Ian Stirling
Wendy Calvert
Dennis Andriashek

Environment Canada   Environnement Canada

Population ecology studies of the polar bear in the area of southeastern Baffin Island

Occasional Paper
Number 44
Canadian Wildlife Service

Environment Canada
Canadian Wildlife Service

Environnement Canada
Service canadien de la faune

Ian Stirling*
Wendy Calvert*
Dennis Andriashek*

Population ecology studies of the polar bear in the area of southeastern Baffin Island

Occasional Paper
Number 44
Canadian Wildlife Service

Aussi disponible en français

*CWS, Edmonton T5K 2J5

Issued under the authority of the
Minister of the Environment
Canadian Wildlife Service

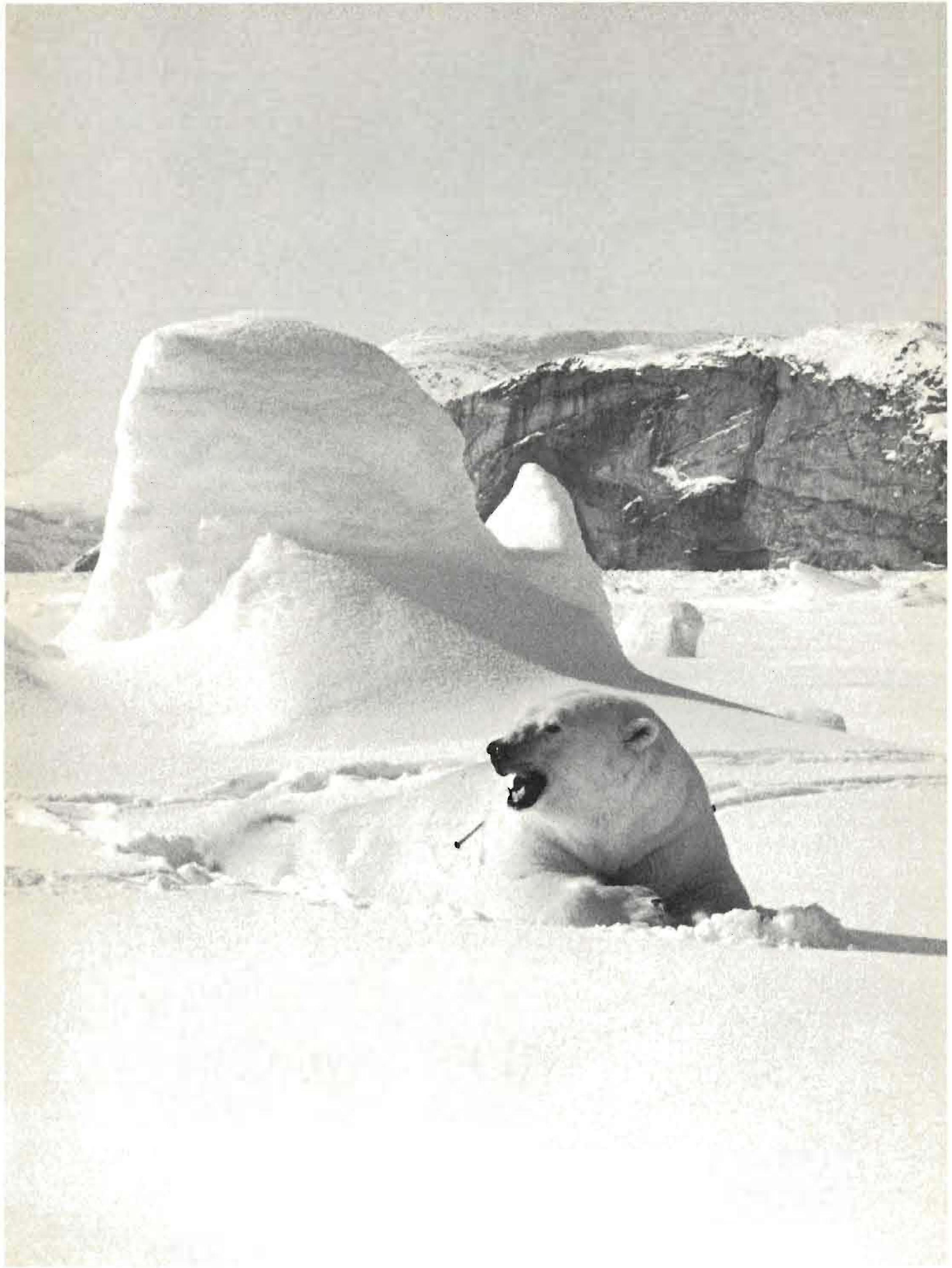
Catalogue No. CW69-1/44E
ISBN-0-662-11097-8
ISSN-0576-6370

Design: Rolf Harder & Associates

Disclaimer

The data were obtained during investigations by the Canadian Wildlife Service, augmented by financial and logistic support from Esso Resources Canada Ltd., Aquitaine Co. of Canada Ltd., Canada-Cities Services Ltd., the Northwest Territories Wildlife Service, and the Polar Continental Shelf Project. Opinions and conclusions are those of the authors and are not necessarily shared by any of the above.

Large adult male being immobilized for tagging (photo by I. Stirling)



Dennis Andriashek with adult female polar bear and newborn cubs prior to tagging (photo by I. Stirling)

Adult female and two 2-year-old cubs travelling across the sea ice (photo by I. Stirling)

Contents

List of figures

Acknowledgements

We particularly acknowledge the support of the following organizations: Canadian Wildlife Service (CWS), Esso Resources Canada Ltd., Aquitaine Co. of Canada Ltd., Canada-Cities Services Ltd., and the Polar Continental Shelf Project. Pauline Smith wrote the description of the study area. She and W.E. Stevens made many other useful suggestions in the course of editing this manuscript. The NWT Wildlife Service (NWT-WS) aided with logistic support in fuel caching, assistance in the field, explaining the research locally to the Hunters and Trappers Associations, and providing access to unpublished reports. For all this help, we particularly thank A. Bourque, J. Bourque, T. Chowns, R.A. Hunter, B. Kovic, E. Land, R. Letkeman, S. Ransom, J. Noble, D. Moshenko, and R.E. Schweinsburg. We are also grateful to the following for assistance in the field and in the laboratory: R. Brading, J. Innes, I. Inookie, C. Jonkel, H.P.L. Kiliaan, P. Pellerin, T.G. Smith, and Jayne Takahashi.

The Inuk Hunters and Trappers Associations from all the settlements within the study area gave much valuable information, advice, and assistance in the field.

Abstract

During 1974–79, 231 polar bears were captured and tagged in the area of southeastern Baffin Island. Subsequently, 41 recaptures were made of 36 bears. An additional 13 tagged bears were reported killed by Inuk hunters. In general, densities of polar bears and their tracks sighted for each 100 km of sea ice habitat were higher than had been recorded in other areas of the Arctic. However, that appeared to reflect a lesser amount of preferred habitat rather than a greater number of bears. Polar bears in the study area travel onto the land much more during late winter and early spring than they do in other areas of the Arctic.

Polar bears along the southeastern coast of Baffin Island show a high degree of fidelity to their winter and spring feeding areas. In only 23% (8/35) of the independent movements recorded did bears move between the two main population centres on the Cumberland and Hall peninsulas. The data suggested that, within the study area, some bears moved south with the ice during winter and then north in spring. The extent to which polar bears within the study area utilize the offshore pack ice remains unknown.

The most important maternity denning areas, in descending order of importance, were around the seaward tips of the Cumberland, Hall, and Meta Incognita peninsulas. The mean litter size recorded during this study was 1.82 ± 0.079 and most females mated for the first time at four years of age. The mean breeding interval, calculated from six females with known minimum intervals between litters, was 3.5 years.

Sex-specific mortality rates calculated from samples over several different ranges of ages were in excess of 20%. These may be too high because of unknown biases in the data but they are still greater than the 12–14% range calculated from polar bear populations in the Western, Central, and High Arctic areas.

Based on mark and recapture data, the population of polar bears in the study area was estimated to be 700–900. The estimates of population size and age-specific reproductive parameters indicate that 75–90 cubs are born each spring.

Résumé

De 1974 à 1979, 231 ours blancs ont été capturés et marqués dans la région du sud-est de l'île Baffin. Par la suite, on a effectué 41 recaptures de 36 ours. On a signalé en outre que 13 ours marqués avaient été tués par des chasseurs Inuk. En général, la densité de la population d'ours blancs et de leurs pistes par 100 km d'habitat de glace de mer était supérieure à celle qui avait été observée dans d'autres régions de l'Arctique. Cependant, il semble que ce fait témoigne d'une réduction de l'habitat privilégié et non de la présence d'un plus grand nombre d'ours. Les ours blancs vivant dans la région observée se déplacent vers la terre davantage à la fin de l'hiver et au début du printemps qu'ils ne le font dans les autres régions de l'Arctique.

Les ours blancs présents le long de la côte sud-est de l'île Baffin sont très fidèles à leurs aires d'alimentation d'hiver et de printemps. Ce n'est que dans 23% (8/35) des trajets indépendants étudiés que l'on a observé chez les ours des déplacements entre les deux principales concentrations des péninsules Cumberland et Hall. Selon les données applicables à la région observée, il semble que certains ours se soient déplacés avec la glace au cours de l'hiver et ce, d'abord vers le sud, puis vers le nord au printemps. On ne sait pas encore dans quelle mesure les ours blancs vivant dans la zone étudiée utilisent les banquises de haute mer.

Le plus grand nombre de tanières de mise bas, par ordre décroissant d'importance, se retrouvent près des extrémités des péninsules Cumberland, Hall et Meta Incognita. La portée moyenne observée au cours de l'étude était de 1,82 ± 0,079, et la plupart des femelles se sont accouplées pour la première fois à l'âge de quatre ans. L'intervalle moyen entre les périodes de reproduction, calculé à partir des données applicables à six femelles dont les intervalles minimums entre les portées étaient connus, était de 3,5 ans.

Les taux de mortalité propres à un sexe précis, calculés à partir d'échantillons pris dans plusieurs catégories d'âge, étaient supérieurs à 20%. Il se peut que ces taux soient trop élevés à cause d'erreurs non décelées dans les données, mais ils sont quand même supérieurs à celui de 12 à 14%, applicable aux populations d'ours blancs des régions de l'Ouest, du Centre et du Haut Arctique.

D'après les données du marquage et de la recapture, on a estimé que la population d'ours blancs dans la région étudiée allait de 700 à 900 individus. Les données relatives à la taille de la population et aux paramètres de reproduction à un âge précis indiquent que de 75 à 90 oursons voient le jour chaque printemps.

Introduction

In 1973, Canada, Denmark, Norway, the United States, and the Soviet Union signed an International Agreement on the Conservation of Polar Bears. That agreement came into effect in 1976 and 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 that baseline studies are done and that the results are utilized to conserve polar bears and their habitat. Thus, population studies on polar bears are needed for management purposes, and baseline studies, for purposes of environmental assessment and the identification of problem areas. The time frame for proposed exploratory drilling in Davis Strait put the immediate needs of assessment ahead of those of management and the international agreement gave a further impetus to this study.

Since 1968 the annual Inuk harvest of polar bears along the southeastern coast of Baffin Island has been regulated through quotas assigned to each settlement. The size of each quota was originally based on previous harvest records and, although some upward adjustments were made, it was not known how the total harvest related to the number of polar bears in the area.

To the south, in the area of Hudson Strait, Ungava Bay, and the Labrador coast, quotas have also been suggested by the Federal–Provincial Polar Bear Technical Committee but the actual harvest has been less restricted and less consistently recorded there than in the Northwest Territories. At present, hunting of polar bears is not permitted in Labrador although the Newfoundland Government reserves the right to reopen the season if warranted on the basis of biological data and if deemed desirable to the economy of the native population. Movements of bears have been recorded between Labrador and southeastern Baffin Island, indicating that they are not discrete subpopulations (Stirling and Kiliaan 1980).

In 1970 the Department of Indian and Northern Affairs leased hectares in Davis Strait to Esso Resources Ltd., Canada-Cities Services Ltd., and Aquitaine Co. of Canada Ltd. for the eventual purpose of drilling offshore for hydrocarbons. Some offshore drilling, not related to the above proposals, has already taken place in the Labrador Sea. Exploratory drilling began in Davis Strait during summer 1979.

Although it is not always recognized, the data required on polar bears for both management and assessment purposes are similar; only their utilization differs. The data fall into five categories: population size; age structure and reproductive rates; population discreteness; seasonal movements, identification of key feeding areas, and areas of summer sanctuary; and, location and extent of denning areas. Basically, wildlife managers use the results to estimate safe sustainable yields and identify critical times or locations at which polar bears may require special protection. In environmental assessment, the same data are used to predict where critical areas are, and how activities might be modified to minimize detrimental effects to (and from) polar bears. It is also essential to establish quantitative baseline information so that, in the event of a "disaster", meaningful monitoring studies can be conducted to determine the effects. This latter aspect may be the most important because we do not know the effects of possible environmental damage or change on polar bears and other marine mammals. Having proper baseline data before and after a sample of known events would be of immense value in determining what sorts of predictions might be realistic in other situations, and in drawing up future regulations or recommendations.

Current information

1. Biology and ecology of the polar bear

The distribution of polar bears is circumpolar. In Canada, the species' range extends from the permanent pack ice of the Arctic Ocean and the High Arctic islands to southern James Bay. At one time popular opinion held that the world population of polar bears was a unit and individuals lived a nomadic existence wandering about the whole circumpolar range. However, tagging and recapture programs, particularly in Canada, Norway, and Alaska, have shown this is not the case and that there are many local subpopulations. The distance or speed at which a bear moves in any particular year probably varies with the rate of change of the ice conditions. During winter and spring, polar bears are dispersed offshore from the mainland and over the ice-covered channels between the islands in the Canadian arctic archipelago. They tend to concentrate along the pressure ice that parallels the coastlines and lies across the mouths of bays and in the vicinity of the floe edge. As break-up of the sea ice proceeds through spring and early summer, the bears move with the ice to hunt seals more effectively. In regions where the ice melts completely, the bears are forced onto the land where they may either wait for freeze-up 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 variable depending on the area and the yearly consistency of ice formation, dispersal, and distribution.

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, normally from about early November to late March or early April. Van de Velde (1971) and Harington (1968) reported instances of females with older cubs denning as well but the extent to which that occurs is not known.

Maternity dens are usually dug on land 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 is 2 m long, 1.5 m wide, and 1 m high (Harington 1968). Lentfer (1975) documented maternity denning 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, i.e. a fertilized egg does not begin to grow immediately but remains in a dormant state in the uterus. Thus, although polar bears mate in May, the fertilized eggs do 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 variation in birth dates, with those in higher latitudes being later. Polar bear cubs are born with their eyes closed and weigh only about 1 kg at birth. By the time they leave the den in March or April, they weigh approximately 9 kg. The females lose weight while nursing their offspring. For the first few days after breaking out of the den, the female and cubs stay near the den and return to it often. The den entrance is surrounded with tracks of the young cubs digging and sliding down banks. In the meantime, the female sometimes digs out and eats ground vegetation. This kind of activity may last as long as 1 to 2 weeks before the family departs for the sea to begin hunting seals (Thomassen and Hansson, in press). Most polar bear cubs in the High Arctic stay with their mother until they are 2½ years old, although a few may remain with her into their fourth year.

On the sea ice, polar bears mainly eat ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*). 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 (Lønø 1970; Stirling 1974; Russell 1975).

Ringed and bearded seals maintain their 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 (Smith and Stirling 1975). In areas where wind, water currents, or tidal action cause the ice to continually crack and subsequently refreeze, seals are apparently more accessible to polar bears and the bears can 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 observations yet to confirm this. During the winter, bears are less abundant in areas, such as deep bays or fiords, 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, in the Western Arctic, ringed seals are more abundant and produce more pups in the bays than in the offshore ice. This also appeared to be the case in the study area (Smith *et al.* 1979). 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.

Polar bears capture seals mainly by stalking them, by waiting for them to surface at a breathing hole (Stirling 1974), or, in spring, by digging out seal pups and sometimes adults from the birth lairs beneath the snow (Stirling and Latour 1978). The bears do not always completely eat the seals they have caught (Stirling 1974; Stirling and McEwan 1975).

