# Ringed Seal Breeding Habitat in Viscount Melville Sound, Barrow Strait and Peel Sound

T.G. Smith
K. Hay
D. Taylor
R. Greendale

ESCOM No. AI-22

Environmental-Social Program
Northern Pipelines

Programme écologique et social
Pipe-lines du Nord

A-2818
@ ACUL

AIPP REPORT 1978

# Ringed Seal Breeding Habitat in Viscount Melville Sound, Barrow Strait and Peel Sound

T. G. Smith
K. Hay
D. Taylor
R. Greendale

Arctic Biological Station
Fisheries and Marine Service
Fisheries and Environment Canada

Published under the Authority of
the Hon. J. Hugh Faulkner
Minister of Indian and Northern Affairs
and the Hon. Len Marchand
Minister of State (Environment)
Ottawa, 1979
INA Publication No. QS-8160-022-EE-A1
ESCOM Report No. AI-22

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

RÉSUMÉ

Deux habitats servant à la reproduction ont été inventoriés en 1975 et en 1976 et se sont avérés semblables du point de vue de la densité des aires de mise bas. On trouve la plus grande quantité de ces aires de mise bas dans le détroit de Barrow, à l'est de l'Île Lowther, dans la baie Aston, dans le nord-ouest de l'Île Somerset et à l'entrée du détroit de Peel. Des inventaires aériens ont démontré que les phoques étaient répartis de façon comparable durant leur séjour sur la banquise. Des estimations de population s'appuyant sur des comptages faits dans les aires de mise bas ont démontré qu'il était possible de sous-estimer grandement l'importance des populations lorsque l'on procède à des comptages aériens des phoques qui séjournent sur la banquise. Des échantillons biologiques prélevés dans la région ont démontré qu'une population adulte en santé l'occupait pendant l'hiver. Nous identifions certaines régions à forte densité de population de phoques et qui constituent de plus des territoires traditionnels de chasse pour les Inuit de Resolute, et nous recommandons que ces régions soient laissées intouchées.

ABSTRACT

Two breeding habitat surveys in 1975 and 1976 revealed the same pattern of birth lair densities. The highest number of birth lairs were found in Barrow Strait east of Lowther Island, in Aston Bay on Northwest Somerset Island and at the head of Peel Sound. Aerial surveys showed comparable seal distributions during the haul-out period. Population estimates based on the birth lair estimates indicate that gross underestimation of population size are possible when based on aerial counts of hauled-out seals. Biological samples taken in the area show a healthy adult population occupying the area during the winter months. Certain areas of high seal density that are also traditional hunting areas for the Inuit of Resolute are identified, and it is recommended that they be left undisturbed.

ACKNOWLEDGEMENTS

We wish to thank the Polar Continental Shelf Project and especially Mr Fred Alt of Resolute for providing lodging, equipment and logistical aid throughout this study. Memogana of Holman, with his amazing knowledge of the sea ice habitat, made the 1976 survey the success it was. Brian Beck, Hagagiak and our Labrador bitch Bug were valuable field assistants. Gary Sleno and Stephanie Lilly provided much of the logistic and technical assistance during the study.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

# 1. INTRODUCTION

This study has as its primary objective the assessment of the fast ice as breeding habitat for the resident ringed seal populations of Viscount Melville Sound, Barrow Strait and Peel Sound. An attempt is made to derive estimates of population size for the areas under consideration as marine crossing routes for the Arctic Islands gas pipeline.

## 2. CURRENT STATE OF KNOWLEDGE

The Barrow Strait and Peel Sound areas, examined in this study, are adjacent to Lancaster Sound, an area unique in the arctic. While few studies have been conducted there, it is apparent from preliminary oceanographic investigations (e.g. Apollonio 1965) and the presence of large seabird colonies (Barry 1961, Nettleship 1974) that this may be one of the most productive areas of the high arctic.

The presence of an open water area throughout the winter in the mouth of Lancaster Sound is a consistently important feature to the high arctic marine mammal populations. Species such as the narwhal *Monodon monoceros*, the white whale *Delphinapterus leucas*, and the walrus *Odobenus rosmarus* are dependent on ice-free areas for over-wintering. The ringed seal *Phoca hispida* and to a lesser extent, the bearded seal *Erignathus barbatus* are both adapted to life in a fast ice habitat. Harp seals *Pagophilus groenlandicus* are only present in the summer months after breakup of the fast ice. There are also reports of the harbour seal *Phoca vitulina* and the hooded seal *Cystophora cristata* being taken very infrequently in the northern Baffin settlements of Pond Inlet and Arctic Bay (Bissett 1967b).

In the area concerned, only the village of Resolute Bay harvests marine mammals. Bissett (1967a) gives harvest statistics which show that the area is not a very important harvesting area compared to many other arctic localities. The greater opportunity for wage earning in this community makes hunting much less important in the total economy.

In 1975, fifty preselected points were reached by helicopter and searched for subnivean ringed seal lairs during the breeding habitat survey in Barrow Strait, Viscount Melville Sound and Peel Sound. Later on, beginning in mid June, a fixed-wing survey was flown to count the number of seals hauled out on the ice during the moulting period in the same areas. From mid June to late July daily counts and behavioural notes were made on seals hauling out on the fast ice of Aston Bay, Somerset Island. Many recordings of under-water vocalizations were made during this period. Biological specimens were also collected.

In 1976 three men with two snowmobiles left Holman on western Victoria Island, crossed the island due east from the end of Prince Albert Sound and proceeded north along the western shore of M'Clintock Channel to the Byam Martin Island and Melville Island areas. The overland and over-ice survey was begun 14 April 1976 and terminated at Resolute Bay on 28 May 1976 after 2,300 miles had been covered. The primary goal of the survey was to conduct more extensive birth lair searches in the areas that have been designated as gas pipeline crossing routes.

In 1977 a study of ice distribution, formation and deformation was made from such information sources as LANDSAT satellite imagery, ice observer reports and notes made during the previous surveys.

## 3. THE STUDY AREA

The area studied is bounded in the west by eastern Melville Island and northern Stefansson Island, in the east by Maxwell Bay on south Devon Island and Prince Leopold Island, to the north by southern Bathurst, Cornwallis and Devon islands, to the south by northern Prince of Wales and Somerset islands.

The area of Lancaster Sound to the east of the study area does not freeze over completely during the winter (Pilot of Arctic Canada, Dept. Energy, Mines & Resources, Ottawa, 1970). Barrow Strait, Peel Sound and the northern channels between Cornwallis, Bathurst, Byam Martin and Melville islands usually have a solid cover of primarily first-year ice by early December. Viscount Melville Sound and M'Clintock Channel, which form the western and southern boundaries of the area studied, are made up of a mixture of multi-year ice floes and areas of highly pressured first-year ice.

Fig. 1 shows the sites searched in 1975 for birth lair density estimates. Fig. 1 also indicates the routes and study areas in the 1976 birth lair survey. Fig. 2 indicates flight paths and densities of hauled-out seals observed during the 1975 fixed-wing aerial surveys. Fig. 3 shows the Aston Bay study area on northwestern Somerset Island.

# 4. METHODS

## 4.1 Breeding Habitat Surveys

The period 8 May to 2 June 1975 was spent travelling over the whole study area by a Bell 206 B helicopter equipped with global navigation equipment. During this period, 50 preselected sites (Fig. 1) were searched for the subnivean lairs of the ringed seal using the method described in Smith & Stirling (1975) and Smith (1976). During each half hour of search time, an estimated area of 3.4 $km^2$ was covered.

In 1976 (Fig. 1) areas were searched for varying periods of time during which the total time elapsed and area coverage estimates were made. Since travel was by snowmobile, much larger sections of sea ice were covered and an attempt was made to look at varying types of ice within each large area. These ice types included pressure ridges, hummocky ice, unstable nearshore areas of rough ice and areas of highly pressured ice in offshore areas.

Each birth lair survey area was mapped using standard plane table survey techniques. A sub-area within the larger search area was thoroughly searched. All subnivean lairs were marked and described and each lair was then mapped from a central location using a plane table. Distances between lairs were further checked by actual measurement using a Trumeter measuring wheel.

## 4.2 Fixed-wing Survey of Hauled-out Seals

The ringed seal is most conveniently surveyed after mid June in the high arctic, when it hauls out on the sea ice during its annual moult. Surveys were carried out in various regions of the study area from 16 June to 28 June 1975. Surveys were not conducted on 17, 19, 20 and 21 June due to weather at Resolute and the surrounding district.

The survey technique used is described by Smith (1973b). The aircraft used was a twin-engined, high-winged Cessna 337 Skymaster. Two observers participated in the survey, one located in the copilot's (right front) seat and the other in the left rear seat. The width of the strip

surveyed was one half mile (0.8 km) on each side of the aircraft, each observer recording onto a tape recorder all information on seals located within this strip. The width of the strip at 300 ft (91.4 m) altitude was calibrated by means of specific landmarks at Resolute. Marks were made on the aircraft windows and wing struts to provide an angle of sight that intersected the ground at a point one half mile from the airplane. The total width of the strip or transect surveyed was thus one mile (1.6 km). The survey altitude was 300 ft (91 m) and this altitude was maintained throughout a day's surveying by the aircraft's altimeter and appropriate airport altimeter settings. An average speed of 130 mph (209 km/h) was maintained during the survey.

In each geographic region of the study area, coastal and offshore (cross-channel) transects were flown on specified days. Each transect originated and ended at specific geographical points. In the case of cross-channel transects, specific compass bearings were maintained with slight in-flight corrections which enabled the transect to end at a pre-determined coastal point. The right front observer navigated during coastal surveys. Coastal surveys were flown one half mile (0.8 km) offshore. Flights were carried out from 0900 to 1500 hours.

Each transect was divided into two-minute intervals (quadrats) by the use of a timer operated by the rear observer. During each two-minute interval, each observer recorded the following information on tape:

1. Information on seals:

   a. Number of seals at each crack or breathing hole in the ice.
   b. Presence of pups if detected.
   c. Number of breathing holes unoccupied by seals.
   d. Reaction of seals to the aircraft.

2. Information on polar bears *Ursus maritimus*:

   a. Polar bears sighted.
   b. Polar bear tracks sighted.
   c. Seal carcasses resulting from bear predation on seals.

3. Information on weather and sea ice types.

The observations used in analysis are those that were on-transect (seals located by observers within the one-mile wide strip). Seals seen off-transect were also noted but excluded from computations of density.

Since the objective of the survey was to determine densities of ringed seals hauled out on the ice in various coastal and offshore regions, division of each transect into two-minute quadrats was essential. At an average ground speed of 130 mph (209 km/h), each two-minute interval provided coverage of about 11.2 $km^2$. However, since densities in various inshore and offshore marine locations were desired, the mean density of seals on all transects flown within a given region was calculated. For offshore regions the area censused was calculated by determining the linear distance flown during cross-channel transects. Inshore densities were computed on the basis of two-minute quadrats (11.2 $km^2$), since the linear distance tracked during coastal surveys was difficult to estimate from maps.

## 4.3 Behavioural Study and Biological Samples

A camp was established at Aston Bay (Fig. 3) on 3 June and remained occupied until 6 July 1975. Daily counts of hauled-out seals were conducted to determine the peak of the haul-out period. A number of 24-hour studies, with counts at two-hour intervals, were also carried out to determine the diurnal peaks of animals lying on the ice. Eighty-seven ringed seals and one bearded seal were collected, mostly near the mouth of Aston Bay, in order to determine the age structure of the animals in the area. Tissue samples were collected for mercury analyses (Smith & Armstrong 1975) and standard biological measurements were taken (Smith 1973a). Reproductive tracts, jaws and stomach contents were collected and preserved.

## 4.4 Ice Study

The main sources of information used for summarizing general winter ice conditions in the area studied (72°-76°N, 90°-106°W) were the ice observers' reports and charts for the years 1964 to 1977 (Anon. 1964-1977). LANDSAT satellite imagery for the years 1973 to 1977 added valuable information on the total ice cover. More

detailed observations were obtained from Lindsay (1975). A general winter ice condition chart was derived from these sources. Zones of predominant multi-year ice, of offshore first-year ice and of sheltered coastal ice were defined and the area covered by each ice type was measured using an acreage grid. The variations in the location of the floe edge (limit of the solid pack) in Barrow Strait and Lancaster Sound were examined for the years 1964-1977. Area measurements were adjusted to those variations.

Using information extracted from Lindsay (1975) the pressure ridge systems in Byam Channel and Wellington Channel were studied in an attempt to determine the extent of annual variation and identify constant features.

# 5. RESULTS

## 5.1 Breeding Habitat Surveys

Table 1 lists the numbers and type of structures found and the mean snow depth across the search sites in 1975. Structures marked ? in Table 1 were sites which were strongly indicated by the trained dog but were not located by us through digging because they were covered with pressure ice slabs. These have been included in the totals for calculations of lair density because past experience has shown us that the dog is almost always right.

Excluding site 18, which was a search along a pressure ridge, the standard searches yielded a mean of one lair or breathing hole every 12.7 minutes and one birth lair every 38.7 minutes. Identical searches in the inshore areas of Amundsen Gulf in 1973 (Smith & Stirling 1975) have yielded one birth lair every 38.4 minutes. However, there are strong indications in that area that there has been some marked annual fluctuations in lair density (Smith & Stirling 1978).

Highest mean total lair densities were found in the Aston Bay area where sites 3, 4, 33 and 46 yielded 4.0 subnivean structures per 0.5 hour search. This was followed by Barrow Strait south of Cornwallis Island (sites 6, 30, 35, 46) where a mean of 3.25 structures was found. Site 45, the search area nearest to the floe edge in this study, yielded 11 subnivean structures, the highest total in the survey. The Peel Sound area (sites 15, 16, 17, 31, 32, 47, 48) had the next highest average of 2.7 structures per search site. The largest number of sites considered was in the proposed crossing route between Bathurst and Prince of Wales Island (sites 10, 19-28 and 37-41) which yielded an average of 2.6 structures per search.

Sites 1, 2 and 11-14 between Byam Martin and Bathurst islands yielded only 1.5 structures per search. No structures at all were found in the extremely flat ice between Byam Martin and Melville islands (sites 42, 43, 44). However a number of well defined pressure ridges in this area contained breathing holes and lairs as shown by polar bear excavations (digs) seen from the helicopter. In Baring Channel, between Russell Island

and north Prince of Wales Island (sites 7-9), only 1.3 structures were found per site. In addition two bearded seal breathing holes were found there. The only other evidence of bearded seals was found at sites 16, 23 and 28.

A ground search was conducted in the area between Resolute Village and the first point east of Resolute, bounded to the south by Griffith Island (Fig. 1). The search pattern was different from the helicopter survey standard search, since the dog was allowed to run into the wind and was followed using a snowmobile. A much greater area per unit time was covered but no estimates are yet available as to the extent of ice surface covered. A total of 75.6 minutes of searching was done on 26 May. This yielded one subnivean structure every 4.45 minutes and one birth lair every 7.56 minutes. This compares well to one birth lair every 6.2 minutes found in the same way in the nearshore Iluvilik area south of Holman on Victoria Island in 1973 (Smith & Stirling 1975).

Fig. 1 shows the eleven principal study areas covered in 1976. Area 1 was located in a field of extensive multi-year floes. This extended approximately 80 miles due north from the northeastern tip of Stefansson Island. The ice consisted of large multi-year floes which had frozen in and which were surrounded by vast areas of heavily pressured ice. Upon our leaving the immediate coastline of Stefansson Island, we noticed that all signs of the major predators of ringed seal, the polar bear and arctic fox *Alopex lagopus*, were virtually absent. Our travel route took us due north from the northeastern tip of Stefansson Island through 86 miles of multi-year pressured ice. Area 1, a station searched for 30 minutes, yielded no subnivean structures.

The second search area (Table 2, area 2) was located in Byam Channel. Areas along the immediate shoreline of western Byam Martin Island were characterized by small pressure ice and ice hummocks extending approximately 1-2 miles to the west. These are generally considered to be of an intermediate value to breeding ringed seals as birth lair sites. Several large pressure ridges crossing Byam Channel from east to west were seen in this area and may be consistent features since they were also observed in 1976. These pressure ridges are

generally thought to be areas of good to excellent cover for birth lairs. A fair number of haul-out lairs were seen with some indication of breeding males in the area, but only one birth lair was located in over 70 minutes of search time.

Search area 3 was located approximately 18 miles to the east of Langley Point on the eastern shore of Byam Martin Island. The area formed the northern boundary of an extensive region of pressured first-year ice located at the southern extremity of Austin Channel. It extended from nearshore on the west coast of Byam Martin Island, east across Austin Channel, continuing along the south coast of Bathurst Island, and as far to the east as Brown Island in the region of Resolute Bay. This whole area of Barrow Strait was impenetrable by snowmobile.

This search area, between Byam Martin Island and Bathurst Island in the Austin Channel, was a region of flat ice crisscrossed by several low pressure ridges running in random directions. It also contained varying degrees of pressured first-year ice. The study area selected contained all types of ice and yielded less subnivean lairs per unit search time than the area of Byam Channel. Again a low density of birth lairs was seen (Table 2, area 3).

Search area 4 was located on the western side of Bathurst Island, in and immediately to the west of de la Beche Bay. The bay ice was relatively flat, containing hummocky ice and relatively deep snow drifts. The ice at the mouth of the bay formed a ridge of pressure ice, immediately to the west of which was relatively flat ice containing low lying ridges and old winter leads. This area (Table 2, area 4) contained significantly higher numbers of birth lairs. The amount of bear activity in the area increased noticeably and several bear sightings were made during our stay there.

