PEARY CARIBOU AND MUSKOXEN ON BATHURST, ALEXANDER, MARC, MASSEY, VANIER, CAMERON, HELENA, LOUGHEED, AND EDMUND WALKER ISLANDS, NORTHWEST TERRITORIES, JULY 1985

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ABSTRACT. An aerial survey to determine numbers and distributions of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) was flown over nine central High Arctic islands in the Canadian Archipelago between 10 and 25 July 1985. The survey area included the islands of Bathurst, Alexander, Marc, Massey, Vanier, Cameron, Helena, Lougheed, and Edmund Walker, Northwest Territories. A systematic unbounded line transect survey was flown at about 90 m above ground level along transects at 6.4-km intervals, for an overall coverage of about 27%. The survey aircraft was a Bell-206B turbo-helicopter on floats, equipped with a Global Navigational System. A four-person survey crew was used. Two hundred and sixty caribou and 264 muskoxen (1+ yr-old), 92 caribou calves, and 54 muskox calves were seen during the survey. Numbers of caribou and muskoxen within the entire survey area were estimated at 724 and 545, respectively. Overall estimated density for all caribou was 3.47 caribou/100 km^{-2} and for all muskoxen was 2.61 muskoxen/100 km^{-2}. Numbers of caribou and muskoxen were greatest on Bathurst Island, with highest densities for each of both species occurring on the northwest of Bathurst. Caribou calves represented 23.7% of all caribou and muskox calves 18.1% of all muskoxen seen on and off survey. Both Peary caribou and muskoxen apparently have increased within the survey area over the past decade (1975-85), but the 1985 estimates of numbers equal only about 15% of the caribou and about 47% of the muskoxen estimated in summer 1961. Population sizes are not yet at levels that would safely support high rates of sustained annual harvests.

RÉSUMÉ. Un relevé aérien visant au dénombrement des populations de Caribous de Peary (Rangifer tarandus pearyi) et de Boeufs musqués (Ovibos moschatus), ainsi qu'au calcul de leur distribution, a été fait au-dessus de neuf îles de la partie centrale de l'archipel du Haut Arctique entre de 10 et de 25 juillet 1985. Le territoire couvert comprend les îles Bathurst, Alexander, Marc, Massey, Vanier, Cameron, Helena, Lougheed, and Edmund Walker, dans les Territoires du Nord-Ouest. Le relevé systématique empruntait la forme de virées transversales non limitées et séparées l'une de l'autre de 6,4-km. L'appareil survolait le territoire à environ 90 m du sol. Cela assurait une couverture globale d'environ 27 %. L'appareil était un hélicoptère à turbine Bell-206B équipé de flotteurs et dirigé grâce à un appareil relié à un système global de navigation. L'équipe du relevé était formée de quatre personnes. Deux cent soixante Caribous et 264 Boeufs musqués (un an et plus), 92 faons et 54 bouvillons ont été aperçus durant le relevé. Les populations respectives ont été évaluées à 724 Caribous et 545 Boeufs musqués sur l'ensemble du territoire couvert. La densité pour l'ensemble des populations est évaluée à 3,47 Caribous au 100 km^2 et à 2,61 Boeufs musqués au, 100 km^2. C'est sur l'île Bathurst qu'il y avait le plus de sujets des deux espèces et sur cette île, la plus forte densité de chacune des espèces a été observée dans la partie nord-ouest de l'île. Les faons représentaient 23,7 % de la population totale de Caribous et les bouvillons représentaient 18,1 % de la population totale des Boeufs musqués observés en cours de relevé ou non. Les deux populations semblent avoir augmenté depuis dix ans (de 1975 à 1985) dans la région couverte par le relevé, mais les résultats du relevé de 1985 pour le Caribou ne sont qu'à environ 15 % de la population évaluée à l'été de 1961 et ne sont pour le Boeuf musqué qu'à environ 47 % de la population évaluée à la même période. Ces populations n'ont pas encore atteint les niveaux auxquels il devient possible de récolter tous les ans, sans danger et de manière soutenue, une proportion élevée de ces ressources.

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INTRODUCTION

Peary caribou (Rangifer tarandus pearyi) once ranged over the Canadian Archipelago and sections of Greenland (Banfield 1961). Currently, however, Peary caribou are restricted to Canada, having died out in Greenland (H. Thing, personal communication). Thus, the Peary caribou is now a unique form of wildlife in the natural heritage of arctic Canada.

Numbers of Peary caribou on the islands of the Canadian Archipelago declined drastically from, at least, 1961 (Tener 1961, 1963) to 1974 (Miller et al. 1977). In 1979 the Canadian Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recognized the Peary caribou as a "Threatened" form of wildlife in Canada. The designation as "Threatened" was based on a Canadian Wildlife Service report to the committee (Gunn, Miller, and Thomas, COSEWIC, 1979; or see Gunn et al. 1981). Recognition of Peary caribou as a "Threatened" form of wildlife makes their conservation and preservation a responsibility of Environment Canada and more specifically the Canadian Wildlife Service under the Canada Wildlife Act.

The muskox (Ovibos moschatus) was designated as an "Endangered" form of wildlife in Canada by Order-in-Council in 1962. Although numbers of muskoxen recently have increased markedly on the southern tier of islands in the Canadian Archipelago (essentially south of 74°N) and on mainland ranges, the order has not been rescinded. Also, numbers of muskoxen on the islands north of 74°N in the High Arctic declined drastically during the severe winter of 1973-74 (Miller et al. 1977) and recovery has not been documented to date. Therefore, as muskoxen occur in association with Peary caribou in the High Arctic they are also monitored with Peary caribou, when possible, by the Canadian Wildlife Service.

Peary caribou and muskoxen essentially are the sole source of fresh red meat from terrestrial animals for Inuit in the Canadian High Arctic; and most Inuit prefer the meat of caribou to muskoxen. The annual replacement value of that fresh meat would represent an appreciable yearly cost to the federal government. Thus, both significant economic and non-tangible values are associated with conserving Peary caribou and muskoxen at usable population levels.

The Canadian Wildlife Service, especially because of its concern for Peary caribou, initiated a 3-yr aerial survey program to evaluate the current statuses of Peary caribou and muskoxen in the Canadian High Arctic. Due to limited resources, the planned aerial surveys are restricted to Melville, Bathurst, Prince Patrick, and Lougheed islands (and some of their small satellite islands). These Queen Elizabeth Islands are the ones which previously supported the greatest numbers of Peary caribou, when first surveyed by air in 1961 (Tener 1963). The following is a progress report of the first year's results obtained from an aerial survey of Bathurst Island;

some of its satellite islands, Alexander, Marc, Massey, Vanier, Cameron, and Helena; and Lougheed and Edmund Walker islands in the Findlay Group to the north-northwest of Bathurst Island, Northwest Territories, July 1985.

SURVEY AREA

1. Islands

The Queen Elizabeth Islands surveyed in July 1985 lie between latitudes 74° and 78°N and longitudes 95° and 107°W (Fig. 1). Total landmass of the islands surveyed is about 20 855 km^2. The survey area is mostly low-lying and mainly below 150 m above mean sea level (amsl) in elevation.

1.1. Bathurst Island

Bathurst Island (16 090 km^2), which lies on the eastern edge of the survey area (Fig. 1), has a distinctive pattern of inlets and intervening ridges and headlands which reflect the underlying geology (Fortier et al. 1963). Most of the coast is sharply sloping, and rugged, but with few cliffs. Because of the long inlets, 25% of the land surface is within 2.5 km of the coast.

The topography of the northern three-quarters of Bathurst Island is dominated by east-northeast folds of bedrock, which form ridged uplands. Erosion has caused regular and continuous ridges with gentle to moderately steep slopes. The drainages either follow the main valleys or cut across ridges forming a trellis pattern. Most of the land (62%) is below 150 m amsl in elevation, and the greatest relief is on the northwest, where bluffs reach 412 m amsl.

The southern quarter of Bathurst Island is mainly a gently undulating plateau mostly below 60 m amsl with few well-defined features. The land is less well-drained than the upland ridges to the north. To the southwest the plateau surface is more dissected with many small ponds.

About 24% of Bathurst Island lies below 60 m amsl. Ground elevations vary considerably among the three survey strata. Most of the terrain below 60 m amsl occurs in Stratum III (5360 km^2). Stratum II (6650 km^2) has about 75% more intermediate and high ground than Stratum I (4080 km^2) or III (Fig. 1).

1.2. Lougheed Island

The Findlay Group (Lougheed, Edmund Walker, Grosvenor, Paterson and Stupart islands) is relatively isolated.

Lougheed Island is the largest (1300 km^2), and like the other islands in the group, is less than 150 m amsl in elevation (Fig. 1). The many small rolling hills and ridges are more

developed on the north where they reach 137 m amsl. The land slopes to a low flat coastal plain except on the southwest of the island.

The vegetation of Lougheed Island has attracted comment from explorers and geologists. Although Savile (1961) suggested that the flora is poor, his conclusion was based on a brief visit to one study site. Stefansson (1921) noted "abundant vegetation". Tener (1963:31) commented that the south central portion of the island was "richly vegetated and dotted with many small ponds". Fortier et al. (1963:574) who described the geology of the island, noted that, "the vegetation is generally more dense than on any other of the Arctic Islands" they visited. Tozer and Thorsteinsson (1964) observed that the extent of vegetation in the Arctic Islands is largely controlled by type of bedrock, and that siltstones are one of the formations that commonly support a good cover of vegetation. Fortier et al. (1963) found siltstones outcropping on most of southern Lougheed.

1.3. Ile Vanier

Ile Vanier is the largest (1130 km^2) of the group of islands known as the Governor General Group (Fig. 1). Like northern Bathurst and the other islands in the group, the topography is dominated by folded upland, with ridges and hills running east-northeast. About one-third (348 km^2) of Vanier is between 150 m and 259 m amsl in elevation. The higher land includes the central Adam Range with a maximum elevation of 259 m amsl. The shoreline is relatively steep with well marked coastal terraces and a narrow coastal plain.