Study area

Kiliaan and Stirling (1978) summarized records of walruses (*Odobenus rosmarus*) being killed by polar bears but it is unlikely that they form a significant part of the bears' diet. Similarly, Freeman (1973) and Heyland and Hay (1976) each recorded a beluga (*Delphinapterus leucas*) that had apparently been attacked by a polar bear.

When fully grown, adult male polar bears in Canada range in weight from 450–550 kg and most adult females weigh between 160–270 kg.

2. Previous knowledge of polar bears in the study area

Ground and aerial denning surveys conducted by the NWT-WS and the CWS from 1973 to 1975 indicated important denning areas at the ends of the three major peninsulas of southeastern Baffin Island (Jonkel *et al.* 1978). Smith *et al.* (1975) and Stirling and Kiliaan (1980) summarized information about polar bears in northern Labrador and their relationship to bears on southeastern Baffin Island.

Annual reviews of the trade in polar bear hides across Canada (Smith and Jonkel 1975a and 1975b; Smith and Stirling 1976; Smith 1977, 1978, 1979) have yielded a limited amount of harvest data for the Davis Strait area.

Historical records of the exploration of southern Baffin Island, consultants' survey reports, and flight records of the Department of National Defence give observations of polar bears. Where they are applicable, such observations are included herein.

1. Physiography

Figure 1 shows the study area and offshore area leased for exploratory drilling. Southeastern Baffin Island lies on the eastern edge of the Canadian Shield (Dunbar and Greenaway 1956). The main part of the Cumberland Peninsula is characterized by many glaciers and sharp peaks and ridges which rise to over 2000 m. The coastline is mountainous and indented by many long fiords.

Although the Hall and Meta Incognita peninsulas are generally rugged, barren, and relatively lake-free, they lack the alpine appearance of the Cumberland Peninsula. Most of the Hall Peninsula is over 600 m high with elevations up to about 1100 m to the northeast where there are numerous small glaciers. Deeply incised south-flowing streams issue into the heads of long narrow inlets. The northern coastline is precipitous with elevations of more than 500 m within 1 km of the coast. The eastern and southern coasts are lower, particularly toward the head of Frobisher Bay and they are fringed by a belt of low islands. The Meta Incognita Peninsula to the south is lower and slopes southwesterly toward Hudson Strait. The northern coast of the peninsula toward the mouth of Frobisher Bay is precipitous with vertical rises of over 600 m. Elsewhere the coastline is less rugged.

Offshore, the submarine slopes are characterized by a narrow gently sloping continental shelf which drops off at a depth of about 200 m (Dunbar 1951). In Davis Strait, off the northeastern tip of the Cumberland Peninsula, the sea floor forms a submarine ridge with a maximum depth of only about 600 m. Although the entrance to Cumberland Sound is 350 to 550 m deep, depths of over 1200 m have been recorded near the head of the sound, southwest of Pangnirtung. Frobisher Bay to the south has a similar fiord-like profile but is generally shallower.

2. Climate

Southeastern Baffin Island experiences long cold winters and short cool summers. The marked variation in sunlight throughout the year is responsible for an annual mean temperature range of 30°C. However, due to the proximity of large areas of open water during winter, the range is not as great as in other areas of the Canadian Arctic. The upland nature of much of the terrain has the effect of increasing precipitation, particularly along the seaward tips of the peninsulas. The following summary is taken from Dunbar and Greenaway (1956) and Canada, Meteorological Branch (1970).

Winter begins in late October to early November as a very stable area of high pressure builds up over most of the Canadian Arctic. Over the Baffin Bay – Labrador Sea area,

Figure 1
Map of the study area, including the borders of Polar Bear Management Zones B, C and D. Offshore areas leased for oil exploration are shaded

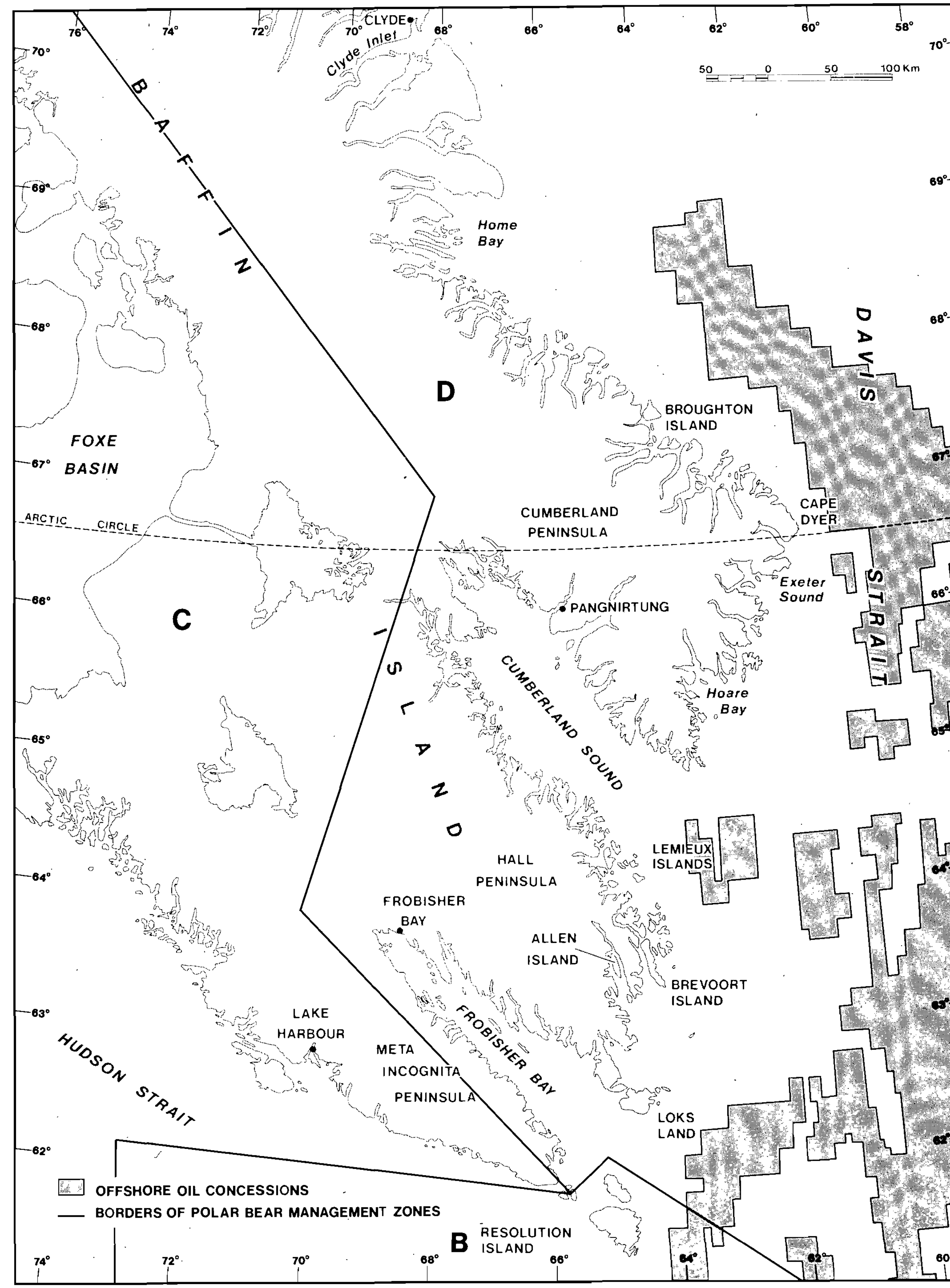


Table 1
Climatic data for Frobisher Bay, NWT (Canada, Atmospheric Environment 1970)

Month	Mean daily* temp.°C	Snow, cm*	Total precip., cm*	Wind† km/h	Wind† direction
January	−26.2	25.7	2.44	15.6	calm/NW
February	−25.2	29.0	2.79	15.6	calm/NW
March	−22.3	21.6	2.06	14.0	calm/NW
April	−14.0	23.6	2.24	17.1	NW/calm
May	− 3.3	21.6	2.29	20.0	NW/SE
June	3.5	8.4	3.78	17.2	NW/SSE
July	7.9	0.3	5.30	13.4	SSE/SE
August	6.9	0.3	5.79	13.7	SSE/SE
September	2.4	14.5	4.34	17.9	NW/SE
October	− 4.7	36.1	4.17	20.1	NW/SE
November	−12.4	37.8	3.68	18.3	NW/calm
December	−20.3	28.2	2.62	16.6	NW/calm
Year	− 8.9	246.9	41.50	16.6	

* 1941–1970
† 1955–1962

as a result of large areas of open water, a semi-permanent trough of low pressure persists and intensifies throughout the winter. Almost continuous cyclonic activity occurs along the line of the trough. These storms are responsible for moderating the winter temperatures (mean daily temperatures −20° to −30°C) and increasing the amount of cloud and precipitation, and wind velocity. Over 100 cm of snow fall in inland areas of southeastern Baffin Island and over 250 cm along the coast. Most snow falls in early winter (late October to early December). Rain or freezing rain may occur during the winter months. Winds are generally from the northwest although the passage of storms interferes with this pattern. The greatest number of calms occurs in winter.

Spring begins in early May as the winter pressure patterns begin to weaken and storms, although still common throughout Baffin Bay and Davis Strait, become less intense. With rapidly increasing daylength, temperatures begin to rise slowly in March. By mid June, most of the snow at lower elevations has melted. The pressure gradients across the Arctic are generally small, although some low pressure areas do move into the Davis Strait area in summer. Winds tend to be variable and change frequently, but the proportion from the east and south increases. Summer tends to be cloudy and fog banks are common over water areas. Precipitation, mainly as rain, reaches a maximum in July and August. July is the warmest month with mean daily temperatures of 4° to 10°C.

By September, with decreasing daylength, temperatures, particularly over the land, fall rapidly. Autumn is the stormiest time of the year and by the beginning of October, most of the area is snow-covered.

From the 1880s to the 1940s the Eastern Canadian Arctic experienced a general climatic warming trend (Bradley and Miller 1972). Since 1960, however, a definite cooling trend has developed. This trend is characterized by a marked decrease in the mean daily summer temperatures (June–August), a marked increase in winter precipitation and in the mean daily winter temperatures (September–May). Consequently, snow accumulation is greater than ablation, and permanent snowbanks are expanding.

Some climatic data for Frobisher Bay (Table 1) are generally representative of the annual cycle in the southeastern Baffin Island area.

3. Vegetation

Southeastern Baffin Island is devoid of trees and the vegetation comprises creeping or trailing shrubs or grass-like herbs, lichens, and mosses. Most species are perennials. Upland and mountain areas, although not presently glaciated, have very little soil cover and are poorly vegetated with a lichen-dominated tundra (Polunin 1948). Plant growth may become very luxuriant in sheltered valleys, particularly toward the southern parts of the study area.

4. Ice conditions

Due to the warming influence of the Atlantic Ocean, a complete ice cover does not form each year in the Eastern Canadian Arctic (Dunbar and Greenaway 1956; Canada, Atmospheric Environment 1966–1976). In bays and inlets along the northern coast of Cumberland Peninsula and in the heads of Cumberland Sound and Frobisher Bay, new ice begins to form in mid October (as late as mid November in some years). The ice gradually increases and spreads southward across Cumberland Sound and the seaward tip of the Hall Peninsula. Ice accumulation off the Meta Incognita Peninsula occurs slightly later. The ice is kept in motion by storms and tidal currents. Except in small bays and inlets, landfast ice does not extend more than a few kilometres offshore. Maximum ice accumulation occurs by March–April at which time Davis Strait north of Cape Dyer is covered with close or consolidated pack ice. South of Cape Dyer, the pack ice is more open. The West Greenland coast remains relatively ice-free.

By June, the ice has begun to melt rapidly and usually by late August most of it has disappeared from the area, except for a few drifting icebergs in Davis Strait and occasionally in Hudson Strait. Ice floes persist along the northern and eastern coasts of the Cumberland Peninsula and to a lesser extent along the eastern coast of the Hall Peninsula. Ice floes drift south from Baffin Bay but the amount depends mainly on wind conditions and varies from year to year. In years of little drift, Davis Strait clears early; for example, in 1968 the approaches to Cape Dyer were clear by 23 July. In other years the ice may never clear from the Cape Dyer area.

5. Currents

The circulation of surface water through the arctic islands is generally weak and in a southerly or easterly direction (Dunbar and Greenaway 1956). Although the Arctic Ocean is the main source of these currents, the circulation in the Eastern Canadian Arctic is also influenced by the inflow of Atlantic Ocean water. Often, however, the general movements are obscured locally by the effects of winds and tides. The following summary is taken from Dunbar (1951).

In the Labrador Sea – Davis Strait area, the circulation is counter-clockwise, although the dominant direction of flow is southward. The West Greenland current, made up mainly of the continuation of the cold East Greenland current and warmer Atlantic drift water, flows northward along the west coast of Greenland at about 14 to 16 cm/s. Part of this current is deflected westward by the Davis Strait ridge, but is prevented from reaching the Baffin Island coast by the strong Canadian current, which carries cold, arctic, and generally less saline water at velocities between 16 and 24 cm/s southward over the Davis Strait ridge. An eddy forms in the West Greenland water where it meets the Canadian current. Velocities of the Canadian current decrease to 4–6 cm/s off the Hall and Meta Incognita peninsulas. The presence of the Canadian current tends to keep water temperatures lower in the western side of the Davis Strait area. Off the Cumberland Peninsula surface temperatures in August–September are only 0° to 1°C. Temperatures increase toward the centre of Davis Strait (about 8°C) and toward the south (about 4°C off the extreme southeastern part of Baffin Island). August–September surface salinities are low and range from 24 to 31‰ off the Cumberland and Hall peninsulas.

The tidal ranges in this region are among the highest in the world with values of spring tides of 11.6 m in Frobisher Bay and 7.6 m in Cumberland Sound (Canada, Canadian Hydrographic Service 1968).

6. Other marine life

The production of phytoplankton and zooplankton determines the productivity of other marine life including, ultimately, polar bears. Even though productivity is low in arctic waters, the phytoplankton are concentrated in a narrow zone and are consequently more easily preyed upon by zooplankton. A number of factors encourage phytoplankton growth (Dunbar 1955). The cold waters contain higher amounts 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 on cliffs, particularly along the seaward tips of the peninsulas and offshore islands on southeastern Baffin Island. An intense diatomaceous bloom occurs in the lower layer of sea ice.

The fishes, which are few in number and species, are mainly benthic and live off marine invertebrates. The lack of pelagic fishes in arctic waters is surprising because there are enough plankton to support populations of seals and whales (Dunbar 1968). The anadromous arctic char (*Salvelinus alpinus*) is the most important pelagic species, particularly in southeastern Baffin Island. Char return to the rivers to breed between mid July and the end of August.

Ringed seals, the main prey species of polar bears, and bearded seals occur throughout the area all year (Mansfield 1967; Smith 1973). Ringed seals are particularly abundant and are closely associated with the landfast ice. Harp seals (*Pagophilus groenlandicus*) and hooded seals (*Cystophora cristata*) migrate through the area in summer. The main harp seal migration follows close to the western side of Davis Strait (Sergeant 1965). The hooded seal population, which is smaller than that of the harp seal, also follows the western side of Davis Strait but then swings eastward south of Cape Dyer to follow the Greenland coast. Walruses occur in small numbers around the mouths of bays and along the tips of peninsulas. Small numbers of harbour seals (*Phoca vitulina*) also occur locally throughout the area.

Whales have been hunted in the area for more than 200 years. Consequently, bowhead whales (*Balaena mysticetus*) which were once abundant, occur only in small numbers. Narwhals (*Monodon monoceros*) and belugas are numerous in the more northern areas of southeastern Baffin Island and a few large whales migrate into the area in summer. Many of them move into the bays and inlets to feed soon after the ice has broken up and moved out.

Methods

1. Tagging and recapture of individual polar bears

The most important task in a study of this nature is to capture and individually tag a large number of polar bears and to obtain subsequent observations on them through their recapture or the return of their tags from Inuk hunters. If there are sufficient observations, quantitative assessments can be made of population size, seasonal movements, and the discreteness of the subpopulations.

