Polar Bear Population Ecology—Arctic Islands Pipeline Route

Preliminary Report 1977

I. Sterling
R.E. Schweinsburg
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Population Ecology of the Polar Bear Along the Proposed Arctic Islands Gas Pipeline Route

Ian Stirling*
R. E. Schweinsburg**
Wendy Calvert*
H. P. L. Kiliaan

*Canadian Wildlife Service
Fisheries and Environment Canada

**Fish and Wildlife Service
Government of Northwest Territories

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This report presents preliminary data and results obtained by Fisheries and Environment Canada for use by the Arctic Islands Pipeline Program. These investigations were carried out under the Environmental-Social Program, Northern Pipelines of the Government of Canada. While the studies and investigations were initiated to provide information necessary for the assessment of hydrocarbon transportation proposals, the knowledge gained is equally useful in planning and assessing other development projects.

RÉSUMÉ

Le but du présent rapport est de fournir les données de base portant sur l'ours blanc et faisant partie intégrante de la vision écologique d'ensemble nécessaire au gouvernement fédéral pour évaluer les conséquences environnementales du pipeline. Deux aspects revêtent une importance particulière. Il faut tout d'abord fournir les données de base sur l'écologie de la population, sa répartition, son abondance, les migrations saisonnières, le nombre de sous-populations spécifiques touchées et l'emplacement des aires importantes d'hibernation, d'alimentation et d'estivage. Il faut ensuite essayer d'identifier les moments du cycle annuel de l'ours blanc où une protection contre les activités de construction et d'utilisation du pipeline ou encore des modifications de ces dernières pourraient s'avérer nécessaire.

De 1970 à 1976, 611 ours blancs ont été capturés, desquels 74 ont été recapturés et 30 tués par des chasseurs inuit. Des relevés aériens et terrestres ont été effectués sur les aires d'hibernation et les observations non publiées ont été recueillies lorsque c'était possible.

Les ours blancs des moyennes et grandes latitudes ont montré un fort degré de fidélité à leurs aires d'alimentation hivernale et estivale. Les résultats d'observations de sujets marqués et recapturés sur deux années ou plus portent à croire eux aussi qu'il existe un fort degré de fidélité pour des régions précises. On a enregistré certaines longues migrations à l'intérieur aussi bien qu'à l'extérieur de la région étudiée, et on a ainsi démontré qu'il existe un nombre limité d'échanges entre les sous-populations spécifiques. À l'intérieur de la région d'étude, les ours blancs du détroit de Barrow, du nord-est et du sud-est de l'île Victoria semblaient constituer des sous-populations spécifiques. On n'a décelé aucune preuve de l'existence de migrations saisonnières des ours blancs vers le nord ou vers le sud. Les aires d'estivage revêtent une importance écologique particulière du fait que la période pendant laquelle les ours peuvent continuer de se nourrir y est significativement plus longue qu'ailleurs.

Il semble que les endroits où surviennent les mises bas sont largement répartis dans la région étudiée et que leur densité soit plus faible qu'en d'autres régions plus limitées sur la côte manitobaine de la baie d'Hudson et dans l'île Wrangel, en URSS. Il est possible que des mises bas surviennent à des densités aussi élevées à certains endroits de la région étudiée, endroits qui n'ont pas encore été découverts ou que nos techniques d'inventaire sont incapables de détecter. On a évalué sur une carte l'importance relative des gîtes de mise bas, compte tenu des limites imposées par l'accessibilité des données.

L'effectif moyen des portées d'oursons de l'année, qui ont été capturées ou observées, a été évalué à 1.64 - 0.51, ce qui est comparable aux données recueillies dans d'autres régions de même latitude. L'effectif moyen lié à l'âge d'une femelle adulte était inférieur (1.51), mais il se trouvait toujours à moins d'un écart-type de la premiere valeur. La proportion des femelles

accompagnées de petits de tout âge (54.5 %, 85/156) et leurs taux de conception et de natalité liés à l'âge (0.210 et 0.159 respectivement) sont inférieurs à ce qui a été évalué dans l'ouest de l'Arctique de 1971 à 1973 (Stirling et al., 1975). La signification profonde de ces valeurs relativement à l'état actuel de la population n'est pas encore claire.

L'âge moyen des ours blancs de chaque sexe, âgés d'un an ou plus et tués par les chasseurs inuit, n'était pas significativement différent de celui des ours capturés appartenant à la même classe d'âge. Ceci porte à croire que la pyramide des âges de l'échantillon tué est représentative de la population totale. Les taux de mortalité liée au sexe des échantillons capturés étaient plus élevés que ceux des échantillons tués, probablement à cause de déviations qui sont traitées dans le rapport. Par conséquent, les taux de mortalité (16.6 % pour les mâles, 12.3 % pour les femelles) des ours tués sont probablement plus représentatifs de la population naturelle. On n'a décelé aucune preuve d'une chasse excessive de la population d'ours de la région étudiée.

Les principaux territoires de chasse à l'ours des Inuit ont tendance à déborder dans des régions de mise bas importantes. La chasse à l'ours blanc revêt toujours une valeur économique importante pour les communautés inuit.

On devrait toutefois noter que le présent rapport est provisoire, et que nos conclusions ne sont pas finales. Comme on l'a déjà souligné, plusieurs aspects des données nécessitent encore des analyses plus raffinées et des recherches supplémentaires pour combler les lacunes.

Nous avons recommandé d'interdire l'installation de zones d'étapes ou la construction dans les aires d'estivage les plus importantes de la baie Graham Moore, des baies du sud-ouest de l'Île Devon et des baies Brentford et Creswell. Moyennant quelques précautions, on pourrait probablement permettre certaines activités locales, durant l'hiver, dans des régions connues de mise bas.

Afin de combler les lacunes de nos connaissances actuelles, nous recommandons des recherches plus poussées dans trois domaines: 1) inventaire des régions adjacentes au tracé projeté qui offrent des possibilités pour la mise bas et qui n'ont pas encore été examinées; 2) marquage et recapture dans des régions précises qui ont jusqu'ici été peu échantillonnées, afin de compléter les études sur les migrations, le caractère spécifique des populations et la fidélité aux aires d'alimentation hivernales et estivales; et 3) analyse plus détaillée des données déjà recueillies portant sur la mortalité et la reproduction, y compris les données de 1977, afin d'augmenter la fiabilité de ces paramètres vitaux de base.

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1. SUMMARY

The objective of this report is to provide baseline information on polar bears as part of the overall ecological background required by the federal overnment to assess the environmental consequences of the proposed gas pipeline. Two aspects are of particular importance. The first is to provide baseline information on the population ecology, distribution, abundance, seasonal movements, number of discrete subpopulations affected, and the location of important denning, feeding, and summer retreat areas. The second is to try to identify important areas or times in the annual cycle of the polar bear that might warrant protection from, or modification of, construction or operational activities.

From 1970 through 1976, 611 polar bears were captured for the first time, 74 were recaptured and 30 were shot by Inuit hunters. Air and ground surveys of maternity denning areas were conducted and unpublished observations were gathered whenever possible.

Polar bears in the Central and High Arctic showed a high degree of fidelity to winter and summer feeding areas. Observations of individually tagged polar bears, recaptured over a series of two or more years, also tended to suggest a strong degree of fidelity for specific areas. Some long distance movements within, as well as out of the study area, were recorded, indicating that a limited amount of exchange between more widely separated subpopulations occurs. Within the study area, the polar bears of Barrow Strait, NE Victoria Island, and SE Victoria Island appeared to be discrete subpopulations. No evidence was found of northward or southward seasonal movements of polar bears. The summer feeding and retreat areas are of particular ecological importance because the period during which bears can continue to feed is significantly longer there than elsewhere.

Maternity denning in the study area appeared to occur over a widespread area, apparently at lower densities than have been reported for more localized denning areas on the Manitoba coast of Hudson Bay and on Wrangel Island, USSR. It is possible that maternity denning occurs at comparably high densities at some locations within the study area but, to date we have not found them in our surveys. The relative importance of maternity denning sites within the study area was evaluated within the limitations of the data available and then plotted on a map.

The mean litter size of cubs of the year that were captured or observed was 1.64 ± 0.51, which was comparable to data recorded in other areas of similar latitude. The age-specific mean litter size for adult female polar bears was lower, 1.51, but was still within one standard deviation of the first value given. The proportion of females 5 years and older accompanied by cubs of any age (54.5%, 85/156), and their age-specific conception and natality rates (0.210 and 0.159 respectively) were lower than were recorded in the Western Arctic from 1971-73 (Stirling *et al.*, 1975). The full significance of these values in relation to the present status of the population is not yet clear.

The sex-specific mean age of polar bears one year of age and over, killed by Inuit hunters did not differ significantly from the sex-specific mean ages of captured polar bears from the same age classes. This suggests that

the age structure of the kill sample is representative of the total population. The sex-specific mortality rates of the capture samples were higher than those of the kill samples, probably because of biases as discussed in the text. Thus, the sex-specific mortality rates (males 16.6%, females 12.3%) of the killed bears are probably more representative of the natural population. There was no evidence that the polar bear population in the study area was currently being overharvested.

The main Inuit polar bear hunting areas tend to overlap with the locations of important maternity denning areas. Polar bear hunting is still of significant economic value to the Inuit communities.

However, it should be noted that this is an interim report and our conclusions are not yet final. As was noted in the report, several aspects of the data still require more refined analyses and additional research to fill gaps.

We recommended that staging or construction activities not be permitted in the most important summer feeding and retreat areas of Graham Moore Bay, the bays of SW Devon Island, Brentford Bay and Creswell Bay. With care, some activities in known maternity denning areas during the winter, on a localized basis, could probably be permitted.

Further investigation was recommended in three areas to fill gaps in the present knowledge: 1) survey of potential denning areas adjacent to the projected pipeline route that have not yet been examined; 2) mark and recapture studies in specific areas which have thus far been undersampled to complete the studies of movements, discreteness of populations, and fidelity to winter and summer feeding areas; and, 3) more detailed analyses of mortality and reproductive data already collected, and to be collected in 1977, to refine the reliability of those vital baseline parameters.

The authors advised against the wider distribution of this interim report at this late date because of its inadequacy in the face of a completed final report. However, it was decided to print it anyway because of possible delays in distributing the final report. Because this is only an interim report it should not be quoted and only the final report should be relied upon for any conclusions.

2. INTRODUCTION

2.1 Nature, Scope and Objectives of the Study

The discovery of natural gas in the Canadian High Arctic has resulted in a proposal to build a pipeline to transport this resource from the Sverdrup Basin to southern Canada and the United States. Construction of such a pipeline is an enormous undertaking and probably requires at least five years to build. Potential disruption to the environment from this project could result from two main areas: 1) construction of the line itself (including pre-construction activities such as staging etc.); and 2) its later presence when operating and being maintained. Consequently, baseline research is being conducted in several general areas and on several species, of which the polar bear (*Ursus maritimus*) is one.

The objective of this report is to provide baseline information on polar bears as part of the overall ecological background required by the federal Government to assess the environmental consequences of the proposed gas pipeline. This will be done from two points of view. The first is to provide baseline information on the population ecology, distribution, abundance, seasonal movements, number of discrete subpopulations affected, and the location of important denning, feeding, and summer retreat areas for polar bears. The second will be to try to identify important areas or times in the annual cycle of the polar bear that might warrant protection from, or modification of, construction or operational activities.

Although not one of the formal objectives of this report, the results will be of direct and long term value to the ongoing management of polar bears by the Government of the Northwest Territories.

Besides its obvious esthetic value, the polar bear represents a substantial component of the cultural and economic base of the Inuit of the Western Arctic. At one time, polar bear meat was used for food for both people and dogs, and the hides were utilized to a lesser degree for trade or the making of clothing. In more recent time however, the principal motivation for polar bear hunting has been the sale of the hides, several of which sold for prices in excess of $3,000 in 1973 (Smith and Jonkel, 1975a). A limited amount of meat is still utilized for food, both by humans and dogs. As such, there is a direct economic value in the polar bear resource plus the sociological and cultural values of a self-supporting existence for the hunters and trappers involved.

In November 1973, Canada, Denmark, Norway, the United States, and the Soviet Union signed an international agreement on the conservation of polar bears (Appendix I) which stated in part: "Each contracting party shall take appropriate action to protect the ecosystems of which polar bears are a part...". This means that Canada has a direct obligation, by International Agreement, to ensure both that baseline studies are done and that the results are utilized to conserve polar bears and their habitat.

3. RÉSUMÉ OF THE CURRENT STATE OF KNOWLEDGE

3.1 Life History of the Polar Bear

The polar bear is circumpolar in distribution. In Canada, its range extends from the permanent pack ice of the Arctic Ocean and High Arctic Islands to southern James Bay.

Although any polar bear may dig a den and use it for a few days during a winter storm, usually only pregnant females regularly den for an extended period, usually from about early November to late March or April. Father F. Van de Velde (pers. comm.) has reported instances of females with older cubs denning up as well but the extent to which this occurs is not known.

The maternity dens are usually dug in deep snow banks on steep slopes, riverbanks, or stream banks located near the sea. The entrance may be several metres long and usually slopes upward into the main chamber. Most dens have one or sometimes two rooms, often with alcoves dug into the walls, and a ventilation hole through the roof. An average den size is seven feet long, by five feet wide, by three feet high (Harington, 1968). Lentfer (1975) has documented that some maternal denning takes place on the drifting pack ice of the Beaufort Sea but the extent to which this occurs is not known.

Polar bears, like several other mammal groups, have delayed implantation. This means that the fertilized egg does not begin to grow immediately but remains in the uterus in a dormant state. Thus, although the polar bear mates in May, the fertilized egg does not implant and begin to grow until about September.

In captivity, the young, normally two, are born anywhere from late November to January. In the wild there is likely as much or more variation in birth dates because of latitudinal differences in the Arctic seasons. Baby polar bears are hairless, blind, and weigh only about 1 1/2 lb (<1 kg) at birth. By the time they leave the den in March or April the cubs weigh approximately 20 lb (9 kg). The females lose weight while suckling the cubs and are hungry when they leave the den.

For the first few days after breaking out of the den, the female and cubs appear to just play near the den and return to it often. The den entrance is surrounded with the tracks of young cubs digging and sliding down banks. In the meantime, most females seem to dig out and eat ground vegetation. This process may last as long as one to two weeks before the family heads for the sea to begin hunting seals. Most polar bear cubs stay with their mothers until they are 2 1/2 years old, although some may remain with the female into their third or fourth years.

Once back on the sea ice the diet of the polar bear consists mainly of ringed and bearded seals. However, observations have been made of bears catching sea birds by diving and coming up beneath them and of bears diving for and eating kelp (Russell, 1975). Seals are mainly captured by stalking, waiting for the animal to surface at a breathing hole (Stirling, 1974a), or, in the spring, digging out seal pups and sometimes adults from the birth lairs beneath the snow. Seals captured are not always completely eaten by the bears that caught them (Stirling, 1974a; Stirling and McEwan, 1975).

When fully grown, adult males in Canada range from about 1,000 to 1,200 lb (450-550 kg) while adult females weigh from about 400 to 600 lb (180-270 kg).

At one time the theory was that the world population of polar bears was a unit and individuals lived a nomadic existence wandering about the whole circumpolar range. However, recent tagging and recapture programs, particularly in Canada, Norway and Alaska, have shown this is not the case. Instead, it appears that most populations are fairly local. In Canada, there may be as many as 15 such relatively discrete subpopulations.

3.2 Previous Knowledge of Polar Bears in the Area of the Proposed Pipeline Route

Published data on the polar bears of this area are few. Some polar bear observations were made during a biological investigation of Prince of Wales Island in 1958 (Manning and Macpherson, 1961) and during a game survey of the Queen Elizabeth Islands in 1961 (Tener, 1963). A preliminary polar bear survey was carried out in the Resolute area in 1962 (Harington, 1963), to obtain data on aspects of size, food habits and general condition of bears and on denning and behavior. That area was chosen partly because of the known high yield of polar bears. Area economic reports for Resolute Bay and the Central Arctic give some data on utilization of polar bears (Bissett, 1967; Villiers, 1969).

Van de Velde (1957 and 1971) gives a number of observations on the natural history of polar bears, Inuit hunting, and a unique set of data on changes in the litter size from pregnancy to the time the cubs are one year of age or older the vicinity of Pelly Bay. Mary-Rousselierre (1957) described Inuit hunting of polar bears in their dens and illustrated one such den. Harington (1968) summarized available knowledge on denning to that time. The trade and value of polar bear hides from the study area in the years 1972-73 to 1974-75 were included in Canada-wide surveys of the subject by Smith and Jonkel (1975 a & b) and Smith and Stirling (1976). Some information on the behavior of undisturbed polar bears during summer were published by Stirling (1974a) and data on seals killed by polar bears have been summarized by Stirling *et al.*, (1977). Jonkel (1976) briefly summarized his observations on polar bears in the vicinity of Strathcona Sound.

In 1970, a general polar bear study was initiated in the High Arctic, based out of Resolute, by Dr. C. Jonkel, formerly of the Canadian Wildlife Service. Tagging and recapturing of tagged bears in the area has continued to date with special emphasis on the area of Lancaster Sound and eastern Barrow Strait area. In 1972, Mr. S. Miller of the NWT Fish and Wildlife Service began a similar study in the Central Arctic, centred on M'Clintock Channel and Hadley Bay on NE Victoria Island. No reports were published from either project. Thus, the data collected will be included in this study. Ground and aerial denning surveys were also conducted in the Jones Sound and western Barrow Strait between 1970 and 1975. The scale and goals of these various projects were expanded and coordinated in 1975 and 1976 with the aid of supplemental funds from AIPP. Stirling *et al.* (1976b) summarized the results available to the end of 1975.

4. STUDY AREA

4.1 General

The study area was restricted to the area of the proposed Eastern Arctic Pipeline route north of Spence Bay. This area includes the large islands and peninsulas of Melville Island, Byam Martin Island, Bathurst Island, Little Cornwallis Island, Cornwallis Island, Grinnell Peninsula, Prince of Wales Island, Somerset Island, and Boothia Peninsula (Fig. 1).

Figure 1 shows the proposed preferred and alternate pipeline routes. These routes are subject to change in the future, but for now the following areas are potential crossings:

(1) Byam Channel between Melville Island and Byam Martin Island,
(2) Austin Channel between Byam Martin Island and Bathurst Island,
(3) Bathurst Island to Little Cornwallis Island to Cornwallis Island,
(4) Barrow Strait between Bathurst Island and Prince of Wales Island,
(5) Barrow Strait between Cornwallis Island and Somerset Island,
(6) Cornwallis Island to Baillie-Hamilton Island to Grinnell Peninsula,
(7) Peel Sound between Prince of Wales Island and Somerset Island,
(8) Franklin Strait between Prince of Wales Island and Boothia Peninsula, and
(9) Bellot Strait between Somerset Island and Boothia Peninsula.

The area around the crossings and for several kilometres inland along the pipeline routes are important in terms of disturbance to polar bears and man-bear interactions. Some of the offshore areas may be important feeding areas while the coastal areas are important for summer retreats and for maternity denning. Proposed pipeline wharf sites, camps, and staging areas will also be areas of high potential for interaction with polar bears.

4.2 Physiography

The area falls within four main geological divisions (Fortier, 1957):

(1) Precambrian shield
(2) Palaeozoic basins
(3) Innuitian folded region
(4) Arctic coastal plain

The Precambrian shield underlies much of the area and is exposed throughout the central part of the Boothia Peninsula, in southwestern Somerset Island and in a narrow strip along the east coast of Prince of Wales Island. The shield is composed of ancient rocks, mainly granites and metamorphic rocks, folded in Precambrian times and now worn down to relatively low rolling terrain. The hard rock, low gradients, glacial action and permafrost explain the haphazard arrangement of numerous lakes and streams. In northern Boothia Peninsula and southwestern Somerset Island, the rocks have been dissected along north-south and east-west joint and fault lines, into rugged hills. Bellot Strait is formed along a well developed east-west fault line.