1.4. Cameron Island

The folded upland that dominates the topography of the islands in the Governor General Group is only evident on the southeast of Cameron Island (1060 km^2), where only 0.6% of the area is above 150 m amsl and reaches a maximum height of 193 m amsl (Fig. 1). North and west across the island is a sloped and scarped lowland.

1.5. Alexander Island

Alexander Island is similar in size (490 km^2) to Massey but lower in elevation (Fig. 1). The 2% of land (11 km^2) above 150 m amsl is mostly in the east where the land rises to 198 m amsl above sea level.

1.6. Massey Island

Less than half the size (440 km^2) of and lower in elevation than Ile Vanier, Massey Island is similar in relief and geological structure (Fig. 1). Only 12% (55 km^2) of the land is above 150 m amsl with a maximum elevation of 210 m amsl.

1.7. Helena Island

The Berkley Group of islands lie about 10 km north of Bathurst (Fig. 1). The largest island is Helena with an area of 220 km^2 of which 40% (132 km^2) is above 150 m amsl. The land rises steeply from the south coast to a maximum of 282 m amsl and slopes gently to the north.

1.8. Edmund Walker Island

Edmund Walker Island (69 km^2) is the second largest island of the Findlay Group (Fig. 1). Its dissected surface rises to 134 m amsl and drops to a low flat coast.

1.9. Ile Marc

Ile Marc is a small (56 km^2), flat, featureless island, below 150 m amsl (Fig. 1).

2. Weather

The climate of the survey area is characterized by long cold winters, short cool summers and low precipitation. Air temperatures average below -17.7°C from December to March. Mean daily temperatures do not rise above 0°C until after 1 June on the extreme south of the survey area, and 15 June on the rest of the survey area (Meteorological Branch 1970). The snow cover usually starts to melt in early June, and rapidly dissipates to bare ground by mid June, except for snowbanks in sheltered sites (Potter 1965). Summer is the period when the ground is generally snow free, and lasts from the beginning of July to the end of August. Winter starts when the mean daily temperature falls below 0°C usually about 15 September. September and October are the stormiest months and much of the annual snowfall may occur in those months. From December to March anticyclones dominate the weather causing frequent calms, clear skies and light snowfall.

An east-west gradient of weather across the western Queen Elizabeth Islands appeared evident for the 1970s from weather records collected at Mould Bay, Prince Patrick Island and Resolute Bay, Cornwallis Island, and empirical observations (Miller et al. 1977). Unfortunately the absence of long-term weather records from Melville allows only an extrapolation of weather from Mould Bay and Resolute Bay to describe weather on Melville. Subjective observations suggest the weather of eastern Melville is most similar to that recorded at Resolute Bay. Thompson (1971) compared 1 year's weather data from the National Museum of Science research station in Polar Bear Pass on central Bathurst Island to data from Resolute Bay. Her results suggested that the differences in the weather between the two locations were the result of the research station's inland site and local topographical effects. Mould Bay tends to have cooler, drier and less stormy weather than Resolute Bay.

The amount and duration of snow cover, especially in spring, are critical to arctic ungulates, but also critical are the types of snow cover and incidences of freezing rain. Wind removes the snow from exposed slopes and redeposits it as shallow but hard compacted cover and drifts in more sheltered and relatively well-vegetated sites. Freezing rain in autumn which results in ground-fast ice before snow cover accumulates; ice layering in the snow, crusting of the snow; and the formation of ground-fast ice in spring (e.g., Miller et al. 1982) compounds the stress of forage unavailability on arctic ungulates. Unfortunately neither the type of snow cover nor the incidence of ground-fast ice or ice layering is available for the western Queen Elizabeth Islands.

METHODS

1. Aircraft

A Bell-206B (Jet Ranger) turbo-helicopter on floats was used as the survey aircraft. The helicopter was equipped with a GNS-500A, Series 2, Global Navigational System.

2. Observers

I used a 4-person survey crew: pilot-navigator-spotter (right front seat); navigator-spotter (left front seat); and a left and a right rear seat observer. The survey crew communicated by use of a voice activated intercommunication system. The helicopter pilot navigated the line transects with the aid of the GNS-500A, making occasional visual reference checks with the 1:250 000 topographical maps. The navigator- spotter navigated visually with the 1:250 000 map sheets; recorded the location of each observation by consecutive numbering (within each stratum) directly onto the map sheet; and called out the number for each observation to the rear seat observers. Both the pilot and the navigator also served as spotters and alerted the rear seat observers to the sighting of animals. If one of the rear seat observers was first to see animals, he called out his sighting to alert the other crew members. The rear seat observer on the side of the helicopter where the animals were located recorded the details of the observation in a field notebook: (1) date; (2) stratum number; (3) transect number; (4) observation number; (5) degrees of angle obtained with hand held clinometer; (6) species and composition of animals sighted, as bulls, calves, and/or others (cows, juveniles, yearlings); and (7) remarks, if any. The animal(s) sighted were circled, if necessary, to determine their number and/or sex and age composition (all 4 crew members participated in the determinations).

3. GNS-500A, Series 2, Global Navigational System

Standard line transects were flown by the "parallel course" method; and (2) "deadheading" courses between predetermined points were flown by the "waypoint coordinates" method (details available in GNS-500A Operator's Manual).

4. Altitude

Altitude above ground level was maintained, as best possible, at about 90 m above ground level (agl) during the survey. Altitude was measured with a standard aviation altimeter (pressure type) in units of 6.1 m (20 ft).

5. Helicopter Speed

The air speed of the helicopter was held at about 160 $km \cdot h^{-1}$. Air speed was read from the aircraft air speed indicator, and ground speed was sporadically obtained from GNS-500A readouts.

6. Angle Of Animal(s) Sighting

Each angle from the animal(s) to the helicopter was indirectly measured in degrees with a hand held clinometer (Suunto Co., Helsinki, Finland). The actual angle obtained was the angle of depression from the horizontal plane of the inflight helicopter to the animal(s) (Fig. 2). Thus, when the height of the helicopter is supposedly known; distance along a horizontal plane (supposedly at ground level) to the animal(s) from the point where the vertical projection of the centre of the helicopter theoretically touches the ground can be obtained from the simple trigonometric function involving the tangent of an acute angle.

Given

(1) A right-angled triangle (ACB) is formed by joining (A) the helicopter, (B) the location of the animal(s) on the ground, and (C) the intercept of a horizontal plane from (A) with a vertical leg from (B) (Fig. 2).

(2) Side (CB) (Fig. 2) = (a) = vertical distance from animal(s).

(3) Side (AC) (Fig. 2) = (b) = horizontal distance from helicopter.

(4) Hypotenuse (AB) (Fig. 2) = (c) = diagonal leg from helicopter.

(5) Alpha (α) angle (BAC) is the acute angle of depression measured with a hand held clinometer by an observer (Fig. 2).

Assumptions

(1) Length (a) (Fig. 2) is equal to the height of the helicopter above ground level.

(2) Length (b) (Fig. 2) is equal to the horizontal distance from the helicopter to the animal(s).

Since $\text{Tangent } \alpha = \frac{a}{b}$

Therefore $b = \frac{a}{\text{Tan } \alpha}$

7. Survey Design

I used a systematic, unbounded line transect type, aerial survey to obtain numbers and distributions of Peary caribou and muskoxen. Evenly spaced north-south line transects were drawn directly onto 1:250 000 topographical map sheets at 6.4 km intervals over each of the 11 strata, originating from a baseline at 99°00'W, 104°00'W, or 106°00'W (Appendices 1 and 2). Selection of a baseline was done mainly as a technical consideration to allow connection of each cross (+) indicator at each 15 minutes of one degree of latitudinal change along that meridian to maximize the subsequent maximize the subsequent accuracy of ruling off transect lines. These indicators appear as crosses (+) for each 15 minutes of latitude and each full degree of longitude in a grid pattern over each entire 1:250 000 Geological Survey of Canada topographical map sheet.

Bathurst Island was divided into three nearly equal sized survey land strata after Miller et al. (1977) on Geological Survey of Canada 1:250 000 topographical map sheets (Fig. 1). The area of each stratum was determined with a planimeter. Strata I and II were separated on land by an arbitrary line drawn from the eastern side of the southernmost projection of Dundee Bight (99°54'W) in the north, south-southeasterly to the north shore of Bracebridge Inlet (99°50'N). There was no common land boundary between Strata I and III. Strata II and III were separated on land by an arbitrary line from the mouth of the river that empties into Goodsir Inlet on the east, westward across the lowlands of Polar Bear Pass to the most easterly edge of Bracebridge Inlet. Major western satellite islands of Bathurst Island were each considered as a separate survey stratum: Alexander, Stratum IV; Marc, Stratum V; Massey, Stratum VI; Vanier, Stratum VII; and Cameron, Stratum VIII (Fig. 1). Helena Island, the major northern satellite island of Bathurst Island, was considered as survey Stratum IX (Fig. 1). In the Findlay Group of islands, (north-northwest of Bathurst Island), Lougheed Island and its major satellite island, Edmund Walker, were considered as Stratum X and Stratum XI, respectively (Fig. 1).

Strata II and III on Bathurst Island were divided into quadrants for the purpose of reporting distributions of Peary caribou and muskoxen, with the axes intersecting at 76°09'N/99°00'W in Stratum II and 75°20'N/99°00'W in Stratum III. Stratum I

essentially consists of two major peninsulas: one, with a forked head, extending westward; and the second peninsula northwestward from the northeastern portion of the first. The base of the western peninsula was considered to extend from the eastern boundary of Stratum I; while the base of the northwestern peninsula was established as a line from the most southwesterly penetration of the waters of Dundee Bight on the east to the most southeasterly penetration of the waters of Erskine Inlet on the west.