Lentfer (1968) and Larsen (1971) have described the techniques of immobilizing and tagging polar bears. Immobilized bears were tagged on the ears, weighed, measured, examined for general condition, tattooed on the inside of each upper lip with the same number as on the ear tag, and had a premolar tooth extracted for age determination. In some instances, numbers were painted on the animals with black Nyanza dye to facilitate recognition of individuals from the air. Table 2 gives the dates of helicopter surveys to mark and recapture polar bears during 1976–79. We captured polar bears of all age and sex classes non-selectively whenever possible. In 1974 and 1975, a total of 13 bears were tagged during earlier CWS denning surveys (Jonkel *et al.* 1978) and data from those bears are included in this report.

In population ecology studies of polar bears, the greatest effort to capture animals is made from late March to early May when the most representative sample of the population is present on the coastal landfast ice and adjacent floes. There are several reasons for this. The tracking conditions are best at that time and a larger number of bears can be captured than is possible when one can only locate them visually. In addition, females with cubs of the year come out of their dens in the spring so that data on productivity and maternity denning areas can be collected. In most areas, females with yearling and 2-year-old cubs, and subadults seem to prefer the fast-ice habitat and adjacent floes. The females usually come into estrus when their cubs reach about 2⅓ years of age and this attracts adult males to the coastline during April and May. Coincidentally, long days and reasonably stable weather conditions prevail over most of the Arctic during the spring, making it possible to conduct a great deal of field work in a short period of time.

Table 2
Dates of helicopter surveys to mark and recapture polar bears along southeastern Baffin Island

Year	Dates
1976	12–21 April
1977	19 April–6 May
1978	4–27 April
	5–15 August
1979	7 April–7 May

In areas where most or all of the ice melts during the summer, the bears must come ashore until freeze-up. Tracking is not possible on land or on bare ice and, because the bears are particularly fat, drugging them is more difficult. Consequently, it is difficult to collect a representative sample during the summer although useful data on seasonal movements and distribution still can be obtained.

2. Recording of tracks

During spring 1976–79, when bear tracks were visible in the snow, we recorded the numbers of tracks seen, the direction of travel, if discernible, and the number of kilometres of habitat flown over. Although these data do not provide absolute numbers of polar bears, they give a comparative measure of relative abundance between areas and years. They also yield data on the direction of seasonal movements and the locations of maternity denning areas.

3. Maternity denning

During winter, undisturbed maternity dens are necessary for the birth and survival of polar bear cubs. Disturbance of female bears in dens can cause abandonment, resulting in the death of the cubs over the short term and the possible loss of critical denning habitat over the long term. For example, Slaney (1974) documented that a female with cubs of the year abandoned their den in the Mackenzie Delta after being disturbed by an exploration team. It is not known what types, or degrees, of activities will disturb bears, affect their behaviour, reduce their chances for survival once disturbed, or influence their fidelity to particular denning areas. Until these factors have been studied, a circumspect approach must be adopted. Therefore, it was important in this study to identify denning habitat.

Four sources of maternity denning information are available: Jonkel *et al.* (1978), unpublished reports of the NWT-WS, observations of Inuk hunters, and this study.

Between 1976 and 1979, the NWT-WS conducted a number of ground surveys and CWS surveyed by helicopter 19 275 km of potential polar bear habitat during the mark and recapture studies (Ransom 1976; Redhead 1976; Bourque 1977; Letkeman 1977; Hunter 1977; Jonkel *et al.* 1978; and Table 4). The ground survey methods were the same as those given by Kiliaan *et al.* (1978) and Jonkel *et al.* (1978). Tracks recorded during these surveys and sightings of females with cubs were plotted to indicate important maternity denning areas.

Our helicopter surveys were not done specifically to gather maternity denning information because the previous ground surveys provided substantial background data. However, during spring helicopter surveys, we recorded the location of tracks and sightings of females accompanied by cubs of the year.

In the study area, most females with cubs of the year leave their dens by mid 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 in the landfast ice close to shore, and often in bays (Stirling *et al.* 1975). A family group may remain in a particular area for several days, or even weeks, although this probably varies with their hunting success and the degree of disturbance by other bears. Thus, females with cubs of the year, recorded on the sea ice prior to mid April, are likely to be close to their denning areas. Because of the mobility of family groups, sightings made after mid April are progressively less reliable as specific indicators of maternity denning sites. However, they are likely indicative of denning in the general area.

4. Calculation of productivity

It is not possible at present to determine age-specific rates of ovulation or conception in polar bears, nor to determine the mortality of cubs prior to leaving their dens. However, by using direct observations of females accompanied by cubs of different ages, estimates can be made of age-specific litter sizes and rates of production of litters. One advantage of this approach is that the results more closely approximate the number and size of litters that actually survive per age class of female. Thus, age-specific natality rates calculated from these data can be used directly in calculations of population statistics or in computer modelling. Another advantage to this approach is that whenever a family group is captured for collection of specimens for age determination, they are marked and their subsequent recapture provides data for use in population estimates and movement studies.

The technique described below can also be used to evaluate possible changes in productivity between years or groups of years (e.g. Stirling *et al.* 1976). In contrast, if few dens are located on a denning survey, one may not know whether productivity has declined or if the survey conditions were simply not as good in that year. Poor weather at a critical period may preclude obtaining reliable data, even in a year of high productivity.

The rate at which females aged "*X*" produced litters (i.e. the age-specific litter-produced rate) was calculated from the data presented in Table 5 and the following formula:

$$\frac{(\text{No. ♀♀ aged } X+1 \text{ with cubs of yr.}) + (\text{No. ♀♀ aged } X+2 \text{ with yrlgs.})}{(\text{No. ♀♀ aged } X+1) + (\text{No. ♀♀ aged } X+2)}$$

The proportion of females in a particular age class accompanied by 2-year-old cubs cannot be used in estimating the age-specific litter-produced rate because cubs may leave their mothers after about 2 years of age and most have done so by 2½.

The mean litter size of females by age class was estimated as follows:

$$\frac{\text{No. cubs of yr., yrlgs, and 2-yr.-olds with ♀♀ aged } X+1, X+2 \text{ and } X+3 \text{ resp.}}{\text{Total no. of litters in above}}$$

The mean litter size thus calculated may be biassed to the low side if a significant proportion of the females lost part but not all of a multiple-cub litter. However, from a conservation point of view, calculations that were affected by this bias would tend to work in favour of the species because the risk of overestimating productivity is minimized.

The natality rates for females of a particular age class, or groups of age classes, were calculated by multiplying the age-specific litter-produced rate by the age-specific mean litter size.

5. Specimens from Inuk hunters

The NWT-WS pays rewards for the jaws of polar bears killed by Inuk 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 the sample of teeth for age determination.

6. Location of summer retreats

We documented areas used by polar bears for summer retreats by recording the locations of bears sighted and captured during mark and recapture studies in the summer and, if possible, noting the behaviour of the bears seen. Information was also sought from members of the settlement Hunters and Trappers Associations.

7. Age determination

Ages were determined by histological sectioning and staining of teeth and counting the annuli in the cementum, using the methods of Thomas and Bandy (1973) with modifications (Stirling *et al.* 1977a).

8. Comparison of age structures

A 2 x 5 contingency table was used to compare the frequency of occurrence of bears in different age groups between age structure samples. The age categories tested were 2–4, 5–9, 10–14, 15–19, and 20+ years. Cubs of the year and yearlings were not included because they cannot legally be taken in the kill samples and they did not appear to be taken representatively in the capture samples. Annual mortality rates were calculated from the age structure of captured bears by determining the slope of an exponential curve. This application assumes a constant annual mortality rate, which is probably not true, but provided the sample is large enough, the technique gives a reasonable estimate. If there were no individuals in an age class, a value of 0.001 was entered.

9. Estimation of population size

We estimated the population size using a technique of multiple mark and recapture modified from a Peterson-type estimate (DeMaster *et al.* 1980). With polar bears, this technique is difficult to use because it is expensive and time consuming to obtain large sample sizes. However, each individual capture or recapture provides additional information on movements, growth, survival, and age so that in terms of data collected per dollar expended, this mark and recapture approach was still the most suitable.

Survival of polar bears in other studies has ranged from about 86 to 90% (Stirling *et al.* 1976, 1978). Consequently, an average value of 0.87 with an arbitrarily assigned variance of 0.0037 was used to cover the range of survival from 0.75 to 0.99 when making the initial calculations of population size. If no marked animals were recaptured in any sample taken after the first time interval (i), a value of 0.001 was entered.

Results and discussion

1. Distribution and movements

During 1974–1979, we captured 231 polar bears in the study area (Table 3, Figs. 2 and 3). Subsequent to tagging, we recaptured 36 individual bears a total of 41 times and resighted 21 bears within a few days or weeks of their capture. Five bears originally captured in other areas were recaptured or shot in the study area. Inuk hunters reported killing 13 tagged bears (including 3 of the 5 bears from outside the study area).

1.1. Late winter and spring distribution

The sea ice conditions along the coast of southeastern Baffin Island are similar from about mid December through to the beginning of break-up in mid to late May. The numbers of polar bears and tracks seen per 100 km of habitat surveyed each year were calculated to evaluate the relative importance of different areas (Table 3, Fig. 4). Because weather and snow conditions can influence the sightings of bears or tracks, comparisons are relative and not absolute. Even so, the consistency between years is noteworthy. In general, densities of bears were higher adjacent to the ends of the three major peninsulas of southeastern Baffin Island. The greatest density of polar bears observed was between Angijak Island and Cape Dyer, on the Cumberland Peninsula. Densities decrease in the larger fiords, such as Frobisher Bay and Cumberland Sound, but the reasons for this are not clear. Although seals are reasonably abundant in large bays such as Cumberland Sound (Smith 1973), the ice tends to be smooth and this is not the kind of habitat in which polar bears prefer to hunt. That fact may, in part, account for the presence of fewer bears there. In addi-

Table 3
Age and sex class of polar bears tagged in the study area, 1974–79 (Single bears 2 1/2 to 4 years inclusive were classed as subadults; bears 5 years of age and older were classed as adults)

Age and sex class	No.
Adult male	47
Adult female (alone)	21
Subadult male	16
Subadult female	24
Adult females with cubs of any age	41
Cubs of the year (with female)	
male	33
female	29
Yearlings (with female)	
male	5
female	1
Two-year-olds (with female)	
male	8
female	4
Three-year-olds (with female)	
male	2
Total	231

Figure 2
Locations at which polar bears were tagged in the study area between late March and mid May, 1974–79

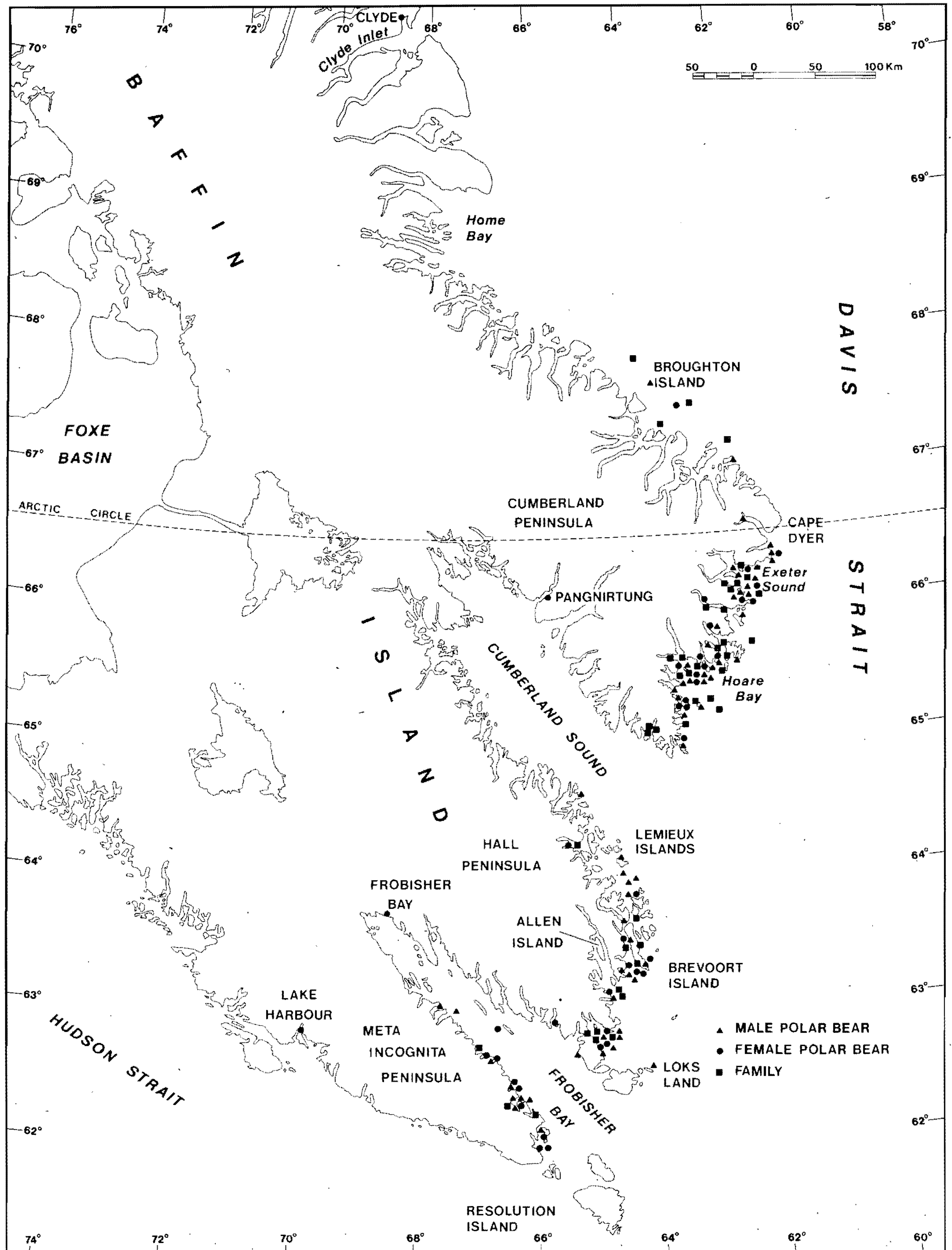
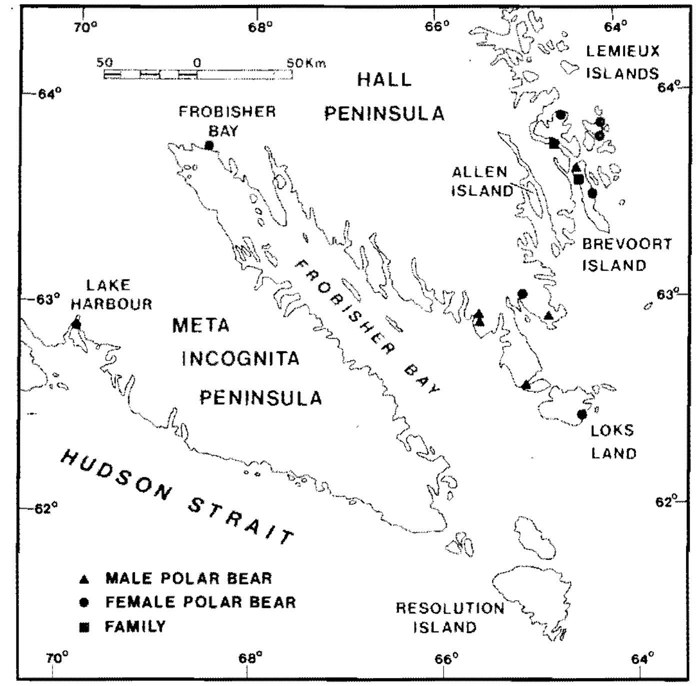


Figure 3
Locations at which polar bears were tagged in the study area during August 1978



tion, the constant pressure of hunting by Inuit in the large bays may also have discouraged polar bears from entering them, and may have reduced the number of seals as well. Smith (1973) reported that the resident ringed seal population in Cumberland Sound was being exploited at approximately double (15.8%) the estimated rate for a safe sustained yield (7.2%). However, we also recorded a lower density of polar bears in Sunneshine Fiord by the DEW line station at Cape Dyer in the spring relative to areas immediately to the south. Cape Dyer has human activity throughout the year, albeit there is little hunting. Although bears are few in the fiord during the spring, they are a constant problem to the station during the summer and fall, which suggests that human activity alone may not be sufficient to account for the low densities of bears in the fiords during spring.

