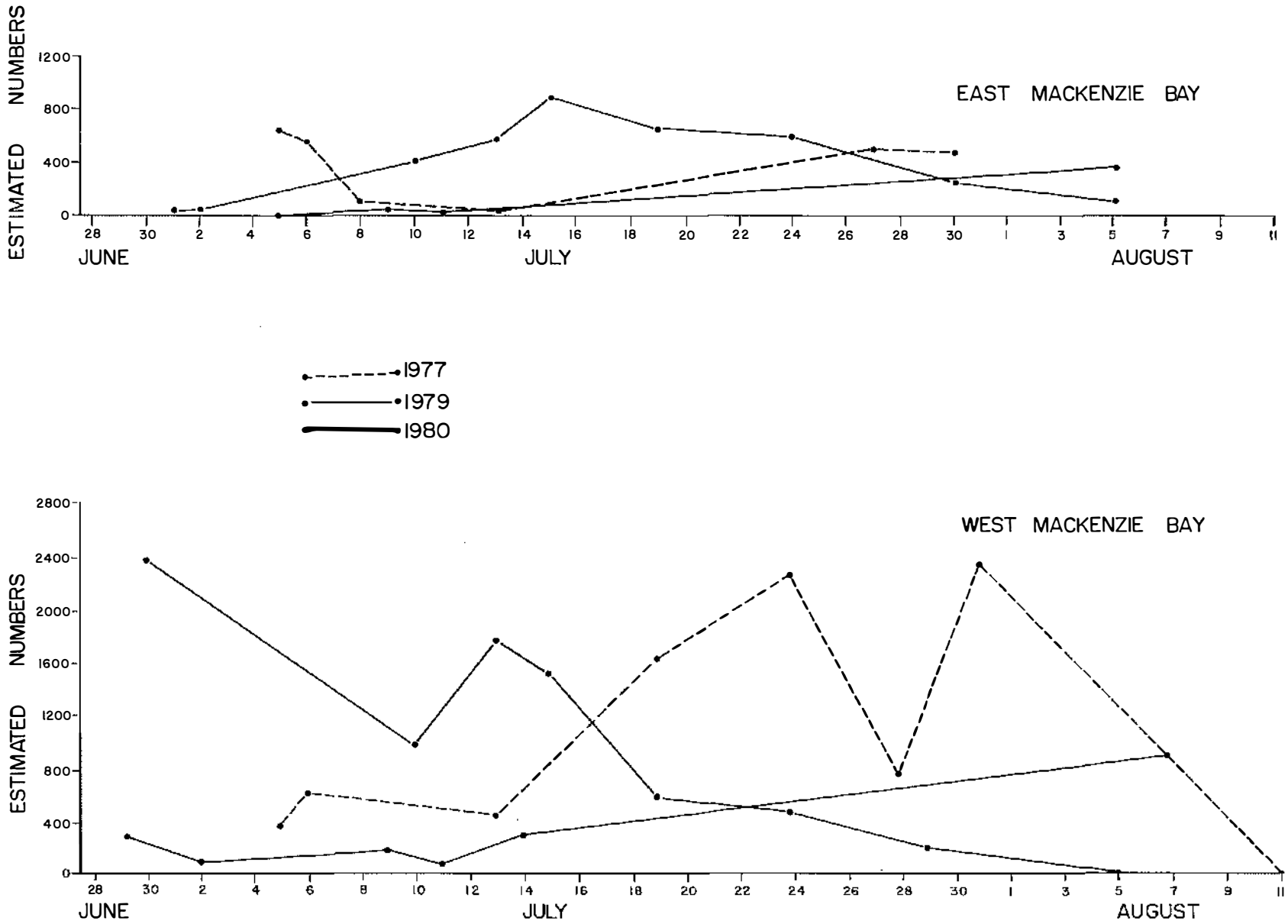


Figure 13. Estimated numbers of white whales in East and West Mackenzie bays, 1977, 1979 and 1980.

Table 13. Maximum estimates of white whales in Kugmallit Bay and Mackenzie estuary, 1976-1981.

Year	Kugmallit Bay	Mackenzie estuary total
1976	2000	5500-6000
1977	1750	5500
1978	780	6600
1979	500	7000
1980	120	4500
1981	1040	3500

Bay). This probably is the main cause of the lower estimates in 1980 and 1981. Differing whale behaviours during surveying may also cause year-to-year variation. The highest maximum estimate, 7000 animals, which was made in 1979, resulted from a survey when it was apparent that most whales were remaining at the surface. In contrast to the usual procedure, no visibility factor was applied to these data. (The usual visibility factor, two, is largely arbitrary and probably results in underestimates -- see 'Methods'.)