8. Measurements And Units

An array of measurement units was employed and had to be converted to the metric system. (1) The GNS-500A gives distance readouts in "international nautical miles": one international nautical mile (hereafter referred to simply as a "nautical mile") equals 1851.999 m (6,076.115 ft) or 1852 m. (2) The air speed indicator in the Bell 206B helicopter gives readings in "U.S. statute miles": one U.S. statute mile (hereafter referred to simply as a "mile") equals 1609.344 m or 1609 m (5,280 ft). (3) The Geological Survey of Canada topographical maps used in this work are scaled in imperial inches (hereafter referred to simply as "inches"). The maps are at a scale of 1:98 425.197 cm or 1:98 425 cm (1:250,000 in). Therefore, each 2.54 cm (1 in) equals 6349.999 m (20,833.333 ft) or 6350 m.

The smallest increment of transect length was measured from 1:250 000 topographical map sheets in units of 0.0625 inches (0.159 cm). Then the total length of each transect in inches was multiplied times 6350 m (value of one inch in metres at 1:250 000 scale) and divided by 1000 to obtain distance in kilometres. Each resultant value of transect length (distance in km) was then rounded off to three places beyond the decimal point and multiplied by the appropriate transect width in kilometres (all values taken to three places beyond the decimal point) to obtain transect area (km^2).

Intervals between transects were first measured on 1:250 000 topographical maps in inches (smallest unit, 0.0625 inches); then resultant values were converted to kilometres by multiplying by 6350 m, dividing by 1000, and rounding to three places beyond the decimal point.

9. Statistical Methods

Density and population estimates as well as their variance estimates and 95% confidence intervals were made for both caribou and muskox populations in all survey strata. The probability $P < 0.05$ was the level of acceptance for significant relationships reported in this study.

The following symbols are used in the estimation procedures that follows.

N = the number of possible transects in the survey area.

n = the number of these N transects that are sampled.

f = n/N, the sampling fraction.

y_i = the number of animals counted on the i'th sampled transect.

x_i = the area of the i'th sampled transect.

Y = the true population of animals in the survey area.

$\overline{Y}$ = the mean number of animals per transect on all N transects.

$\overline{X}$ = the mean area of all transects.

A = total area.

R = the true mean density of animals in the survey area, $R = \overline{Y}/\overline{X}$.

d_i = $y_i - \hat{R}x_i$ where $\hat{R}$ is an estimator of R.

The standard estimator for the true mean density R is the ratio estimate:

$$\hat{R} = \frac{\sum_{i=1}^{n} y_i/n}{\sum_{i=1}^{n} x_i/n} = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i} = \frac{\bar{y}}{\bar{x}}$$

where $\bar{y}$ = the mean count of animals on the sampled transects, $\bar{x}$ = the mean area of the sampled transects.

Following the methods described by Kingsley and Smith (1981) an estimate of the variance of R is found by:

$$\hat{V(R)} = (1 - f) \frac{\sum_{i=1}^{n-1} (d_i - d_{i+1})^2}{2n\,(n-1)\bar{x}^2}$$

The estimate of the true population Y is found by multiplying the density estimate by the total area under consideration, that is: $\hat{Y} = \hat{R}\,A$ and the estimate of the variance of Y is obtained by multiplying the variance estimator of R by the square of the survey area.

$$\hat{V}(Y) = [A^2 \cdot \hat{V}(R)].$$

Confidence intervals (95%) for the true density and the true population total are given by:

$$R: \quad \hat{R} \pm t_{\frac{}{2}, n-1} \sqrt{\hat{V}(R)}$$

$$Y: \quad \hat{Y} \pm t_{\frac{}{2}, n-1} \sqrt{\hat{V}(Y)}$$

The estimates were calculated on the basis of a maximum strip transect width of 1.714 km wide (0.857 km either side of the helicopter). Thus, all observations with a measured angle of depression of 6° or more were used in calculating the estimates. Observations with measured angles below the horizon of 5° or less were considered to be "off transect" and were not included in the above analysis.

10. Definitions Of Terms Or Style

10.1. On transect

In this report all animals seen "on transect" are those animals that were seen within a strip width of 857 m on either side of the helicopter. The location of animals within that strip width was determined by the observer by reading an angle of depression of 6° or more with the hand held clinometer. The 857-m-wide strip from each side of the helicopter was combined for a maximum feasible strip width of 1.714 km.

10.2. On survey

In this report animals seen "on survey" are all of the animals seen by the observers while the helicopter was flying along the line transects. This condition excludes all animals seen only while the helicopter was flying to or from the line transects (that is, flying to or from fuel caches or the base camp).

10.3. Off survey

In this report all animals seen "off survey" are those animals seen only while the helicopter was flying to or from fuel caches or the base camp (excludes all animals seen on survey).

10.4. Sex/age classification

Recognition of muskoxen was restricted to bulls, calves, and others. No special effort was made to separate cows from juveniles and no attempt was made to identify yearlings.

Peary caribou were recognized and classified by sex/age class as follows.

10.4.1. "Bulls" (mature males, assumed 4+ yr-old) are recognized by the relatively large size and advanced development of their new antler growth, which is exaggerated by the presence of velvet on the antlers. Diagnostic characteristics of the antler growth include the large diameter of the main beams; the long, posteriorly curved main beams; and the presence of well-developed, anteriorly directed brow or bez tines. Secondary characteristics include large body size, relatively large head size; and presence of new pelage, especially on the lateral parts of the body and on the face. When the caribou under consideration exhibits male-like antler growth, the following exercise is used to distinguish bulls from juvenile males. The observer distinguished mature males from juvenile males by mentally evaluating the length of the new antler growth present in relation to the length of the animal's head (from crown of skull to tip of nose). When the antler growth is longer than the head - the animal is classified as a bull; and if shorter than the head - a juvenile male.

10.4.2. "Cows" (mature females, assumed 3+ yr-old) are recognized by the retention of hard antlers from the previous year or the absence of antlers and any new growth of antlers. In some few cases, minor new growth on the simple main beams has begun (such new growth most likely occurs among individuals just coming of age or possibly some few older cows that maintained better physical condition because they did not have the added burden of carrying a fetus and nursing a calf in the current year). Cows, especially those that produced a calf in the current year, still retain much of their previous winter's pelage and have a faded, lifeless, often patchy appearance about them (relative to other sex/age classes in July). The general drab appearance of a successful maternal cow often remains clearly recognizable into August of the year.

10.4.3. "Juvenile males" (males, assumed 1-3 yr-old) are recognized by their new pelage and their advance, well-developed, but relatively small (when compared to bulls) new antler growth. Also, their relatively small body size (especially that of yearlings), when compared to adults, aids in their separation from bulls and cows.

10.4.4. "Juvenile females" (females, assumed 1-3 yr-old) are recognized by their new pelage, new antler growth, and relatively small body size (particularly yearlings). They are separated from juvenile males by the new antler growth appearing shorter than the ears and being restricted to small spike-like main beams or at the most, small main beams with minute branching. Antler growth characteristics together with the relatively small body size and new pelage separates them from cows or bulls.

10.5. Caribou group or muskox herd

A "caribou group" or "muskox herd" is composed of two or more individuals of the same species that were seen in close association (no fixed minimum or maximum distance of separation but usually much closer than 100 m) and apparently spatially isolated from other individuals of the same species at the time of observation. Two or more individuals (of the same species) are considered as one group even if they were more than 100 m apart but moved together when disturbed by the survey aircraft.

10.6. Bull-only caribou group or bull-only muskox herd

A "bull-only caribou group" is composed of mature males only (bulls, assumed 4+ yr old, relatively large antler size). In July of the year both bulls and immature males (at least 2-yr-old and possibly 1-yr olds) are readily recognizable by their relatively advanced antler development from other sex/age classes of Peary caribou. A "bull-only muskox herd" is composed of only bulls (assumed 4+ yr old) that can be readily recognized by their large body size, and their relatively large horn size and well developed boss area of the horns.

10.7. Mixed sex/age caribou group or mixed sex/age muskox herd

A "mixed sex/age caribou group" or a "mixed sex/age muskox herd" may be mixed by sex or age or both and contains any possible combination of bulls, cows, juveniles, yearlings, or calves (when bulls could not be recognized, the presence of both sexes was not determined).

10.8. Values in parentheses

When values are given in parentheses (x+y) they always equal 1+ yr-old animals plus calves in this report: e.g., caribou (36+11) equals 36, 1+ yr-old caribou plus 11 caribou calves.

10.9. Estimates

The reader may note that slight inconsistencies sometimes occur between the summations of estimates by each survey stratum when compared with their counterparts that are obtained from a single estimate of several or all survey strata. The magnitude of these discrepancies is insignificant and they are pointed out only to assure the reader that the errors are the results of the method of machine calculation and not errors or transcription.

10.10. Sites

In this report a solitary animal is not considered as a group. Therefore, the term "site" is used to distinguish any

observation regardless of whether it involved a solitary animal or a group of two or more animals. Site is essentially synonymous with observation.

10.11. Western satellite islands

The five relatively small satellite islands of Alexander, Marc, Massey, Vanier, and Cameron that lay off the western coast of Bathurst Island will be collectively referred to in this report as the "five western satellite islands".

RESULTS AND DISCUSSION

I flew 3831 km of line transects between 10 and 26 July 1985 over nine central Queen Elizabeth Islands: Bathurst, Alexander, Marc, Massey, Vanier, Cameron, Helena, Lougheed, and Edmund Walker (Tables 1 and 2). About 87% (3329 km) of those transects were flown between 10 and 25 July 1985 (Tables 1 and 2). Then, on 26 July 1985, flights were repeated along 502 km of transects over the five western satellite islands: thus Alexander, Marc, Massey, Vanier, and Cameron islands were surveyed twice (Tables 1 and 2). However, results from the second set of data did not vary significantly from the first, so only the first complete survey of all nine islands is reported herein in detail. The aerial survey of the nine islands covered about 5705 km^2 for an overall coverage of about 27% (Table 2), based on the maximum feasible strip transect width of 1.714 km (857 m either side of the aircraft) at 6.4-km intervals.

