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

Ian Stirling*
Wendy Calvert*
Dennis Andriashek*

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* CWS, Edmonton T5K 2J5
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.
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

6 Acknowledgements
7 Abstract
7 Résumé
8 Introduction
9 Current information
9 1. Biology and ecology of the polar bear
10 2. Previous knowledge of polar bears in the study area
10 Study area
10 1. Physiography
10 2. Climate
12 3. Vegetation
12 4. Ice conditions
12 5. Currents
13 6. Other marine life
13 Methods
13 1. Tagging and recapture of individual polar bears
14 2. Recording of tracks
14 3. Maternity denning
14 4. Calculation of productivity
14 5. Specimens from Inuk hunters
15 6. Location of summer retreats
15 7. Age determination
15 8. Comparison of age structures
15 9. Estimation of population size
15 Results and discussion
15 1. Distribution and movements
15 1.1. Late winter and spring distribution
19 1.2. Utilization of terrestrial habitat during spring
19 1.3. Fidelity to winter and spring feeding areas
19 1.4. Summer distribution
19 1.5. Seasonal movements and delineation of subpopulations
23 2. Maternity denning areas
23 3. Litter size and productivity
27 4. Age structure and mortality rates
27 5. Estimation of population size
29 6. Implications of offshore drilling

30 References

List of tables
12 Table 1. Climatic data for Frobisher Bay, NWT
13 Table 2. Dates of helicopter surveys to mark and recapture polar bears along southeastern Baffin Island
15 Table 3. Age and sex class of polar bears tagged in the study area, 1974–79
17 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
26 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
26 Table 6. Mean litter sizes of cubs of different ages captured in the study area, 1974–79
26 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
26 Table 8. Age-specific natality rates of adult female polar bears from different areas in the Canadian Arctic
26 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
26 Table 10. Sex-specific mortality rates of capture samples, calculated by fitting exponential curves to age structures in Table 9
27 Table 11. Summary of mark and recapture data from the whole study area and estimates of population size (N) at time i
27 Table 12. Summary of mark and recapture data from the Cumberland Peninsula and estimates of population size (N) at time i
27 Table 13. Summary of mark and recapture data from the Hall Peninsula and estimates of population size (N) at time i
29 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
29 Table 15. Number of cubs produced by a population of 700 polar bears by age class and in total
List of figures

11 Figure 1. Map of the study area, including the borders of Polar Bear Management Zones B, C and D  
16 Figure 2. Locations at which polar bears were tagged in the study area between late March and mid May 1974-79  
17 Figure 3. Locations at which polar bears were tagged in the study area during August 1978  
18 Figure 4. Number of polar bears and tracks sighted per 100 km of potential habitat surveyed in different locations within the study area  
20 Figure 5. The recorded movements of polar bears captured between late March and May of one year and recaptured or shot between 1 January and mid May one or more years later  
21 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.  
22 Figure 7. Movements made by polar bears which were sighted in the same season in which they were originally captured  
24 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  
25 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  
28 Figure 10. Known locations of polar bear kills by Inuk hunters, 1963-79

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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 mean breeding interval, calculated from six females with marked cubs, was 2.1 years. The mean litter size during the study was 1.82 ± 0.079. The most important maternity denning areas, in descending order of importance, were around the seaward tips of the Cumberland 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 cette faible moyenne 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 explorés que l'on a observé chez les ours des déplacements entre les deux principales concentrations d'ours blancs du Cumberland et de 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 nantis de mise bas, par ordre décroissant d'importance, se retrouvent près des extrémités des péninsules Cumberland et Hall. Les données relatives à la taille de la population et aux paramètres de reproduction à un âge précis sont disponibles pour 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 ours naissent 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

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 the 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 see many local subpopulations. The dis-

2. 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 the 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 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 on land and how there may be 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 mostly characteristic 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 routinely dig 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 as 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 for a period of one month. The bears we known to be the case in the study area (Smith et al. 1979). Whether or not the seas 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 caput spins mainly by stalking them, by waiting for them to surface at a breathing hole (Stirling 1974), and in spring, by digging out seal pups and sometimes adults from the birth lair 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).
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.

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 peninsula. 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 in the Canadian Arctic. The upland nature of much of the terrain has the effect of increasing precipitation, particularly along the seaward tips of the peninsula. The following summary is taken from Dunbar and Greenaway (1956) and Canada, Meteorological Branch (1970).

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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 perennial. Upland and mountain areas, although not presently glaciated, have very little soil cover and are poorly vegetated with a lichen-dominated tundra (Poulton 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). In bays and inlets along the northern coast of Cumberland Peninsula and in the heads of Baffin and Davis Straits, surface 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 western part 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, 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.

Spring brings increasing daylength, daylength begins to rise slowly in March. By May, 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 of north 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°C to 10°C.