If industry activities were responsible for the year-to-year variations in numbers, one would expect to see an effect in Kugmallit Bay, where most of the industry traffic is concentrated. The highest estimate of whales in Kugmallit Bay occurred in 1976 (Fig. 4), when Esso was constructing Kugmallit H-59 using material barged from Tuft Point (Fig. 1). There were up to 13 round trips (26 vessel movements) per day related to that operation alone. This is a higher level of traffic than was observed in 1981 (maximum = 14 vessel movements/day) but fewer whales were estimated to use Kugmallit Bay in 1981 than in 1976. Although exact figures on the total amount of traffic are not available prior to 1980, our general impression is that there was less activity in 1977 than in 1976, then a gradual increase from 1978 to the present. There was a decrease in the number of whales using Kugmallit Bay during 1977 to 1980, but the numbers increased again in 1981. As will be discussed below, the pattern of high or low numbers appears to be determined early in the season, before industry activities are well underway. Thus, the variation in numbers from one year to another is not correlated with the level of industry activity, and the maximum number present in any given year is obtained before exploration activities reach a high level.

Effect of Ice on Whale Distribution and Abundance

Initial whale distribution and abundance within the estuary appears to be determined by the timing of the whale migration relative to the timing of the first breach in the landfast ice barrier in the eastern (Kugmallit Bay) and the western (Niakunak Bay) parts of the estuary. Generally the two areas are accessible about the same time (Table 3). However, in 1979 and 1981 there was a noticeable disparity in the timing of the breakup in the two areas; Niakunak Bay was accessible before Kugmallit Bay in both years. There was a corresponding disparity in the number of whales using the

concentration areas (5948 whales in Niakunak Bay vs. 496 in Kugmallit Bay in 1979 and 2464 vs. 1040 in 1981).

In 1980, there was also a great disparity in the peak number of whales using the two parts of the Mackenzie estuary: 4234 animals in Niakunak Bay and 120 in Kugmallit Bay (Fraker and Fraker 1981). Although the break-up in the two areas was almost simultaneous, 27 June for Niakunak Bay and 30 June for Kugmallit Bay, reconnaissance surveys indicated most whales had migrated past Kugmallit Bay before that area became accessible. Two surveys subsequent to the breaching of the ice in Kugmallit Bay failed to detect any migrating animals.

In 1978, the landfast ice was breached very late in both parts of the estuary (Fraker 1978). The whale migration to the estuary region was over before either area was accessible that year. Most of the whales had gone past Kugmallit Bay and had gathered seaward of the landfast ice barrier across Niakunak Bay to wait for the ice to be breached there. Thus, there were large numbers of whales in Niakunak Bay, but relatively small numbers in Kugmallit Bay. Insufficient data on the whale migration are available for years prior to 1978 to analyze the results.

Whale Harvest

The 1981 harvest (149 animals) was the most successful one since 1976 and was well above the 1972-1980 average of 131. Tuktoyaktuk hamlet, Kendall Island and Niakunak Bay camps landed more than their average number of whales. Kugmallit Bay camps landed fewer whales than usual.

If the harvests from the concentration areas are examined, each area produced at least its usual number of whales. In 1981, the harvests from Kugmallit Bay, Niakunak Bay and the Kendall Island area were 92, 35 and 22 whales, respectively. The nine-year averages for these areas are 91.1, 28.3 and 11.6, respectively (Table 8).

A discussion of harvest size is meaningless without an indication of hunting effort. Although a numerical estimate of the number of active hunters or the time spent hunting is not available for 1981, local fisheries officers suggest the increase in the harvest in 1981 was accompanied by an increase in hunting effort, due to good weather and an influx of hunters

from traditionally nonhunting communities (DFO 1981). Muktuk from the whales landed by the Niakunak Bay camps was shared with four families from Holman Island.

The lower number of whales landed by the Kugmallit Bay camps in 1981 as compared to 1972-1980 was due partly to a decrease in hunting effort. Inuvik hunters use either the Kugmallit Bay camps or Kendall Island, and several hunters have switched back and forth between the two locations, depending on the success of the hunt in each area and the weather. If the catch for these two areas is combined, 52 animals were taken in 1981, compared with an average of 52.5 for the period 1972-1980 (Table 8).

Generally the timing of the hunt corresponds to the timing of the arrival of the whales. The hunt was earlier in 1979 and 1981 than in 1978 and 1980 (Fig. 8). This pattern was particularly noticeable in Kugmallit Bay. Until 1980, the Kendall Island camps had been occupied later than camps in the other two areas. Since 1980, no such differences have been found.

Collecting data on the sex and length (≈age) composition of the harvest may help us to assess the general status of the white whale population, and these two characteristics have been recorded since 1974. Age measurements, using dentinal layers, have not been made regularly.