Search area 5 was located on the northern border of an extensive patch of rough ice between Brown Island and Griffith Island immediately to the south of Resolute Bay. Ice in this area consisted of flat stretches containing low pressure ridges and fields of hummocky ice. Signs of polar bears decreased noticeably which was likely due to the increased number of Inuit hunting out from Resolute Bay. Birth lair densities were less

than those found on western Bathurst Island (Table 2, area 5).

Search area 6 was located between Resolute Bay on Cornwallis Island and Griffith Island, directly to the south of the village. This contained in its eastern extremity a large amount of heavily pressured first-year ice. The search area, located on the edge of this heavily pressured ice, was in relatively stable ice containing high pressure ridges and flat expanses with old winter leads. Subnivean lair density was similar to those found in area 5 (Table 2, area 6). It was noticeable in this search area that there was a total absence of predator activity. No signs of either arctic fox or polar bear digs were seen. This again is attributed to the close proximity of the village and increased Inuit traffic.

Search area 7 was located on the eastern shore of Lowther Island. The area immediately bounding the shore was made up of heavily pressured first-year ice. Just past this fringe lay an area of relatively stable ice containing low ridges and ice hummocks. To the north along Lowther Island an extensive area of heavily pressured first-year ice was found which extended toward the north and northwest. This appeared to be the southern extent of the heavily pressured ice encountered during our travels across the southern tip of Bathurst Island.

Lairs were found in all types of ice in the Lowther Island study area. A higher density of total subnivean structures was seen here than in any of our previous study areas. Most subnivean structures, however, consisted of haul-out lairs or breathing holes and the density of birth lairs was relatively low. Large numbers of bears and many signs of bears were seen in the vicinity.

Search area 8 was located 12 miles to the east-northeast of the previous search area on Lowther Island. The ice in the area was stable with intersecting low lying pressure ridges and old winter leads. Most of the subnivean structures found at this search site were located in either the old leads or low pressure ridges. Since this was one of the last sites searched in the study, the leads had actually begun to reopen and several fresh

cracks were seen. In this area a higher density of total subnivean structures was found than in the Lowther Island search. A higher number of birth lairs was also located (Table 1, area 8).

Search area 9 was located off Palmerson Point on the northeastern tip of Russell Island. The area consisted of a fringe of hummocky ice along the north shore of Russell Island extending approximately one mile offshore. From the northeastern tip of Russell Island a series of low lying pressure ridges and winter leads radiated generally in a northeasterly direction. The overall lair density on Russell Island was comparable to the other search areas immediately to the northeast of it. Very few birth lairs were found in this area. Not shown in Table 1 is a search made along one old winter lead. During this search 76 breathing holes were found over a distance of 1937 metres giving an average distance of 25.5 metres between breathing holes. The area appeared to be heavily utilized by seals concentrating along these old cracks. During the search period in the Russell Island area an increasing number of seals began to scratch open the breathing holes and haul out onto the surface of the ice.

Aston Bay (search area 10), located on the northwest corner of Somerset Island, contained several different ice types. The inner regions of the bay consisted of flat, first-year ice into which had frozen a significant number of pieces of second-year ice which had apparently floated into the bay during the previous summer. The outer regions of the bay contained a fringe of medium pressured first-year ice. Outside the mouth of the bay at the southwestern corner was an area of heavily pressured first-year ice. The area immediately inside the mouth of the bay contained numerous intersecting low lying pressure ridges and old winter leads. Table 1 shows that a relatively large number of subnivean structures was found in Aston Bay and at its mouth. Birth lair densities for Aston Bay were comparable to the areas east of Lowther Island and to the de la Beche Bay region on western Bathurst Island.

Search area 11 was located at the mouth of Peel Sound approximately 7 miles to the west-northwest of Aston Bay. The ice in this region consisted of stable, flat ice containing occasional low pressure ridges and ice hummocks. This area contained a similar density of total subnivean structures and birth lairs to the Aston Bay area (Table 2, area 11).

## 5.2 Mapping of Breeding Habitat

Five maps were made during the birth lair surveys. Their locations are indicated by the large dots on Fig. 1. Table 3 lists the subnivean structures and the evidence of predation found in each of the mapped areas. In order to derive a minimum estimate of the surface area searched, the longest distance from the datum (plane-table point) was used as the radius of the circle whose area was to be calculated. This is thought to give estimates of lair densities (Table 3) which would be somewhere between the maximum and minimum possible, depending on how the particular search area was defined.

Fig. 4 shows schematically the development of the type of situation which leads to a typical distribution of subnivean structures in a small part of the ringed seal breeding habitat. Areas of heavily pressured ice containing much multi-year ice are thought not to contain a significant number of breeding seals. Areas of extreme pressured first-year ice, especially near shore, contain seals as seen by bear activity but cannot be evaluated effectively by the techniques used during this study. Generally ringed seals are found in significant quantities in relatively stable first-year ice. Smith & Stirling (1975) have described the sequence of events leading to the formation of subnivean structures and the different kinds of lairs. Both the ice stability and the snow cover are important in determining whether seals will maintain breathing holes in an area and, later, if these holes will develop into a subnivean structure.

Although direct observational data are lacking for the early fall months, when ice is forming and breathing hole site selection is taking place, a number of assumptions can be made. It is likely that seals stay with the last areas of open water (Fig. 4a), given that other requirements such as availability of food are equal. One would expect that breathing holes would be located along cracks, pressure ridges and small localized pressured areas, termed ice hummocks, and along the edge of these areas. This is in fact what is seen later on when the ice has finally stabilized (Fig. 4b, c). Eventually, when the ice cover is fast, a typical situation containing all components can be represented as in Fig. 4d.

## 5.3 Fixed-wing Survey of Hauled-out Seals

### 5.3.1 Geographic variation in seal density

Densities of ringed seals on fast ice are given in Tables 4 and 5, for coastal and offshore areas respectively. These values represent average densities on all transects in a particular geographic area. For comparative purposes, approximate values of density for these same areas have been extracted from Fig. 12 in Finley (1976), who conducted surveys for LGL Ltd. over the same study area (except Viscount Melville Sound) from 1 June to 9 July 1975. The survey technique was identical to our own, although the Global Navigation System gave them more precise headings on cross-channel transects and a radar altimeter permitted the maintenance of a more precise altitude. Finley (1976) used a Cessna 337 aircraft.

The densities of ringed seals in coastal areas are similar to those given by Finley (1976). The overall coastal density was 0.69 seals/km$^2$, compared to 0.53 seals/km$^2$ obtained by Finley. The two sets of values are similar where density is high (e.g. N. Prince of Wales Island and Russell Island), or where coverage was intensive (e.g. Aston Bay). In some coastal areas the values are very different, probably due to a difference in the amount of coverage of the areas and the date of the surveys. Finley (1976) surveyed the Austin Channel and Byam Martin Island area on 1 July while we surveyed this area on 16 June, which could account for the large difference in density observed between the two surveys. There is evidence for movement of ringed seals into coastal embayments in late spring, thus artifactually increasing the density of the local population. In general, however, there is good agreement between the two surveys.

Table 5 provides values of density of ringed seals in offshore areas. There is good agreement between our data and values extracted from Finley (1976). The disparate values for the Graham Moore Bay area can be explained by the difference of timing of the two surveys; we surveyed this area on 16 June while Finley surveyed the area on 1 July.

According to Tables 4 and 5, coastal densities of ringed seals are greatest along N. Somerset Island, N. Prince

of Wales Island, Russell Island, coastal Peel Sound, and Aston Bay, while the highest densities in offshore regions occur in S. Wellington Channel and Barrow Strait. Densities are generally low in the western part of the study area, including Viscount Melville Sound (0.34-0.42 seals/km$^2$) and Graham Moore Bay (0.29 seals/km$^2$). On a transect from Lowther Island to southeast Melville Island, Finley's (1976) Fig. 12 shows a density of less than 0.19 seals/km$^2$. The floe edge, an area of unstable ice, supported very few hauled-out ringed seals.

Finley (1976) has calculated a somewhat higher overall density for offshore areas (0.88 seals/km$^2$) than that computed in our study (0.56 seals/km$^2$). The area of greatest density in both surveys is Aston Bay and offshore Peel Sound adjacent to the mouth of Aston Bay. Maximum densities recorded in Aston Bay are 8.62 seals/km$^2$ (Finley, Davis & Richardson 1974) and 7.66 seals/km$^2$ (Aston Bay ground study).

Finley (1976) calculated an overall density of 0.68 seals/km$^2$ during the LGL survey while our overall density is 0.61 seals/km$^2$.

Table 6 presents average densities on north-south transects across east Barrow Strait as a function of distance to the west of the floe edge at Prince Leopold Island. There is no consistent change in density proceeding westward from the floe edge, and it is apparent that seal density is variable from one locale to another in a large marine area and probably dependent on such factors as age and stability of ice, snow cover, and food availability.

### 5.3.2 Utilization of breathing holes and cracks by ringed seals

Table 7 shows that groups were twice as large at cracks (3.2) as at breathing holes (1.53). The greatest number of seals seen at a single hole was 25, while up to 100 could be seen at a single crack. Holes were more highly favoured by seals than sea ice cracks, with 75.1% of the seals hauled out near breathing holes. We also found that about one half of the observed breathing holes had seals hauled out beside them (Table 7).

No consistent change in utilization of cracks and holes by seals over the course of the aerial survey could be identified.

5.3.3 Ground counts at Aston Bay and concurrent aerial surveys

Results of ground and aerial surveys of Aston Bay on 20, 25 and 28 June are shown in Table 8. On 20 June the seal densities from ground and aerial counts were very close (3.80 and 3.73 seals/$km^2$, respectively) but on 25 and 28 June the ground counts were considerably higher than aerial counts (4.15-4.21 seals/$km^2$ and 2.42-2.91 seals/$km^2$, respectively). Glare from the ice decreased aerial detectability of the seals on 25 June, but the reasons for underestimation of density by the 28 June aerial survey are not clear. All of the aerial surveys were flown along the north coast of Aston Bay, an area also surveyed from the ground observation site.

Table 8 also shows that the aerial survey overestimated the proportion of seals using breathing holes. The trend of variation in this proportion with date is the same for both the aerial and ground censuses.

5.4 Behavioural Observations, Aston Bay

Table 9 lists the maximum daily counts of ringed seals hauled out on the ice of Aston Bay on the northwest corner of Somerset Island (Fig. 4). The visibility scale 1-5 has the following meaning: (1) inaccurate over 3 miles; (2) inaccurate over 4 miles; (3) inaccurate over 5 miles; (4) inaccurate over 6 miles; (5) visibility 8 miles; includes whole study area.

Seals were listed as occurring along leads or at breathing holes (Fig. 5). Two major leads opened early in the counts of the Aston Bay study area (Fig. 4). During the period 4 to 30 June a higher proportion of seals was seen along the leads than at breathing holes. After 1 July the opposite was true. This is believed to be caused by the wetness of the ice along the leads during the heavy melt period. Seals at this time selected the drier sites near the breathing holes from which to haul out.

There was a gradual build-up of numbers throughout the study period. Although rain and strong wind appeared to

affect the numbers, this did not obscure the trend toward higher numbers as time progressed. A maximum count of 671 was obtained from the Aston Bay study area on 7 July. This represents a maximum density of 7.66 seals/$km^2$.

Several counts were made on each observation day whenever conditions permitted. Table 10 shows the number of seals expressed as a percentage of the highest count each day. On 17, 18 and 19 June counts were made periodically throughout the day and night. The maximum number of seals on the ice was seen between 1300 and 1700 hours (Fig. 6). This agrees with previous studies on the diurnal haul-out pattern (Smith 1973a, 1973b). In many cases the counts were begun at 0900 hours and these were the highest counts seen during the day. Often visibility changed during the day and affected the counts, or local weather conditions such as heavy rain on 28 June drove the seals into the water. Excluding such days with adverse weather conditions, the minimum number of seals present during the time period 1300 to 1700 hours was 52% of the daily maximum (Table 10).

## 5.5 Biological Collections

### 5.5.1 Aston Bay samples

Eighty-six ringed seals and one bearded seal were collected near and to the north of the mouth of Aston Bay. The sex ratio of the ringed seals did not depart from unity (45M : 41F). Eighty-two percent were collected by shooting them beside leads or cracks, the remainder being shot after they hauled out of a breathing hole. Only 13% of all seals had recently fed. Of these, 33% (5/15) were shot at night (2100-0900) and 10.3% (6/58) were shot during the day. Ringed seals have previously been noted to be crepuscular feeders (Smith & Geraci 1976) and a larger sample of seals collected at night would undoubtedly show a higher proportion of full stomachs. The mean percentage of food composition by volume for twelve seals taken in Aston Bay was 25% fish, 67% plankton and 8% benthic organisms.

Of the seals collected, two were young of the year (0+ years), three were adolescents (age 1+ to 6+ years) and

the rest were adult animals. Of the 42 adult females, 7 years or older, 34 showed an active corpus luteum. If this is taken as a sign of pregnancy, the reproductive rate is 81%, similar to that found in other studies (Johnson, Fiscus, Ostensen & Barbour 1966; Smith 1973a).

Few wounds from interspecific fighting were seen. Only three males and two females, one a small adolescent found wandering about beside a lead, had any evidence of bites. One male and one female were collected with possible bullet wounds. One female had a large partially healed wound which might have been inflicted by a polar bear. One adult female was found dead on the ice beside a breathing hole. The cause of death was not found.

Twenty-four percent of the seals collected had not yet exhibited any signs of beginning the annual moult. This might be interpreted to mean that these animals had just recently begun to haul out, and perhaps had come in from the Lancaster Sound open water area where they had overwintered.

The mean body measurements for adult males and females combined were as follows: nose to tail length, 139.5 cm; maximum girth, 111.5 cm; and blubber thickness over the sternum 3.9 cm. These compare well with measurements taken by Smith (1973a) on east Baffin Island and thought to be representative of a healthy population of ringed seals.

### 5.5.2 Biological samples obtained elsewhere in the study area

Tables 11a and b show the species composition and the mean percentage composition of fish, plankton and benthos found in stomach collections made in several localities in the large study area.

Only one other area, the flat ice region on the northeastern tip of Russell Island was sampled extensively for ringed seals. Here 27 seals found at breathing holes along frozen leads radiating to the northeast were collected. The large majority of these seals (Fig. 7) were adult animals (20/27 older than 6+ years; mean age 10.2 years) with a sex ratio of 17M : 10F. It is worthy of note that none of the six adult females showed an active corpus luteum or a recent corpus albicans.

## 5.6 Ice Conditions

### 5.6.1 General description

The total ice cover does not vary much from year to year in the Canadian arctic but the distribution and concentration of multi-year ice and the formation of pressure ridges and cracks are dependent on weather conditions during the previous break-up and freeze-up periods.

In general, ice begins to form in early September at the latitude of Barrow Strait. The earliest formation occurs adjacent to old unmelted floes and produces very weak ice which is easily broken up by winds, tides and currents. As temperature falls in October, a solid unmoving ice sheet covers most of the channels, except for Lancaster Sound and Prince Regent Inlet where the ice is in restricted motion throughout the winter. As the ice consolidates over the channels, the multi-year floes that drifted during the summer are cemented together by locally formed first-year ice. Although the distribution of multi-year ice depends mainly on the prevailing winds during break-up, it is possible to establish a regular pattern in the ice types commonly found over the various channels. Fig. 8 is a summary of winter ice conditions, derived from observations made from 1961 to 1977. Lancaster Sound is generally covered by close pack composed of first-year ice. The most usual limit of this unstable ice is located around Prince Leopold Island, crossing north to Maxwell Bay. Flaw leads and pressure ridges can form at any time in Lancaster Sound, depending on the wind regime. The same conditions apply, to a lesser extent, to Prince Regent Inlet. On the other hand, the south coast of Devon Island (northern Lancaster Sound) is bordered by stable shore-fast ice.

The floe edge at Prince Leopold Island is at its most usual location, but in certain years it extends into Barrow Strait westward to Griffith Island, and in other years the solid pack reaches the northwest tip of Bylot Island (Fig. 9).

In normal years, when the floe edge is at Prince Leopold Island, Barrow Strait is usually covered by a solid sheet of heavily ridged first-year ice. Although new ice begins to form early in September,

winds, currents, tides and the proximity of the unstable ice-cover in Lancaster Sound, generally keep the pack in motion until consolidation in December. This temporary motion of the floes in Barrow Strait causes the formation of many pressure ridges. There is little information available on yearly patterns of orientation, size or distribution of these ridges.

Westward of Lowther Island in Viscount Melville Sound the ice-cover is a mixture of multi-year ice and second-year ice, cemented together in late October by locally formed ice. The proportion of old ice in this area varies considerably during years with extreme weather conditions, but generally shows a gradual increase of old ice in a westward direction.

The channels to the north of Barrow Strait, Wellington Channel and McDougall Sound, are normally covered with heavily rafted and ridged first-year ice by December. The strong southward current produces areas of open water early in the summer and a great amount of multi-year polar pack ice is flushed through these channels into Barrow Strait. Thus scattered multi-year floes may be found in this area during years of early freeze-up. Since the final consolidation does not normally occur before December, the new ice formed in early October is greatly affected by the strong southward current and the wind regime. Heavily ridged, this ice has a thick snow-cover almost every year.

Byam Channel, Austin Channel, and Byam Martin Channel, north of Viscount Melville Sound, are covered by a mixture of multi-year, second-year and locally formed ice. The amount of multi-year ice is generally more than 50% of the total cover, although Byam Channel is mainly ridged first-year ice. The areas along the coast of Bathurst Island are of the sheltered coastal type and are covered by stable, infrequently ridged first-year ice.

To the south of Barrow Strait, Peel Sound is covered by flat first-year ice with small ridges, except for the Browne Bay zone where a fringe of small islands parallel to the coast protects the ice from any deformation.