In general, the densities of bears and tracks sighted/100 km throughout the study area (Table 4) were higher than recorded in the Western Canadian Arctic (Stirling *et al.* 1975). From late winter through late spring, the preferred habitat of polar bears is landfast ice and adjacent rough ice that sometimes moves, opens, and refreezes in the areas parallel to coastlines, lead systems, floe edges, and across the mouths of bays (Stirling *et al.* 1975; 1978). In most places in the Western Arctic, the band of landfast ice is 20–50 km wide, and the whole of Amundsen Gulf is frozen in most years. Similarly, in the Central and High Arctic most of the inter-island channels freeze completely during winter. By comparison, in the Baffin Island study area, the landfast ice, which comprises the preferred habitat, is usually only a few kilometres wide, with open water or pack ice found close to a line drawn from headland to headland. Consequently, the high densities of tracks and bears observed is a reflection of the smaller amounts of habitat available rather than of a larger population. From a research point of view, the advantage of a higher density is that larger samples of bears may be obtained per unit of survey effort.

In 1978, we tried to survey polar bears offshore by helicopter. We flew about 949 km at distances up to 80 km offshore to obtain comparative data on polar bears in that habitat (Table 4). We did not make more extensive surveys because of a lack of navigational aids and logistic back-up. Although we sighted no polar bears, we recorded a relatively high density of tracks, indicating that a substantial proportion of the polar bear population frequents the pack ice adjacent to the landfast ice. We saw many bear tracks going in both directions; it was obvious that bears found on the landfast ice were also utilizing the pack ice.

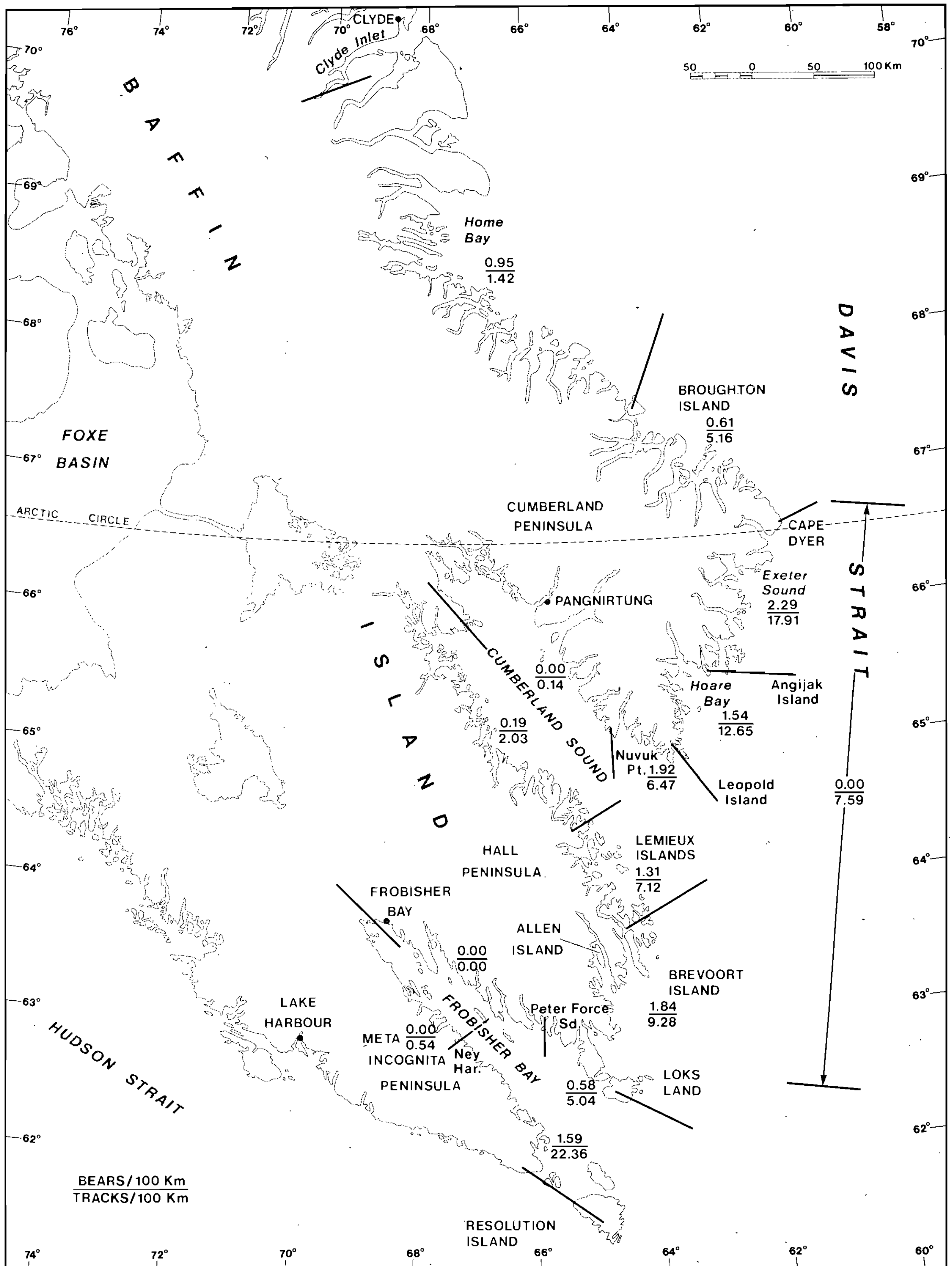
The extent to which different age and sex classes of polar bears utilize the offshore pack ice in Davis Strait is not known. MacLaren Marex (1979a and b) reported bears and their tracks more than 200 km offshore in Davis Strait and Sergeant (1974) has also recorded them in March at a hooded seal whelping patch on the pack ice about 200 to 250 km offshore from Brevoort Island, Hall Peninsula. Although Sergeant (1977) has suggested that the bears may travel offshore specifically to prey on this large concentration of seals, the data are insufficient for evaluating that hypothesis.

Table 4
Number of polar bears and tracks seen per 100 km of sea-ice habitat surveyed along southeastern Baffin Island between late March and mid May, 1976–79

	No. km habitat surveyed*					No. polar bears seen /100 km habitat					No. tracks seen /100 km habitat				
	1976	1977	1978	1979	Total	1976	1977	1978	1979	Average	1976	1977	1978	1979	Average
Cumberland Peninsula															
N. of Broughton Island	240	119	274	—	633	0.00	2.52	1.09	—	0.95	0.42	0.00	2.92	—	1.42
Broughton Island – Cape Dyer	185	274	273	256	988	2.16	0.73	0.00	0.00	0.61	1.08	6.20	11.72	0.00	5.16
Cape Dyer – Angijak Island	—	550	697	1630/1266	2877/2513	—	1.64	2.30	2.52	2.29	—	25.27	25.82	10.35	17.91
Angijak Island – Leopold Island	519	575	1111	777	2981	1.54	4.18	1.44	1.80	1.54	8.86	20.21	9.90	13.51	12.65
Leopold Island – Nuvuk Point	152	—	310	110	572	1.97	—	2.58	0.00	1.92	8.55	—	5.16	7.27	6.47
Nuvuk Point – Pangnirtung	464	—	240	145/0	849/704	0.00	—	0.00	0.00	0.00	0.22	—	0.00	0.00	0.14
Hall Peninsula															
Pangnirtung – Popham Bay	115	105	414	398	1032	0.00	0.00	0.24	0.25	0.19	0.00	0.00	2.19	3.02	2.03
Lemieux Islands	—	—	375	1377/1015	1752/1390	—	—	0.80	1.45	1.31	—	—	7.47	7.00	7.12
Brevoort Island – Loks Land	138	889	1199	2236/1458	4462/3684	4.35	2.14	1.00	2.01	1.84	10.14	10.57	9.92	7.89	9.28
Loks Land – Peter Force Sound	32	72	—	171/154	275/2581	0.00	1.39	—	0.00	0.58	3.13	2.78	—	6.49	5.04
Peter Force Sound – Frobisher	16	—	80	164/80	260/176	0.00	—	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00
Meta Incognita Peninsula															
Frobisher – Ney Harbour	—	—	—	838/558	838/558	—	—	—	0.00	0.00	—	—	—	0.54	0.54
Ney Harbour – tip of peninsula	—	—	685	1071/648	1756/1333	—	—	2.19	1.21	1.59	—	—	32.26	11.88	22.36
Offshore surveys between Cape Dyer and Loks Land	—	—	949	—	949	—	—	0.00	—	0.00	—	—	7.59	—	7.59

* Where two values are separated by a diagonal slash, the first is the number of km flown during which both bears and tracks could have been sighted and the second is the number of km flown on which ground visibility was only good enough to see bears.

Figure 4
Number of polar bears and tracks sighted per 100 km of potential habitat surveyed in different locations within the study area



1.2. Utilization of terrestrial habitat during spring

During late winter and early spring polar bears along the southeastern coast of Baffin Island travel onto the land to a much greater extent than has been observed in the Western and High Arctic. Even though such behaviour is common throughout the Arctic during the summer after the ice melts, we have not observed elsewhere regular travel on land during the spring. We believe that more bears travel on land in southeastern Baffin Island because of physical and behavioural factors, both related to the limited amount of landfast ice.

Firstly, because of the strong southerly sea current in Davis Strait and the prevailing offshore winds, the edge of the fast ice extends only about as far seaward as a line drawn between headlands. In addition, the large tidal range causes strong local currents between islands which create areas of open water (polynias) within the landfast ice. We have recorded tracks which indicate that polar bears of all age and sex classes (but most often family groups and subadults) have learned to use passes and ridges to travel on land between bays or other fast ice areas. Thus, bears can avoid swimming long distances around points or across channels where currents are strong; where drifting ice pans are unstable; or where ice is being broken and rafted by high winds.

Secondly, in areas of high polar bear density, individuals probably encounter each other more often. Stirling (1974 and unpublished) documented that family groups and subadults usually are subordinate to the adult males and will avoid them if possible. This may be because of fear of predation. Because of the potential dangers in crossing open water areas, going overland may be the best escape, particularly for females with young of any age. Because adult males are much larger, they may avoid overland journeys because they overheat more when climbing hills. Consequently, males may travel more slowly on uneven ground or even avoid such trips unless they are really necessary. Overland journeys therefore may present an effective escape mechanism for family groups and subadults.

Often, when an encounter between unrelated bears occurs in southeastern Baffin Island, there is limited ice habitat available in which avoidance behaviour can take place. Consequently, the most effective action would be to leave the area completely. As such, this fairly elaborate form of avoidance behaviour could be quite an effective learned anti-predator behaviour. If such behaviour occurred with some degree of regularity, and it is our belief that it does, then individual polar bears would soon learn the geography of their home range very well. Certainly, the subjective impression one gets when tracking bears on longer journeys is that their movements are directional and that they utilize the shortest routes between areas.

If the above hypothesis is true, one would predict that the proportion of family groups and subadults making extensive climbs and journeys would be higher than that of adult males. Between 1976 and 1979, we followed eight sets of polar bear tracks to the tops of large islands over 300 m in altitude, or inland more than 15 km. This sample does not include tracks of females with cubs of the year that may have been leaving their maternity denning areas. Six of these sets of tracks were made by females accompanied either by cubs of the year or yearlings. One was a lone non-estrous 4-year-old female and one was a 4-year-old non-estrous female with a 7-year-old adult male about a kilometre behind her, following her tracks. In four other instances, when bears on the sea ice were approached by helicopter, they tried to escape by moving onto the land. It was difficult to turn them back onto the sea ice, even with the helicopter, and one bear escaped because he climbed high enough on a hillside to pass into a low-lying cloud layer through which it was unsafe to fly. Of the remaining three bears, one was a non-estrous 4-year-old female, one was a 17-year-old adult female with three cubs of the year, and one was a lone 19-year-old adult male. Although the sample size is small, the results are consistent with the hypothesis that family groups and subadults travel overland more often than other polar bears.

1.3. Fidelity to winter and spring feeding areas

Figure 5 shows the recorded movements of polar bears captured between late March and mid May and recaptured or shot between 1 January and mid May one or more years later. Individual polar bears displayed a high degree of seasonal fidelity to the areas in which they were first tagged. In only eight (23%) of the 35 independent movements illustrated in Figure 5 were bears recorded moving between the two main population centres on the Cumberland and Hall peninsulas. Six of the eight bears moved south. The mean distances moved between the original capture and subsequent recaptures (or kills) in the same season one or more years later were calculated for adults and subadults. Although in each sex the mean distances moved by subadults were greater than for adults, the differences were not significant, possibly because of the small sample size, so the adults and subadults were pooled by sex. The mean distances between capture and recapture (or kill) sites for males and females respectively were 105.5 ± 58.7 km ($n = 13$) and 108.68 ± 43.99 ($n = 19$), differences that were not significant. (The values following the means indicate the 95% confidence interval i.e. $\pm 1.96\sqrt{SD^2/n}$.) Only three recorded movements exceeded 200 km. The mean distances were not significantly different from those calculated for spring movements of male and female polar bears in the Central and High Arctic, which were 98.3 ± 22.8 km ($n = 68$) and 136.7 ± 62.1 km ($n = 40$) respectively (Stirling *et al.* 1978). From these data, we suggest the home range of polar bears during the winter and spring feeding period has a radius of 100 to 150 km.

1.4. Summer distribution

We tagged 17 polar bears during a brief period in August 1978 (Fig. 3). This was the only survey done in summer. We did not sight any polar bears in the upper reaches of Frobisher Bay. During the course of extensive boat travel in Cumberland Sound and Frobisher Bay during the open water period, Inuk hunters from Frobisher Bay and Pangnirtung report that most bears remain on the end of the peninsulas and associated islands. Each summer many bears visit the DEW line site at Cape Dyer, on the northeast end of the Cumberland Peninsula. Pilots and hunters or researchers with camps on the ends of the peninsulas report seeing bears regularly during that period. Although the evidence is limited, it appears that there are more bears around the ends of the peninsulas than elsewhere.

1.5. Seasonal movements and delineation of subpopulations

Figure 6 shows the movements of polar bears captured between late March and mid May and recaptured or shot between August and November of the same or subsequent years, or captured in August and recaptured or shot between December and mid May of the same or subsequent years. Between 1975 and 1978, 15 polar bears were captured and tagged to the north of Cape Dyer and 29 to the west of the tip of the Meta Incognita Peninsula as far as Cape Dorset (Stirling *et al.* 1979).