1. Numbers Seen During Survey And Their Distributions

1.1. Peary caribou

On Bathurst Island I saw 43.9% of the caribou (63+27) in Stratum II; followed closely by 36.1% of the caribou (57+17) in Stratum I; and I saw the least number (20.0%) of caribou (31+10) in Stratum III (Table 3). Within stratum distribution of caribou varied but only a weak pattern and only a few areas of concentration could be discerned. In Stratum II the majority (62.2%) of the caribou (37+19) were in the NW quadrant; 20.0% (14+4) in the SW quadrant; 11.1% (7+3) in the NE quadrant; and only 6.7% (5+1) in the SE quadrant. In Stratum I caribou were about evenly distributed between both peninsulas: 51.4% (30+8) on the W peninsula; and 48.6% (27+9) on the NW peninsula. In Stratum III most (56.1%) of the caribou (17+6) were in the NE quadrant; 22.0% (5+4) in the SW quadrant; 12.2% (5+0) in the NW quadrant; and only 9.7% (4+0) in the SE quadrant.

Caribou occurred at greater than expected rates only on strata I and II and at less than the expected rate on Stratum III ($P < 0.005$) based on all caribou seen on each stratum compared to the relative landmass of each stratum. Caribou within Stratum I

occurred at about the expected rate on both the NW and W peninsulas (P >0.05) on a relative landmass basis. Caribou within Stratum II occurred at a greater than expected rate on the NW quadrant; at a rate about as expected on the SW quadrant; and at less than expected rates on the NE and the SE quadrants (P <0.005) on a relative landmass basis. Caribou within Stratum III occurred at a greater than expected rate on the NE quadrant and at less than expected rates, on the SE, SW, and the NW quadrants (P <0.005) on a relative landmass basis.

No pattern for the observed distributions of caribou on the eight small islands could be discerned (Table 3). In general, groups of caribou appeared to be more often coastal in distribution rather than on the interior of each small island.

In July 1985 most caribou on Bathurst Island occurred on the northern portion of the island as previously reported for the June-August period (Tener 1963, Fischer and Duncan 1976, Miller et al. 1977, Ferguson 1987). The relative importance of northwestern versus northeastern Bathurst appears to vary among years or possibly within years. The greatest proportion of caribou on Bathurst was reported for the northeast between 19 June and 7 July 1961 (Tener 1963), 25-26 August 1974 (Miller et al. 1977), 25-26 June 1975 (Fischer and Duncan 1976), and 10-13 August 1981 (Ferguson 1987). However, the greatest proportion of caribou was reported on the northwest for the period 18-25 August 1974 by Fischer and Duncan (1976) and 10-25 July 1985 during this study. In 1985 the high proportion of caribou on northwestern Bathurst appeared to be further reflected in the relatively high numbers of caribou on the five western satellite islands, especially Massey Island and Ile Vanier. Possibly, the distribution in 1985 was caused by prevailing snow or ice conditions during winter 1984-85, and the redistribution persisted into the open water period and thus into summer 1985.

1.2. Muskoxen

On Bathurst Island I saw the majority (151+23) of muskoxen (58.2%) in Stratum III; 30.1% (71+19) were in Stratum I; and 11.7% (27+8) were in Stratum II (Table 4). In Stratum III most (50.6%) of the muskoxen (78+10) were in the SW quadrant; followed closely by 46.5% (68+13) in the NW quadrant; only 2.9% (5+0) in the NE quadrant; and none in the SE quadrant. In Stratum I most (78.9%) of the muskoxen (56+15) were on the W peninsula and the remaining 21.1% (15+4) were on the NW peninsula. In Stratum II most (71.4%) of the muskoxen (19+6) were in the SE quadrant; the remaining 28.6% (8+2) were in the SW quadrant; and there were no muskoxen seen in either the NE or NW quadrants.

Muskoxen occurred at greater than expected rates on Strata III and I and at a less than expected rate on Stratum II (P <0.005) based on the relative landmass of each stratum. Muskoxen within Stratum III occurred at greater than expected rates on the SW

and the NW quadrants and at less than expected rates on the SE and the NE quadrants ($P < 0.005$) on a relative landmass basis. Muskoxen within Stratum I occurred at a greater than expected rate on the W peninsula and at a less than expected rate on the NW peninsula ($P < 0.005$) on a relative landmass basis. Muskoxen within Stratum II occurred at greater than expected rates on the SE and SW quadrants and at less than expected rates on the NE and NW quadrants ($P < 0.005$) on a relative landmass basis.

I saw muskoxen while I was on survey (1st survey only) on only one of the eight small islands surveyed, Alexander (Table 4).

Stratum III on Bathurst Island remained the most important summering area for muskoxen in July 1985, as it has been indicated in June-July 1961 (Tener 1961, 1963), August 1974 (Fischer and Duncan 1976, Miller et al. 1977), June 1975 (Fischer and Duncan 1976), and August 1981 (Ferguson 1987).

2. Numbers Seen Only Off Survey And Their Distributions

2.1. Peary caribou

I saw an additional 39 caribou (no calves) during positioning flights on Bathurst Island: 25, Stratum II; 8, Stratum I; and 6, Stratum III. I saw a cow-calf pair off survey on Lougheed Island and a mature bull on Edmund Walker Island. Caribou seen off survey on the other six small islands were also seen on survey transects.

2.2. Muskoxen

I saw an additional 52 muskoxen (includes 13 calves) during positioning flights on Bathurst Island: 25 (19+6), Stratum I; 15 (12+3), Stratum II; and 12 (8+4), Stratum III. No additional muskoxen were seen off survey on the other eight islands during the first survey on 11 July 1985 (our pilot had seen two bull muskoxen 5 days before on southwest Cameron Island; I saw two solitary muskox bulls on Cameron Island and one solitary bull on Ile Vanier on 26 July 1985 during our 2nd survey of those islands).

2.3. Wolves

On Bathurst Island I made five sightings of single wolves, most likely all different individuals. One wolf was standing over a dead muskox calf when sighted (I do not know if the calf was killed by the wolf). I saw no wolves on the other eight islands surveyed in July 1985.

3. Estimates

All estimates presented in these results (Tables 5-8) are those obtained from use of the maximum feasible strip transect width

of 1.714 km (857 m either side of the aircraft) at 6.4-km intervals. The calculations for the estimates are based on the assumption that the helicopter was 90 m agl when each observation was made. This means that only those animals that were seen along the line transects for which readings to the nearest degree (on hand held clinometers) of the angle from the horizontal plane of the helicopter to the animals were 6° or greater were used to obtain the estimates. All animals sighted at 5° or less were considered "off transect" in the calculation of estimates. Two sets of estimates were produced. The first set (Tables 5-8) includes all animals regardless of age and is used for comparisons with previous studies, as all previous researchers included calves in their estimates. The second set (App. 3-6) excludes calves and considers only 1+ yr-old animals, and is presented only in tabular form in the appendices. The second set of estimates have been included because I believe that estimates for management purposes should be based on only those animals 1+ yr-old, as calves frequently suffer high losses throughout the first year of life. Thus, high calf mortality can distort estimates of numbers that include calves by as much as 20 to 25%. Therefore, I suggest that for management decisions, only 1+ yr-old animals be considered, when determining allowable rates of harvest and considering the status of each population.

3.1. Estimates of Peary caribou densities

The overall estimate of density of all caribou on the nine-island survey area was 3.470 caribou/100 km^{-2} (Table 5). The collective density estimate on the five western satellite islands was 4.774 caribou/100 km^{-2} and exceeded the density estimate of 3.078 caribou/100 km^{-2} on Bathurst Island by 55.1%. Estimated densities of caribou varied markedly among survey strata (Table 5). Higher densities were obtained for the four survey strata that constituted four of the five western satellite islands than on any of the three strata on Bathurst Island (Table 5). Although the 1985 estimated overall density of Peary caribou is 2.8 times greater than the 1974 estimate (Miller et al. 1977), it is still 6.8 times less than the density estimate for 1961 (Tener 1961, 1963).

By far the all-time highest estimate of density of Peary caribou on islands in the Canadian High Arctic was for Lougheed Island in summer 1961, 101.9 caribou/100 km^{-2} (Tener 1961, 1963). However, the same pattern of relatively high densities of caribou on the small western satellite islands of Bathurst Island compared to those on Bathurst also occurred in summer 1961 (Tener 1961, 1963). Although Massey Island had the highest estimated density of caribou in 1985 among the five western satellite islands, it had the lowest density in summer 1961 (Ile Marc was not surveyed in 1961). Estimated numbers of caribou on the five western satellite islands in summer 1974 were negligible and associated densities were lower than those for caribou on Bathurst Island (Miller et al. 1977). The number of caribou had also declined

markedly on Bathurst Island, but the densities were reduced less on Bathurst than on the five western satellite islands.

3.2. Estimates of muskox densities

Muskoxen were only seen on the strip transect areas on two of the nine islands surveyed (Table 6). The overall estimate of density for all muskoxen on the entire nine-island survey area was 2.612 muskoxen/100 km^{-2}. The density estimate for Stratum IV (Alexander Island) exceeded the densities obtained on strata I-III on Bathurst Island (Table 6). Although the estimated overall density of all muskoxen on the survey area in 1985 is 3.3 times greather than the density estimate in 1974 (Miller et al. 1977), it is still 2.1 times less than the density estimate for 1961 (Tener 1961, 1963).

3.3. Estimates of Peary caribou numbers

In this report I make the assumption that the 1325 caribou estimated for Lougheed Island in summer 1961 (Tener 1961, 1963) were part of the overall inter-island population of Peary caribou that uses Bathurst Island and the satellite islands of Bathurst during the annual cycle of movements to seasonal ranges.

In July 1985 the estimated number of caribou within the nine-island survey area was 724: about 68% were on Bathurst Island and the remaining 32% were on the five western satellite islands (Table 7). Tener (1961, 1963) estimated that in summer 1961 there were 4890 caribou within the same area as surveyed in summer 1985. However, Miller et al. (1977) estimated that 863 caribou were left on that area in August 1973, and only 259 caribou were left in August 1974 after a drastic die-off in winter 1973-74.

