Ian Stirling
H.P.L. Kiliaan

Population ecology studies of the polar bear in northern Labrador

Environment Canada Environnement Canada

0016388A S

OCCASIONAL PAPER (CANADIAN WILDLIFE SERVICE)

Occasional Paper
Number 42
Canadian Wildlife Service

Environment Canada
Canadian Wildlife Service

Environnement Canada
Service canadien de la faune

Ian Stirling*
H.P.L. Kiliaan*

Population ecology studies of the polar bear in northern Labrador

Occasional Paper
Number 42
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. CW69-1/42E
ISBN-0-662-10802-7
ISSN-0576-6370

Design: Rolf Harder & Associates

Contents

Acknowledgements

We particularly acknowledge the following organizations without whose support this research could not have been done: Canadian Wildlife Service, Esso Resources Canada Ltd., Aquitaine Co. of Canada Ltd., Canada-Cities Service Ltd., the Northwest Territories Wildlife Service, and the Polar Continental Shelf Project. Pauline Smith edited the manuscript and gave much constructive criticism to the scientific content. We thank the following for their assistance in the field and in the laboratory: D. Andriashek, R. Brading, W. Calvert, J. Innes, S. Luttich, P. Pellerin, and Jayne Takahashi. We are grateful for the cooperation of the Newfoundland Wildlife Branch in this study.

Abstract

During spring 1976–79 we marked and recaptured polar bears in northern Labrador. Thirty-seven polar bears were captured and individually tagged. Most were found along the interface between the coastal landfast ice and the drifting pack ice, especially around the mouths of bays. The mark and recapture data indicated a low population (60–90 bears) in the area. Fifty to 80% fewer polar bears and tracks were seen per 100 km of potential habitat surveyed than recorded for other areas of the Arctic. This also indicates a smaller population.

At least some of the polar bears present on the Labrador coast in the spring travel great distances at other times of the year. Journeys were recorded between northern Labrador and both southeastern Baffin Island and northern Hudson Bay. These movements may be seasonal in nature and influenced by sea currents which carry the pack ice on which polar bears sometimes hunt. The number of polar bears that spend the whole year in northern Labrador is unknown.

No evidence of maternity denning was found and the reproductive rates of females captured in northern Labrador were lower than in other areas of the Arctic.

The polar bears in northern Labrador are on the southern edge of their range. Consequently, small environmental changes may have a greater effect on the distribution, numbers, and reproductive parameters there than in other areas of the Arctic. The polar bears found in Labrador are part of a population that is shared with and harvested by Inuit from both the NWT and Quebec. In addition, offshore drilling, with its attendant potential for environmental damage, is now taking place and more activity is projected in Davis Strait and the Labrador Sea. Evolving management practices will have to accommodate all these factors.

Résumé

De 1976 à 1979, nous avons effectué, durant le printemps, des études fondées sur le marquage et la recapture d'ours blancs dans le nord du Labrador. Nous avons capturé et marqué 37 ours blancs. Ces ours se trouvaient en général répartis le long de la zone intermédiaire entre la banquise cotière et la glace de dérive, notamment près des embouchures des baies. Selon l'analyse des données sur le marquage et la recapture, l'aire d'étude abritait une population peu abondante, soit de 60 à 90 ours. Le nombre d'ours blancs et de pistes par 100 km d'habitat potentiel étudié était de 50 à 80 pour cent inférieur à celui d'autres régions de l'Arctique, ce qui dénote aussi une population plus restreinte.

Au moins une partie de la population d'ours blancs présents sur la côte du Labrador au printemps entreprend de grands déplacements à d'autres périodes de l'année. Nous avons noté des échanges d'ours entre le nord du Labrador, d'une part, et le sud-est de l'île Baffin et le nord de la baie d'Hudson, d'autre part. Il se peut que ces déplacements soient saisonniers et qu'ils soient influencés par les courants marins qui transportent la glace de dérive sur laquelle les ours blancs chassent quelquefois. Nous ne savons pas combien d'ours blancs passent toute l'année dans le nord du Labrador.

Nous n'avons pas trouvé de tanière de mise bas et le taux de reproduction des femelles capturées dans le nord du Labrador était plus bas que dans les autres régions de l'Arctique.

Les ours blancs dans le nord du Labrador se trouvent à la limite sud de leur aire de dispersion. Par conséquent, de petits changements environnementaux peuvent y avoir de plus grandes répercussions sur la répartition, le nombre et la reproduction de cette espèce que dans d'autres régions de l'Arctique. Il est maintenant évident que les ours blancs trouvés au Labrador font partie d'une population que se partagent et que chassent les Inuit des Territoires du Nord-Ouest et ceux du Québec. Par ailleurs, le forage hauturier qui se déroule actuellement entraîne des risques de dégâts environnementaux et l'on prévoit encore plus d'activités à l'avenir dans le détroit de Davis et la mer du Labrador. Les pratiques de conservation devront donc évoluer de façon assez souple pour tenir compte de tous ces facteurs.

Introduction

For some years, the status of the polar bear in Labrador has been uncertain. Historical records, such as Cartwright's journals from the 1770's (Townsend 1911) reported large numbers of polar bears fishing for salmon in the Eagle and White Bear rivers in southern Labrador, and several polar bears were killed in that area in subsequent years. However, the impression in more recent years has been that there are few polar bears in Labrador. Whether this apparent downward trend in numbers resulted from over-hunting or long-term climatic changes, or both, is unknown. In response to concern that the polar bears in Labrador might constitute a discrete and possibly endangered subpopulation, the Newfoundland Government closed the hunting season on that species at the end of 1970, although they retained the right to reopen it if new data indicated it was safe to do so.

In November 1973, Canada, Denmark, Norway, the United States and the Soviet Union signed an International Agreement on the Conservation of Polar Bears, which 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 both that baseline studies are done and that the results are utilized to conserve polar bears and their habitat.

Thus, because offshore drilling for petrochemicals was being undertaken in the Labrador Sea and more exploratory drilling was being planned for that area, as well as to the north in Davis Strait, there was a further need for population ecology studies for management purposes and baseline studies for purposes of environmental assessment and the prediction of problem areas.

Smith *et al.* (1975) reviewed the status of polar bears in Ungava Bay and northern Labrador (Polar Bear Management Zone B) on the basis of data available from miscellaneous surveys and reports, and specimens from polar bears killed by Inuk hunters. They were unable to draw any firm conclusions because of the fragmentary nature of the data but they found no evidence of a polar bear population large enough to sustain even the recorded harvest in that area. At the same time, however, ages of the few bears from which specimens were available did not indicate that overharvesting was taking place. This left two possible explanations: *(a)* that the population contained in Zone B was larger than suspected or *(b)* that the area currently delineated as Zone B did not contain the whole subpopulation from which the harvest was being taken. Smith *et al.* (1975) recommended that more research be undertaken on the population ecology of the polar bears in the area of Hudson Strait, southeastern Baffin Island, Ungava Bay and the Labrador coast with a view toward developing a more effective management plan for the bears in that area. This paper reports the results of new research conducted along the northern Labrador coast. Where applicable, we include data from the earlier surveys reported by Smith *et al.* (1975).

Study area

Figure 1 shows the northern Labrador study area, north of Hebron, which constitutes the eastern portion of Polar Bear Management Zone B. The Labrador coast is mountainous and indented by numerous long, narrow fiords. The terrain rises steeply to sharp peaks 900 to 1600 m in elevation and discontinuous permafrost prevails throughout most of the area. Offshore, the continental shelf is narrow and gently sloping, and drops off steeply at about 200 m in depth (Dunbar 1951).