To the east and west of the exposed finger of the Precambrian shield are Palaeozoic basin sediments. These flat-lying, mainly limestone and sandstone sediments, which are thin and low-lying in the south (Palaeozoic lowlands), become thicker northward to form smooth plateaus up to 600 m high (Palaeozoic uplands). These sediments occur throughout most of Prince of Wales

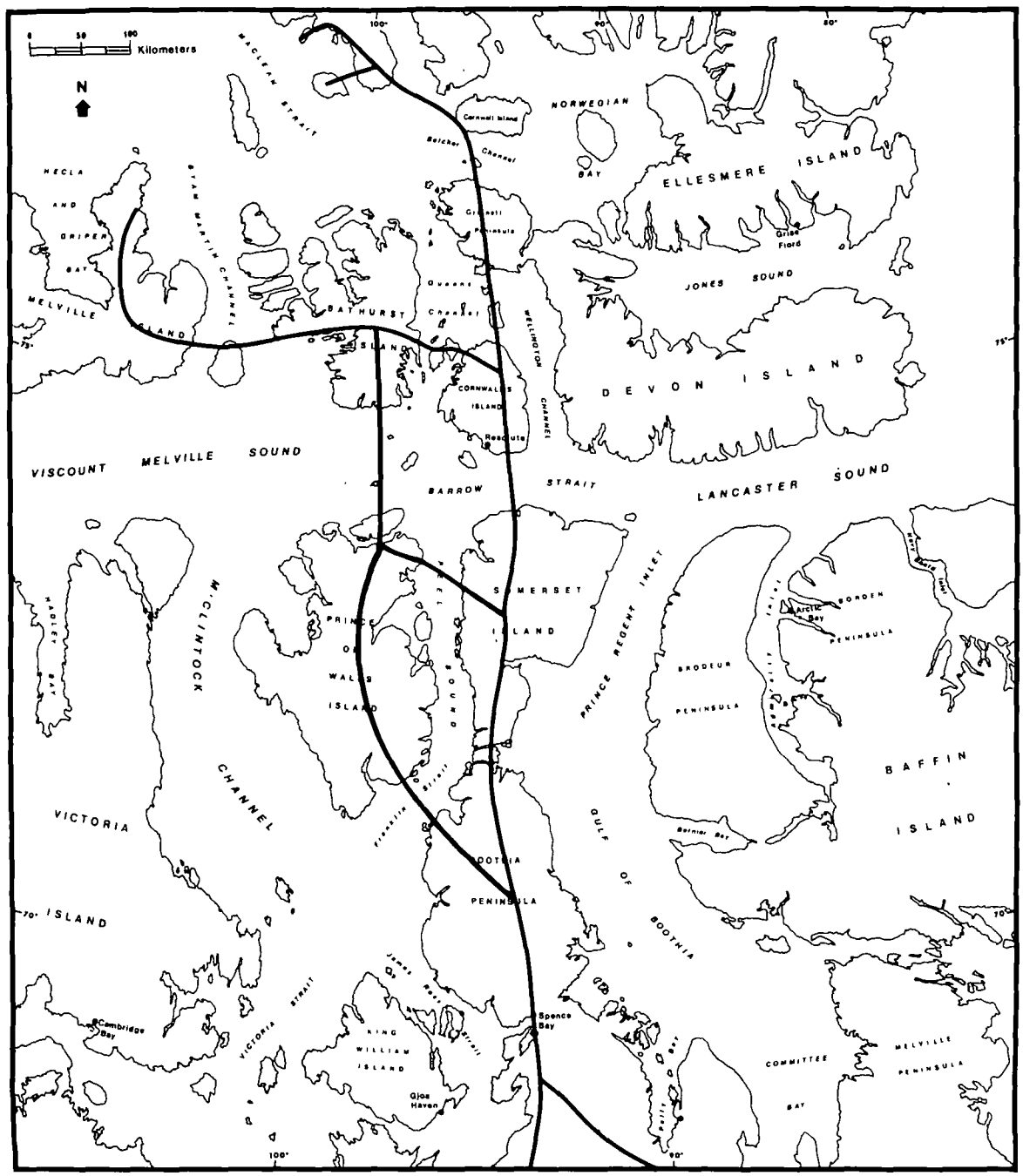

Figure 1. Map of the study area with the proposed route and alternatives for the Arctic Islands gas pipeline.

Island, in narrow strips in southwestern, southeastern and northeastern Boothia Peninsula, most of Somerset Island, southwestern Devon Island and a narrow strip along the southern coast of Bathurst Island. The Palaeozoic lowlands have a typically low topography with ill-defined drainage systems, many lakes and a flat, featureless coast. Some glacial deposits in the form of drumlins, eskers and moraines, are found in these areas. The lowland areas occur in southern Boothia Peninsula and much of western and southern Prince of Wales Island. Where the plateaus or Palaeozoic uplands reach the coast, there are steep cliffs with steeply banked talus slopes which are best developed along the northern coast of Somerset Island and southern coasts of Devon and Cornwallis islands. Deep valleys have formed in the easily eroded limestone and sandstone rocks. In contrast to the shield and lowland areas, there are few lakes and the drainage has a definite pattern. The northern part of Prince of Wales Island is made up of the Palaeozoic uplands but relief is lower and the valleys wider than in the other upland areas.

To the north of the shield and plateau areas, stretching from Prince Patrick Island across most of Melville, Bathurst, Cornwallis and northwestern Devon islands to northern Ellesmere Island is the Innuitian or Arctic Islands folded belt. This is made up of a series of parallel folds of Palaeozoic and Mesozoic rocks which run approximately east-northeast to west-southwest. Apart from a few bold ridges, the surface is a fairly even plateau with elevations below 400 m and dissected by deep valleys. Submergence has been responsible for the occurrence of most of the inlets on Bathurst Island. Faulting, in addition to submergence, may have contributed to the formation of the straits between the islands off the northwestern coast and also of Goodsir and Bracebridge inlets in the south.

The northwestern part of the Queen Elizabeth Islands, including most of Melville and Bathurst islands was thought not to have been glaciated. The remaining part of the area was glaciated and has therefore been subjected to the effects of glacial erosion and deposition. Evidence of isostatic rebound is shown by the presence of numerous raised beaches throughout the area. The Arctic Islands were originally part of the mainland but due to submergence, during glaciation, channels and inlets have developed along former drainage systems (Fortier 1957). Now water and land occur in almost equal proportions. All the channels are on the continental shelf with deepest parts in the eastern end of Lancaster Sound (800 m) and the western end of M'Clure Strait (500 m). Barrow Strait shoals to about 55 m and is comparable in depth to most channels to the north and south. The Arctic Islands fall within the zone of continuous permafrost (Brown 1967). The active layer is thin and permafrost is hundreds of feet thick.

4.3 Vegetation

Phytogeographically, the vascular flora of the area falls within the Arctic Archipelago Province (Porsild, 1955). Although it is comparatively poor in species (327), it has a relatively high number of endemics, implying that part of the area may not have been glaciated. Generally the population structure of the arctic vegetation is simple and of low density, i.e., few species with much unoccupied ground between individuals. All plant species are low-growing. The low summer and winter temperatures eliminate all but the really hardy species. The growing season is much delayed and reduced. The low light intensity

at these high latitudes is partly compensated by the long photo-period during the summer months. The presence of permafrost with only a shallow active layer forming each summer, reduces the effective depth of roots but helps reduce water loss and partly compensates for the low precipitation. Even so, vegetation is largely confined to areas of runnoff from snow banks, or in depressions where mositure accumulates. The more open, drier areas tend to be colonized by wood rushes, mountain avens and purple saxifrage. Mountain avens, willows, sedges, mosses and lichens are more characteristic of the moister, more densely vegetated areas,

4.4 Climate

The Arctic Archipelago typically has long, very cold winters and short, cool summers. The marked variation in solar radiation throughout the year is responsible for the extreme temperature range between winter and summer and the continuous dark period in winter and daylight in summer. The following summary is taken from Dunbar and Greenaway (1956) and Meteorological Branch (1970).

The onset of winter in the Resolute area occurs in late October as a very stable area of high pressure builds up over the western part of the Arctic Islands and the Mackenzie Basin. As most of the open water is covered with ice and snow, modifying effects are much reduced and the area experiences a continental type of climate. Temperatures are well below zero, being lowest in February. Because of the dominance of the very cold and dry Arctic airmasses, precipitation is very light (30-40 cm total snowfall for winter) and skies are generally clear. Surface winds are light, usually from the north or northwest, and calms are frequent. Much of the snow is reworked by winds into hard-packed drifts. Some fog occurs over the few small areas of open water which persist throughout the winter.

With rapidly increasing daylength, temperatures begin to rise slowly in March. Warming is generally delayed as much heat is lost through reflection from ice and snow, in melting ice and snow, and reflection from increased cloud cover. By early May the strong winter pressure system starts to weaken and spring begins. Snowfall increases as the moisture-holding capacity of the air increases. Temperatures rise rapidly, particularly over the land, and begin to rise above freezing in late May.

Spring is short and by early or mid-July summer begins. No strong pressure gradients exist although frequent but generally weak depressions move across the Arctic Islands. Over a third of the total annual precipitation falls within the two summer months (July and August). Usually these are the only snow-free months. July is the warmest month and maximum temperatures over the land can be quite high but are stabilized over the channels and stay within 1 to 7° C.

Autumn usually begins in early September as the winter pressure patterns begin to establish. Day-length decreases rapidly and intense cyclonic activity and strong winds develop as a result of marked temperature differences between the rapidly cooling land areas and the unfrozen water areas. September and October are usually the stormiest months and most snow falls at this time. Fog and low cloud are common.

By late October, little open water remains and the marked temperature gradients between land and water areas no longer exist.

Some climatic data for Resolute are given as being generally representative of the annual cycle in the Arctic Islands study area (Table 1).

Table 1. Climatic data for Resolute, NWT.

Month	Temperature °C	Snow (cm)	Total Precip. (cm)	Wind (km/hr)
January	-32.4	2.5	0.25	16.3
February	-34.3	3.0	0.30	15.4
March	-31.3	3.0	0.30	15.4
April	-22.7	5.6	0.56	15.4
May	-10.3	9.1	0.91	17.7
June	0.6	4.8	1.30	19.5
July	4.6	1.0	2.36	19.5
August	3.0	3.8	3.15	17.9
September	- 4.5	14.0	1.85	19.3
October	-14.6	16.0	1.60	20.4
November	-24.1	5.8	0.58	16.4
December	-29.0	4.3	0.43	14.5
Total	-16.2	73.2	13.61	-

4.5 Ice

The waters of the Arctic Islands receive no warming influences from air or ocean currents and are consequently ice-covered for all or part of the year. Local variations in the size and depth of water bodies, tides and currents, orientation of channels, and bays affect the amount and duration of ice-cover, but generally these increase in a northwesterly direction (Dunbar and Greenaway 1956; Atmospheric Environment, 1964-1972). There is a great deal of variation in patterns of formation and break-up both from locality to locality and from year to year. A virtually complete ice-cover forms over the channels every winter.

The winter distribution varies little from year to year. Most of the channels are completely ice-covered except for open water areas in Lancaster Sound, eastern Barrow Strait, Bellot Strait, and in Penny Strait and Queens Channel, particularly between Baillie-Hamilton Island and the Grinnell Peninsula. Lancaster Sound forms a western arm to the Northwater which does not completely freeze over during the winter. Ice floes persist in Lancaster Sound-Baffin Bay area but the ice cover is rarely complete. In Lancaster Sound, the consolidated pack-ice usually extends as far east as a line from Maxwell Bay on southern Devon Island to Prince Leopold Island on northeastern Somerset Island. Other open water areas or polynias are surrounded by sea-ice and are maintained as a result of strong currents. Their size varies from year to year. A polynia persists throughout the winter to the southeast of Cornwallis Island and in some years extends from Griffith Island across Wellington Channel

and Barrow Strait. Maximum ice development is reached in late April-early May with thicknesses of 1.5-2.5 m in the bays and inlets but slightly thinner in the channels, except where rafting and pressure ridging have occurred.

During May and June, with increasing insolation and temperatures, the ice surface begins to melt and break up. The areas most open in winter break up first. By mid-August of most years Lancaster Sound, the inlets along the north Baffin coast, Barrow Strait as far west as Lowther Island, northern Peel Sound and Prince Regent Inlet are clear of ice. Large areas of open water occur throughout the Wellington-Queens Channel area north of Cornwallis Island. Ice from Wellington Channel and Peel Sound moves into Barrow Strait and then drifts eastward under wind and current action through Lancaster Sound. Much of the ice from Prince Regent Inlet is concentrated by an anticlockwise current in the Gulf of Boothia where the ice gradually rots. Some ice may move south through Fury and Hecla Strait to Foxe Basin. In some years the ice disappears completely from this area. The ice in southern Peel Sound and Franklin Strait begins to break up in June but remains in situ. In some years the ice melts completely. M'Clintock Channel remains ice-filled year round although some melting and break-up occur along the shores but only small amounts of ice move south through Victoria Strait into Queen Maud Gulf. Floating pack-ice also remains in Viscount Melville Sound and Byam Martin Channel. North of Melville and Bathurst islands, the ice-pack is permanent — virtually no break-up occurs apart from some meltwater puddles forming on the ice surface. Minimum ice cover occurs during late August to late September but large areas remain ice-covered. The actual distribution is determined primarily by wind action, except in the north.

The dates of freeze-up vary from year to year but the small bays and protected inlets are usually the first to freeze over. In the Queen Elizabeth Islands (north of Viscount Melville Sound-Barrow Strait-Lancaster Sound) freeze-up begins in mid-September whilst further south, nearer the mainland, it is in late September. At the same time new ice forms over narrow leads and over open water areas in the pack-ice. Often this new ice is broken up in storms but soon reforms. Peel Sound, Franklin Strait, James Ross Strait, M'Clintock Channel, Victoria Strait, and Byam Martin Channel are usually frozen into rough consolidated pack-ice by late October to early November. The pack-ice in Viscount Melville Sound often does not become consolidated and stop moving until early December. Wellington Channel, Prince Regent Inlet to Committee Bay and the inlets along the northern Baffin coast freeze over by November. Possibly due to the influence of northwesterly winds, the western side of Prince Regent Inlet is the last part to freeze over. The ice in this inlet, as far south as Committee Bay, is not consolidated for most of the winter and a lead often persists from the mouth along the northern Somerset coast.

4.6 Currents

The circulation of surface water through the Arctic Islands is generally weak and in a southerly or easterly direction (Dunbar and Greenaway, 1956; Collin, 1963). The Arctic Ocean to the northwest is the main source area of these currents with some influence from the Baffin Bay circulatory system in the east. Often the general movements are obscured locally by the effects of winds and tides.

The dominant current through Parry Channel (M'Clure Strait-Viscount Melville Sound-Barrow Strait-Lancaster Sound) is in an easterly direction into

Baffin Bay. Some of the water flows southward into the channels to the south of Parry Channel. In the channels to the north, flow is generally in a southerly direction into Parry Channel with strong southeasterly currents through Penny Strait and Wellington Channel. In Wellington Channel and in Prince Regent Inlet, although the predominant current direction is southerly along the western coasts, a comparatively weak northerly drift occurs along the eastern coasts. Most of the outflow from Prince Regent Inlet and Gulf of Boothia is southwards through Fury and Hecla Strait and into Foxe Basin.

The predominantly easterly flow through Lancaster Sound is disturbed by a significant permanent eddy at its eastern end. As a result, a westerly flowing current is established along the north shore of Lancaster Sound from Baffin Bay into Barrow Strait. In summer the westerly current has a velocity of about 19 km/day whereas the predominant easterly flow along the south shore has a velocity of about 17 km/day. The inflow of warmer water from Baffin Bay into Lancaster Sound has a significant effect on raising the surface temperature of the waters. Surface water with temperatures ranging from 1.0 to 5.0° C and salinities of 30.0 to 33.5‰ are characteristic. The more pronounced surface layer of warmer and more saline water in Lancaster Sound has the effect of delaying freeze-up in winter and in most years ice cover is never complete. Break-up and movement of ice out of the area occurs early and consequently allows for greater surface heating during the prolonged ice-free period of the year.

Water of Baffin origin, which is influenced by the inflow of warmer Atlantic water, has a subsurface maximum temperature of 1.0° C between 300 and 600 m with a salinity of 34.5‰ at 500 m. The shallow sill at 150 m in Barrow Strait forms a boundary between the Arctic Ocean and Baffin Bay water masses, by effectively preventing cold Arctic Ocean water at lower depths from moving into Lancaster Sound.

Tidal range is highest in the southeastern part of the Arctic Islands but throughout most of the area the range is less than 1.5 m. At Resolute the tidal range has a maximum of less than 2 m. Strong local currents result from tides in some narrow channels, for example, Bellot Strait. Larger fluctuations in sea level result from changes in barometric pressure and winds.

4.7 Biological Life

The production of phyto- and zoo-plankton determines the productivity of other marine life including, ultimately, polar bears. Generally, productivity is low in Arctic waters mainly as a result of low temperatures reducing growth rates. Also the phyto-plankton is concentrated in a narrow zone and is consequently more easily preyed upon by zoo-plankton. However, a number of factors tend to encourage phytoplankton growth (Dunbar, 1955). The cold waters contain higher proportions of dissolved gases, are more viscous thereby aiding cell flotation, and are exposed to longer photoperiods during the long summer days. A constant summer supply of nutrients is returned to the marine environment through the excrement of the large number of seabirds which spend the summer in the Arctic Islands. An intense diatom bloom occurs in the lower layer of sea-ice.

Fishes are few in species and number and are mainly benthic. Growth rates are slow and productivity depressed. The anadromous arctic char has a wide summer distribution, but returns to the rivers and lakes in fall, after a short, rapid growth period at sea.

Ringed seals *(Phoca hispida)*, bearded seals *(Erignathus barbatus)* and harp seals *(Pagophilus groenlandicus)* occur throughout the area, although harp seals are only summer visitors. Walruses *(Odobenus rosmarus)* are present during summer in most areas but during winter are found only in the area around Queens Channel-Cardigan Strait and Hell Gate. Both ringed and bearded seals are present around leads and open patches of water among the ice in winter. They are not confined to these areas as they are capable to some degree of maintaining breathing holes through the ice.

Walrus, narwhals *(Monodon monoceros)* and belugas *(Delphinapterus leucas)* are numerous in some areas. Few larger whales presently exist in the area. Many of these animals move into the bays and inlets soon after the ice has broken up and moved out, to feed on the phyto-planktonic bloom which was under the ice.

5. METHODS AND SOURCES OF DATA

5.1 Field Techniques

5.1.1 Tagging and recapture of individual polar bears

The most important single task in a study of this nature is to individually tag a large sample of polar bears and to obtain subsequent observations of them through recapture of the animals themselves or return of their tags from Inuit hunters. If a sufficient number of observations are made, quantitative assessments can be made of population size, seasonal movements, and the discreteness of the subpopulation resident in the area. The techniques of immobilizing and tagging polar bears were described by Lentfer (1968) and Larsen (1971). When the polar bears were immobilized, they were tagged on the ears, weighed, measured, examined for general condition, tattooed on the inside of the upper lip on each side with the same number as was on the ear tag, and a premolar tooth was extracted for age determination. In some instances, numbers were painted on the animals with black nyanza or Lady Clairol dye to facilitate easy recognition of individuals from the air and, consequently, resighting of these individuals for periods of up to a few months.

5.1.2 Recording of tracks

During some of the spring field work in 1975 and 1976, when tracks were visible in the snow, notes were kept on the numbers of tracks seen, the direction of travel if discernable, and the number of kilometres of available habitat flown over. Although these data do not relate to absolute numbers of polar bears, they may give a comparative measure of relative abundance between areas and years. They may also, under some circumstances, yield data on the direction of seasonal movements and the location of maternity denning areas.

5.1.3 Denning information

Undisturbed winter denning is necessary for the production and survival of polar bears. Disturbance of female bears in their dens could cause abandonment, resulting in mortality of cubs over the short term, and possibly loss of critical denning habitat over the long term. One instance of an exploration team causing abandonment of a den in the Mackenzie Delta was documented by Slaney (1974). It is not known what types, or degrees, of

activities will disturb bears, affect their behavior, affect their chances for survival once disturbed, or influence their fidelity to particular denning areas. Until these factors are known, a circumspect approach must be adopted. Therefore an important part of this study is to define important denning habitat along the pipeline route.

During the period that helicopters were used extensively for mark and recapture studies in the spring, all sightings and captures of females with cubs of the year were recorded in order to delineate coastal regions which might be important for maternity denning. All tracks of females with cubs of the year leaving the land or seen in coastal areas should have been recorded but this was only done in a few cases. The available data were plotted on maps to indicate possible denning areas. Helicopters were also used to search potential denning habitat in areas where females with cubs of the year were seen or in which Inuit hunters reported that denning occurred. When searching for dens, helicopters flew at an altitude of 15-50 m at an airspeed of 120-180 km/h.

In two areas, the north coast of Devon Island and the NW and NE coasts of Prince of Wales Island, ground searches were made using oversnow machines. The search parties consisted of three observers, equipped with two oversnow machines and two komatiks, with sufficient supplies to last the entire period on the ice. Prior to the surveys, fuel caches were put out by air.

One oversnow machine with two observers travelled over the beach, or as close as the terrain permitted. The second oversnow machine, with one observer, travelled parallel to the shoreline, 1 km or more further out, depending on where the best tracking conditions were. This second party served as a check on tracks leaving the shore that the first party might not have seen. Travelling was done in the best hours of light at 8-16 km/h. The ability to see old or wind-blown tracks was reduced at higher speeds. Sometimes family groups returned to the land briefly. Thus, close attention was paid to the number of tracks going onto or leaving the shore in order to minimize double counting.

Systematic aerial or ground searches for polar bear dens were not made over the whole area because of the paucity of data collected for the amount of money and manpower expended. However, all dens found by us or reported by reliable observers were recorded. Tracks of females with cubs of the year leaving their dens on the land for the sea, or sightings of the bears themselves in the early spring, were plotted to aid identification of areas important for maternity denning.

