PEARY CARIBOU CONSERVATION STUDIES, BATHURST ISLAND COMPLEX, NORTHWEST TERRITORIES, APRIL-AUGUST 1994 AND JUNE-JULY 1995

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ABSTRACT: Field activities associated with the ecological studies of the inter-island population of Peary caribou (*Rangifer tarandus pearyi*) within the Bathurst Island complex, south-central Queen Elizabeth Islands, Northwest Territories, were carried out in April-August 1994 and June-July 1995. A Bell 206L, "Long Ranger" turbo-helicopter on skid gear and equipped with a Global Positioning System was used in all studies. Nonsystematic aerial searches were made to (1) collect data on relative numbers, distributions, and movements/migrations; (2) carry out radio telemetry tracking flights to relocate telemetry neck-collared caribou to evaluate annual mortality and fecundity; (3) recapture caribou collared in summer 1993 and capture different caribou in summer 1994 to equip them with new satellite telemetry neck-collars; (4) carry out sex/age composition counts; (5) obtain statistics on caribou social formations; and (6) evaluate annual calf production and early survival of newborn calves. We counted and segregated by sex/age class 826 and 1084 caribou in June and July 1995, respectively. Both breeding cows and bulls were well-represented but the majority of animals in each sample were juveniles and yearlings. Caribou were nonrandomly distributed among the 13 search zones on Bathurst Island on a relative landmass basis ($P < 0.005$) and significantly overrepresented ($P < 0.005$) on coastal sites compared to interior sites, on northern Bathurst compared to the southern Bathurst, and on eastern Bathurst compared to western Bathurst. Seasonal intra- and inter-island movements and migrations by satellite and radio telemetry neck-collared caribou were documented. The winter 1993/94 was favourable to caribou survival and not a single carcass was found in summer 1994. Calving was early and initially successful in summer 1994 at 26% calves among all caribou seen by 12 June. Early survival of newborn calves in summer 1994 was, however, only moderately successful at 18% calves among all caribou seen by 6 August 1994. All 17 of the caribou equipped with telemetry neck-collars in summer 1993 were accounted for each month from April to July 1994. Two of those 17 telemetry neck-collared caribou had died in winter 1993/94 (1 bull, 1 cow). Yearling recruitment among the 14 telemetry neck-collared cows that were alive in July 1994 was 100%. The winter of 1994/95 was severe and we found 56 caribou carcasses in summer 1995, with the same amount of aerial search effort that yielded not a single carcass in summer 1994. Two of the 7 1994 satellite telemetry neck-collared caribou (1 bull, 1 cow) and, also, two more of the 8 1993 radio telemetry neck-collared caribou (2 cows) still alive in summer 1994

died in winter 1994/95. The 1995 calf crop was markedly poor, with only 9% calves among all caribou seen by 24 June and subsequently rising to only 11% by 11 July 1995. Peary caribou have suffered a serious set back in the population growth within the Bathurst Island complex in 1995.

RÉSUMÉ: D'avril à août 1994 ainsi qu'en juin et juillet 1995, nous avons fait divers travaux sur le terrain dans le cadre d'études consacrées à l'écologie de la population inter-insulaire de caribous de Peary (*Rangifer tarandus pearyi*) appartenant au complexe de l'île Bathurst, située dans le secteur centre-sud des îles de la Reine-Élizabeth (Territoires du Nord-Ouest). Dans tous les cas, nous avons utilisé un hélicoptère «Long Ranger» Bell 206L à turbomoteur et à patins d'atterrissage équipé d'un dispositif de positionnement global. Des vols de repérage non systématiques ont été effectués pour 1) recueillir des données sur les nombres relatifs, les distributions, les déplacements et les migrations; 2) retrouver par radiotélédétection les caribous porteurs d'un collier émetteur pour une évaluation de la mortalité et de la fécondité annuelles; 3) recapturer les caribous auxquels on a mis un collier émetteur au cours de l'été 1993 et capturer d'autres sujets au cours de l'été 1994 pour leur mettre un nouveau collier émetteur dont le signal est capté par satellite; 4) faire des dénombrements en fonction du sexe et de l'âge; 5) recueillir des données sur les formations sociales des caribous; 6) évaluer la production annuelle de faons et le taux de survie à court terme des nouveau-nés. En juin et juillet 1995, nous avons dénombré 826 et 1 084 caribous, respectivement, que nous avons répartis en fonction du sexe et de l'âge . Les femelles et les mâles en âge de se reproduire étaient bien représentés, mais les plus nombreux dans les deux échantillons étaient les juvéniles et les jeunes de un an. Les caribous étaient distribués de façon non aléatoire dans les 13 zones de recherche de l'île Bathurst en fonction d'une étendue relative ($P < 0,005$) et surreprésentés dans une mesure significative ($P < 0,005$) dans les zones côtières par comparaison aux zones de l'intérieur des terres, dans le nord de l'île, par comparaison au sud, et dans l'est, par comparaison à l'ouest. Nous avons aussi étudié les migrations et les déplacements saisonniers dans l'île et d'une île à l'autre par télédétection (radio et satellite) des caribous porteurs d'un collier émetteur. L'hiver 1993-1994 a été favorable : aucune carcasse n'a été trouvée à l'été 1994. La mise bas a commencé tôt et a d'abord été favorable à l'été 1994, avec une proportion de 26 % de faons sur la totalité des caribous vus jusqu'au 12 juin; par contre, la survie à court terme de ces nouveau-nés n'a été que moyennement bonne, la proportion de faons n'atteignant que 18 % des caribous observés jusqu'au 6 août. D'avril à juillet 1994, chacun des 17 caribous auxquels on avait mis un collier émetteur à l'été 1993 a été repéré à chaque mois; sur ce nombre 2 sont morts à l'hiver 1993-1994

(1 femelle et 1 mâle). Le recrutement des jeunes de un an issus des 14 femelles porteuses d'un collier et vivantes en juillet 1994 a atteint 100 %. L'hiver 1994-1995 a été dur : nous avons trouvé 56 carcasses à l'été 1995, après un effort de recherche par vols aériens de même envergure que celui de l'été 1994, au cours duquel aucune carcasse n'avait été découverte. Des 7 caribous auxquels on a vait mis un collier émetteur de signaux captés par satellite en 1994, 2 sont morts (1 mâle et 1 femelle); en outre, des 8 bêtes porteuses d'un collier émetteur de signaux radio (installé en 1993) encore vivantes à l'été 1994, 2 autres sont mortes à l'hiver 1994-1995. En 1995, la production de faons a été très faible, la proportion de faons par rapport à l'ensemble de caribous vus jusqu'au 24 juin n'étan que de 9 % et seulement de 11 % au 11 juillet 1995. La croissance de la population de caribous de Peary a accusé une forte baisse dans le complexe de l'île Bathurst en 1995.

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INTRODUCTION

The Peary caribou *(Rangifer tarandus pearyi)* is unique to arctic Canada and it is a socially important, economically valuable part of Canada's natural heritage. The Peary caribou was listed in 199l, however, as an "Endangered" form of wildlife by the Committee On The Status Of Endangered Wildlife In Canada (COSEWIC: Miller 1990). This most recent assignment was an uplisting from the 1979 "Threatened" classification by COSEWIC based on the first Canadian Wildlife Service (CWS) status report on Peary caribou to COSEWIC (Gunn *et al.* 1979).

Peary caribou on the southwestern and south-central Queen Elizabeth Islands (QEI) of the Canadian Arctic Archipelago were dangerously low in number during the 1970s into, at least, the late 1980s (Miller *et al.* 1977, Gunn *et al.* 1979, 1981, Miller 1987*a*, 1987*b*, 1988, 1989, 1990). Melville, Bathurst, and Prince Patrick islands in descending order (Fig.1) have been, and still are the three major islands of significance for Peary caribou, based on the number of caribou estimated on each compared to numbers on all other QEI in 1961 (Tener 1961, 1963), 1972-74 (Miller *et al.* 1977), and 1985-88 (Miller 1987*a*, 1987*b*, 1988, 1989). Peary caribou on Melville and Prince Patrick were in an overall and apparently continual decline since 1961 to, at least, the late 1980s (Tener 1963, Miller *et al.* 1977, Miller 1987*b*, 1988). Bathurst Island, where Peary caribou underwent the greatest proportional loss in number on an island basis during the catastrophic winter of 1973-74 (Miller *et al.* 1977), is the only major island where the caribou are known to have shown signs of recovery from the 1973-74 low (Miller 1987*a*, 1987*b*, 1988, 1989, 1995). Caribou on south-central QEI appear to have been in an overall positive state of population growth since, at least, the 1980s into the early 1990s (Miller 1987*a*, 1989, 1991, 1992, 1993, 1994, 1995) and by 1993 had reached 70% of the number estimated in 1961 (Tener 1963, Miller 1995), but have subsequently declined to *ca.* 50% of the 1961 estimate in 1995, based on the findings presented herein.

Bathurst Island was the principal caribou hunting area for the Inuit of Resolute, Cornwallis Island, prior to the cataclysmic die-off of caribou in 1973-74. The general lack of caribou on Bathurst Island thereafter caused the Inuit hunters of Resolute to impose a voluntary ban on caribou hunting on Bathurst Island in 1975 (Freeman 1975, Ferguson 1987). The ban was apparently honoured until 1990

although a desire to again hunt caribou on Bathurst Island was voiced in 1988 and 1989. Annual rates of caribou harvested on Bathurst Island have increased since 1990 but the annual rate of kill remains well below the maximum level that could have been sustained annually by the then present caribou population.

The CWS has selected Bathurst Island to continue ecological studies of the relationship between Peary caribou and their environment as the Inuit of Resolute have resumed hunting caribou on Bathurst Island (which makes those caribou essentially the only hunted population of Peary caribou on the QEI, except for some limited hunting on southern Ellesmere Island by the Inuit of Grise Fiord). Peary caribou on Bathurst Island are the most accessible to Resolute within the QEI. Those caribou also have, at least in theory (based on known past population size), a potential for increasing in number to a level that would sustain annual harvests of meaningful sizes. At present, only those Peary caribou on Bathurst Island (and some smaller satellite islands) are known to have experienced any marked increase in number from their 1973-74 low, while Peary caribou on Melville and Prince Patrick islands (and their respective satellite islands) showed no indication of recovery when last surveyed in 1986 and 1987 (Miller 1987*b*, 1988).

The use of satellite and radio telemetry was initiated in July-August 1993 to investigate daily and seasonal movements/migrations and year-round distributional use of range by Peary caribou on the south-central QEI. The 1994 field season was devoted solely to the continuation of satellite and radio telemetry studies. The emphasis for the 1995 field season was shifted in June 1995, however, because of evidence of a probable major winter die-off among muskoxen (*Ovobos moschatus*) and possibly also among Peary caribou on the south-central QEI. Therefore, much of the 1995 field effort was devoted to the documentation of those mortalities. The remainder of the 1995 field activities included relocations of collared-caribou by radio telemetry, sex/age composition counts, and an evaluation of calving success and early calf survival. The following is a biennial progress report on field activities for Peary caribou studies on Bathurst Island and some of Bathurst's satellite islands during the 1994 and the 1995 seasons.

STUDY AREA

1. Bathurst Island Complex

The study area is termed the "Bathurst Island complex" (BIC) and for the purpose of this research includes a complex of 30 islands that lie within the south-central portion of the QEI and to the south in the immediately adjacent waters of Viscount Melville Sound and Barrow Strait (Figs. 1-6). The study area lies between 74° and 77° N latitude and 93° and 105° W longitude, and the collective landmass of the 30 islands equals *ca.* 27 550 km². The islands are mostly low-lying and mainly below 150 m above mean sea level in elevation. Geology, topography, and vegetation within the study area have been described in detail (e.g., Dunbar and Greenaway 1956, Thorsteinsson 1958, Savile 1961, Fortier et al. 1963, Tener 1963, Blake 1964, Kerr 1974, Wein and Rencz 1976, Edlund 1983, 1990).

For the purposes of this study, the 30-island study area is divided into three levels of importance: (1) one principal island; (2) nine major satellite islands (all but Helena Island, Ile Marc, and Sherard Osborn Island >400 km²); and (3) 20 secondary satellite islands (each island <50 km², except Griffith, Lowther, and "Bull" islands).

1.1. The principal island

The principal island is Bathurst Island (16 090 km²) which is the largest and most important "game" island within the south-central QEI (Figs. 1, 2). A "primary study area" for intensive ground studies was selected on a northeastern coastal site (*ca.* 100 km²) between the Walker and Moses Robinson rivers (centred at *ca.* 76°00' N, 97°40' W).

1.2. Major satellite islands

The nine major satellite islands of Bathurst Island (Figs. 1-4), in terms of possible movements or migrations of Peary caribou within the BIC, are the "five western major satellite islands" of Vanier (1130 km²), Cameron (1060 km²), Alexander (490 km²), Massey (440 km²), and Marc (56 km²) on the northwestern coast; the "two northern major satellite islands" of Helena (220 km²) and Sherard Osborn (51 km²) off the northern coast; and the "two eastern major satellite islands" of Cornwallis (7000 km²) and Little Cornwallis (410 km²).

1.3. Secondary satellite islands

The 20 secondary satellite islands (Figs. 1-6) are the nine southern secondary satellite islands of Browne, Garrett, Griffith, Hamilton, Lowther, Somerville, and Young in Barrow Strait, and Baker and Moore in Intrepid Passage; the seven eastern secondary satellite islands of Neal (Neal Islands are treated as one island), Truro, and Wood in McDougall Sound, Kalivik and Milne in Crozier Strait, and Crozier and Baring in Queens Channel; the three west-central secondary satellite islands of Bradford in Graham Moore Bay and "Bull" (the largest unnamed island in Graham Moore Bay, where we consistently have seen bull caribou each summer) and "Muskox" (a small unnamed island just to the east of "Bull Island" that had 65 muskoxen summering on it in July 1985, apparently after being trapped there by an early open-water season) in Bracebridge Inlet at the head of Graham Moore Bay; and Ile Pauline, lying in Perse Strait off the south coast of Ile Vanier.

These 20 small secondary satellite islands are known to or are likely to receive migrant caribou from Bathurst Island during periods of springtime environmental stress (e.g., Bissett 1968, Miller and Gunn 1978, 1980) and thus are included in the study area. All of these islands are poorly vegetated and not one is of a size that could support any significant number of Peary caribou on a year-round basis. Because of their usually exposed nature, however, these small islands could collectively provide, and sometimes have provided, valuable temporary relief for caribou fleeing widespread forage unavailability elsewhere within the BIC. These 20 small islands collectively total only about 603 km^2.

2. General Climate

The climate of the study 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 generally do not rise above 0°C until after 1 June on the extreme south of the study area, and 15 June on the north of the study area (Meteorological Branch 1970). Snow cover usually begins melting in early June, and often rapidly dissipates to bare ground through 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.

Weather patterns within the study area are varied. A comparison of 1 year's weather data from the Canadian Museum of Nature research station in Polar Bear Pass on central Bathurst Island with data from the Atmospheric Environment Service (AES) weather station at Resolute, Cornwallis Island, suggests that the differences in the weather between the two locations (93 km apart) are the result of the research station's inland site and local topographical effects (Thompson 1971). The AES weather station at Mould Bay, Prince Patrick Island, tends to have cooler, drier and less stormy weather than the AES weather station at Resolute, Cornwallis Island (Maxwell 1981: 700 km apart).