Long, cold winters and short cool summers characterize the area although marked fluctuations in solar radiation may occur throughout the year. The annual mean temperature range is about 30°C. However, because of the proximity of large areas of open water during winter, the cold temperatures are not as extreme as in other areas of the Canadian Arctic. Rain or freezing rain may occur during winter although most precipitation falls in July and August. Summer tends to be cloudy and fog banks are common over water. Northwesterly winds usually prevail in particular during winter.

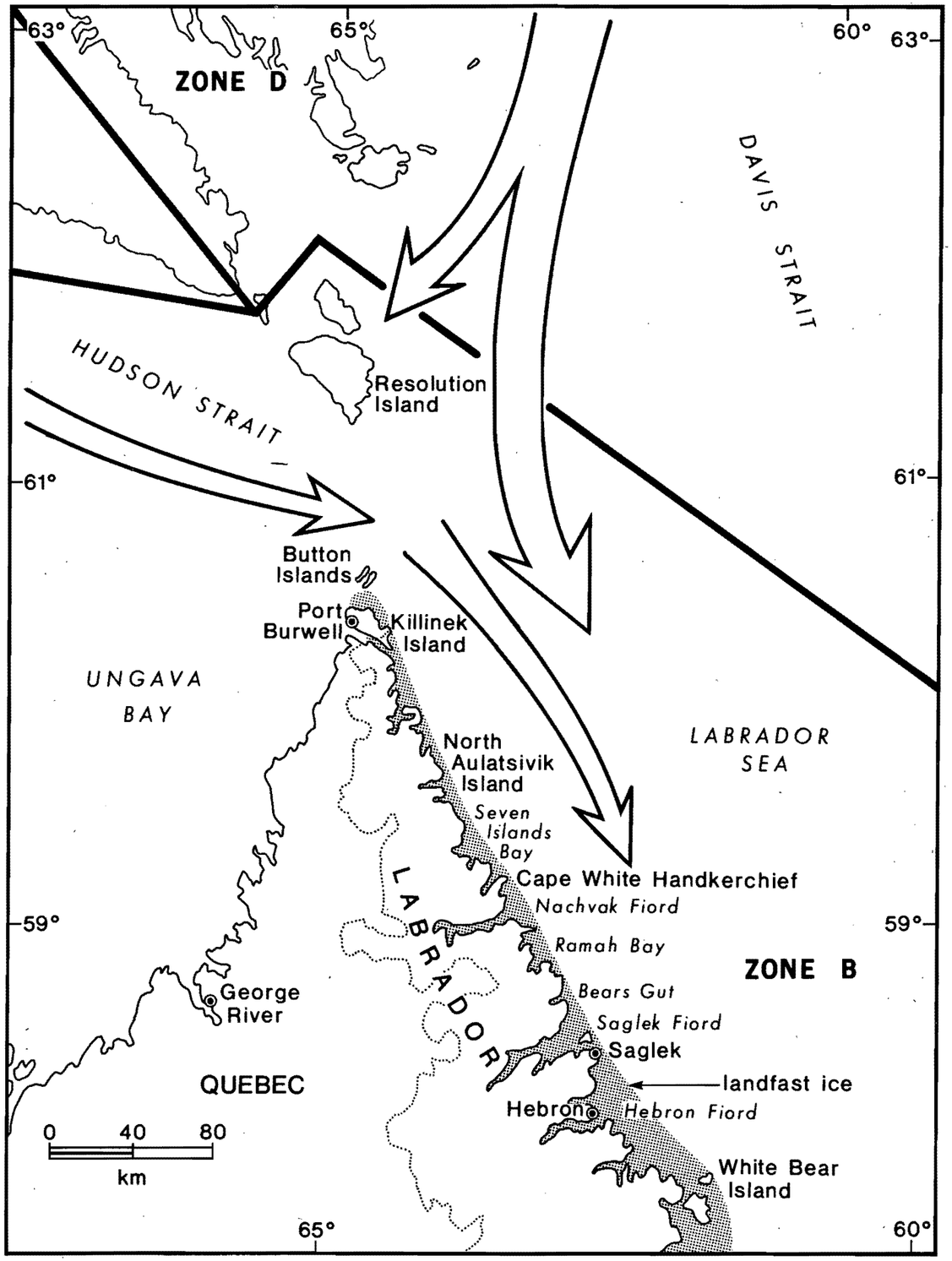
Freeze-up begins in the bays and inlets along the northern Labrador coast by late October or, in some years, late November (Canada, Canadian Hydrographic Service 1965). By early December, large amounts of pack ice are being carried by the southerly currents from western Davis Strait or by easterly currents through Hudson Strait into the Labrador Sea. Maximum ice accumulation occurs by March–April. At this time the eastern edge of the pack ice lies 160–240 km off the northern Labrador coast and extends south to the east coast of the island of Newfoundland (unpub. data, Canada, Ice Climatology). The larger, heavier ice floes tend to be in the central or core part of the long tongue of pack ice along the Labrador coast. The size of floes gradually decreases to the south and the pack becomes more open. Few floes over 100 m drift south of Hamilton Inlet in the southern part of Labrador. The edge of the landfast ice along the northern Labrador coast tends to remain close to the shoreline, more or less delineated by an imaginary line drawn from headland to headland. The proximity of the western edge of the pack ice to the landfast ice is determined mainly by wind direction. Because of prevailing northwesterly winds, a permanent or semi-permanent lead persists between the landfast ice and the pack ice. However, in the area around Nachvak Fiord and the Okak Islands (about 35 km south of White Bear Island) and the area north of Hamilton Inlet, the pack ice remains close against the landfast ice throughout the winter. Hudson Strait, to the west of the Button and Resolution islands area, is usually completely ice-covered. By the end of June, breakup is complete in most areas, but scattered ice floes may be present until late July, or early August in extreme years. Offshore winds accelerate breakup and clearance of ice away from the Labrador coast.

In the Labrador Sea area, the circulation is anti-clockwise, although the dominant direction of flow is southward (Fig. 1). The Canadian current carries cold, arctic, and generally less saline water at velocities between 16 and 24 cm/s southward along the eastern coast of Baffin Island. Velocities of this current decrease to 4–6 cm/s off southeastern Baffin Island but off the northern Labrador coast they increase to about 9–11 cm/s due to the outflow from Hudson Strait. The presence of the Canadian current tends to keep water temperatures lower in the western side of the Labrador Sea.

A weaker, anti-clockwise circulation is present in the Hudson Strait–Ungava Bay area. A westerly current, influenced mainly by the Canadian current, flows along the north coast of Hudson Strait until it is deflected southward and joins the major current which carries cold water from Foxe Basin and Hudson Bay eastward. The outflow from Hudson Strait meets the Canadian current and forms the Labrador current which flows southward along the Labrador coast (Fig. 1). The velocities of these currents tend to be highest during the spring and summer when coastal drainage and meltwater add to their volume.

Along the northern Labrador coast, tidal ranges are usually between 1 and 1.5 m, except at the Button Islands at the entrance to Hudson Strait where they range from 4 to over 5 m (Canada, Canadian Hydrographic Service 1965). In Hudson Strait, tidal currents, except at neap tides, are capable of reversing the general eastward flow of water through the strait.

Figure 1
Location map of the study area. Arrows indicate the direction of the sea currents



Materials and methods

Because of budgetary and logistic problems, a large-scale coordinated project throughout Polar Bear Management Zone B was not possible. However, each spring from 1976 through 1979, we were able to mark and recapture a sample of polar bears along the Labrador coast, north of Hebron Fiord (Table 1).