An area of closely packed old ice tends to build up in M'Clintock Channel in October, making it an area of very rough and hummocky ice.

5.6.2 Area measurements

Areas covered largely by relatively stable first-year ice are shown in Fig. 8. Area calculations for this ice category are given for different geographical localities in Table 12.

5.7 Other Game Sighted During the Study

5.7.1 Polar bears

5.7.1.1 Polar bear sightings during the 1975 breeding habitat survey

Seventy-one live bears and one carcass left by Inuit were sighted in the 1975 helicopter survey. None of the bears bore ear tags. The location of these sightings are given in Table 13. Table 14 lists the number of digs and kills of ringed seals by bears in different areas covered by the helicopter survey. Unfortunately data cannot be used to calculate kill success reliably since it could not always be determined that digs resulted in successful kills.

5.7.1.2 Polar bear sightings during 1975 fixed-wing survey

Table 15 summarizes the polar bear sightings recorded during the aerial survey in various geographical areas (Fig. 10), for each of which is calculated an index of bear abundance. This index is the number of bear sightings (tracks and live bears) per $km^2$ of ice surface censused. The calculated index was highest at the floe edge (0.210 sightings/$km^2$) and in western Viscount Melville Sound (0.075 sightings/$km^2$). The index was much lower in all other regions and the overall value for the survey was 0.020 sightings/$km^2$.

In total, 198 sets of tracks and 15 polar bears were observed. Seven seal carcasses left by polar bears, and one polar bear attendant at a carcass were also observed. Three of the eight kills were near the floe edge at Prince Leopold Island.

5.7.1.3 Predation by polar bears and arctic foxes seen in the 1976 breeding habitat survey

Table 16 shows the percentage predation attempts by both polar bears and arctic foxes seen during our search for subnivean structures in the various study areas. The number or percentage of polar bear digs are a good indication of the general ringed seal abundance in a given area. The maximum number of polar bear digs was seen in area 4 located on the western coast of Bathurst Island in the de la Beche Bay region. Generally large numbers of digs were seen also in the areas between northern Prince of Wales Island and Lowther Island. The mouth of Peel Sound also had a large amount of polar bear activity. Predation attempts by arctic foxes were confined to search sites near the coast. The largest numbers of arctic fox digs were found in the Lowther Island nearshore search sites and the Aston Bay area. The number of lairs considered in Table 16 is too low to give any reliable measure of predation success.

Table 17 shows the location of bear kills found during the study. The largest proportion of ringed seals killed by bears were pups of the year. The largest number of kills were located in the Russell Island, Peel Sound and Lowther Island areas of Barrow Strait.

5.7.2 Miscellaneous game sightings

5.7.2.1 Other game sightings during the 1975 survey

Table 18 lists sightings of other marine mammals during the 1975 birth lair survey. All of these were made while flying along the floe edge located between Prince Leopold Island and Maxwell Bay. Table 19 lists the birds seen, also mostly along the floe edge and associated with the large breeding colonies on Prince Leopold Island and Port Leopold.

Several species of terrestrial mammals were seen during the 1975 survey and are listed in Table 20. In several instances caribou *Rangifer tarandus* were seen on small islands in Barrow Strait and crossing Peel Sound from east to west.

5.7.2.2 Other game sightings during the 1976 survey

Table 21 lists sightings of terrestrial mammals sighted along the 1976 survey route (Fig. 1). In the overland crossing from the end of Prince Albert Sound to Isachsen Point on the west coast of M'Clintock Channel very few sightings of any wildlife were made. After leaving the west coast of Victoria Island, we quickly ran out of signs of caribou and arctic foxes (3-40 miles). No further caribou tracks were seen for the rest of the crossing and none were seen on the east coast of Victoria Island as far north as northern Stefansson Island. Two sightings of muskoxen *Ovibos moschatus* were made on the crossing of Victoria Island: one of three bulls and another of a single bull. Not mentioned in Table 21 were numerous sightings of the willow ptarmigan *Lagopus lagopus*. No signs were seen of lemmings *Lemmus sibiricus* & *Dicrostonyx torquatus* or arctic hares *Lepus arcticus* on the crossing. One herd of muskoxen containing five adults and two yearling calves was seen on the east coast of Stefansson Island. The crossing between northeastern Stefansson Island to Byam Martin Island was through multi-year floes surrounded by highly pressured first-year ice. This area was devoid of any signs of polar bears or arctic foxes. Polar bears had been sighted prior to our leaving the northeast coast of Stefansson Island all along the eastern coast of M'Clintock Channel from Isachsen Point. Bears became generally abundant in all areas after we had reached Byam Channel. One male arctic wolf *Canis lupus* was collected on the west coast of Byam Martin Island. The animal had been searching for lemmings without much apparent success. Bear sightings and sightings of fresh bear tracks became increasingly abundant as we moved towards southwestern Bathurst Island. De la Beche Bay on western Bathurst Island appears to be an area heavily utilized by polar bears. One juvenile female polar bear came into our camp at Cape Cockburn on southwestern Bathurst Island, which resulted in our having to shoot it in self-defense. The specimens have been turned over to the Canadian Wildlife Service.

It became very apparent as we approached the sphere of influence of the Resolute Bay community that signs of polar bears became increasingly rare. Few Inuit were actually met on the sea ice but tracks were seen in the Browne Island area, were abundant in the area between

Griffith Island and Resolute Bay, and signs of past Inuit activity were also seen in the Aston Bay area and in the area around Russell Island and Lowther Island. Caribou were sighted in Aston Bay itself and tracks were seen crossing Peel Sound in a westerly direction. Fox signs became increasingly noticeable as we approached the south coast of Cornwallis Island and the northwest coast of Somerset Island. On Lowther Island we located four caribou that were in extremely poor condition. Several nearby areas had been heavily grazed, but the caribou had apparently experienced difficulty in penetrating the rather hard snow cover.

# 6. DISCUSSION

The subnivean lair densities found in the 1975 and 1976 surveys were similar. Fixed point surveys using a helicopter as in 1975 are not strictly comparable to the snowmobile supported surveys because of the increased area of search in the latter (Smith & Stirling 1978). Table 22 compares the search effort in the two different surveys. Where comparable locations were considered for total number of subnivean structures found, the ranks of the localities in terms of relative abundance are similar but the search times per lair were quite different. Greater differences appear in the ranking of birth lair abundance. The differences can be explained mainly on the increased area searched and general lack of restraint on the searching dog when it was followed by snowmobile. Because of this the ground searches are thought to be a better approximation of absolute lair density for a given area.

The comparison between the ground snowmobile search done in 1975 and the search of areas 5 and 6 in nearby areas in 1976 yield similar densities of birth lairs (15.4 minutes and 11.6 minutes search time per birth lair respectively) but somewhat different densities of total subnivean structures (8.69 and 2.47 minutes per lair respectively). The reasons for the differences are not immediately apparent but might be partially attributable to the greater area searched in 1975 (139 minutes as opposed to 105 in 1976). Invariably the greater the area searched, the greater the probability of including an aggregation of seals along such structures as pressure ridges or old leads.

The most suitable ice for breeding seals was found in the mouth of Peel Sound, Aston Bay and the region north of Prince of Wales Island. The vast area of heavily pressured rough ice seen in the area bounded to the south by Lowther Island, to the east by Browne Island, and extending to the west as far as the mouth of Viscount Melville Sound and almost up to the southern shore of Bathurst Island appeared to be generally unsuitable. No direct observations were made on the actual density of lairs in this area because of difficulties in travelling through it. Austin Channel to the north of this area of rough ice appeared to be excellent breeding habitat for the ringed seal. The nearshore

areas in the de la Beche Bay region on western Bathurst Island were especially good.

The ice of Byam Channel along both the west coast of Byam Martin Island and the east coast of Melville Island containing hummocky ice areas is good breeding habitat for the ringed seal. In addition, the large pressure ridges, which are apparently consistent features crossing east to west in Byam Channel, are the location of a generally good density of subnivean structures.

The area of ice from southern Byam Martin Island to northern Stefansson Island was made up of multi-year floes surrounded by heavily fractured pressured ice. This area appeared to be devoid of seals and signs of their predators were totally absent. The route which we followed was apparently just within what was probably the edge of the open water area existing during the summer of 1975. Of all areas studied, the ice immediately to the east of Lowther Island appeared to contain the highest density of breeding seals. Similar densities were found in the area immediately to the north of Russell Island and in the area just adjacent to the shore of Lowther Island. Generally, good densities of birth lairs were found in Aston Bay, especially in the deeper part of the bay where surrounding pieces of ice had frozen in. Fair densities of birth lairs were seen in the de la Beche Bay area on western Bathurst Island.

Attempts to map areas occupied by the subnivean structures of the ringed seal have helped to shed some light on how the sites are initially selected and how ringed seals are distributed in a typical situation. Areas of fast ice not having been subjected to radical deformation during the early winter months appear to be the preferred habitat. Immediate site selection is made along cracks and the last areas of open water. Thus breathing holes are maintained in close proximity to such identifiable features as pressure ridges and leads which have eventually frozen, in cracks associated with areas of minor ice pressuring (ice hummocks) and along the edge of more extensive fields of rough ice. Few seals are ever found in areas containing multi-year ice. Areas of first-year ice that are extensively pressured appear to contain few seals, although we have

not adequately surveyed these regions and do not know what age classes of seals might utilize them. There appears to be a certain utilization of nearshore heavily pressured ice by ringed seals since polar bears seem to exploit this habitat regularly. Again, with our present techniques, we have not been able to quantify this nor establish what segment of the seal population is occupying this habitat. Possibly the existence of tide cracks and also food might make this area attractive for some seals.

The large variation in estimated densities of subnivean structures calculated from the five different maps made during the 1976 survey (Table 3) points to the heterogeneity of the fast ice habitat. Apart from difficulties in establishing the exact extent of the area surveyed, such factors as the number of pressure ridges, old leads and ice hummocks, and other factors such as abundance and availability of food must influence the density of seals from one area to the next.

Excluding the Russell Island area, which was atypical since it contained non-breeding seals along old leads in very flat ice, the density of total subnivean structures varied from $0.84/km^2$ to $11.86/km^2$. The density of birth lairs varied from $0.38/km^2$ to $3.09/km^2$. Using the latter figures and the area calculations in Table 12, it is possible to derive estimates of the number of young produced in the whole study area.

A maximum estimate of young produced would be 265,710, while a minimum number could be 32,676. If the rate of increase of the population is assumed to be 8% (Smith 1973b) this would represent a total population of seals for the area ranging from a maximum of 3,321,300 to a minimum of 408,400. The large variation of birth lair densities, apart from indicating the high heterogeneity of the fast ice breeding habitat, also indicates that much more extensive surveys are needed before reliable estimates of total population can be derived. It is also apparent that there are certain sectors of the stable fast ice, such as was seen near Russell Island, which contain seals that are non-breeding members of the total population. It is not possible at present to estimate the total area occupied by this component.

Fixed-wing aerial surveys of ringed seals hauled out on fast ice have in the past been used as a tool to estimate the population size in different arctic areas. There is generally good agreement between densities obtained by Finley (1976) and those calculated in this study for various coastal and offshore areas (Tables 4 and 5). Surveys carried out by LGL Ltd. in 1974 (Finley *et al.* 1974) yielded higher densities overall than our studies and those of Finley (1976) in 1975. The overall mean density in the study area in 1974 was 1.9 seals/km$^2$ (Davis, Finley, Bradstreet, Holdsworth & McLaren 1975). Offshore regions had an average density of 1.93 seals/km$^2$ (Finley *et al.* 1974). However, the LGL surveys in 1974 were designed to census sea birds and the coverage of fast ice areas was neither adequate nor representative.

Finley *et al.* (1974) confirm the trends observed in the present study. For example high densities were observed in Aston Bay (average of 4.05 seals/km$^2$), the mouth of Aston Bay (8.62 seals/km$^2$ on 18 June 1974), and west Barrow Strait (4.73 seals/km$^2$) on one transect from Lowther Island to Griffith Island; 7.98 seals/km$^2$ on one transect from Griffith Island to Cornwallis Island. No seals were seen during surveys in Bracebridge Inlet, Byam Channel and Austin Channel.

In the present study, no evidence of variation in seal density with distance offshore was detected. This is generally confirmed by Finley (1976), with one exception in Peel Sound where coastal densities were higher than offshore densities (Tables 1 and 2).

During the 1975 surveys, the highest densities of hauled-out ringed seals were observed in Aston Bay and the offshore area of Peel Sound from Russell Island to Aston Bay. Large numbers of seals were hauled out alongside cracks in this part of Peel Sound and near the mouth of Aston Bay.

Heterogeneity in ringed seal abundance within a single marine area is evident from Finley's (1976) study and our own study. Barrow Strait provides a good example (Table 5), and seal densities were also variable in Viscount Melville Sound. Highest densities in this sound occurred in its south central portion (Smith, Taylor & Hagagiak 1976). All large marine areas and

island coasts in the study area display this heterogeneity superimposed on the larger-scale variation of density within the study area.

Finley (1976) confirms the data presented here on the utilization of cracks and breathing holes by seals. He found no significant seasonal change in the differential utilization of cracks and holes by seals. However, he did find that group sizes at holes were larger during the early part of his survey, which encompassed the period 1-24 June. No such changes were detected over the briefer duration of our survey (16-28 June). Finley did not detect any seasonal or spatial changes in group size at cracks in the sea ice. He detected a small increase in the proportion of groups utilizing offshore cracks later in the season and a small increase in the proportion of groups utilizing coastal breathing holes later in the season as well. A shift to utilization of breathing holes was evident in Aston Bay in early July (Table 5).

Table 7 demonstrates no significant trend in group size at holes and cracks as a function of date. The proportion of seals using breathing holes varies considerably and without trend from date to date, averaging 75.1% over the survey.

Polar bear sightings (tracks and live bears) correlated poorly with seal densities in the various geographic areas (Table 15). The high density of bears and tracks (0.210 sightings/$km^2$) at the floe edge was also observed by Finley *et al.* (1974) and Finley (1976), who also noted large numbers of bears in spring along the coasts of southwest Devon Island, northeast Prince of Wales and Russell islands, and in Barrow Strait. He noted a scarcity of bears in Peel Sound and Aston Bay, confirmed by the present study. Finley (1976) observed one bear in Aston Bay during the 1975 LGL survey.

The difficulty in correlating bear sightings with seal densities probably lies in the fact that, as the season progressed, the snow on the ice melted, thus obliterating the tracks. Western Viscount Melville Sound supported a low seal density (0.42 seals/$km^2$) yet had the second highest bear density (0.075 tracks and bears/$km^2$). This can be explained by the fact that this marine area was surveyed early in the season and the snow cover had not

yet melted. The problem is further complicated by spatial and temporal variation in the proportion of resident seals hauled out on the ice. The season was less advanced in western Viscount Melville Sound than in Barrow Strait, and fewer seals would have been hauled out on the ice.

Of any single small area, Aston Bay supported the highest density of the ringed seal. The seal density on the ice of this bay achieved a maximum of 7.66 seals/$km^2$ on 7 July, based on a ground count of 87.6 $km^2$ of ice. In late June our aerial survey produced densities of 2.42-3.73 seals/$km^2$ (mean of 3.15 seals/$km^2$), while ground counts just prior to the aerial survey gave densities of 3.80 to 4.21 seals/$km^2$. Finley (1976) gives a mean density of 4.69 seals/$km^2$ on the ice of Aston Bay from 18-27 June 1975.

During late June and early July, a marked increase in the density of seals hauled out on the ice of Aston Bay was observed. A similar increase in density in Aston Bay was noted by Finley (1976) from 18-25 June. This increase occurred at the same time as break-up of the fast ice of west Barrow Strait, and it appears likely that the increase in density of hauled-out seals in Aston Bay was due to an influx of seals from areas outside the bay. The break-up of the ice results in increased wandering of seals in offshore areas and in increased accessibility to inshore fast ice areas, leading to a build-up of seals in the late fast ice of coastal inlets and embayments. Other large bays may exhibit this phenomenon. One of us (KH) noted an aggregation of ringed seals on the diminishing fast ice of Cunningham Inlet after mid July of 1974.

As seal density increased in Aston Bay, the proportion of seals hauled out beside breathing holes increased, reaching a level of over 90% by 5 July (Fig. 6). K. Finley (pers. comm.) has noted a similar increase in the proportion of seal groups using holes in coastal areas as the season progresses. Better drainage of the ice near holes may be relevant in this regard.

The reason for underestimation of seal density on the ice of Aston Bay by aerial census becomes apparent upon consideration of the proportion of seals hauled out beside holes as opposed to cracks. During the three

days of aerial survey, the proportion of seals at holes was at a maximum of about 50% on 20 June. Thus, the minimum proportion of seals hauled out alongside cracks was 50%. The aerial survey tended to overestimate the proportion at breathing holes, although this proportion followed the same time trend when calculated from both aerial and ground counts.

This suggests that the airborne observers underestimated the numbers of seals along cracks. When the seals alongside a crack are numerous and closely spaced, accurate counts are impossible and the observer can only make an estimate. It is a well-known fact that most observers underestimate the number of animals they see when the animals are aggregated in herds or flocks (Caughley 1977). It thus appears likely that our underestimation of density for Aston Bay was caused by significant underestimation of the numbers of seals aggregated along cracks, which are numerous across the ice of Aston Bay during June and July and which provide the seals ample access to the ice.