Geographical and/or temporal (within one harvest season or year-to-year) variations in the sex ratio and mean length of landed whales may occur. In the Mackenzie estuary, sex ratio has shown more variation than length. The year-to-year variation in sex composition was greatest for the years 1974-1978, when only small percentages of the harvest were examined (Table 9). Since 1979, there has been no significant change in the sex ratio of the catch. If we pool the data from the last three years, then the male:female ratio is 1.11:1.0 (139 males, 125 females). In 1979, 1980 and 1981, a greater percentage of whales landed at Kendall Island has been female than at the Niakunak Bay camps. The sex ratio of whales landed by the Kugmallit Bay camps has varied from year-to-year (Table 10), but there is no trend. In 1981, there was a statistically significant change in sex composition of the catch for the first half of the season (71% males) versus the latter half (76% females); however, this difference was not apparent in 1979 or 1980. (There are too few data to analyze for other years.)

Mean lengths of landed whales have been less variable than the sex ratio. There were no geographical or seasonal differences in the average length of landed males in 1979 or 1981; however, in 1980, males landed in the first half of the season were smaller, on average, than males landed in the latter half. Also, in 1980, the mean length of landed males varied from area to area: the largest males on average were from near Aklavik, second largest from Kugmallit Bay, third largest from near Kendall Island, and smallest from Niakunak Bay. Significant differences in mean length of landed females have been observed for certain years, particularly 1976 and 1981; however, no trend is obvious. Geographical variation in average length of landed females was observed in 1980. No seasonal variation was found for average length of landed females in 1979 to 1981 (Table 11).

Since there are few apparent trends in the year-to-year, geographical and seasonal differences, it seems likely that the variations in sex composition and length are in factors affecting the harvest rather than the status of the white whale population. Changes in hunter preferences and/or the particular groups of whales hunted, assuming segregation by age and sex, would affect the sex ratio and mean length of landed animals.

Some of the variations noted are undoubtedly the result of changes in hunter preferences. During interviews, hunters have indicated that they become less selective the less successful they are. Inuit with steady jobs who wish to hunt have to do so during time off and thus often they would have a limited period of time to get a whale. These hunters might be less selective than hunters who have a longer time to land a whale. Some changes in hunter selectivity are unexplainable. In 1981 a few hunters said that they wanted to take a juvenile because the muktuk was better and subsequently they did do so. Such a desire has been infrequently stated in previous years. Changes in hunter preferences may explain the variations observed in the sex ratio of the catch and the mean length of females landed. Because hunter preferences change over time and are infrequently expressed, it is not possible to analyse them.

Variations in the characteristics of landed white whales taken in other areas have been observed. Because aging was not done on many whales taken in the Mackenzie estuary, it is not meaningful to compare our data on lengths of

landed whales to those of others. A comparison of the sex ratios of the animals caught in different areas and at different times shows a wide range of results (Table 14). The sex ratio of the whales in the Mackenzie estuary catch in 1979-1981, the years when a high percentage of the catch was examined, is not unusual. However, males comprised most of the catch from 1974-1978, as well as the catch in the 1950's and 1960's that was reported by Sergeant and Brodie (1969). Of particular interest to this study are the changes in the sex ratios of animals harvested at Whale Cove, Hudson Bay (Sergeant 1973). Although all of the whales taken at Whale Cove were collected by nets, a method which eliminates hunter selectivity, there were significant year-to-year variations in the sex ratio of the animals caught.

Given the wide variation in the sex ratios shown in Table 14 and the variations in length observed in the Mackenzie estuary harvests, it seems probable that hunter selectivity does not explain all of the variations observed. Many of the results reported (e.g., Sergeant 1973; Degerbøl and Nielsen 1930) are of whales taken by less selective methods such as netting. Some of the variations reported are due to segregation of white whales by age and sex. Commercial whalers operating around Spitsbergen found some shoals that were predominately male, with a very few adult females, and others that were a mixture of males, females and young (Lønø and Øynes 1961). Similarly, Potelov and Ognetov (1974, cited by Gurevich 1980) and Ognetov (1978, cited by Gurevich 1980) found either all-male white whale groups or male-female groups but no all-female groups. There were indications that the age composition of white whale herds varied geographically and seasonally in the central Canadian high Arctic (Finley 1976).

In the Mackenzie estuary a small percentage of the total number of whales present in one season are landed and examined. Also, weather often causes the hunting effort to be concentrated into a few days. If whales do segregate into groups on the basis of sex and age, chance could be an important determinant of the sex ratio and length composition of the harvest.

Effects of Hunting on Whales in Kugmallit Bay

A few of the more important considerations when trying to determine the effect of hunting on whales in Kugmallit Bay are:

Table 14. Sex ratios of white whale harvests reported in the literature.