Table 1
Dates and locations of helicopter surveys to mark and recapture polar bears in northern Labrador

Year	Dates	Area
1976	24–30 March	Button Islands — Hebron Fiord
1977	23–28 March	Killinek Island — Saglek Fiord
1978	19 March–3 April	Killinek Island — Hebron Fiord
1979	17–27 March	Killinek Island — Hebron Fiord

1. Tagging and recapture of individual polar bears

The techniques of immobilizing and tagging polar bears were described by Lentfer (1968) and Larsen (1971). Immobilized bears were ear-tagged, 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 1 summarizes the dates and locations of helicopter surveys to mark and recapture polar bears during 1976–79. The surveys concentrated on the landfast ice except for two brief surveys over the pack ice: one in 1976, 60 km east of Cape White Handkerchief and one in 1978, 80 km east of Saglek. The small size of the ice floes adjacent to the edge of the landfast ice made tracking, sighting, or capturing bears very difficult.

We asked Inuk hunters in Quebec and NWT to send us tags from captured bears. From these recoveries we obtained additional information on movements and survival of marked bears.

2. Recording of tracks

Whenever polar bear tracks were visible, we noted the number, their direction of travel if discernible, and the number of kilometres of available habitat flown over. Although these data do not represent absolute numbers of polar bears, they give a comparative measure of relative abundance between areas and between years in the same area, and may yield information on directions of seasonal movements.

3. Age determination

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

4. Population estimation

Based on mark and recapture data collected during 1976–79, we estimated the size of the population using a modified Peterson Index developed by DeMaster *et al.* (in press). We used an average survivorship of 0.87, with an arbitrarily assigned variance of .0037 to cover the range of survivorship from .75 to .99, to calculate the number of animals present in the population at time *i*. These values are based on survival rates calculated for polar bears in the Western Arctic (Stirling *et al.* 1976) and the High Arctic (Stirling *et al.* 1978).

5. Calculation of reproductive values

Using data from females captured with cubs of different ages, we determined several reproductive values. We used all data available from Zone B to enlarge the sample size. To calculate the age-specific litter-produced rate of females aged X years, from the data presented in Table 4, we used 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 of an age class which are accompanied by 2-year-old cubs cannot be used in the calculation of litter production because cubs may leave their mothers some time after their second birthday, and most have done so by 2½ years. Thus, females captured after their 2-year-old cubs have departed would cause an estimate to be too low. The litter-produced rate calculated in this manner applies to the time of conception and the females are not actually accompanied by cubs until the following year.

Estimates of the mean litter size use litters of cubs of any age which are accompanying their mothers. The mean litter size calculated in this fashion may be biassed to the low side if a significant proportion of the females lost part but not all of a litter. However, from a conservation-

ist's point of view, this bias minimizes the risk of overestimating productivity.

The natality rate was calculated by multiplying the litter-produced rate by the mean litter size. Age-specific natality rates could not be calculated in this study because of a lack of data. Therefore, data from all adult females were pooled.

Results and discussion

1. Distribution

For the most part, our data on distribution are limited to March–April, during which months the sea ice is the heaviest and the greatest number of bears are present along the Labrador coast. During 1976–79, we captured and individually tagged 37 polar bears along the northern Labrador coast (Table 2, Fig. 2). An additional, eight polar bears were sighted but not captured. Polar bears tended to be concentrated along the interface between the coastal landfast ice and the drifting pack ice, especially around the mouths of bays. Most bears and tracks were seen between Hebron Fiord and Seven Islands Bay on landfast ice or on floes within one kilometre of the floe edge. From satellite photos, it appears that the pack ice is closest to the land between Nachvak Fiord and Okak Bay which probably explains why more bears appear to come ashore in that area.

In addition, two polar bears were tagged in northern Labrador in 1974–75, and 10 bears in Ungava Bay in 1974 (Table 2). Even on a subjective basis, it was apparent that the density of polar bears along the northern Labrador coast was much lower than in other areas of polar bear range. For example, after a couple of days of surveying for the mark and recapture studies, it was often difficult to find new bears. We sometimes had to stop searching and wait two or three days for mixing to take place between bears on the pack and landfast ice. The best time for finding bears was usually after an onshore wind brought the

Table 2
Age and sex class of polar bears tagged in northern Labrador from 1974 to 1979, and Ungava Bay in 1974 (Single bears 2 years of age to 4 years inclusive were called subadults, bears 5 years of age and older were called adults.)

Age and sex class	N. Lab. 1974–75	Ungava Bay 1974	N. Lab. 1976–79
Adult male	—	4	8
Adult female (alone)	—	1	4
Subadult male	1	—	10
Subadult female	1	—	4
Adult female with cubs of any age	—	2	4
Cubs of the year (with ♀)			
male	—	2	—
female	—	1	—
Yearlings (with ♀)			
male	—	—	2
female	—	—	—
2-year-olds (with ♀)			
male	—	—	3
female	—	—	1
Female unclassified	—	—	1
Total	2	10	37

Figure 2
Locations at which polar bears were tagged in the study area during 1976–79