The relation between the actual population size of breeding seals occupying an area of ice and the number of seals counted during the haul-out period is still very unclear. If we consider Aston Bay only where the maximum density of seals obtained from ground counts on 7 July was 7.66/km$^2$ we can then estimate that there was a density of approximately 15 seals/km$^2$ using 50% as the number of seals under the ice during the count (Smith 1973a). In the birth lair surveys Aston Bay was shown to have one of the highest birth lair densities of the 11 search areas in the 1976 study. Using the highest absolute birth lair density calculated in Table 3 (3.09/km$^2$) and the assumption that this represents 8% of the population this would result in an estimate of 39 seals/km$^2$ or more than twice the number of seals estimated by the aerial survey of hauled out seals. Since the estimate made from birth lairs includes all age classes of the population (neonates, adolescents and adults) it might in fact be an overestimate since the adolescent age classes are known to be absent from the breeding areas during the winter. There is good evidence however from the radical build-up in numbers of seals in such areas as Aston Bay that there is likely an influx in the spring of seals from other areas and likely of adolescent seals from the open water of adjacent Lancaster Sound.

Size and body condition of seals taken in Aston Bay and Barrow Strait are comparable to those of the Home Bay region on eastern Baffin Island (Smith 1973a). Blubber thickness and stomach contents indicate that the animals overwintering in the study area were well fed and healthy. This was further supported since no abnormalities or diseases were documented on gross examination and there was only a small number of wounds from intraspecific fighting.

The Russell Island sample taken along several frozen leads in areas of extremely flat unpressured ice with little snow cover indicates that there may be a segregation occurring between breeding and non-breeding adult seals in the large area of stable fast ice occupied during the winter months. The reproductive rate estimated for the breeding females of Aston Bay was 81%, almost exactly that found in two other studies of ringed seals (Johnson *et al.* 1966; Smith 1973a). None of the Russell Island females showed either a recent corpus luteum or a corpus albicans, probably indicating that they were also barren the previous year. The probability of obtaining six barren females from a normal mammal population (using .81 as the reproduction rate) can be calculated as $(.19)^6$. It is evident from this extremely low probability that segregation of non-breeding females is occurring. Stirling, Archibald & DeMaster (1977) and Smith & Stirling (1978) present evidence of decreasing reproductive rates from barren mature ringed seals collected in the offshore Beaufort Sea area. It is possible that they sampled some non-breeding segment of the population in that area, although evidence from other sources in the area pointed to an actual decline in production. The occurrence of non-breeding aggregations in the fast ice have never been demonstrated, although McLaren (1962) comments on the possibility that adult females found in peripheral, and therefore unsuitable, ice conditions might be barren.

Broad extrapolations of lair densities are possible at present but must be considered only a rough approximation to actual population numbers. The primary characteristics of sea ice which act as discriminant functions on the number and distribution of ringed seals are the degree of stability during the period of ice formation and consolidation and the quantity and quality of such

features as leads, pressure ridges, ice hummocks and their associated snow cover. Unfortunately these cannot presently be assessed in a quantitative manner using such information sources as LANDSAT satellite imagery which covers a sufficiently large geographical area. Satellite imagery was used primarily to determine total extent of ice cover and movement.

Although the ice observer reports are more detailed, they do not provide information on location, orientation and extension of pressure ridges or lead systems. For this reason, only large-scale zones of old ice, first-year offshore ice and sheltered coastal ice could be derived from these observations. The aerial ice surveys are conducted only from June to December; therefore the general winter conditions had to be extrapolated from the situation during the freeze-up period.

It appears that if further refinements are needed in the estimates of the absolute size of ringed seal populations more detailed birth lair habitat maps covering a much larger area would have to be combined with ice surveys using both ground and low level aerial surveys. Coverage of a sufficient number of bays and transects across stable ice areas, including areas of flat ice with little snow cover, would lead to more accurate estimates. Other factors which must have a direct effect on the spacing of seals in the fast ice, such as the presence and availability of food and the proximate mechanisms of spacing in the form of territorial behaviour, are not yet understood and little data exist on them.

# 7. CONCLUSIONS

1. Good densities of breeding ringed seals exist in the Barrow Strait and Peel Sound areas of the proposed pipeline.

2. Seals occupying these fast-ice areas are mostly adults in good health. The adjacent open-water areas of Lancaster Sound probably contain the adolescent segment of the population in the winter.

3. In the spring months there is evidence of aggregation of seals in certain areas of good fast ice such as Aston Bay.

4. Population estimates based on aerial surveys alone likely underestimate the total population of the area.

## 8. SUMMARY

Ringed seal breeding habitat surveys in 1975 and 1976 revealed similar lair densities. Highest densities were found in the area of Barrow Strait immediately adjacent to eastern Lowther Island. Comparable high densities were found at the head of Peel Sound and in Aston Bay on northwestern Somerset Island.

Aerial surveys of hauled-out seals, while showing comparable densities to surveys done by Polar Gas in 1974 and 1975, were found to underestimate seals both because of experimental error and because it is impossible to count seals under the ice. When population estimates based on aerial surveys are compared to estimates derived from birth lair densities, a large underestimate is indicated. However, we have not as yet been able to derive exact estimates of population using the birth lair density technique because of the highly variable nature of sea ice and the much larger sample size of detailed mapped areas needed. Aerial surveys also show that large numbers of seals tend to aggregate in areas such as Aston Bay in late spring.

The biological samples collected during this study indicate that the population in the area is healthy and well fed. There is an indication from the samples taken in early spring that most seals in the fast ice habitat are adults. We have also found strong evidence of a segregation of adult seals into breeding and non-breeding groups.

It is felt that certain traditional hunting areas such as Aston Bay and Russell Island should be subject to the minimum of disturbance both during the construction phase of the pipeline and by permanent facilities which might be built there. It would be preferable to avoid Aston Bay altogether. Further research, of the type intended to monitor the actual effects of pipeline construction and operation, should be planned. Detailed recommendations follow.

## 9. IMPLICATIONS AND RECOMMENDATIONS

In Barrow Strait the areas of the proposed pipeline crossing between southern Bathurst Island and northern Prince of Wales Island east of Lowther Island contain some of the best breeding habitat for ringed seals seen during this study. The same is true for the proposed crossing area between Prince of Wales and Somerset islands in the head of Peel Sound, especially in the area of Aston Bay.

The Inuit of Resolute hunt seals near their village which has a fair density of breeding animals between Browne Island and eastern Griffith Island. They also use Aston Bay in the spring months as a traditional seal hunting area. The Russell Island area on northern Prince of Wales Island is a favourite bear hunting area during the months of February to April.

There does not exist any direct evidence of what the effect of a pipeline would be on ringed seal populations. Certainly there will be disturbance along the immediate routes during the construction phase but the extent is not predictable. Pumping stations situated in such areas as Aston Bay and Russell Island, with their high noise levels, and other forms of disturbance occasioned by maintenance crews could well cause both seals and bears to avoid these areas permanently. It is known that heavily travelled areas near Inuit villages have few if any seals. Here the disturbance is of a more direct nature since the seals are actively hunted (Bradley 1970). Other marine mammals such as the walrus *Odobenus rosmarus* and white whale *Delphinapterus leucas* have also been known to change their distribution in the face of human disturbance (Sergeant & Hoek 1974).

Once the pipeline has been built the disturbance along the crossing areas will probably be minimal and, providing the construction phase has not permanently shifted the seal distribution for some presently unidentified reason, it would be expected that their numbers should return to normal. It is important that the permanent facilities such as pumping stations and maintenance activities be planned in such a way as to avoid the most important hunting localities and minimize the disturbance.

## 10. NEED FOR FURTHER STUDY

Some thought should be given to establishing research projects which would enable us to monitor the effects of the pipeline during its construction phase and when it becomes operational. These investigations would allow us to make continuing recommendations of the type which will help to minimize adverse effects. They will also provide important baseline data useful in future pipeline projects.

Such a research program might include:

1. Annual studies of health and stress indicators in freshly captured or shot seals--we have already identified several important indicators of stress and have recently begun studies which seek to quantify these stress-related phenomena (Geraci & Smith 1976).

2. A program to monitor the primary and secondary productivity in the area from year to year since recently documented large scale changes in annual seal production in the southeastern Beaufort Sea (Smith & Stirling 1978) point to our lack of knowledge of the lower trophic levels.

3. Collection of annual catch statistics on all marine mammals and accompanying samples of the population age structure to determine whether changes occur in the local stocks.

4. A systematic annual aerial survey of hauled-out seals for the Barrow Strait area, continued through the construction phase, to provide direct evidence on the extent of disturbance.

5. Continuation of the birth lair survey in Aston Bay through the same period. If pumping stations should be built in any region where birth lair surveys have been conducted it would be of importance to do comparable surveys to compare densities of breeding seals.

6. Survey of the extremely highly pressured nearshore ice and extensive offshore areas of first-year pressured ice, which have not yet been quantitatively assessed by the methods employed in this study. The nearshore habitat, especially, appears to contain a segment of the ringed seal population and appears to be an important feeding niche for the polar bear.

7. Study of the movements and seasonal segregation of age classes in the Barrow Strait-Lancaster Sound area. Evidence during the study and from other studies on polar bears have shown that a significant number of seals occur in the open water areas of Lancaster Sound during the winter months. In other areas of the arctic it has been shown (McLaren 1958, Smith 1973b) that a large segment of the ringed seal population, possibly as much as 70% of the animals, occupies the far offshore areas of open water during the winter. As yet, very little is known about why the animals are there, what are the food species they are utilizing and what resources in fact are being exploited in this habitat. Also important in this connection are the apparently large numbers of bearded seals in the area and along the floe edge during the spring months. Little is known about the basic biology of this species and virtually nothing is known about its ecological niche.

# TABLES

Table 1. Birth lairs and associated structures found during 0.5 hour search periods at 50 sites (see Fig. 1) in the Viscount Melville Sound, Barrow Strait and Peel Sound study area during 1975.

| Search site | No. of bearded seal breathing holes | No. of ringed seal breathing holes | No. of ringed seal haul-out lairs | No. of ringed seal birth lairs | No. male haul-out lairs | Snow depth cm (n=30) $\bar{X}$ | Snow depth cm (n=30) S.D. | Total structures |
|---|---|---|---|---|---|---|---|---|
| 1 | .. | 1 | .. | .. | 1 | 25.7 | 9.1 | 2 |
| 2 | .. | .. | 2 | .. | .. | 22.6 | 13.1 | 2 |
| 3 | .. | 1 | .. | 3 | .. | 24.7 | 12.3 | 4 |
| 4 | .. | .. | 1 | 2 | 1 | 18.2 | 8.0 | 4 |
| 5 | .. | .. | 1 | .. | .. | 18.8 | 17.4 | 1 |
| 6 | .. | 2 | 2 | .. | 3 | 24.6 | 13.2 | 7 |
| 7 | .. | 2 | 2 | .. | 1 | 15.7 | 5.7 | 5 |
| 8 | 2 | .. | .. | .. | .. | 33.5 | 5.1 | 2 |
| 9 | 0 | 0 | 0 | 0 | .. | 30.4 | 11.5 | .. |
| 10 | .. | 1 | 1 | .. | .. | 23.6 | 14.9 | 2 |
| 11 | .. | .. | 1 | .. | 1 | 17.5 | 19.7 | 2 |
| 12 | .. | .. | 2+(1?) | .. | .. | 18.2 | 18.1 | 2+(1?) |
| 13 | .. | .. | 1 | 1 | 1 | 16.5 | 8.3 | 3 |
| 14 | 0 | 0 | 0 | 0 | .. | 34.9 | 32.1 | .. |
| 15 | .. | 2+(1?) | .. | 4 | 3 | 42.6 | 20.4 | 9+(1?) |
| 16 | (1?) | 1 | .. | 1 | .. | 39.0 | 18.8 | 2+(1?) |
| 17 | 0 | 0 | 0 | 0 | .. | 29.0 | 17.3 | .. |
| 18 | Pressure ridge searched for 18 minutes over length of 2910 metres | | | | | | | |
| | .. | 8 | 1 | .. | 1 | .. | .. | 10 |
| 19 | .. | 1 | 2 | .. | 1 | 27.9 | 13.6 | 4 |
| 20 | .. | 1 | 2 | .. | 1 | 29.9 | 19.9 | 4 |
| 21 | 0 | 0 | 0 | 0 | .. | 18.4 | 10.3 | .. |
| 22 | .. | .. | 2 | 2 | .. | 18.2 | 7.2 | 4 |
| 23 | 1 | .. | 1 | 1 | .. | 18.6 | 10.2 | 3 |
| 24 | .. | .. | 2 | 1 | .. | 24.5 | 27.3 | 3 |
| 25 | .. | .. | 3 | 1 | 1 | 30.8 | 24.1 | 5 |
| 26 | .. | .. | .. | 1 | .. | 17.0 | 16.2 | 1 |
| 27 | .. | .. | 4 | 1 | 1 | 24.5 | 18.5 | 6 |
| 28 | 3 | .. | .. | .. | .. | 19.0 | 10.6 | 3 |
| 29 | .. | .. | 1 | .. | .. | 32.6 | 12.8 | 1 |
| 30 | .. | .. | .. | 2 | .. | 22.3 | 17.3 | 2 |
| 31 | .. | 1 | 1 | .. | .. | 21.7 | 5.4 | 2 |
| 32 | .. | .. | 1 | 1 | .. | 20.2 | 6.1 | 2 |
| 33 | .. | .. | 2 | 2 | .. | 22.0 | 9.7 | 4 |
| 34 | .. | 1 | 1 | .. | .. | 10.6 | 3.9 | 2 |
| 35 | .. | 1 | 2 | 1 | 1 | 30.1 | 11.5 | 5 |
| 36 | .. | .. | 2 | 1 | .. | 28.7 | 18.1 | 3 |
| 37 | .. | 1 | .. | .. | 1 | 25.5 | 15.3 | 2 |
| 38 | .. | 1+(1?) | 2 | (1?) | .. | 26.5 | 18.9 | 3+(2?) |
| 39 | .. | .. | (1?) | .. | .. | 30.5 | 22.0 | (1?) |
| 40 | 0 | 0 | 0 | 0 | .. | 14.1 | 7.6 | .. |
| 41 | .. | .. | 2 | 1 | .. | 16.5 | 12.2 | 3 |
| 42 | 0 | 0 | 0 | 0 | .. | 27.3 | 13.5 | .. |
| 43 | 0 | 0 | 0 | 0 | .. | 17.1 | 7.0 | .. |
| 44 | 0 | 0 | 0 | 0 | .. | 20.7 | 7.7 | .. |
| 45 | .. | 4 | 5 | 2 | .. | 48.9 | 21.7 | 11 |
| 46 | .. | 1 | 1 | 3 | .. | 13.5 | 10.9 | 5 |
| 47 | .. | .. | .. | 3 | .. | 23.7 | 24.8 | 3 |
| 48 | .. | .. | .. | 2 | .. | 10.4 | 10.1 | 2 |
| 49 | .. | 2 | 3 | .. | .. | Advanced melt | | 5 |
| 50 | .. | 1 | .. | 1 | .. | Advanced melt | | 2 |

? Lair not found but strongly indicated by dog.

Table 2. Number of different subnivean structures found in the main search areas during the 1976 breeding habitat survey.

| Search area | Total search time | Birth lairs | Haul-out lairs | Male haul-out lairs | Breathing holes | Minutes/ lair* | Minutes/ birth lair |
|---|---|---|---|---|---|---|---|
| 1 | 30 | 0 | 0 | 0 | 0 | .. | .. |
| 2 | 74.6 | 1 | 13 | 4 | .. | 4.1 | 74.6 |
| 3 | 169.9 | 2 | 15 | 7 | .. | 7.1 | 85.0 |
| 4 | 44.0 | 6 | 5 | .. | 3 | 3.1 | 7.3 |
| 5 | 74.7 | 4 | 7 | .. | 3 | 5.3 | 18.7 |
| 6 | 59.4 | 4 | 5 | .. | 5 | 4.2 | 19.8 |
| 7 | 102.0 | 5 | 24 | .. | 12 | 2.5 | 20.4 |
| 8 | 35.5 | 5 | 8 | .. | 8 | 1.7 | 7.1 |
| 9 | 40.2 | 1 | 1 | 7 | 6 | 2.7 | 40.2 |
| 10 | 141.7 | 19 | 8 | 2 | 12 | 3.5 | 7.5 |
| 11 | 34.8 | 4 | 5 | 1 | .. | 3.5 | 8.7 |

*includes all types of lairs and breathing holes

Table 3. Density of subnivean lairs and predation attempts in areas surveyed by plane table techniques during the 1976 breeding habitat survey.

| Location | Estimated area of survey site | No. birth lairs | No. male lairs | No. haul-out lairs | No. breathing holes | No. bear digs | No. bear kills | Fox digs | Density of subnivean structures |
|---|---|---|---|---|---|---|---|---|---|
| Austin Channel | 13.04 $km^2$ | 5 | 2 | 3 | 1 | 3 | 2 | 0 | 0.84/$km^2$ |
| NE Russell Island (Palmerson Pt.) | 1.51 $km^2$ | 1 | 0 | 0 | 18 | 3 | 1 | 0 | 16.52/$km^2$ |
| Lowther Island east | 9.31 $km^2$ | 7 | 0 | 6 | 7 | 11 | 3 | 0 | 2.15/$km^2$ |
| Lowther Island 12 miles east | 1.94 $km^2$ | 6 | 0 | 8 | 9 | 13 | 3 | 0 | 11.86/$km^2$ |
| Griffith Island (north coast) | 4.48 $km^2$ | 3 | 0 | 5 | 5 | 0 | 0 | 1 | 2.90/$km^2$ |

Table 4. Densities of hauled-out ringed seals in coastal areas, 1975.

| Area | Area surveyed ($km^2$) | Total no. seals | Mean density[d] (no./$km^2$) | Mean density[e] (no./$km^2$) |
|---|---|---|---|---|
| S. Devon I.[a] | 145.2 | 63 | 0.44 | 0.58 |
| N. Somerset I.[b] | 248.9 | 248 | 1.00 | 0.63 |
| S. Cornwallis I. | 352.6 | 138 | 0.39 | 0.72 |
| McDougall Sound | 757.0 | 320 | 0.42 | 0.84 |
| S. Bathurst I., Austin Channel[c] | 570.4 | 158 | 0.28 | 0.62 |
| Byam Martin I., E. Melville I. | 414.8 | 33 | 0.08 | 0.74 |
| N. Prince of Wales I., Russell I. | 539.2 | 417 | 0.77 | 0.79 |
| Peel Sound | 1161.4 | 1181 | 1.02 | 0.91 |
| Aston Bay | 165.9 | 522 | 3.15 | 4.69 |
| Maxwell Bay | 165.9 | 34 | 0.20 | 0.39 |
| De la Beche Bay | 41.5 | 17 | 0.41 | 1.35 |
| Total | 4562.8 | 3131 | 0.69 | 0.53 |

[a] excluding Maxwell Bay

[b] excluding Aston Bay

[c] excluding De la Beche Bay

[d] this study

[e] approximations extracted from Fig. 12 in Finley (1975).