The amount and duration of snow cover, especially in spring, are critical to arctic ungulates, and 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 that results in ground fast ice before snow cover accumulates, ice layering in the snow cover, crusting of the snow, and the formation of ground fast ice in spring (e.g., Miller et al. 1982, Miller 1992, 1993, 1994) compound the stress of forage unavailability on arctic ungulates. Despite these known conditions, detailed range-wide information on type of snow cover and the incidence of ground-fast ice or ice layering is generally unavailable for the QEI.

METHODS

1. VHF Radio Tracking Of Collared Caribou

A Bell 206L turbo-helicopter on high skid gear was used as the VHF radio tracking aircraft. The helicopter was flown at 600 to 1800 m above ground level (agl) and a cruising speed (*ca.* 180 km • h^{-1}) while searching for very-high-frequency (VHF) radio signals in the 164 MHz range. When a collared caribou was detected close by, we descended to 15 to 60 m agl to make visual verification of the collared animal and to determine the sex/age composition of the companion animals (social grouping).

I used a 3-person tracking crew: pilot-navigator-spotter (right front seat); radio-tracker (left front seat); and navigator-spotter; (right rear seat). Both the helicopter's Global Positioning System (GPS) and 1:250 000 topographical maps were used for navigation. For each collared animal located, the radio-tracker recorded: (1) date; (2) animal ID. no.; (3) location, based on helicopter GPS; (4) composition of animals sighted, as bull, cow, calf, juvenile male, juvenile female, yearling male, or yearling female; and (5) remarks, if any. The animals were circled, if necessary, to determine their number and sex/age composition (all 3 crew members participated in the determinations).

2. Capture, Handling, And Collaring Of Caribou, 1994

A Bell 206L (Jet Long Ranger) turbo-helicopter on high skid gear also was used as the pursuit aircraft for the capture effort. The helicopter was flown at 60 to 90 m agl and a cruising speed of *ca.* 180 km • h^{-1} while searching for the target animals (that is, the 7 1993 satellite neck-collared caribou). Air speeds were reduced to between 50 and 90 km • h^{-1} during close approach and pursuit of animals. Caribou were captured by use of an aerial net-gun technique (Barrett *et al.*, 1982). In 1994, I used a three-person team, plus the pilot, as the aerial net-gun capture crew. Two net-guns, a 4-barrel gun and a 3-barrel gun, with a spare net for each gun were carried on board the helicopter. When a target caribou was spotted, the helicopter was landed several hundred metres away from the animals on the best vantage point available. Two of the crew members disembarked; removed the right rear door, which was equipped with "quick release pins"; and placed the door on the ground along with all extra equipment and gear not needed for the actual capture. The helicopter then took-off, with one crew member left on the ground with the extra gear, and manoeuvred into position for pursuit with the net-gunner in the right rear door and one crew member in the left front seat to keep the net-gunner informed about the target animal's position. Once the net was fired and it was on the animal, the helicopter was landed *ca.* 30 m from the animal and the two crew members got out of the helicopter and secured the animal in the net. The helicopter returned to and picked up the one previously positioned crew member waiting on the ground: the right rear door was put back on and the equipment and gear reloaded on the helicopter. They then returned to the capture site and assisted in the handling and collaring of the animal.

It was predetermined from 1993 results (Miller 1995) that each single "chase" and the actual final "pursuit time" would not exceed a 3 min • event^{-1} and preferably would be held at a 2.5 min • event^{-1}, unless capture appeared eminent within the next 30 s. Also, each chase had to be separated by at least a 5-min-interval or more to allow the animal to settle down and rest between chases. Longer waits would be employed, if it was judged that the animal was moving to a potentially better capture site (e.g., less rock rubble on the surface of the ground; a gentle up slope to the terrain; and a favourable upwind approach path to the target animal).

Telemetry packages for the Satellite Platform Transmitter Terminal (PTT) collars and for the conventional VHF radio telemetry collars were built by Telonics Telemetry, Electronics Consultants, 932 E. Impala Avenue, Mesa, Arizona 85204-6699, U.S.A. The PTT-year (366 days) was divided into four seasons: season 1, 70 days duration (22 Jul-30 Sep), with a 5-day duty cycle of 6 h on/114 h off; season 2, 46 days (1 Oct-15 Nov), 2-day duty cycle of 6 h on/42 h off; season 3, 180 days (16 Nov-14 May), 5-day duty cycle of 6 h on/114 h off; and season 4, 70 days (15 May-23 Jul), 2-day duty cycle of 6 h on/42 h off. The 164 MHz range was used as the VHF frequency band. Collars were colour-coated bright yellow to make them highly visible to observers and Inuit hunters.

The Service Argos Inc. "Data Collection and Location System" is carried by two National Oceanic and Atmospheric Administration (NOAA) satellites in simultaneous low earth orbit (Service Argos, 1989: *ca.* 800 km altitude). Each orbit period around the earth (one revolution) takes *ca.* 102 min; therefore, each satellite makes *ca.* 14 revolutions a day (with a maximum combined potential of 24 usable passes per day by the two satellites at north of 72^0 N latitude). Pertinent information on satellite telemetry is thoroughly covered in the Service Argos Inc. Users Manual (1988) and System Guide (1989) and in the U.S. Fish and Wildlife Service publication by Fancy *et al.* (1988) in which they present (1) an overview of the Service Argos Inc. Data Collection and location system; (2) a history of tracking wildlife by satellite; (3) description of system components, satellite transmitters, satellites used with the data collection and location system, satellite orbits, signal acquisition and transfer to processing centres, and location determination; (4) applications

to wildlife research and management, transmitter manufacturers, specifications, costs, sensor development and calibration, location accuracy and precision in wildlife applications, reliability of transmitter packages, real-time processing with a local user terminal, and effects of the collar on the animal; (5) geographic information systems; (6) a description of a software package for processing Argos data; (7) data retrieval, Argos file types (dispose files, telex files, ajour file), and Argos commands; (8) an explanation of satellite orbital elements; (9) a glossary of special terms; and (10) how to get started with Service Argos Inc. (ARGOS).

ARGOS location-data were retrieved in quality "Location Classes". From the beginning of the Satellite telemetry study in July 1993 until June 1994, the highest Location Class was, Class 3, followed in descending order of quality by Class 2 and Class 1. Class 0 locations were provided as a special service and had to be requested from Service ARGOS at extra costs. Quality control for a Class 3 location was "very strict", required a minimum of five messages, with at least 420 s between first and last received messages; a Class 2 location had "standard" quality control, also required a minimum of five messages, with at least 420 s between first and last received messages; and a Class 1 location had only "loose" quality control, required a minimum of four messages, with at least 240 s between first and last received messages. A Class 0 location had no quality control, required only a minimum of two messages, with at least 4 s and less than 240 s between the first and the last received message.

During one satellite pass over a transmitter the satellite receives a certain number of messages, depending on duration of pass and repetition period of the transmitter. Previous to June 1994 ARGOS "Location Classes" were based on geometric conditions during the satellite pass and assumed nominal transmitter quality. Although Location Classes generally provided good estimates of accuracy, they tended to overestimate accuracy for low-quality transmitters and under-estimate that of high-quality transmitters. Subsequently, ARGOS improved the accuracy of location estimates by considering the "measured quality" of the oscillator together with the velocity at which the mobile was moving, and by revising "Class 0" for low-quality locations. Service Argos recently improved the way they calculated locations from three messages, which commonly are used out of necessity by biologists using marginal

transmitters (i.e., those with low power, sporadic transmissions, etc.). The new algorithms became operational on 15 June 1994. Currently, the Location Class is alphanumeric: 3, 2, 1, 0, A, B, or Z (App. 1). The assumed accuracies of the Location Classes are now "Class 3," <150 m; "Class 2," <350 m; "Class 1," <1000 m; and "Class 0," >1000 m (the accuracy of a "Class A," "Class B," or "Class Z" location-datum is unestimated). Class 0 locations are now included in the "Standard Service" and Class A, B, and Z are provided as a special service ("Auxiliary Processing" or "Service Plus") and must be requested from ARGOS at additional costs.

Background. We captured 17 Peary caribou by aerial net-gunning from a Bell 206L turbo-helicopter within the Bathurst Island complex, Northwest Territories, between 27 July and 1 August 1993 (Miller 1995). Ten of the 17 caribou were captured on Bathurst Island: nine on the northeastern section of the island north of Polar Bear Pass and one on south-central Bathurst south of Polar Bear Pass. The remaining seven caribou were captured on three of the five western major satellite islands of Bathurst Island: one on Ile Vanier, three on Alexander Island, and three on Massey Island (none was captured on Cameron Island or on Ile Marc). Fifteen of the captured caribou were adult females (cows) and the remaining two were adult males (bulls). Seven of them, six cows and one bull, were fitted with telemetry neck-collars that each housed a satellite PTT package and a VHF radio package. Those seven animals are hereafter referred to as "PTT-collared" caribou. The other 10 captured caribou, nine cows and one bull, were equipped with telemetry neck-collars that each housed only a VHF radio package. These 10 animals are hereafter referred to as "VHF-collared" caribou.

3. Nonsystematic Helicopter Searches

I divided Bathurst Island into 13 "search zones" for the purpose of nonsystematic aerial searches (App. 2): (1) northeast coast (NEC); (2) northeast interior (NEI); (3) southeast coast (SEC); (4) southeast interior (SEI); (5) south coast (SC); (6) southwest coast (SWC); (7) southwest interior (SWI); (8) northwest coast (NWC); (9) northwest interior (NWI); (10) north coast, western section (NCW); (11) north coast, eastern section (NCE); (12) north Polar Bear Pass (NPBP), and (13) south Polar Bear Pass (SPBP). Zones 12 and 13, Polar Bear Pass (PBP), include all of the lowlands from the middle of the

valley north to the crest of high ground and a nearly equal distance to the south from near the head of Goodsir Inlet through the pass to near the head of Bracebridge Inlet. All coastal search zones consist of strips of land that extend about 5 km inland from the sea coast, with the one exception of PBP. For comparisons of major land divisions, PBP is considered as a "coastal site" in the "Coastal vs. Interior" comparison because of the "shoreline effect" created by the river-lake system passing through the wet central lowlands of the pass. All of the land area divisions (search zones) were tied to the three aerial survey strata of Bathurst Island (App. 2; Fig. 2) used by Miller et al. (1977) and Miller (1987*a*, 1989). The middle lowlands of PBP, through central Bathurst Island, was used to divide Bathurst into north and south sections (Miller 1995: the common boundary of survey Stratum (St.) II and St. III, Fig. 2). The northern portion of Bathurst Island was divided into eastern and western halves along the common land and water boundaries of St. I and St. II (Miller 1995). The southern portion of Bathurst Island was divided in half on an east and west basis along the 99° 00' W meridian (passing just west of the head of Bracebridge Inlet at the north end to just west of Dyke Ackland Bay on the south coast. Also, in the "East vs. West" comparison, all of the NPBP and 60% of the SPBP are included in the "East" and 40% of the SPBP is included in the "West"; and 30% of the SC is included in the East and 70% of the SC in the West. Additionally, each of Bathurst Island's major and secondary satellite islands was treated as a separate search zone.

A Bell 206L turbo-helicopter on high skid gear also was used as the search aircraft. The helicopter was flown at 60 to 100 m agl and air speed of *ca.* 96 to 180 km • h^{-1} during the searches (usually at cruising speed when searching for animals). Slower speeds were temporarily maintained when examining groups of caribou.

A 3-person aerial search team was used in 1994 and 1995: pilot-navigator-spotter (right front seat); spotter-observer-recorder (left front seat); and a right rear seat spotter-observer. Both the helicopter's GPS and 1:250 000 topographical maps were used for navigation. The left front seat observer recorded all observations in a field book: (1) date; (2) location; (3) composition of animal(s) sighted in each group or as solitary individuals, as bull, cow, calf, juvenile or yearling (juveniles and yearlings were separated by sex); and (4) remarks, if any. The animals

sighted were circled, if necessary, to determine their number and sex/age composition (all 3 crew members participated in the determinations).

I met with the Government of the Northwest Territories (GNWT), Department of Renewable Resources (DRR), Resource Officer and members of the Resolute Hunters & Trappers Organization (HTO) on 12 June 1995. We discussed the evidence that they had found for a high rate of winter deaths among muskoxen in the Eleanor Lake area of Cornwallis Island (specimens had been collected by the Resolute, GNWT, DRR, Resource Officer from several dead muskoxen and sent for analyses to the Saskatchewan Veterinary College, Saskatoon). The Resource Officer and the members of the HTO appraised me of their findings and their concern for the possibility that the muskox deaths could have been caused by infectious disease. They expressed concern for the possibility of tainted water supplies being used by summer field parties, and wanted more information on the extent and magnitude of the apparent winter die-off of muskoxen. I agreed with them that the matter should be investigated further. Therefore, I volunteered to shift some of my resources into a more intensive and extensive aerial search for muskox carcasses within the Bathurst Island complex and to do a cursory evaluation of the status of the muskox population within the BIC in June-July 1995 (App. 3).

4. Numbers, Distributions, And Movements/Migrations

Relative numbers of caribou by search zone and by island within the BIC were determined by nonsystematic helicopter searches. The maximum count obtained during a discrete search period can provide some insight into the likely seasonal population levels by island and for the entire BIC. Distributions and intra-island movements and seasonal migrations by search zone or an entire island were determined by nonsystematic helicopter searches over land areas of the various islands within the BIC. Evidence for inter-island movements of caribou within the BIC was obtained by PTT satellite location-data and by VHF radio tracking helicopter flights.

5. Sex/Age Composition And Social Groupings

Segregation of caribou seen during aerial activities by sex/age classes (bulls, cows, calves, juveniles and yearlings) were used in 1995 to determine the approximate sex/age structures of the

"precalving" and "postcalving" population segments on an island basis and between and among islands. The overall data base from combined aerial activities allowed approximations of the precalving and postcalving sex/age compositions of the entire inter-island population of Peary caribou within the BIC. These data provide some insight into the current population dynamics and the potential for growth of the caribou population within the BIC.

5.1. Sex/age classification

A combination of dimorphic diagnostic characteristics, including body size, antler size, antler form, antler growth patterns, and timing of pelage change allow the Peary caribou's segregation into seven sex/age classes. Some aspects of their respective grouping behaviour and initial flight behaviour in response to human-induced novel stimuli in the caribou's environment also helps in making some of the sex/age separations. Thus, Peary caribou in this study are recognized, classified, and placed in sex/age classes as follows.

5.1.1. "Bulls" (mature males, assumed 4+ yr-old) are recognized in May through mid June 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 are 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 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 observer distinguishes 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. By late June the distinction between the larger antlers of bulls compared to those of juvenile males becomes more obvious, and there is no chance of confusing the two sex/age classes during July and August, with one possible exception. Males just coming of age, "borderline bulls", are classified as "bulls" when their antler growth is characterized by large-diameter main beams that are directed strongly posteriad, and considerable terminal growth on the main beam is yet to occur. When the

main beams of the antlers are directed posteriorly but have already begun to curve anteriorly along the middle and terminal portions of the main axes, and the antlers, seemingly, are going to be only slightly longer than the anterio-posteriad axis of the head, from the nose to the back of the neck, the animal is classified as a "juvenile male".