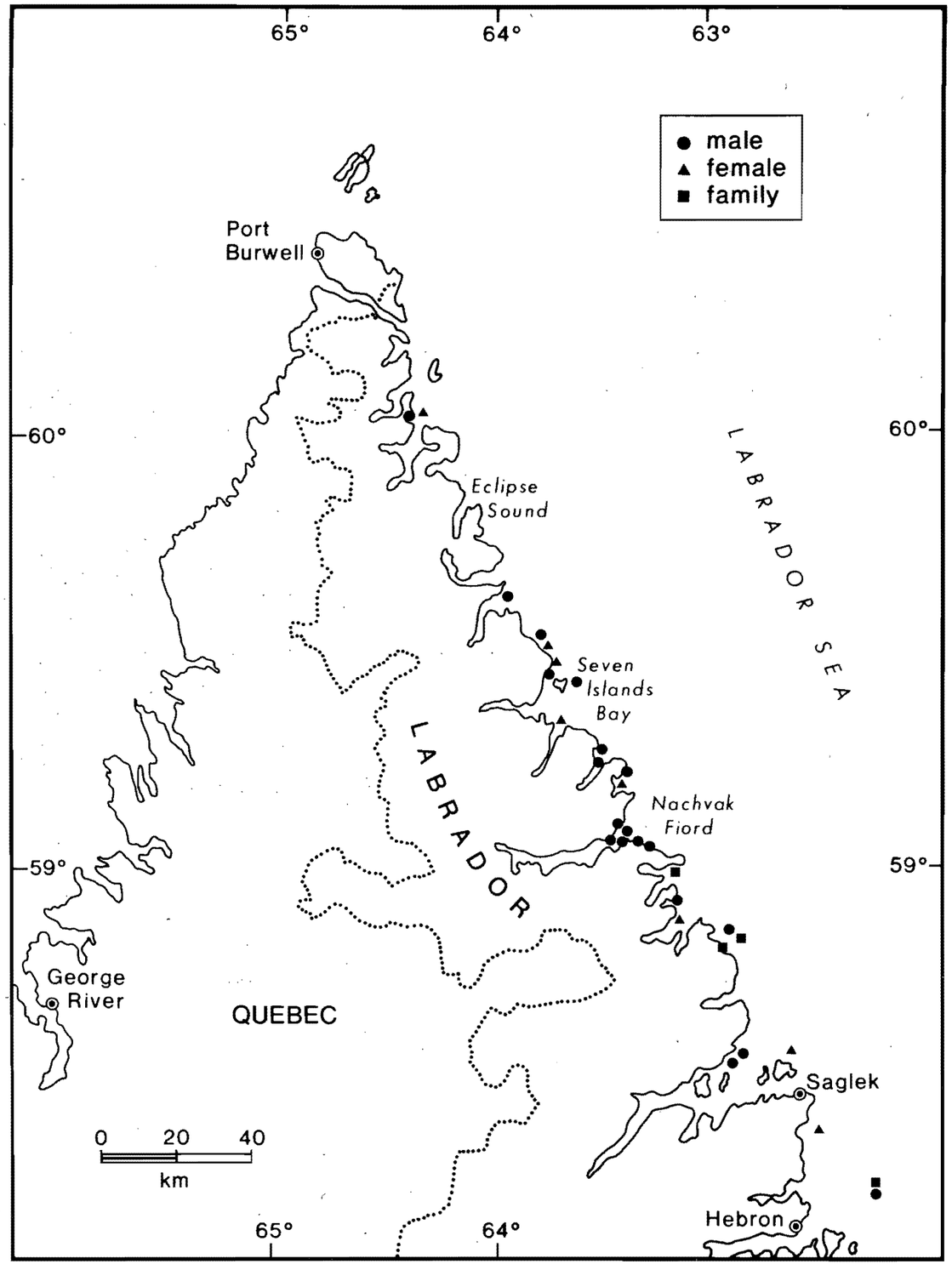


Table 3
Number of polar bears and tracks seen per 100 km of sea ice habitat surveyed along the northern Labrador coast in March–April 1976–79

Category	Year				Total km and mean values
	1976	1977	1978	1979	
No. km potential polar bear habitat surveyed	4325	2515	2910	3757	13 507
No. polar bears seen/ 100 km habitat surveyed	0.35	0.44	0.48	0.61	0.47
No. tracks seen/100 km habitat surveyed	—	3.42	4.64	2.58	3.46

pack ice up tightly against the landfast ice. However, the prevailing northwesterly winds tend to keep the pack ice away from the coast except in the area around Nachvak Fiord and Okak Bay. Fresh snow, when it occurred, greatly facilitated tracking. Because of the logistic and safety problems involved, we could not determine how many bears were present on the ice floes in the further offshore areas of the Labrador Sea. However, the presence of polar bears in the offshore floes has been well recorded by the sealing vessels that operate there in late March and early April (Smith *et al.* 1975; T. Øritsland, pers. comm.). The numbers of polar bears in that area probably fluctuates from year to year depending on the size of the ice floes and the extent of the ice coverage. For example, in March 1973 when several polar bears were killed on the island of Newfoundland (an unusual occurrence), the pack ice was heavier than normal and onshore winds blew it up against the coastline.

The mean numbers of bears and tracks sighted per 100 km of potential habitat surveyed over the four years were 0.47 and 3.46 respectively (Table 3). These values are about 50 to 80% lower than have been recorded in other areas of the Arctic (Stirling *et al.* 1975; Stirling *et al.* 1979), which further supports the suggestion of low numbers and densities of polar bears along the northern Labrador coast.

2. Movements

Six tagged polar bears were recaptured in the study area one or more years later. The only bear tagged during the May 1975 survey was killed by Inuit in the Seven Islands Bay area in March 1976. Five recaptures of four individual bears were made outside the study area. Two bears were recorded shot outside the study area by Inuk hunters, including one of the aforementioned. One bear that was originally captured outside the study area was recaptured along the northern Labrador coast.

The recorded movements of 10 polar bears captured during March–April of one year and recaptured or shot by Inuk hunters during the same period one or more years later are shown in Figure 3. Even though the sample is small, it represents more than 25% of the marked population. These data indicate that some polar bears show a fairly high degree of fidelity to the northern Labrador coast during the spring.

Figure 4 shows the recorded movements made by three tagged polar bears between seasons. The bear that moved between the northern Labrador coast and Ungava Bay was not part of the present sample (Smith *et al.* 1975) but is included here for completeness.

Despite the fact that the sample size was small, extensive movements were recorded for a fairly large proportion of the population (Figs. 3 and 4). Clearly, many of the polar bears found on the northern Labrador coast have attachments to other geographic areas. Although seven of the bears tagged on the Labrador coast during spring were recaptured or shot close to where they were originally tagged, four, including one of the above, moved quite extensively (Figs. 3 and 4).

Since the currents flow from southeastern Baffin Island south along the Labrador coast, it may be that some bears are brought there from more northerly areas every year. Similarly, bears from Hudson Strait, or possibly even from areas further west, may be carried on the sea ice by the prevailing currents through that channel until they reach the Labrador Sea and swing south. In the event of bears being moved long distances on the ice, many would probably try to return to their areas of origin. Some bears may regularly make long-distance seasonal movements, although information on this possibility is lacking.

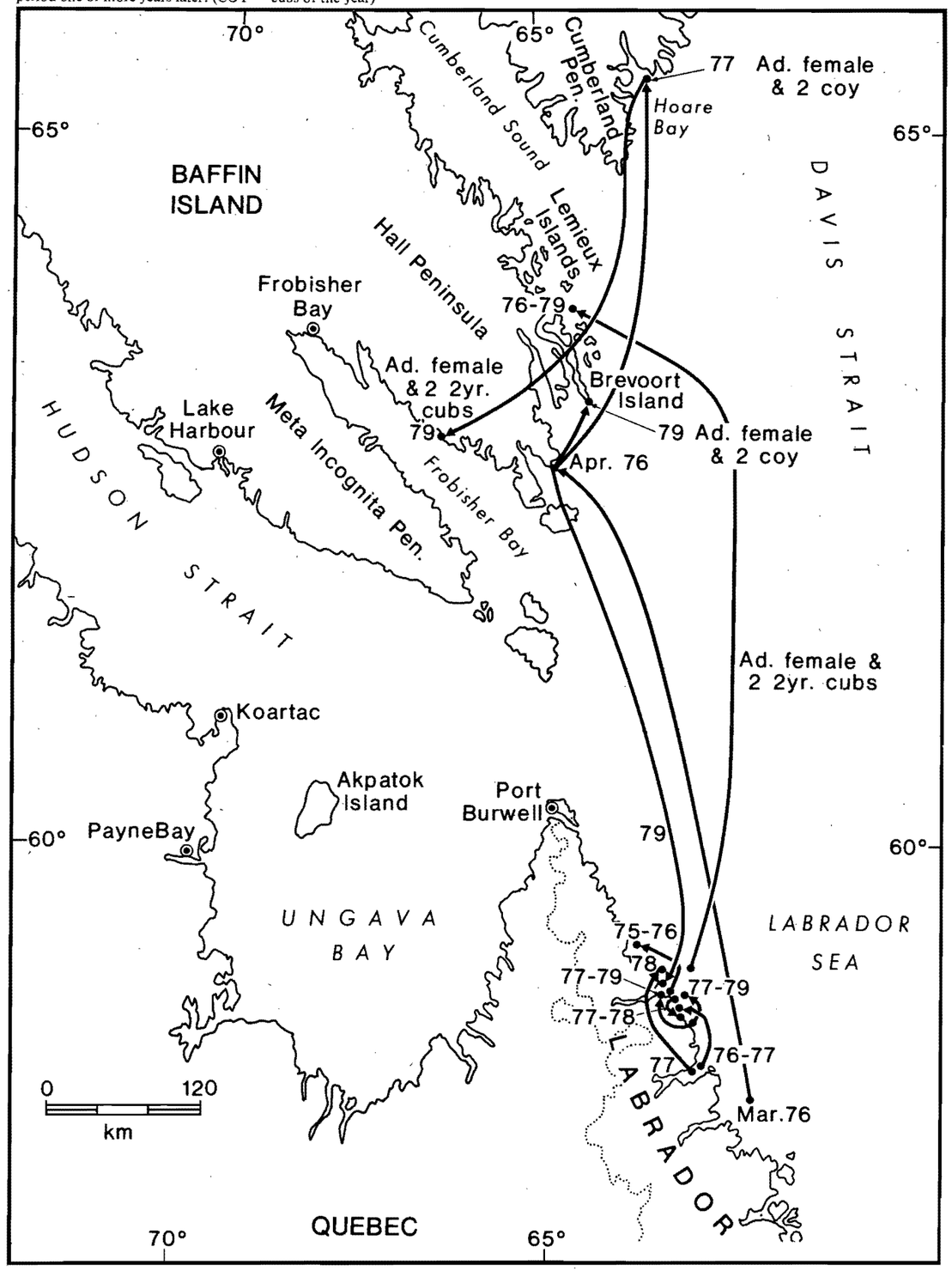
The movement hypotheses discussed above are supported to some extent by data. Grenfell *et al.* (1913) reported that every year a number of polar bears landed along the coast between St. John's and Cape Chidley and, immediately thereafter, headed northward. Similarly, many of the tracks which we sighted in Labrador during March and early April, 1976–79, were headed north, as if the bears were leaving the area. A total of 15 resightings were made on 12 individually marked bears within a few days of their being captured (Fig. 5). In all but four instances, the movements were either local (< 10 km, $n = 5$) or indicated a significant northerly component (> 10 km, $n = 6$).