Between 1977 and 1979, 60 polar bears were killed by Inuk hunters at Broughton Island, 39 at Lake Harbour, and 30 at Cape Dorset. Only one of these bears was tagged in the study area between Cape Dyer and the tip of the Meta Incognita Peninsula (Fig. 4). Undoubtedly some movement along

Figure 5
The recorded movements of polar bears captured between late March and mid May of one year and recaptured or shot between 1 January and mid May one or more years later

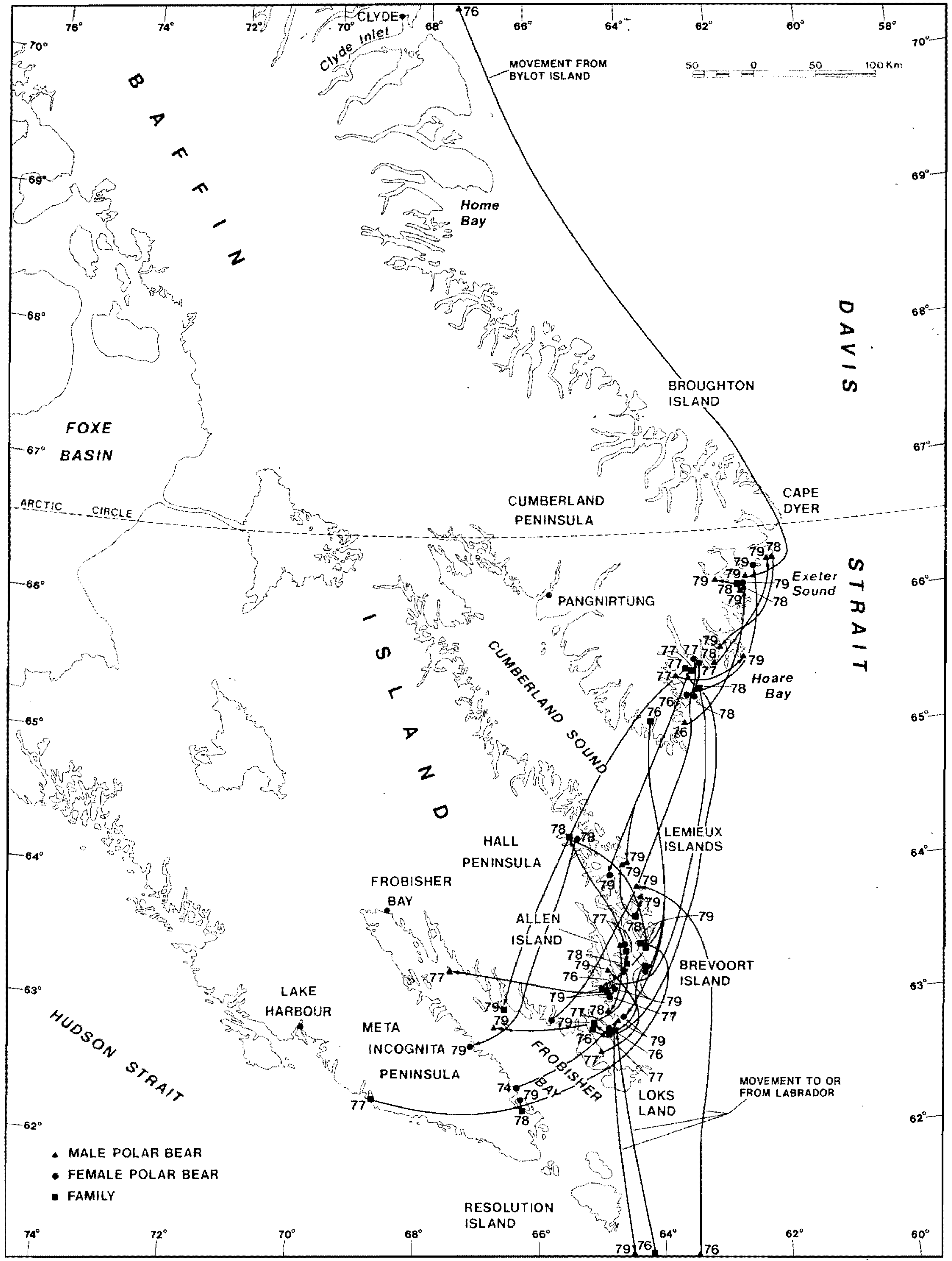


Figure 6
The recorded movements of polar bears captured between late March and mid May of one year and recaptured or shot between August and November of the same or subsequent years, or captured in August of one year and recaptured or shot between December and mid May of the same or subsequent years

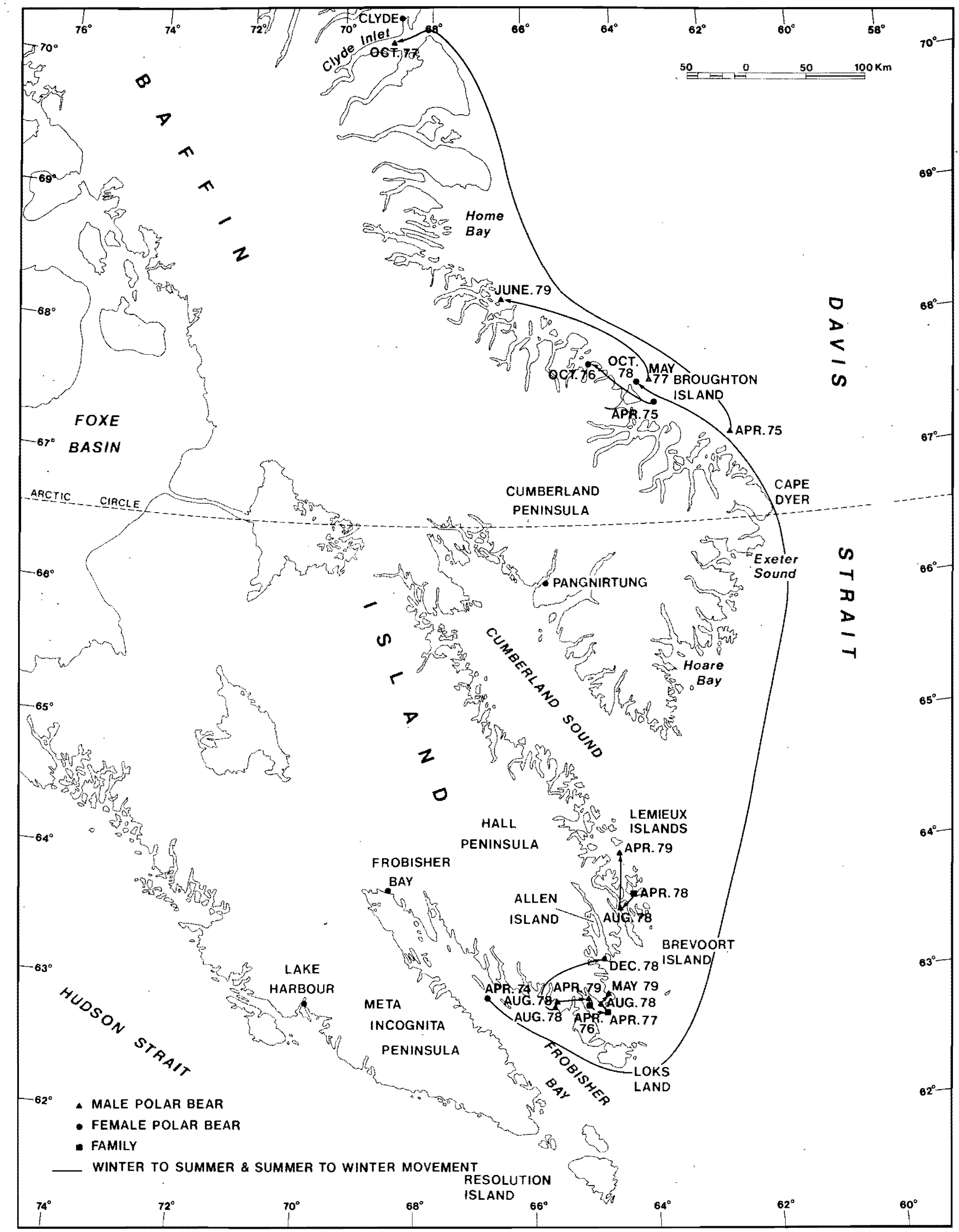
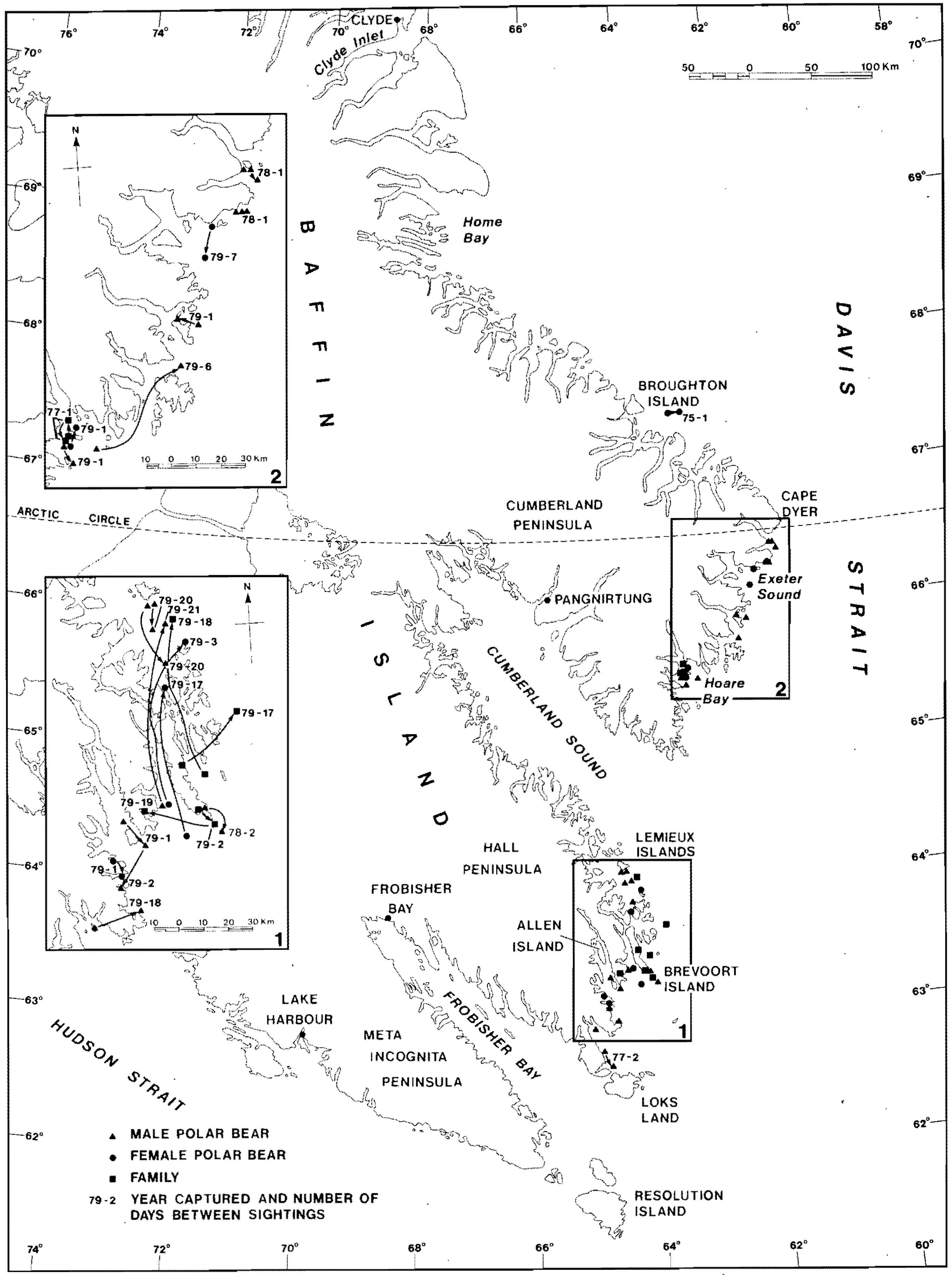


Figure 7
Movements made by polar bears which were resighted in the same season in which they were originally captured. Numbers indicate the year and the number of days between the original capture and subsequent resightings



the coast occurs: a male cub of the year tagged near Broughton Island was killed as a 2-year-old 421 km to the north near Clyde. Also, a yearling male tagged on the northern end of Baffin Island was killed as a 4-year-old 1040 km to the south in Exeter Sound, on the Cumberland Peninsula. However, we suggest that such long journeys are not made by most of the population.

The available data do not indicate extensive seasonal movements even within the study area. Although Inuk hunters in southeastern Baffin Island are unaware of any seasonal movements, there are limited data which suggest that some bears move south during winter and north during the summer. For example, four of the five tagged bears shot during the winter by Inuk hunters on the Hall Peninsula had been tagged previously on the Cumberland Peninsula. The extent to which polar bears travel offshore into Davis Strait remains unknown but this could result in their being carried to the south on the ice floes. Several of the bears resighted during the spring in which they were first captured indicated a definite northerly movement (Fig. 7).

Seasonal movements have also been recorded between southeastern Baffin Island and northern Labrador (Stirling and Kiliaan 1980). Because the sea currents flow south along the coast of Baffin Island towards northern Labrador, some bears are passively transported out of the study area each year. Stirling and Kiliaan (1980) reported an adult female with two 2-year-old cubs moving 525 km from Labrador to Baffin Island in a period of about 3 weeks in 1975. Four years later, one of the cubs, by then an adult male, was recaptured back on the Labrador coast near where he had originally been tagged, raising the possibility that some bears make the journey regularly. Another adult male, captured on the Labrador coast in 1976 was recaptured in the Lemieux Islands on the south side of Cumberland Sound in 1979, a distance of about 540 km. The regularity with which such movements occur, or the numbers of polar bears involved are unknown. However, it appears that polar bears which are transported to the Labrador Sea during winter begin to move north along the Labrador coast by spring and cross Hudson Strait in order to return to southeastern Baffin Island (Stirling and Kiliaan 1980). Through the use of satellite telemetry at some time in the future, we may be able to obtain more detailed information on the pattern, extent, and importance of seasonal movements of polar bears along southern Baffin Island and the Labrador coast.

2. Maternity denning areas

Jonkel *et al.* (1978) identified the seaward tips of the Meta Incognita, Hall, and Cumberland peninsulas in ascending order of importance as the main denning areas. Our continuing observations support their conclusion (Figs. 8 and 9).

Jonkel *et al.* (1978) estimated that the combined productivity of these areas was 100–120 cubs in 1974 and 140–160 for 1975. Although those estimates provide approximations, the problems involved in determining such values are enormous. For example, their 1975 helicopter survey was flown from 5 to 10 days after the most recent snowfall and to some degree overlapped areas which had been surveyed earlier by oversnow machine. When surveys are flown under such conditions, it is almost impossible to avoid duplication in counting families of polar bears and their tracks. Even after trying to eliminate duplicate sightings, Jonkel *et al.* (1978) reported sightings or tracks of 62 females with cubs of the year after surveying 11 805 km under good tracking conditions in 1975.

In 1979, tracking conditions were also excellent because fresh snow fell every few days throughout the field season. Even though we made no effort to avoid duplicate sightings, we recorded sightings or tracks of only 30 females with cubs of the year in 9173 km of surveying. In 1978, tracking conditions were poorer because there was little fresh snow and old tracks could persist for several days or even weeks, depending upon local winds. Although we made no effort to avoid duplication and included records of tracks which were obviously old, we recorded sightings or tracks of 51 family groups in 6607 km of surveying. While recognizing there can be great variation between years in productivity, we suspect that the estimate of 140–160 cubs produced in 1975 may be too high.

3. Litter size and productivity

The data on the age and litter size of cubs accompanying female polar bears of each age class in the study area were tabulated (Table 5) to facilitate subsequent calculations of reproductive values (Tables 6 and 7).

The mean litter size of cubs of the year was similar to, but slightly higher than, those reported from other areas (Stirling *et al.* 1978). Our data also showed a larger litter size than was reported by Jonkel *et al.* (1978): 1.82 ± 0.079 vs. 1.6. Even larger mean litter sizes of 2.27 and 2.00 cubs respectively have been reported from polar bears in Ontario and Manitoba (Jonkel *et al.* 1976; Stirling *et al.* 1977b).

The age-specific litter-produced rates, litter sizes, and natality rates of female polar bears in the study area are presented in Table 7. From the high age-specific natality rate (0.501) it is apparent that the majority of females conceive for the first time at 4 years of age. This is supported by the low natality rate of 5-year-old females (0.167) which suggests that they are not mating because they are accompanied by cubs of the year. Similarly, the low natality rate of 3-year-old females (0.031) confirms that very few conceive at that age.

The age of first conception in the study area (4 years) is the same as in the High and Central Arctic regions (Stirling *et al.* 1978) but differs from the Western Canadian Arctic and Alaska where female polar bears do not conceive for the first time until they are 5 years of age (Stirling *et al.* 1976; Lentfer 1976). The reason for this difference is not known.

The natality rate of adult females (0.541) was higher than that reported in other areas (Table 8). It is possible that this higher value could have resulted from a sampling bias. Both yearling and 2-year-old cubs were markedly under-sampled in proportion to cubs of the year. Consequently, the contribution made by females accompanied by yearling cubs in the calculation of natality rates was under-represented. The effect of this may be illustrated by comparing natality rates calculated only from females aged 5–26 years with cubs of the year (0.903) with a value which uses data from females with cubs of the year and yearlings (0.541). In comparison, natality rates calculated only from data from females accompanied by cubs of the year in the Western, Central, and High Arctic regions are quite similar to values calculated for females accompanied by cubs of the year and yearlings (unpub.). The higher natality rate of adult females in the study area, compared with other regions of the Arctic (Table 8), is also influenced by the higher mean litter size of cubs of the year but this is not sufficient to account for the differences discussed above.