Peary caribou numbers within the nine-island survey area have from 1961 to 1985 (1) declined by about 82% during the first 12 years; (2) then, experienced a marked die-off in winter 1973-74 and further declined at least to as little as about 5% of their 1961 numbers; and finally, have then taken almost a decade to apparently recently increase somewhat to about 15% of their 1961 numbers. Thus, caribou on the area have not yet even recovered to their 1973 estimated level, and still remain about 85% below their 1961 estimated level.

If the lack of statistical support is ignored, the apparent increase in the number of caribou within the nine-island survey area from 1974 to 1985 seems appreciable. However, realization that the 1985 estimate is still only about 15% as large as the 1961 estimate puts the situation into truer context. The currently estimated (1985) number of caribou remains too low to sustain any appreciable level of harvest on an annual basis.

The Inuit of Resolute Bay should be complemented on their maintenance of their voluntary ban on hunting of Peary caribou on Bathurst Island, initiated in 1975. I think that, if the increase in caribou on Bathurst Island is real and it continues, it would be in the best interest of the Resolute people to persist with their ban on hunting there for at least a while longer (probably a minimum of 5 years) to possibly assure ample time for a significant recovery.

High Arctic Peary caribou probably cannot be "stockpiled" over the long run as they are periodically or sporadically subjected to high "density independent" mortality caused by unavailability of forage which is brought on by unfavourable snow and ice conditions (Parker et al. 1975; Miller et al. 1977, 1982). However, upswing periods in the cyclic-like changes in numbers of High Arctic caribou apparently can be overall positive for 20 to 30 years or even as long as 50 years, as suggested by studies in Greenland (Vibe 1967). Thus, substantial populations (as in 1961) could be built up, supporting limited annual sustained harvests. I think for the time being, until better data are obtained, that an arbitrary level of 1000 estimated 1+ yr-old caribou should be set as a threshold inter-island herd size for initiating harvesting on the survey area. Even then, every effort should be made to promote continued harvesting of caribou and muskoxen on Prince of Wales and Somerset islands with little or no utilization of animals on Bathurst Island until necessary.

As an agency charged with encouraging the wise use of the nation's renewable resources the Canadian Wildlife Service should attempt to create a position that balances the preservation and conservation of those resources with their consumption. We must not lose sight of the fact that proper conservation includes wise utilization of the resource, when "standing stocks" will sustain such use (or when habitats are seriously threatened).

A renewable resource such as Peary caribou complicates this issue of sustained utilization because of the likelihood of the caribou suffering high mortality at time intervals of various but unknown (unpredicable) lengths. We cannot yet predict the severity of the Peary caribou's environment over time with any high degree of accuracy. More knowledge must be gained on how and why Peary caribou used their environment as they do during all seasons of the year, especially during the late winter (spring) "pinch-period" on into calving and early postcalving periods.

3.4. Estimates of muskox numbers

In July 1985 the estimated number of muskoxen within the nine-island survey area was 545: about 96% were on Bathurst Island and the remaining 4% were on Alexander Island (Table 8). Tener (1961, 1963) had estimated 1161 muskoxen on the same survey area in summer 1961. But the estimated number in the area had dropped from

672 by late winter 1973 to only 164 muskoxen by summer 1974 (Miller et al. 1977). Muskoxen had been seen on transect only on Bathurst and Cameron islands in 1961 and only on Bathurst Island in late winter 1973 and summer 1974 (Tener 1961, 1963; Miller et al. 1977). Although the number of muskoxen estimated on Bathurst Island in 1985 (if statistical significance is ignored) suggests an increase of about 232% from summer 1974, it is still only about 47% of the 1961 estimate.

4. Group Formations

4.1. Peary caribou groupings

I made 72 different sightings of caribou during the aerial survey in July 1985 (Tables 9, 10 and 11). The mean number of individuals seen per observation was 4.9 and ranged from 1 to 17. Nine of those observations were of solitary caribou: seven mature bulls and two juveniles. The remaining 63 observations were of groups of two or more caribou: 12 bull-only groups, mean 3.2 (± 1.29 S.D.), range 2-5; and 51 mixed sex/age groups, mean 6.0 (± 3.28 S.D.), range 2-17. Calves were present in 45 of the 51 mixed sex/age groups and not present in only six. There was no significant difference between mean sizes of mixed sex/age groups with calves present and those without any calves ($P > 0.05$) based on a comparison of the average numbers of 1+ yr olds.

The average caribou group size (excluding singles) in July 1985 (5.4) was slightly higher than the June-July 1961 value of 4.7 (Tener (1963) but lower than the August 1974 value of 6.4 (Miller et al. 1977). The higher mean group size in August 1974 may have been mostly, if not solely, a reflection of the severe winter die-off during 1973-74 (Miller et al. 1977), resulting in fewer but larger summertime groupings in 1974.

4.2. Muskox groupings

I made 43 different sightings of muskoxen during our aerial survey in July 1985 (Tables 12, 13 and 14). The mean number of individuals per observation was 7.4 and ranged from 1 to 25. Eleven of those observations were of solitary mature bulls. The remaining 32 observations were of herds of two or more muskoxen: 12 bull-only herds, mean 2.3 (± 0.49 S.D.), range 2-3; and 20 mixed sex/age herds, mean 14.0 (± 5.34 S.D.), range 2-25. Calves were present in 16 of the 20 mixed sex/age herds and not present in only four. There was no significant difference between mean sizes of mixed sex/age herds with calves present and those without any calves ($P > 0.05$) based on a comparison of the average number of 1+ yr olds only.

The average muskox herd size in July 1985 (9.6) appears markedly higher than the 5.6 and 4.0 values reported in June-July 1961 (Tener 1963) and August 1974 (Miller et al. 1977) respectively.

The low August 1974 value undoubtedly reflects the severe winter of 1973-74, and the effects of high mortality were strongly evident in the summer groupings by size and composition (Miller et al. 1977). The relatively high July 1985 mean value possibly reflects recent favourable conditions of muskox survival.

5. Early Calf Survival

5.1. Peary caribou

I saw 93 calves among 393 caribou (on and off survey) for an overall proportional representation of 23.7% calves. Overall representation based on "on survey" observations only (Table 3) ran slightly higher (26.1%) than the corresponding "on and off survey" values. The 92 calves seen on aerial survey averaged 2.0 $\pm$ 1.09 S.D./group (n = 45) and ranged from 1 to 6/group (Table 15).

The percentage of calves among all caribou was 22.1% on Bathurst Island and collectively 25.9% on the five western satellite islands, Alexander, Marc, Massey, Vanier, and Cameron (Table 15). Percentage of calves among all caribou seen on the above six islands averaged 22.4% $\pm$ 9.07% S.D. and ranged from 34.6% (Ile Massey) down to 6.7% (Cameron Island) (Table 15). No clear pattern could be discerned between mean group size and the number of calves present in the groups (Table 16).

In June-July 1961, 19.8% of the caribou seen on transect were calves. Initial calf production in summer 1974 was nil or early calf mortality was nearly complete. Miller et al. (1977) failed to see any caribou calves during the August 1974 aerial survey. However, 9.0% calves among 55 caribou segregated over summer 1974 were reported by Fischer and Duncan (1976). Initial production and early survival of calves appeared high in July 1985. However, previous surveys of caribou on Bathurst Island have shown that the first year of life can be severe with high mortality among calves associated with high losses among 1+ yr-old caribou in some years (Miller et al. 1977). Therefore, it cannot be assumed that a significant increase in the number of caribou will necessarily follow.

5.2. Muskoxen

I saw 67 calves among all muskoxen (on and off survey) for an overall proportional representation of 18.1% calves. Overall representation based on "on survey" observations only ran slightly lower (17.0%) than the corresponding "on and off survey" values. The 54 calves seen on aerial survey averaged 3.4 $\pm$ 1.50 S.D./group (n = 16) and ranged from 1 to 6/group (Table 17).

All but four of the calves were seen on Bathurst Island (Table 4); therefore, no island breakdown is warranted. The relatively low percentage of calves in Stratum III of Bathurst

Island (Tables 7 and 16) results from the combination of a relatively high percentage of bulls when compared with bulls in strata I and II on Bathurst and the presence of three mixed sex/age groups, totalling 35 individuals, without any calves in them. No pattern could be discerned between mean group size and the number of calves present in each of the groups (Table 18).

In June-July 1961 only 9.0% of the muskoxen seen on transect were calves. As for caribou, initial calf production or early survival in 1974 was nil (Fischer and Duncan 1976, Miller et al. 1977). One muskox calf was seen among 135 muskoxen in June 1974 (Fischer and Duncan 1976) and none was seen among 105 muskoxen in August 1974 (Miller et al. 1977). Seven (10%) muskox calves were seen among 69 muskoxen in June 1975 (Fischer and Duncan 1976). Thus, initial calf production and survival appeared relatively good in July 1985. However, yearling muskoxen as well as calves are apparently subject to high winter losses in some years. Thus, any likely increase in the number of muskoxen cannot be predicted with confidence only on the basis of favourable early survival of calves.

6. Bracebridge-Goodsir Inlet Area

The valley between Bracebridge and Goodsir inlets is about 20 km wide, 10 km to either side of the line that joins the two inlets and forms the southern boundary of Stratum II and the northern boundary of Stratum III. The valley runs about 60 km from east to west across central Bathurst Island and is known as Polar Bear Pass. The area is of special interest because of the long-term biological studies conducted there at Canada's National Museum of Science, High Arctic Research Station, and because the area has been accepted as a National Wildlife Area under the direction of Environment Canada. Therefore, I have compiled separately the total numbers of caribou and muskoxen seen on the area by Tener (1961), Miller et al. (1977), Ferguson (1987), and this study. Values in parenthesis are percentages of total numbers of the species seen both on and off survey.

In June-July 1961 only one of the caribou seen by Tener (1961) was on the area. In August 1974, 41 (49%) caribou seen by Miller et al. (1977) were on the area. In August 1981 Ferguson (1987) saw no caribou on the area. In July 1985 only 22 (19+3, 9.0%) caribou seen were on the area.