Few sightings of polar bears are reported from the northern Labrador coast although we recognize that in recent years the area has not been extensively visited or surveyed. Occasional sightings of bears are made during the summer along the Labrador coast (S. Luttich, Newfoundland Wildlife Branch, pers. comm.). However, even on a subjective scale of comparison, such records are few in comparison with the numbers of sightings made in similar areas further to the north on Baffin Island or to the west on Akpatok Island (Smith *et al.* 1975; Stirling *et al.* 1979) suggesting that the resident population of polar bears in Labrador is small.

In March 1976, an adult female polar bear, accompanied by two 2-year-old cubs, was captured near Watchman Island on the Labrador coast. The subsequent data collected on the members of this family are particularly interesting in terms of the possible relationships of polar bears from southeastern Baffin Island and northern Labrador (Fig. 3). Three weeks after the initial capture, the whole family was recaptured near Cape Farrington on southeastern Baffin Island, about 525 km north of where they were first caught. A year later, in April 1977, the adult female was recaptured again 310 km further north in Hoare Bay at the end of the Cumberland Peninsula with two cubs of the year. In March 1979, when her second recorded litter of cubs was 2 years old, they were all shot by Inuk hunters about two-thirds of the way up Frobisher Bay. The female cub of the original family at 5 years of age, was captured at the south end of Brevoort Island off the Hall Peninsula in April 1979, and with two cubs of her own. The male cub of the original litter, then also 5 years of age, was recaptured in March 1979 back in Labrador, 118 km north of where he was originally captured 3 years before and 418 km south of where he was last captured.

A male polar bear, aged 8 years when he was first captured in northern Labrador in March 1976, was recaptured in the Lemieux Islands near the mouth of Cumberland Sound in early May 1979. He had lost his tags and the last number in his lip tattoo could not be read with certainty. However, he could only have been one of three bears which were all tagged in the same general area so that

Figure 3
The recorded movements of polar bears captured during March–April of one year and recaptured or shot by Inuit hunters during the same period one or more years later. (COY = cubs of the year)



he was approximately 540 km north of where he was first tagged. On the basis of the data collected on the above four bears, it seems likely that much of the normal home range of some of the bears found on the Labrador coast lies along southeastern Baffin Island. Some of these bears probably drift south to Labrador on the ice floes during the winter, possibly with some degree of regularity, and then migrate northward again during the spring.

Following their original captures in Labrador, two bears were recaptured or shot to the west during the subsequent summer or fall (Fig. 4), suggesting that they may have drifted east with the ice in Hudson Strait in early winter and were returning to their points of origin. One bear tagged on Mansel Island in Hudson Bay in summer 1978 was recaptured in Napaktok Bay, Labrador, (about 25 km southeast of Hebron) the following spring, which also suggests an eastward drift on the floe ice in Hudson Strait during the early winter.

The most interesting of these recoveries was the bear that was captured in spring 1977 on the Labrador coast, recaptured there in the spring of 1978, and then shot on Southampton Island in October 1978, a movement of over 1050 km. Unfortunately, it is not possible to know if that bear spent the whole year in Labrador or if it had gone west into or through Hudson Strait in the intervening year and returned again to Labrador on the drifting ice by the spring. In any case, the available data suggest that some of the bears found on the Labrador coast during the winter come from northern Hudson Bay and that these bears may be migrating back west through Hudson Strait during the spring. The Inuk hunters at Lake Harbour have commented that in the spring there is a movement of polar bears from east to west along the northern coastline of Hudson Strait, although the extent to which this occurs has not been quantified. A similar movement may occur along the northern coast of Quebec but it is impossible to document at present because of the lack of specimens or ear tags from polar bears killed by Inuk hunters in that area.

In conclusion, it appears, from the movement data gathered to date, and the almost total absence of data of any kind on maternity denning on the Labrador coast, that a large proportion of the polar bears found there originate from other areas.

The pattern of those movements is of particular interest in relation to the apparently low numbers of polar bears on the northern Labrador coast. From an analysis of archeological and historical records from Greenland, Vibe (1967) suggested that Baffin Bay and Davis Strait have been subjected to three main drift-ice stages, each of which has had significant ecological effects. Each stage, lasting several decades, has been repeated several times during the last 800 years. Vibe recognized three drift-ice stages:

Figure 4
The recorded movements of three polar bears moving either to or from the Labrador coast between seasons