Table 5. Densities of hauled-out ringed seals in offshore areas, 1975.

| Area | Area surveyed ($km^2$) | Total no. seals | Mean density[e] (no./$km^2$) | Mean density[f] (no./$km^2$) |
|---|---|---|---|---|
| E. Barrow Strait[a] | 864.9 | 724 | 0.84 | 0.85 |
| S. Wellington Channel | 63.6 | 64 | 1.01 | 1.54 |
| Peel Sound | 504.2 | 243 | 0.48 | 0.82 |
| Graham Moore Bay, Austin Channel, Byam Channel | 654.4 | 190 | 0.29 | 0.52 |
| W. Barrow Strait[b] | 1640.0 | 1302 | 0.79 | 0.85 |
| E. Viscount Melville Sd.[c] | 1055.8 | 357 | 0.34 | .. |
| W. Viscount Melville Sd. | 1010.1 | 424 | 0.42 | .. |
| Floe edge[d] | 114.1 | 1 | 0.01 | .. |
| Total | 5907.1 | 3305 | 0.56 | 0.88 |

[a]east of Griffith I. (excluding ice edge at Prince Leopold I.)

[b]east of Young I.

[c]demarcation between E. and W. Viscount Melville Sd. is a line from Ede Pt. (NW Prince of Wales I.) to Schomberg Pt. (W. Bathurst I.).

[d]from Maxwell Bay (Devon I.) to Prince Leopold I.

[e]this study

[f]approximations extracted from Fig. 12 in Finley (1975).

Table 6. Densities of hauled-out ringed seals on north-south transects in east Barrow Strait[a].

| Distance to west of floe edge (km) | Area surveyed ($km^2$) | Total no. seals | Mean density (no./$km^2$) |
|---|---|---|---|
| 50.7 | 94.6 | 38 | 0.40 |
| 64.9 | 128.9 | 148 | 1.15 |
| 88.2 | 127.3 | 151 | 1.19 |
| 112.6 | 83.2 | 58 | 0.70 |
| 128.8 | 112.6 | 172 | 1.53 |
| 138.9 | 173.0 | 101 | 0.58 |
| 158.2 | 114.2 | 48 | 0.42 |

[a]area includes Barrow Strait east of Griffith I.

Table 7. Utilization of breathing holes and cracks by ringed seals hauling out on the ice[a].

| Date | Group size: Breathing holes Mean | Group size: Breathing holes Maximum | Group size: Cracks Mean | Group size: Cracks Maximum | Percent of total seals using holes | Percent of observed holes with seals |
|---|---|---|---|---|---|---|
| June 16 | 1.35 | 4 | 2.24 | 12 | 75.8 | 66.7 |
| 18 | 2.05 | 25 | 2.15 | 9 | 94.9 | 49.1 |
| 20 | 2.02 | 20 | 4.56 | 100 | 76.6 | 59.7 |
| 23 | 1.37 | 10 | 1.77 | 20 | 85.9 | 62.7 |
| 24 | 1.61 | 8 | 3.87 | 50 | 55.2 | 43.2 |
| 25 | 1.41 | 9 | 3.56 | 20 | 64.4 | 40.4 |
| 26 | 1.61 | 11 | 2.23 | 9 | 84.4 | 26.3 |
| 27 | 1.18 | 4 | 1.63 | 4 | 95.9 | 29.1 |
| 28 | 1.63 | 7 | 2.56 | 12 | 74.9 | 54.5 |
| Total[b] | 1.53 | 25 | 3.20 | 100 | 75.1 | 48.0 |

[a]calculated for each day over the entire study area

[b]weighted means

Table 8. Comparison of aerial and ground counts of seals at Aston Bay, Somerset Island, 1975.

| | Ground counts[a] | | | | Fixed-wing survey | | | |
|---|---|---|---|---|---|---|---|---|
| Date | No. of seals | Area censused ($km^2$) | Seals per $km^2$ | Percent of seals at holes | No. of seals | Area censused ($km^2$) | Seals per $km^2$ | Percent of seals at holes |
| June 20 | 333 | 87.6 | 3.80 | 50.5 | 136 | 36.3 | 3.73 | 66.1 |
| June 25[b] | 363 | 87.6 | 4.15 | 34.7 | 106 | 36.3 | 2.91 | 44.1 |
| June 28 | 369 | 87.6 | 4.21 | 48.0 | 88 | 36.3 | 2.42 | 60.8 |

[a] the maximum density of seals on the ice of Aston Bay was 7.66 seals/$km^2$ on July 7; 93.4% of the seals were at breathing holes

[b] reflected light from the ice surface hindered accurate aerial counts on this date

Table 9. Daily maximum counts of ringed seals hauled up on the ice of Aston Bay, Somerset Island (Fig. 4) June-July 1975.

| Date | No. of seals at breathing holes | No. of seals on cracks | Total | Visibility scale (see text) | Wind direction | MPH |
|---|---|---|---|---|---|---|
| 4/6 | 8 | 1 | 9 | .. | S | 15-20 |
| 5/6 | 28 | 14 | 42 | .. | S | 15-20 |
| 6/6 | .. | .. | 63 | .. | S | 5 |
| 7/6 | .. | .. | 130 | .. | S | 5-10 |
| 8/6 | 96 | 160 | 256 | 5 | .. | 0 |
| 9/6 | 31 | 85 | 113 | 4 | NW | 2 |
| 10/6 | 127 | 122 | 249 | 5 | NW | 5-10 |
| 11/6 | 108 | 161 | 269 | 5 | .. | 0 |
| 13/6 | 148 | 156 | 304 | 5 | N | 5-10 |
| 14/6 | 95 | 89 | 184 | 2 | S | 5 |
| 15/6 | 46 | 88 | 134 | 3 | W | 5-10 |
| 16/6 | 78 | 189 | 267 | 5 | W | 10 |
| 17/6 | 126 | 182 | 308 | 4 | W | 10 |
| 18/6 | 143 | 198 | 341 | 5 | W | 10 |
| 19/6 | 139 | 217 | 356 | 5 | .. | 0 |
| 20/6 | 168 | 165 | 333 | 5 | W | 10 |
| 21/6 | 43 | 73 | 116 | 4 | SE | 10 |
| 22/6 | 171 | 237 | 408 | 5 | E | 5 |
| 23/6 | 143 | 201 | 344 | 4 | NW | .. |
| 24/6 | 126 | 197 | 323 | 4 | NW | 10 |
| 25/6 | 126 | 237 | 363 | 4 | NW | 5 |
| 26/6 | 142 | 212 | 354 | 5 | NW | 10 |
| 27/6 | 169 | 203 | 372 | 4 | W | 5 |
| 28/6 | 177 | 192 | 369 | 4 | SW | 15-20 |
| 29/6 | 161 | 82 | 243 | 4 | NW | 5 |
| 30/6 | 76 | 248 | 324 | 4-5 | NW | 5 |
| 1/7 | 371 | 109 | 480 | 4 | W | 5 |
| 2/7 | 335 | 94 | 429 | 4-5 | NW | 1-2 |
| 3/7 | 427 | 75 | 502 | 5 | NW | 0-5 |
| 4/7 | 412 | 64 | 476 | 5 | .. | 0 |
| 5/7 | 449 | 34 | 483 | 5 | SW | 5-10 |
| 6/7 | 560 | 43 | 603 | 4 | W | 0-5 |
| 7/7 | 627 | 44 | 671 | 5 | NW | 5 |
| 8/7 | 494 | 53 | 547 | 5 | WSW | 10 |

Table 10. Number of seals expressed as a percentage of the highest count each day in Aston Bay, June-July 1975.

| | Hours of day | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 8/6 | . | . | . | . | . | . | . | . | 100 | . | . | . | . | . | . | 65 | . | . | . | . | 50 | . | . | . |
| 10/6 | . | . | . | . | . | . | . | . | 100 | . | . | . | . | 97 | . | . | . | 80 | . | . | . | . | . | . |
| 17/6 | . | . | . | . | . | . | . | . | 70 | . | 57 | . | 92 | . | 100 | . | 91 | . | 82 | . | 74 | . | 70 | . |
| 18/6 | 58 | . | 29 | . | 44 | . | . | 83 | . | . | . | . | . | . | . | . | 100 | . | . | . | 74 | . | . | . |
| 19/6 | 50 | . | . | . | . | . | . | . | 67 | . | . | . | 100 | . | 72 | . | 69 | . | . | 6 | . | . | 0 | . |
| 20/6 | 12 | . | . | . | 66 | . | . | . | 100 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 21/6 | . | . | . | . | . | . | . | . | . | . | . | . | 72 | . | . | . | 100 | . | . | . | 52 | . | . | . |
| 22/6 | . | . | . | . | . | . | . | . | 100 | . | . | . | 91 | . | . | . | 52 | . | . | . | 45 | . | . | . |
| 23/6 | . | . | . | . | . | . | . | . | . | . | . | . | 100 | . | . | . | 95 | . | . | . | 66 | . | . | . |
| 25/6 | . | . | . | . | . | . | . | . | 100 | . | . | . | 87 | . | . | . | 59 | . | . | . | 45 | . | . | . |
| 26/6 | . | . | . | . | . | . | . | . | 100 | . | . | . | 82 | . | . | . | 100 | . | . | . | 89 | . | . | . |
| 27/6 | . | . | . | . | . | . | . | . | 100 | . | . | . | 98 | . | . | . | 82 | . | . | . | . | 71 | . | . |
| 28/6 | . | . | . | . | . | . | . | . | 100 | . | . | . | 42 | . | . | . | 21 | . | . | . | . | . | . | . |
| 1/7 | . | . | . | . | . | . | . | . | 85 | . | . | . | 100 | . | . | . | 80 | . | . | . | 82 | . | . | . |
| 2/7 | . | . | . | . | . | . | . | . | 100 | . | . | . | 88 | . | . | . | 81 | . | . | . | . | . | . | . |
| 7/7 | . | . | . | . | . | . | . | . | . | 100 | . | . | . | 71 | . | . | . | 80 | . | . | . | 71 | . | . |
| 8/7 | 62 | . | . | . | 88 | . | . | . | 100 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

Table 11. Species composition (a) and mean percentage by volume (b) of fish, plankton and benthos found in the stomachs of ringed seals.

(a)

| | | |
|---|---|---|
| | Fish | *Boreogadus saida* |
| | Plankton | |
| | Crustacea | *Mysis oculata* |
| | | *Onisimus glacialis* |
| | | *Anonyx nugax* & *A. sarsi* |
| | | *Parathemisto libellula* |
| | Benthos | Decapoda |

(b)

| | Sample no. | $\bar{X}$ percent by volume | | |
|---|---|---|---|---|
| | | Fish | Plankton | Benthos |
| Gascoyne Inlet | 2 | 50 | 50 | .. |
| Byam Martin Island | 2 | 45 | 55 | .. |
| Russell Island | 5 | 40.7 | 50.7 | 8.6 |
| Lowther Island | 2 | .. | .. | 100 |

Table 12. Area measurements of first-year ice for sheltered coastal areas and bays and offshore areas in the study region.

| | Surface ($km^2$) |
|---|---|
| **Sheltered coastal areas and bays** | |
| 1. Radstock Bay and Maxwell Bay | 1070 |
| 2. SW Cornwallis I. to Griffith I. | 825 |
| 3. Browne Bay (Prince of Wales I.) | 2430 |
| 4. Baring Channel | 755 |
| 5. Graham Moore Bay | 3470 |
| 6. Byam Channel | 1540 |
| **Offshore areas** | |
| 1. Peel Sound | 9260 |
| 2. Lancaster Sound-Barrow Strait (to Lowther I.) | |
| a) floe-edge at Prince Leopold I. (most years) | 17065 |
| b) floe-edge at Griffith I. (1969, 1974, 1976) | 3860 |
| c) floe-edge at Borden Peninsula | 34190 |
| 3. Wellington Channel | 6775 |
| 4. McDougall Sound, and Berkeley Strait | 9970 |
| 5. Austin Channel and Byam Martin Channel | 10130 |

Table 13. Polar bear sightings and associated data gathered during the 1975 helicopter supported breeding habitat survey.

| Date | Location of birth lair search stations (see Fig. 1) | Bears sighted | Adult/cub ratio | Behaviour and/or hunting habitat |
|---|---|---|---|---|
| 10/5 | 1-2 | 3 | 1:2 | Hunting along pressure ridges and in pressured near-shore ice (Wood Island). |
| 12/5 | 7-10 | 1 | ... | Hunting at breathing hole, hummock ice area. |
| 13/5 | 11-14 | 2 | ... | Flat ice W of Bracebridge Inlet, Bathurst Island. |
| 15/5 | 17-18 | 1 | ... | Hunting along open water near Creswell Bay, Somerset Island. |
| 18/5 | 29 | 1 | ... | Very rough ice near shore of Griffith Island. |
| 19/5 | 30-33 | 1(dead) | ... | Shot along lead NW of Limestone Island. |
| 20/5 | 34-35 | 3 | ... | South coast of Devon and along flbe edge to Prince Leopold Island. |
| 23/5 | 42-44 | 4 | ... | Hunting along ridges, in flat ice and hummocky ice. |
| 25/5 | ... | 1 | ... | Hunting in rough ice along SE coast of Cornwallis Island. |
| 28/5 | 45 | 15 | 2:1 | South Devon Island, along floe edge to Port Leopold. |
| 29/5 | 46-48 | 7 | 7:1 | Six bears in Peel Sound north of Bellot Strait. One in Bellot Strait area south of Fort Ross. |
| 30/5 | ... | 24 | 3:1 | East coast of Somerset Island along floe edge to Maxwell Bay, Devon Island along S Devon and Cornwallis to Resolute. |
| 31/5 | 49-50 | 5 | 2:3 | Head of Peel Sound between Aston Bay, Somerset Island and Russell Island. |
| 1/6 | ... | 4 | 1:1 | On floe edge or west of floe edge. |

Table 14. Predation of ringed seals by polar bears seen in the 1975 breeding habitat survey.

| Date | No. of digs | No. of kills | Location and habitat type |
|---|---|---|---|
| 10/5 | 41 | 8 | Southern and southwestern Bathurst Island in pressured ice nearshore. |
| 11/5 | 18 | 1 | Aston Bay and N Somerset Island. Pressure ridges. |
| 12/5 | 1 | .. | Around Russell Island, N Prince of Wales Island. Flat ice with hummocks. |
| 13/5 | 10 | 1 | Between Byam Martin and Bathurst Island. Flat ice with pressure ridges and ice hummocks. |
| 14/5 | 6 | 0 | Large bays, flat ice, east side of Prince of Wales Island in Peel Sound. |
| 15/5 | 6 | 1 | Large bays, flat ice, east side of Prince of Wales Island in Peel Sound. |
| 16/5 | 8 | 0 | N-S crossing Barrow Strait just west of Lowther Island. Ice hummocks and flat areas. |
| 17/5 | 4 | 3 | N-S crossing Barrow Strait just east of Lowther Island. Ice hummocks and flat areas. |
| 18/5 | 11 | 2 | Around Griffith Island. Pressured ice near shore. |
| 19/5 | 27 | 1 | Barrow Strait to head of Peel Sound. Ice hummocks and large expanses of flat ice. |
| 20/5 | 5 | 0 | N coast of Somerset Island. Ice hummocks and flat ice areas. |
| 22/5 | 2 | 0 | N-S across Barrow Strait 15 miles W of Lowther Island. Ice hummocks, pressured areas. |
| 23/5 | 32 | 1 | W of Byam Martin Island. Very flat ice with few well defined pressure ridges. |
| 28/5 | 3 | 3* | Along S coast of Cornwallis and Devon islands to floe edge.<br>*All kills at floe edge, one was a bearded seal. |
| 29/5 | 30 | 3 | Along W coast Somerset Island, Peel Sound. Ice with hummocks and well defined pressure ridges. |
| 30/5 | 1 | 5* | E coast of Somerset Island, along floe edge to S coasts of Devon and Cornwallis islands.<br>*All kills at leads or at breathing holes in flat area on east coast Somerset Island. |
| 31/5 | * | 3 | NE of Aston Bay, Somerset Island. Flat ice, very low pressure ridges.<br>*Lairs have begun to melt open. |
| 1/6 | 9 | 4* | S coasts of Cornwallis and Devon islands along floe edge. Variety of ice types.<br>*Two kills were at lead or on the floe edge. |

Table 15. Observations of polar bears during the 1975 fixed-wing survey.

| Area[a] | No. of sightings of tracks | No. of sightings of bears | Total sightings | Area surveyed ($km^2$) | Sightings per $km^2$ | Bear predation on seals: No. kills observed | Bear predation on seals: No. bears observed at kill |
|---|---|---|---|---|---|---|---|
| E. Barrow Strait | 14 | 3 | 17 | 1601.1 | 0.011 | 2 | ... |
| S. Wellington Channel | 0 | 0 | 0 | 63.6 | 0 | ... | ... |
| Peel Sound | 3 | 0 | 3 | 1665.7 | 0.002 | ... | ... |
| Graham Moore Bay, Austin Channel, Byam Channel | 60 | 7 | 67 | 1513.7 | 0.044 | ... | ... |
| McDougall Sound[b] | 3 | 0 | 3 | 757.0 | 0.004 | ... | ... |
| W. Barrow Strait | 3 | 0 | 3 | 1899.9 | 0.002 | 1 | ... |
| E. Viscount Melville Sound | 11 | 1 | 12 | 1678.7 | 0.007 | 2 | 1 |
| W. Viscount Melville Sound | 83 | 1 | 84 | 1124.3 | 0.075 | ... | ... |
| Floe edge | 21 | 3 | 24 | 114.1 | 0.210 | 3 | ... |
| Total | 198 | 15 | 213 | 10418.1 | 0.020 | 8 | 1 |

[a]Limits of geographic areas designated in footnotes of Table 2.