Location	Year(s)	Number of males landed	Number of females landed	Sex ratio (male:female)	Literature source
Mackenzie Estuary	1979-1981	139	125	1.11	Fraker and Fraker 1979, 1981 this report
	1974-1978	94	25	3.76	Slaney 1974, 1975; Fraker 1977a, b, 1978
	1950s	94	32	2.94	Sergeant and Brodie 1969
coast of western Alaska	1977-1979	106	89	1.19	Seaman and Burns 1980
Somerset Island, Canadian high arctic	1975	11	5	2.20	Finley 1976
Whale Cove, Hudson Bay	1961	25	68	0.37	Sergeant 1973
	1962(early)	35	37	0.95	Sergeant 1973
	1962(late)	44	29	1.52	Sergeant 1973
	1963	27	27	1.00	Sergeant 1973
	1964	31	88	0.35	Sergeant 1973
	1968	98	84	1.17	Sergeant 1973
Churchill, Hudson Bay	1949	93	87	1.07	Doan and Douglas 1953
	1950	176	117	1.50	Doan and Douglas 1953
	1951	383	198	1.93	Doan and Douglas 1953
West Greenland	1926-1927	206	279	0.74	Degerbøl and Nielsen 1930
Sakhalin	1930	299	162	1.85	Dorofeev and Klumov 1936

1. the hunting is not co-ordinated and many hunters do not have far to go; thus it is very difficult to estimate the hunting effort;
2. hunting may occur anywhere in the concentration area; and
3. in some years too few whales are present to confidently detect seasonal changes in whale distribution or abundance.

During systematic aerial surveys in 1981 we recorded the number and location of hunting boats as well as the number and location of white whales. There was a statistically significant correlation (r_s = 0.924, N = 11, $p<0.01$; Siegel 1956) between the number of hunting boats observed and the southernmost line on which whales were observed (Fig. 14). Although it is not possible to do a statistical test on the results, we observed more whales in the western part of Kugmallit Bay the more hunting boats there were. These results are not surprising since hunters generally are coming from Tuktoyaktuk or the Kugmallit Bay camps and thus are approaching the whales from the south or southeast (Fig. 1).

Effects of Oil and Gas Exploration on the White Whale Harvest in Kugmallit Bay

From the outset of oil and gas exploration, there has been concern about possible effects on whaling. Kugmallit Bay is the area where most of the industry activities occur and it is the area that sustains much (62% in 1981) of the whale harvest in the Mackenzie estuary. Thus, in the Kugmallit Bay area there is the greatest potential for industry to interfere with whaling. For this reason much of the 1981 survey effort was expended on Kugmallit Bay and data on vessel movements through the area were gathered.

When comparing whaling success and amount of vessel traffic, only results from 1 to 25 July were used. This was the period when all of the hunting in Kugmallit Bay took place (Fig. 8). There was no obvious relationship between hunting success and number of industry vessels moving through Kugmallit Bay (r = +0.209; Fig. 15). In general, industry vessel activity increased as July progressed while the most successful days for hunting were at the beginning and the end (the 4th and 25th of July). Hunting success was more closely related to the estimated number of whales present.