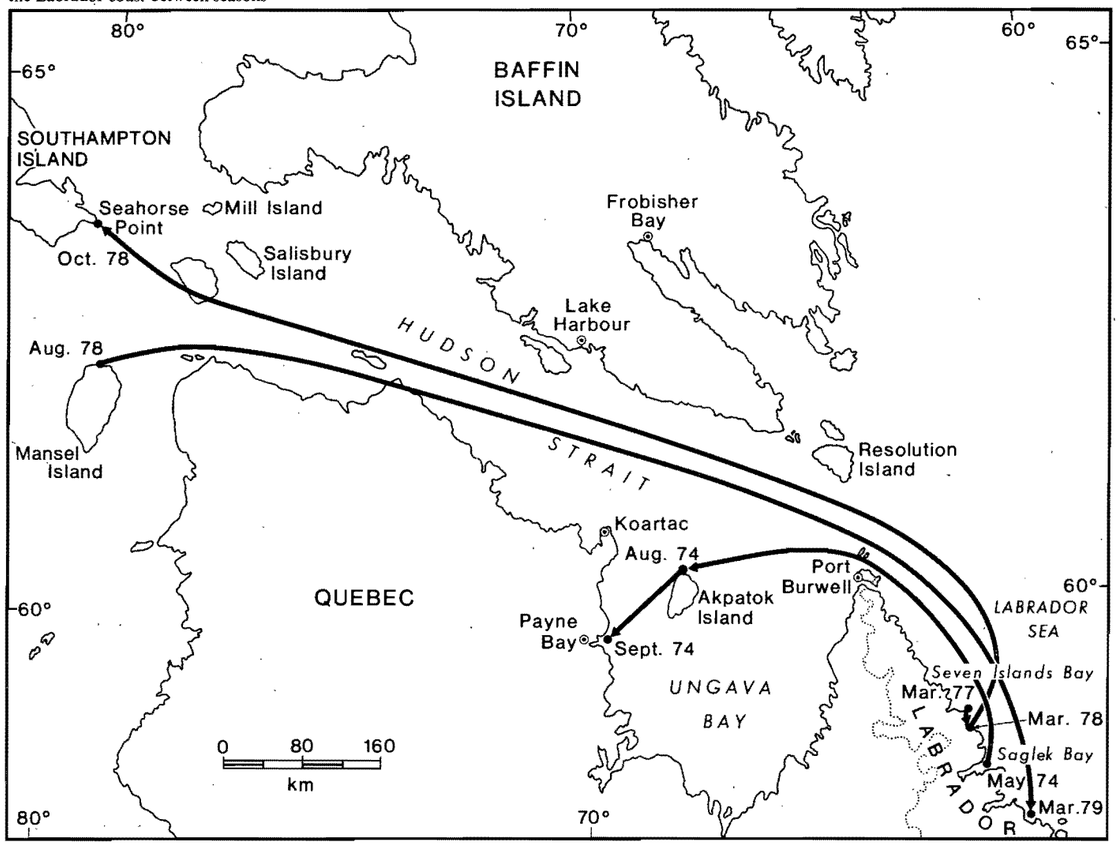
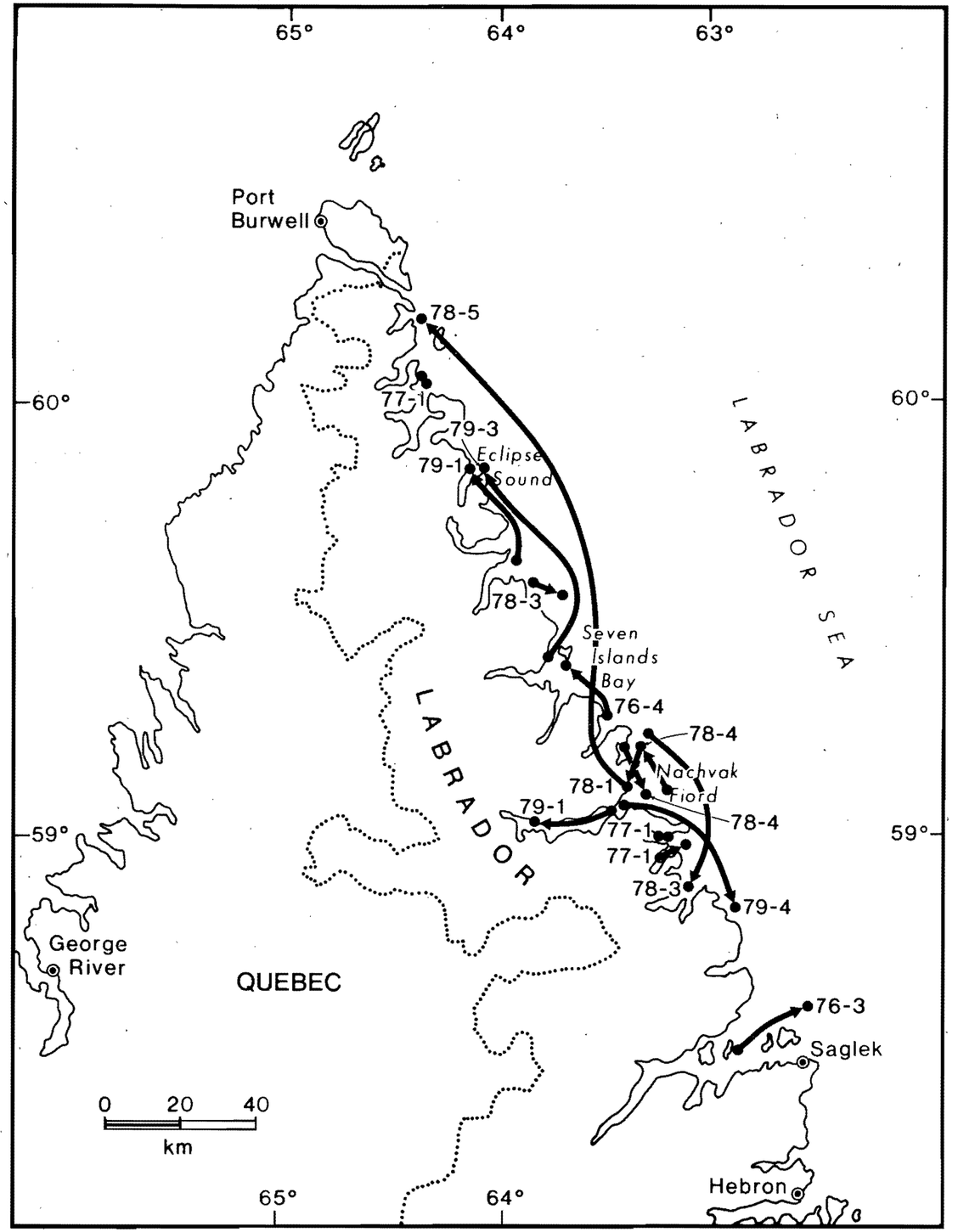


Figure 5
Movements made by polar bears which were resighted in the same season in which they were originally captured. Numbers indicate the year and the number of days between the original capture and subsequent resightings.



stagnation, pulsation, and melting. During an ice stagnation stage the climate tends to become colder and relatively small amounts of drift ice are released from the Arctic Ocean. With a gradual amelioration of the climate, vast amounts of drift ice are released. During this pulsation stage, large numbers of polar bears may be transported to areas which are outside their range during the other two stages. As the climate continues to become milder, the great advances of the ice stop and the limit of the polar bear range is shifted much further north. This constitutes the melting stage. With a deterioration of the climate back to colder conditions, the ice gradually builds up. This is the stagnation stage. Polar bear range begins to expand southward but does not reach the extent it did during a pulsation stage. At present, Vibe considers the area to be under the influence of the stagnation stage. Consequently, polar bear range is not as extensive as in the past. This may partially explain the relatively low numbers of polar bears along the Labrador coast at the present time. The observations of polar bears (summarized in Smith *et al.* 1975) on and around the island of Newfoundland by Cabot in 1497 (Markham 1893) and Cartier in 1534 (Stephens 1890), in southern Labrador by Cartwright (Townsend 1911) in the 1770's and along the entire Newfoundland coast by Grenfell (Grenfell *et al.* 1913) all fall within pulsation stages as determined by Vibe.

3. Maternity denning

Historical records suggest that there may have been more polar bears in Labrador in earlier times but the data available are not sufficiently detailed to be clear on the point. Nor do the records we are aware of specifically mention maternity denning. However, in most years the pack ice does not drift far enough south until December, so that some pregnant female polar bears may not be transported to the Labrador coast in time to den. This would, of course, preclude maternity denning except by females that had spent the summer along the northern Labrador coast.

Brice-Bennett (1977) summarized information on polar bear denning along the Labrador coast, gleaned from Inuk hunters. The basis of the data was living memory and information passed down from past generations. Based on these interviews, some maternity denning had apparently been observed in the areas of Button, White Bear and North Aulatsivik islands, and between Saglek and Seven Islands Bay. However, there was no indication of how often maternity denning might have been reported or how many bears might have utilized these areas. Also, it is unclear if denning refers only to maternity denning or to occasional denning by other bears as well, which may occur at any time throughout the winter.