In June-July 1961 Tener (1961) saw 167 (69%) of the muskoxen in the valley. In August 1974 there were fewer muskoxen in the valley, 20 (19%), both in absolute numbers and as a percentage of the total (Miller et al. 1977). In August 1981 Ferguson (1987) saw 47 (37+10, 20.5%) of the muskoxen in the valley. In July 1985 only 29 (23+6, 8.3%) muskoxen were seen in the valley. However, there were 65 (52+13) muskoxen trapped by open water on a 5 km^2 island in the head of Bracebridge Inlet which could be considered as part of the valley segment of muskoxen. If so, the July 1985 count for the area would be 94 (75+19, 26.8%) muskoxen seen.

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Table 1

Basic statistics for aerial survey of nine High Arctic islands, NWT, July 1985

Survey area Island	Stratum	Date(s) surveyed July 1985	Total length of transects (km)
Bathurst	I	12, 20, 25	649.283
	II	16, 17, 18	1046.957
	III	13	862.410
Alexander	IV	11 & 26[a]	75.010[b]
Marc	V	11 & 26[a]	8.731[b]
Massey	VI	11 & 26[a]	71.040[b]
Vanier	VII	11 & 26[a]	176.609[b]
Cameron	VIII	11 & 26[a]	171.052[b]
Helena	IX	18	52.387
Lougheed	X	10	205.186
Edmund Walker	XI	10	9.922

[a]Island surveyed twice in July 1985: 1st time on the 11th and the 2nd time on the 26th.

[b]Total length of transects for one survey only (two surveys would equal 2 x value given for each island).

Table 2

Basic statistics for obtaining estimates of Peary caribou and muskoxen from a systematic aerial survey at about 27% overall coverage (1.714-km wide strip transects at 6.4-km intervals) of nine High Arctic islands, NWT, July 1985

Survey area Island	Stratum	Total transects possible	Number of transects surveyed	Area surveyed (km^2)
Bathurst	I	74	20	1112.87
	II	66	18	1794.48
	III	62	17	1478.17
Alexander	IV	22	6	128.57
Marc	V	7	2	14.96
Massey	VI	25	7	121.76
Vanier	VII	33	9	302.71
Cameron	VIII	25	7	293.18
Helena	IX	22	6	89.79
Lougheed	X	25	7	351.69
Edmund Walker	XI	3	1	17.01

Table 3

Peary caribou seen during aerial survey of nine High Arctic islands, NWT, July 1985

Survey area by island	Caribou seen			Total 1+ yr-old caribou	Total all caribou
	Bulls	Calves	Others[a]		
Bathurst	43	54	108	151	205
Alexander	4	5	15	19	24
Marc	0	1	3	3	4
Massey	0	18	34	34	52
Vanier	10	13	29	39	52
Cameron	10	1	4	14	15
Helena	0	0	0	0	0
Lougheed	0	0	0	0	0
Edmund Walker	0	0	0	0	0
Total	67	92	193	260	352

[a]Includes all females 1+ years old and young males.

Table 4

Muskoxen seen during aerial survey of nine High Arctic islands, NWT, July 1985

Survey area by island	Muskoxen seen			Total 1+ yr-old muskoxen	Total all muskoxen
	Bulls	Calves	Others[a]		
Bathurst	57	50	192	249	299
Alexander	4	4	11	15	19
Marc	0	0	0	0	0
Massey	0	0	0	0	0
Vanier	0	0	0	0	0
Cameron	0	0	0	0	0
Helena	0	0	0	0	0
Lougheed	0	0	0	0	0
Edmund Walker	0	0	0	0	0
Total	61	54	203	264	318

[a]Includes all females 1+ years old and young males (and some older bulls).

Table 5

Estimates of densities of Peary caribou on nine High Arctic islands, NWT, July 1985, based on systematic aerial survey at about 27% overall coverage (1.714-km wide strip transects at 6.4-km intervals)

Survey area		Number of animals seen	Density/100 km^{-2}		
Island	Stratum	on transects[a]	Estimate	Variance	95% C.I.[b]
Bathurst	I	55	4.942	4.556	0.475- 9.410
	II	48	2.675	1.212	0.352- 4.998
	III	32	2.165	0.644	0.463- 3.866
Alexander	IV	10	7.778	60.272	0.000-27.738
Massey	VI	21	17.247	21.777	5.828-28.666
Vanier	VII	18	5.946	10.748	0.000-13.506
Cameron	VIII	14	4.775	9.652	0.000-12.377
Strata I-III		135	3.078	0.565	1.575-4.582
Strata IV-XI		63	4.774	1.616	2.231-7.316
Strata I-XI		198	3.470	0.415	2.208-4.733

[a]No caribou were seen within strip transect areas on Marc, Helena, Lougheed, and Edmund Walker islands.

[b]When the low confidence limit is a negative value, it is reported as 0.000.

Table 6

Estimates of densities of muskoxen on nine High Arctic islands, NWT, 1985, based on systematic aerial July survey at about 27% overall (1.714-km wide strip transects at coverage 6.4-km intervals)

Survey area		Number of animals seen	Density/100 km^{-2}		
Island	Stratum	on transects[a]	Estimate	Variance	95% C.L.[b]
Bathurst	I	62	5.571	4.908	0.935-10.208
	II	34	1.895	1.334	0.000- 4.332
	III	46	3.112	2.723	0.000- 6.610
Alexander	IV	7	5.444	22.279	0.000-17.580
Strata I-III		142	3.238	0.819	1.428- 5.048
Strata IV-XI		7	0.530	0.207	0.000- 1.441
Strata I-XI		149	2.612	0.488	1.242- 3.981

[a]No muskoxen were seen within strip transect areas on Marc, Massey, Vanier, Cameron, Helena, Lougheed, and Edmund Walker islands.

[b]When the low confidence limit is a negative value, it is reported as 0.000.

Table 7

Estimates of numbers of Peary caribou on nine High Arctic islands, NWT, July 1985, based on systematic aerial survey at about 27% overall coverage (1.714-km wide strip transects at 6.4-km intervals)

Survey area		Number of animals seen on transects[a]	Population estimates		
Island	Stratum		Estimate	Variance	95% C.I.[b]
Bathurst	I	55	201.6	7583.6	19.4-383.9
	II	48	177.9	5359.0	23.4-332.3
	III	32	116.0	1850.8	24.8-207.2
Alexander	IV	10	38.1	1447.1	0.0-135.9
Massey	VI	21	75.9	421.6	25.6-126.1
Vanier	VII	18	67.2	1372.4	0.0-152.6
Cameron	VIII	14	50.6	1084.4	0.0-131.2
Strata I-III		135	495.3	14630.7	253.4-737.2
Strata IV-XI		63	227.5	3669.5	106.3-348.6
Strata I-XI		198	723.8	18045.1	460.5-987.1

[a]No caribou were seen within strip transect areas on Marc, Helena, Lougheed, and Edmund Walker islands.

[b]When the low confidence limit is a negative value, it is reported as 0.0.

Table 8

Estimates of numbers of muskoxen on nine High Arctic islands, NWT, July 1985, based on systematic aerial survey at about 27% overall coverage (1.714-km wide strip transects at 6.4-km intervals)

Survey area		Number of animals seen on transects[a]	Population estimates		
Island	Stratum		Estimate	Variance	95% C.I.[b]
Bathurst	I	62	227.3	8169.4	38.1-416.5
	II	34	126.0	5901.2	0.0-288.1
	III	46	166.8	7822.7	0.0-354.3
Alexander	IV	7	26.7	534.9	0.0- 86.1
Strata I-III		142	521.0	21194.9	229.8-812.2
Strata IV-XI		7	25.3	470.1	0.0- 68.6
Strata I-XI		149	544.7	21241.8	259.0-830.3

[a]No muskoxen were seen within strip transect areas on Marc, Massey, Vanier, Cameron, Helena, Lougheed, and Edmund Walker islands.

[b]When the low confidence limit is a negative value, it is reported as 0.0.

Table 9

Grouping statistics from aerial survey of Peary caribou on nine High Arctic islands, NWT, July 1985

Island[a]	No. groups incl. singles	No. singles	Group size excl. singles	
			Mean	Range
Bathurst	48	8	4.9	2-12
Alexander	3	0	8.0	4-10
Marc	1	0	4.0	4-4
Massey	9	0	5.8	2-14
Vanier	8	0	6.5	2-17
Cameron	3	1	7.0	7-7

[a]No Peary caribou were seen while we were on survey on Helena, Lougheed, or Edmund Walker Lougheed, islands.

Table 10

Group statistics for Peary caribou on Bathurst Island, NWT, obtained by aerial survey, July 1985

Group types by survey stratum	Group statistics				
	N	Mean	± S.D.	Range	95% C.I.
Stratum I					
Bull-only groups	2	4.5	0.71	4-5	1.0[a]-10.8
Mixed sex/age groups with calves					
calves included	9	5.9	2.80	3-12	3.7-8.0
calves excluded	9	4.0	2.34	2-9	2.2-5.8
Mixed sex/age groups without calves	2	4.0	2.83	2-6	1.0-29.4
Stratum II					
Bull-only groups	2	3.5	2.12	2-5	1.0-22.6
Mixed sex/age groups with calves					
calves included	15	4.9	2.75	2-9	3.3-6.4
calves excluded	15	3.1	2.19	1-8	1.8-4.3
Mixed sex/age groups without calves	2	3.5	0.71	3-4	1.0-9.8
Stratum III					
Bull-only groups	4	3.2	1.26	2-5	1.2-5.2
Mixed sex/age groups with calves					
calves included	4	6.8	3.30	2-9	1.5-12.0
calves excluded	4	4.2	2.22	1-6	0.7-7.8
Strata I-III					
Bull-only groups	8	3.6	1.30	2-5	2.5-4.7
Mixed sex/age groups with calves					
calves included	28	5.5	2.82	2-12	4.4-6.6
calves excluded	28	3.5	2.22	1-9	2.7-4.4
Mixed sex/age groups without calves	4	3.8	1.71	2-6	1.0-6.5

[a]Actual calculated statistic was a negative value.