5.1.2. "Cows" (mature females, assumed to be mostly 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 a 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 in a 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 calved 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 Jul). The general drab appearance of a successful maternal cow usually remains clearly recognizable into August of the year (individual variation, however, may be important after late Jul). Whenever possible, the presence of a stained "vulval patch" or a distended udder in combination with retained hard antlers in June is noted (cf. Bergerud 1961, 1964). Empirical impressions formed over several years of spring and summer (May-Aug) aerial searches indicate that the adult cow-like characteristics ascribed to a "breeding cow" apply to all parturient females regardless of age. Therefore, a certain but unknown, and most likely annually changing, percentage of "breeding cows" in each year would actually be pregnant juvenile or yearling females. On occasion, obviously small-sized "breeding cows" are recognized but consistent comparative size distinctions over time are not currently feasible or possible. Thus, "breeding cows" represent the sum total of all females (1+ yr-old) in the population that have either produced a calf (viable or nonviable) or carried a fetus to near- or full-term in that year.

5.1.3. "Juvenile/yearling males" (males, assumed 1-3 yr-old) are recognized in May through mid June by their new pelage, and their relatively small body size (especially that of yearlings), which, when compared to adults, aids in their separation from bulls and cows. (Initially, an attempt is made to separate juvenile males from yearling males.) The advanced, well-developed, but relatively small (when compared to bulls)

new antler growth of at least 2- and 3-yr olds is used to separate them from juvenile females. Yearling males are judged by their associations, relative antler development and body size, as well as the absence of a "vulval patch", when possible (cf. Bergerud 1961). By late June and early July there could be some confusion between the diagnostic characteristics of some juvenile male antlers (most likely those of 2-yr olds) and those of some females, especially nonpregnant females and particularly those females just "coming of age". At that time, it appears that the most accurate basis for separation of some juvenile males from heavily antlered females lies in the comparative shapes and priorities of antler growth. That is, the growth of juvenile (and, seemingly, yearling) male antlers is directed to the development of strongly posteriorly curved main beams. When viewed from above (from a low-level helicopter) the two main beams of males are directed both backwards and outwards, the pair giving a posteriorly inclined "V-shaped" appearance from above. Such male main beams are devoid of any strong (readily noticeable) terminal growth of lateral tines. Most often, one or more of usually the 1st (bez) or occasionally the 2nd (trez) tine(s) are well-developed in an oblique, upwards, anteriorad direction, usually well exceeding 50% of the lineal growth of the main beams in length. The same conditions but on a smaller scale appear to apply to yearling males during the same time period (except that the terminal portion of one or both main beams may be beginning to fork). Whether our ability to identify and separate juvenile/ yearling males from some cows (especially young nonbreeders) or possibly even from some juvenile/yearling females is reduced in late July through August of the year is unknown (but likely is so to some degree).

5.1.4. "Juvenile/yearling females" (females, assumed 1-2 yr-old) are recognized in May through mid June by their new pelage, new antler growth, relatively small body size (particularly yearlings) and the presence, when visible, of a "vulval patch" (and the absence of a distended udder) (cf. Bergerud 1961, 1964). Yearling females are separated from juvenile/yearling males or juvenile females by their 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 simple branching. Antler growth characteristics, together with the relatively small body size and new pelage, separate juvenile/yearlings from cows or bulls. (Initially, an attempt is made to separate juvenile and yearling males from juvenile and yearling females.) In late June and early July, antler growth

of some juvenile females vs. some juvenile (and possibly some yearling) males becomes more difficult to separate. It appears that the main diagnostic characters of juvenile females (and nonpregnant cows) with relatively large antlers are more of form and apparently of growth priorities than of size. The main beam of the juvenile female antler tends to be more upright in its earlier stages of growth than that of the juvenile or yearling male. The main beam of a female exhibits initial curvature in an anteriorad direction at a relatively early stage compared to at least juvenile and possibly yearling males. Also, relatively little growth appears to be devoted to the development of proximal (bez and trez) tines in females, with such growth of those tines on females usually being much less than 50% of the length of the main beams. Highly stained pelage in the area of the vulva appears to be essentially characteristic of females only. The occurrence of "scours" in some juvenile or yearling males could lead to possible confusion in a few cases in most years. Group association with "breeding cows" just prior to, during, or immediately after calving, seemingly, strongly favours classification of juvenile/yearling animals of otherwise undetermined sex as females (as does association of juvenile/yearling males with bulls, but apparently to a lesser extent for juvenile/yearling males than for juvenile/yearling females associated with "breeding cows"). Whether our ability to identify and separate juvenile/yearling females from some cows (especially nonbreeders) or possibly even from some juvenile/yearling males is reduced in late July through August of the year is unknown.

5.1.5. "Calves" (male or female, assumed newborn in June of the year) are obvious throughout summer by their relatively small size compared to other sex/age classes. No attempt is made to sex calves (cf. Bergerud 1961) during aerial composition counts.

5.2. Caribou social formations

A "caribou social group" is composed of two or more individual caribou that are 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 individual caribou are considered as one group even if they are more than 100 m apart but moved together when disturbed by the survey aircraft.

5.2.1. Mixed sex/age caribou group

A "mixed sex/age caribou group" may be mixed by sex or age or both and could contain any possible combination of bulls, cows, juveniles, yearlings, or calves (when bulls cannot be recognized, the presence of both sexes might not be determined with complete confidence).

Mixed sex/age groups can occur as any of 22 possible combinations of designated sex/age classes: (1) cow-only; (2) cow/calf; (3) cow/juvenile; (4) cow/yearling; (5) cow/calf/juvenile; (6) cow/calf/ yearling; (7) cow/juvenile/yearling (8) cow/calf/juvenile/yearling; (9) bull/cow; (10) bull/cow/calf; (11) bull/cow/juvenile; (12) bull/cow/ yearling; (13) bull/cow/calf/juvenile; (14) bull/cow/calf/yearling; (15) bull/cow/ juvenile/yearling; (16) bull/cow/calf/juvenile/yearling; (17) juvenile/ yearling; (18) juvenile-only; (19) yearling-only; (20) bull/juvenile; (21) bull/yearling; and (22) bull/juvenile/yearling.

The presence of a calf in a mixed sex/age group without a cow being present would be considered an unstable anomalous social grouping (a temporary gathering) and thus would not be considered as a valid mixed sex/age group. The presence of a calf (female or male) in a male-only group would also be considered an anomaly and would not be considered as a valid male-only group. Such anomalous groupings would be recorded but they would not be used in the calculation of any statistics for either mixed sex/age or male-only groups.

A juvenile or yearling caribou can be either female or male in a mixed sex/age group if at least one cow is present, but can only be female if no cow is present. Two or more juveniles or yearlings in a mixed sex/age group can be either sex or of mixed sex if at least one cow is present, and can be either all females or mixed by sex if no cows are present.

5.2.2. Male-only caribou group

A "male-only caribou group" can be composed of mature males only (assumed 4+ yr-old bulls with relatively large antler size) or juvenile males or yearling males or any combination of bulls, juvenile males, and/or yearling males. In June-July of the year both bulls and immature males (at least 2- and 3-yr olds and possibly 1-yr olds) are

readily recognizable by their relatively advanced antler development from other sex/age classes of Peary caribou.

Male-only groups can occur as any of seven possible combinations of designated male age classes: (1) bull-only (2) bull/ juvenile male (3) bull/yearling male; (4) bull/juvenile male/yearling male; (5) juvenile males; (6) yearling males; and (7) juvenile male/yearling male.

6. Calf Production And Early Survival Of Calves

Initial calf production (calving success) was measured by the maximum percentage of calves among all individual caribou seen and the maximum ratios of newborn calves per 100 breeding cows, per 100 2+ yr-old females, and per 100 1+ yr-old females in grouped samples of different individuals obtained by aerial searches in June and July 1995 (only). Early survival of newborn calves was determined by examination of percentages of calves among all individual caribou seen and the ratios of calves per 100 breeding cows, per 100 2+ yr-old females, and per 100 1+ yr-old females in grouped samples of different individuals obtained by aerial searches in June and July 1995 (only). Out of necessity, the small sex/age composition samples obtained in association with VHF radio telemetry tracking flights were used to evaluate calving and early survival of calves in June and July 1994.

RESULTS AND DISCUSSION

Project field activities were carried out during four temporal periods in 1994 (6-16 Apr, 4-11 May, 1-12 Jun, and 13 Jul-10 Aug). The first three field periods (Apr, May, and Jun) were devoted solely to VHF radio telemetry tracking flights. The main objective for the fourth field period (Jul-Aug) was the capture of caribou by aerial net-gunning to place seven new PTT-collars into service. Relocations of neck-collared caribou by VHF radio telemetry was also carried out during the fourth field period.

The 6-week field period, 10 June to 22 July 1995, was shorter in duration than in all other years of this Project (l989-94) and we were operational with helicopter support for less than 4 weeks. We had helicopter support only from 17 June to 12 July and again on 15 July 1995. We carried out two sets of low-level (l00 m agl or less) nonsystematic aerial searches to obtain sex/age composition counts

(which also could be used as "minimal population counts"): 17-24 June and 7-11 July. We also searched for caribou carcasses, and muskox carcasses (App. 3) during the above two periods. In addition, we expended an additional 20 hours searching for carcasses, primarily in habitats or sections of Bathurst Island preferred by muskoxen (App. 3). The remainder of the airborne time was devoted to high-level (900-1800 m above sea level) VHF radio telemetry tracking flights.

1. VHF Radio Tracking

High-level flights were carried out under favourable weather conditions (bright or partial sunshine and clear or scattered cloud cover) in April and May 1994. High-level tracking flights during June 1994 were often hindered or prevented by extensive and persistent low cloud cover or fog. Weather conditions in late July and early August 1994 were highly variable and high-level flights were made where and when possible during relatively brief periods of favourable conditions. High-level flights essentially were not possible in the helicopter during June 1995. Continual low overcast and frequent fog prevented any aerial searches from 25 June until 2 July 1995. Sunny periods prevailed throughout the day on only 6 days from 17 June to 12 July 1995.

1.1. April 1994

We flew VHF radio telemetry tracking flights in a Bell 206L turbo-helicopter within the Bathurst Island complex between 9 and 11 April 1994 (25.8 hours). All 17 VHF signals were detected and 15 (14 cows and 1 bull) of the 17 collared caribou were successfully visually located by the low-level airborne observers (Table 1). The 14 cows each still had a calf in their company, indicating an exceptionally high rate of calf survival for those 14 cows from June 1993 to April 1994. Caribou in social groups with the 14 cows totalled 60, ranged from two to eight animals per group, and averaged 4.2 ± 0.50 (SE) per group (Tables 2,3). No bulls were present in any of the female groups (Table 2), and none was seen near any of the female groups. One collared bull was found in the company of one other bull and a juvenile male. Both bulls had only "buttons" of new antler growth, while the juvenile male retained his last year's hard antlers (these two bulls were the only bulls seen in Apr 1994).

All of the animals appeared healthy and active. Essentially the entire range was snow-covered but the snow cover appeared shallow

over large areas, with the dark substrate showing through. Loss of snow cover due to sublimation appeared to be negligible as of 11 April 1994. Snow depths in feeding craters ranged from 3 to 10 cm in thickness at six sites that were examined during mid-April 1994. Although the surface and upper portion of the snow cover were hard-packed by wind action, the bottom of the snowpack was granular and crumbly. Thus, the caribou had relatively easy access to forage by chipping off chunks of hard snow (mostly, *ca.* 15 x 20 cm by 3 to 10 cm thick at the above 6 sites) with their front hooves and pushing the snow blocks out of the feeding crater with their front feet. The caribou then simply pushed the granular bottom snow off the vegetation with their noses or sometimes they also used their front hooves to free and reach the forage for ingestion.

The collar of the 15th cow (93-15) was found on a coastal site on northeastern Bathurst Island (Table 1) along with a few long bone fragments. The collar was left in place so that we could return to the site, when it was snow-free, to try to determine if the cow died of predation or some other cause. It appeared likely, however, that too little of the carcass remained to discern the cause of death with certainty. The collar was bitten by either a wolf (*Canis lupus*) or a polar bear (*Ursus maritimus*). The signal from the collar of the second bull (93-12) was tracked to a south-central site on the south coast of Cameron Island (Table 1) but the bull or the collar could not be visually located. It appeared that the collar was under a snowbank in a gully. Therefore, we ended the search until a later date in 1994, when the snow would be melted off that site.

There were 63 caribou in the 15 groups in which collared caribou were seen (Tables 2, 3). Cows and calves represented 76% of the 63 caribou segregated in those groups; juvenile females represented 19%; bulls, 3%; and the one juvenile male, *ca.* 2% (Table 3). We saw an additional 73 caribou in 18 different groups (mean = 4.1 ± 0.39 SE; range, 2-8). Thus, we saw in total 136 caribou in 33 groups that averaged 4.1 ± 0.31 SE and ranged from two to eight animals per group. Although we did not fully segregate all individuals in the 18 groups with no collared caribou present, we did determine that there were no bulls present in any of those 18 groups.

1.2. May 1994

Emphasis was placed on the relocation of the 15 telemetry neck-collared caribou that were still alive in April 1994. We also collected urine samples and fecal pellet samples from snow cover around feeding craters; partially repaired one of two remote automatic monitoring weather station kits on northeastern Bathurst Island; and carried out a further search for the telemetry neck-collar from the bull caribou assumed to be dead or to have lost his collar on south-central Cameron Island.

We flew VHF radio telemetry tracking flights in a Bell 206L turbo-helicopter within the Bathurst Island complex on 5 and 6 May 1994 (16.6 hours). All 17 VHF signals were detected and the 15 (14 cows and 1 bull) collared caribou found alive in April were again successfully visually confirmed by the low-level airborne observers (Table 4). The 14 cows each still had their 1993 calf at heel, which indicated a continuation of the exceptionally high rate of calf survival for those 14 cows from June 1993 to May 1994. Caribou in social groups with the 14 cows totalled 113, ranged from two to 18 animals per group, and averaged 8.1 ± 1.12 SE per group (Tables 5, 6). Only one bull was present in any of the female groups (Table 5), and no other bulls were seen near any of the female groups. One collared bull was found in the company of two other bulls and a juvenile male. All three bulls had considerable new antler growth, while the juvenile male had only several centimetres of new antler growth present (seemingly, suggesting that it was the same juvenile male seen with the PTT-collared bull in Apr, who then still had hard antlers present).

All of the animals appeared healthy and active. Essentially the entire range was snow-covered. Although some fresh snow had fallen between searches, the snow cover still appeared shallow over large areas, with the dark substrate showing through. Loss of snow cover due to sublimation appeared to be only slightly advanced from 11 April 1994 and still restricted to the more exposed sites. Snow depths in feeding craters still ranged from 3 to 10 cm in early May as in mid-April 1994. The surface and upper portion of the snow cover were hard-packed by wind action, and the bottom of the snowpack was still in a sugary state. Thus, the caribou continued to have relatively easy access to forage.