Smith *et al.* (1975, p. 2) summarized the combined information from aerial surveys and Inuk reports, from 1970 to 1975, as follows:

> A possible maternity den, tracks of a female with young and a temporary den were observed on 28 March 1973 in Seven Islands Bay. George River Inuit reported an unoccupied den and tracks of a female and young in the same area on 10 March 1974, and they had taken a female and two cubs in the Eclipse Sound area in March 1970. Further south, in May 1974, tracks of females with young were observed in the Ramah Bay — Bear's Gut area.

Some maternity denning is suspected on Akpatok Island in Ungava Bay as well.

From 1976 through 1979, we surveyed 13 507 km of polar bear habitat along the northern Labrador coast. During that period, we saw no female polar bears with cubs of the year, or their tracks. Nor did we learn of any maternity dens or sightings of females with cubs that might have been reported by Inuit.

Based on our experience in other areas of the Arctic, it is our subjective impression that suitable habitat for maternity denning is relatively abundant in northern Labrador. However, even though maternity denning may have occurred in the area in the past (Brice-Bennett 1977), albeit to an unknown extent, the present data suggest that little, if any, maternity denning now occurs along the northern Labrador coast. If the incidence of maternity denning has decreased, it may have been caused by long-term climatic changes that affected the southerly drift of the pack ice, excessive hunting pressure, or a combination of the two. In southern Greenland, Vibe (1967) suggests that climatic conditions may be too unstable to maintain a large polar bear population and that thawing during winter may deter maternity denning. The effects of these environmental factors on polar bears on the Labrador coast are unknown.

Female polar bears are highly vulnerable to hunters in the fall while they are searching for a suitable denning site. In most other areas of the Arctic, these sites are close to the coast and the females walk up and down the coast for many kilometres, especially around bays, testing different snow drifts for suitability. At this time the young ice begins to form along the coastlines, particularly in the bays. Males and non-pregnant females (with or without cubs) move out onto the ice to hunt seals as soon as possible. The result is that pregnant females are easiest to track and hunt at the same time that travelling by oversnow machine is easiest. In the spring, when females and their cubs of the year first come out of their dens, they remain in the bays and along the landfast ice where, again, they are most vulnerable to hunting. Although the hunting season for Labrador Inuit has been closed since 1970, it is well known that Inuit from George River in Quebec, and from Port Burwell, NWT, until its closure in 1978, have continued to hunt on the Labrador coast in the spring. Similarly, Inuit in northern Quebec have continued their practice of unrestricted hunting of polar bears during the summer and fall on offshore islands such as Akpatok in Ungava Bay where pregnant females are likely to be prior to seeking a maternity denning site in the area (Smith *et al.* 1975). Consequently, we suspect that the apparent absence of maternity denning in Labrador may have been influenced more strongly by hunting pressure than by climatic factors. Stirling *et al.* (1975) described an apparently similar situation along the southern coast of the eastern Beaufort Sea.

4. Litter size and productivity

The available data on age and litter size of the cubs accompanying female polar bears of each age class in Zone B during 1974–79 are given in Table 4. Although the sample size from Zone B is not large enough to warrant a detailed analysis, overall values were calculated for the proportion of females accompanied by cubs of any age; litter-produced rate; mean litter size; and natality rate (Table 5). From a comparison of the reproductive values calculated for female polar bears in Zone B with those from the Western Canadian Arctic during 1971–73 or the High Arctic (Stirling *et al.* 1978, Table 5), it is clear that productivity is low in Zone B. This is probably especially true of the northern Labrador coast, as indicated by the apparent absence of maternity denning there.

Table 4
Age class and litter size of cubs accompanying female polar bears of each age class, captured or recaptured in Zone B during 1974–79

Age of ♀♀	Total no. ♀♀ of each age	No. ♀♀ accompanied by cubs of any age	Age and litter size of cubs accompanying ♀♀					
			Cubs of year		Yearlings		2-year-old	
			1	2	1	2	1	2
4	2	0	—	—	—	—	—	—
5	1	0	—	—	—	—	—	—
6	1	0	—	—	—	—	—	—
7	2	2	1	1	—	—	—	—
8	1	1	—	—	—	—	—	1
9	2	1	—	—	—	—	—	1
12	1	1	—	—	1	—	—	—
13	2	0	—	—	—	—	—	—
14	1	0	—	—	—	—	—	—
16	1	1	—	—	1	—	—	—
30	1	0	—	—	—	—	—	—

Table 5
Comparison of litter-produced rates, litter sizes, and natality rates of adult female polar bears from 4–30 years of age and the number of females 5–30 years of age from Zone B accompanied by cubs of any age compared to the Western Canadian Arctic in 1971–73 and the High Arctic from 1970–77 (Stirling *et al.* 1978). Sample size is in parentheses.

Category	Area		
	Zone B	Western Arctic (Zone H)*	High Arctic (Zone F)
(1) % ♀♀ 5–30 yr with cubs of any age	50.0 (6/12)	82.2 (37/45)	59.1 (75/127)
(2) litter-produced rate for ♀♀ 4–30 yr	0.160 (25)	0.326 (86)	0.249 (27)
(3) mean litter size for ♀♀ 4–30 yr	1.50 (6)	1.70 (33)	1.69 (62)
(4) natality rate for ♀♀ 4–30 yr	0.240 —	0.554 —	0.421 —

*Females in the Western Arctic mature one year later than they do in the High Arctic or Labrador areas. Consequently the age ranges for the Western Arctic are 6–30 for category 1 and 5–30 for categories 2 to 4.

Table 6
Age and sex composition of capture and recapture samples from northern Labrador in 1974–75, Ungava Bay in 1974, and northern Labrador in 1976-79

Age	N. Lab. 1974–75		Ungava Bay 1974		N. Lab. 1976–79	
	♂	♀	♂	♀	♂	♀
0	—	—	2	1	—	—
1	—	—	—	—	2	—
2	—	1	—	—	5	2
3	—	—	—	—	2	1
4	1	—	—	—	8	2
5	—	—	—	—	6	1
6	—	—	1	1	1	—
7	—	—	—	2	1	—
8	—	—	—	—	—	1
9	—	—	—	—	—	2
10	—	—	1	—	—	—
11	—	—	—	—	—	—
12	—	—	—	—	—	1
13	—	—	—	—	—	2
14	—	—	—	—	—	1
15	—	—	—	—	1	—
16	—	—	1	—	—	1
30	—	—	—	—	—	1
Unaged	—	—	1	—	1	1
Total	1	1	6	4	27	16

5. Age structure and mortality rates

Table 6 gives the age and sex composition of the capture and recapture samples from Zone B during 1974–79. The samples are too small to attempt to calculate mortality rates but a few qualitative points can be noted. Males outnumbered females by about 1.7:1 throughout Zone B. Only three of the males were 10 or more years of age although the older age classes of adult females were well represented. This may support the hypothesis that adult males tend to be distributed further offshore on the moving ice (Stirling *et al.* 1975).

6. Estimate of population size

The population estimates $\hat{N}_i$, based on mark and recapture data during 1976–79 only, have been relatively consistent, ranging between about 60 and 90 bears along the northern Labrador coast during spring (Table 7). Despite the small sample sizes, the consistently high annual rates of recapture, $\hat{p}_i$, and probability of capture, p(cap), indicate that the results are in the right order of magnitude and further support the suggestion of a relatively small population. It should be kept in mind, however, that this estimate only applies to the period of late winter and early spring because the data on movements indicate that part of the population moves to other areas by late spring or early summer.