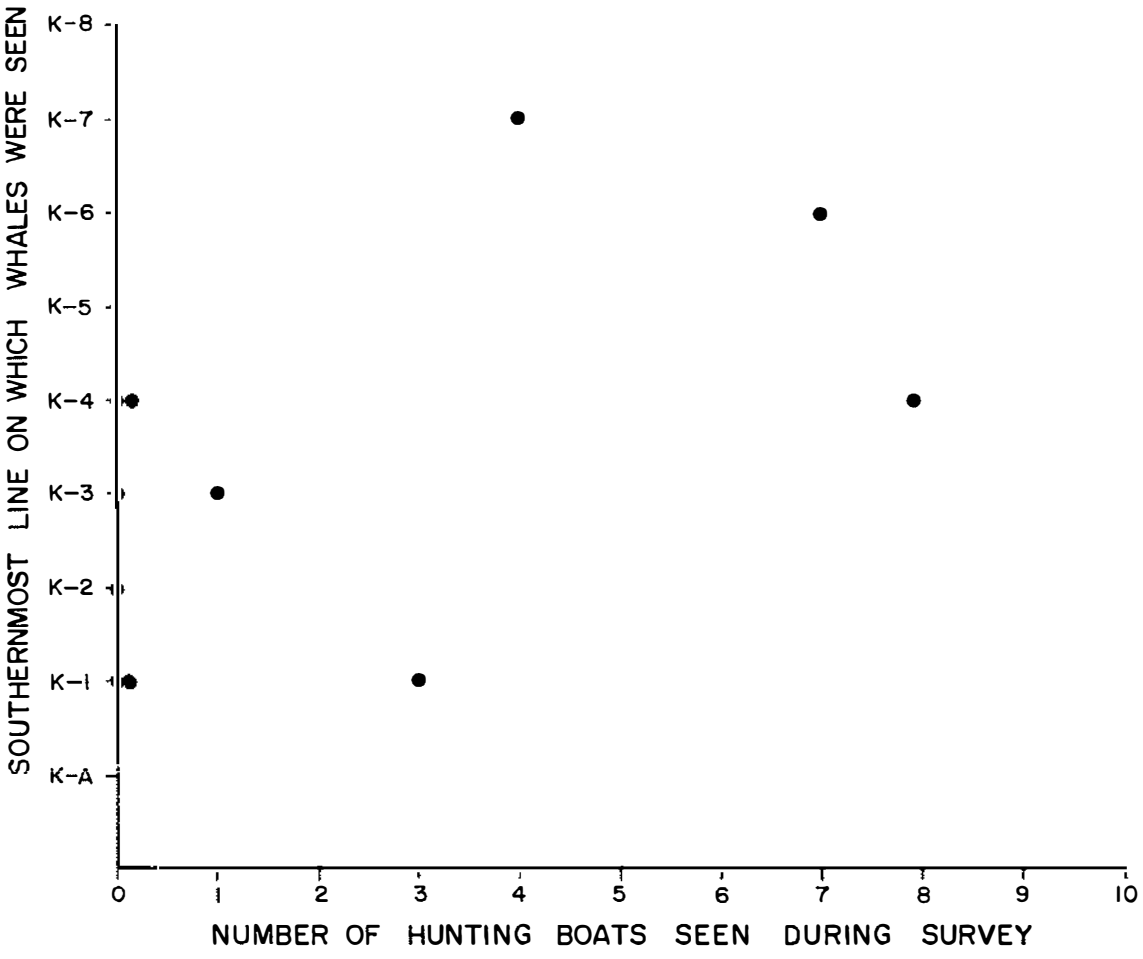


Figure 14. Relationship between penetration of whales into Kugmallit Bay and number of hunting boats pursuing whales. Data are from 1981 systematic aerial surveys (Appendix 1).