Data from other areas indicate that female polar bears keep their cubs for 2½ years and, consequently, mate only every third year. If, for some reason, adult females in the study area bred in alternate years, it might explain the higher natality rate calculated from females with cubs of the year. However, the mean breeding interval calculated from six adult females tagged in the study area with known minimum intervals between litters (3, 3, 3, 4, 4, and 4 yrs) was 3.5 years. The average

Figure 8
Observations of female polar bears accompanied by cubs of the year and sightings of their tracks, made along the Cumberland Peninsula, between late March and early May, 1976–79

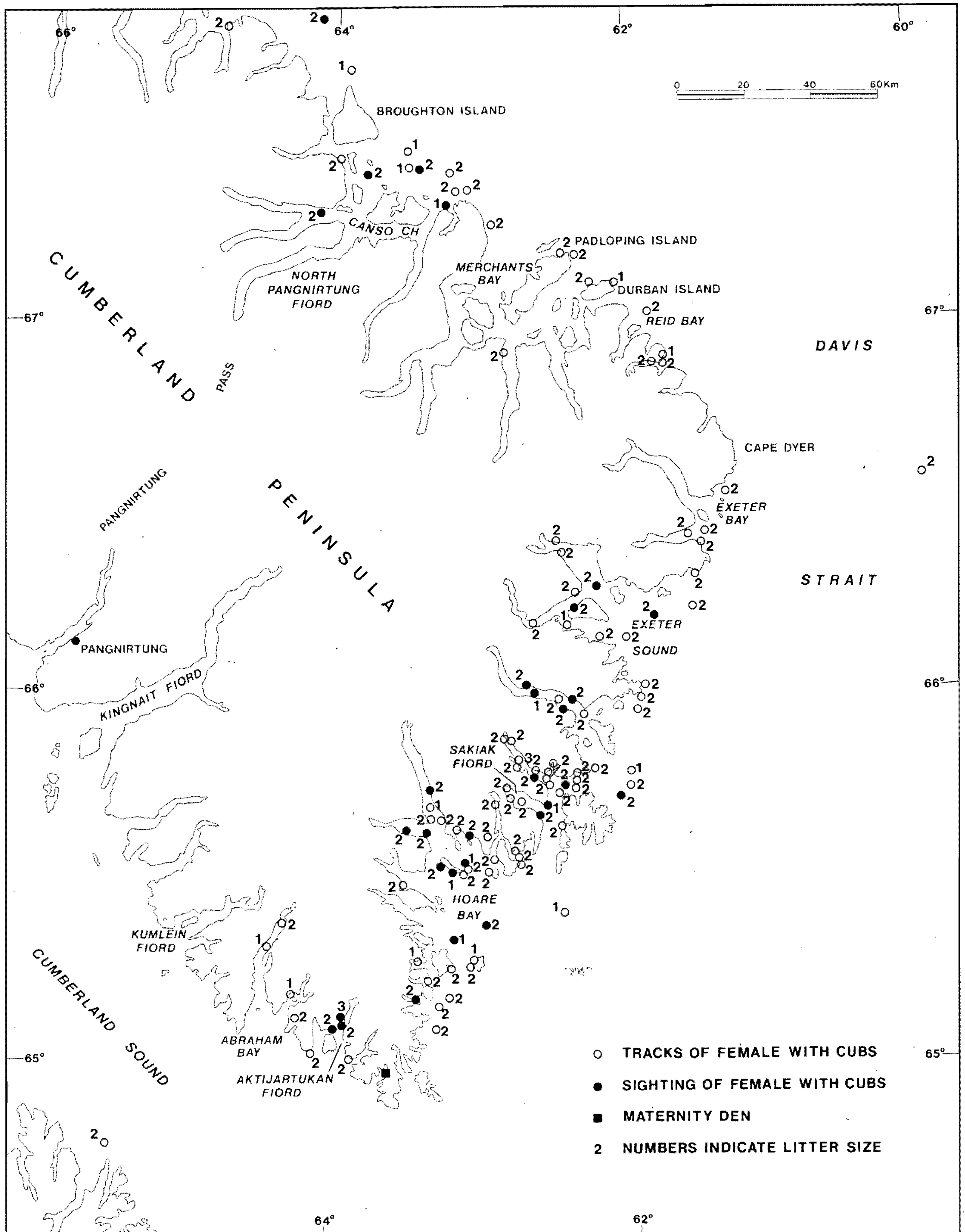


Figure 9
Observations of female polar bears accompanied by cubs of the year and sightings of their tracks, made along the Hall and Meta Incognita peninsulas between late March and early May, 1976–79

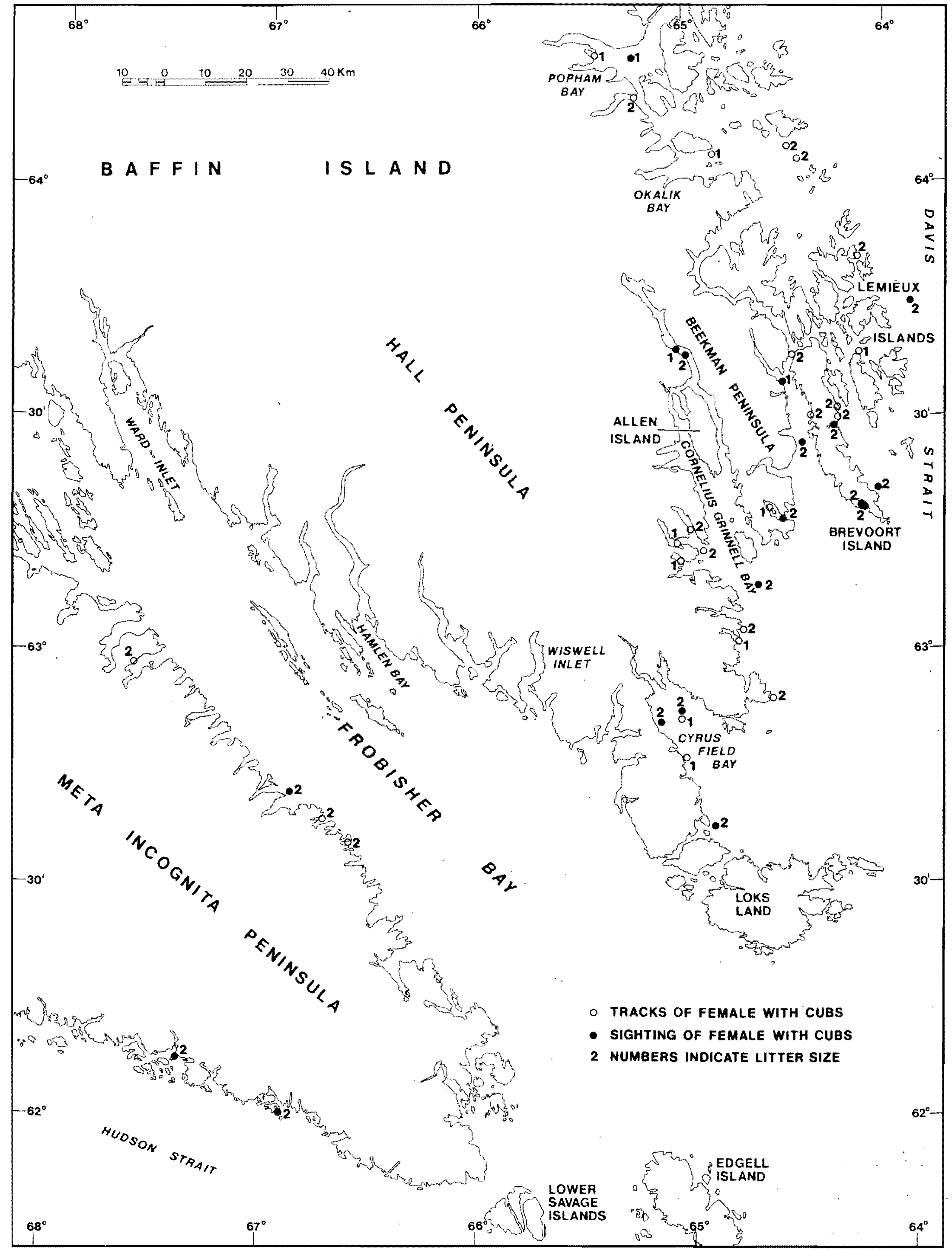


Table 5
Age and litter size of cubs accompanying female polar bears of each age class, captured or recaptured in the study area, 1974–79

Females			Age and litter size of cubs accompanying female								
			Cubs of yr.			Yrlgs.		2-year-old		3-year-old	
Age	Total no. of each age	No. accompanied by cubs of any age	1	2	3	1	2	1	2	1	2
3	11	—	—	—	—	—	—	—	—	—	—
4	13	—	—	—	—	—	—	—	—	—	—
5	19	9	2	6	—	1	—	—	—	—	—
6	9	4	3	—	—	—	—	1	—	—	—
7	9	8	1	5	—	—	—	1	1	—	—
8	12	9	—	5	—	—	2	—	1	—	1
9	7	5	1	2	—	—	1	1	—	—	—
10	4	4	—	3	—	1	—	—	—	—	—
11	2	—	—	—	—	—	—	—	—	—	—
12	3	2	—	1	—	—	1	—	—	—	—
13	4	3	—	2	—	—	—	—	1	—	—
14	—	—	—	—	—	—	—	—	—	—	—
15	1	1	—	1	—	—	—	—	—	—	—
16	1	—	—	—	—	—	—	—	—	—	—
17	1	1	—	—	1	—	—	—	—	—	—
18	1	—	—	—	—	—	—	—	—	—	—
19	1	1	—	—	—	—	—	1	—	—	—
24	1	1	—	1	—	—	—	—	—	—	—
25	1	1	—	—	—	1	—	—	—	—	—
26	1	—	—	—	—	—	—	—	—	—	—

Table 6
Mean litter sizes of cubs of different ages captured in the study area, 1974–79

Category	Mean litter size	95% confidence limits	Sample size
Cubs of the yr.	1.82	±.155	34
Yearlings	1.57	±.396	7
2-year-olds	1.43	±.396	7

Table 7
Age-specific litter-produced rates, litter sizes, and natality rates of female polar bears in the study area, as calculated from Table 5. Sample sizes of females and litters respectively are in parentheses

Age class of females, yrs.	Age-specific litter-produced rate (no. of females)	Age-specific mean litter size (no. of litters)	Age-specific natality rates
3	0.031 (32)	1.00 (1)	0.031
4	0.286 (28)	1.75 (8)	0.501
5	0.167 (18)	1.00 (3)	0.167
5–9	0.320 (75)	1.75 (24)	0.560
10–14	0.263 (19)	2.00 (5)	0.526
15–19	0.143 (7)	3.00 (1)	0.429
20–26	0.333 (6)	1.50 (2)	0.500
5–26	0.299 (107)	1.81 (32)	0.541

Table 8
Age-specific natality rates of adult female polar bears from different areas in the Canadian Arctic (from Stirling *et al.* 1978; Tables 8 and 9; and this study)

Sample	Ages of ♀*	Natality rate
Western Arctic (1971–73)	6–25	0.500
High Arctic (1970–77)	5–29	0.421
Central Arctic (1972–77)	5–24	0.388
Southeastern Baffin Island (1974–79)	5–26	0.541

* In the Western Arctic, females do not breed for the first time until they are 5 years of age compared to 4 years in other areas of the Canadian Arctic. The upper limits of the age span represents the oldest female in each sample.

Table 9
Age structure of polar bears captured or recaptured between 1974 and 1979 or killed by Inuk hunters in the study area, 1968–79

	Bears killed		Bears captured	
Age	♂	♀	♂	♀
0	2	3	33	29
1	4	7	8	3
2	16	8	11	6
3	10	13	11	11
4	17	14	11	13
5	11	7	8	19
6	4	6	6	9
7	5	5	6	9
8	1	4	6	12
9	2	1	6	7
10	7	1	6	4
11	1	—	3	2
12	2	2	1	3
13	2	2	1	4
14	2	—	—	—
15	1	—	1	1
16	2	—	2	1
17	2	—	1	1
18	—	—	—	1
19	—	1	2	1
20	1	—	—	—
21	—	—	—	—
22	1	—	2	—
23	—	—	1	—
24	—	—	—	1
25	—	—	—	1
26	—	—	—	1
Total (aged)	93	74	126	139
Unaged	120	65	1	—

Table 10
Sex-specific mortality rates of capture samples, calculated by fitting exponential curves to age structures in Table 9

Sex	Age range over which curves fitted	Annual mortality rate
Males	0–19	29.7
Males	2–19	31.7
Females	0–19	20.7
Females	2–19	23.2
Females	5–19	27.3
Males and females	0–19	22.1
Males and females	2–19	23.6

breeding interval calculated by Lentfer (1976) from seven tagged adult female polar bears in Alaska was 4.13 years. If females weaned their cubs at 1½ vs. 2½ years of age, one would predict that fewer females accompanied by 2-year-old cubs would be captured than with yearling cubs. Although sample sizes were again small, there were six litters of yearlings and seven of 2-year-olds captured with their mothers, which is obviously not significantly different. Thus, it appears from the available data, that female polar bears along the coast of southeastern Baffin Island probably breed every third year rather than in alternate years.

4. Age structure and mortality rates

Table 9 shows the number of polar bears of each age and sex class captured or recaptured during our 1974–79 surveys, or killed by Inuk hunters during 1968–79 in the study area. Figure 10 gives the known locations where polar bears were killed by Inuk hunters. A total of 219 bears killed by Inuk hunters could not be included in the calculations because either age or sex or both were not known. The frequency of occurrence of males and females in the five different age categories (Methods, section 8) in the capture sample was not significantly different ($\chi^2 = 4.86$; df = 4; $p>.05$). However, from Table 9, almost twice as many females as males were caught in the 5- to 9-year-old age group (56:32), a difference which was significant ($\chi^2 = 4.40$; df = 1; $p<.05$). That may reflect a greater susceptibility of adult females to capture during the spring when accompanied by cubs of the year along the coastal landfast ice, or they may be more highly represented simply because there are more of them relative to older age classes. It is unlikely that the lower numbers of 5- to 9-year-old males could reflect a higher mortality rate since the proportion of animals of each sex over 10 years of age is so similar.

The incompleteness of the Inuk kill data and the unknown extent to which the sample could be biassed makes interpretation of the data somewhat tenuous. However, some points may still be considered. The frequency of occurrence of males and females in the five different age categories in the kill sample was not significantly different ($\chi^2 = 6.40$; df = 4; $p>.05$). This may be a reflection of the small size of the samples in as much as only 9.4% of the females 2 years of age and older were 10 or more years of age (6/64), compared with 24.1% of the males (21/87), a difference that was statistically significant ($\chi^2 = 5.47$; df = 1; $p<.05$). The age structure of the killed males was not significantly different from that of the captured males ($\chi^2 = 3.90$; df = 4; $p>.05$) but those of the killed and captured females were ($\chi^2 = 13.44$; df = 4; $p<.05$). The reason for the significant difference was that females aged 10 years or older were poorly represented in the kill sample compared to the capture sample.

From Table 9 it appears that, in total, males were taken more frequently than females in the Inuk harvest. However, in the female portion of the harvest, the younger adult females with the greatest reproductive potential predominated.

Sex-specific mortality rates were calculated over two ranges of age classes for males and three for females (Table 10). Male and female mortality rates over the same range of ages were not significantly different so mortality rates were calculated for pooled samples as well (Table 10). The mortality rates calculated from all the samples exceeded 20%. Interpretation of these results is confounded by the extent to which yearlings and 2-year-olds were undersampled. However, these mortality rates are still higher than the 12 to 14% values calculated for females in the Western, Central and High Arctic areas (Stirling *et al.* 1976 and 1978). To attempt to calculate values which were not biassed by the under-sampling of younger age classes, we calculated the mortality rates of females from 5 to 19 years of age in the study area (Table 10), 5–20 years from the High Arctic (Stirling *et al.* 1978, Table 11) and 5–24 years from the Central Arctic (Stirling *et al.* 1978, Table 10). In all cases this estimation gave a higher mortality rate than was calculated from 2 years of age and older (27.3 vs. 23.2%; 17.1 vs. 13.8%; and 14.0 vs. 12.1% respectively), but the difference was greatest in the study area. Although we suspect that the mortality rates calculated here may be too high, it still appears that they are higher than from other areas. This should be a matter of future concern in terms of both management practices and environmental assessments.