Table 11

Group statistics for Peary caribou on Alexander, Marc, Massey, Vanier, and Cameron islands, NWT, obtained by aerial survey, July 1985

Group types by island and survey stratum	Group statistics				
	N	Mean	± S.D.	Range	95% C.I.
Alexander - IV					
Bull-only groups	1	4.0		4-4	
Mixed sex/age groups with calves					
calves included	2	10.0		10-10	10.0-10.0
calves excluded	2	7.5	0.71	7-8	1.1-13.8
Marc - V					
Mixed sex/age groups with calves					
calves included	1	4.0		4-4	
calves excluded	1	3.0		3-3	
Massey - VI					
Mixed sex/age groups with calves					
calves included	9	5.8	3.83	2-14	2.8-8.7
calves excluded	9	3.8	2.90	1-10	1.5-6.0
Vanier - VII					
Bull-only groups	3	2.0		2-2	2.0-2.0
Mixed sex/age groups with calves					
calves included	4	10.0	4.69	7-17	2.5-17.5
calves excluded	4	6.8	2.99	4-11	2.0-11.5
Mixed sex/age groups without calves	1	6.0		6-6	
Cameron - VIII					
Mixed sex/age groups with calves					
calves included	1	7.0		7-7	
calves excluded	1	6.0		6-6	
Mixed sex/age groups without calves	1	7.0		7-7	

Table 12

Herd statistics from aerial survey of muskoxen on nine High Arctic islands, NWT, July 1985

Island[a]	No. herds incl. singles	No. singles	Herd size excl. singles	
			Mean	Range
Bathurst	40	10	9.6	2-25
Alexander	2	0	9.5	7-12
Cameron	1	1		

[a]No muskoxen were seen while we were on survey on Marc, Massey, Vanier, Helena, Lougheed, or Edmund Walker islands.

Table 13

Herd statistics for muskoxen on Bathurst Island, NWT, obtained by aerial survey, July 1985

Herd types by survey stratum	Herd statistics				
	N	Mean	± S.D.	Range	95% C.I.
Stratum I					
Bull-only herds	3	2.0		2-2	2.0-2.0
Mixed sex/age herds with calves					
calves included	6	12.8	3.76	8-18	8.9-16.8
calves excluded	6	9.7	2.80	6-12	6.7-12.6
Stratum II					
Bull-only herds	1	3.0		3-3	
Mixed sex/age herds with calves					
calves included	2	15.5	7.78	10-21	-54.4-85.4
calves excluded	2	11.5	4.95	8-15	-33.0-56.0
Stratum III					
Bull-only herds	8	2.4	0.52	2-3	1.9-2.8
Mixed sex/age herds with calves					
calves included	7	16.8	6.72	7-25	10.6-23.1
calves excluded	7	13.6	5.80	6-21	8.2-18.9
Mixed sex/age herds without calves	3	11.7	0.58	11-12	10.2-13.1
Strata I-III					
Bull-only herds	12	2.3	0.49	2-3	2.0-2.6
Mixed sex/age herds with calves					
calves included	15	15.1	5.70	7-25	11.9-18.2
calves excluded	15	11.7	4.74	6-21	9.1-14.4
Mixed sex/age herds without calves	3	11.7	0.58	11-12	10.2-13.1

Table 14

Herd statistics for muskoxen on Alexander Island, NWT, obtained by aerial survey, July 1985

Herd types by survey stratum	Herd statistics				
	N	Mean	± S.D.	Range	95% C.I.
Stratum IV					
Mixed sex/age herds with calves					
calves included	1	12.0		12-12	
calves excluded	1	8.0		8-8	
Mixed sex/age herds without calves	1	7.0		7-7	

Table 15

Statistics for Peary caribou calves obtained by aerial survey of nine High Arctic islands, NWT, July 1985

Island[a] and survey stratum	Number of calves	Calves as % of total caribou seen on island	Number groups with calves present	Calves/group		
				Mean	± S.D.	Range
Bathurst - I	17	23.0	9	1.9	0.60	1-3
Bathurst - II	27	30.0	15	1.8	1.01	1-4
Bathurst - III	10	24.4	4	2.5	1.29	1-4
Bathurst - I-III	54	26.3	28	1.9	0.94	1-4
Alexander - IV	5	20.8	2	2.5	0.71	2-3
Marc - V	1	25.0	1	1.0		1-1
Massey - VI	18	34.6	9	2.0	1.00	1-4
Vanier - VII	13	25.0	4	3.3	1.89	2-6
Cameron - VIII	1	6.7	1	1.0		1-1

[a]No calves seen on Helena, Lougheed, and Edmund Walker islands during aerial survey.

Table 16

Group statistics for Peary caribou groups with calves present, based on 1+ yr-old individuals only and given by number of calves present in each group, aerial survey, nine High Arctic islands, NWT, July 1985

Group Statistics	Number of calves/group				
	1	2	3	4	6
N	17	17	7	3	1
Mean	2.4	3.9	5.8	6.3	11.0
± S.D.	1.66	1.90	1.95	3.21	
Range	1-8	2-8	3-9	4-10	11-11
95% C.I.	1.55-3.25	2.93-4.87	4.06-7.54	0.40-12.20	

Table 17

Statistics for muskox calves obtained by aerial survey of nine High Arctic islands, NWT, July 1985

Island[a] and survey stratum	Number of calves	Calves as % of total muskox seen on island	Number herds with calves present	Calves/herd		
				Mean	± S.D.	Range
Bathurst - I	19	21.1	6	3.2	1.60	2-6
Bathurst - II	8	22.9	2	4.0	2.83	2-6
Bathurst - III	23	13.2	7	3.3	1.38	1-5
Bathurst - I-III	50	16.7	15	3.3	1.54	1-6
Alexander - IV	4	21.1	1	4.0		4-4

[a]No calves seen on Marc, Massey, Vanier, Cameron, Helena, Lougheed, and Edmund Walker islands during aerial survey.

Table 18

Herd statistics for muskox herds with calves present, based on 1+ yr-old individuals only and given by number of calves present in each herd, aerial survey, nine High Arctic islands, NWT, July 1985

Herd Statistics	Number of calves/herd					
	1	2	3	4	5	6
N	1	5	2	5	1	2
Mean	6.0	8.8	16.0	11.0	20.0	13.5
± S.D.		2.77	7.07	3.67		2.12
Range	6-6	6-13	11-21	8-17	20-20	12-15
95% C.I.		5.61-9.12	(-)25.52-37.52	6.78-15.22		7.05-19.95

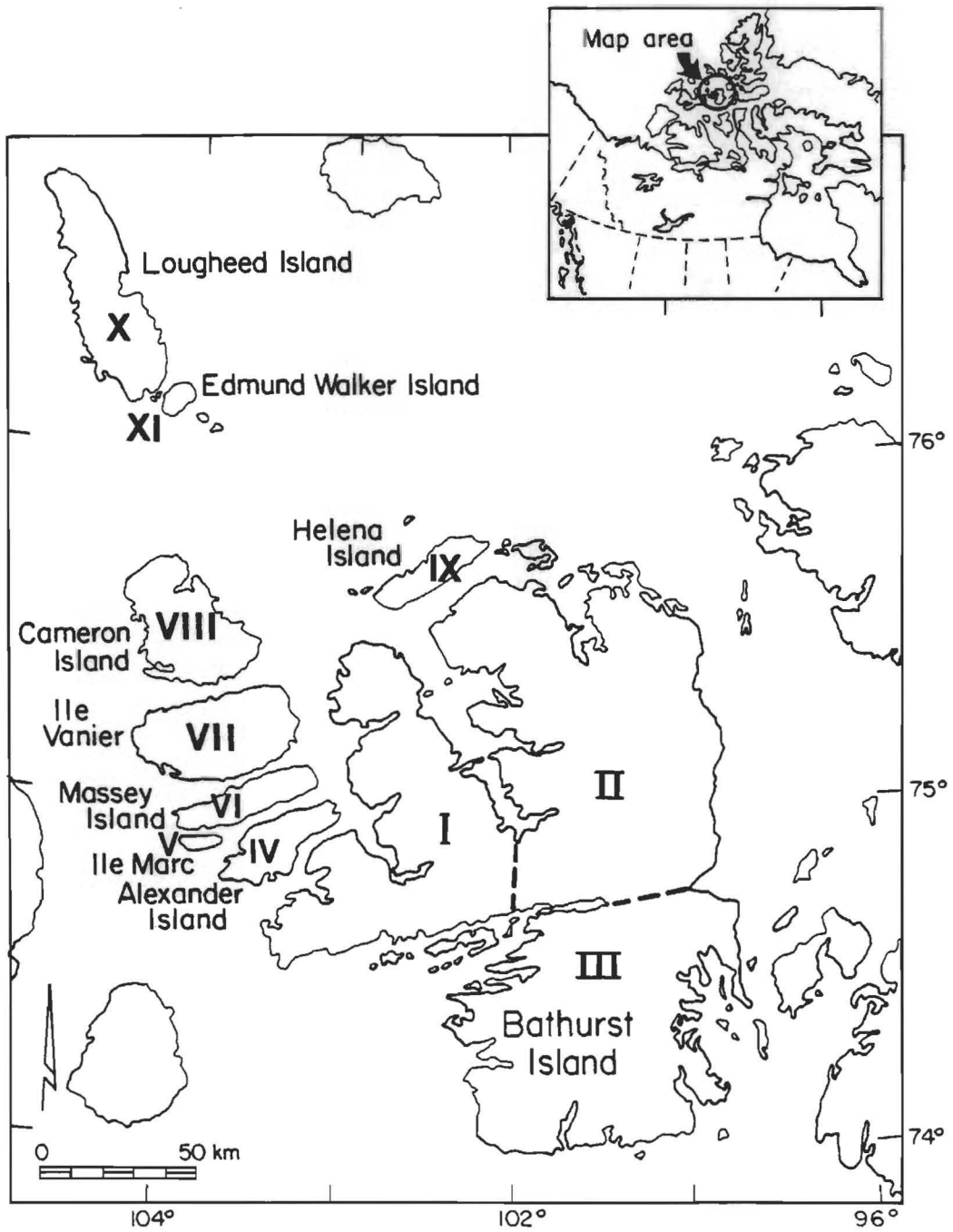

Figure 1. Locations of the 11 survey strata used in July 1985 aerial survey of nine central Queen Elizabeth Islands, NWT