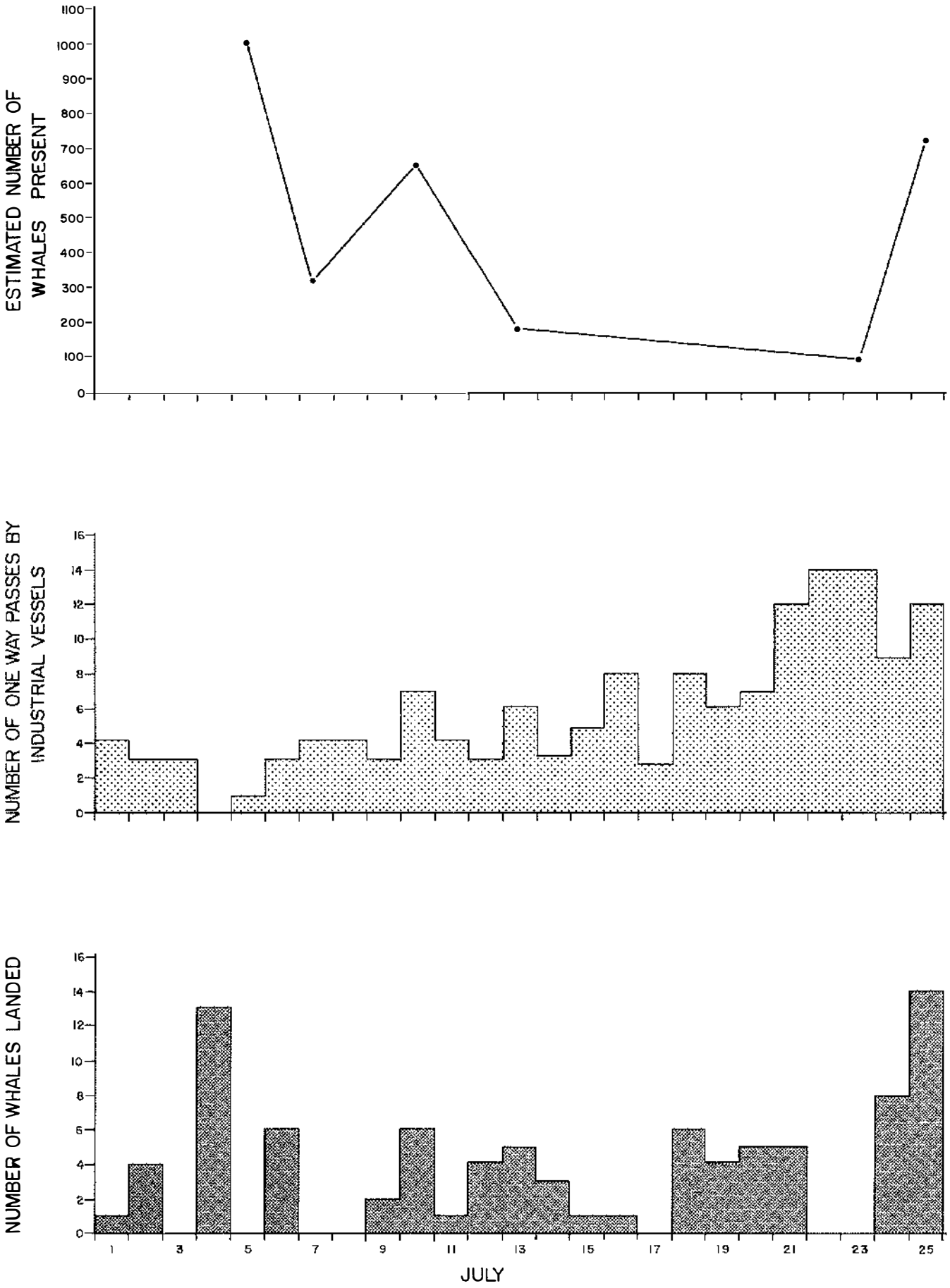


Figure 15. Number of whales landed, number of passes by industrial vessels and estimated number of whales, Kugmallit Bay, 1-25 July 1981.

Effect of Human Activities on White Whales

Ten years of study have provided several insights into the reactions of white whales to human activities. Neither hunting nor exploration has produced any long-term effects on whales in the Mackenzie estuary. However, a variety of short-term effects have been observed:

1. whales do not react to stationary structures, such as artificial islands, but may react to noisy and/or moving vehicles; for example, whales moved away from the 'Supplier I' when it started moving but passed within 100 m of the stationary 'Supplier III' on 23 June;
2. whales appear to be more sensitive when there is less space in which to maneuver, e.g., in narrow leads in the ice;
3. the whales' reaction depends on the amount of vessel activity, e.g.. an average of 22 barge movements per day interfered with whale movements around Tuft Point in 1976, but in 1977, when there were only seven movements per day, no interference was observed;
4. whales react more intensely the longer the duration of the disturbance, e.g., whales appear to be harder to hunt as the hunting season progresses; and
5. the whales' activity affects the extent to which they are disturbed, e.g., in 1979, whales that were feeding appeared to be less sensitive to helicopters than whales that were moving (Fraker and Fraker 1979).

LITERATURE CITED

Braham, H.W. and B.D. Krogman. 1977. Population biology of the bowhead (*Balaena mysticetus*) and beluga (*Delphinapterus leucas*) whale in the Bering, Chukchi and Beaufort Seas. Northwest and Alaska Fisheries Center Processed Report, National Marine Fisheries Service, Seattle, Washington. 29 p.

Degerbøl, M. and N. Nielsen. 1930. Biologiske iagttagelser over og maalinger af hvidhvalen [*Delphinapterus leucas* (pall.)] og dens fostre. Medd. om Gronland 77:119-144.

D.F.O. (Department of Fisheries and Oceans). 1981. Beluga whale observers program, Canadian Western Arctic, summer 1981. Inuvik station, Inuvik, N.W.T.

Doan, K.H. and C.W. Douglas. 1953. Beluga of the Churchill region of Hudson Bay. Fisheries Research Board of Canada Bulletin No. 98, Univ. of Toronto Press, Ottawa. 27 p.

Dorofeev, S.V. and S.K. Klumov. 1936. K Voprosu ob opredelenii vozrasta belukhi i sostava kosyakov (on age determination and herd composition of beluga). Tr VNIRO 3:24-34. (Original not seen; cited by Sergeant 1973.)

Eberhardt, L.L., D.G. Chapman, and J.R. Gilbert. 1979. A review of marine mammal census methods. Wildl. Monograph No. 63. 46 p.

Finley, K.J. 1976. Studies of the status of marine mammals in the central district of Franklin: N.W.T., June-August 1975. Unpubl. Rep. by LGL Ltd., Toronto, Canada, for Polar Gas Project, Toronto, Canada. 183 p.

Finley, K.J., and W.G. Johnston. 1977. An investigation of the distribution of marine mammals in the vicinity of Somerset Island with emphasis on Bellot Strait, August-September 1976. Unpubl. Rep. by LGL Limited, Toronto, Canada for Polar Gas Project, Toronto, Ontario. 91 p.

Finley, K.J., G.W. Miller, M. Allard, R.A. Davis, and C.R. Evans. 1982. The beluga (*Delphinapterus leucas*) of northern Quebec: distribution, abundance, stock identity, catch history and management. Can. Tech. Rep. Fish. Aquat. Sci. (in press).