The collar of the 15th cow was relocated on the coastal site on northeastern Bathurst Island (Table 4). The site was still mostly snow-covered, so the collar was left in place to allow us to return to the site, when it was snow-free, to try to determine if the cow died of predation or some other cause. A cursory search suggested, however, that it was likely that too little of the carcass remained to discern the cause of death with certainty. We again radio-tracked on the south-central site on the south coast of Cameron Island (Table 4) but the bull's Caracas or his VHF-collar could not be found. It still appeared that the collar was in a deep snow-filled gully. Therefore, we decided not to search for the collar until the snow melted later in 1994.

There were 117 caribou in the 15 groups in which collared caribou were seen (Tables 5, 6). Cows and calves represented 79% of the 117 caribou segregated in those groups; juvenile females represented 17%; bulls, 3%; and the one juvenile male, *ca.* 1% (Table 6). We saw an additional 83 caribou in 19 different groups (mean = 4.4 ± 0.47 SE; range, 2-8). Thus, we saw in total 200 caribou in 34 groups that averaged 5.9 ± 0.61 SE and ranged from two to 18 animals per group. Although we did not fully segregate all individuals in the 19 groups with no collared caribou present, we did determine that there were no bulls present in any of those 19 groups.

1.3. June 1994

We flew VHF radio telemetry tracking flights in a Bell 206L turbo-helicopter within the Bathurst Island complex on 4 and 6 June 1994 (14.6 hours). All 15 (14 cows and 1 bull) of the collared caribou still alive in May 1994 were detected by VHF radio telemetry and were successfully visually located by the low-level airborne observers in June (Table 7). Only three of the 14 cows still had 1993 calves (yearlings in Jun 1994) in their company. One of those three cows already had produced her 1994 calf, the other two cows had not (but both subsequently calved later in 1994). Ten of the 11 remaining collared cows each had a newborn 1994 calf at heel. The one remaining collared cow had neither her yearling (1993 calf) nor any newborn 1994 calf in her company, when seen on 4 June. Her solitary nature and her behavioural response to us suggested that she was close to giving birth (when next seen in Jul, she had her 1994 calf at heel). Caribou in social groups with the 14 cows totalled 63, ranged from two to 12 animals per group, and averaged 4.5 ± 0.85 SE per

group (Tables 8,9). No bulls were present in any of the female groups (Table 8), and none was seen near any of the female groups. One collared bull was found in the company of two other bulls and a juvenile male. All three bulls exhibited considerable new antler growth, while the antler growth of the juvenile male had been relatively slow to that date (seemingly, suggesting that the juvenile was the same one that was with the PTT-collared bull in May and Apr 1994).

Snowmelt in the region came exceptionally early in 1994, with positive temperatures associated with moderate to heavy rainfalls on several days at the end of May (Resolute AES, weather records). By 4 June, most of the lower elevation range on Bathurst Island was snow-free. Even the higher elevations were patchy, often with large tracks of land exhibiting as much or more snow-free ground as snow-covered areas. It appeared that the season was about 3 weeks in advance of most years.

On 6 June, we returned to the site of the dead cow on northeastern Bathurst Island and retrieved the VHF-collar. The immediate site where the collar laid was snow-free although there were still snow patches and about 50% of the area was still snow-covered. We searched the area on-foot but no additional parts of the carcass were found, except for a few more leg-bone fragments adjacent to the collar and a large cluster of old winter hair about 10 m from the collar. There were no strips of skin found in association with the hair or elsewhere in the area. The total absence of any skeletal or other body parts, other than a few small leg-bone fragments, is quite puzzling (we returned to the area on two later occasions in Jul, when the area was totally snow-free, but no new evidence could be found). It is difficult to assume that wolves, even in association with scavenging arctic foxes (Alopex lagopus), could have so completely cleaned up the carcass (especially in the absence of any substantial sign of predators or scavengers having been around the death site). It seems more likely that a hungry polar bear could have completely scavenged the carcass, as the caribou died less than 20 m from the shore. Therefore, the cause of death as well as what animals subsequently utilized the carcass are unknowns.

No attempt was made in early June to search out the missing bull on Cameron Island. We judged that the snow-clad drainage

where the bull's VHF radio signal emanated from in April and May 1994 would still be at least partially clogged with snow and likely would remain so until July. Therefore, we decided to wait until late July before resuming that effort.

There were 65 caribou in the 15 observations in which collared caribou were seen (Tables 8, 9). Cows and calves represented 83% of the 65 caribou segregated in those 15 observations, yearling females represented 9%; juvenile females, 5%; and bulls, 3% (Table 9). We saw an additional 100 caribou in 22 different observations (mean = 4.5 ± 0.64 SE; range, 1-14). Thus, we saw in total 165 caribou in 37 observations that averaged 4.5 ± 0.50 SE and ranged from one to 14 animals per observation. There were no bulls present in any of the additional 22 observations. Cows and newborn calves represented 81% of the 165 caribou segregated by us in June 1994.

1.4. July-August 1994

Collared caribou were radio-tracked and visually located on 8 days (during 30 h of flying in a Bell 206L turbo-helicopter for aerial net-gunning operations) between 21 and 31 July and 4 days (18.1 h devoted solely to radio-tracking) between 2 and 6 August 1994 (Tables 10, 11, 12). Ten of the collared caribou were relocated by radio telemetry and seen one to four times each during July 1994 (Tables 10, 11). Subsequently, all 16 of the collared caribou (includes 1994 and 1993 collared animals) were relocated by radio telemetry and 15 of them were each seen once in early August 1994 (Table 12). As of 6 August, nine of those 16 caribou were on Bathurst Island, seven in the northeast, one in the southwest, and one in the southeast; three were on Alexander Island; two, on Ile Marc; one, on Massey; and one, on "Bull Island".

The 12 cows seen in early August 1994 each still had a calf in their company (the 13th cow still had her calf with her when last seen on 24 Jul 1994). Caribou in social groups with the 12 collared cows totalled 81, ranged from three to 10 animals per group, and averaged 6.8 ± 0.62 SE per group. No bulls were present in any of the female groups (Table 13), although one yearling male was seen in one female group. Three male-only groups were seen (Table 13), none of them was closely associated with any of the female groups.

There were 97 caribou in the 15 groups in which collared caribou were seen in early August 1994 (Tables 13, 14). Cows and calves represented 47% of the 97 caribou segregated in those groups; juvenile females, 23%; bulls, 13%; yearling females, 13%; juvenile males, 3%; and a yearling male, 1%.

On 31 July 1994, we returned to the approximate site-location of the April and May origins of the signal from the VHF-collared bull on south-central Cameron Island. The bull's collar was found close by at 76.409° N, 103.654° W after an intensive low-level (5-20 m) helicopter search of the area. Further aerial searching of the entire drainage system and on-foot searches in the vicinity of where the VHF-collar was found revealed no evidence whatsoever of any carcass remains that could be linked to the VHF-collared bull. Judging from the lay of the land and the location of the bull's collar at about mid-slope on the south-facing bank of a deep (*ca.* 10 m) section of gully in a major drainage, the collar likely had been under 3-5 m of snow cover for most of the winter to some time in late June or early July 1994. The bull could still be alive, having simply slipped his collar after casting his antlers in early winter. I believe, however, that the nature of the ripped collar favours the supposition that the bull died in early winter 1993/94. The collar had canine-tooth punctures in it from a wolf or wolves. More important, wolves had bitten and torn the collar completely through as though to remove it from around the neck of the bull. Although there were no blood stains on the collar, the rip (with small bits of collar material missing from along the margins of the tear) associated with the severing of the collar was more consistent with an act of forced removal of the collar while held in place around the animal's neck rather than the results of some investigatory wolf or wolves engaged in "play fighting" or serious fighting over possession of the collar. The absence of any blood stains on the collar could be explained by its early removal from the carcass before the neck became bloody or by the collar being exposed to cold meltwater over a prolonged period while the snow cover melted away from around it. Whether the bull died of predation or some other cause and merely was fed on by scavenging wolves remains unknown.

1.5. July 1995

The VHF radio tracking effort in July 1995 was restrictive in time and space, with only *ca.* 15 hours of high-level searches carried out

(Tables 15, 16, 17). The then prevailing low cloud cover continually hindered high-level flying in the helicopter and caused us to either abandon searches or reduce coverage over major areas of Bathurst Island and the satellite islands.

All seven of the PTT-collared caribou (4 cows and 3 bulls) were relocated by VHF radio telemetry and visually accounted for by us between 4 and 15 July 1995 (Tables 15, 16). One cow (94-03) and one bull (94-05) had died during winter 1994/95: the cow on south-central coastal Bathurst Island and the bull on interior northeast Cameron Island. Only one of the three PTT-collared cows alive in July 1995 had a calf at heel (94-06). Neither of the other two cows had a 1995 calf in her company when seen in July 1995 but both appeared to have a yearling animal at heel during flight, suggesting that in each case it probably was their respective 1994 calf. The one satellite PTT-collared cow that had a young calf at heel in July 1995 appeared to still have her 1994 calf also in her company. All four of the PTT-collared females had each produced an apparently viable calf in June 1993 and June 1994, and all of those calves were still each with their mother when the cows were last seen during both the 1993 (Miller 1995) and the 1994 field seasons.

At least one (94-07) of the other two PTT-collared bulls was definitely still alive in July 1995, and was mobile and appeared healthy during our cursory visual observation of him. A state of confusion exists, as to whether we actually saw two different PTT-collared bulls as we think we did. Subsequently, after returning from the field, I have found out that the ARGOS location-data for bull (94-01) indicated that he has been at one location since before June 1995. It is my belief, however, that we located this bull (94-01), after flying to its approximate ARGOS satellite location, by VHF radio signal and visually identified him on northeast Bathurst Island on 4 July 1995 (Table 15). We saw a large antlered bull with a bright yellow neck-collar that was mobile and appeared healthy in a group of 10 caribou (Table 16). We overflew the collared bull at less than 30 m above him and got the usual "off-scale" sound from our VHF transmitter, verifying that we had the right animal for that particular frequency. The animal was definitely a large bull with a bright yellow neck-collar and, I believe, he was on the correct VHF radio frequency (also, 94-01 was on VHF 164.430 MHz and 94-07 was on 164.810 MHz, so there was no chance of overlap between those two frequencies).

The only other collared bull (94-07) left in the system (still equipped with an active PTT and VHF telemetry package) was placed some 40 km north-northwest on the NCE of Bathurst Island on that date by ARGOS satellite location-data. We also picked up that bull's signal with our VHF radio transmitter, when we flew past its location (based on ARGOS satellite location-data). Unfortunately, however, we were en route for Cameron Island and did not know that there was any special need for expending the extra time searching him out on that date. On 11 July 1995 we located this bull (94-07) by VHF radio signal (after flying to the approximate location indicated by the ARGOS satellite location-data) and visually identified him (Table 15). The bull (94-07) was in the same immediate area that he was placed in by both PTT satellite location-data and the VHF radio telemetry signal on 4 July 1995. His companion group was only half the size and of different sex/age composition than the group that 94-01 was in on 4 July 1995. This bull's antlers were much larger in appearance than those carried by the bull that we believe was 94-01 that we saw on 4 July 1995. I cannot believe that the bull that we saw on 4 July was the same bull that we saw on 11 July, as the bull seen on 11 July had much larger antlers, and I cannot imagine that the first bull could have made that much additional growth in just one week, 4-11 July 1995. This matter possibly can be rectified in July 1996, if I have the opportunity to search the area identified by ARGOS satellite location-data as the persistent long-term location for bull 94-01.

On 15 July 1995, we obtained the use for that day only of a Bell 206L helicopter on floats to search for the one remaining satellite PTT-collared caribou (cow, 94-04) that had not yet been relocated by VHF radio telemetry flights and visually identified by us during June or July 1995. ARGOS satellite location-data indicated that the animal was probably on the north end of Baring Island, a small island lying *ca.* 50 km essentially due east of the CWS "Walker River" camp (Fig. 2), and across several considerable stretches of open water (polynyas). The animal was successfully located and identified by us on 15 July; and, thus, completed our 1995 check of the seven satellite PTT-collared caribou.

The skeleton of a VHF-collared cow (93-14) was found on northeastern Bathurst Island on 4 July 1995 (93-14 had been captured on northeastern Bathurst Island on 1 Aug 1993; subsequently, she was relocated 10 times by VHF radio telemetry on northeastern Bathurst

Island between 5 Aug 1993 and 2 Aug 1994). The carcass was "Completely Utilized," only the bones of the two hind legs, the vertebral column, and the severed skull remained. The collar was lying on the ground next to the backbone. Although there were bunches of hair scattered about, no portion of the skin could be found. The skull might have been crushed, as the right temporal and frontal areas were missing. Apparently, having been forcibly broken away, leaving an irregular separation line. The skull could have been damaged during predation by a wolf or simply from a scavenging wolf. Marrow from a femur was, however, firm and waxy to the touch and skin-coloured in appearance.

A live VHF-collared cow (93-10) was relocated on Alexander Island and visually identified by us on 4 July 1995. She was in a social grouping of six animals (3 cows, 2 (1995) calves, and 1 yearling female). Each of the calves followed a cow without a telemetry neck-collar during their flight responses and the female yearling followed the VHF-collared cow. Therefore, I assume the VHF-collared cow either did not give birth in 1995 or she had lost her calf before 4 July. It is most likely that the female yearling was the VHF-collared cow's 1994 calf. This VHF-collared cow (93-10) was captured on Alexander Island on 30 July 1993 and subsequently detected by radio telemetry and seen six times between 16 August 1993 and 8 August 1994 (5 times on Alexander Island and once, 10 Apr 1994, on Ile Vanier).

A second live VHF-collared cow (93-17) was relocated and visually identified on the NCE of Bathurst Island on 6 July 1995. She was in a social grouping of 15 animals (6 cows, 2 (1995) calves, 4 juvenile females, and 3 yearling females). Neither calf appeared to belong to 93-17 but one of the yearling females followed closely at the side of the VHF-collared cow during the flight responses. Therefore, I assume that the VHF-collared cow either did not give birth in 1995 or she had already lost her calf by 6 July. Also, it is likely that one of the yearling females was the VHF-collared cow's 1994 calf.

VHF radio signals from two additional cows (93-09 and 93-11) were briefly detected while we were overhead Alexander Island on 4 July 1995. We could not relocate and visually identify them, however, as we were "deadheading" for a fuel cache under deteriorating weather conditions. We were then forced by poor weather to give up our search

effort on the satellite islands and return to camp. The opportunity to resume the search on the satellite islands never presented itself again during the remainder of the 1995 field season. Thus, there were 40 caribou in the seven groups in which collared caribou were seen in early July 1995 (Tables 15, 16, 17). Cows and calves represented about 38% of the 40 caribou segregated in those groups; yearling males, 20%; yearling females, 18%; juvenile females, 10% juvenile males, 7%; and bulls, 7%.

1.6. Survival and fecundity of collared caribou, 1993-95

The seven PTT-collared caribou (6 cows and 1 bull) equipped with PTT-collars in 1993 all survived from July-August 1993 to August 1994. Eight of the 10 VHF-collared caribou (all cows) also survived from July-August 1993 to August 1994 (one VHF-collared cow is known to be dead and one VHF-collared bull is assumed to be dead). The six PTT-collared cows and the eight VHF-collared cows each reared their calf from June 1993 to at least May 1994, yielding an exceptionally high rate of calf survivorship ("yearling recruitment"). Also, all six PTT-collared cows and the eight VHF-collared cows subsequently each gave birth to a calf in June 1994, demonstrating a continued high level of fecundity.