5. Estimation of population size

Table 11 presents the mark and recapture data for the study area and the estimated polar bear population in 1978 and 1979, using the 0.87 survivorship rate (Methods, section 9). In order to facilitate a more detailed analysis of the estimates, the same calculations were also done for the Cumberland Peninsula and the Hall Peninsula including Frobisher Bay (Tables 12 and 13) as if they were independant areas. Since the results in Results, section 4 indicated that survivorship of polar bears in

Table 11
Summary of mark and recapture data from the whole study area and estimates of population size (N) at time i*

Parameter*	1 1974–75	2 1976	3 1977	4 1978	5 1979
n_i	13	17	49	86	104
m_i	—	0.001	6	7	25
R_i	13	17	49	86	100
$\hat{P}_i$	—	0.0001	0.12	0.08	.24
$\hat{M}_i$	—	—	24.63	58.84	119.92
se$\hat{M}_i$	—	—	3.18	6.68	13.40
$\hat{N}_i$	—	—	201.88	726.38	499.66
se$\hat{N}_i$	—	—	82.40	277.88	103.89
p(cap)	—	—	0.24	0.12	0.21

* Terms defined by DeMaster *et al.* (1980) as follows:
n_i = total no. of animals captured in ith sample; m_i = total no. previously marked animals captured in the ith sample; R_i = total no. marked animals (including recaptures released in the ith sample); $\hat{p}_i$ = portion of animals marked in population = m_i/n_i; $\hat{M}_i$ = no. tagged animals available for sampling just prior to the ith census; and, p(cap) = estimated probability animals alive at time i will be recaptured = m_i/M_i.

Table 12
Summary of mark and recapture data from the Cumberland Peninsula and estimates of population size (N) at time i

Parameter	1 1974–75	2 1976	3 1977	4 1978	5 1979
n_i	7	9	28	43	50
m_i	—	0.001	0.001	2	7
R_i	7	9	28	43	50
$\hat{P}_i$	—	0.0001	0.0001	0.05	0.14
$\hat{M}_i$	—	—	—	35.78	66.80
se$\hat{M}_i$	—	—	—	4.23	8.02
$\hat{N}_i$	—	—	—	761.28	477.13
se$\hat{N}_i$	—	—	—	536.56	178.39
p(cap)	—	—	—	0.06	0.10

Table 13
Summary of mark and recapture data from the Hall Peninsula and estimates of population size (N) at time i

Parameter	1 1974–75	2 1976	3 1977	4 1978	5 1979
n_i	6	8	21	43	54
m_i	—	0.001	5	5	13
R_i	6	8	21	43	50
$\hat{P}_i$	—	0.0001	0.24	0.12	0.24
$\hat{M}_i$	—	—	11.50	23.92	53.87
se$\hat{M}_i$	—	—	1.81	3.27	6.35
$\hat{N}_i$	—	—	48.32	206.25	233.55
se$\hat{N}_1$	—	—	20.77	92.28	60.52
p(cap)	—	—	0.43	0.21	0.24

Figure 10
Known locations of polar bear kills by Inuk hunters, 1969–79

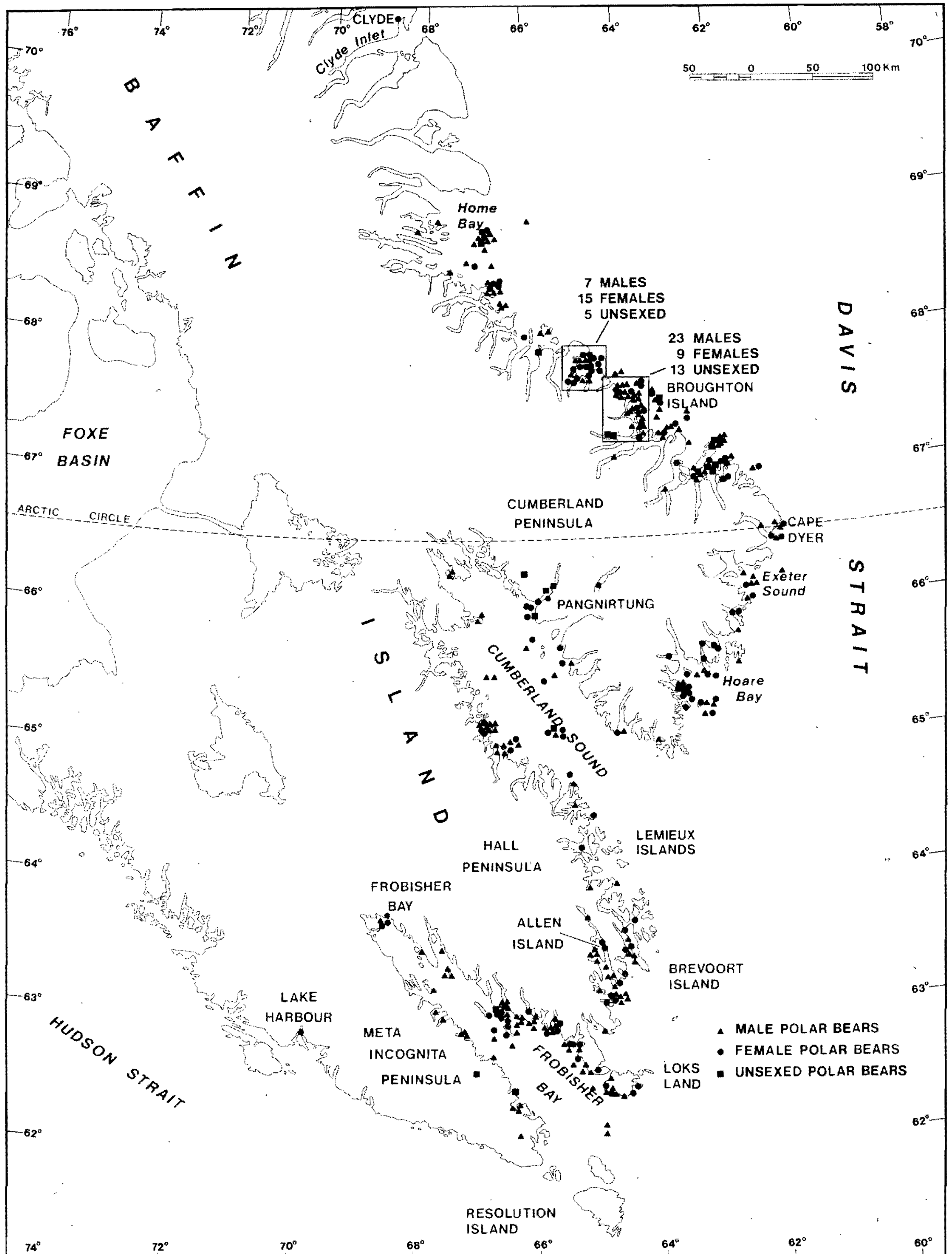


Table 14
Comparison of the estimates of the size of the polar bear population along southeastern Baffin Island, made using survival rates of 0.87 and 0.80

	Population estimates			
	Calculated with 0.87 survivorship		Calculated with 0.80 survivorship	
Area	1978	1979	1978	1979
Hall Peninsula	206	234	180	195
Cumberland Peninsula	761	477	675	415
Hall and Cumberland Peninsula, independent calculations pooled	967	711	855	610
Total study area	726	500	641	436

Table 15
Number of cubs produced by a population of 700 polar bears by age class and in total, assuming a 1:1 sex ratio, a constant annual mortality rate of 0.13 and age-specific natality rates given in the table calculated from the litter-produced rates and mean litter sizes by age class at the time of conception, from data in Table 7, but applied to the number of females in the age class in the year the cubs are actually born and leave the den

Females		Natality rate	No. cubs produced/age
Age, yrs	No.	(cubs/♀/yr.)	class/yr.
0	48.08	—	—
1	41.83	—	—
2	36.39	—	—
3	31.66	—	—
4	27.55	0.031	0.85
5	23.96	0.501	12.00
6	20.85	0.541	11.28
7	18.14	0.541	9.81
8	15.78	0.541	8.54
9	13.73	0.541	7.43
10	11.94	0.541	6.46
11	10.39	0.541	5.62
12	9.04	0.541	4.89
13	7.87	0.541	4.26
14	6.84	0.541	3.70
15	5.95	0.541	3.22
16	5.18	0.541	2.80
17	4.51	0.541	2.44
18	3.92	0.541	2.12
19	3.41	0.541	1.84
20+	2.98	0.541	1.61
Total	350.00		88.87

the study area might be lower than in other regions, the estimates were also calculated using a survivorship of 0.80 in order to examine the effect of differences in this variable (Table 14).

The proportion of recaptures in the total capture sample was much higher in 1979 than in 1978 (24.0% vs. 8.1%; Table 11). This had the effect of lowering the estimate of population size to 500 from 726 (Table 14), a decrease of 31.1%. This difference appears to have resulted mainly because of the influence of the mark and recapture data from the Cumberland Peninsula, where the independent estimate dropped by 37.3% (761 to 477) between 1978 and 1979 (Table 12).

In both 1978 and 1979, the recapture rate on the Hall Peninsula was about double that on the Cumberland Peninsula while the population estimate was about half, or less. Additional observations also indicate a smaller population of polar bears on the Hall Peninsula. In winter 1978–79, five of the 18 bears (27.8%) killed by Inuk hunters from Frobisher Bay had been tagged in the study area compared with two out of 14 bears (14.3%) killed on the Cumberland Peninsula by hunters from Pangnirtung. (The two tagged bears killed in 1979 by Pangnirtung hunters had been tagged only four days before at which time we were accompanied by an Inuk observer at the request of the Pangnirtung Hunters and Trappers Association.) After tagging bears on the Hall Peninsula from 10 to 16 April 1979, we departed for the Cumberland Peninsula until 29 April. In the next six days on the Hall Peninsula, we saw 29 bears, of which 15 had already been captured in that season, six had been captured in earlier years but not previously in 1979, and only eight bears were caught for the first time. This suggests that a very high proportion of the polar bears in the area of the Hall Peninsula had been tagged and, consequently, that the total population size was not large.

All the members of four families of bears, captured together in earlier years, were recaptured independently in 1979. One bear was in northern Labrador (Stirling and Kiliaan 1980). Two out of three members of two additional families were also captured independently in 1979. Although it is difficult to quantitatively evaluate these observations on a subjective basis, the probability of recapturing so many complete families of bears as independent animals must become greater as the total population size decreases.

Estimating the size of the polar bear population in the study area by summing the independent estimates for the Cumberland and Hall peninsulas in 1978 and 1979 gave values of 967 and 711 respectively. These are 33.2 and 42.3% higher respectively than the estimates made of the population as a whole (Table 14). In comparison, changing the mortality values in the calculations, from 0.87 to 0.80, only reduced the estimates in the order of 12 to 14% which, considering the size of the standard errors on all the estimates, is probably not important here. Although analyzing the available mark and recapture data from polar bears on the Cumberland and Hall peninsulas independently was useful for evaluating their relative contributions, it is obvious from the movement data (Results, section 1) that they are all part of the same population. Consequently, estimating the total population in the study area by summing the artificially independent calculations may result in an overestimation because of the lower rate of recapture on the Cumberland Peninsula. Conversely, a population estimate using all the data might be too low because of the high recapture rate on the Hall Peninsula. After evaluating the evidence subjectively, we conclude that the size of the polar bear population in the study area is about 700+ animals.

Using a population estimate of 700 and the age-specific reproductive values presented in Table 7, one can calculate a production of about 89 cubs per year in the study area (Table 15). If the mortality rate of the population is higher than the value of 0.13 used in this calculation, as suggested in Results, section 4, the number of cubs produced per year will be lower. Also of course, if the population is larger the number of cubs produced will be greater. However, even increasing the population to 900 only increases annual productivity to 114 cubs. Consequently, we suspect that the 1975 estimate of productivity (Jonkel *et al.* 1978) may be 30% or more too high.

6. Implications of offshore drilling

For polar bears, the two potential threats from oilspills and blowouts are as follows (Stirling and Kiliaan 1980):

a) fouling of the hair from swimming in oil-covered water might impair an animal's ability to thermoregulate; and

b) bears might be damaged internally by ingesting oil when licking their fouled hair to clean it or by eating seals that were fouled with oil.

The deleterious effect of oiled fur on the ability of a polar bear to thermoregulate successfully would probably be greater on the younger bears and family groups, which are thinner and use more of their energy intake for growth and nursing than on the older and fatter lone adults. The results of recent experiments on the effects of oil on polar bears suggest these concerns are valid (unpub.). Similarly, it is not known whether seals, upon which bears depend for food, would die or move away from a fouled area in large enough numbers to detrimentally affect the bears. However, it has been demonstrated that natural short-term changes in the environment can cause a halving of the seal population followed by a subsequent decline in polar bear numbers and reproductive rates (Stirling *et al.* 1977).

If a blow-out or major oilspill occurred, its potential for detrimental effects on polar bears would depend on where and when it occurred, where the slick went if there was one, how thick the slick was, what kind of crude it was, and for how long the situation existed.

Because of the southerly direction of the major currents in western Davis Strait, it seems unlikely that oil on the surface of the water would get near enough to the Cumberland Peninsula to harm any polar bears. That situation might be changed by onshore winds. More likely, depending on the currents and winds which prevail at the time of a blow-out, the oil would be carried in the direction of the Hall Peninsula, Resolution Island, and the Labrador coast. The possible effects of an oil spill on polar bears in the offshore pack ice of Davis Strait cannot be assessed at present because of lack of information. Rectifying this situation will require a quantitative study of seasonal movements in late winter and early spring using satellite tracking methods and mark and recapture studies from a platform in the offshore pack ice.

The maintenance of a logistic support base at the southeastern end of Brevoort Island may affect the local movements of bears during the winter and may displace a small number of denning females. However, considering the abundance of available alternative denning sites and habitat in which seals may be hunted, detrimental effects resulting from logistic activities are judged to be insignificant. Similarly, disruption to bears caused by aircraft travelling between Brevoort Island and a drill ship is likely to be minimal.

During the summer, activities around the logistic base at Brevoort Island may stimulate some local movements by bears which spend the summer on or near the island. Displacement is not likely to have detrimental effects on the few bears affected but some bears will probably be attracted to the site. We have already reported that most polar bears in the study area spend the summer at the ends of the main peninsulas and on associated islands and have documented the extent to which they travel extensively on the land in winter. Consequently, we believe that there is a high probability of person-bear conflicts in the vicinity of Brevoort Island in all seasons, though more so during the summer. Therefore we recommend that adequate precautions on camp cleanliness and vigilance be practised and that detection and deterrent systems for polar bears be established.

References

Bourque, J. 1977. Polar bear denning survey — Broughton Island 1977. Unpubl. Rep. to Regional Superintendent Northwest Territ. Wildl. Serv. Frobisher Bay, Northwest Territ. 12 p. (typed).

Bradley, R.S.; Miller, G.H. 1972. Recent climatic change and increased glacierization in the Eastern Canadian Arctic. Nature 237(5355): 385–387.

Canada, Atmospheric Environment. 1966–1976. Ice summary and analysis. Canadian Arctic. Environment Canada, Toronto. Sep. Rep. for 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1972.

Canada, Canadian Hydrographic Service. 1968. Pilot of Arctic Canada. Vol. 2. Dep. Energy, Mines, Resourc. Ottawa. 468 p.

Canada, Meteorological Branch. 1970. Climate of Arctic Canada. Dep. Energy, Mines, Resour. Ottawa. 71 p.

DeMaster, D.; Kingsley, M.C.S.; Stirling, I. 1980. A multiple mark and recapture estimate applied to polar bears. Can. J. Zool. 58: 633–638.

Dunbar, M.J. 1951. Eastern Arctic waters. Fish. Res. Board Can. Bull. No. 88. 131 p.

Dunbar, M.J. 1955. Marine life. Pages 119–138 *in* Kimble, George H.T.; Good, Dorothy. eds. Geography of the Northlands. Am. Geogr. Soc. Spec. Publ. No. 32.

Dunbar, M.J. 1968. Ecological development in polar regions; a study in evolution. Prentice-Hall, Inc., Englewood Cliffs. N.J. 119 p.

Dunbar, Moira; Greenaway, Keith R. 1956. Arctic Canada from the air. Def. Res. Board Can. Queen's Printer, Ottawa. 541 p.

Freeman, M.M.R. 1973. Polar bear predation on beluga in the Canadian Arctic. Arctic 26: 163–164.