5.1.4 Calculation of productivity

Productivity may also be assessed through analyses of age-specific litter sizes and conception rates. There are two main advantages to this approach as opposed to trying to assess productivity through maternity denning surveys and counting the number of cubs produced. First, family groups have to be captured so that specimens for age determination can be obtained. In the process, more bears are marked and recaptured for later use in population estimates and movement studies. Second, age-specific natality rates (expressed as female cubs/adult female/year) may be calculated annually, or by groupings of years, by multiplying the age-specific litter size times the conception rate and

dividing by two (assuming a 1:1 sex ratio). This facilitates an assessment of the importance of any changes that may have occurred because the data can be compared directly between years and areas. For example, in the Western Arctic it appeared that in 1974-75 the polar bear population declined markedly in numbers and productivity compared to 1971-73. As mentioned earlier, a comparison of mean litter size showed little difference but a comparison of age-specific natality rates showed that productivity dropped by one-half (Stirling *et al.*, 1975). In contrast, if few dens are located on a denning survey, it may remain unknown whether productivity has declined or if the survey conditions were simply poorer that year. Poor weather at a critical period may preclude obtaining reliable data even in a year of high productivity.

The following is the method developed by Stirling (unpublished) to calculate changes in the productivity in the Western Arctic (Stirling *et al.*, The data are tabulated to give details of the age and litter size of cubs accompanying female polar bears of each age class (see Table 4). The age at which females with cubs conceived can be calculated by subtracting the age of her cubs, plus one year to allow for delayed implantation and gestation time, from the age of the female. For example, an eight-year-old female with cubs of the year conceived them at the age of seven, or one with yearling cubs conceived them at the age of six and so on. Estimates of the conception rates of females of any age class can be made from the proportion of females in the sample, one and two years older, that were accompanied by cubs of the year and yearlings respectively. The numerators and denominators of these two values were pooled to calculate the best estimate of the conception rate for a particular age class or group of age classes. For example, the conception rate of five-year-old females in Table 4 equals the number of six-year-old females with cubs of the year, plus the number of seven-year-old females with yearlings, divided by the total number of six and seven-year-old females

$$\frac{4 + 0}{24 + 12} = \frac{4}{36} = 11.11\%$$

An estimate of conception rate, including the proportion of females of an age class accompanied by two-year-old cubs cannot be made because most cubs usually leave their mothers by about 2½ years of age. Thus, females captured after their 2½-year-old cubs had departed would cause an estimate of be biassed too low.

Because of the way these age-specific conception rates are calculated, they do not include intrauterine mortality or the loss of whole litters of cubs prior to two years of age. Also, possibly pregnant females captured in summer and fall would be classed as lone females and therefore would not be included in calculations of conception rates.

However, the advantage of this method is that the results more closely approximate the number and size of litters that actually survived per age class of females, and thus are more meaningful for use in calculation of population statistics or computer simulation of population dynamics.

Estimates of the mean litter size, by age class, of females at the time of conception may be made in a similar fashion to the calculation of conception rate except that all females accompanied by cubs of any age may be included. For example, from Table 4, the mean litter size of

females which conceived at five years of age can be estimated as follows: four six-year-old females had a total of six cubs of the year, no seven-year-old females had yearlings with them, and one eight-year-old female had one two-year old cub; giving a total of seven cubs with five females, or a mean litter size of 1.66.

The mean litter size calculated in this fashion may be biassed to the low side if a significant proportion of the females lost part a multiple cub litter. Although this bias did not appear to be significant in the Western Arctic, it may be in other areas. However, from a conservation point of view, calculations that were affected by this bias would tend to work in favor of the species.

5.1.5 Location of important feeding areas

Important feeding areas were documented by simply recording the locations of bears sighted and captured at each season of the year; noting where and how seals were killed; whenever possible, determining the age, sex, and species of seal killed; and the degree of utilization of the carcasses.

5.1.6 Specimens from Inuit hunters

Rewards were paid for the skulls of polar bears killed by Inuit hunters and for the return of ear tags or lip tattoos from tagged bears. From these specimens we obtained additional information on the movements and survival of tagged polar bears and enlarged our sample of teeth for age determination.

5.1.7 Aerial survey - fixed-wing

A fixed-wing survey was conducted in July 1975 along the shoreline and proposed pipeline route of Boothia Peninsula to search for bears. The survey was flown in a Dornier at a height of 91 m and all wildlife seen on an estimated 400-m strip was counted. Only the shoreline was searched, where bears were more readily visible because of the high degree of contrast of their white fur with the dark background. Previous experience has shown that searching for bears on the ice when flying transects is not reliable.

5.2 Laboratory Techniques

5.2.1 Age determination

Preliminary estimates of ages were made from skulls; when available, on the degree of fusion of the basisphenoid-basioccipital, maxillal-premaxillal, and nasal sutures; condylobasal length; coronoid height; interorbital breadth; and sagittal crest development after Manning (1964).

Ages were further refined by histological sectioning and staining of teeth and counting the annuli in the cementum, using the methods of Thomas and Bandy (1973) with modifications by H.P.L. Kiliaan and W. Calvert (Stirling *et al.*, 1977).

5.2.2 Basic data reduction

Data were recorded in a variety of manners and with variable detail by different investigators over the years on standardized forms, in written field notes, and directly onto 1:250,000 scale maps. We attempted to tabulate the data as required directly from the original source, with as much consistency as possible, into whatever format was required for the various analyses.

5.2.3 Estimation of population size

The greatest problem in attempting to estimate the size of a population of wild animals is to obtain an adequate sample of representative observations. It is considerably more difficult, as well as expensive, when there is a relatively small number of individuals spread out over a vast area. In addition, polar bears are often difficult to see and may even hide or leave the transect when an approaching aircraft is heard. For these reasons, it is not practical to obtain a reliable estimate of the size of a polar bear sub population by aerial surveying.

Ideally, we would like to use one of the mark and recapture techniques. However, we are uncertain at present of what biases were involved in selecting the animals tagged in earlier years. Thus, we cannot use them to attempt a population estimate at this time. It may be feasible to attempt such a calculation after next season's data collection.

It is possible to make a crude estimate of the minimum size that a polar bear population would have to be to support a harvest of a particular size if the age structure and reproductive parameters of that population are known, as well as the age and sex structure of the animals harvested by the Inuit. We will present some general discussion of this aspect but a more developed application of such a model will not be available until later in the year.

5.2.4 Economic significance of polar bears to Inuit settlements

Résumés of the trade in polar bear hides in Canada from 1972-73 to 1974-75 have been published by Smith and Jonkel (1975a & b) and Smith and Stirling (1976). Based on these summaries and more recent unpublished information on the trade in polar bear hides from the fur auction houses and settlements, a review of the economic significance of the polar bears hunted by Inuit along the proposed pipeline route was prepared by Pauline Smith for inclusion in this report.

6. RESULTS AND DISCUSSION

6.1 Distribution and Movements

During the winter and spring, polar bears are dispersed over the ice covered inter-island channels throughout the Central and High Arctic. They tend to concentrate along the pressure ice that parallels the island coastlines and lies across the mouths of bays. Polar bears also appear to concentrate in areas such as Western Lancaster Sound or east of Bellot Strait where the ice moves and refreezes periodically though the winter.

Ringed and bearded seals maintain their own breathing holes from freeze-up to break-up by abrading the ice with the heavy claws on their foreflippers. These breathing holes are located on the last cracks to close over during freeze-up. In areas where wind, water currents, or tidal action cause the ice to crack and subsequently refreeze, seals are apparently more accessible to polar bears and the bears are able to hunt more successfully (Stirling and McEwan, 1975; Stirling *et al.*, 1975). We suspect that seals also tend to concentrate where natural cracks form because it is easier to breathe there but we have no direct data with which to test this hypothesis yet. During the winter, bears tend to be less abundant in areas such as deep bays which have expanses of flat annual or multi-year ice that has moved little throughout the winter (Stirling *et al.*, 1975). Smith and Stirling (1975) have demonstrated that ringed seals are more abundant and produce more pups in the bays than in the offshore ice. Whether or not the seals in the bays, whose breathing holes and birth lairs are under deep snow drifts, are less accessible to the bears during spring is not known. Certainly some polar bears , particularly females with cubs of the year, go into the bays to hunt seals at the birth lairs but in general, bears are more abundant in the offshore areas at that time of year.

As break-up proceeds through the spring and early summer, the bears move with the ice in order to be able to continue hunting seals. (Polar bears can not hunt or catch seals in open water). The distance or rate a bear moves in a particular year probably varies with the rate of change of the ice conditions. In areas where the ice melts completely, the bears are forced onto the land where they may either wait for freeze-up again or walk to an area where the sea is still covered with ice.

As soon as the sea freezes in the fall, polar bears move back onto the ice to hunt seals. The pattern of seasonal movements and distribution is probably variable depending on the area and the consistency between years of ice formation, dispersal, and distribution.

Table 2 summarizes the number of days of helicopter survey on which mark and recapture studies were conducted, by geographic area and season, from 1970 through 1976. During those surveys, 611 polar bears were tagged in the study area. Figure 2 shows where those bears were tagged. Subsequent to tagging, 74 polar bears have been recaptured, 30 were shot by Inuit hunters, and two were shot in self defence. The movement data were segregated to examine three questions: the fidelity of polar bears to specific areas in the same season of different years, seasonal movements, and the extent of the recorded movements shown by individual animals that have been recaptured over a span of two years or more.

6.1.1 Fidelity to winter and early spring feeding areas

Figure 3 shows the recorded movements of polar bears captured between late March and early May and recaptured or shot during the same season in one or more subsequent years. Movements in excess of 400 km were recorded for only five bears and the majority of recaptures were made less than 150 km from where the bears were originally tagged.

The results were biassed in that the water bodies adjacent to Cornwallis Island and NE and SE Victoria Island were surveyed more thoroughly (Table 2) than,

Table 2. Number of days of helicopter surveys on which mark and recapture studies were conducted, by geographic area and season, from 1970 through 1976.

Area	No. days of helicopter survey	
	Spring	Summer
1. Viscount Melville Sound, Hadley Bay	25	2
2. Franklin St, Victoria St, Queen Maud Gulf, James Ross St	50	4
3. Gulf of Boothia, Committee Bay	12	8.5
4. Barrow St, Lancaster Sound	74	30
5. Prince Regent Inlet	13	7.5
6. Peel Sound	12	6
7. Jones Sound	15	8
8. Norwegian Bay	12	2
9. McDougall Sound, Penny St, Queens Channel	10	6
10. SE Queens Channel, Wellington Channel	14	9
11. Graham Moore Bay, Byam Martin Channel, Northern Bathurst Is	3	6
12. Admiralty Inlet	-	13
13. Eclipse Sound, Navy Board Inlet	-	4
Total	240	106

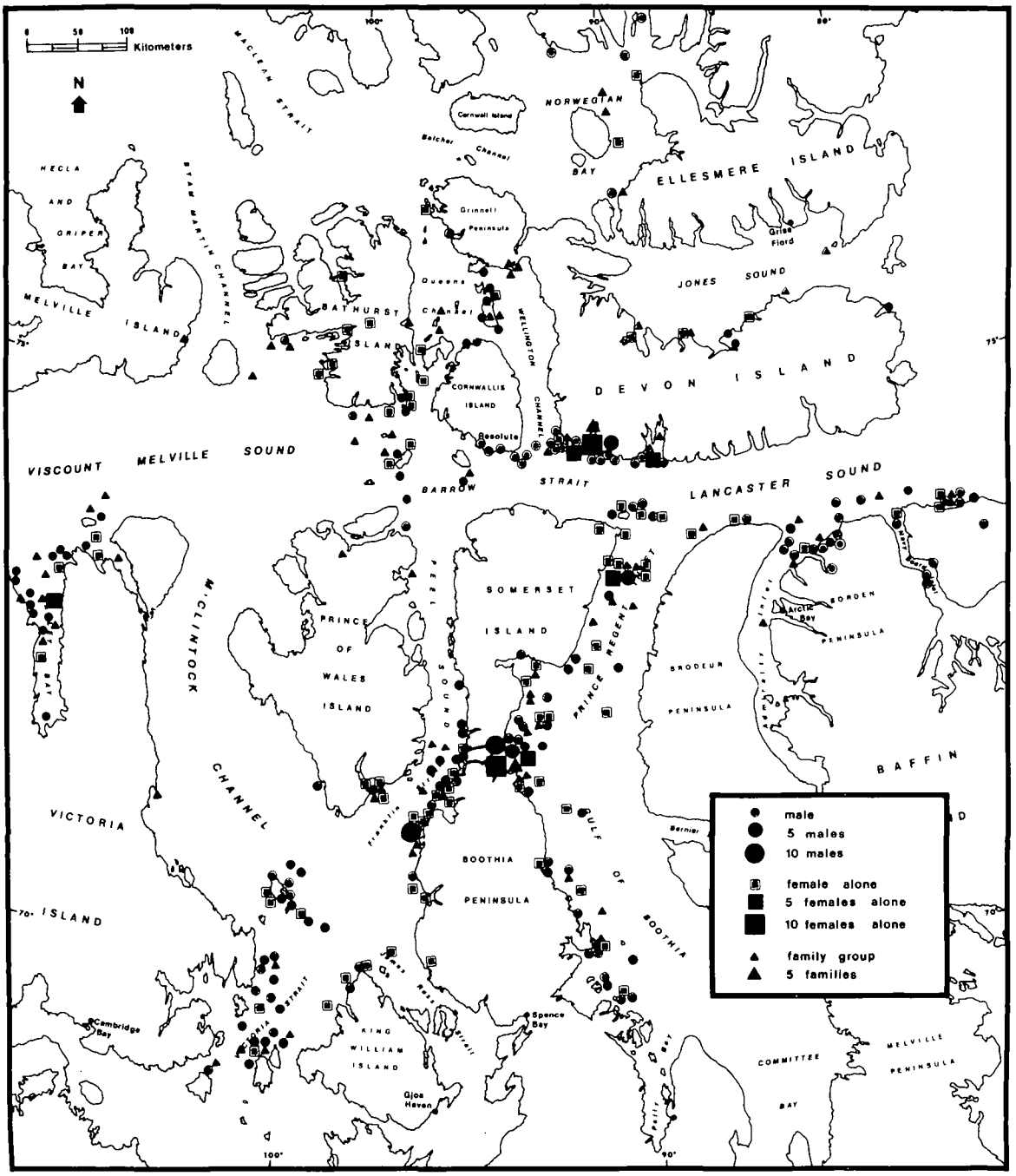

Figure 2. Locations at which polar bears were tagged in the Central and High Arctic from 1970 through 1976.

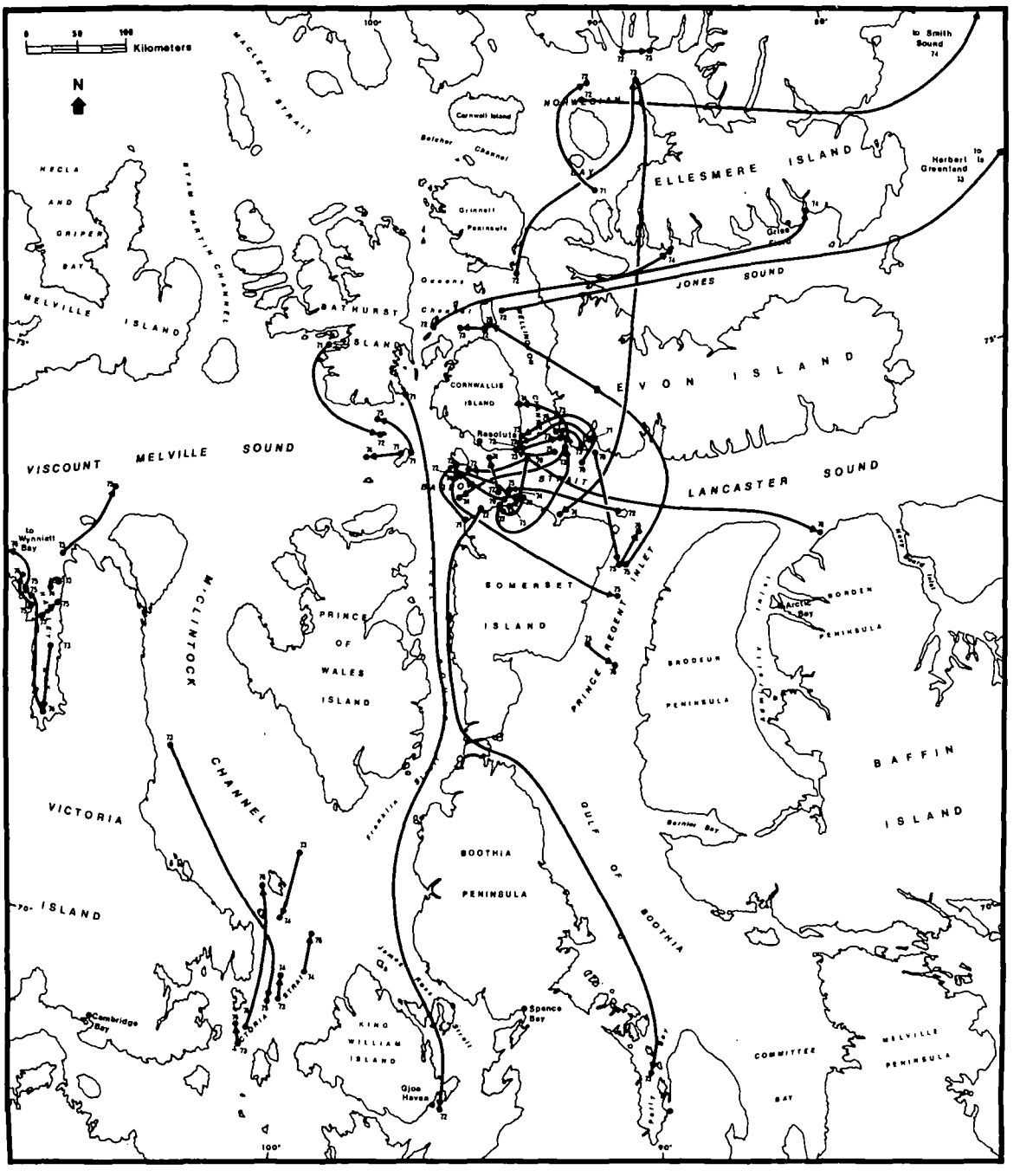

Figure 3. The recorded movements of polar bears captured between late March and early May and recaptured during the same season in one or more subsequent years.

for example, were areas such as northern Queens Channel, southern Prince Regent Inlet, or the Gulf of Boothia. However, Inuit hunters from Gjoa Haven, Spence Bay, and Pelly Bay kill over 40 polar bears a year and to date, they have taken only two bears that were tagged in the northern half of the study area, which suggests that little exchange takes place. No exchange of bears has been recorded during the winter between the most intensively surveyed areas of Barrow Strait, or NE and SE Victoria Island, suggesting that those populations of bears show a high degree of fidelity to their winter and early spring feeding areas.

6.1.2 Fidelity to areas of summer feeding and retreat between years

Figure 4 shows the recorded movements of polar bears captured between late June and the end of August and recaptured during the same season in one or more subsequent years. Fewer helicopter surveys for mark and recapture studies were conducted in the summer than in the spring (Table 2), especially in the areas west of Barrow Strait. However, the results were essentially the same as in the previous section, again indicating a high degree of fidelity to particular areas during the summer. One area that was surveyed intensively was the bays of SW Devon Island where bears showed a high degree of fidelity. The ice remains in bays such as Radstock Bay on SW Devon Island for at least a month or two after the nearby water bodies are ice free. The same is true of Brentford Bay, just SE of Bellot Strait, where one bear returned to within a few kilometres of where it was first recaptured after having been in the north end of Wellington Channel during at least one intervening summer (Figure 4).

6.1.3 Movements of polar bears between winter and summer

The recorded movements of polar bears captured between late March and the end of May and then recaptured during July or August of the same year were plotted to see if any clear seasonal movement patterns could be detected (Fig. 5). Inuit hunters from Resolute Bay have reported that polar bears move north up Peel Sound and Prince Regent Inlet during the spring but our data neither prove nor disprove this suggestion. Although seven of the bears recaptured were recorded further north than they were when originally captured, compared to four that were further south, the recorded movements were less suggestive of a migration than of individual movement patterns of particular bears to summer fast ice retreats such as those at Brentford Bay, Prince Alfred Bay, or the bays of SW Devon Island.

6.1.4 Movements of polar bears between summer and winter

The recorded movements of polar bears captured during July and August and then recaptured between late March and the end of May of the following year were plotted to see if any clear seasonal movement patterns could be detected (Fig. 6). As in the previous section, no particular direction was associated with the recorded seasonal movements. However, it probably was significant that several of the bears appeared to have moved from possible summer retreats such as Prince Alfred Bay, Radstock Bay, and Austin Channel back out into the known winter concentration areas of Barrow Strait and Lancaster Sound.