Table 7
Summary of mark and recapture data from Zone B and estimates of population size ($\hat{N}$) at time i

i	1	2	3	4
Year	1976	1977	1978	1979
n_i*	11	9	8	15
m_i	0	1	2	3
R_i	11	9	8	15
$\hat{p}_i$	0	0.11	0.25	0.20
$\hat{M}_i$	—	9.57	15.29	18.52
S.E. $\hat{M}_i$	—	1.30	2.38	3.28
$\hat{N}_i$	—	87.00	61.14	92.60
S.E. $\hat{N}_i$	—	88.29	41.14	52.14
p(cap)	—	0.10	0.13	0.16

*Terms defined by DeMaster *et al.* (in press) as follows:
n_i = total no. of animals captured in the 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);
$\hat{p}_i$ = proportion 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 = $m_i/\hat{M}_i$.

7. Future management implications

The Government of Newfoundland closed the hunting season for polar bears in 1970 because of concern that the local population might be small, relatively discrete, and possibly endangered. Newfoundland did, however, reserve the right to reopen the season if subsequent research indicated it would be safe and if other circumstances indicated it would be a useful management practice.

In 1978, following the closing of Port Burwell, NWT, the quota of eight bears allocated to that settlement was divided, four to Quebec and four to Newfoundland. On the basis of present data on population size and movements, this redistribution of the quota would probably not be detrimental to the population, depending on how they were taken. However, the Labrador area is situated on the southern periphery of the normal range of the polar bear. Therefore, small environmental changes may have a greater influence on distribution, abundance, and reproduction of polar bears there than they would in more northerly regions. Future management practices should be flexible enough to accommodate such variations. Stirling *et al.* (1976) and Stirling and Latour (1978) indicate that, in the population sense, the safest management practice is to protect family groups completely and to restrict hunting to the period from 1 January to 31 May. This protects pregnant females in the fall when they are looking for dens and reduces orphaning of cubs and yearlings because the mothers are not killed. It also tends to concentrate the hunt more on the male component of the population, which is less important in the reproductive sense, and on lone subadults, which probably have a slightly higher natural mortality. In addition, harvesting polar bears in winter ensures that the hides are in prime condition and therefore achieve the greatest economic return. In recent years, this latter consideration has been a major concern to the fur auction houses (Smith 1978).

It was also hoped that closing the hunting season in Labrador would encourage maternity denning in the area. However, to date our data give no indication of maternity denning, let alone a possible increase. To an unknown extent, this could be related to present hunting practices throughout Zone B. Although hunting of polar bears in northern Labrador is forbidden, Inuit from George River in Ungava Bay sometimes hunt there. Inuit along the north coast of Quebec also hunt polar bears during the open water period on the islands where family groups of bears spend the summer. For example, in 1965 the Inuit of Payne Bay killed 27 bears on Akpatok Island and in 1973 they took all nine bears seen on the island (Smith *et al.* 1975). The Inuit in northern Quebec do not always adhere to the recommended quotas and biological specimens for monitoring the age and sex composition of the kill are rarely obtained. However, there are indications that this situation is improving. Because family groups of polar bears tend to be found on those islands during the summer, they are more vulnerable to being killed. If removal of polar bears along the northern Quebec coast during the summer and fall continues, it could help to prevent the establishment or re-establishment of maternity denning along the northern Labrador coast.

Although the data available to date are limited, maternity denning is not extensive along the northern Quebec coast, although some denning takes place on the NWT islands in Ungava Bay (Smith *et al.* 1975) and Hudson Strait. Consequently, some of the bears found in northern Quebec, like those in northern Labrador, have originated from northern Hudson Bay and southern Foxe Basin.

Smith *et al.* (1975) noted that the annual recorded kill in northern Quebec and Labrador was in the order of 30 to 50 bears, which would require 600 bears or more resident in the area if the harvest was to be sustained by a local population. To date, there are no data which indicate a population of that size. The recorded harvest in recent years has declined to between 10 and 32 bears, although problems in recording polar bear kills by Quebec Inuit preclude an accurate estimate of the harvest. It seems most likely that the majority of the bears being harvested in northern Quebec are being produced in other areas, mainly the NWT. Therefore, if Newfoundland's conservation objectives for polar bears in northern Labrador are to be achieved, management of all aspects will have to be closely coordinated with Quebec and the NWT.

8. Implications of offshore drilling

For polar bears, oilspills and blowouts present two potential threats:

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

b) that 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.

At present, we have no data with which to evaluate either of these possibilities.

The proposed drilling sites are well offshore where the prevailing currents flow south. Consequently, during the open water season, the chance of oil on the surface causing significant damage to the few bears present along the coastline is negligible.

The consequences of an uncontrolled blowout, continuing throughout the winter, are less clear. The seasonal distribution, numbers, and movements of polar bears in the offshore pack ice are not known. Thus, the potential damage is more difficult to predict. The impression gained from data on the nearshore aspects is that the overall density of polar bears on the pack ice off the Labrador coast may not be very high in comparison with other areas of the Arctic. However, those bears may represent a significant proportion of the polar bears that occur in Labrador, even if many of them are only there on a temporary basis. They may also represent part of the available nucleus from which a local population of denning polar bears might develop.

The maintenance of a logistic support base at Saglek, with its attendant local disturbance, will likely not interfere with polar bears during the summer since there are probably few there anyway. However, there is the serious possibility during both the summer and winter that bears may be attracted to the camp periodically and pose a threat to personnel and equipment. In other parts of the Arctic, a substantial proportion of the problem bears killed have been subadult males and it is evident from the age structure of the captured sample (Table 6) that these bears form a significant proportion of the polar bear population along the Labrador coast during the spring at least.

Literature cited

Brice-Bennett, C. 1977. (ed.) Our Footprints are Everywhere. Inuit Land Use and Occupancy in Labrador. Dollco Printing Ltd. 380 p.

Canada, Canadian Hydrographic Service. 1965. Labrador and Hudson Bay Pilot. Dep. Mines Tech. Surv. Ottawa. 552 p.

DeMaster, D.; Kingsley, M.C.S.; Stirling, I. (In press). A multiple mark and recapture estimate applied to polar bears. Can. J. Zool.

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

Grenfell, W.T. and others. 1913. Labrador: the country and the people. MacMillan Co., New York. 529 p.

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

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

Markham, C.R. 1893. The Journal of Christopher Columbus and John Cabot and Gaspar Corte Real. Hakluyt Soc., London. 259 p.

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

Smith, Pauline; 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.

Stephens, H.B. 1890. Jacques Cartier and his four voyages to Canada. W. Drysdale and Co., Montreal. 163 p.

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

Stirling, I.; Archibald, R.; DeMaster, D. 1977. Distribution and abundance of seals in the eastern Beaufort Sea. J. Fish. Res. Bd. Canada. 34:976-988.

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 Resour. Canada Ltd., Aquitaine Canada Ltd., Canada-Cities Serv. Ltd., and the N.W.T. Fish Wildl. Serv. 88 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.; Pearson, A.M.; Bunnell, F.L. 1976. Population ecology studies of polar and grizzly bears in northern Canada. N. Amer. Wildl. Conf. Trans. 41:421-430.

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. Manag. Serv. Dep. Environ. Edmonton. 93 p.

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

Townsend, C.W. (ed.) 1911. Captain Cartwright and his Labrador Journal. Dana Estes and Co., Boston. 385 p.

Vibe, C. 1967. Arctic animals in relation to climatic fluctuations. Meddelelser om Grønland 170(5). 227 p.

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. Bilingual publication.
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 H. J. 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