Five of the seven PTT-collared Peary caribou first captured in 1993 were recaptured in July 1994 and equipped with new PTT-collars (93-01 = 94-03, 93-03 = 94-04, 93-04 = 94-02, 93-06 = 94-06, and 93-08 = 94-05). Subsequently, two of those five PTT-collared caribou died in winter 1994/95 (one cow 94-03; and one bull 94-05). Only one (94-06) of the four PTT-collared cows still alive in July 1995 had a newborn calf at heel. Although the other three cows (94-02, 94-03, and 94-04) all were without 1995 calves, each appeared to have a yearling in their company that most likely was their respective 1994 calf. Thus, one of the PTT-collared cows (94-06) calved in 3 years consecutively from 1993 to 1995 and the other three PTT-collared cows (94-02, 94-03, and 94-04) calved in just 2 (1993-94) out of those 3 years, with each producing no calf in 1995. The fate of one of the two new bulls first collared in July 1994 (94-01) currently remains a debatable issue (seemingly, either the animal has somehow lost its PTT package but retained its collar with the VHF package [an improbable occurrence] or we somehow misidentified

him on 4 Jul 1995 [at present, seemingly, also an improbable event]). The second bull (94-07) was indeed still alive in July 1995.

One more of the VHF-collared caribou is known to have died in winter 1994/95. Thus, as of July 1995, three of the 10 caribou captured in July-August 1993 and equipped with VHF-collars are known or assumed to be dead (2 cows, 93-15 in 1994, and 93-14 in 1995; and 1 bull, 93-12, assumed in 1994). Two of the remaining seven VHF-collared cows (93-10 and 93-17) were confirmed alive but without a newborn calf in July 1995. The fate of each of the other five VHF-collared cows remains unknown (after Aug 1994). All were last seen alive, each with a calf at heel, in August 1994: 93-07, Massey Island; 93-09, 93-11, Alexander Island; and 93-13, 93-16, Bathurst Island.

On the basis of VHF radio telemetry relocations, all 11 of the 18 different Peary caribou equipped with telemetry neck-collars in 1993 and 1994 and captured on Bathurst Island remained year-round on Bathurst Island from July 1993 to July 1995. ARGOS satellite location-data from the eight PTT-collared caribou among the 11 caribou that were captured on Bathurst Island indicate that the VHF information is sometimes incomplete and, thus, at least sometimes inadequate. We know from those eight PTT-collared caribou captured on Bathurst Island that some of them actually did leave Bathurst Island and subsequently return there between VHF radio telemetry detections during the 1993-95 time period. VHF radio telemetry relocations do demonstrate that those seven caribou captured on the western major satellite islands moved extensively among those five islands between July 1993 and July 1995 (Table 18). But again, ARGOS satellite location-data indicate that the travels of those seven caribou were much more varied and extensive than suggested by the VHF relocations alone. Therefore, a more complete evaluation of seasonal movements and annual migrations awaits the detailed analyses of the ARGOS satellite location-data obtained between August 1993 and potentially, at least, August 1996.

2. Capture, Handling, And Collaring Of Caribou, 1994

Nine caribou (6 maternal cows, each with a calf at heel; and 3 bulls) were captured by aerial net-gunning (cf. Barrett, *et al.* 1982). Seven of those caribou were fitted with new (1994 series) telemetry

neck-collars and released. Each collar housed both a satellite PTT package and a VHF radio telemetry package (Table 10).

The capture effort in 1994 required 24.5 hours of helicopter flying time. Searching for target animals throughout the BIC expended 83% (20.4 h) of the flying time devoted to the capture effort. We used 4.1 hours of the flying time to carry out the actual approach, chase, and pursuit phases associated with the capture of the nine caribou. That is, once the target animal was sighted, the helicopter was landed, one crew member and extra gear were off-loaded, the right rear door was removed, and the helicopter was again airborne with only two crew members and the pilot onboard to start the approach phase.

Four of the seven caribou equipped with PTT-collars were maternal cows (each with a calf at heel) and the other three were prime bulls. Three of the PTT-collared cows were captured on northeastern Bathurst Island and the fourth on Ile Marc (all 4 carried satellite PTT-collars in 1993/94). The bull that was captured on Ile Marc also carried a satellite PTT-collar in 1993/94. The other two bulls were not collared before 1994: one was captured on northeastern Bathurst Island; and the other on "Bull Island". The sample of satellite PTT-collared bulls was increased to evaluate the possibility of "subpopulations" or, at least, the presence of more than one discrete rutting area within the Bathurst Island complex during the autumn rutting period.

The other two caribou captured in July 1994 were recaptures: both were maternal cows and each had carried a PTT-collar in 1993/94. Neither received a new collar, as the sample of PTT-collared bulls was increased from one to three and there were only seven new (1994) PTT-collars in total.

One of these two cows was the second animal to be captured on the first day of the capture effort in 1994 (animal 93-02, 24 Jul 1994). Although the actual capture of the cow appeared favourable (i.e.,1-min final pursuit time; animal went down easy; there was little struggling in the net; and the capture site had a relatively smooth and soft surface, with few protruding rocks of any size). When the cow tried to rise to her feet, however, she fell back onto her left leg and broke her left carpel bone on a small, rounded rock (*ca.* 10 cm in diameter and only

6-8 cm above the surface of the ground). Her calf likely would have been satisfactorily "metabolically weaned" within 2 or 3 weeks of the event (cf. Lavigueur and Barrette 1992) and possibly could have survived thereafter on its own. Thus, I judged to let the cow go free and to monitor her from a distance with VHF radio telemetry to see if she remained active. Previous experience with and the knowledge of similar injuries to ungulates suggested that the cow likely could survive to wean her calf and possibly could survive indefinitely, if no wolves found her during recovery or subsequently targeted her preferentially because of the noticeably unusual gait that she would develop from the handicap. Therefore, the cow was released, with her 1993 PTT-collar in-place, to rejoin her calf for as long as possible. The idea was to recapture her again before the end of the 1994 field season, if it was deemed desirable to do so. Otherwise, the cow would be left to her fate, which we would document as best possible. The cow had remained in a small area before capture during, at least, June to July 1994. VHF radio signal detections on 27 July and 3 August 1994 indicated that the cow was active and still within her previous area of occupation. The weather deteriorated after 3 August and the helicopter had to be reassigned to another project on 7 August 1994. Therefore, the 1993 PTT-collared cow was left afield. ARGOS satellite location-data transmitted between August 1994 and July 1995 indicated that the cow never left the general area of capture, but possibly remained alive for some time after July 1995. The ARGOS satellite location-data from August 1994 until July 1995 will have to be analysed in greater detail to see if it can be determined when the cow actually died. The cause(s) of her death was not determined but it most likely occurred because she was predisposed to wolf predation by her human-induced injury associated with her capture. Her collar was recovered on 4 July 1995 at *ca.* 20 km east-southeast of where she had been captured on 24 July 1994.

The other of the two cows (animal 93-05) was recaptured on 31 July 1994. She received a deep puncture wound to the anterio-lateral surface of the gluteus medius on the right hindquarter: similar to a more posteriad wound received in the biceps femoris by a cow (93-09) during capture on 29 July 1993. That animal, 93-09, is known to have subsequently recovered from her injury and was last seen alive more than a year later on 6 August 1994, with a 1994 calf at heel.

"Approach time" to the target animal did not vary much for the nine caribou captured in July 1994 (range 2-5 min, mean = 3.3 min ± 1.22 SE), as it did for the 17 caribou captured in July-August 1993 (Miller 1995: range 2 to 23 min, mean 6.2 min ± 1.69 SE). The lack of much variation in 1994 most likely resulted because seven of the nine target animals were highly visible with bright yellow neck-collars Also, the two bulls that were not captured before were clearly visible because they had the largest antlers of any animal in each of their groups. Although the target group was lost from sight on four occasions, when the helicopter was landed, the groups all were quickly relocated once the helicopter was again in the air, mainly because of the brightly coloured neck-collars on the target animals. Also, in 1994, we did not have the option of switching to another target animal or target group on occasions when the original animal selected stayed on unsuitable terrain or was not responding in a manner that made the capture attempt feasible (e.g., running on a heavily rock strewn area, running downhill, running downwind during periods of strong winds, etc.). In 1993 we switched the target animal or even the target group on occasion, if deemed necessary, thus, prolonging the initial approach time (Miller 1995). Once the target animal was being chased following the initial approach, it was never chased for more than a 3-min duration in 1994.

The actual "pursuit time" during the final chase leading to the capture of the animal ranged from only 1 to 3 min (mean 1.9 min ± 0.24 SE). I had previously decided that actual pursuit time should not exceed a 3 min·event^{-1} and that it preferably be less (1.5 - 2.5 min) based on 1993 results (Miller 1995). When the same animal was pursued more than once each chase was restricted to a 2- to 3-min duration (n = 21, mean = 2.7 min ± 0.08 SE) with at least a 5-min-interval and as much as a 12-min-interval (mean = 6.4 min ± 0.41 SE) between each chase. I had judged that at least three of the 17 caribou captured in July-August 1993 were heavily stressed, three others were moderately stressed, three were moderately to lightly stressed, and eight were only mildly stressed during capture based on their rates and intensities of breathing and struggling during restraint (Miller 1995). Only the three caribou pursued for 4 min in 1993 exhibited continuous heavy, uncontrolled breathing essentially throughout their period of restraint, but the three had regained control over their breathing by the time they were released. All three of those caribou struggled frequently and often with strong bursts of leg

movements throughout all or most of the time that they were restrained. As a result of the shorter chase times and intervening rest periods between chases none of the nine caribou captured in July 1994 appeared to be heavily stressed. All nine of the caribou in July 1994 exhibited some initial short bouts of rapid breathing, switching quickly to regular controlled breathing during restraint. Their struggling varied from moderate to light brief bursts, especially during the initial period of restraint. Much of the restraint period for each animal was characterized by essentially no struggling or at most brief bouts of light jerky movements. Thus, it appears, based on rates of respiration that none of the nine caribou was heavily stressed in July 1994.

All six of the netted cows received some damage to their antlers, which were in the velvet stage, from the fall to the ground or while initially struggling in the net. The antler damage in 1994, when we used only the 3-barrel net-gun with a smaller lighter net, was not nearly as severe as that which occurred in 1993 (Miller 1995) with the 4-barrel net-gun and its larger heavier net. The three bulls in 1994 received no antler damage during capture other than some minor scraping and ripping of the antler velvet, as was the case for the two bulls in 1993 (Miller 1995).

All of the animals in July 1994 rose quickly to their feet, when freed from the net, and left the immediate area at a walk, trot, or a combination of those two gaits. None of the animals galloped away upon release. In 1993, I judged that evaluation of how an animal rose to its feet after its release, or why it did what it did, is confounded by several factors. The positions of the people (crew members and the pilot) around the animal; the presence of the helicopter, and especially, whether the animal focussed on the helicopter upon rising; any attempt by the crew to direct the animal towards its social group (and whether the social group was still in sight or not); bright sunlight causing temporary blindness or blurred vision, when the blindfold is first removed; and other conditions, all contribute to the type and speed of the animal's response upon release. Whether an animal walks, trots, or runs away (or uses some combination of those gaits) does not appear to be related to the total length of "chase time(s)," final "pursuit time," or "handling time" or the apparent degree of stress experienced by the animal while restrained and being handled. Even disorientation upon release is not necessarily truly indicative of the degree of stress caused by capture, restraint, and handling. Perhaps,

the best indication of a favourable event is when the animal quickly and easily rises to its feet and departs under a sure gait, regardless of whether it is a walk, trot, gallop or any combination thereof.

Location data subsequently have been retrieved from each of the seven PTT-collared caribou. Data obtained from ARGOS's monthly location-data computer diskettes have been consolidated in a master file. Accuracy determinations of ARGOS satellite location-data points are being made for each pair of latitude/longitude values from each pass received from August 1993 through March 1995. At present, we are still developing a program that will be satisfactory for analyses of the ARGOS satellite location-data files. Location-data maps will be produced for further evaluation of the ARGOS satellite location-data information. No caribou were captured for this project in 1995.

3. Nonsystematic Helicopter Searches

Persistent, widespread, unfavourable weather conditions prevented any continual low-level airborne work from being completed in late July and early August 1994. Therefore, the following deals only with nonsystematic, low-level aerial searches carried out in June and July 1995 to obtain relative numbers, sex/age compositions, and a measure of the relative severity of winter 1994/95 by carcass counts for both Peary caribou, and also for muskoxen but only in June 1995 (App. 3).

3.1. Numbers, distribution, and carcasses, 1995

In general, weather and background conditions were not conducive to aerial searches during June 1995, and high-level flights essentially were not possible in the helicopter during that time period. The mottled background (snow-covered vs. snow-free patches) in the last half of June 1995 hindered the detection of carcasses, particularly caribou carcasses. Low overcast and frequent fog cover hindered or even prevented low-level aerial searches in early July 1995.

3.1.1. June 1995

We counted 826 caribou on 6 of the 8 days between 17 and 24 June 1995 (Tables 19-23; App 4, 5). Only 68% (559) of those caribou were on Bathurst Island proper (Tables 20-23; App. 5). The remaining 32% (267) caribou were seen collectively on six major satellite islands to the west (Alexander, 31.5%; Massey, 18.4%; Vanier, 12.7%; & Marc,

2.6%) and to the north (Helena, 18.4%; & Sherard Osborn, 4.5%) and on two secondary satellite islands in Graham Moore Bay ("Bull", 8.2%; and "Muskox," 3.7%). No live caribou were seen on the western major satellite island of Cameron. Also, none was seen on the secondary satellite islands of Baker and Moore in Intrepid Passage or on Bradford Island in Graham Moore Bay. On average, about 51 caribou were seen per 100 min of aerial search effort. In June 1995, caribou on Bathurst island were overrepresented at rates greater than expected by chance alone ($P < 0.005$) on coastal sites, when compared to interior sites; on the north of the island, when compared to the south of the island; and on the east of the island, when compared to the west of the island (Tables 22, 23). Nearly 80% (446) of the 559 caribou seen on Bathurst Island were on the northern portion of the island (north of PBP); followed by 12% (70) in the PBP area; and only 8% (43) on southern Bathurst (south of PBP). Eighty-two percent (366) of the 446 caribou seen on northern Bathurst were on northeastern sites. The distribution observed in late June 1995 is highly comparable to previous observations made within the Bathurst Island complex (1989-93: Miller 1991, 1992, 1993, 1994, 1995).

3.1.2. July 1995

We counted 1084 caribou on all 5 days between 7 and 11 July 1995 (Table 19, 24-27; App. 6, 7). On average, about 98 caribou were seen per 100 min of aerial search effort. The count was restricted to Bathurst Island because the helicopter was on skid gear and there were extensive areas of open water interjacent to the satellite islands and Bathurst Island. In July 1995, as in June 1995, caribou were overrepresented at rates greater than expected by chance alone ($P < 0.005$) on coastal sites, when compared to interior sites; on the north of Bathurst island, when compared to the south of the island; and on the east of Bathurst Island, when compared to the west of the island (Tables 26, 27). Over 91% (991) of the 1084 caribou were seen on northern Bathurst; followed by only 5% (51) on southern Bathurst; and only 4% (42) in the PBP area. On northern Bathurst, 76% (757) of the 991 caribou were on northeastern sites. Again, the observed pattern of distribution in July, like June, was highly comparable to previous observations made in July 1989-93 (Miller 1991, 1992, 1993, 1994, 1995).