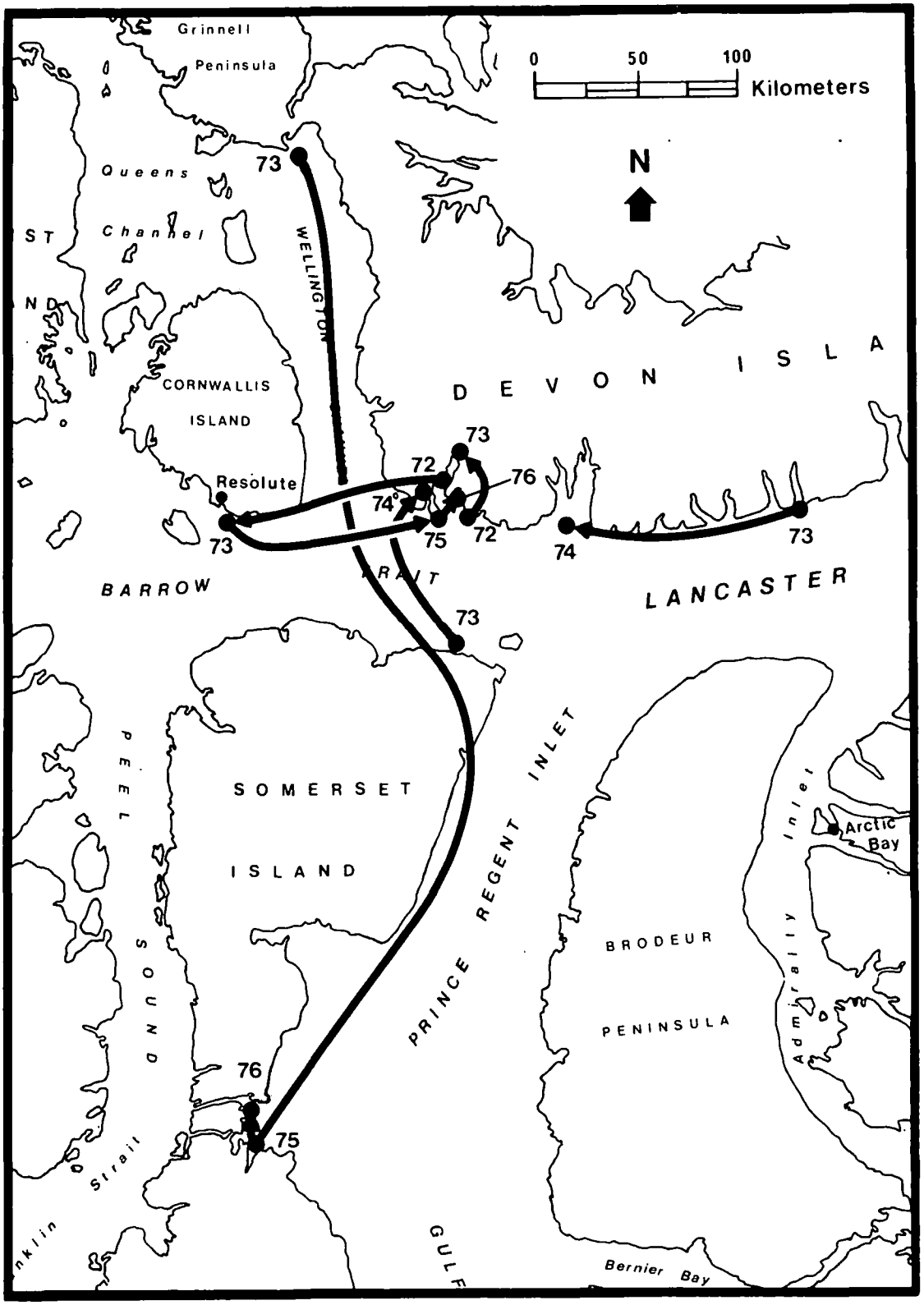

Figure 4. The recorded movements of polar bears captured between late June and the end of August and recaptured during the same season in one or more subsequent years.

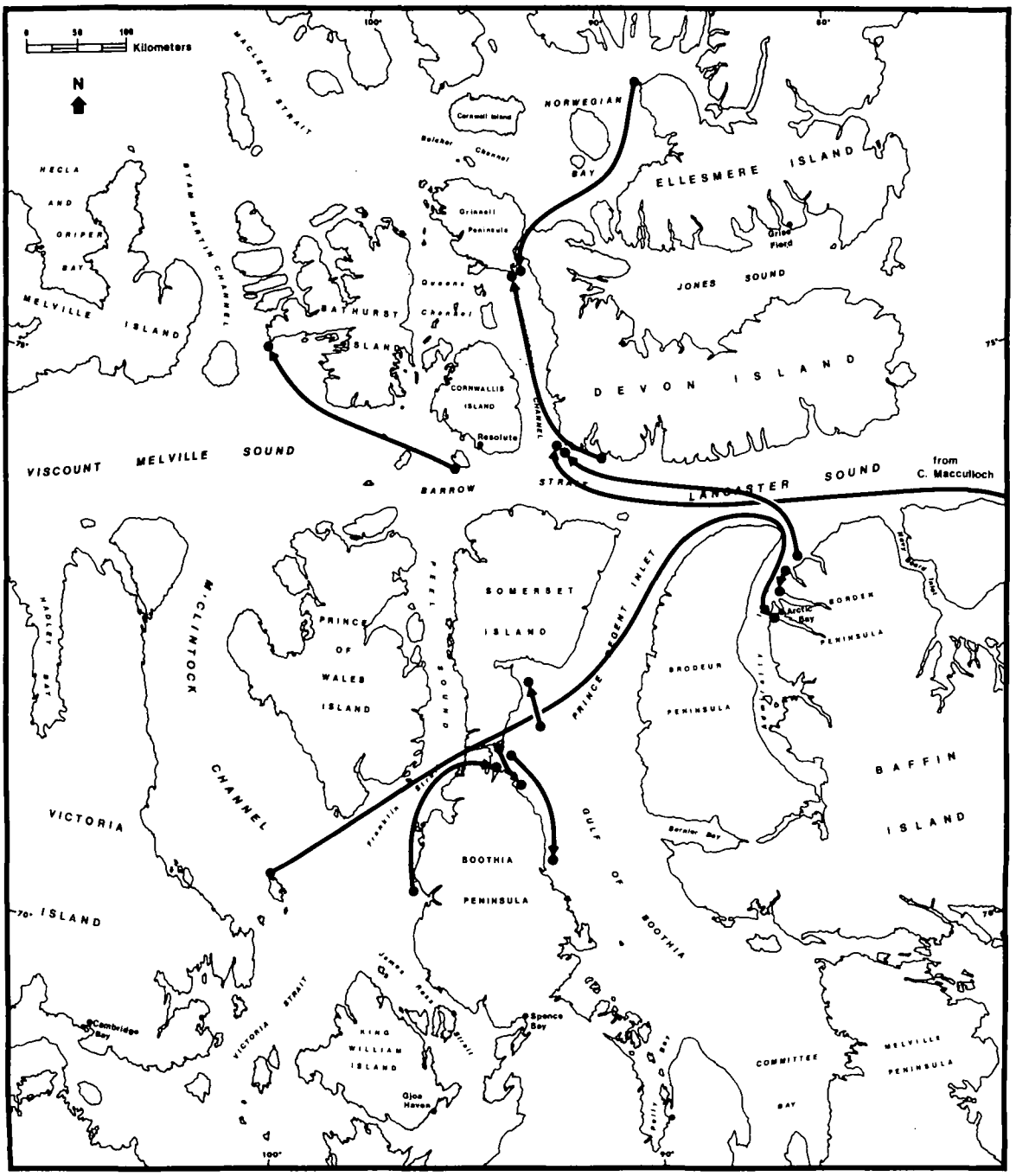

Figure 5. Recorded movements of polar bears captured between late March and the end of May and then recaptured during July and August of the same year.

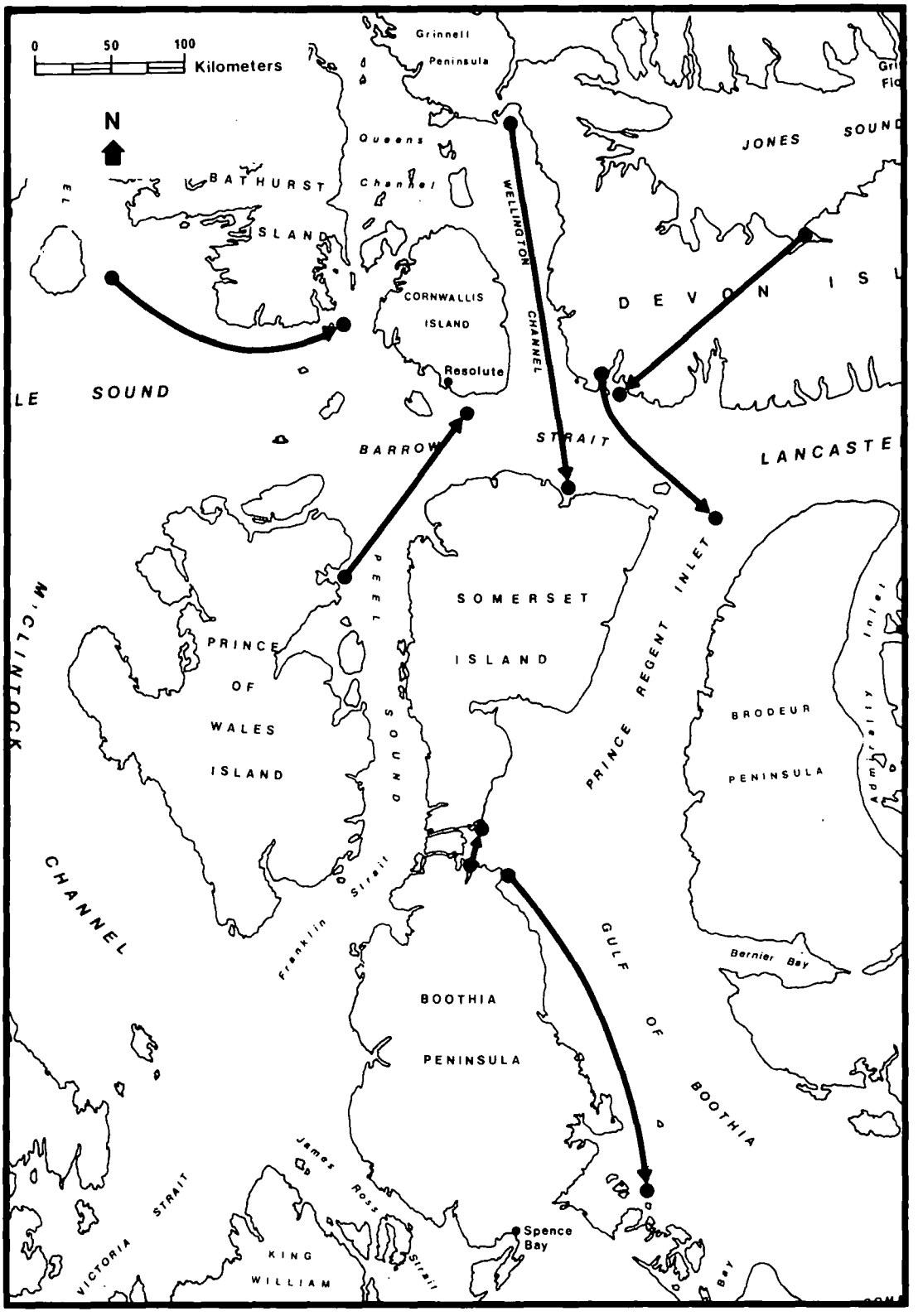

Figure 6. Recorded movements of polar bears captured during July and August and then recaptured between late March and the end of May of the following year.

6.1.5 Movements of individual polar bears recorded over a span of two years or longer

No radio tracking of individual polar bears was done to determine home range size on this study. Such a study, if it was to be done properly, would take several years and would probably show great variation between years and geographic areas because of variability in ice conditions and in seal distribution and productivity. The recorded movements of individual male and female polar bears, recaptured at any season over a span of two years or longer, were plotted to obtain some relative insight into the extent of the home ranges of male and female polar bears within the study area (Figs. 7 & 8). The pattern is quite clearly one of fidelity to a general area, indicating that individual bears probably get to know a region and then restrict most of their movements to the same hunting, denning, or summer retreat locations. In general, the movements of males were more extensive than those of females, as has been reported for other bears (e.g. *Ursus arctos;* Pearson, 1975). Of particular note is the fidelity of the females to the bays on the south coast of Devon Island.

6.1.6 Summer distribution

Figure 9 shows where polar bears were captured during the summer surveys (Table 2). Note that the sightings are concentrated in areas where there are bays or other irregularities along the coastline, such as small islands, compared to areas of smooth coastline. Particularly noteworthy examples are Brentford Bay on NE Boothia Peninsula and the bays of SW Devon Island.

During the summer, the ice cover in most of the interisland channels becomes greatly reduced or disappears altogether. As noted earlier, after the channels become ice free, the last ice to disappear is in the bays where irregular coastlines or small islands may delay break-up. In addition, the bays are the first areas to freeze-up again in the fall. In some years, parts of certain bays or channels may remain ice covered throughout the summer. Consequently, because polar bears must have sea ice to be able to hunt seals, the bays where the period of ice cover is significantly longer are extremely important feeding areas. This extended hunting period is probably especially important for females accompanied by cubs of any age and pregnant females that need to deposit additional fat before giving birth to new cubs during the coming winter. The high degree of fidelity of polar bears for these summer feeding areas (Fig. 4) further emphasizes the ecological significance of these bays to the bears.

6.2 Maternity Denning Areas

Figure 10 summarizes information on confirmed denning areas, areas where denning has been recorded but apparently at low density, possible denning areas, areas of minor importance for denning, and areas not adequately searched along the proposed pipeline route. It should be noted at this point that because of the limitations on the kinds of data it is possible to collect on this subject, we are able to talk of densities only in terms of relative subjectivity and that no comparisons or assessments are absolute. In Figures 11 to 14, sections of the study area are presented on a larger scale in order to illustrate the observations upon which the conclusions were based. For each Figure, there is also a summary of the extent to which each area was searched by researchers

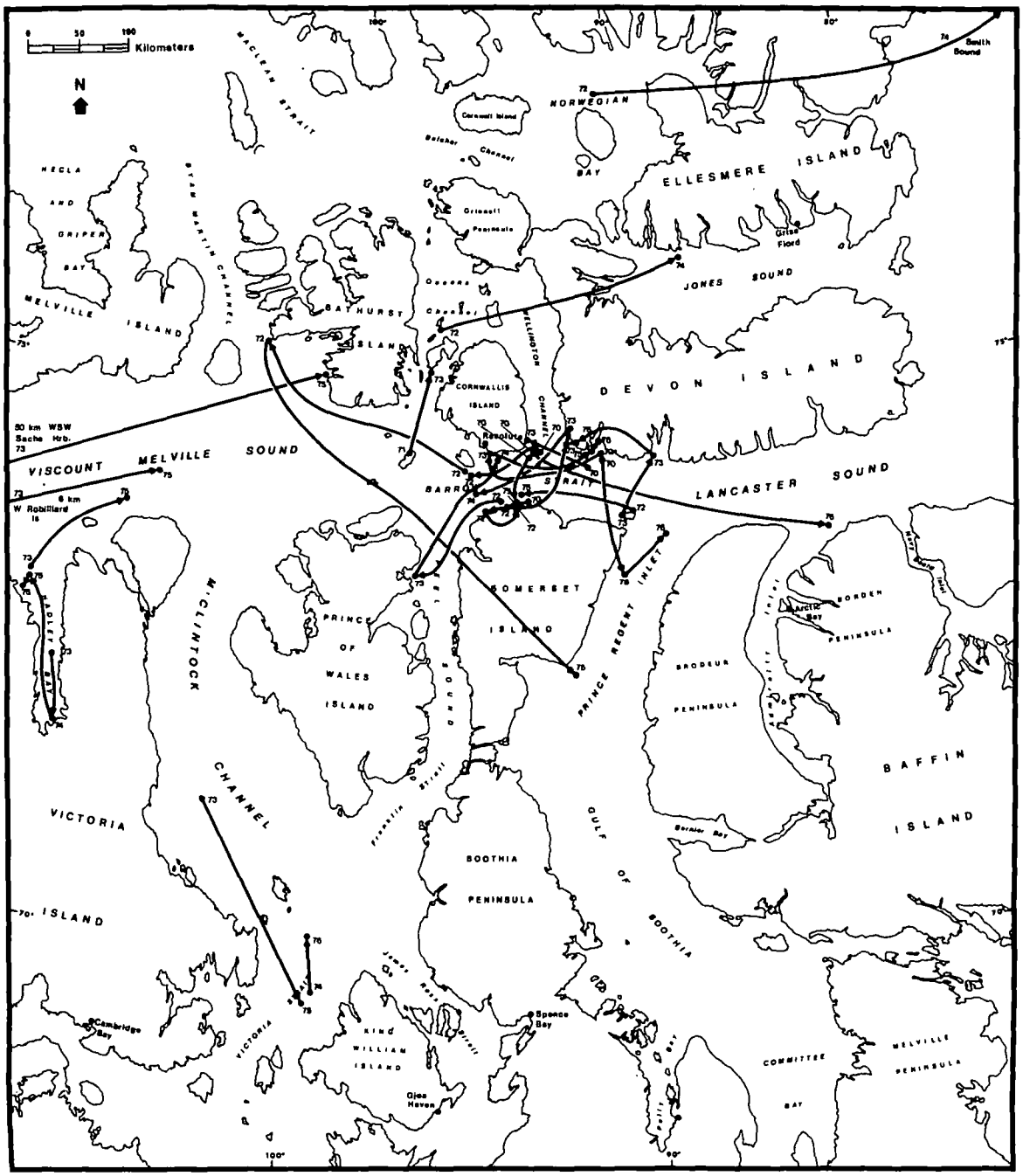

Figure 7. Recorded movements of individual male polar bears recaptured at any season over a span of two or more years.

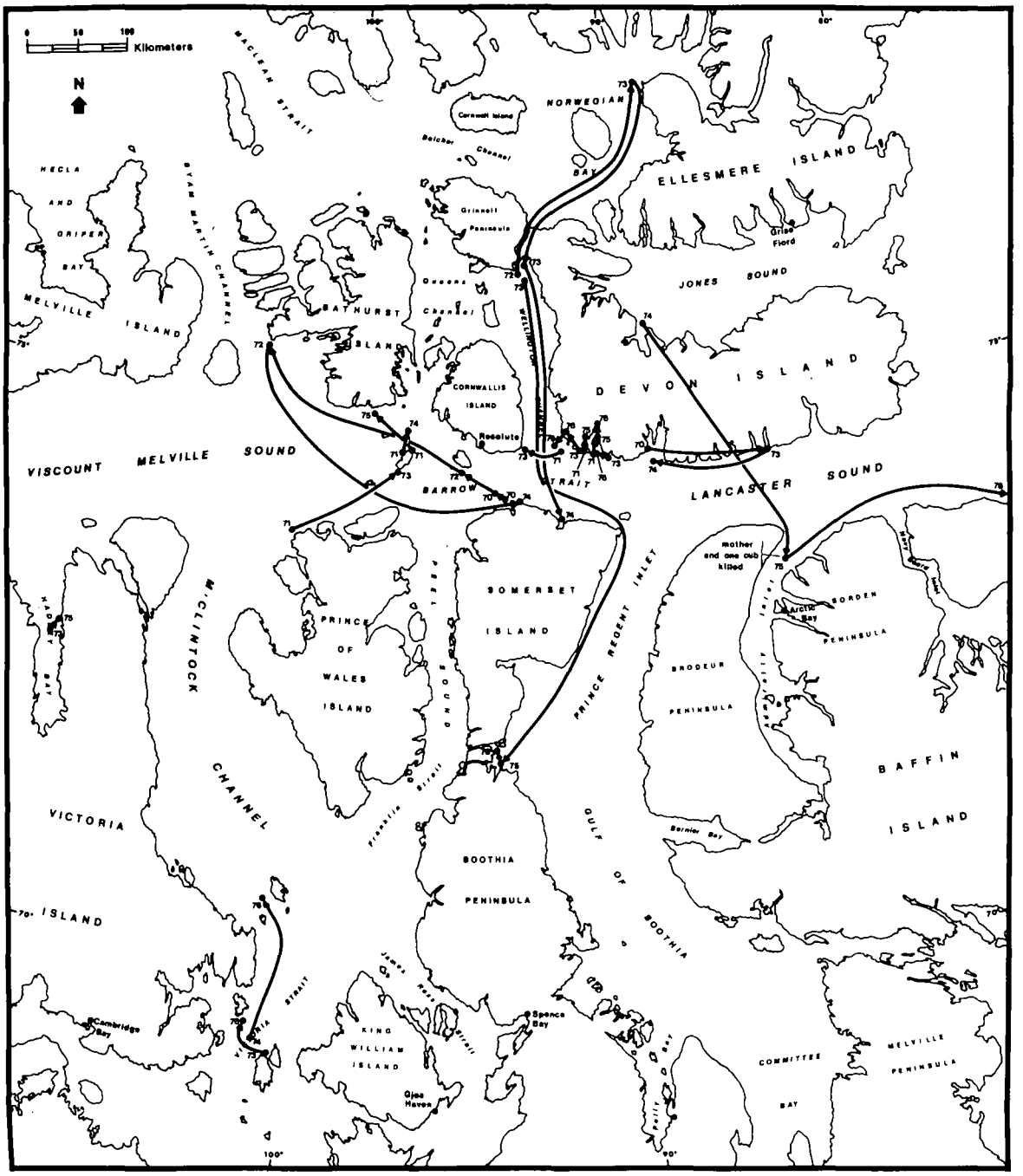

Figure 8. Recorded movements of individual female polar bears recaptured at any season over a span of two or more years.