Fraker, M.A. 1976. Summer environmental program, Mackenzie River Estuary. Volume 2, White Whale Studies. Unpubl. Rep. by F.F. Slaney and Company, Limited, Vancouver, Canada, for Imperial Oil Limited, Calgary, Canada. 62 p.

Fraker, M.A. 1977a. The 1976 white whale monitoring program, Mackenzie Estuary, N.W.T. Unpubl. Rep. by F.F. Slaney and Company, Limited, Vancouver, Canada, for Imperial Oil Limited, Calgary, Canada. 73 p.

Fraker, M.A. 1977b. The 1977 whale monitoring program, Mackenzie Estuary, N.W.T. Unpubl. Rep. by F.F. Slaney and Company, Limited, Vancouver, Canada, for Imperial Oil Limited, Calgary, Canada. v + 53 p.

Fraker, M.A. 1978. The 1978 whale monitoring program, Mackenzie Estuary, N.W.T. Unpubl. Rep. by F.F. Slaney and Company, Limited, Vancouver, Canada, for Esso Resources Canada Limited, Calgary, Canada. 28 p.

Fraker, M.A. 1979. Spring migration of bowhead (*Balaena mysticetus*) and white whales (*Delphinapterus leucas*) in the Beaufort Sea. Can. Fish. Marine Serv., Tech. Rep. 859. 36 p.

Fraker, M.A. and P.N. Fraker. 1979. The 1979 whale monitoring program, Mackenzie Estuary. Unpubl. Rep. by LGL Limited, Sidney, Canada, for Esso Resources Canada Limited, Calgary, Canada. 51 p.

Fraker, M.A., C.D. Gordon, J. McDonald, J.K.B. Ford and G. Cambers. 1979. The distribution of white whales (*Delphinapterus leucas*) in the Mackenzie estuary and the relationship to physical and chemical factors. Can. Fish. Mar. Serv. Tech. Rep. 863: v+ 56 p.

Fraker, P.N. and M.A. Fraker. 1981. The 1980 whale monitoring program, Mackenzie Estuary. Unpubl. Rep. by LGL Limited, Sidney, Canada, for Esso Resources Canada Limited, Calgary, Canada. 98 p.

Gurevich, V. 1980. Worldwide distribution and migration patterns of the white whale (beluga), *Delphinapterus leucas*. Rep. Int. Whal. Comm. 30:465-480.

Kleinenberg, S.E., A.V. Yablokov, B.M. Bel'kovich and M.N. Tarasevich. 1964. Beluga (*Delphinapterus leucas*), investigation of the species. Akad. Nauk SSSR, Institut Morfologii Zhivotnykh Im. A.N. Severtsova, Moscow. 450 p. (Translated into English, 1969, Israel Program for Scientific Trans., Jerusalem. 376 p.)

Koski, W.R. and R.A. Davis. 1979. Distribution of marine mammals in northwest Baffin Bay and adjacent waters, May-October 1978. Unpubl. Rep. by LGL Limited, Toronto, Canada, for Petro-Canada, Calgary, Canada. 305 p.

Lønø, O. and P. Øynes. 1961. Hvithvalfangsten ved Spitsbergen (White whale fishery at Spitsbergen). Tidende 1961 (7):267-287.

Ognetov, G.N. 1978. Composition of white whale congregations in the Soviet Arctic. (Abstract) 2nd Congrdss. Theriol. Internat., Brno.:355. (Original not seen; cited by Gurevich 1980).

Potelov, V.A. and G.N. Ognetov. 1974. The estimation of the abundance and structure of groups of belugas (*D. leucas*, Pall.) in the White Sea. 1st Congress. Theriol. Internat., Mosc.:79-80. (Original not seen; cited by Gurevich 1980).

Seaman, G.A. and J.J. Burns. 1980. Preliminary results of recent studies on belukhas in Alaskan waters. Unpubl. manu. for Alaska Department of Fish and Game, Fairbanks, AK. 31 p.

Sergeant, D.E. 1973. Biology of white whales (*Delphinapterus leucas*) in western Hudson Bay. J. Fish. Res. Bd. Can. 30:1065-1090.

Sergeant, D.E. and P.F. Brodie. 1969. Body size of white whales (*Delphinapterus leucas*). J. Fish. Res. Bd. Can. 26:561-580.

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Company, Toronto. 312 p.

Slaney, F.F. and Company, Limited. 1973. Environmental impact assessment, Immerk Artificial Island Construction, Mackenzie Bay, Northwest Territories. Volume 2, Environmental studies. Unpubl. Rep. by F.F. Slaney and Company, Limited, for Imperial Oil Limited, Calgary, Canada. 65 p.