[b]All tracks were seen in Goodsir Inlet.

Table 16. Predation attempts by polar bears and arctic foxes seen during the 1976 birth lair searches.

| Search area | Number of subnivean structures found | Polar bear % lairs dug into | Arctic fox % lairs dug into |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 2 | 18 | 38.9 | 0 |
| 3 | 24 | 20.8 | 0 |
| 4 | 9 | 89.0 | 11.0 |
| 5 | 14 | 14.3 | 35.7 |
| 6 | 14 | 0 | 0 |
| 7 | 41 | 43.9 | 12.2 |
| 8 | 21 | 47.6 | 0 |
| 9 | 15 | 46.6 | 6.7 |
| 10 | 41 | 19.5 | 12.2 |
| 11 | 10 | 60.0 | 10.0 |

Table 17. Bear kills of ringed seals found during the 1976 breeding habitat survey.

| Date | Location | Age of seal | Snow depth cm | Remarks |
|---|---|---|---|---|
| 24/4 | 5 miles NE Stefansson Island | ? | 60 | Blood only |
| 4/5 | Austin Channel | 8+ | 70 | Haul-out lair |
| 5/5 | Austin Channel | ? | 65 | Blood only |
| 6/5 | De la Beche Bay | 0+ | .. | Found on surface |
| 8/5 | South Cape Cockburn | 0+ | 68 | Predated birth lair |
| 9/5 | Moore Island | 0+, 4+ | .. | Old kills, on surface of ice |
| 13/5 | Russell Island | 19+ | .. | Along low ridge |
| 17/5 | Aston Bay | 0+ | 70 | Birth lair |
| 18/5 | Peel Sound | 1+ | 70 | Haul-out lair |
| 18/5 | Peel Sound | 5+ | 40 | Haul-out lair |
| 22/5 | Lowther Island | 0+? | 45 | Blood only |
| 22/5 | Lowther Island | 0+ | 65 | Edge of rough ice |
| 25/5 | 12 miles ENE Lowther Island | 0+, 0+ | 55 & 65 | Low ridges |
| 27/5 | SW Griffith Island | 0+ | .. | Old dig |

Table 18. Sightings of other marine mammals during the 1975 helicopter survey.

| Date | White whale (Beluga) | Location or flight track |
|---|---|---|
| 20/5 | 12 adults | Prince Leopold I. cliff |
| | 8 | Prince Leopold I. cliff |
| | 9 & 1 calf | Prince Leopold I. cliff |
| 28/5 | 15 & 1 calf | Going S along floe edge |
| 30/5 | 2 | Going S along floe edge |
| | 2 & 1 grey calf (2 years old) | North along floe edge |
| | 2 & 2 yearling calves | Going S along floe edge |
| 1/6 | 22 adults<br>6 calves | Going S along floe edge |
| | Walrus | |
| 20/5 | 2 | Ice pan off floe edge at Prince Leopold I. |
| 30/5 | 8 | Ice pans off floe edge and in water close to cliffs at N side of Prince Leopold I. |
| 1/6 | 4 | Ice pans and in water at floe edge |
| | Bearded seal | |
| 30/5 | 3 | Ice pans off floe edge |
| 1/6 | 1 | Pan near floe edge |

Table 19. Bird sightings during the 1975 helicopter survey.

| Date | Species | Location or flight tracks |
|---|---|---|
| 15/5 | Old Squaws[1] | E Somerset I. coast |
| | 2 Ptarmigan[2] | Stanwell Fletcher to Resolute |
| 20/5 | 68 Glaucous Gulls[3] | Along open water edge going S towards Prince Leopold I. |
| | 2015 Thick-billed Murres[4] | Going S along the floe edge for approximately 15 km from a point N to Prince Leopold I. |
| | 50-60 King Eiders[5] | Large flock S of Prince Leopold I. |
| 23/5 | Glaucous Gulls | Mouth of Bracebridge Inlet |
| 25/5 | 2 Kittiwakes[6] | |
| | 2 Glaucous Gulls | |
| | Glaucous Gulls | N tip of Browne I. along coast of Devon |
| | Hawk sp?[7] | |
| 28/5 | 3 King Eiders | NW of Gascoyne Inlet |
| | Glaucous Gulls | Cliffs between Gascoyne Inlet and Radstock Bay |
| | King & Common Eiders[8] | S along floe edge going W |
| | Old Squaws | |
| 29/5 | Common Eiders | |
| | 3 Snowgeese (greater ?)[9] | Near Bellott Strait |
| 30/5 | 3 Old Squaws | Fury Point |
| | 2 Black Guillemots[10] | |
| | 3 flocks Kittiwakes | |

[1] *Clangula hyemalis*
[2] *Lagopus* sp.
[3] *Larus hyperboreus*
[4] *Uria lomvia*
[5] *Somateria spectabilis*
[6] *Rissa tridactyla*
[7] Accipitridae
[8] *Somateria mollissima*
[9] *Chen caerulescens*
[10] *Cepphus grylle*

Table 20. Sightings of terrestrial mammals during the 1975 helicopter survey.

| Date | Caribou | Location or flight tracks |
|---|---|---|
| 15/5 | 14 | Creswell Bay to Stanwell Fletcher Lake to Resolute |
| 22/5 | 5 | Centre of Young I., Barrow Strait |
| 23/5 | 1 track | E to W near Otrick I. |
| 29/5 | 10 | W across Peel Sound from Somerset I. |
| | 30 | W along Somerset coast |
| 31/5 | 6 + tracks | Towards Back Bay from Somerset I. |
| | Muskox | |
| 10/5 | 18 adults & 2 calves | Polar Bear Pass, Bathurst I. |
| 14/5 | 51 | N shore Browne Bay, Prince of Wales I. |
| 23/5 | 17 | SW of National Museum Camp, Bathurst I. |
| | Arctic fox | |
| 11/5 | 1 | Cunningham Inlet, Somerset I. |
| 14/5 | 1 | N shore of Browne Bay, Prince of Wales I. |
| | tracks | 15 miles W of Lock I., Prince of Wales I. |
| 19/5 | 1 track | Back Bay, Prince of Wales I. |
| 23/5 | 1 track | Bracebridge Inlet, Bathurst I. |
| 31/5 | 1 track | N-S to Baring Channel |
| | 1 | On sea ice of Aston Bay, Somerset I. |
| 2/6 | tracks | Barrow Strait, S of Resolute |

Table 21. Miscellaneous game sightings along the 1976 survey route.

| | Location | Numbers | Remarks |
|---|---|---|---|
| 16/4 | Kagloruiak River | 3 caribou, 1 fox, fox tracks | on river about 50 miles inland |
| 17/4 | Crossing Victoria I. | no caribou tracks - ptarmigan | |
| 18/4 | Crossing Victoria I. | fox and lemming tracks, ptarmigan, 3 muskoxen, 2 fox | |
| 19/4 | Inland to coast M'Clintock Channel | 1 muskox, ptarmigan, female bear + 2 cubs + 2 lone bears | on coast |
| 23/4 | Stefansson I. E | 7 muskoxen, female bear + 2 cubs, 2 lone bears (bear killed seal) | rough ice |
| 24/4 | N of Stefansson I. | 2 bears, ++ bear tracks | old multi-year and broken floe |
| 25/4 | N into rough ice about 58 miles | few bear tracks, no fox signs | |
| 29/4 | Byam Martin Channel | female, 450-500 lb polar bear, no tags. Male wolf collected on island | near camp |
| 30/4 | Byam Martin Channel | ++ fresh bear tracks | |
| 2/5 | S Byam Martin | bear tracks | on land and in very rough ice along island shore |
| 6/5 | De la Beche Bay, Bathurst I. | 1 large male polar bear (no tags), 1 female + 1 cub (no tags), ++ tracks in bay, few digs | |
| | N side de la Beche Bay | concentration of arctic hares | |
| 7/5 | Cape Cockburn | ++ bear tracks. Killed 1 female bear in camp (2-year old) | |
| 8/5 | Cape Cockburn 60 miles N&S in rough ice to Moore I. | 1 large male polar bear (no tags), 15 tracks (bear) along edge | rough ice |
| 9/5 | Moore I. S&E to Browne I. | 7 bears, 27 fresh bear tracks, most going SE | |
| 10/5 | Browne I. to Resolute | 2 fresh bear tracks | |
| 12/5 | Russell I. | ++ bear tracks, 3 seal kills (bear den Palmerson Pt. E side on high point) | |
| 13/5 | Russell I. | 4 bears, edge of Russell I., a.m.; lone female, female + 2 cubs | |
| 14/5 | Russell I. | 4 bear dens on Russell I., 7 bears (no tags) all males | |
| 15/5 | Russell I. to Aston Bay | bear 12 miles E Russell I., 6 bear digs; 3 caribou Aston Bay going W; tracks on ice going W | on ridge; wolf tracks following caribou |
| 16/5 | Aston Bay | 1 male bear near camp had tracked us 4 miles | |
| 17/5 | Aston Bay | fox signs and digs in bay | |
| 18/5 | Aston Bay to Russell I. | female polar bear + 3 cubs, 10 miles W of Aston Bay on flat ice, 2 lone bears | |
| 20/5 | Russell I. to Lowther I. | 4 caribou Lowther I. | caribou starving |
| 22/5 | Lowther I. | Kittiwakes? gulls?, wolf in area | |
| 25/5 | 12 miles ENE Lowther I. | 8 bears | |
| 27/5 | To N side Griffith I. | female bear + 3 cubs | in flat area east of Griffith I. |

Table 22. Comparison of search effort per subnivean structure found during the breeding habitat surveys of 1975 and 1976.

| Locations compared | | Minutes/subnivean structure | | | |
|---|---|---|---|---|---|
| | | 1975 | | 1976 | |
| 1975 | 1976 | Min/ lair* | Min/birth lair | Min/ lair* | Min/birth lair |
| Sites 42, 45 | Area 2 | 0 | 0 | 4.1 | 74.6 |
| Sites 11-14 | Area 3 | 60 | 0 | 7.1 | 85.0 |
| Sites 1-2 | Area 4 | 20 | 0 | 3.1 | 7.3 |
| Site 24 | Area 5 | 20 | 30 | 5.3 | 18.7 |
| Ground search | Area 6 | 4.4 | 7.6 | 4.2 | 19.8 |
| Site 23 | Area 9 | 15.0 | 30.0 | 2.7 | 40.2 |
| Sites 3, 4, 33, 46 | Area 10 | 7.5 | 12.0 | 3.5 | 7.5 |
| Sites 7, 31, 32 | Area 11 | 11.3 | 90.0 | 3.5 | 8.7 |

*includes birth lairs, male and female haul-out lairs and breathing holes

FIGURES

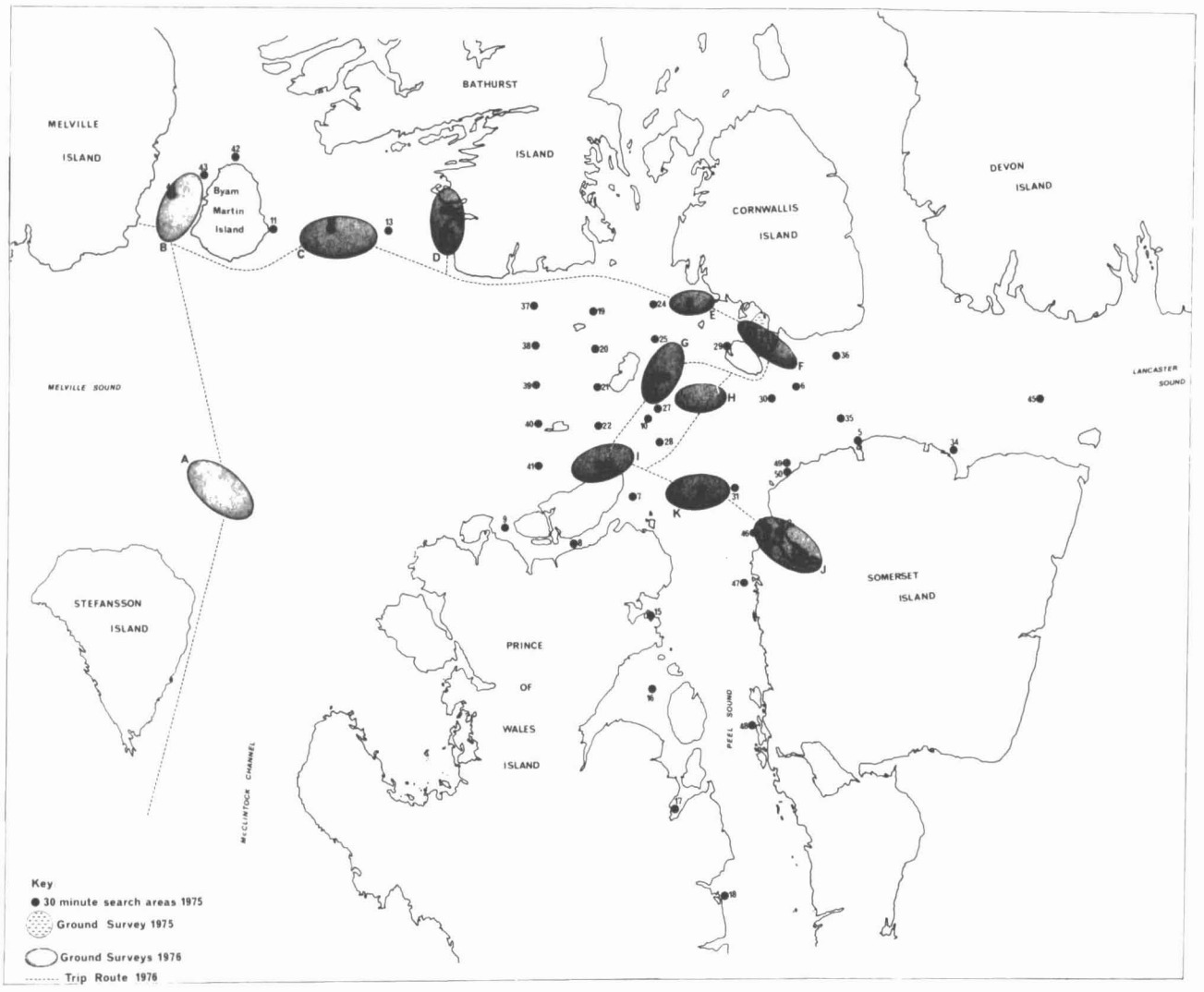


Fig. 1. Location of 1975 breeding habitat search sites, and routes and search sites during the 1976 breeding habitat survey.

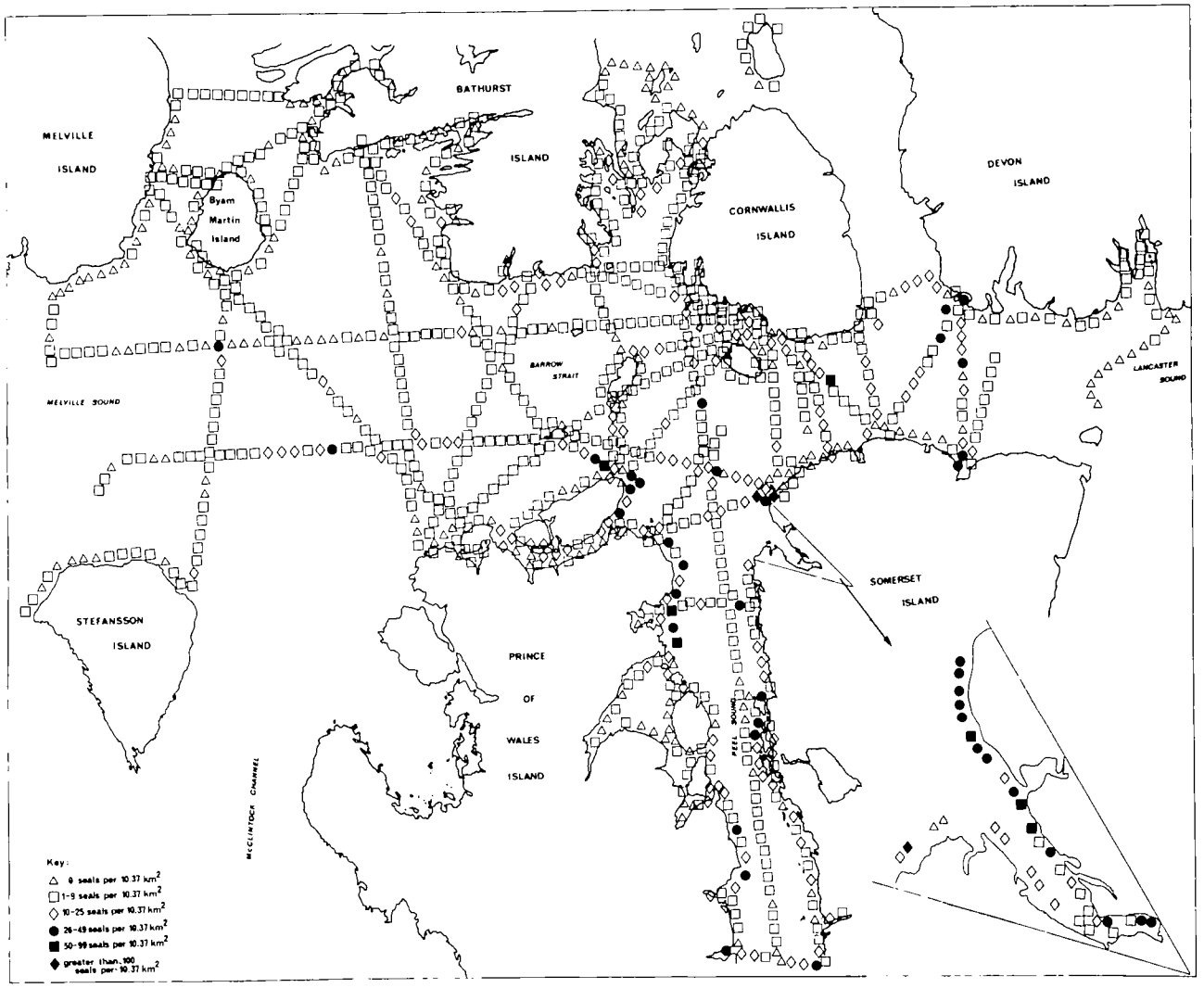


Fig. 2. Flight paths and densities of hauled-out ringed seals in the 1975 fixed-wing survey.