3.2. Caribou carcasses, June-July 1995

We found 56 caribou carcasses between 17 June and 12 July 1995 (Tables 28, 29). The 56 caribou carcasses were classified as 17 cows, 15 bulls, 13 of unknown sex or age, and 11 juvenile/ yearlings. Utilization of the 56 carcasses by predators or scavengers was nearly complete in all cases: 53 were "Completely Utilized" and the remaining 3 were "Heavily Utilized." The sparseness of the remains made sex/age classification difficult, particularly for cows and juveniles, or essentially impossible when the skull and antlers were missing. Thus, the relatively large proportion of unknowns (23%) in the sample of 56 carcasses makes any assessment of carcass representation by sex/age classes in comparison to the sex/age structure of the June or the July 1995 live caribou count of limited value. On the other hand, however, even when we assume that all of the 13 unknowns were not bulls and we compare bulls to all other sex/age classes in the sample of 56 carcasses and the two counts of live caribou, bulls are overrepresented in the carcass sample. That is, carcasses of bull caribou occur in the sample at a rate greater than expected by chance alone, when compared to the representation of bulls in the June or the July count of live caribou ($P < 0.005$). The role that wolves played in the deaths of these 56 caribou cannot be discerned. There is no doubt, however, that everyone of the 56 carcasses had been fed on by a wolf or wolves (as well as by one or more scavengers in most or all cases). Therefore, it remains possible that wolves killed an unknown proportion of these caribou either before or after the caribou had become weakened by extreme prolonged undernutrition.

Caribou carcasses were found at rates greater than expected by chance alone on the SPBP, SWC, and NEC (Table 29). All caribou carcasses found in the SPBP were on the extreme southeastern coastal end of the pass, which is dominated by a large low-elevation plain that slopes gradually to the south. In reality, if it were not for the existing boundaries of the "Polar Bear Pass National Wildlife Area", this portion of the SPBP would be considered mainly as on the SEC rather than in the SPBP zone. When this adjustment is made, the relative number of carcasses in the SEC becomes highly significant in relation to the number of carcasses found elsewhere on Bathurst Island in June and July 1995. Also, although more caribou carcasses were found in the NEI than in any single one of the other 12 search zones on Bathurst Island, the relatively

large land area of the NEI reduces the observed contribution to a nonsignificant level (Tables 28, 29).

4. Sex/Age Composition And Social Groupings

Sex/age segregation of Peary caribou within the Bathurst Island complex was not completed in July-August 1994, as planned, because of the extremely unfavourable weather conditions that prevailed at that time. The weather was so poor that no attempt was made to even initiate sex/age composition counts during that period.

We carried out aerial sex/age counts of Peary caribou within the BIC between 17-24 June and 7-11 July 1995 (sex/age composition counts also were carried out for muskoxen between 17-24 Jun 1995: see App. 3). All of the caribou were classified by sex/age class: bulls, adult males 4+ yr old; juvenile males, 2-3 yr old; yearling males, 1-yr olds; breeding cows, mostly 3+ yr old (females that showed signs of having carried a fetus or produced a calf or actually had a calf at heel when seen in 1995 - maternal cows); juvenile females, 2-yr olds and possibly some 3-yr olds or a few older females that were not pregnant in 1994/95; and yearling females (1-yr olds).

4.1. June 1995

Sex/age composition of the 826 caribou was recorded as 14% bulls, 25% breeding cows, 9% newborn calves, 13% juvenile males, 11% juvenile females, 17% yearling males, and 11% yearling females (Table 19). The 9% value for newborn calves is low at only ±50% the expected rate for the last 2 weeks of June, based on rates of calves among all caribou counted in late June of previous years (Miller 1991, 1992, 1993, 1994, 1995). Females 1+ yr-old represented *ca.* 52% of the precalving caribou population. This late June estimate for the representation of 1+ year-old females in the precalving population of caribou within the Bathurst Island complex may be low, based on the resultant values obtained for females 1+ years old in the early July 1995 segregation count.

It appears, based on the June sample, that the precalving BIC population of caribou approximated 15% bulls, 28% breeding cows, 14% juvenile males, 12% juvenile females, 19% yearling males, and 12% yearling females. Yearling recruitment appears to be in error at an

exceptionally high, if not impossible, 31%, suggesting that all of the previous year's (1994) calves survived to their second summer of life (theoretical maximum rate of growth for the species is set at 0.3, Bergerud 1978, 1980).

The sex/age structure of the overall sample of 826 caribou is indicative of a healthy, but not necessarily a potentially fast-growing population, with about (1) 92 1+ yr-old males ◦ 100 1+ yr-old females^{-1}, (2) 73 2+ yr-old males ◦ 100 2+ yr-old females^{-1}, (3) 54 bulls ◦ 100 breeding cows^{-1}, (4) 57% of the animals in the juvenile and yearling classes, and (5) 52 1+ yr-old females ◦ 100 1+ yr-old caribou^{-1}. The sex/age ratios in this sample suggests that the caribou population within the BIC is shifting toward males and juvenile/yearling animals over females and adults. This condition could in the short-term reduce the potential for fast growth of the population. If, however, the female component of the juvenile/yearling segment of the population survives at high annual rates for the next several years, the population will once again have the potential for rapid growth (it is likely that for unknown reason(s) this sample is misleading, based on differences in the larger Jul 1995 sample).

Bathurst Island contributed only 68% of the 826 caribou to the overall sample in June 1995 (Table 19). Proportional collective representations for bulls, calves, juvenile males, and yearling males were nonsignificantly ($P > 0.1$) higher and for cows, juvenile females, and yearling females nonsignificantly lower on six major and two secondary satellite islands sampled in June 1995 than on Bathurst Island. The greatest discrepancy between the sex/age composition of caribou in the count from Bathurst Island vs. the count for the remainder of the BIC sampled in June 1995 appears to be for representation of newborn calves: Bathurst Island, 6.8% vs. 13.1% collectively for the eight satellite islands ($P > 0.1$). The exceptionally high and essentially equal values for yearling recruitment on Bathurst Island (27.9%) and on the eight satellite islands (27.7%) are contradictory and not readily explainable. Yearlings should have suffered proportionately high mortality in a harsh winter and the winter of 1994/95 apparently was one, based on the high carcass count and the poor 1995 calf crop and the early survival of those calves.

Caribou were nonrandomly distributed among the search zones on Bathurst Island and between Bathurst Island and eight satellite islands by sex/age class during late June 1995 (Tables 19, 20-23; App. 5). Proportionately more caribou were seen on the eight satellite islands than on Bathurst Island, when the collective landmass of the eight satellite islands is compared to the land area of Bathurst Island on a relative landmass basis ($P < 0.005$). Caribou on Bathurst Island, regardless of sex/age class, were relatively overrepresented in four search zones (Table 20, 21; App. 5: NEC, NPBP, NCE, and NEI; all search zones are given by their relative descending order of magnitude). Bulls exhibited the widest-ranging preferences among search zones, with significant overrepresentation in five zones (NPBP, NEC, NWC, SPBP, and SEC); followed by yearling males in four zones (NEC, NPBP, NCE, and SPBP); juvenile males in three zones (NPBP, NWC, and NEC); yearling females also in three zones (NPBP, NCW, and NCE) and juvenile females in only two zones (NCE and NCW). Cows were overrepresented in only two (NEI and NCE) of the 13 search zones and newborn calves in only one (NEI) of those two zones. Spatial separation between cows and bulls (or 1+ yr-old males in general) appeared evident on Bathurst Island in June 1995 (App. 5), only six bulls (*ca.* 8% of all bulls) were seen in just three of the 134 mixed sex/age groups, indicating that cows and bulls were maintaining spatial separation at that time of the year.

Distributions by sex/age class could not be discerned with confidence for the low-density samples of caribou on the six major satellite islands and the two secondary satellite islands where they were found in late June 1995. There appeared to be a general tendency for all sex/age classes of caribou seen on those islands in late June 1995 to favour coastal sites. In past years, early and mid summer distributions on, at least, the major satellite islands indicated a general shift from coastal to interior sites as summer progressed (Miller 1991, 1992, 1993, 1994, 1995). None of the secondary satellite islands is apparently large enough or has enough terrain relief from coastal to interior areas to cause the summertime shift in caribou distribution observed on larger islands in response to the phenology of forage plants.

The sex/age composition of the population of 1+ yr-old caribou within the BIC favoured juvenile and yearling animals (Table 19)

at 131 juvenile/yearlings:100 adults or 56.7% of all 1+ yr-old caribou were juvenile/yearlings. Most important, there were only 49.4 breeding cows:100 juvenile/yearlings and only 26.9 bulls:100 juvenile/yearlings. Males were somewhat (*ca.* 20%) overrepresented at 48% of the 1+ yr-old animals (54.5 bulls:100 breeding cows, 104.7 2+yr-old males:100 breeding cows, or 171.1 1+ yr-old males:100 breeding cows). The ratio of yearling males to yearling females, 155.6 yearling males:100 yearling females or 60.9% males among all yearlings is 10 to 20% high in terms of the established "secondary sex ratio" for the species of 51-55 males to 45-49 females at birth for the species (e.g., Kelsall 1968, Skoog 1968, Miller 1974, 1982, Bergerud 1978).

The apparent overrepresentation of yearlings cannot be explained with confidence. No plausible considerations comes readily to mind, except the possibility that for reason(s) unknown the yearling contribution to the sample is grossly overrepresented.

Caribou were seen on 255 sites within the BIC between 17 and 24 June 1995 (Table 30). Groups of two or more individuals contributed 85.9% of those observations. The remaining 14.1% of the observations were of solitary animals: 10 bulls; 10 cows; 6 juvenile males; 5 juvenile females; and 5 yearling males. All groups (n = 219) averaged 3.6 ± 2.01 SD and ranged from 2 to 14 members each: mixed sex/age groups (n = 134), mean 3.5 ± 2.14 SD, range 2-14; and male-only groups (n = 85), mean 3.8 ± 1.80 SD, range 2-12. Nearly 57% (n = 470) of all caribou seen were in mixed sex/age social groups; 38.7% (n = 320) were in male-only groups; and only 4.4% occurred as solitary animals. Five of the seven sex/age classes were represented by solitary individuals, only newborn calves and yearling females were not (which can be explained by their strong bonds with their maternal cows).

There was no significant difference between mixed sex/age groups and male-only groups (Table 30: t-test; $P > 0.05$). Also, the overall mean group size for mixed sex/age groups with calves present did not average significantly greater than the mean for mixed sex/age groups without calves present (Table 30: t-test; $P > 0.05$). The presence of newborn calves in those groups did, however, create a significant difference, when calves were excluded vs. those that had no calves (Table 30: t-test; $P < 0.05$). Mixed sex/age groups with no calves present

when seen averaged significantly larger than the mean number of 1+ yr-old individuals in mixed sex/age groups with calves (Table 30: t-test; $P < 0.05$). The largest male-only group seen was 86% as large as the largest mixed sex/age group with calves present (12 vs. 14, respectively). The sample for social formations on Bathurst Island in June 1995 seems large enough to be meaningful, but does not closely follow the same general patterns exhibited in 1993 (Miller 1995).

Calves were present in only 38.0% (n = 51) of all mixed sex/age groups seen or only 23.3% of all social groupings of two or more individuals. Only 39.3% (n = 83) of the breeding cows (n = 211) were in groups with calves present, and only 9.4% (n = 17) of all juvenile/yearling females (n = 181) were in those groups. Males were noticeably absent from mixed sex/age groups in late June 1995, only 5.5% of all 1+ yr-old males seen were in mixed sex/age groups and none of those was in mixed sex/age groups with calves present. The possibility of seeing a caribou group with no females was 1 in 2.4 on average.

4.2. July 1995

The sex/age composition of the 1084 caribou was recorded as 12% bulls, 25% breeding cows, 11% calves, 11% juvenile males, 21% juvenile females, 8% yearling males, and 12% yearling females. The 11% rate for newborn calves is only half or less as great as expected in early July, based on rates of calves among all caribou counted in early July of previous years (Miller 1991, 1992, 1993, 1994, 1995). It is most likely that the relatively high rate of juvenile females results from the classification of some mature cows that lost their fetuses early or were not pregnant in winter l994/95 exhibiting advance pelage chance and antler growth because of their relatively good nutritional status. It appears, based only on the Bathurst Island count in July 1995, that about 64% of the precalving population were females 1+ years old, which is 23% higher than the 52% rate estimated in June 1995 for a major portion of the entire Bathurst Island complex (see Section 4.1.) and 16% higher than the 55% rate for Bathurst Island only in June 1995.

We segregated 1084 caribou by 7 sex/age classes during our nonsystematic aerial searches of only Bathurst Island between 7 and 11 July 1995 (Table 19). It appears, based on that sample, that the precalving Bathurst Island segment of the BIC population of caribou

approximated 14% bulls, 27% breeding cows, 13% juvenile males, 23% juvenile females, 9% yearling males, and 14% yearling females. Yearling recruitment was high at 20.5%, suggesting that at least 68% of the previous year's (1994) calves survived to their second summer of life. The late summer sex/age composition of the postcalving population was 13% bulls, 24% breeding cows, 11% calves, 11% juvenile males, 21% juvenile females, 8% yearling males, and 12% yearling females.

The sex/age structure of the overall sample of 1084 caribou is indicative of a healthy and potentially fast-growing population, with about (1) 55 1+ yr-old males • 100 1+ yr-old females^{-1}, (2) 52 2+ yr-old males • 100 2+ yr-old females^{-1}, (3) 51 bulls • 100 breeding cows^{-1}, (4) 59% of the animals in the juvenile and yearling classes, and (5) 64 1+ yr-old females • 100 1+ yr-old caribou^{-1}. It continues to appear evident that the BIC population of Peary caribou has been in a overall positive state of growth from at least the mid 1980s and possibly from the early 1980s (although severe losses have occurred between 1993 and 1995, based on the findings herein).

Caribou were nonrandomly distributed among the search zones on Bathurst Island by sex/age class during early July 1995 (Tables 19, 24-27, App. 7). Caribou on Bathurst Island, regardless of sex/age class, were relatively overrepresented in only three of the 13 search zones (Table 24, 25; App. 7: NCE, NEC, and NCW, in descending order). Bulls exhibited the widest-ranging preferences among search zones, with overrepresentation in five zones (NCW, NEC, NPBP, SPBP, and NCE), followed by juvenile males in four zones (NEC, NCE, SEC, and NCW) and yearling males also in the same four zones (NEC, NCW, SEC, and NCE); and juvenile females and yearling females in three common zones (NCE, NEC, and NCW). Cows and newborn calves were overrepresented in only two zones (NEC and NCE). The usual June-July spatial separation by search zone between bulls (and usually juvenile males, if not also yearling males) and cows was not as readily evident on a search zone basis in 1995 as in earlier years of the study (1989-94). Cows were overrepresented in common with bulls, juvenile males, and yearling males in two zones (App. 5: NCE and NEC). The number of bulls or even all 1+ yr-old males present in mixed sex/age groups was, however, insignificant (12 bulls or 31 1+ yr-old males, 9% each). Thus, spatial separation between cows and bulls or females and males in

general was maintained during June and July 1995 (although that separation between cows and bulls was masked by their common strong occurrence in the same three search zones).