Slaney, F.F. and Company, Limited. 1974. White whale study, Herschel Island-Cape Dalhousie, coastal region of the Beaufort Sea. Unpubl. Rep. by F.F. Slaney and Company, Limited, for Imperial Oil Limited, Calgary, Canada. 29 p.

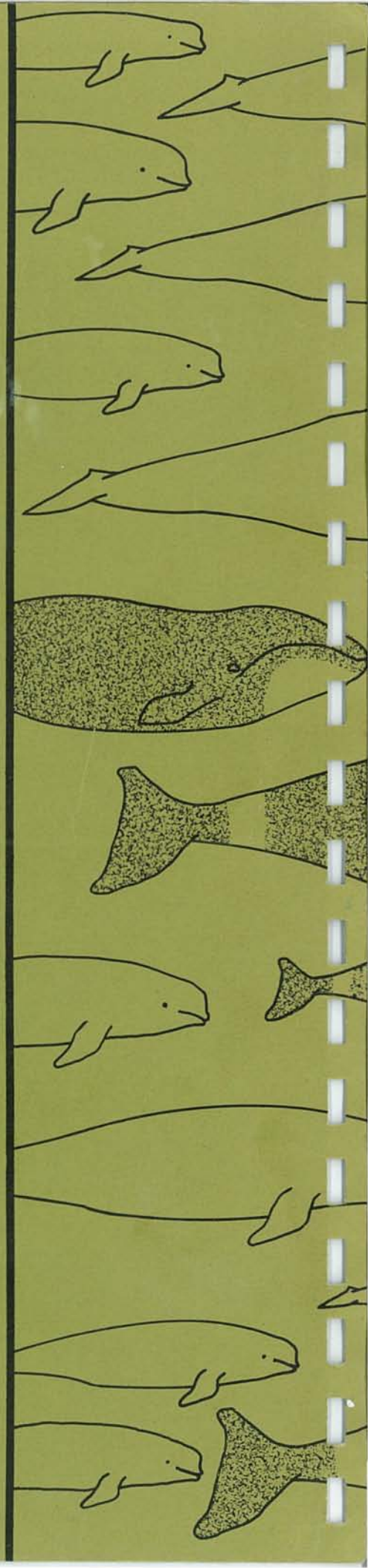
Slaney, F.F. and Company, Limited. 1975. Summer environmental program, Mackenzie River Estuary. Volume 3, White whale studies. Unpubl. Rep. by F.F. Slaney and Company, Limited, for Imperial Oil Limited, Calgary, Canada. 53 p.

Appendix 1. Number of whales counted during aerial surveys in the Mackenzie estuary, by survey line and area, 1981. NS means that line was not surveyed on that date.

	Niakunak Bay Survey Lines												
Dates	N-C	N-B	N-A	N-1	N-2	N-3	N-4	N-5	N-6	N-7	N-8	N-9	Totals
19 June	0	0	0	0	0	0	0	0	26	15	NS	NS	41
21 June	0	0	0	0	0	0	0	0	0	11	NS	NS	11
29 June	0	0	0	0	45	72	103	109	68	13	10	NS	420
6 July	2	12	24	4	16	15	41	98	132	165	84	23	616
11 July	NS	NS	0	0	0	0	0	0	0	100	156	210	466
Totals	2	12	24	4	61	87	144	207	226	304	250	233	1554

Appendix 1. Continued.

Dates	Kugmallit Bay Survey Lines															
	K-A	K-1	K-2	K-3	K-4	K-5	K-6	K-7	K-8	K-9	K-10	K-11	K-12	K-13	K-14	Totals
6 July	0	1	174	67	4	4	3	7	0	0	NS	NS	NS	NS	NS	260
8 July	0	0	0	27	21	5	0	3	2	1	4	17	NS	NS	NS	80
10 July	0	2	0	2	9	45	37	42	5	6	0	4	11	1	NS	164
13 July	0	0	0	0	3	2	13	7	3	17	2	0	NS	NS	NS	47
16 July	0	0	5	4	7	0	6	0	NS	NS	NS	NS	NS	NS	NS	22
18 July	0	0	0	0	0	0	1	0	0	5	0	NS	NS	NS	NS	6
21 July	0	7	0	0	0	0	0	0	0	3	1	5	NS	NS	NS	16
23 July	NS	0	0	0	0	0	0	12	2	0	0	13	NS	NS	NS	27
25 July	NS	0	0	57	65	33	6	18	4	NS	NS	NS	NS	NS	NS	183
28 July	NS	0	0	0	20	8	0	36	2	15	5	0	2	5	47	140
1 August	NS	0	0	0	4	3	2	0	0	0	NS	NS	NS	NS	NS	9
5 August	NS	0	0	0	0	0	0	0	0	0	0	NS	NS	NS	NS	0
Totals	0	10	179	157	133	100	68	125	18	47	12	39	13	6	47	954



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