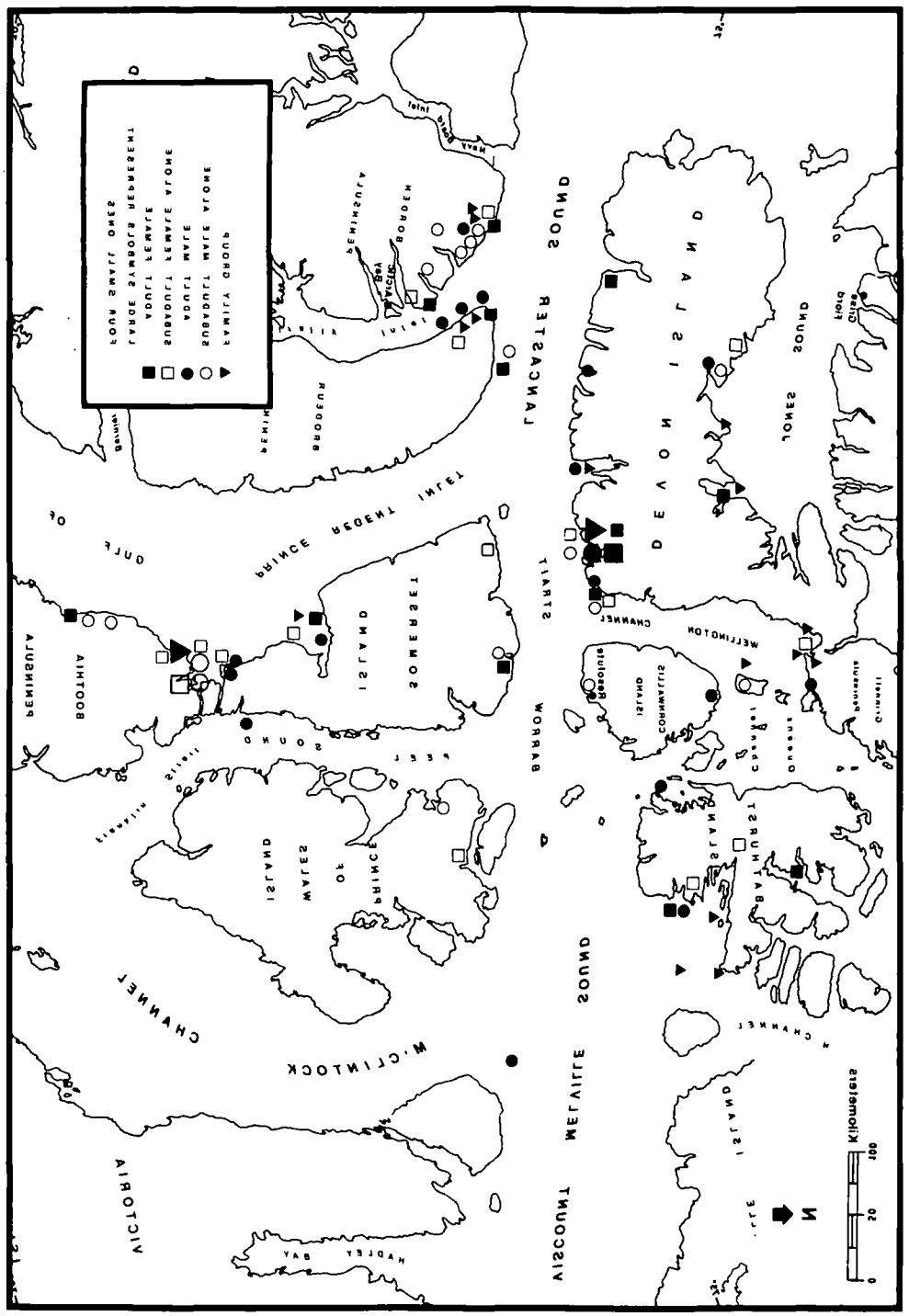

Figure 9. Locations where polar bears were captured during summer surveys.

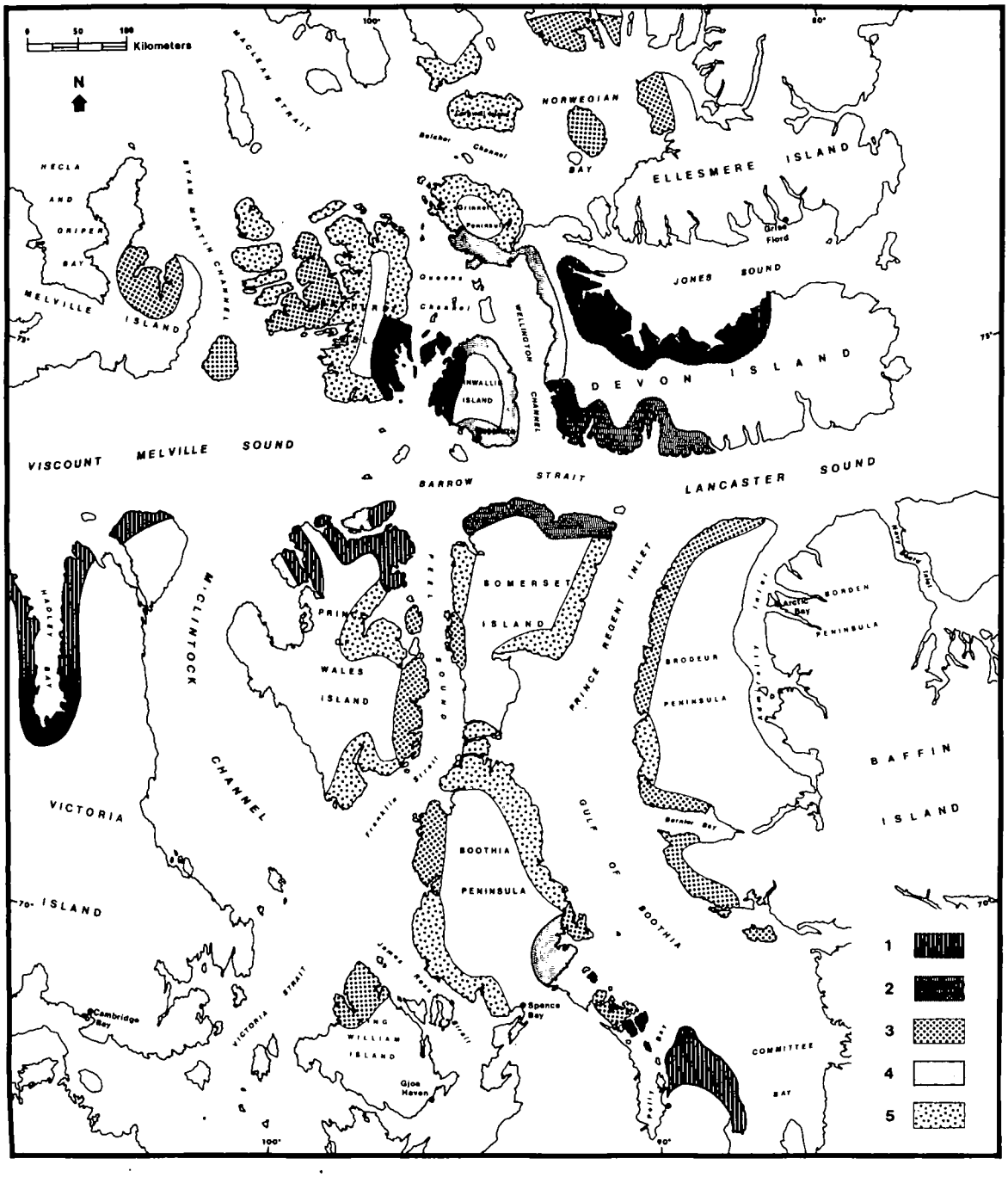

Figure 10. Summary of information on confirmed denning areas, areas where denning has been confirmed but apparently at low density, possible denning areas, areas of minor importance for denning, and areas not adequately surveyed. (1. confirmed denning areas; 2. denning recorded but apparently at relatively lower densities; 3. possible denning area; 4. surveyed no positive data; 5. inadequately surveyed).

and of any other sources of information. Unfortunately because of the variety of sources and the variability in the detail of the records of individuals, particularly in earlier years, the summaries are not as precise as might otherwise be desired. In a relative sense however, they indicate the basis on which conclusions have been drawn.

The maternity denning areas will be discussed in relation to water bodies because the bears spend most of their time on the ice whenever the channels are frozen and probably den on the adjacent land masses. No polar bear maternity dens have been recorded on the sea ice in the Canadian Arctic Islands and to date only one has been confirmed elsewhere (Lentfer, 1975). It is also relevant to discuss the maternity denning areas in relation to the inter-island channels and their coastlines because those are the areas in which pipeline construction activity will be most important to polar bears.

Dens, female polar bears with cubs of the year, and tracks of females with cubs of the year, observed by researchers or reported by reliable observers, are plotted on the maps. In the study area, most females with cubs of the year leave their dens by the middle of April and go to the nearest sea ice to hunt seals. They tend to segregate themselves from the rest of the population and feed on ringed seal pups on the land-fast ice in the bays (Stirling *et al.*, 1975). A family group feeding in a particular area may remain there for several days, or possibly weeks, although this probably varies considerably with hunting success and the degree of disturbance from other bears. Thus, females with cubs of the year, recorded on the sea ice prior to the middle of April, were likely very close to the land area where their maternity dens were. Because of the mobility of family groups, sightings made after the middle of April are probably progressively less reliable with time as specific indicators of where maternity denning occurred. However, it is likely that they are still indicative of a general area. Thus, on the maps, the captures, sightings, and track data for females with cubs of the year are coded to when the records were made in order to indicate their value relative to the delineation of denning areas.

6.2.1 Viscount Melville Sound

Twenty-five helicopter survey days were flown on the south side of Viscount Melville Sound in the vicinity of Hadley Bay, Wynniatt Bay and Stefansson Island on the following dates:

1973: April 20-23, May 3
1974: March 31, April 1-3, 6, 8-10
1975: April 12-15, 17-19, May 2
1976: April 19, May 19-21

During this period, seven family groups were seen before mid-April and five after that date (Fig. 11). No dens were located in the area and no tracks were recorded. On the basis of the number and locations of adult females with cubs of the year that were captured, maternity denning probably occurs each year along the coastlines of the bays and islands of NE Victoria Island (Fig. 10).

No ground or aerial searches have been made for maternity dens or females with cubs of the year on the eastern coast of Melville Island or Byam Martin Island. However, four dens were reported by R.H. Russell (pers. comm.), one on

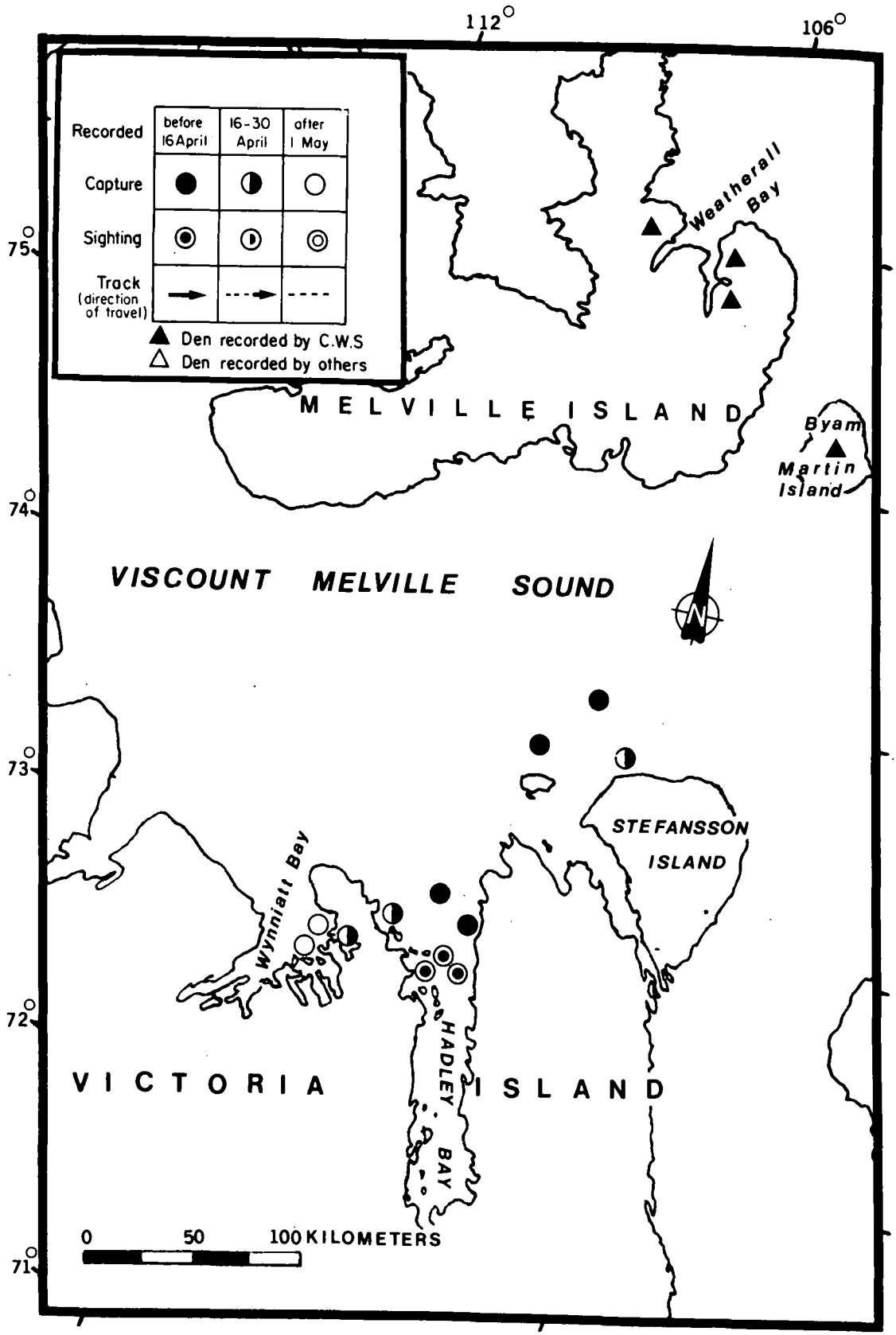

Figure 11. Locations of observations and captures of female polar bears with cubs of the year and tracks of females with cubs of the year on the land areas adjacent to Viscount Melville Sound.

Byam Martin Island and three in the vicinity of Weatherall Bay. Unquantifiable but regular reports of polar bears have been made by pilots in the vicinity of Weatherall Bay and the east coast of Melville Island. On the basis of these sightings and the dens reported by Russell, we have designated these locations as possible maternity denning areas (Fig. 10).

6.2.2 Franklin Strait, Victoria Strait, Queen Maud Gulf, and James Ross Strait

Fifty helicopter survey days were flown in these areas on the following dates:

1972: April 9, 10, 15, 17, 18, 27, 29
1973: April 9-14, 27-29, May 3
1974: April 18-25, 28
1975: April 6-9, 20-24, 26, 27, 30, May 2
1976: April 1, 4, 5, 13-16, 19, May 8, 10, 12

During this period only one female with cubs of the year was captured before mid-April and one after mid-April (Fig. 12). No tracks were recorded and no ground surveys have been conducted. Inuit hunters report that maternity denning occurs on the northern portion of King William Island. E. Lyle, Regional Game officer at Spence Bay, has reported seeing dens in the area between Wrottesley Inlet and Pasley Bay (pers. comm.) but the exact number and location of these sightings is unknown. On the basis of these observations, we have designated both areas as possibilities for maternity denning (Fig. 10).

6.2.3 Gulf of Boothia and Committee Bay

Twelve helicopter survey days were flown on the western sides of these water bodies, based mainly out of Spence Bay on the following dates:

1976: March 29, 31, April 6, 8, 20, May 7, 16, 17, 21, 25, 26, 27

During the helicopter surveys, two family groups were recorded before mid-April and four afterward (Fig. 12). No dens were observed and no tracks were recorded.

The best data on maternity denning in this area come from a remarkable collection of observations made by Inuit hunters and carefully recorded on 1:250,000 maps by Father F. Van de Velde, formerly of Pelly Bay and now resident at Hall Beach. Father Van de Velde plotted all polar bear dens and sightings that Inuit hunters from Pelly Bay could remember having seen in their hunting area. These records are condensed and presented in Figure 12. The numbers encircled indicated higher density or preferred locations within the denning area. On the strength of these records, the northern portion of the Simpson Peninsula and the Harrison Islands were designated as a confirmed denning area (Fig. 10).

Inuit from Spence Bay and Pelly Bay report that maternity denning also occurs on islands around Lord Mayor Bay, the Astronomical Society Islands, and Thom Bay but we do not have specific data on numbers or locations of dens. Thus, we have designated these regions possible denning areas (Fig. 10).

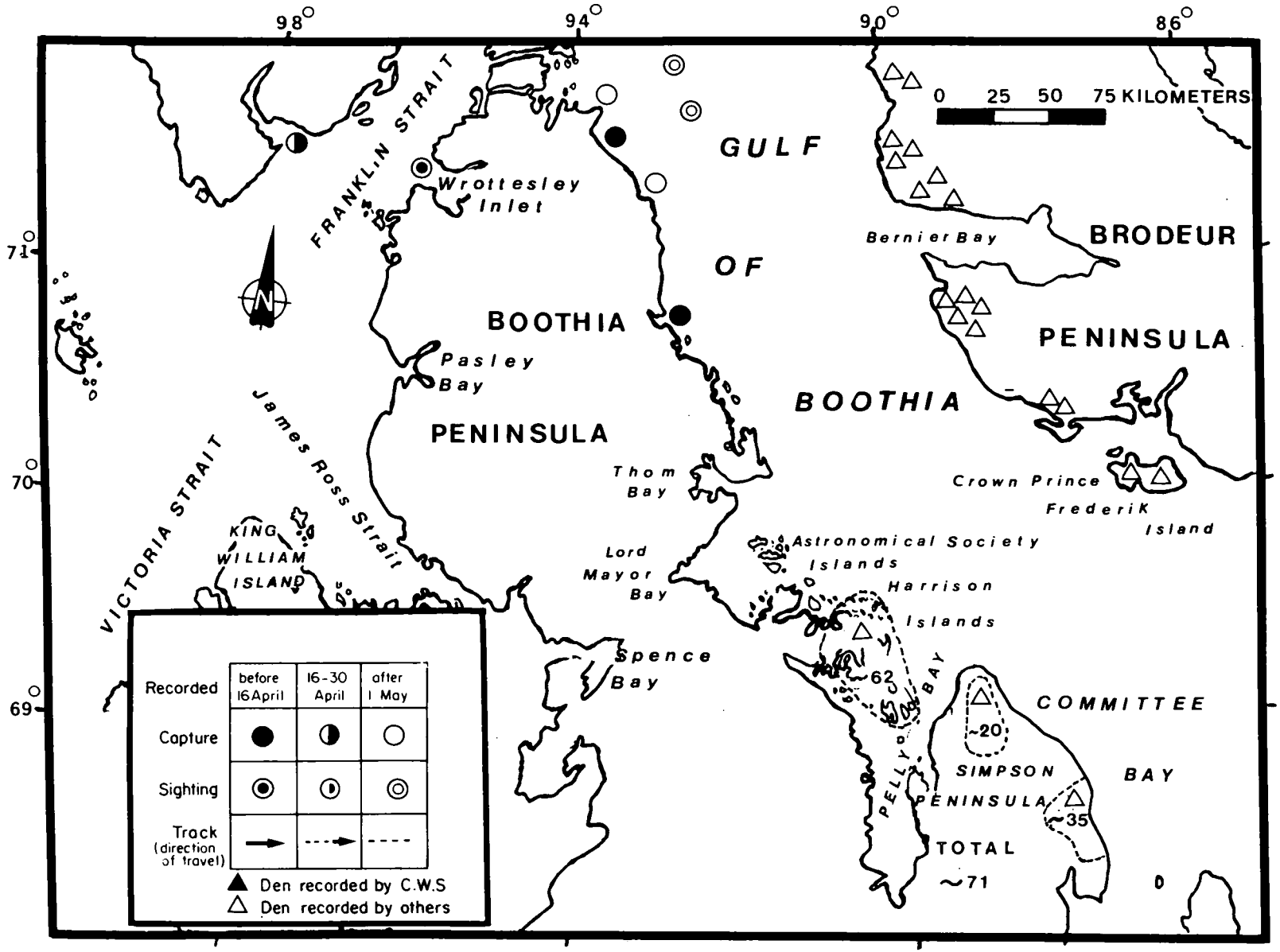

Figure 12. Locations of observations and captures of female polar bears with cubs of the year and tracks of females with cubs of the year on the land areas adjacent to Franklin Strait, Victoria Strait, Queen Maud Gulf, James Ross Strait and Gulf of Boothia.