The sex/age composition of the population of 1+ yr-old caribou on Bathurst Island in early July 1995 favoured juvenile/yearling animals (Table 19) at about 143 juvenile/yearlings:100 adults or 59% of all 1+ yr-old caribou were juvenile/yearling animals. There were 216 juvenile/yearlings:100 breeding cows and 426 juvenile/yearlings: 100 bulls. Males were well represented at 51 bulls:100 breeding cows, 52 2+yr-old males:100 breeding cows, or 55 1+ yr-old males:100 breeding cows (essentially equal to the 40 males:60 females 1+ yr-olds used as the "yardstick" standard for the average theoretical caribou population). The ratio of yearling males to yearling females, *ca.* 67 yearling males:100 yearling females or *ca.* 40% males among all yearlings does not agree favourably with the established "secondary sex ratio" for the species of 51-55 males to 45-49 females at birth for the species (e.g., Kelsall 1968, Skoog 1968, Miller 1974, 1982, Bergerud 1978).

The apparent overrepresentation of juveniles compared to yearlings (35.8% vs. 23.0%) cannot be fully explained with complete confidence but there are plausible considerations. Much of the apparent inflation in the number of juvenile males most likely results from the sex/age class being contributed to by, at least, 2 age classes (2-yr-old and 3-yr-old males) and possible also from a 3rd age class by some 4-yr-old bulls with relatively poor antler development. The apparent inflation in the juvenile female sex/age class could come from a contribution of unknown size of nonpregnant cows and even some cows that were pregnant but lost their fetus before, or their neonate at or about, the time of calving. Such animals could be mistakenly identified as juvenile females because of their better pelage (advanced change in pelage) and relatively advanced antler development (new growth). Perhaps, of greatest importance in 1995, would be the likelihood of a large number of adult females (cows plus otherwise breedable 2+ and 1+ yr old females) not conceiving or, more likely after becoming pregnant, subsequently losing their fetuses or neonates. Such females would not then develop the advanced drab appearance of a successful parturient or maternal cow (a "breeding cow") in June and July of the year. Thus, this discrepancy in appearance could lead to some or many of those females

being mistakenly classified as juvenile (2+ yr-old) or yearling (1+ yr-old) females, when they actually were unsuccessful breeding cows (mostly 3+ yr old but also some 2+ and possible even 1+ yr-old females). This condition could pertain more in 1995 than in previous years because of the markedly poor performance of the 1995 calf crop compared to other years of the study (1989-94). Although we might have erred in this direction on many occasions in early July 1995, I do not believe that we consistently made this type of error in our sex/age identifications in the other years of the study, at least not to the same degree.

Caribou were seen on 244 sites on Bathurst Island between 7 and 11 July 1995 (Table 31). Groups of two or more individuals contributed 86.9% of those observations. The remaining 13.1% of the observations were of solitary animals: 10 bulls; 8 juvenile males; 7 juvenile females; 5 yearling males; 1 cow; and 1 yearling female. All groups (n = 212) averaged 5.0 ± 3.35 SD and ranged from 2 to 24 members each: mixed sex/age groups (n = 142), mean 5.4 ± 3.73 SD, range 2-24; and male-only groups (n = 70), mean 4.1 ± 2.15 SD, range 2-11. Over two-thirds (70.4%) of all the caribou seen on Bathurst Island in early July 1995 were in mixed sex/age social groups; 26.6% were in male-only groups; and only 3.0% occurred as solitary animals. Six of the 7 sex/age classes were represented by solitary individuals, only newborn calves were not (and if they had been, it would have been considered an anomaly).

Overall, mixed sex/age groups averaged significantly larger than male-only groups (Table 31: t-test; $P < 0.05$). The overall mean group size for mixed sex/age groups with calves present also averaged significantly greater than the mean for mixed sex/age groups without calves present (Table 31: t-test; $P < 0.05$). The presence of newborn calves in those groups accounted for the significant difference, as there was no significant difference between mixed sex/age groups with calves, when calves were excluded vs. those mixed sex/age groups that had no calves (Table 31: t-test; $P > 0.05$). The largest male-only group seen was only 45.8% as large as the largest mixed sex/age group with calves present (11 vs. 24, respectively).

Calves were present in 43.0% (n = 61) of all mixed sex/age groups seen or only 28.8% of all social groupings with two or more

individuals. Only 67.3% (n = 177) of the breeding cows were in groups with calves present, and only 39.9% (n = 143) of all juvenile/yearling females were in those groups. Only 9.1% of all 1-yr-old males seen (bulls = 12, juvenile/yearling males = 19) occurred in those mixed sex/age groups with calves present, indicating that spatial separation between cows and bulls and even between females and males in general had actually continued into early July 1995. The possibility of seeing a caribou group with no females was 1 in 3.0 on average.

The sample for social formations in early July 1995 was large enough to be meaningful, and in terms of relative numbers and nonrandom distributions by sex/age classes among the 13 search zones on Bathurst Island followed the same general patterns exhibited in 1985 (Miller 1987*a*), 1988 (Miller 1989), 1989 (Miller 1991), 1990 (Miller 1992), 1991 (Miller 1993), 1992 (Miller 1994), and 1993 (Miller 1995).

5. Calf Production And Early Survival Of Calves

The winter of 1993/94 apparently was favourable for the survival of caribou within the BIC, not a single carcass (caribou or muskox) was found in *ca.* 50 hours of low-level helicopter flying. In stark contrast, many caribou (and muskoxen, App. 3) died during the winter of 1994/95. In addition, it appears that the severe environmental stresses of winter 1994/95 are strongly reflected in the low production and survival of calves in summer 1995.

5.1. June-August 1994

The summer (fourth) field period in 1994 did not start until 13 July because the remaining helicopter support was not enough to blanket the 2-month period from 12 June to 10 August. Thus, the later starting date was chosen because late July and early August had proven a good time for the capture of caribou within the BIC in 1993 (also, the net-gunner was available only at that time in 1994). Therefore, we must rely mainly on the small samples of caribou obtained by sex/age composition in association with the VHF radio telemetry tracking flights in June and August (Tables 8, 9, 13, 14) for an evaluation of calving and early survival of calves in 1994.

Although the evaluation is limited by the small sizes of the samples , some, seemingly, accurate but tentative conclusions can be

drawn from these limited data and my empirical impressions during spring and summer 1994. The data in Tables 8 and 9 (from 15 groups with telemetry neck-collared caribou present) indicate that 35.4% of the 65 caribou segregated by sex/age class in June 1994 were newborn calves. This exceptionally high, proportional value for newborn calves among all caribou seen in June of the year seems to suggest a rate of calf production greater than the theoretical maximum of 0.3 for the species (Beregerud 1978, 1980). We must remember, however, that there were absolutely no bulls or even younger males present in any of the 14 mixed sex/age groups in the sample and only two bulls in the one male-only group. Therefore, the 35.4% must be adjusted to correct for the missing male segment of the BIC caribou population (based on the assumption that an accurate split between the sexes for 1+ yr-old animals in a typical caribou population is 40:60 or 66.7 males:100 females). When we do so, the rate for newborn calves is reduced to 25.6%, a still high but more believable value. This value, 25.6%, suggests that calving was already *ca.* 85% complete by 12 June 1994. This would be the earliest peak for calving by Peary caribou within the BIC recorded between 1989 and 1994 and would suggest that winter 1993/94 was quite favourable for the caribou within the BIC (Miller 1991, 1992, 1993, 1994, 1995). Thus, calving appears to have been well-advanced by 12 June 1994.

When we look at the calf representation among the 97 caribou (from 15 groups with telemetry neck-collared caribou present) segregated by sex/age class between 2 and 6 August 1994, we find that calves represent nearly 22% of all caribou counted. Some males were present in the August sample but more than half (*ca.* 57%) of them were still lacking, when it is assumed that 1+ yr-old males should have equalled 40% of all 1+ yr-old animals in the sample. Thus, when we assume that the 59 1+ yr-old females should equal 60% of the sample, the 22% value for calves is reduced to *ca.* 18%. This suggests that if the theoretical maximum proportion of calves was reached in June 1994, 40% of those calves already had died by the first week of August 1994. On the other hand, maximum calf production in June 1994 could have fallen short of the maximum level by an unknown amount. If so, proportional mortality among newborn calves would have been lower than the apparent 40%. Thus, although the calving peaked early in 1994, early survival of calves through August appeared to be only moderately favourable.

5.2. June 1995

Calves represented only 8.8% of all caribou seen and counted in late June 1995 (Tables 19, 32, 33). This low value represents only 29% of the theoretical maximum annual rate of population growth for the species (e.g. Bergerud 1978, 1980). On average, throughout the BIC only *ca.* 35 cows out of every 100 breeding cows each had a calf at heel in late June 1995. Calf:female ratios of only about 24 calves:100 2+ yr-old females and 19 calves:100 1+ yr-old females suggested that only *ca.* 30% and 26% of the average maximum expected annual rates of reproduction among female caribou within the BIC had been realized by or maintained as of 24 June 1995 (based on the assumptions that (1) on average, 82% of all 2+ yr-old females should calve annually (Bergerud 1980) and (2) 72% of all 1+ yr-old females should be pregnant annually (Dauphine 1976). It appears, therefore, that either calving was still in its early stages during the end of June 1995 and much more was still possible in July 1995 or as much as 70% of the theoretical initial calf production within the BIC had already been lost by 24 June 1995. These findings compare quite unfavourably with other reported rates of initial (perinatal) calf mortalities in caribou (e.g., Tener 1961, 1963; Zhigunov 1961; Bergerud 1971, 1974, 1978, 1980; Miller 1974, 1991, 1992, 1993, 1994; Miller and Broughton 1974; Parker et al. 1975; Fischer and Duncan 1976; Miller et al. 1977, 1988; Baskin 1983; Mauer et al. 1983, Whitten et al. 1984).

Calf:female ratios were collectively three-fold greater on the four western major satellite islands where caribou were seen in June 1995 than on Bathurst Island in June 1995 (Table 32). Thus, representation of newborn calves among all caribou seen was also markedly greater on the four western major satellite islands than on Bathurst Island (Table 33). Essentially all of the observed differences were, however, caused by the high contribution of females with newborn calves, especially breeding cows (and the absence of male caribou) on Massey Island (Table 19). As in past years (Miller 1993, 1994, 1995), the proportion of newborn calves among all caribou seen on Massey Island in June 1995 exceeds the theoretical maximum annual rate of increase for the species, because of the absence of males on Massey Island. When the sample of caribou on Massey Island is adjusted for the missing males, the observed 40.8% calves among all caribou drops to 29.3%, which is still essentially the maximum value expected (0.3) in a free-ranging caribou population.

Calf:female ratios in the Massey Island sample suggest that calving mainly had been completed by 24 June 1995, and there had been only light mortality among newborn calves or, at most, only a few cows that had not yet calved. These conditions were all in total contrast to the findings from the other areas of the BIC in late June 1995 (Tables 19, 32, 33).

5.3. July 1995

Newborn calf representation among all caribou seen on Bathurst Island was still markedly low by 11 July 1995 (Table 19), even though it had increased 65% from 24 June 1995 (Tables 32, 33). It appears from the proportional increase observed in newborn calves present on Bathurst Island from late June to mid July 1995 that considerable calving took place after 24 June, but most calving likely was completed by (or before) 7 July (App. 6: 12.2% calves on 7 Jul vs. 12.8% on 11 Jul or 44.6 calves vs. 48.3 calves:100 breeding $cows^{-1}$, respectively).

Calving was extremely poor based on both the June and the July 1995 sex/age composition counts. Initial production of caribou calves appears to have been *ca.* 40% or less of the theoretical maximum annual rate of increase of the species. The alternative is that early mortality of calves was exceptionally high in June-July 1995. Most likely, however, it was a combination of above two probabilities. That is, both initial production of calves was low and early mortality of calves was high in June-July 1995. The net results are evident, when coupled with the high level of mortality among 1+ yr-old caribou in winter 1994/95, the BIC caribou population has suffered a significant set back in population growth during 1995. Unfortunately, no population estimate from a systematic aerial survey exists for summer 1995. I believe, however, that mortality approached *ca.* 25-30 % in 1995, based on all the existing associated evidence from the high carcass count (including 2 out of the 7 satellite neck-collared animals) and the noticeably poor calf crop in 1995. I think that my empirical guess provides an acceptable working assumption, as the resultant ratio of one caribou seen:1.7 caribou extrapolated is in total agreement with the last systematic aerial survey of caribou within the BIC in 1988 (that is, 635 caribou seen vs. 1103 caribou estimated in 1988 and 1084 caribou seen vs. 1866 caribou extrapolated in 1995). Thus, the magnitude of any possible associated error likely would not be

significantly greater in 1995 than it was in 1988. In reality, the only difference is that in 1988 we had a statistical measure of variation associated with the mean estimate. If, as I suggest, however, any management prescriptions are based on the actual number of caribou counted, the absence of any statistical measure is of no meaningful consequence to the resource's management. In effect, what we have is management of and "Endangered" resource based on a "minimal population count", which is a relatively safe (of known accuracy) and, thus, a properly cautious approach to take in the conservation and management of Peary caribou on the QEI.

6. Wolves

We saw only one wolf on Bathurst Island during our helicopter searches in July -August 1994. The wolf was seen at the west end of PBP, apparently, stalking a group of 18 muskoxen. A second wolf was seen standing over a dead wolf on an interior site on northeastern Cameron Island (close by where the bull (94-05) caribou's VHF collar was found). Either the wolf was about to start feeding on the carcass or some other scavenger had opened the abdomen: the carcass was otherwise intake. The dead wolf appeared to have been under the snow on the north-facing slope of a gully for at least most of the winter. No wolves were seen anywhere within the BIC during the April, May, or June 1994 field periods.

No wolves were seen in June or July 1995 on Bathurst Island. One wolf was seen in July 1995 on a north-central coastal area of Helena Island. The wolf's pelage was smeared with dirt of dried blood over much of its body. The stains appeared black at a distance but could have been dried blood, possibly from rolling on some wet site or on an old carcass. We did not investigate closely because the wolf was on a ridge above a group of four caribou (2 bulls, 1 juvenile male, and 1 yearling male) and appeared to be stalking them. No wolves were seen anywhere within the BIC in June 1995.