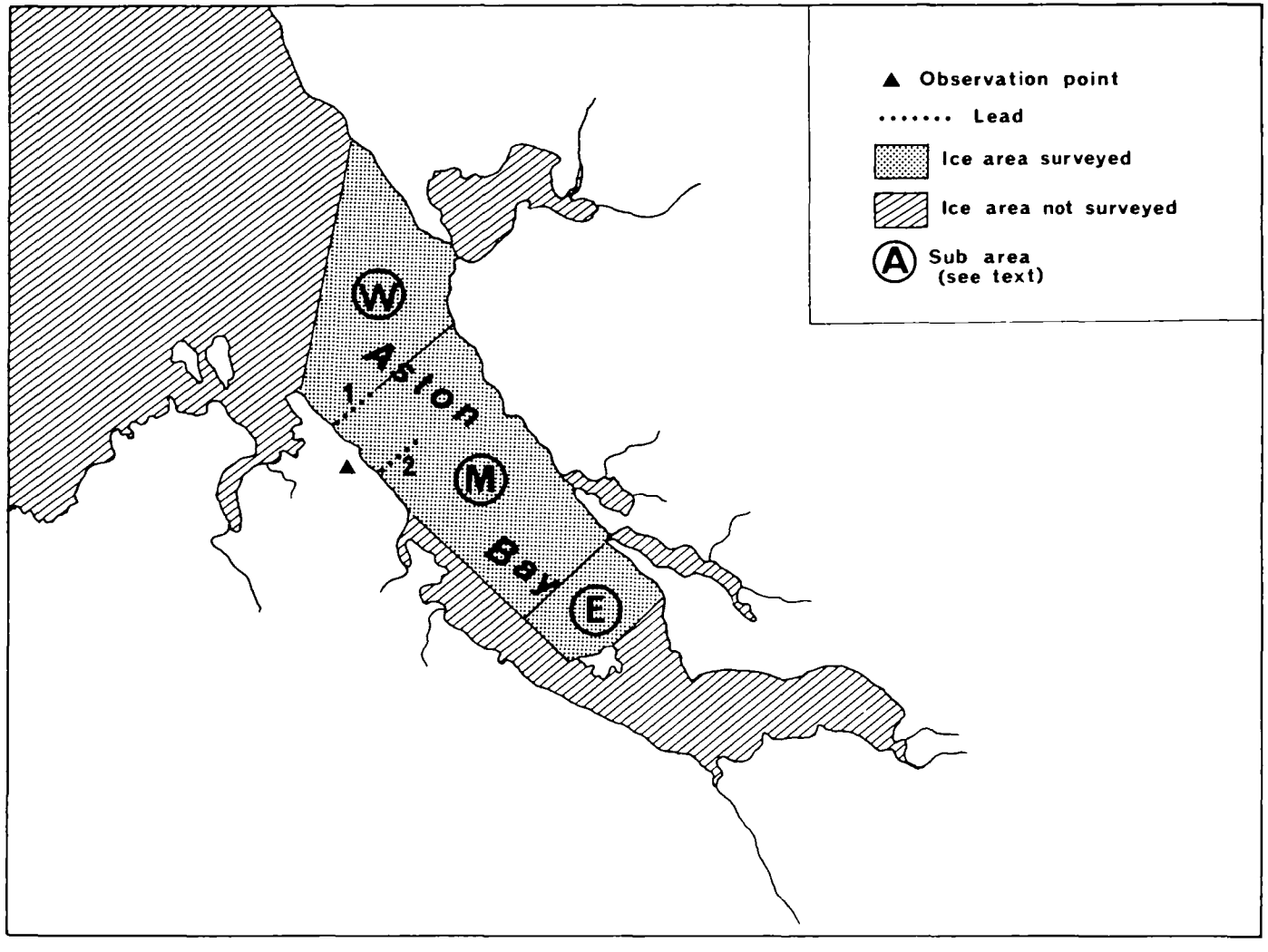


Fig. 3. Aston Bay (northwest Somerset Island) study area 1975.

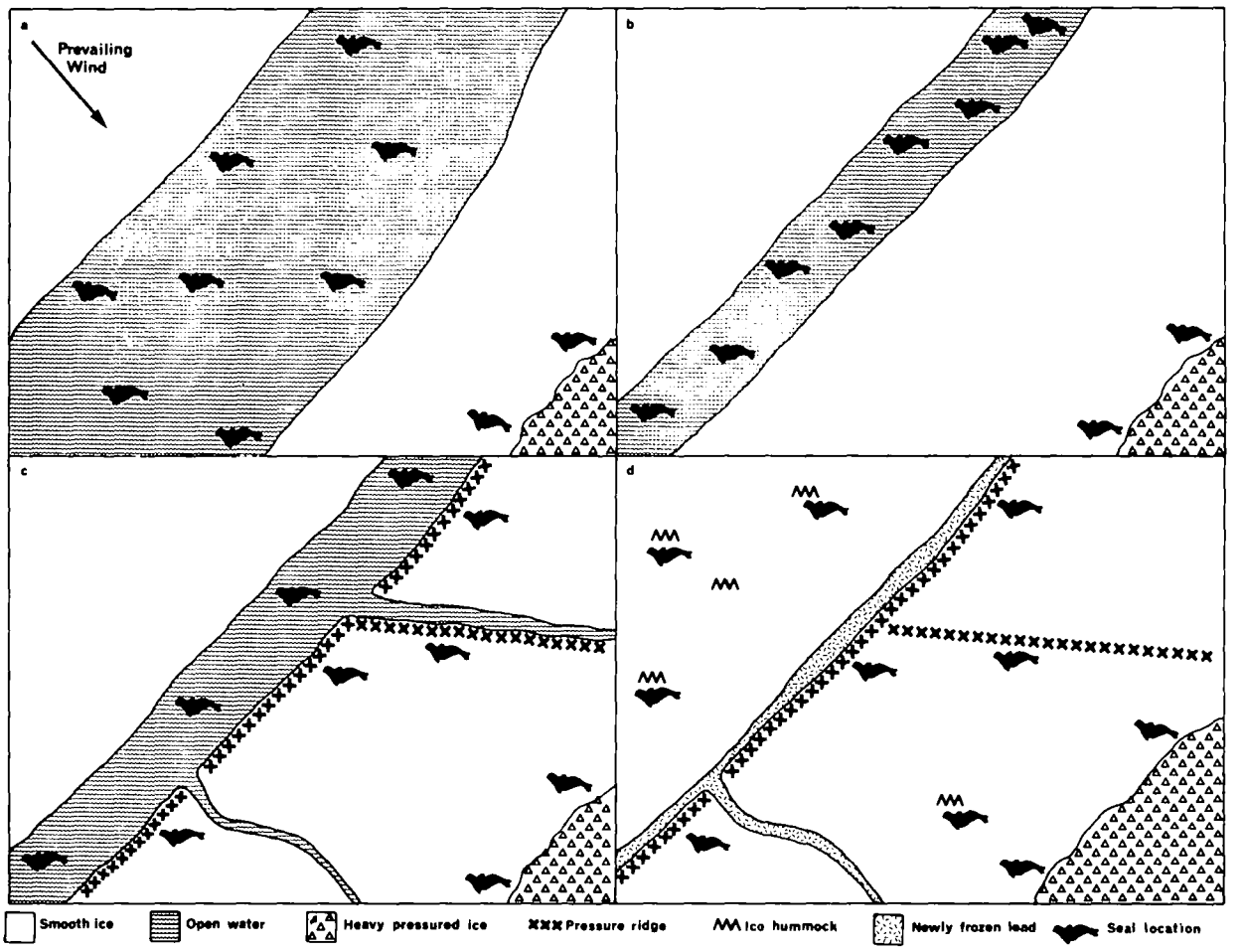


Fig. 4. A schematic representation of the way in which ringed seals occupy specific sites in the fast ice during the freeze up, deformation and final consolidation of fast ice: a) seals in last open water; b) open water reduced to large lead; c) deformation caused by winds and currents creating pressure ridges, and areas of much pressure ice; d) final complete freeze up and stabilization.

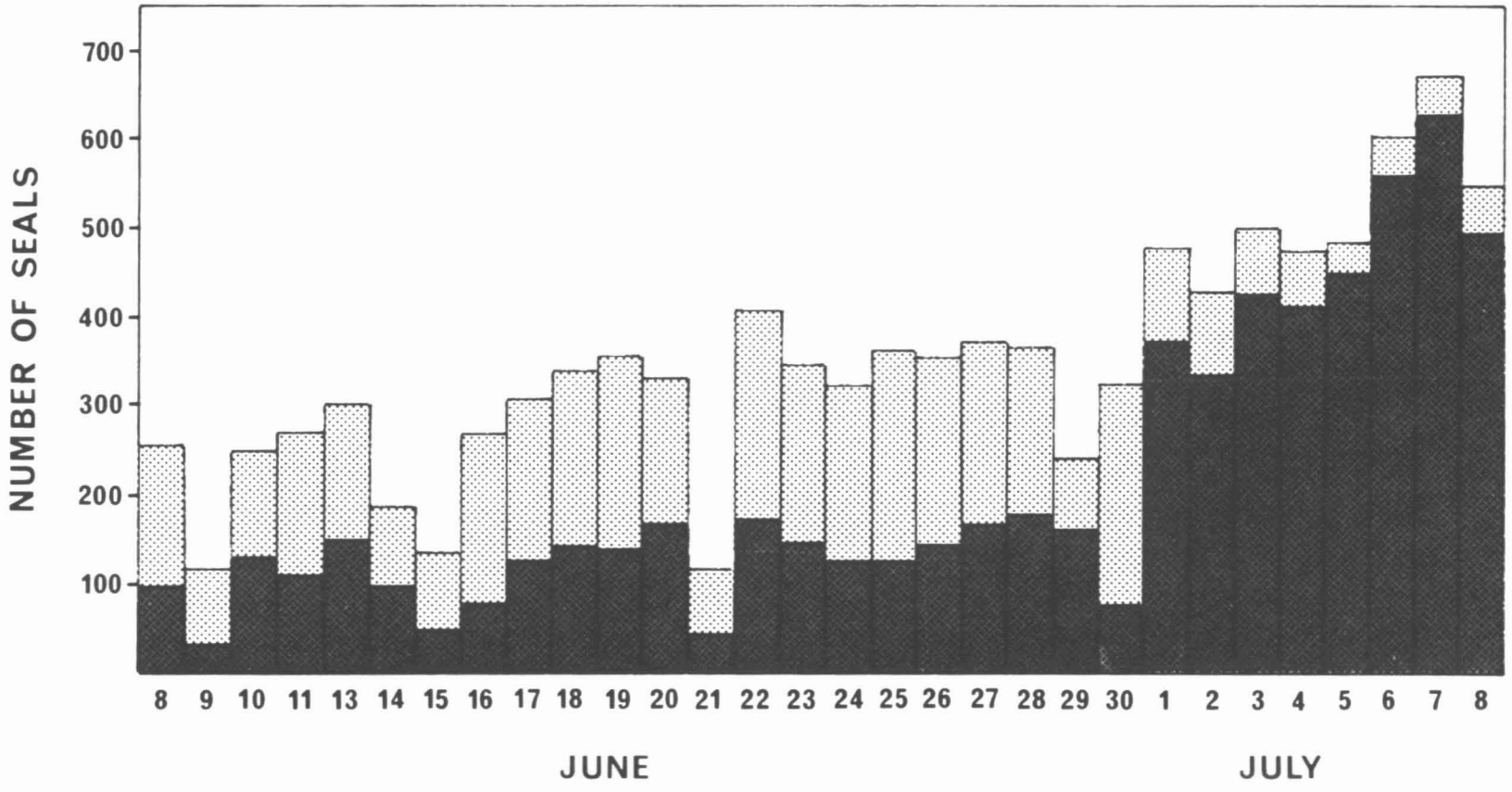


Fig. 5. Number of seals at breathing holes and along cracks in Aston Bay during June and July 1975.

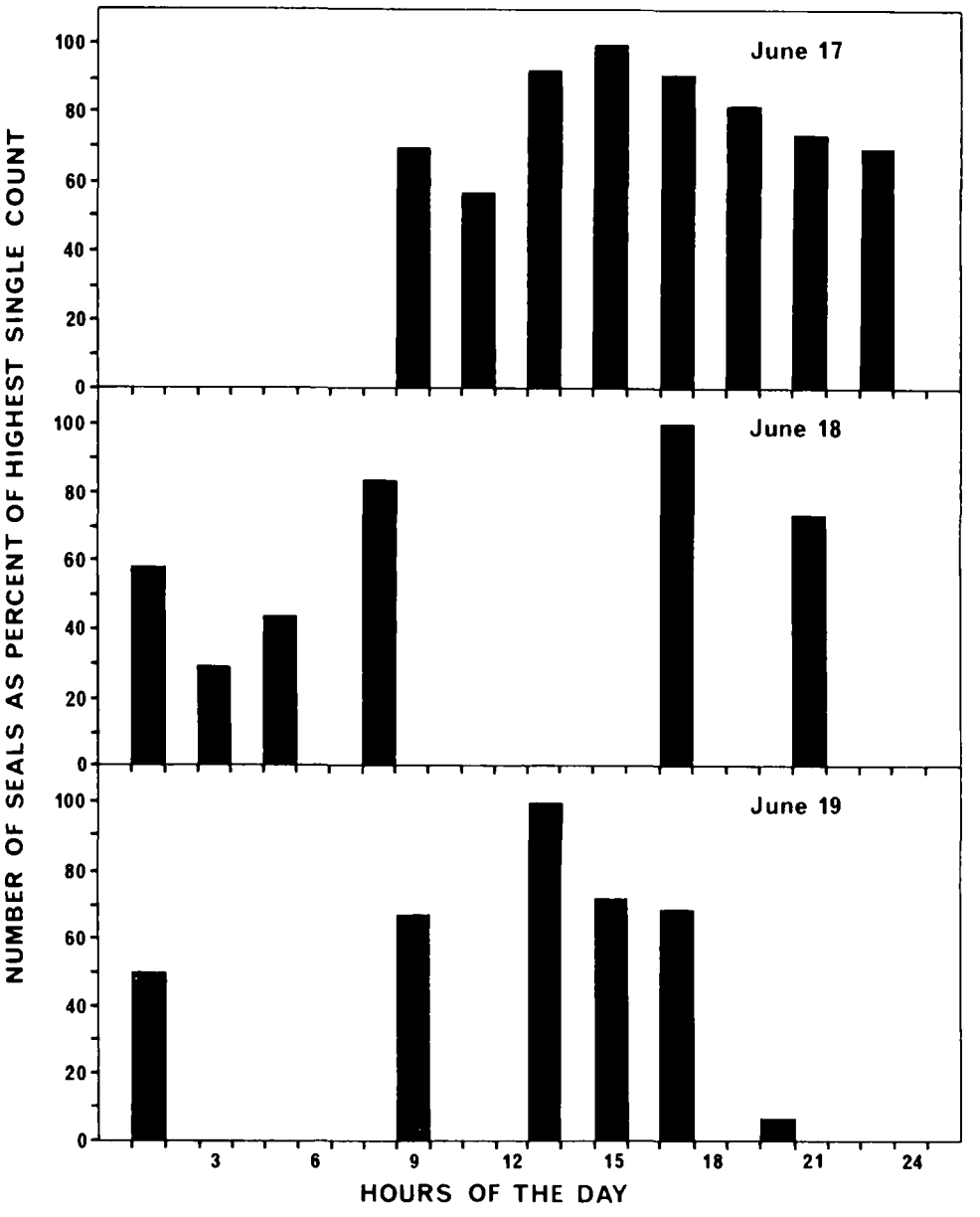


Fig. 6. Diurnal variation in the number of seals counted at 2-hour intervals on days in Aston Bay during June-July 1975.