On the basis of the locations of 17 maternity dens reported by Inuit hunters from Arctic Bay in the vicinity of Bernier Bay and Crown Prince Frederik Island, we have designated those locations as possible maternity denning areas (Fig. 10).

6.2.4 Barrow Strait and Lancaster Sound

A total of 74 helicopter survey days were flown in Barrow Strait and Lancaster Sound on the following dates:

1970: May 8-14, 16-17
1971: May 8, 26, 27, 28
1972: April 10, 13, 18, 19, May 8, 17
1973: April 2-5, 7, 9, 11, 12, May 10-11
1974: April 1, 2, 7, 20, 22, 30, May 1, 3, 4, 6, 8, 9, 14-16, 20
1975: April 11, 11-14 (2 helicopters on 11th), 20, 22, 26, 30, May 3, 16
1976: April 9, 10, 12, 12-14 (2 helicopters on 12th), 16-18, 20, 22 24, 31, May 1, 2, 5, 13, 27

During this period, 11 dens were located, 3 family groups before mid-April, and 15 family groups after mid-April (Fig. 13). Considering the great amount of search effort that was concentrated in this area, very few positive data on maternity denning areas were obtained. Although we have identified the south coast of Devon Island, the SW corner of Cornwallis Island, the islands in Barrow Strait, and the north coast of Somerset Island as maternity denning areas, available to date suggest that the density of dens and productivity are low and no specific sites appear critical (Fig. 10). No ground surveys were conducted in these areas and few data on tracks of family groups were recorded, although Kiliaan recalls seeing an unspecified number of tracks along the SW corner of Devon Island in 1970 and 1971.

Twelve helicopter survey days were flown in Peel Sound on the following dates:

1972: 1 day, no date recorded
1973: April 3
1974: March 24-26, 30
1975: April 13, 26
1976: April 20, 21, 22, May 7

Fifteen days of ground searches were conducted with oversnow vehicles along the NW and NE coast of Prince of Wales Island on the following dates:

1974: March 28-30, April 7, 11, 12
1975: March 27-30, April 1, 2, 4, 5, 12

In the course of these searches, six dens were located, two family groups were captured before mid-April, and fifteen sets of tracks of females with cubs were observed prior to mid-April (Fig. 13). Two additional den sites were reported by other biologists and by Inuit hunters. It appears that maternity denning occurs on the NW and NE coast of Prince of Wales Island at low densities, but probably with greater regularity than on the north coast of Somerset Island (Fig. 10).

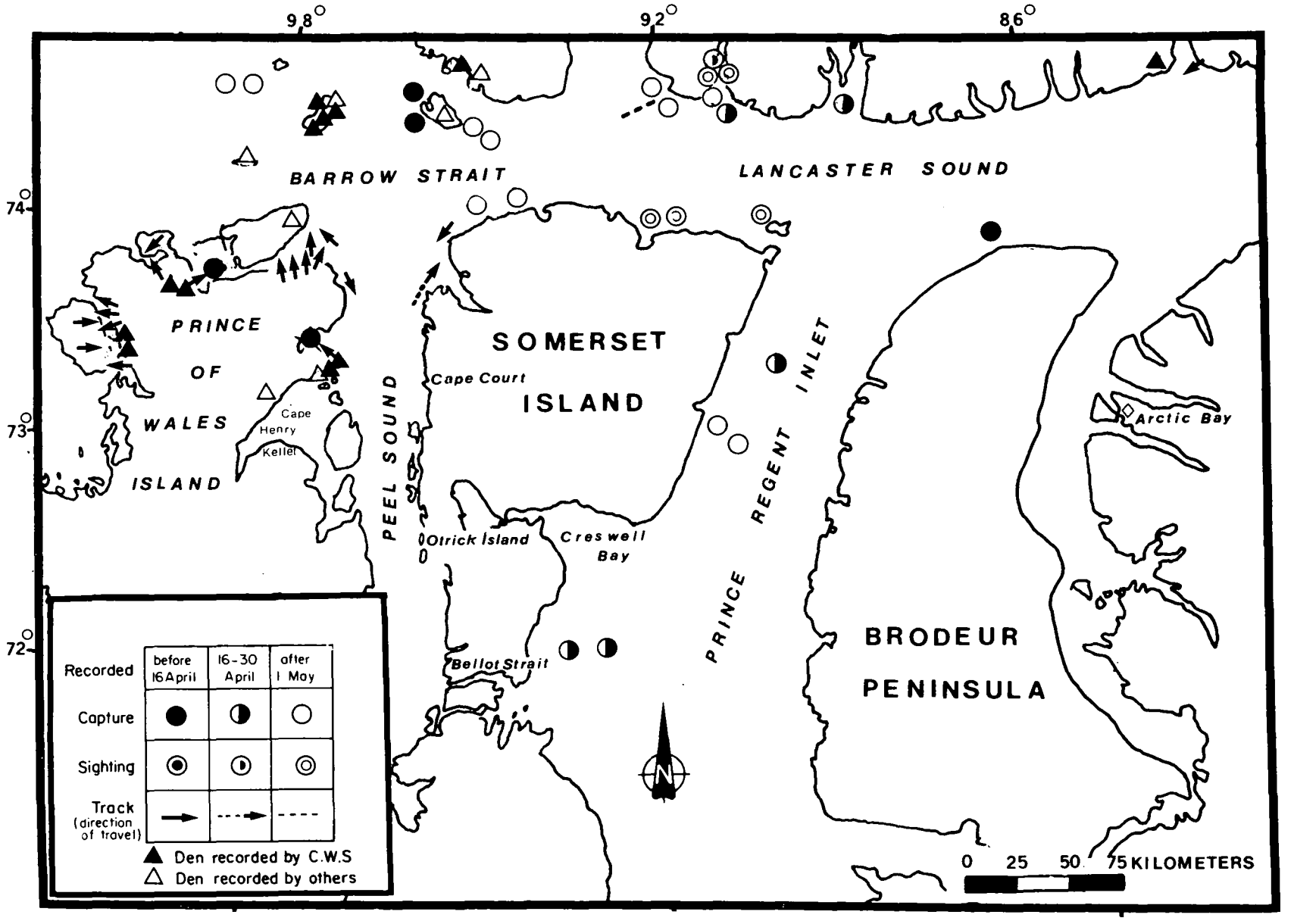

Figure 13. Locations of observations and captures of female polar bears with cubs of the year and tracks of females with cubs of the year on the land areas adjacent to Barrow Strait, Lancaster Sound, Peel Sound, and Prince Regent Inlet.

Inuit hunters from Resolute who used to live along the west coast of Somerset Island report that maternity denning occurs on the Pandora Islands, the east coast of Prince of Wales Island between Cape Henry Kellett and Le Ferve Inlet and on the west coast of Somerset Island between Cape Court and Ostrich Island (Fig. 10). Although these specific areas have not been searched, we suspect that denning in that area probably only occurs at low density because we have observed so few bears in Peel Sound in our surveys there during both spring and summer.

Thirteen helicopter survey days were flown in Prince Regent Inlet on the following dates:

1975: April 20, 22, 30, May 3
1976: April 20-24, May 6, 15, 20, 23

All the surveying was done after mid-April and only five females with cubs of the year were seen, all of which were captured (Fig. 13). No tracks were recorded. Inuit hunters from Resolute report maternity denning on the east coast of Somerset Island between Creswell Bay and Bellot Strait. Inuit hunters from Arctic Bay report that maternity denning occurs on the west coast of the Brodeur Peninsula. No dens have been located in either of these areas but females with cubs of the year have been captured in both areas, indicating the possibility of maternity denning there (Fig. 10).

6.2.5 Jones Sound

Fifteen helicopter surveys were flown in Jones Sound on the following dates:

1971: May 26, 27, 28
1972: April 9, 18, May 10
1973: March 31, April 1, 2, 8, 11, May 11-13, 31

Four days of aerial survey with a single otter were done on the north coast of Devon Island on April 9, 10, 13 and 20, 1972. Seventy-one days of ground surveys were conducted using oversnow vehicles on the following dates:

1971: 22 survey days between 17 March and 23 April
1972: 24 survey days between 20 March and 20 April
1973: 25 survey days between 17 March and 18 April

Only one female with cubs of the year was seen and one such group captured (Fig. 14). During the three years of these surveys, tracks of 59 females with 102 cubs of the year were located (Fig. 14). Of these, 50 were recorded before mid-April and nine after that date. Six maternity dens were located (Fig. 14). The greatest number of dens were found between Eidsbotn Bay and Truelove Inlet. That region of the north coast of Devon Island is designated as a denning area (Fig. 10). No survey data are available for the south coast of Ellesmere Island but Inuit from Grise Fiord who hunt there report that little maternity denning occurs there.

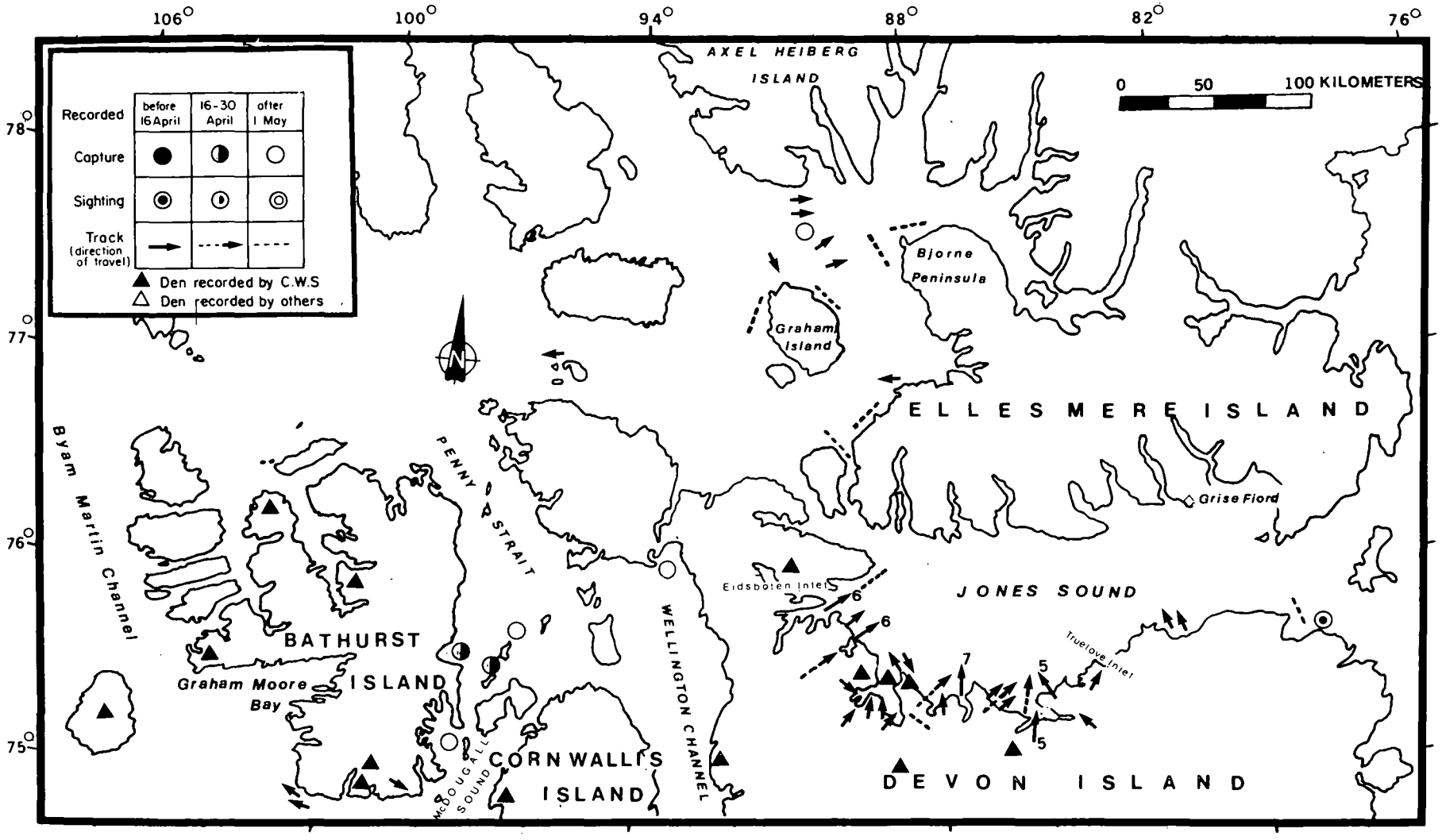

Figure 14. Locations of observations and captures of female polar bears with cubs of the year and tracks of females with cubs of the year on the land areas adjacent to Jones Sound, Norwegian Bay, McDougall Sound, Penny Strait, Queens Channel, Wellington Channel, Graham Moore Bay, and Byam Martin Channel.

6.2.6 Norwegian Bay

Twelve helicopter survey days were flown in this area on the following dates:

1971: May, 1 day (no date recorded)
1972: April 11, 12, 30, May 1, 2, 4, 5
1973: April 8, 13, 14, 15

One female with cubs of the year was captured and the tracks of 13 such groups were recorded (Fig. 14). The locations of these records suggest that Graham Island, the south coast of Axel Heiberg Island and the west side of the Bjorne Peninsula (Ellesmere Island) are possibly maternity denning areas (Fig. 10).

6.2.7 McDougall Sound, Penny Strait, Queens Channel

Ten helicopter survey days were flown in this area on the following dates:

1970: May 18, 19
1971: May 14
1972: April 12, 25
1974: May 13
1976: April 19, 29, 30, May 12

Four females with young of the year were captured, tracks of one such group leaving the land on SE Bathurst Island were recorded, and two maternity dens were reported (Fig. 14). The families caught could have come from anywhere on the SE coast of Bathurst Island or the west coast of Cornwallis Island, These locations were designated as areas where maternity denning occurs but probably at relative low density (Fig. 10).

6.2.8 SE Queens Channel, Wellington Channel

Fourteen helicopter surveys days were flown in this area on the following dates:

1972: April 11, 12, May 5
1973: March 30, April 8, 11-14, May 13
1976: April 19, 20, 30, May 12

Only one den was recorded on the west coast of Devon Island and one female with cubs of the year (Fig. 14). No records were kept of tracks of females with cubs of the year that might have been seen. The paucity of observations of females with cubs of the year in this area suggests that it is not a potentially important area for maternity denning (Fig. 10).

6.2.9 Graham Moore Bay, Byam Martin Channel, Northern Bathurst Island

Only three helicopter surveys days were spent in this area on the following dates:

1971: May 15
1973: April 12
1974: May 3

No females with cubs of the year were seen and no records were kept of tracks of such groups that might have been seen. Three active maternity dens were reported by R.H. Russell in 1973, one on central Byam Martin Island and two on western Bathurst Island (Fig. 14), indicating these areas are potentially important for maternity denning (Fig. 10).

6.2.10 General comments on maternity denning areas

The recurrent theme through all the data discussed in the previous sections and summarized on Figures 10 to 15 is that in general, considering the extent of the aerial surveys that have been conducted, few observations have been made of maternity dens or of female polar bears with cubs of the year. Unfortunately, few sightings of tracks of females with cubs of the year were recorded during the helicopter surveys. This would have helped in assessing the relative importance of some areas for maternity denning.

It is relevant to compare the results of the aerial and ground surveys conducted on the north coast of Devon Island (Fig. 14) and on the NW and NE coasts of Prince of Wales Island (Fig. 13). On the north coast of Devon Island, only two females with cubs of the year were actually seen in 19 days of aerial surveys compared to the recording of tracks of 56 females with 98 cubs of the year on the ground surveys. However, it required a large time commitment (three men for 71 days each) to collect the data. Comparable results were obtained on the NW and NE coasts of Prince of Wales Island. This indicates that if the time and manpower are available, ground surveys probably give more information on specific areas. The locations of sightings and captures of females with cubs of the year in the spring in other areas, especially prior to mid-April, probably indicate that the maternity denning occurred on the adjacent coastal area. Ground surveys in these areas might reveal the tracks of many more females with cubs of the year than were actually seen on the aerial surveys.

Based on fixed-wing aerial surveys of the polar bear denning area on the Manitoba coast of Hudson Bay, an estimated 150 cubs were produced in 1975 and 1976 from an area about 100 by 50 km in size (Cross, 1975 & 1976). In comparison, in a variety of locations of unspecified area on Wrangel Island, Uspenski and Kistchinski (1972) located a total of 190 maternity dens in 1969 and 1970, using both ground and aerial surveys. On Wrangel Island, two to five dens were often located on a single slope.

Nowhere in the Central or High Arctic have we conducted maternity denning surveys in which comparably high numbers of dens, or cubs of the year, have been recorded in a single year. This could have been influenced by inadequacies in our survey techniques that we are unaware of, or, to date we have simply missed high density productivity areas. However, another explanation could be that suitable habitat for maternity denning in the study area appears, superficially at least, to be virtually unlimited. In comparison, there are very few islands available where maternity denning could take place north of the Siberian coast and none off the coast of Manitoba, relative to the vast expanses of apparently available feeding habitat. Thus, it could be that polar bear maternity denning is more concentrated in these areas than in the Canadian Arctic Archipelago.

At first inspection, the data provided by Father F. Van de Velde (pers. comm.) for the Simpson Peninsula and the islands to the northwest, appear to represent a high density maternity denning area (Fig. 12). However, his records represent a compilation of all dens seen by Inuit hunters from Pelly Bay in living memory. Thus, while it is clear that the areas he has designated are probably the most important ones in the region, it seems unlikely that the annual cub production approaches the numbers recorded by Cross (1975 & 1976) or Uspenskii and Kistchinski (1972).

Therefore, on the basis of the data available to date, it appears that the pattern in the Central and High Arctic is one of widespread maternity denning at relatively low densities.

6.3 Litter Size and Productivity

6.3.1 Litter size

Table 3 presents data on polar bear litter size collected in the study area by direct observation, Van de Velde's (1957) unique data from Pelly Bay, and comparative data from other areas. The litter size of female polar bears in the study area and other areas of the Arctic appear comparable. Only in Hudson Bay (Jonkel *et al.*, 1972 & 1976) does it appear that the mean litter size may be consistently larger than in more northerly parts of the polar bear's range.

Various authors (e.g. Van de Velde, 1957; Lønø, 1970; Lentfer, 1976) have compared the mean litter size of cubs of different ages in an attempt to estimate mortality rates prior to weaning. In this study for example, the mean litter size of polar bear cubs based on tracks leaving the dens was higher than that of litters captured or sighted on the sea ice at a later date (Table 3). However, the difference in mean litter size was not statistically significant ($t = 1.29$, $df = 156$, $p > 0.1$). In a sample collected from the Western Arctic from 1971-73, the mean litter size of two-year-old cubs was higher than that of yearlings which was suggestive of a low mortality rate prior to weaning (Stirling, 1974b). However, in the Western Arctic, between 1971-73 and 1974-75, the polar bear population dropped by about a third and the natality rates by a half (Stirling *et al.*, 1975). At the same time, the mean litter size (cubs of all ages pooled) changed only slightly from 1.69 ± .05 to 1.61 ± .08. However, at the same time, the proportion of adult females accompanied by cubs of any age dropped from 82.2% (37/45) to 54.7% (35/64), a difference that was highly significant ($X^2 = 9.10$, $df = 1$, $p < 0.01$). Thus, although a great deal of cub mortality took place, it was not reflected in the mean litter size. Obviously some litters are reduced in size because of the loss of a cub, but the above data suggest that females from the Western Arctic, during 1971-75 at least, tended to either keep or lose whole litters.

6.3.2 Productivity

Table 4 presents the age and litter size of cubs accompanying female polar bears of each age class, captured in the Central and High Arctic from 1970 through 1976. An additional 30 family groups could not be included in this table because teeth were either not collected or broken when being pulled. Table 5 presents the age-specific conception rates, litter sizes,

Table 3. Data on polar bear litter size collected in the study area by direct observation and comparative data from other areas.