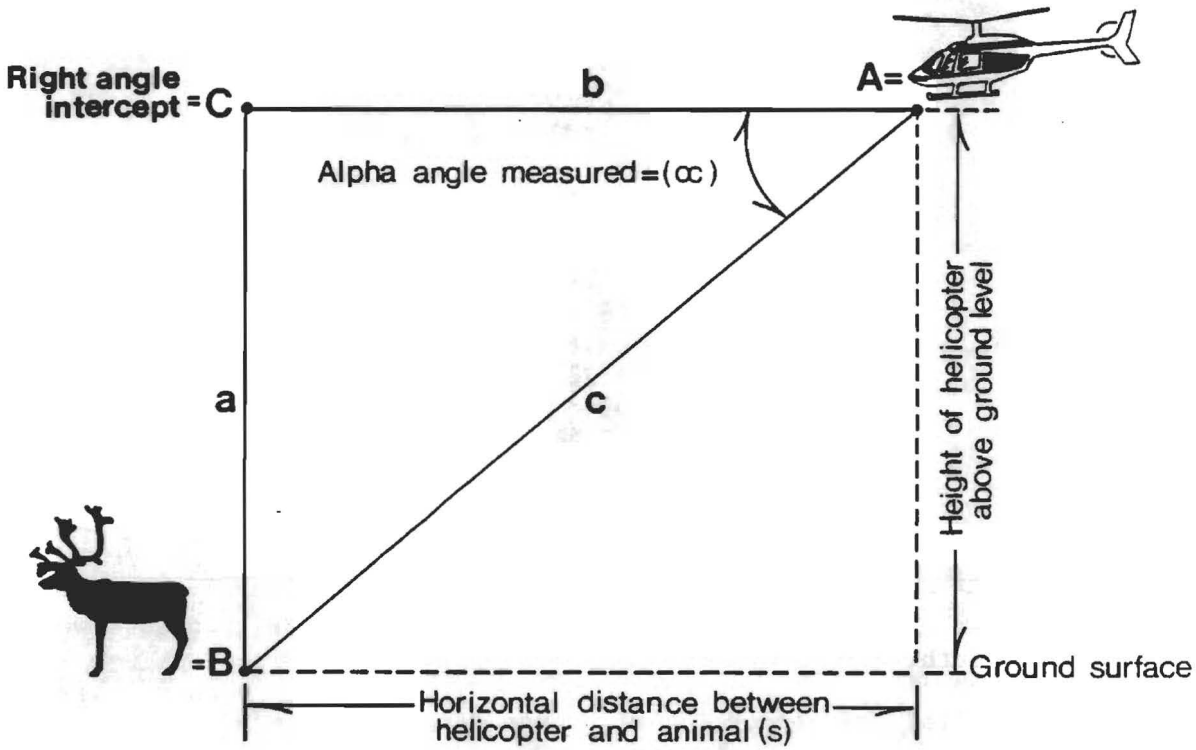

Figure 2. Schema of angle measured with hand held clinometer for calculation of horizontal right angle distance to animal(s) sighted along line transects

Appendix 1

Distribution of line transects on Bathurst Island by survey stratum, NWT, July 1985

Transect number	Distance of transect from baseline by stratum (km)					
	I		II		III	
1	west[a]	101.6	west[a]	50.8	west[a]	44.4
2		95.2		44.4		44.4
3		88.9		38.1		38.1
4		82.6		31.8		31.8
5		76.2		38.1		25.4
6		69.8		31.8		19.0
7		63.5		31.8		12.7
8		82.6		25.4		6.4
9		76.2		19.0		BL[b]
10		69.8		12.7	east[a]	6.4
11		76.2		6.4		12.7
12		69.8	east[a]	BL[b]		19.0
13		69.8		6.4		25.4
14		63.5		12.7		31.8
15		57.2		19.0		38.1
16		50.8		25.4		38.1
17		44.4		31.8		44.4
18		38.1		38.1		
19		31.8				
20		25.4				

[a]Distances are west or east of the baseline, all line transects were north-south.

[b]The baseline was common for all three strata: 99°00'W.

Appendix 2

Distributions of line transects on eight small High Arctic islands adjacent to Bathurst Island, NWT, July 1985

	Distance of transect from baseline (km)			
	Island	Island	Island	Island
	Alexander	Marc	Massey	Vanier
1	east[a] 19.0	east[a] 6.4	east[a] 6.4	west[a] 12.7
2	25.4	12.7	12.7	6.4
3	31.8		19.0	BL[b]
4	38.1		25.4	east[a] 6.4
5	44.4		31.8	12.7
6	50.8		38.1	19.0
7			44.4	25.4
8				31.8
9				38.1
	Cameron	Helena	Lougheed	Edmund Walker
1	west[a] 12.7	west[a] 38.1	east[a] 6.4	east[a] 50.8
2	6.4	44.4	12.7	
3	BL[b]	50.8	19.0	
4	6.4	57.2	25.4	
5	12.5	63.5	31.8	
6	19.0	69.8	38.1	
7	25.4		44.4	

[a]Distances are west or east of the baselines, all line transects were north-south.

[b]The locations of the baselines were as follows: Alexander, Marc, Massey, Vanier, and Cameron, 104°00'W; Helena, 99°00'W; and Lougheed and Edmund Walker, 106°00'W.

Appendix 3

Estimates of densities of 1+ yr-old Peary caribou on nine High Arctic islands, NWT, July 1985, based on systematic aerial survey at about 27% overall coverage (1.714-km wide strip transects at 6.4-km intervals)

Survey area		Number of animals seen	Density/100 km^{-2}		
Island	Stratum	on transects[a]	Estimate	Variance	95% C.I.[b]
Bathurst	I	43	3.864	2.627	0.472- 7.256
	II	31	1.728	0.415	0.368- 3.087
	III	22	1.488	0.296	0.335- 2.641
Alexander	IV	7	5.445	29.533	0.000-19.417
Massey	VI	12	9.855	5.506	4.113-15.597
Vanier	VII	16	5.286	7.897	0.000-11.766
Cameron	VIII	13	4.434	8.422	0.000-11.536
Strata I-III		96	2.189	0.273	1.143- 3.235
Strata IV-XI		48	3.637	1.041	1.597- 5.678
Strata I-XI		144	2.524	0.214	1.617- 3.431

[a]No caribou were seen within strip transect areas on Marc, Helena, Lougheed, and Edmund Walker islands.

[b]When the low confidence limit is a negative value, it is reported as 0.000.

Appendix 4

Estimates of densities of 1+ yr-old muskoxen on nine High Arctic islands, NWT, July 1985, based on systematic aerial survey at about 27% overall coverage (1.714-km wide strip transects at 6.4-km intervals)

Survey area		Number of animals seen	Density/100 km^{-2}		
Island	Stratum	on transects[a]	Estimate	Variance	95% C.L.[b]
Bathurst	I	47	4.223	2.643	0.820– 7.626
	II	26	1.449	0.721	0.000– 3.241
	III	41	2.774	1.982	0.000– 5.758
Alexander	IV	7	5.445	22.278	0.000–17.580
Strata I–III		114	2.599	0.498	1.189– 4.010
Strata IV–XI		7	0.530	0.207	0.000– 1.441
Strata I–XI		121	2.121	0.301	1.045– 3.196

[a]No muskoxen were seen within strip transect areas on Marc, Massey, Vanier, Cameron, Helena, Lougheed, and Edmund Walker islands.

[b]When the low confidence limit is a negative value, it is reported as 0.000.

Appendix 5

Estimates of numbers of 1+ yr-old Peary caribou on nine High Arctic islands, NWT, July 1985, based on systematic aerial survey at about 27% overall coverage (1.714-km wide strip transects at 6.4-km intervals)

Survey area		Number of animals seen on transects[a]	Population estimates		
Island	Stratum		Estimate	Variance	95% C.I.[b]
Bathurst	I	43	157.6	4372.8	19.2-296.1
	II	31	114.9	1835.5	24.5-205.3
	III	22	79.8	849.8	18.0-141.6
Alexander	IV	7	26.7	709.1	0.0- 95.1
Massey	VI	12	43.4	106.6	18.1- 68.6
Vanier	VII	16	59.7	1008.4	0.0-133.0
Cameron	VIII	13	47.0	946.3	0.0-122.3
Strata I-III		96	352.2	7075.6	184.0-520.5
Strata IV-XI		48	173.3	2363.5	76.1-270.6
Strata I-XI		144	526.4	9311.8	337.3-715.5

[a]No caribou were seen within strip transect areas on Marc, Helena, Lougheed, and Edmund Walker islands.

[b]When the low confidence limit is a negative value, it is reported as 0.0.

Appendix 6

Estimates of numbers of 1+ yr-old muskoxen on nine High Arctic islands, NWT, July 1985, based on systematic aerial survey at about 27% overall coverage (1.714-km wide strip transects at 6.4-km intervals)

Survey area		Number of animals seen	Population estimates		
Island	Stratum	on transects[a]	Estimate	Variance	95% C.I.[b]
Bathurst	I	47	172.3	4400.3	33.5-311.2
	II	26	96.4	3190.1	0.0-215.5
	III	41	148.7	5694.0	0.0-308.6
Alexander	IV	7	26.7	534.9	0.0- 86.1
Strata I-III		114	418.3	12882.4	191.3-645.3
Strata IV-XI		7	25.3	470.1	0.0- 68.6
Strata I-XI		121	442.3	13079.5	218.0-666.6

[a]No muskoxen were seen within strip transect areas on Marc, Massey, Vanier, Cameron, Helena, Lougheed, and Edmund Walker islands.

[b]When the low confidence limit is a negative value, it is reported as 0.0.