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

By the end of 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 associated with the northwestward decrease in the mean daily summer temperatures (January–August), a marked increase in winter precipitation and in the mean daily winter temperatures. The greatest increase is in the northwest sector of the study area. Snow accumulation is greater than ablation, and permanent snowbanks are expanding.

3.3 21.6 2.29

<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature °C</th>
<th>Snow, cm²</th>
<th>Wind direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>15.6</td>
<td>29.0</td>
<td>NW</td>
</tr>
<tr>
<td>February</td>
<td>29.0</td>
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<td>NW</td>
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<tr>
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<td>April</td>
<td>23.6</td>
<td>0.2</td>
<td>NW</td>
</tr>
<tr>
<td>May</td>
<td>20.5</td>
<td>0.0</td>
<td>NW</td>
</tr>
<tr>
<td>June</td>
<td>8.4</td>
<td>3.7</td>
<td>NW</td>
</tr>
<tr>
<td>July</td>
<td>8.4</td>
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<td>NW</td>
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<tr>
<td>August</td>
<td>0.3</td>
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<tr>
<td>September</td>
<td>0.3</td>
<td>6.9</td>
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<tr>
<td>October</td>
<td>3.7</td>
<td>8.4</td>
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<td>NW</td>
</tr>
<tr>
<td>December</td>
<td>24.9</td>
<td>41.3</td>
<td>NW</td>
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</tbody>
</table>

3.3 21.6 2.29

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. This is associated with the winter temperatures (mean daily temperatures to -30°C) and increasing the amount of cloud and precipitation, and wind velocity. Over 100 cm of snow falls 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 semi-permanent areas. winds tend to be variable and change frequently, but the proportion of north 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°C to 10°C.

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<td>7.9</td>
<td>NW</td>
</tr>
<tr>
<td>March</td>
<td>7.9</td>
<td>2.0</td>
<td>NW</td>
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<tr>
<td>April</td>
<td>23.6</td>
<td>0.2</td>
<td>NW</td>
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<tr>
<td>May</td>
<td>20.5</td>
<td>0.0</td>
<td>NW</td>
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<td>June</td>
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<td>September</td>
<td>0.3</td>
<td>6.9</td>
<td>NW</td>
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<tr>
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<td>3.7</td>
<td>8.4</td>
<td>NW</td>
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<td>3.7</td>
<td>8.4</td>
<td>NW</td>
</tr>
<tr>
<td>December</td>
<td>24.9</td>
<td>41.3</td>
<td>NW</td>
</tr>
</tbody>
</table>

3.3 21.6 2.29
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 recaptured 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 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 on Baffin Island and Cape Dyer, on the Cumberland Peninsula. Densities decrease in the larger firths, such as Frobisher Bay and Cumberland Sound.

Table 3

<table>
<thead>
<tr>
<th>Age and sex class</th>
<th>No.</th>
<th>Adult male</th>
<th>Adult female</th>
<th>Subadult male</th>
<th>Subadult female</th>
<th>Adult male with cubs of any age</th>
<th>Cubs of the year (with female)</th>
<th>Male</th>
<th>Female</th>
<th>Two-year-olds (male)</th>
<th>Three-years-old (female)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age and sex class</td>
<td>No.</td>
<td>Adult male</td>
<td>Adult female</td>
<td>Subadult male</td>
<td>Subadult female</td>
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<td>Cubs of the year (with female)</td>
<td>Male</td>
<td>Female</td>
<td>Two-year-olds (male)</td>
<td>Three-years-old (female)</td>
<td>Total</td>
</tr>
<tr>
<td>Single (both sexes)</td>
<td>24</td>
<td>7</td>
<td>10</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>Single (male) and olders were classed as subadults; bears 5 years of</td>
<td>47</td>
<td>14</td>
<td>17</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>23</td>
</tr>
</tbody>
</table>

During winter, undisturbed maternity dens are necessary for the birth and survival of polar bear cubs. Disturbance of cubs in dens can cause abandonment, resulting in the deaths 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 circumstantial 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 9275 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 in 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 go farther offshore only if the sea ice is thin. 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 areas. 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, it is known that cubs are 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 reproduction rates can be evaluated by 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 cubs of the year, their locations 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 cubs 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:

\[
\text{No. of cubs of yr. + cubs with yr.} + \text{No. of cubs aged} X\text{ + 1} + \text{No. of cubs aged} X\text{ + 2} + \text{cb of X + 3} + \text{cubs of yr. * 24 \text{ km} of habitat}
\]

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 24 km of habitat.