Geographic Area	Reference	Records of Litter Size								
		Embryo			Tracks leaving den			Captures & Sightings		
		$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N
Canadian Central and High Arctic	This study	-	-	-	1.76	.64	101	1.64	0.51	56
Pelly Bay	Van de Velde (1957)	1.92	-	36	-	-	-	1.71*	0.59	56
NE Greenland	Manniche (1910)	-	-	-	-	-	-	1.71*	0.47	35
Wrangel Is	Uspenskii & Kistchinski (1972)	-	-	-	-	-	-	1.85	-	20
Western Arctic	Stirling *et al.*, (1975)	-	-	-	-	-	-	1.68	0.48	19
Alaska	Lentfer (1976)	-	-	-	-	-	-	1.70	0.46	10
Zoos	Harington (1968)	-	-	-	-	-	-	1.64	0.47	58
Hudson Bay (Manitoba)	Jonkel *et al.*, (1972)	-	-	-	-	-	-	1.90	-	52
Hudson Bay (Ontario)	Jonkel *et al.*, (1976)	-	-	-	-	-	-	2.27	-	12

* based on counts of cubs before leaving the den.

Table 4. Age and litter size of cubs accompanying female polar bears of each age class, captured in the Central and High Arctic, 1970-76.

Age of ♀♀	Total No. ♀♀ of each age	No. ♀♀ accompanied by cubs of any age	Age and Litter Size of Cubs Accompanying Females					
			Cubs of Year		Yearlings		2-year-olds	
			1	2	1	2	1	2
3	25	-	-	-	-	-	-	-
4	23	-	-	-	-	-	-	-
5	20	10	5	2	3	-	-	-
6	24	15	2	2	4	4	3	-
7	12	5	2	2	-	-	1	-
8	20	14	-	8	5	-	1	-
9	12	8	2	4	1	1	-	-
10	8	3	1	1	-	1	-	-
11	12	5	1	3	-	-	1	-
12	6	3	1	1	-	1	-	-
13	13	8	1	1	3	2	-	1
14	5	-	-	-	-	-	-	-
15	4	1	-	-	-	1	-	-
16	2	1	1	-	-	-	-	-
17	3	2	-	-	2	-	-	-
18	3	3	1	1	-	1	-	-
19	3	3	-	-	1	1	1	-
20	3	2	1	-	1	-	-	-
21	2	1	-	-	-	-	1	-
22	1	-	-	-	-	-	-	-
23	2	1	-	-	-	-	1	-
24	-	-	-	-	-	-	-	-
25	1	-	-	-	-	-	-	-

Table 5. Age-specific conception rates, litter sizes, and natality rates of female polar bears in the Central and High Arctic, 1970-1976, calculated from the data in Table 4.

Age Class of Females	Age-specific Conception Rate	Age-specific Litter Size	Age-specific Natality Rates
3 yr.	0.070	1.00	0.035
4 yr.	0.341	1.38	0.235
5 yr.	0.111	1.40	0.078
5-25 yr.	0.198	1.51	0.149
6-25 yr.	0.210	1.51	0.159

and natality rates calculated from the data in Table 4. For comparison, Table 6 gives the same age-specific parameters calculated for polar bears in the Western Arctic in 1971-73 when the population was apparently thriving compared to 1974-75 when numbers and productivity declined markedly. These values have been recalculated since being published by Stirling *et al.*, (1975) but the end results are essentially the same.

Several points should be noted in comparing the results presented in Tables 5 and 6. In almost all the age-specific reproductive parameters, female polar bears in the Central and High Arctic were markedly lower than their counterparts in the Western Arctic in 1971-73.

FromTable 4, it appears that there may be more partial loss of litters than apparently occurred in the Western Arctic. The mean litter sizes of cubs of the year, yearlings, and two-year-olds that were captured and aged were: 1.58 (68/43), 1.37 (44/32), and 1.10 (11/10). Thus, the method used to calculate the age-specific litter size may have incorporated some of the possible bias noted in Section 5.1.4. However, the number of females five years of age and older, accompanied by cubs of any age, was only 54.5% (85/156) which was almost identical to the figure for the declining population of the Western Arctic in 1974-75 (54.7%) and contrasted markedly with 1971-73 Western Arctic value which was 82.2%. This result, coupled with the fact that the age-specific conception and natality rates in the Central and High Arctic were only two-thirds of the equivalent values in the Western Arctic in 1971-73, make it clear that productivity is considerably lower in the former area. We have not yet been able to conduct analyses to attempt to determine whether the reproductive parameters calculated represent a relatively stable or changing population.

One curious difference between the two areas was that the onset of breeding in the Central and High Arctic, as indicated by a marked rise in the natality rate (Table 5), appeared to occur at four years of age compared to five years of age in the Western Arctic. The same methods and some of the same personnel were involved in determining the ages of both samples, so that the interpretation of the specimens should have been consistent.

However, a biological reason for such difference is not readily apparent. This aspect must be carefully re-examined using all extant and new data from both areas.

6.4 Age Structure and Mortality Rates

Table 7 gives numbers of polar bears of each age and sex class captured in the study area from 1970-76 and killed from 1959-76. Unfortunately, the samples are not complete because specimens were not turned in from all the bears shot, nor collected from all the bears captured.

Table 8 gives the sex specific mean ages of the kill and capture samples from the study area, one year of age and older and five years of age and older in order to compare the mean ages of the total population and of the adult segment only. Because cubs of the year cannot legally be killed, they were not included in the comparisons in order to avoid bias. There were no significant differences between the mean ages of males and females of the same

Table 6. Age-specific conception rates, litter sizes, and natality rates of female polar bears in the Western Canadian Arctic in 1971-73 and in 1974-75.

Age Class of Females	Age-specific Conception Rate		Age-specific Litter Size		Age-specific Natality Rates	
	1971-73	1974-75	1971-73	1974-75	1971-73	1974-75
3 yr. *	0.071	0.650	1.50	1.25	0.0450	0.0375
4 yr. +	0.000	0.400	-	1.25	0.0450	0.0375
5 yr.	0.500	0.333	1.66	1.80	0.4150	0.2997
5-25 yr.	0.325	0.178	1.70	1.61	0.2762	0.1433
6-25 yr.	0.292	0.180	1.70	1.54	0.2482	0.1433

* 0.06 was used as the conception rate for 3 and 4-year-old females in all years.

+ 1.50 was used as the litter size of 4-year-old females in 1971-73.

Table 7. Number of polar bears of each age and sex class captured in the study area from 1970-76 and killed from 1959-76. (The samples are not complete because specimens were not turned in from all the bears shot, nor collected from all bears captured).

Age	Number in Sample			
	Killed Bears		Captured Bears	
	♂	♀	♂	♀
0	2	1	10	10
1	10	7	19	20
2	31	23	25	33
3	32	17	23	25
4	20	17	21	23
5	15	9	20	20
6	9	8	17	24
7	13	9	20	12
8	9	9	10	20
9	4	1	11	12
10	4	8	10	8
11	3	2	12	12
12	6	1	8	6
13	2	4	6	13
14	1	1	7	5
15	4	3	5	4
16	5	3	2	2
17	2	2	3	3
18	3	2	2	3
19	2	2	2	3
20	2	1	2	3
21	1	3	2	2
22	-	1	-	1
23	1	1	-	2
24	-	1	2	-
25	1	1	-	1
Total	182	137	239	267

Table 8. Sex-specific mean ages of killed and captured bears from the study area, based on data in Table 7.

Sample Group	N	Mean ± Standard Deviation
Killed Bears		
♂♂ ≥ 1 yr.	180	6.31 ± 5.19
♂♂ ≥ 5 yr.	87	10.21 ± 5.04
♀♀ ≥ 1 yr.	136	7.11 ± 5.87
♀♀ ≥ 5 yr.	72	11.04 ± 5.59
Captured Bears		
♂♂ ≥ 1 yr.	229	7.02 ± 4.99
♂♂ ≥ 5 yr.	141	9.82 ± 4.37
♀♀ ≥ 1 yr.	257	7.08 ± 5.19
♀♀ ≥ 5 yr.	156	10.05 ± 4.63

age categories within the kill or capture samples or between them (Table 9). This suggests that the age structure of the kill sample from the Central and High Arctic is probably representative of the population. In comparison, Stirling *et al.*, (1975) found that in the Western Arctic, the mean age of captured males was significantly higher than the mean age of killed males but that there was no significant difference between the mean ages of captured or killed females. This apparently resulted because females with cubs of any age and subadults of both sexes were distributed closer to shore and were therefore more vulnerable to Inuit hunters. Adult males were further offshore in the moving ice of the open lead systems that parallel the coast in that region and where travel on the sea ice is extremely hazardous. All bears were more equally vulnerable to being caught during helicopter surveys. In the Central and High Arctic, the inter-island channels tend to freeze completely. As discussed earlier, this results in the tendency for any ice movement to be associated more with the shorelines than the offshore areas, as is the case in the Western Arctic. Thus, all ages and sex classes of polar bears appear to be closer to shore where seals are apparently more accessible. Consequently, all bears are more accessible to the Inuit of that region. In addition, the offshore ice in the interisland channels is more safely accessible by oversnow machine because of its greater stability.

In Alaska, Lentfer (1973) showed that in 7 years (1966-72), the pooled average age of harvested males and females (>2 years) dropped from 8.1 (n = 47) to 5.6 (N = 72) and suggested that the difference was caused by overhunting, which illustrates the importance of monitoring this parameter. Subjectively, from the average ages of males and females in the kill sample from the study area (Table 8), the population does not appear to be overharvested.

The sex-specific mortality curves of the kill and capture samples from 2 to 25 years of age were calculated by fitting exponential curves to the age structures (Table 10). The mortality rates of males were significantly greater than those of females in the kill but not the capture samples ($F = 4.05$, $df = 22,23$, $p < 0.01$ and $F = 0.14$, $df = 22, 23$, $p > 0.05$ respectively), as would be expected in a polygynous mammal. However, the mortality rates of males and females in the capture samples were both higher than in the kill samples, although the difference was only significant for females ($F_{males} = 0.011$, $df = 22, 23$, $p > 0.05$ $F_{females} = 4.07$, $df = 22, 23$, $p < 0.01$). The reasons for these differences are not clear. There may have been biases in sampling in earlier years that we are unaware of. In addition, for some unknown reason teeth were not collected from all bears that were captured. We know which bears these were but we have not yet attempted to evaluate the effect of these missing data on the slope of the mortality curves. Possibly the most important bias results when a tooth breaks during collection in the field and the worker does not ensure the collection of a complete tooth. This happened for 18 males and 22 females. Broken teeth cannot be aged reliably and thus, those animals cannot be included in the tabulations. Because teeth tend to become more brittle with age, this bias could cause the older age classes to be underrepresented. Consequently, mortality curves calculated from the age structure of captured bears could be artifically high. This aspect needs to be examined more closely.

We are not in a position at this time to attempt any estimates of population size.

Table 9. *t*-tests conducted on sex-specific mean ages of kill and capture samples, based on data in Table 8.

Test Groups	*t*	Degrees of Freedom	Level of Significance
Kill ♂♂ vs. kill ♀♀			
≥ 1 yr.	0.37	297	none
≥ 5 yr.	0.99	157	none
Capture ♂♂ vs. capture ♀♀			
≥ 1 yr.	0.13	484	none
≥ 5 yr.	0.41	295	none
Kill vs. capture			
♂♂ ≥ 1	1.41	407	none
♂♂ ≥ 5	0.59	226	none
♀♀ ≥ 1	0.47	392	none
♀♀ ≥ 5	1.40	226	none

Table 10. Sex-specific mortality curves of kill and capture samples, from 2 to 25 years of age, calculated by fitting exponential curves to the age structures in Table 7.

Sample Group	Annual Mortality Rate
Captured ♂♂	17.2%
Captured ♀♀	16.6%
Killed ♂♂	16.6%
Killed ♀♀	12.3%

Footnote: Before calculating the mortality curves, the following artificial smoothing was done in the frequencies of occurrence in the oldest age classes: Killed ♂♂ 22 - 25 yrs., 0.50 each; Captured ♂♂ 22 - 24 yrs., 0.66 each; and Captured ♀♀ 24 - 25 yrs., 0.50 each.

6.5 Inuit Utilization of Polar Bears Along the Proposed Pipeline Route

6.5.1 Hunting patterns

In prehistoric times, Inuit hunting camps were widespread in the Central and High Arctic so that polar bears were hunted on almost all coastal areas at one time or another (Freeman, 1976a). In more recent times however, the Inuit have moved into the much more centralized Arctic communities we know today. With these changes in the distribution of resident Inuit hunters, there has also been a marked change in the areas in which polar bears are regularly hunted (Freeman, 1976b).

The known locations where Inuit hunters killed polar bears between 1968 and 1976 are plotted in Figure 15. In general, the areas in which bears were killed by Inuit correlate fairly closely with known and suspected maternity denning areas and with Freeman's (1976b) summary of present day Inuit polar bear hunting areas.

Figure 16 shows where tagged polar bears, known to have been killed by Inuit hunters from settlements in or near the study area, were originally captured. Although the sample size is not large, the data indicate that most of the polar bears harvested were first tagged in the general area in which they were killed. However, some longer distance movements have been recorded, indicating that more information is still needed to fully assess the extent of the distribution of the polar bear population being harvested by each community.

Hunting is restricted to Inuit and to a limited number of sport hunters guided by Inuit, and is strictly controlled through the implementation of the NWT quota system. In 1967, quotas based on past known harvests were established for each settlement and by 1969 a fairly accurate record of the polar bear harvest was available. All polar bear hides are tagged with a self-locking metal tag which is numbered and labelled with NWT. Settlements are usually penalized for any overkills by reducing the quota accordingly for the following year.

The hunting season is open from 1 October to 31 May the following year and females with cubs (<137 cm or 54 in long) are protected. Cubs reach the legal hunting length when they are about one year old. Table 11 summarizes the annual quotas and known kills for each of the settlements from 1967-68 to 1974-75. Quotas for 1975-76 and 1976-77 are also given. Even though all the eight settlements do not fall within the immediate study area, the Inuit from these settlements hunt bears from sub-populations that do occur within the study area.

In 1973, a quota of 12 bears was designated for the Melville Island area. As there is no permanent Inuit settlement in that region, the quota is alloted to adjacent settlement(s) based on proposals submitted to the NWT-FWS. In 1973-74, the quota was allotted to Spence Bay and in 1975-76 to Resolute and Grise Fiord. In 1974-75, and so far for 1976-77, no allotment has been made. These quota allotments are in addition to the regular settlement quota.

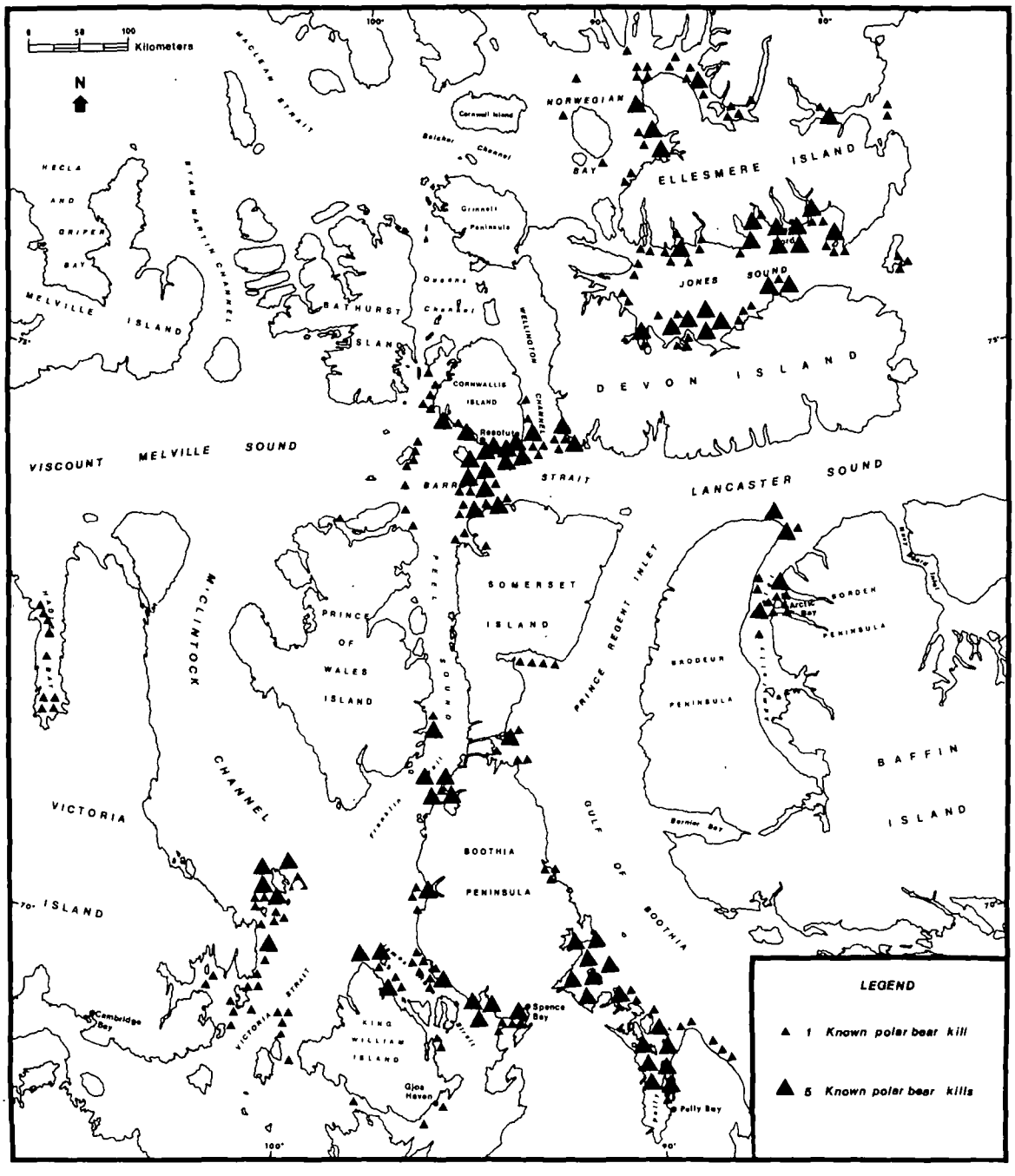

Figure 15. Known locations of polar bear kills by Inuit from 1968 to 1976.

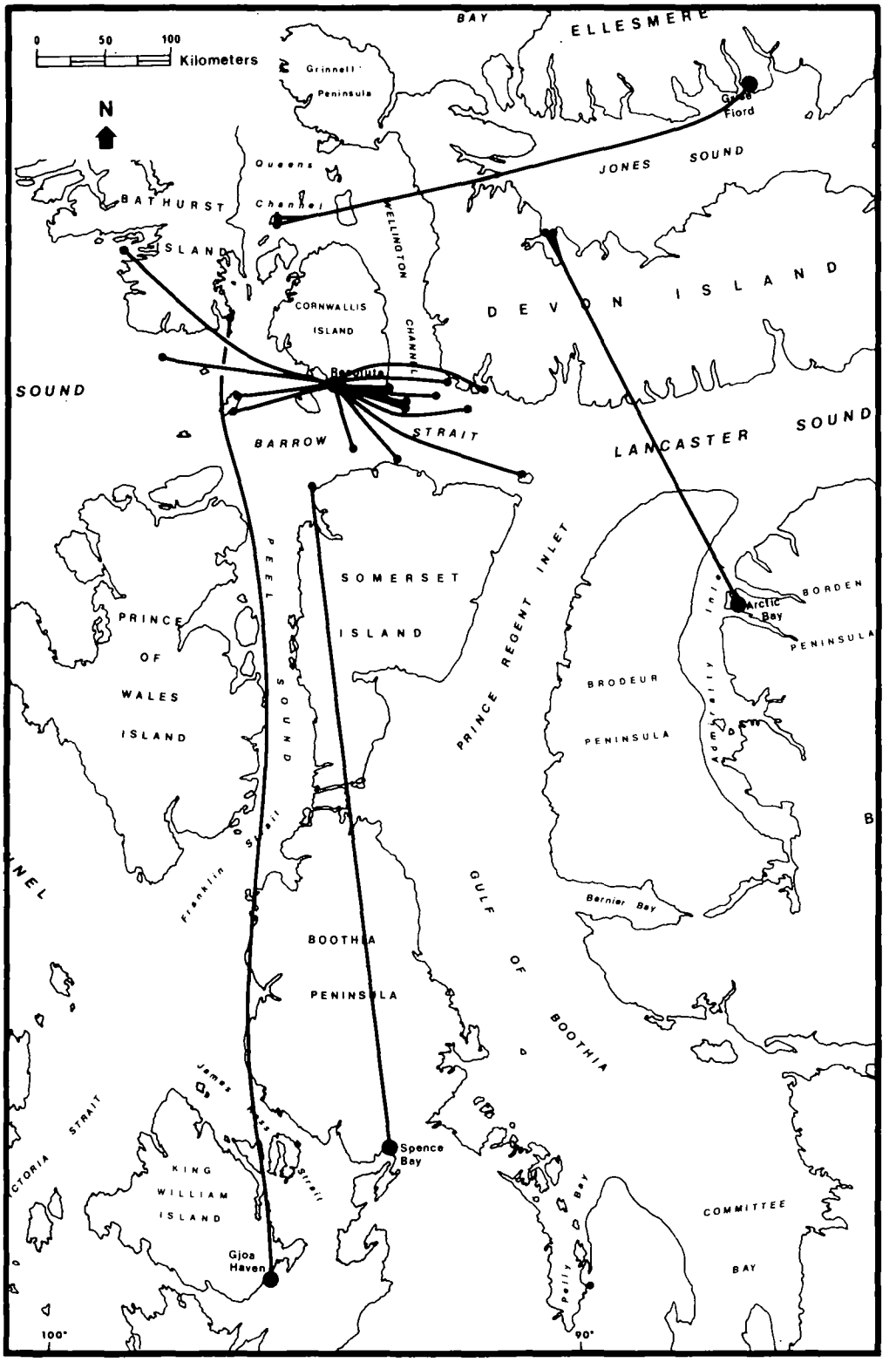

Figure 16. Locations where polar bears killed in Inuit settlement quotas were originally captured.