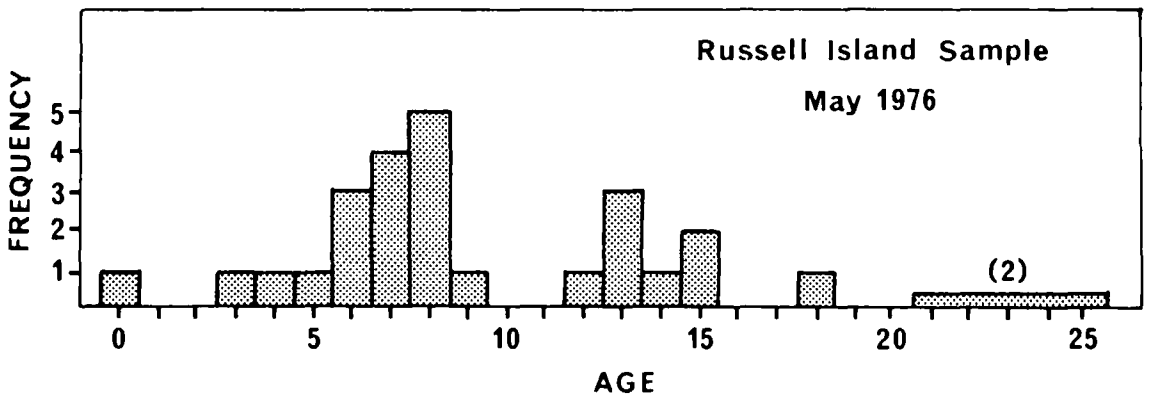


Fig. 7. Age structure of ringed seals taken along a refrozen lead off the northeastern tip of Russell Island in 1976.

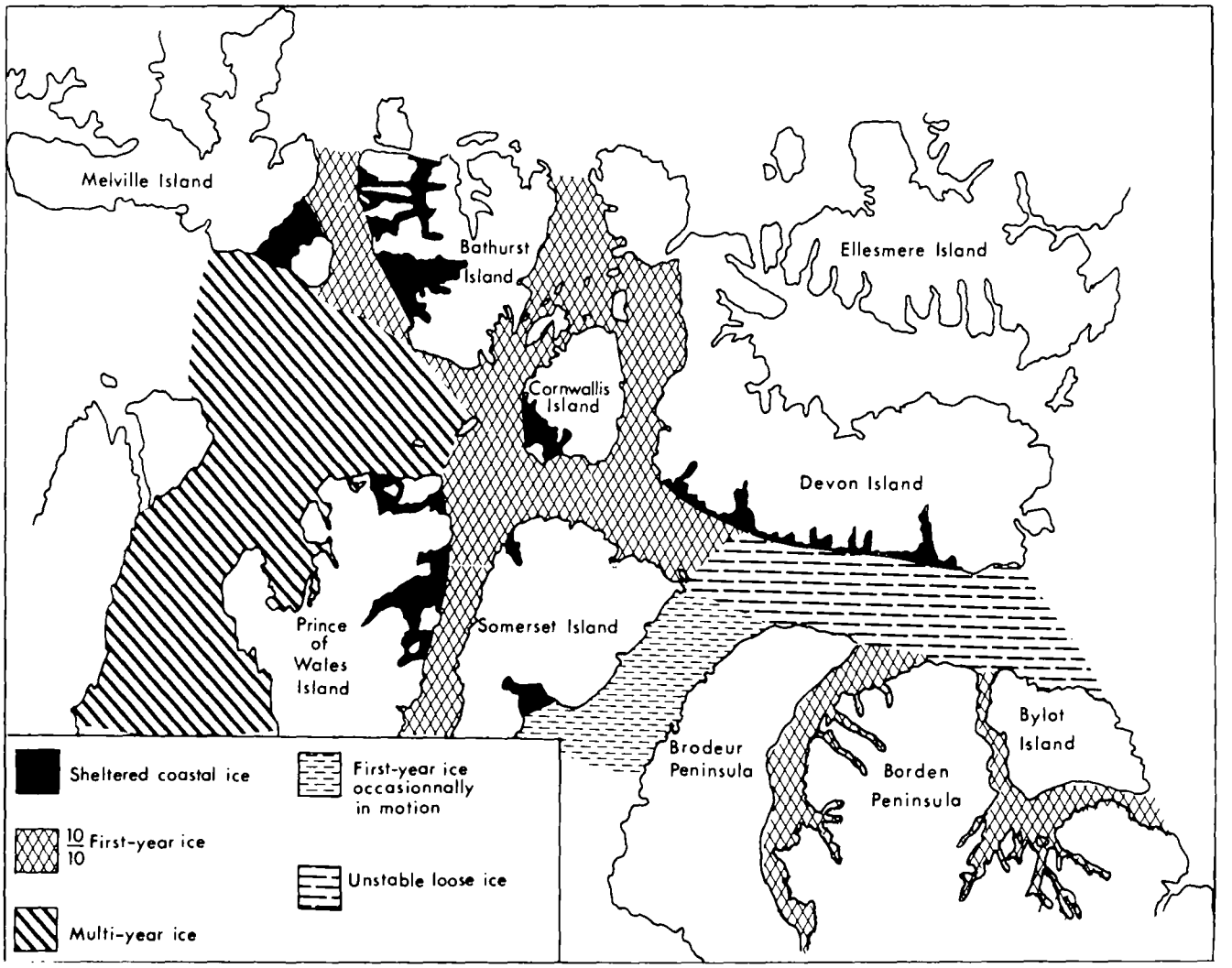


Fig. 8. Summary map of winter ice conditions from LANDSAT imagery and ice observer reports from 1964 to 1977.

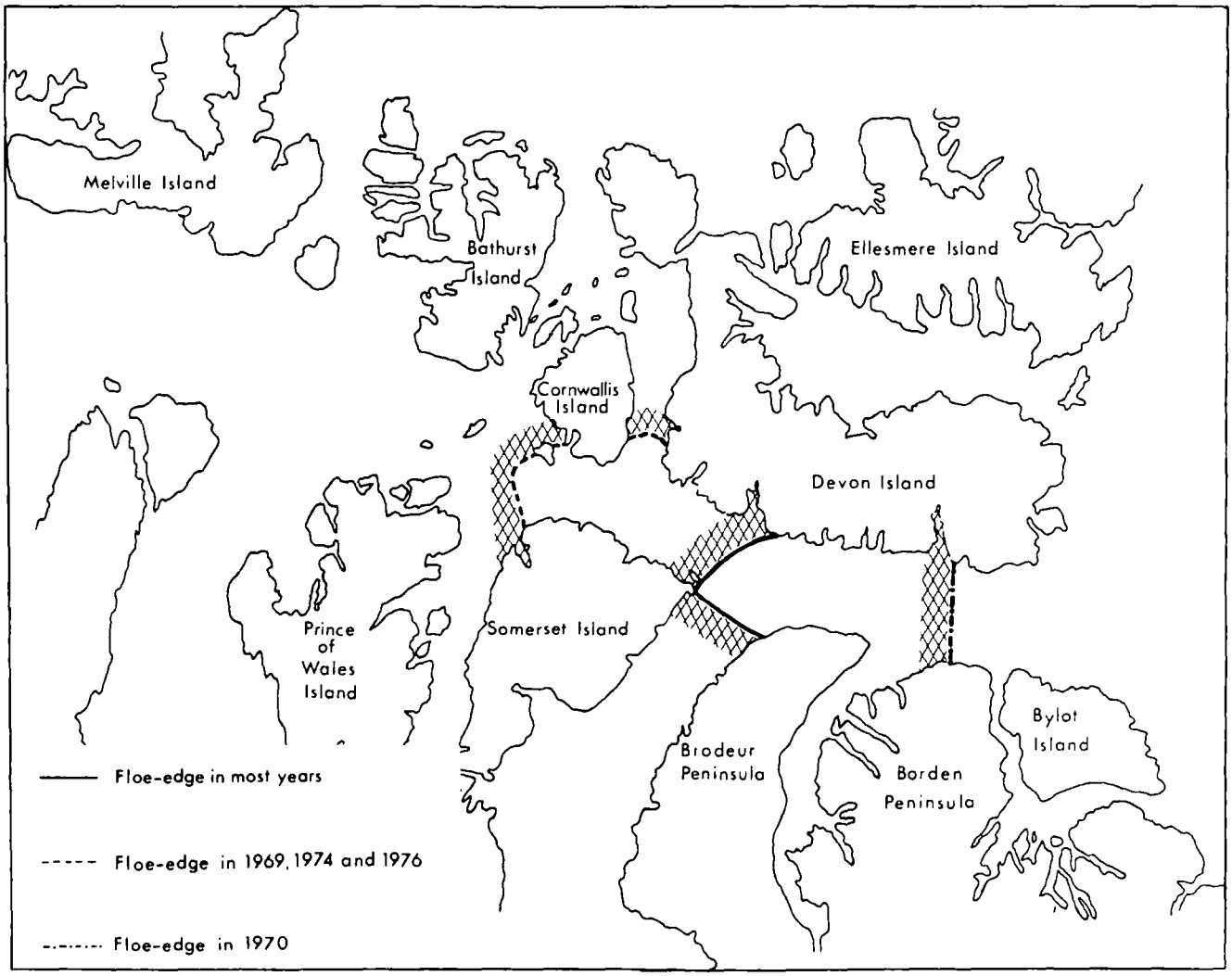


Fig. 9. Map showing the variation in the location of the floe edge during the years 1964 to 1977.

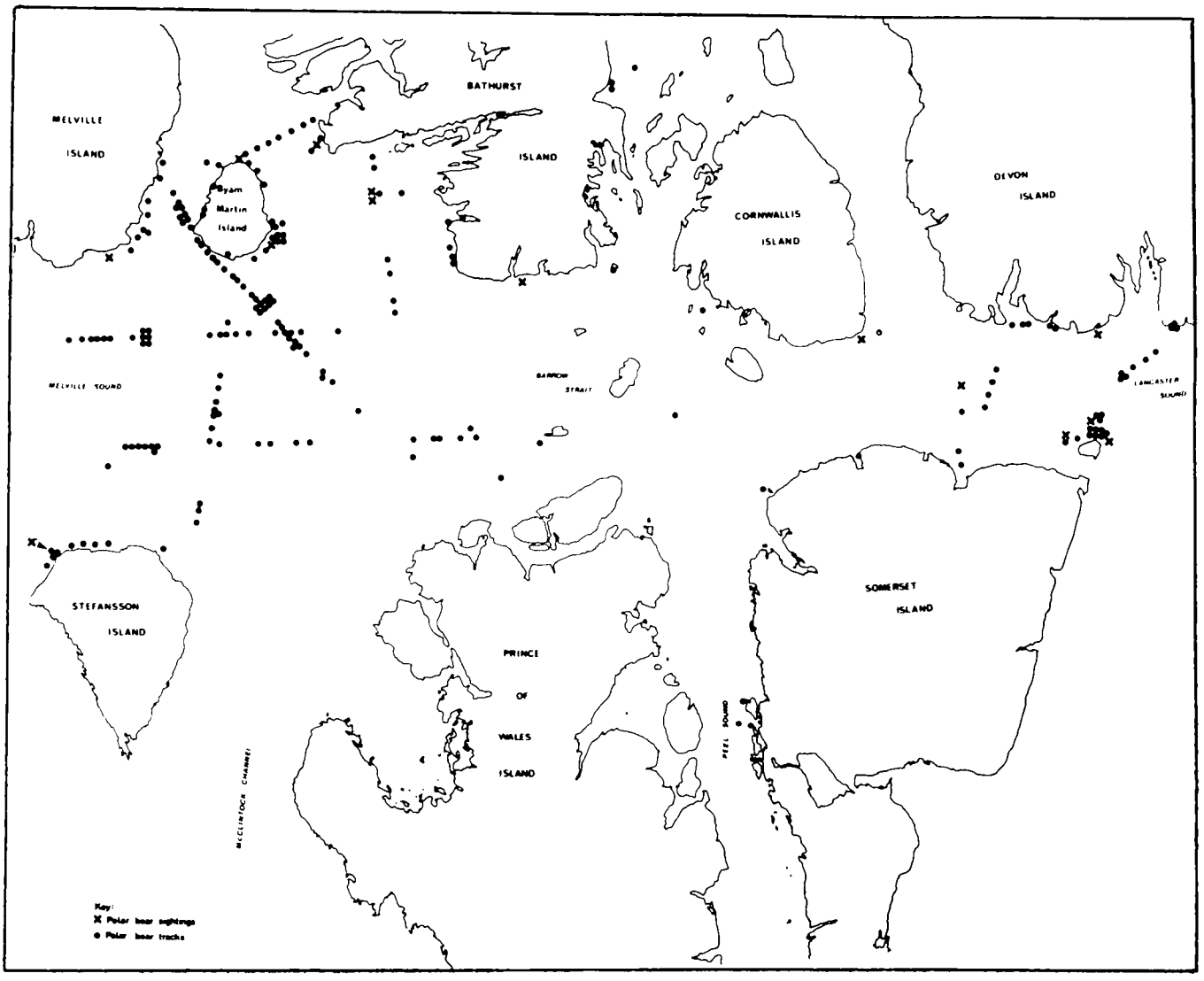


Fig. 10. Location of polar bear sightings during the 1975 fixed-wing survey.

## 11. REFERENCES

Anon. 1964-1977. Weekly ice charts. Canada, Dept. Fish. & Environ., Ice Forecasting Central, Ottawa.

Apollonio, S. 1965. Chlorophyll in arctic sea ice. Arctic 18: 118-122.

Barry, T. W. 1961. Sea-bird colonies of Prince Leopold Island and vicinity. Can. Field-Nat. 75: 72-73.

Bissett, D. 1967a. Resolute--an area economic survey. Canada, Dept. Indian Affairs & Northern Development, Industrial Div., A.E.S.R. 67/1, Vol. 2: 175 p.

1967b. Northern Baffin Island--an area economic survey. Canada, Dept. Indian Affairs & Northern Development, Industrial Div., A.E.S.R. 67/1, Vol. 1: 209 p.

Bradley, J. M. 1970. Ringed seal avoidance behaviour in response to Eskimo hunting in northern Foxe Basin. McGill Univ., Geog. Dept., M.Sc. Thesis: 113 p.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, London. 244 p.

Davis, R. A., K. Finley, M. Bradstreet, C. Holdsworth & M. McLaren. 1975. Studies of the numbers and distribution of birds and marine mammals in the central Canadian arctic--1974. A supplement. Prepared for Polar Gas Project (Toronto, Ont.). LGL Ltd., Toronto, Ontario.

Finley, K., R. A. Davis & W. J. Richardson. 1974. Preliminary studies of the numbers and distribution of marine mammals in the central Canadian arctic--1974. Prepared for Polar Gas Project (Toronto, Ont.). LGL Ltd., Toronto, Ontario.

Finley, K. 1976. Studies of the status of marine mammals in the central district of Franklin, N.W.T., June-August 1975. Prepared for Polar Gas Project (Toronto, Ont.). LGL Ltd., Toronto, Ontario.

Geraci, J. R. & T. G. Smith. 1976. Direct and indirect effects of oil on ringed seals (*Phoca hispida*) of the Beaufort Sea. J. Fish. Res. Board Can. 33(9): 1976-1984.

Johnson, M. L., C. H. Fiscus, B. T. Ostenson & M. L. Barbour. 1966. Marine mammals, pp. 887-924 *in* N. J. Wilimovsky (ed.). Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Comm., Div. Tech. Inf. Ext., Oak Ridge, Tennessee.

Lindsay, D. G. 1975. Sea ice atlas of arctic Canada. Canada, Dept. Energy, Mines & Resources, Ottawa. Cat. No. M78-4/1975: 213 p.

McLaren, I. A. 1958. The biology of the ringed seal (*Phoca hispida* Schreber) in the eastern Canadian arctic. Bull. Fish. Res. Board Can. 118: 97 p.

1962. Population dynamics and exploitation of seals in the eastern Canadian arctic, pp. 168-183 *in* M. W. Holdgate & E. D. LeCren (eds.). Exploitation of natural animal populations. John Wiley & Sons Inc., Blackwell. Oxford.

Nettleship, D. 1974. Seabird colonies and distributions around Devon Island and vicinity. Arctic 27: 95-103.

Sergeant, D. E. & W. Hoek. 1974. Seasonal distribution of bowhead and white whales in the eastern Beaufort Sea, pp. 705-720 *in* John C. Reed & John E. Sater (eds.). The coast and shelf of the Beaufort Sea. Arctic Institute of North America.

Smith, T. G. 1973a. Population dynamics of the ringed seal in the Canadian eastern arctic. Bull. Fish. Res. Board Can. 181: 55 p.

1973b. Censusing and estimating the size of ringed seal populations. Fish. Res. Board Can. Tech. Rep. 427: 18 p.

1976. Predation of ringed seal pups (*Phoca hispida*) by the arctic fox (*Alopex lagopus*). Can. J. Zool. 54: 1610-1616.

Smith, T. G. & F. A. J. Armstrong. 1975. Mercury in seals, terrestrial carnivores and principal food items of the Inuit from Holman, N.W.T. J. Fish. Res. Board Can. 32: 795-801.

Smith, T. G. & J. R. Geraci. 1976. The effect of contact and ingestion of crude oil on ringed seals of the Beaufort Sea. Beaufort Sea Project Tech. Rep. 5: 67 p.

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

1978. Variation in the density of ringed seal (*Phoca hispida*) birth lairs in the Amundsen Gulf, Northwest Territories. Can. J. Zool. (In press)

Smith, T. G., D. Taylor & Hagagiak. 1976. Breeding habitat and population surveys of seals in the Viscount Melville Sound, Barrow Strait and Peel Sound areas. Interim report to the Arctic Islands Pipeline Program: 30 p.

Stirling, I., R. Archibald & D. DeMaster. 1977. The distribution and abundance of seals in the eastern Beaufort Sea. J. Fish. Res. Board Can. 34: 976-988.