Harington, C.R. 1968. Denning habits of the polar bear (*Ursus maritimus* Phipps). Can. Wildl. Serv. Rep. Ser. No. 5. 30 p.

Heyland, J.D.; Hay, K. 1976. An attack by a polar bear on a juvenile beluga. Arctic 29: 56–57.

Hunter, R.A. 1977. Report on 1977 polar bear denning survey, 24 March – 5 April, Hoare Bay, Baffin Region. Unpubl. Rep. to Reg. Supt. Northwest Territ. Wildl. Serv., Frobisher Bay, Northwest Territ. 14 p. (typed).

Jonkel, C.; Land, E.; Redhead, R. 1978. The productivity of polar bears (*Ursus maritimus*) in the southeastern Baffin Island area, Northwest Territories. Can. Wildl. Serv. Prog. Note No. 91. 7 p.

Jonkel, C.; Smith, P.; Stirling, I.; Kolenosky, G.B. 1976. Notes on the present status of the polar bear in James Bay and the Belcher Islands. Can. Wildl. Serv. Occ. Pap. No. 26. 40 p.

Kiliaan, H.P.L.; Stirling, I. 1978. Observations on over-wintering walruses in the eastern Canadian Arctic. J. Mammal. 59: 197–200.

Kiliaan, H.P.L.; Stirling, I.; Jonkel, C. 1978. Polar bears in the area of Jones Sound and Norwegian Bay. Can. Wildl. Serv. Prog. Note No. 88. 21 p.

Larsen, T. 1971. Capturing, handling, and marking polar bears in Svalbard. J. Wildl. Manage. 35: 27–36.

Lentfer, J.W. 1968. A technique for immobilizing and marking polar bears. J. Wildl. Manage. 32: 317–321.

Lentfer, J.W. 1975. Polar bear denning on drifting sea ice. J. Mammal. 56: 716.

Lentfer, J.W. 1976. Polar bear reproductive biology and denning. Alaska Dep. Fish and Game Final Rep. Projects W-17-3 and W-17-4. 22 p.

Letkeman, R. 1977. 1977 polar bear survey. Unpubl. rep. to Reg. Supt. Northwest Territ. Wildl. Serv. Frobisher Bay, Northwest Territ. 10 p. (typed).

Lønø, O., 1970. The polar bear (*Ursus maritumus* Phipps) in the Svalbard area. Norsk Polarinstitutt Skrifter Nr. 149. 103 p.

MacLaren Marex Inc. 1979a. Report on aerial surveys of marine mammals and birds in southern Davis Strait and eastern Hudson Strait, in March 1978 for Esso Resourc. Can. Ltd., and Can.-Cities Serv. Ltd. Arct. Pet. Oper. Assoc. Proj. No. 146. pp. 5–12 to 5–23.

MacLaren Marex Inc. 1979b. Report on aerial surveys of birds and marine mammals in the southern Davis Strait between April and December 1978, for Esso Resourc. Can. Ltd., Aquitaine Co. of Can. Ltd., and Can.-Cities Serv. Ltd. Arct. Pet. Oper. Assoc. Proj. No. 146. Vol. III, Marine Mammals.

Mansfield, A.W. 1967. Seals of Arctic and Eastern Canada. Bull. J. Fish. Res. Board Can. 137. 35 p.

Polunin, N. 1948. Botany of the Canadian Eastern Arctic. Part 3. Vegetation and ecology. Nat. Mus. Can. Bull. No. 104. 304 p.

Ransom, S. 1976. 1976 polar bear survey. Unpubl. Rep. to Reg. Supt. Northwest Territ. Wildl. Serv. Frobisher Bay, Northwest Territ. 11 p. (typed).

Redhead, R. 1976. 1976 Hoare Bay polar bear (*Ursus maritimus* Phipps) survey report. Unpubl. Rep. to Reg. Supt. Northwest Territ. Wildl. Serv. Frobisher Bay, Northwest Territ. 14 p. (typed).

Russell, R.H. 1975. The food habits of polar bears of James Bay and southwest Hudson Bay in summer and autumn. Arctic 28: 117–129.

Sergeant, D.E. 1965. Migration of harp seals *Pagophilus groenlandicus* (Erxleben) in the Northwest Atlantic. J. Fish. Res. Board Can. 22: 433–464.

Sergeant, D.E. 1974. A rediscovered whelping population of hooded seals *Cystophora cristata* Erxleben and its possible relationship to other populations. Polarforschung 44: 1–7.

Sergeant, D.E. 1977. Research on hooded seals in the Western North Atlantic in 1977. Int. Comm. Northwest Atl. Fish. Res. Doc. 77/xi /57.

Slaney, F.F. & Co. Ltd. 1974. 1972–1974 environmental program Mackenzie Delta, NWT, Canada. Vol. 5. Mammals. Unpubl. Rep. to Imp. Oil Can. Ltd. Can. Arct. Gas Study.

Smith, Pauline A. 1977. Résumé of the trade in polar bear hides in Canada, 1975–76. Can. Wildl. Serv. Prog. Note No. 82. 8 p.

Smith, Pauline A. 1978. Résumé of the trade in polar bear hides in Canada, 1976–77. Can. Wildl. Serv. Prog. Note No. 89. 5 p.

Smith, Pauline A. 1979. Résumé of the trade in polar bear hides in Canada, 1977–78. Can. Wildl. Serv. Prog. Note No. 103. 6 p.

Smith, Pauline A.; Jonkel, C.J. 1975a. Résumé of the trade in polar bear hides in Canada, 1972–73. Can. Wildl. Serv. Prog. Note No. 43. 9 p.

Smith, Pauline A.; Jonkel, C.J. 1975b. Résumé of the trade in polar bear hides in Canada, 1973–74. Can. Wildl. Serv. Prog. Note No. 48. 5 p.

Smith, Pauline A.; Stirling, I. 1976. Résumé of the trade in polar bear hides in Canada, 1974–75. Can. Wildl. Serv. Prog. Note No. 66. 7 p.

Smith, Pauline A.; Stirling, I.; Jonkel, C.; Juniper, I. 1975. Notes on the present status of the polar bear (*Ursus maritimus*) in Ungava Bay and northern Labrador. Can. Wildl. Serv. Prog. Note No. 53. 8 p.

Smith, T.G. 1973. Population dynamics of the ringed seal in the Canadian Eastern Arctic. Bull. J. Fish. Res. Board Can. 181. 55 p.

Smith, T.G.; Hammill, M.H.; Doige, A.W.; Cartier, T.; Sleno, G.A. 1979. Marine Mammal Studies in Southeastern Baffin Island Fisheries and Aquatic Sciences. Manuscr. Rep. No. 1552. 70 p.

Smith, T.G.; Stirling, I. 1975. The breeding habitat of the ringed seal (*Phoca hispida*): The birth lair and associated structures. Can. J. Zool. 53: 1297–1305.

Stirling, I. 1974. Midsummer observations on the behavior of wild polar bears (*Ursus maritimus*). Can. J. Zool. 52: 1191–1198.

Stirling, I.; Kiliaan, H.P.L. 1980. Population ecology studies of the polar bear (*Ursus maritimus*) in northern Labrador. Can. Wildl. Serv. Occ. Pap. No. 42. 19 p.

Stirling, I.; Latour, P.B. 1978. Comparative hunting abilities of polar bear cubs of different ages. Can. J. Zool. 56: 1768–1772.

Stirling, I.; McEwan, E.H. 1975. The caloric value of whole ringed seals (*Phoca hispida*) in relation to polar bear (*Ursus maritimus*) ecology and hunting behavior. Can. J. Zool. 53: 1021–1027.

Stirling, I.; Archibald, W.R.; DeMaster, D. 1977a. Distribution and abundance of seals in the eastern Beaufort Sea. J. Fish. Res. Board Can. 34: 976–988.

Stirling, I.; Pearson, A.M.; Bunnell, F.L. 1976. Population ecology studies of polar and grizzly bears in northern Canada. North Amer. Wildl. Conf. Trans. 41: 421–430.

Stirling, I.; Andriashek, D.; Latour, P.; Calvert, W. 1975. The distribution and abundance of polar bears in the eastern Beaufort Sea. A final rep. to the Beaufort Sea Proj. Fish. Mar. Serv. Dep. Environ. Victoria, B.C. 59 p.

Stirling, I.; Kiliaan, H.P.L.; Calvert, W.; Andriashek, D. 1979. Population ecology studies of polar bears in the area of southeastern and southern Baffin Island and northern Labrador. Prog. Rep. to the Can. Wildl. Serv., Esso Resourc. Can. Ltd. Aquitaine Co. of Can. Ltd. and the Northwest Territ. Wildl. Serv. 88 p.

Stirling, I.; Schweinsburg, R.E.; Calvert, W.; Kiliaan, H.P.L. 1978. Population ecology of the polar bear along the proposed Arctic Islands Gas Pipeline Route. Final Rep. to the Environ. Manage. Serv. Dep. Environ. Edmonton. 93 p.

Stirling, I.; Jonkel, C.; Smith, P.; Robertson, R.; Cross, D. 1977b. The ecology of the polar bear (*Ursus maritimus*) along the western coast of Hudson Bay. Can. Wildl. Serv. Occ. Pap. No. 33. 64 p.

Thomas, D.C.; Bandy, P.J. 1973. Age determination of wild blacktailed deer from dental annulations. J. Wildl. Manage. 37: 232–235.

Thomassen, I.; Hansson, R. Behavior of polar bears with cubs of the year in the denning area. **(In press).** In. C. Meslow (Ed). Proc. of the Fifth Int. Conf. on Bear Res. and Manage. Madison, Wisc. March 1980.

Van de Velde, R. 1971. Bear stories. Eskimo (New Series) 1: 7–11.

Other publications in the Occasional Papers Series

No. 1
Birds protected in Canada under the Migratory Birds Convention Act, 4th ed. Aussi disponible en français.
Cat. No. R69-1/1
No. 2
Canadian bird names, French, English and scientific.
Publication bilingue.
Cat. No. R69-1/2
No. 3
Use of aerial surveys by the Canadian Wildlife Service by D.A. Benson.
Out of print.
Cat. No. R69-1/3
No. 4
Queen Elizabeth Islands game survey, 1961 by J.S. Tener.
Cat. No. R69-1/4
No. 5
Age determination in the polar bear by T.H. Manning.
Cat. No. R69-1/5
No. 6
A wildlife biologist looks at sampling, data processing and computers by D.A. Benson.
Out of print.
Cat. No. R69-1/6
No. 7
Preliminary report on the effects of phosphamidon on bird populations in New Brunswick by C.D. Fowle. Out of print.
Cat. No. R69-1/7
No. 8
Birds of Nova Scotia–New Brunswick border region by G.F. Boyer.
Cat. No. R69-1/8
No. 9
Effects of dietary methylmercury on Ring-necked Pheasants, with special reference to reproduction by N. Fimreite.
Cat. No. R69-1/9
No. 10
Trends in populations of barren-ground caribou over the last two decades: a re-evaluation of the evidence by G.R. Parker.
Cat. No. R69-1/10
No. 11
The Canada migratory game bird hunting permit and related surveys by D.A. Benson.
Cat. No. R69-1/11
No. 12
Observations on duck hunting in eastern Canada in 1968 and 1969 by J.H. Boyd.
Cat. No. R69-1/12
No. 13
Evaluation of ecological effects of recent low water levels in the Peace–Athabasca Delta by H.J. Dirschl.
Cat. No. CW69-1/13
No. 14
The Great Cormorants of eastern Canada by A.J. Erskine.
Cat. No. CW69-1/14
No. 15
Distribution of barren-ground caribou harvest in north-central Canada by G.R. Parker.
Cat. No. CW69-1/15
No. 16
Bird migration forecasts for military air operations by H. Blokpoel.
Cat. No. CW69-1/16
No. 17
Waterfowl populations on the Peace–Athabasca Delta, 1969 and 1970 by D.J. Nieman and H.J. Dirschl.
Cat. No. CW69-1/17
No. 18
Gammarus predation and the possible effects of *Gammarus* and *Chaoborus* feeding on the zooplankton composition in some small lakes and ponds in western Canada by R.S. Anderson and L.G. Raasveldt.
Cat. No. CW69-1/18
No. 19
A summary of DDE and PCB determinations in Canadian birds, 1969 to 1972 by M. Gilbertson and L. Reynolds.
Cat. No. CW69-1/19
No. 20
Development of a simulation model of Mallard Duck populations by C.J. Walters, R. Hilborn, E. Oguss, R.M. Peterman and J.M. Stander.
Cat. No. CW69-1/20
No. 21
Use of museum specimens in toxic chemical research by A.M. Rick.
Cat. No. CW69-1/21
No. 22
Impoundments for waterfowl by W.R. Whitman.
Cat. No. CW69-1/22
No. 23
Minimizing the dangers of nesting studies to raptors and other sensitive species by R.W. Fyfe and R.R. Olendorff.
Cat. No. CW69-1/23
No. 24
Waterfowl damage to Canadian grain: current problems and research needs by L.G. Sugden.
Cat. No. CW69-1/24
No. 25
Census techniques for seabirds of arctic and eastern Canada by D.N. Nettleship.
Cat. No. CW69-1/25
No. 26
Notes on the present status of the polar bear in James Bay and Belcher Islands area by Charles Jonkel, Pauline Smith, Ian Stirling and George B. Kolenosky.
Cat. No. CW69-1/26
No. 27
Limnological and planktonic studies in the Waterton Lakes, Alberta by R. Stewart Anderson and Roderick B. Green.
Cat. No. CW69-1/27
No. 28
Birds and mammals of the Belcher, Sleeper, Ottawa, and King George Islands, Northwest Territories by T.H. Manning.
Cat. No. CW69-1/28
No. 29
Developments in PPS sampling — Impact on current research by A.R. Sen.
Cat. No. CW69-1/29
No. 30
Dynamics of snowshoe hare populations in the Maritime Provinces by Thomas J. Wood and Stanley A. Munroe.
Cat. No. CW69-1/30
No. 31
Migration and population dynamics of the Peace–Athabasca Delta goldeye population by D.B. Donald and A.H. Kooyman.
Cat. No. CW69-1/31
No. 32
The effects of fire on the ecology of the Boreal Forest, with particular reference to the Canadian north: a review and selected bibliography by John P. Kelsall, E.S. Telfer and Thomas D. Wright.
Cat. No. CW69-1/32
No. 33
The ecology of the polar bear *(Ursus maritimus)* along the western coast of Hudson Bay by Ian Stirling, Charles Jonkel, Pauline Smith, Richard Robertson and Dale Cross.
Cat. No. CW69-1/33
No. 34
Canvasback habitat use and production in Saskatchewan parklands by Lawson G. Sugden.
Cat. No. CW69-1/34
No. 35
The diets of muskoxen and Peary caribou on some islands of the Canadian High Arctic by Gerald R. Parker.
Cat. No. CW69-1/35
No. 36
Observations of Mallards in the parkland of Alberta by Michael F. Sorensen.
Cat. No. CW69-1/36
No. 37
The wildlife valuation problem: A critical review of economic approaches by William A. Langford and Donald J. Cocheba.
Cat. No. CW69-1/37
No. 38
Spatial changes in waterfowl habitat, 1964-74, on two land types in the Manitoba Newdale Plain by G.D. Adams and G.C. Gentle.
Cat. No. CW69-1/38
No. 39
Patterns of pelagic distribution of seabirds in western Lancaster Sound and Barrow Strait, Northwest Territories, in August and September 1976 by D.N. Nettleship and A.J. Gaston.
Cat. No. CW69-1/39
No. 40
Responses of Peary caribou and muskoxen to helicopter harassment by Frank L. Miller and Anne Gunn.
Cat. No. CW69-1/40
No. 41
Avian Community structure of six forest stands in La Mauricie National Park, Quebec by J.-L. DesGranges. Aussi disponible en français.
Cat. No. CW69-1/41E
No. 42
Population ecology studies of the polar bear in northern Labrador by Ian Stirling and H.P.L. Kiliaan. Aussi disponible en français.
Cat. No. CW69-1/42E
No. 43
Census methods for murres, *Uria* species: a unified approach by T.R. Birkhead and D.N. Nettleship. Aussi disponible en français.
Cat. No. CW69-1/43E