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

\[
\text{No. of cubs of yr. + cubs with yr.} + \text{No. of cubs aged} X\text{ + 1} + \text{No. of cubs aged} X\text{ + 2} + \text{cb of X + 3} \times 24 \text{ km of habitat}
\]

The mean litter size thus calculated may be biased to the low side if a significant proportion of the females lost part or not all of their cubs to a predation or to a hunting pressure. However, even 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 centum, using the methods of Thomas and Bundy (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 in the sampling years 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. 1986). With polar bears, this technique is difficult to use because it is expensive and time consuming to obtain large sample sizes. However, each individual bear capture provides additional information on movements, growth, survival, and age so that in terms of data collected per dollar expended, this mark and recapture approach is almost costless.

Survival of polar bears in other studies has ranged from about 60 to 90% (Stirling et al. 1976, 1978). Consequently, an average survival rate of 0.87 with an arbitrarily assigned variance of 0.0307 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 (1), a value of 0.001 was entered.
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 during the spring, they are a constant problem to the station during the summer and fall, which suggests that human activity deterred 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 amounts of data 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 Marx (1975a 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 (1975) 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.

In general, the densities of bears and tracks sighted/100 km² 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 reforms in the areas parallel to coastlines, lead systems, ice 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 Amandshen 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 amounts of data may be obtained per unit of survey effort.

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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 sex­classes (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 overhear more slowly on uneven ground or 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 an effective learned anti-predator behaviour. If such behaviour occurred with some degree of regularity, and if 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 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 an 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 17­year-old non-estrous female with two 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. ± 1.96 SD/√n) Only three recorded movements exceeded 200 km. These 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. 5). 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 peninsula report seeing bears regularly during that period. Although the evidence is limited, it appears that there are more bears around the ends of the peninsula 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 in September of different years. Between 1975 and 1976, 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, 50 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.
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 northeastern tip 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. Maturity denning areas

Jonkel et al. (1978) identified the seaward tips of the Meta Incognita, Hall, and Cumberland peninsulas as areas 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 these estimates provide approximations, the productivity 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 an overflight 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 by surveying 18,050 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 1973 km of surveying. In 1978, tracking conditions were somewhat better 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).

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. 1978).

The age-specific litter-size productivity 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 (0.301) 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 natality rate of adult females (0.541) is the same as in the High and Central Arctic regions (Stirling et al. 1978) but differs from the Western Canadian Arctic and the coastal areas in Greenland where female polar bears do not conceive for the first time until they are 5 years of age (Stirling et al. 1976; Lefter et al. 1976). The reason for this difference is not known.

The natality rate of female polar bears in the study area, 0.541 is 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 marked 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 underestimated. The effect of this may be illustrated by comparing natality rates calculated only from females aged 5-26 years with cubs of the year which uses data from females with cubs of the year and yearlings (0.541). In comparison, natality rates calculated only from data 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 some of their cubs for 2 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 reported for the study area. The mean breeding interval calculated from six adult females tabulated (Table 5) to facilitate subsequent calculations of reproductive values (Tables 6 and 7).

Because estuarine surveying is limited to 10-20 days, we suspect that the estimate of 1980-200 cubs produced in 1975 may be too high.
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.
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 1½-2½ years of age, one would predict that fewer females accompanied by 2-year-olds would be captured than with yearlings. 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 south- eastern 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 was 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 ($\chi^2 = 4.86; df = 4; p > 0.05$). That may reflect a greater susceptibilty 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 biased 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 ($\chi^2 = 3.18; df = 4; p > 0.05$). This may be a reflection of the small size of the sample 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 20% of the males (20/100), a difference which was statistically significant ($\chi^2 = 5.47; df = 1; p < 0.05$). The age structure of the killed males was not significantly different from that of the captured males ($\chi^2 = 3.00; df = 4; p > 0.05$), but those of the 19 killed and captured females were ($\chi^2 = 13.44; df = 4; p < 0.05$).

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. Since the 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 complicated 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 Arctic (Stirling et al. 1976 and 1978). To attempt to calculate values which were not biased by the under-sampling of younger age classes, we calculated the mortality rates of females 5-19 years of age in the study area (Table 10). 5-20 years was the High Arctic (Stirling et al. 1976, Table 1) 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 vs. 13.8%; and 19 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 survival rate. 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 independent areas. Since the results in Results, section 4 indicated that survivorship of polar bears in...
...continued from previous page...

...and to total, assuming a 3.1% annual mortality rate.  

The proportion of recaptures in the total capture sample was much higher in 1979 than in 1978 (24.0% vs. 8.1%; Table 12). This had the effect of lowering the estimate of population size to 700 (Table 14), a decrease of 31.1%. This suggests that a very high proportion of the polar bears in the area were 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 and Peninsula in 1978 and 1979 gave values of 967 and 711 respectively. These are 32.3 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 estimated population 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 Peninsula 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 become fouled with oil.

Water might impair an animal’s ability to thermoregulate; and 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.

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strated 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. 1976).

If a blow-out or major oil spill 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 surprisingly little oil from the platform 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 oceanic storms. 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 changes 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 eastern south-east end of Brevoort Island may affect the local movements of bears 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.

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