Table 11. Polar bear quotas (Q) and kills (K) in the study area, by settlement (including settlements outside the area that hunt bear from subpopulations extending within the area) 1966-77.

	YEAR									
	1967-68*	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
SETTLEMENT	Q K	Q K	Q K	Q K	Q K	Q K	Q K	Q K	Q K+	Q K
Arctic Bay	10- U°	12- 7	12-12	12-12	12-12	12-12	12-13	12-12	12-	12-
Cambridge Bay	10-10	10- 8	10-10	10- 9	10-11	10-10	14-12	14-14	14-	14-
Gjoa Haven	8- U	10- 5	10- U	8- 6	8- 8	8- 8	9- 9	9- 9	9-	9-
Grise Fiord	17- U	27-17	27-23	27-27	27-27	33-33	33-33	33-29	33-	33-
Pelly Bay	9- U	11- 7	11- 6	10-10	10-10	10-10	10-10	10-10	10-	10-
Pond Inlet	9- U	11-11	11-11	13-13	13-14	13-14	13-13	13-13	13-	13-
Resolute	50-52	40-47	40- U	34-33	34-33	34-34	34-35	34-34	34-	34-
Spence Bay	23- U	23-23	23-25	22-21	22-25	22-24	22-23	22-22	22-	22-
Melville Island							12- 6	12- 0	12-	12-
TOTALS	136-62	144-125	144-87	136-131	136-140	142-145	159-154	159-143	159-	159-

*Game management year extends from 1 July to 30 June the following year
+Kill data for 1975-76 not available yet
°U=number of polar bears killed unknown

6.5.2 Economic value of Inuit polar bear hunting

Since 1972, a close check on the prices paid for polar bear hides has been maintained (Smith and Jonkel, 1975a & b; Smith and Stirling 1976). During the early 1970's the prices paid rose very rapidly reaching a peak in December 1973 when the maximum price of $3,600 was paid (Smith and Jonkel, 1975a). Since then prices have declined considerably but are still higher than prices paid in 1971-72 (Table 12). During the last four years (1971 to 1975) the harvesting of polar bears in the study area has grossed about $50,000 annually. During 1973-74 when prices were highest, the gross income from the sale of polar bear hides was probably in the order of 1/4 million dollars. However, during 1974-75 a similar number of bears were harvested but the income (estimated at $80,000) was much reduced from the previous year. Income for 1975-76 may be somewhat higher as the market for polar bear hides has recovered slightly. In general, the larger the hide the more valuable it is but the condition of the hunted bear and the care taken in preparing the hides also markedly affect its value (Smith and Stirling, 1976).

Table 12. Average known prices (in dollars) paid to hunters and estimated total value for polar bear hides from eight Arctic settlements in the vicinity of the proposed pipeline route, 1971-72 to 1974-75. (Numbers of skins are in parentheses).

Settlement	1971-72	1972-73	1973-74	1974-75
Arctic Bay		840(12)	1,686(10)	959(11)
Cambridge Bay	400(11)		691(4)	500(14)
Gjoa Haven	419(8)			333(10)
Grise Fiord		1,824(13)		579(7)
Pelly Bay				200(6)
Pond Inlet			1,590(5)	566(11)
Resolute		1,041(34)		573(8)
Spence Bay	375(10)		1,420(8)	620(11)
Ave.	397(29)	1,172(59)	1,442(27)	561(78)
Ave. (all settlements in Canada)	365(143)	824(212)	1,293(221)	613(272)
Est. total value to above 8 settlements	51,000 - 56,000	120,000 - 170,000	200,000 - 222,000	80,000 - 88,000

Under the NWT Game Ordinance (1968), a limited sport-hunt at the request of particular settlements has been permitted since January 1970. The tags allotted to the sport-hunt are taken from the settlement quota and cannot be used at a later date, even if the sport-hunt is unsuccessful. The sport-hunt, through outfitting fees, facilitates a potential for additional revenue to the

native hunters. However, during 1973-74 when the price of polar bear hides rose considerably, interest by the Inuit hunters declined (Smith and Jonkel, 1975b). To many Inuit hunters, the effort involved in servicing a sport-hunt did not justify the financial gain. Table 13 lists the settlements in the study area which offered sport-hunts, the number of applicants, the number of successful hunts, and the cost per hunt since January 1970. Because of the decrease in the value of polar bear hides, the cost of the hunt may have to be adjusted to attract more prospective hunters.

Table 13. The number and cost (in dollars) of sport-hunts by Inuit settlements hunting in the study area 1970-76.

Year	Settlement	No. applicants	No. successful sport-hunts	Cost per hunt
1970	Resolute	3	3	2,500
1970-71	Resolute	4	4	2,500
1971-72	Resolute	4	3	2,500
1972-73	Pond Inlet	4	3	2,500
1973-74	Pond Inlet	1	1	3,500
1974-75	Pond Inlet	1	0	4,500
1975-76	Cambridge Bay	2	1	4,000
1970-76		19	15	

In summary, it is clear that polar bear hunting is of significant economic importance to the Inuit along the proposed pipeline route. Polar bear hunting is also reputed to still be of significant cultural importance to the Inuit but we are not qualified to comment on this question. It is clear however that any significant disruption of polar bear distribution, survival, or natality rates could have significant economic effects on adjacent communites, and possibly important cultural effects as well.

7. CONCLUSIONS

1. Polar bears in the Central and High Arctic showed a high degree of fidelity to winter and summer feeding areas. Observations of individually tagged polar bears, recaptured over a series of two or more years, also tended to suggest a strong degree of fidelity for specific areas. Some long distance movements within, as well as out of the study area, were recorded, indicating that a limited amount of exchange between more widely separated subpopulations occurs. Within the study area, the polar bears of Barrow Strait, NE Victoria Island, and SE Victoria Island appeared to be discrete subpopulations. No evidence was found of northward or southward seasonal movements of polar bears. The summer feeding and retreat areas are of particular ecological importance because the period during which bears can continue to feed is significantly longer there than elsewhere.

2. Maternity denning in the study area appeared to occur over a widespread area, apparently at lower densities than have been reported for more localized denning areas on the Manitoba coast of Hudson Bay and on Wrangel Island, USSR. It is possible that maternity denning occurs at comparably high densities at some locations within the study area but that either we have not found them yet or our survey techniques to date have been inadequate to detect them. The relative importance of maternity denning sites within the study area was evaluated on a map, within the limitations of the data available.

3. The mean size of litters of cubs of the year that were captured or observed was 1.64 ± 0.51, which was comparable to data recorded in other areas of similar latitude. The age-specific mean litter size for adult female polar bears was lower, 1.51, but was still within one standard deviation of the first value given. The proportion of females accompanied by cubs of any age (54.5%, 85/156), and their age-specific conception and natality rates (0.210 and 0.159 respectively) were lower than were recorded in the Western Arctic from 1971-73 (Stirling *et al.*, 1975). The full significance of these values in relation to the present status of the population is not yet clear.

4. The sex-specific mean age of polar bears one year of age and over, killed by Inuit hunters did not differ significantly from the sex-specific mean ages of captured polar bears from the same age classes. This suggests that the age structure of the kill sample is representative of the total population. The sex-specific mortality rates of the capture samples were higher than those of the kill samples, probably because of biases as discussed in the text. Thus, the sex-specific mortality rates (males 16.6%, females 12.3%) of the killed bears are probably more representative of the natural population. There was no evidence that the polar bear population in the study area was currently being overharvested.

5. The main Inuit polar bear hunting areas tend to overlap with the locations of important maternity denning areas. Polar bear hunting is still of significant economic value to the Inuit communities.

However, it should be noted that this is an interim report and our conclusions are not yet final. As was noted in the report, several aspects of the data still require more refined analyses and additional research to fill gaps.

8. IMPLICATIONS AND RECOMMENDATIONS

8.1 The Concept of Critical Areas

The following statement from Stirling *et al.* (1975) introduced their comments on the potential environmental effects on polar bears of offshore drilling the Beaufort Sea:

> "In the simplest of terms, the survival of any species is dependent on its ability to feed and reproduce successfully. Thus, the most important aspect of the conservation and management of a species is the protection of the most important areas of feeding and breeding habitat. If that condition is met, a population can recover, in time, from a large scale reduction

in numbers, be it caused by accident or by design. Attempts to preserve, in this instance the maximum number of individual polar bears, would be of little value if the key feeding and denning areas were destroyed."

Therefore, in this section, we have oriented our comments on the potential effects of pipeline construction and operation to its influence on the two key aspects, feeding and breeding areas.

8.2 Matters Relating Specifically to Pipeline Construction and Operation

8.2.1 Maternity Denning

Despite the fact that maternity denning has been recorded at low density, there are certainly areas in the Central and High Arctic Islands that are more important than others, as indicated in Figure 10. The areas of greatest importance relative to pipeline construction and staging areas are probably the Simpson Peninsula and Harrison Islands, northern Prince of Wales Island, SW Devon Island, and possibly NW Somerset Island. A superficial inspection of Figures 14 and 15 might indicate that SW Cornwallis Island, the islands of Barrow Strait, and south and western Bathurst Island could be critical. However, the number of dens and females with cubs of the year recorded are few in relation to the large amount of time spent there by researchers and Inuit hunters. Had coverage in Barrow Strait and Lancaster Sound been similar to Jones Sound or Norwegian Bay for example, there would probably be very few records.

Therefore, it appears that the pattern is one of widespread maternity denning at low density although, as noted earlier, this impression could have resulted in part at least from inadequacies in the survey technique. As such, even a high level of disturbance at localized sites is unlikely to have serious consequences to the population as a whole, although a few individual dens may be disrupted. However, widespread disturbance along protracted areas of coastline in the area described above (and delineated in Figs. 10 to 15) could cause premature abandonment and increased mortality of cubs of the year to a significant portion of a local group of bears. Consequently, such a practice should not be permitted. Ideally, activities along coastlines where maternity denning occurs should be restricted to the period from 30 April to 1 October to a distance of 10 km inland, to avoid disturbance of pregnant females.

8.2.2 Summer feeding and refuge areas

From Figures 9 and 4, it is clear that polar bears both concentrate at, and show a high fidelity to, specific summer feeding and/or refuge areas. The bays in these areas are ice covered for a considerable proportion of the year, thus enabling polar bears to hunt seals there during periods when they cannot feed elsewhere. The localized nature of these sites makes them even more important to polar bears, possibly to the point where they should be defined as critical. The most important of the areas, that we can identify at present, are Graham Moore Bay, Brentford Bay, the bays of SW Devon Island, and Creswell Bay. These areas should be completely protected.

8.2.3 Related comments

In terms of polar bears, pipeline construction or operational activities on inland areas would not appear to have serious consequences. Similarly, pipelaying activities or flying over open water areas during the summer would probably not be important. Winter pipelaying activities between islands would have to be considered more carefully. Because winter feeding habitat is much more widely available, localized disturbance or even disturbance along a specified route might not be too serious. However, the use of ice breakers to extend the open water season in Lancaster Sound and Barrow Strait would cause significant changes in the distribution of polar bears in that area and possibly to their mortality and natality rates as well.

Although we have been given no details at this point in time, we understand that plans are well advanced to consider the establishment of a large natural gas processing plant somewhere on SE Melville Island. Large tankers would then be used to take the gas out. If this occurs, there will probably be considerable pressure to utilize icebreakers all the way into Viscount Melville Sound to extend the shipping season. Any such plans should be fully examined and the effects carefully considered and monitored.

8.3 Matters of Scientific Importance

When the next year of field work and analyses are completed we hope to be able to provide baseline data in three areas: fidelity to feeding areas and discreteness of subpopulations, natality and litter size rates by age class of adult females, and mortality curves for the male and female segments of the population. These are three of the most vital areas against which any assessment of possible detrimental effects of pipeline construction and operation would have to be measured. If no significant changes could be shown, it would have to be concluded that the particular activity under scrutiny had caused no significant detrimental effects to polar bears.

We could probably not demonstrate significant changes in fidelity to maternity denning areas, or levels of productivity in those areas, but that would be less important if it could be demonstrated that the survivorship of adult females and their age-specific natality and litter size rates remained unchanged.

Of a more general scientific nature, eventual comparisons of these data with those from other areas will greatly enhance our ecological understanding of the relationships between polar bears and their habitats. Hopefully, one of the major benefits will be that we will be able to ask better questions and gather the relevant data more efficiently and effectively for future environmental baseline studies such as that required for EAMES.

Although not one of the formal goals of this study, future management-oriented research and monitoring by the NWT Fish and Wildlife Service will be founded on the baseline data gathered and analyzed during this study. The extent of the study undertaken will reflect well on Canada in terms of its commitment to the Agreement on the Conservation of Polar Bears.

8.4 Judgements Not Verifiable From This Study

One proposal has suggested that the pipeline be built above the ground. We do not expect that such an obstacle would critically impede polar bear movements but we wish to record that the effects of such structures on uninitiated polar bears are unknown.

The possibility of increased pollution of the sea because of the introduction of contaminants during the enormous logistic exercise involved cannot be ignored. The polar bears, being at the top of the food chain, are potentially most vulnerable. Baseline toxicological studies have not been addressed in this study, or in other AIPP studies so far as we are aware and we wish to record the point.

9. NEED FOR FURTHER STUDY

9.1 Maternity Denning Areas

Although we have not yet recorded any high density maternity denning areas in the Central and High Arctic, some locations were of greater importance than others. The locations of possible denning areas and areas which had been inadequately surveyed were shown in Figure 10. Clearly many of those areas, such as the Brodeur Peninsula, do not need to be surveyed for this study. However, we feel that the unknown areas most likely to be affected by pipeline construction and operation should be surveyed by helicopter before the middle of April, 1977. Specific areas which should be surveyed are north and south of Bellot Strait, the east coasts of Somerset Island and Boothia Peninsula, the south and southwest coast of Bathurst Island, Byam Martin Island, and the Grinnell Peninsula. These searches should be conducted in conjunction with mark and recapture studies to gather further data on fidelity to winter feeding areas and movements.

9.2 Movements and Discreteness of Subpopulations

The high degree of fidelity of the polar bears in Barrow Strait and NE and SE Victoria Island to their winter and summer feeding and retreat areas, and consequently their apparent discreteness from each other, were shown in Section 6.1 and Figs. 2 to 9. However, the relationship of the above groups of polar bears to those in areas important to pipeline considerations, such as the western Gulf of Boothia, James Ross Strait, Bellot Strait, northern Queens Channel, Graham Moore Bay, Austin Channel, or Byam Channel, was not clear. This aspect will be partially investigated through the mark and recapture studies in the spring, as discussed above. However, to complete the studies of movements and discreteness of populations, we recommend that mark and recapture studies during the summer should concentrate on the important areas designated above. In addition such surveys will add valuable data to the evaluation of the possibly critical summer feeding and retreat areas.

9.3 Population Statistics

Female polar bears in the study area appeared to have rather low age-specific conception and natality rates. Similarly, some possible anomalies were noted in the analyses of mortality curves and age at first breeding. More detailed analyses need to be conducted, by breaking the data into a series of subsamples, to see if any trends are apparent or if the subsamples are

homogeneous. It is vital that we have the best possible understanding of our baseline data on mortality rates and reproductive parameters because it will be critical for any meaningful evaluation of the effect of some activity that might be needed.

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APPENDIX I

12. APPENDIX I

AGREEMENT

ON

THE CONSERVATION OF POLAR BEARS

THE GOVERNMENTS of Canada, Denmark, Norway, the Union of Soviet Socialist Republics, and the United States of America,

RECOGNIZING the special responsibilities and special interests of the States of the Arctic Region in relation to the protection of the fauna and flora of the Arctic Region;

RECOGNIZING that the polar bear is a significant resource of the Arctic Region which requires additional protection;

HAVING DECIDED that such protection should be achieved through co-ordinated national measures taken by the States of the Arctic Region;

DESIRING to take immediate action to bring further conservation and management measures into effect;

HAVE AGREED AS FOLLOWS:

ARTICLE I

1. The taking of polar bears shall be prohitited except as provided in Article III.

2. For the purpose of this Agreement, the term "taking" includes hunting, killing and capturing.

ARTICLE II

Each Contracting Party shall take appropriate action to protect the ecosystems of which polar bears are a part, with special attention to habitat components such as denning and feeding sites and migration patterns, and shall manage polar bear populations in accordance with sound conservation practices based on the best available scientific data.

ARTICLE III

1. Subject to the provisions of Articles II and IV, any Contracting Party may allow the taking of polar bears when such taking is carried out:

   (a) for *bona fide* scientific purposes; or

   (b) by that Party for conservation purposes; or

   (c) to prevent serious disturbance of the management of other living resources, subject to forfeiture to that Party of the skins and other items of value resulting from such taking; or

(d) by local people using traditional methods in the exercise of their traditional rights and in accordance with the laws of that Party; or

(e) wherever polar bears have or might have been subject to taking by traditional means by its nationals.

2. The skins and other items of value resulting from taking under sub-paragraphs (b) and (c) of paragraph 1 of this Article shall not be available for commercial purposes.

ARTICLE IV

The use of aircraft and large motorized vessels for the purpose of taking polar bears shall be prohibited, except where the application of such prohibition would be inconsistent with domestic laws.

ARTICLE V

A Contracting Party shall prohibit the exportation from, the importation and delivery into, and traffic within, its territory of polar bears or any part or product thereof taken in violation of this Agreement.

ARTICLE VI

1. Each Contracting Party shall enact and enforce such legislation and other measures as may be necessary for the purpose of giving effect to this Agreement.

2. Nothing in this Agreement shall prevent a Contracting Party from maintaining or amending existing legislation or other measures or establishing new measures on the taking of polar bears so as to provide more stringent controls than those required under the provisions of this Agreement.

ARTICLE VII

The Contracting Parties shall conduct national research programmes on polar bears, particularly research relating to the conservation and management of the species. They shall as appropriate coordinate such research with research carried out by others Parties, consult with other Parties on the management of migrating polar bear populations, and exchange information on research and management programmes, research results and data on bears taken.

ARTICLE VIII

Each Contracting Party shall take actions as appropriate to promote compliance with the provisions of this Agreement by nationals of States not party to this Agreement.

ARTICLE IX

The Contracting Parties shall continue to consult with one another with the object of giving further protection to polar bears.

ARTICLE X

1. This Agreement shall be open for signature at Oslo by the Governments of Canada, Denmark, Norway, the Union of Soviet Socialist Republics and the United States of America until 31st March 1974.

2. This Agreement shall be subject to ratification or approval by the signatory Governments. Instruments of ratification or approval shall be deposited with the Government of Norway as soon as possible.

3. This Agreement shall be open for accession by the Governments referred to in paragraph 1 of this Article. Instruments of accession shall be deposited with the Depositary Government.

4. This Agreement shall enter into force ninety days after the deposit of the third instrument of ratification, approval or accession. Thereafter, it shall enter into force for a signatory or acceding Government on the date of deposit of its instrument of ratification, approval or accession.

5. This Agreement shall remain in force initially for a period of five years from its date of entry into force, and unless any Contracting Party during that period requests the termination of the Agreement at the end of that period, it shall continue in force thereafter.

6. On the request addressed to the Depositary Government by any of the Governments referred to in paragraph 1 of this Article, consultations shall be conducted with a view to convening a meeting of representatives of the five Governments to consider the revision or amendment of this Agreement.

7. Any Party may denounce this Agreement by written notification to the Depositary Government at any time after five years from the data of entry into force of this Agreement. The denunciation shall take effect twelve months after the Depositary Government has received the notification.

8. The Depositary Government shall notify the Governments referred to in paragraph 1 of this Article of the deposit of instruments of ratification, approval or accession, of the entry into force of this Agreement and of the receipt of notifications of denunciation and any other communications from a Contracting Party specially provided for in this Agreement.

9. The original of this Agreement shall be deposited with the Government of Norway which shall deliver certified copies thereof to each of the Governments referred to in paragraph 1 of this Article.

10. The Depositary Government shall transmit certified copies of this Agreement to the Secretary-General of the United Nations for registration and publication in accordance with Article 102 of the Charter of the United Nations.

(Note: The Agreement came into effect in May 1976, three months after the third nation required to ratify did so in February 1976).