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Table 1. Locations of 17 telemetry neck-collared Peary caribou within the Bathurst Island complex, Northwest Territories, April 1994

	Island locations		Global Positioning System locations, Apr 1994	
Animal ID # (sex)[a]	Where captured Jul/Aug 1993	Where found Apr 1994	Lat. N°	Long. W°
93-01(F)	Bathurst	Bathurst	76.017	99.213
93-02(F)			76.172	99.503
93-03(F)			75.990	98.026
93-04(F)			75.805	99.784
93-05(F)			76.234	99.421
93-13(F)[b]			75.196	99.012
93-14(F)			75.944	97.896
93-15(F)[c]			76.406	97.696
93-16(F)			76.209	99.091
93-17(F)			76.654	98.633
93-12(M)[d]	Vanier	Cameron	76.408	103.663
93-09(F)	Alexander	Bathurst	76.102	101.567
93-10(F)		Vanier	76.278	103.200
93-11(F)			76.082	103.405
93-06(F)	Massey		76.112	103.499
93-07(F)		Cameron	76.362	103.870
93-08(M)		Pauline	76.028	103.538

continued

Table 1. Continued

[a] Sex: F equals females and M equals male.
[b] 93-13(F) was the only caribou captured south of Polar Bear Pass in July/August 1993 and she was still on the southern portion of Bathurst Island when relocated in April 1994.
[c] Animal died sometime in winter 1993/94.
[d] 93-12(M) is assumed to either be dead or has slipped his collar after casting his antlers.

Table 2. Social groupings associated with 15 visually located telemetry neck-collared Peary caribou, Bathurst island complex, Northwest Territories, April 1994

Animal ID # (sex)[a]	Bulls	Cows	1993[b] Calves	Juv.[c] M	Juv. F	Group size
93-01(F)		1	1			2
93-02(F)		2	2			4
93-03(F)		3	1			4
93-04(F)		3	2		2	7
93-05(F)		1	1		1	3
93-13(F)		3	3			6
93-14(F)		1	1		2	4
93-16(F)		2	1		2	5
93-17(F)		1	1			2
93-09(F)		1	1			2
93-10(F)		4	3		1	8
93-11(F)		1	1			2
93-06(F)		2	1		2	5
93-07(F)		3	1		2	6
93-08(M)	2			1		3

[a] Sex: F equals female and M equals male.
[b] Calves born in June 1993 (also could be classified as short-yearlings in Apr of the year).
[c] Juv. equals juvenile animals.

Table 3. Sex/age class statistics for Peary caribou in social groupings with telemetry neck-collared caribou present, Bathurst Island complex, Northwest Territories, April 1994

Statistics	Bulls	Cows	1993 claves	Juvenile males	Juvenile females	All observations
Summation of individuals in groups	2	28	20	1	12	63
Mean number of individuals seen per group	0.1	1.9	1.3	0.1	0.8	4.2
± SE of the mean group representation	0.13	0.29	0.21	0.07	0.24	0.50
Range of individuals within each group	0-2	0-4	0-3	0-1	0-2	2-8
Number of groups with sex/age classes present	1	14	14	1	7	15

Table 4. Locations of 17 telemetry neck-collared Peary caribou within the Bathurst Island complex, Northwest Territories, May 1994

Animal ID # (sex)[a]	Island locations: Where captured Jul/Aug 1993	Island locations: Where found May 1994	Global Positioning System locations, May 1994: Lat. N°	Global Positioning System locations, May 1994: Long. W°
93-01(F)	Bathurst	Bathurst	76.188	98.762
93-02(F)			76.201	99.503
93-03(F)			75.976	98.093
93-04(F)			75.843	99.674
93-05(F)			76.238	99.427
93-13(F)[b]			75.206	98.875
93-14(F)			76.013	97.697
93-15(F)[c]			76.408	97.691
93-16(F)			76.247	98.653
93-17(F)			76.657	98.504
93-12(M)[d]	Vanier	Cameron	76.409	103.656
93-09(F)	Alexander	Bathurst	76.017	101.534
93-10(F)		Alexander	75.859	102.980
93-11(F)		Massey	75.927	103.475
93-06(F)	Massey	Vanier	76.084	103.808
93-07(F)		Massey	75.986	103.280
93-08(M)			75.937	103.778

continued

Table 4. Continued

[a] Sex: F equals females and M equals male.
[b] 93-13(F) was the only caribou captured south of Polar Bear Pass in July/August 1993 and she was still on the southern portion of Bathurst Island when relocated in May 1994.
[c] Animal died sometime in winter 1993/94.
[d] 93-12(M) is assumed to either be dead or has slipped his collar after casting his antlers.

Table 5. Social groupings associated with 15 visually located telemetry neck-collared Peary caribou, Bathurst island complex, Northwest Territories, May 1994

Animal ID # (sex)[a]	Bulls	Cows	1994[b] Calves	Juv[c] M	Juv F	Group size
93-01(F)		4	1		3	8
93-02(F)		2	2			4
93-03(F)	1	6	3		4	14
93-04(F)		9	6		3	18
93-05(F)		5	4		1	10
93-13(F)		3	3			6
93-14(F)		3	3		2	8
93-16(F)		2	1		1	4
93-17(F)		1	1			2
93-09(F)		5	1		5	11
93-10(F)		4	3		1	8
93-11(F)		3	3			6
93-06(F)		3	3			6
93-07(F)		4	4			8
93-08(M)	3			1		4

[a] Sex: F equals female and M equals male.
[b] Calves assumed born in June 1994 (also could be classified as short-yearlings in May of the year).
[c] Juv. equals juvenile animals.

Table 6. Sex/age class statistics for Peary caribou in social groupings with telemetry neck-collared caribou present, Bathurst Island complex, Northwest Territories, May 1994

Statistics	Bulls	Cows	1993 claves	Juvenile males	Juvenile females	All observations
Summation of individuals in groups	4	54	38	1	20	117
Mean number of individuals seen per group	0.3	3.6	2.5	0.1	1.3	7.8
± SE of the mean group representation	0.21	0.56	0.40	0.07	0.43	1.08
Range of individuals within each group	0-3	0-9	0-6	0-1	0-5	2-18
Number of groups with sex/age classes present	2	14	14	1	8	15

Table 7. Locations of 17 telemetry neck-collared Peary caribou within the Bathurst Island complex, Northwest Territories, June 1994

Animal ID # (sex)[a]	Island locations: Where captured Jul/Aug 1993	Island locations: Where found Jun 1994	Global Positioning System locations, Jun 1994: Lat. N°	Global Positioning System locations, Jun 1994: Long. W°
93-01(F)	Bathurst	Bathurst	76.392	99.286
93-02(F)			76.181	99.368
93-03(F)			75.986	98.140
93-04(F)			76.104	98.983
93-05(F)			76.422	99.859
93-13(F)[b]			75.206	98.810
93-14(F)			76.275	98.737
93-15(F)[c]			76.408	97.691
93-16(F)			76.512	98.774
93-17(F)			76.179	99.037
93-12(M)[d]	Vanier	Cameron	76.409	103.654
93-09(F)	Alexander	Massey	75.996	102.812
93-10(F)		Alexander	75.907	102.792
93-11(F)		Massey	75.935	103.543
93-06(F)	Massey	Alexander	75.774	103.278
93-07(F)		Massey	75.958	103.208
93-08(M)		Alexander	75.798	102.788

continued

Table 7. Continued

[a] Sex: F equals females and M equals male.
[b] 93-13(F) was the only caribou captured south of Polar Bear Pass in July/August 1993 and she was still on the southern portion of Bathurst Island when relocated in June 1994.
[c] Animal died sometime in winter 1993/94.
[d] 93-12(M) is assumed to either be dead or has slipped his collar after casting his antlers.

Table 8. Social groupings associated with 15 visually located telemetry neck-collared Peary caribou, Bathurst island complex, Northwest Territories, June 1994

Animal ID # (sex)[a]	Bulls	Cows	1994[b] Calves	Juv.[c] M	Yrl.[c] F	Group size
93-01(F)		1	1			2
93-02(F)		6	6			12
93-03(F)		1	1			2
93-04(F)		1	1			2
93-05(F)		3	3			6
93-13(F)		1				1
93-14(F)		2		1	1	4
93-16(F)		2	2			4
93-17(F)		2	2			4
93-09(F)		2	2			4
93-10(F)		4	3	1		8
93-11(F)		4		1	4	9
93-06(F)		1	1			2
93-07(F)		1	1		1	3
93-08(M)	2					2

[a] Sex: F equals female and M equals male.
[b] Calves born in June 1994, (also could be classified as yearlings in Jun of the year).
[c] Juv. equals juvenile animals and Yrl. equals yearling animals.

Table 9. Sex/age class statistics for Peary caribou in social groupings with telemetry neck-collared caribou present, Bathurst Island complex, Northwest Territories, June 1994

Statistics	Bulls	Cows	1994 calves	Juvenile males	Yearling females	All observations
Summation of individuals in groups	2	31	23	3	6	65
Mean number of individuals seen per group	0.1	2.1	1.5	0.2	0.4	4.3
± SE of the mean group representation	0.13	0.41	0.41	0.11	0.27	0.81
Range of individuals within each group	0-2	0-6	0-6	0-1	0-4	1-12
Number of groups with sex/age classes present	1	14	11	3	3	15

Table 10. Capture sites for seven telemetry neck-collared Peary caribou, Bathurst Island complex, Northwest Territories, 24-31 July 1994

Animal ID # (Sex)[a]	July 1994	Satellite ID #	VHF frequency (164 MHz)	Capture locations		
				Island	Lat.° N	Long.° W
94-01(M)	30	21122	.430	"Bull"	75.621	100.189
94-02(F)	27	21118	.580	Bathurst	75.948	98.708
94-03(F)	24	21119	.670		76.017	98.338
94-04(F)	29	21120	.680		75.996	98.712
94-05(M)	31	21121	.710	Marc	75.882	103.428
94-06(F)		21123	.730		75.864	103.404
94-07(M)		21124	.810	Bathurst	76.426	98.520

[a] Sex: M equals male and F equals female.

Table 11. Locations of five of the 10 telemetry neck-collared Peary caribou captured on Bathurst Island in July-August 1993, Northwest Territories, July 1994[a]

	Island locations		Global Positioning System locations, Jul 1994	
Animal ID # (sex)[b]	Where captured Jul/Aug 1993	Where found Jul 1994	Lat. N°	Long. W°
93-01(F)	Bathurst	Bathurst	76.029	98.282
			76.023	98.338
93-02(F)			76.096	99.959
			76.096	98.908
93-03(F)			76.054	97.996
			76.036	97.976
			75.999	98.684
93-05(F)			75.905	98.558
			75.881	99.014
93-13(F)[b]			75.586	98.254
			75.525	98.962
			75.362	99.610

[a] The data in this table must be combined with the data in Table 10 to obtain all VHF locations in July 1994: note, 93-01 became 94-03 and 93-03 became 94-04.

[b] Sex: F equals female.

Table 12. Locations of 15 telemetry neck-collared Peary caribou within the Bathurst Island complex, Northwest Territories, August 1994

	Island locations		Global Positioning System locations, Aug 1994	
Animal ID # (sex)[a]	Where captured Jul/Aug 1993/94	Where found Aug 1994	Lat. N°	Long. W°
94-01(M)	"Bull"	"Bull"	76.614	100.268
94-02(F)	Bathurst	Bathurst	76.358	99.201
94-03(F)			76.066	98.192
94-04(F)			76.024	99.238
94-05(M)	Marc	Marc	75.876	103.652
94-06(F)			75.864	103.418
94-07(M)	Bathurst	Bathurst	76.420	98.510
93-07(F)	Massey	Massey	76.040	102.607
93-09(F)	Alexander	Alexander	75.913	102.454
93-10(F)			75.910	102.672
93-11(F)			75.389	103.013
93-13(F)[b]	Bathurst	Bathurst	75.389	99.728
93-14(F)			75.510	97.484
93-16(F)			75.965	98.801
93-17(F)			76.092	99.136

[a] Sex: F equals females and M equals male.
[b] 93-13(F) was the only caribou captured south of Polar Bear Pass in July/August 1993 and she was still on the southern portion of Bathurst Island when relocated in June 1994.

Table 13. Social groupings associated with 15 visually located telemetry neck-collared Peary caribou, Bathurst Island complex, Northwest Territories, August 1994

Animal ID # (sex)[a]	Bulls	Cows	1994[b] Calves	Juvenile males	Juvenile females	Yearling males	Yearling females	Group size
94-01(M)	6							6
94-02(F)		3	3		2		1	9
94-03(F)		1	1		3		2	7
94-04(F)		2	2					4
94-05(M)	4			1				5
94-06(F)		1	1			1		3
94-07(M)	3			2				5
93-07(F)		3	3		1			7
93-09(F)		2	2		3			7

continued

Table 13. Continued

Animal ID # (sex)[a]	Bulls	Cows	1994[b] Calves	Juvenile males	Juvenile females	Yearling males	Yearling females	Group size
93-10(F)		1	1		1		1	4
93-11(F)		2	2		2		1	7
93-13(F)		3	1		4		1	9
93-14(F)		2	1		2		2	7
93-16(F)		1	1		3		5	10
93-17(F)		3	3		1			7

[a] Sex: M equals male and F equals female.
[b] Calves assumed born in June 1994.

Table 14. Sex/age class statistics for Peary caribou in social groupings with telemetry neck-collared caribou present, Bathurst Island complex, Northwest Territories, August 1994

Statistics	Bulls	Cows	1994 calves	Juv.[a] males	Juv. females	Yrl.[a] males	Yrl. females	All observations
Summation of individuals in groups	13	24	21	3	22	1	13	97
Mean number of individuals seen per group	0.8	1.6	1.4	0.2	1.5	0.1	0.8	6.5
± SE of the mean group representation	0.49	0.29	0.27	0.14	0.26	0.07	0.35	0.52
Range of individuals within each group	0-6	0-3	0-3	0-2	0-4	0-1	0-5	3-10

continued

Table 14. Continued

Statistics	Bulls	Cows	1994 calves	Juv.[a] males	Juv. females	Yrl.[a] males	Yrl. females	All observations
Number of groups with sex/age classes present	3	12	12	2	10	1	7	15

[a] Juv. equals juvenile animals and Yrl. equals yearling animals.

Table 15. Locations of 11 of the 16 telemetry neck-collared Peary caribou within the Bathurst Island complex, Northwest Territories, July 1995

	Island locations		Global Positioning System locations, Jul 1995	
Animal ID # (sex)[a]	Where captured Jul/Aug 1993/94	Where found Jul 1995	Lat. N°	Long. W°
94-01(M)	"Bull"	Bathurst	76.452	98.702
94-02(F)	Bathurst	Bathurst	76.132	98.382
94-03(F)[b]			75.635	97.492
94-04(F)		Baring	75.941	95.872
94-05(M)[b]	Marc	Cameron	76.471	103.634
94-06(F)		Alexander	75.773	103.325
94-07(M)	Bathurst	Bathurst	76.553	98.041
93-02(F)[b]	Bathurst		75.116	98.878
93-10(F)	Alexander	Alexander	75.815	103.002
93-14(F)[b]	Bathurst	Bathurst	76.160	98.139
93-17(F)			76.349	99.834

[a] Sex: F equals females and M equals male.
[b] Animal had died sometime in winter 1994/95.

Table 16. Social groupings associated with 11 of the 16 visually located telemetry neck-collared Peary caribou, Bathurst Island complex, Northwest Territories, July 1995

Animal ID # (sex)[a]	Bulls	Cows	1995[b] Calves	Juvenile males	Juvenile females	Yearling males	Yearling females	Group size
94-01(M)	1			1		8		10
94-02(F)		2		1			1	4
94-03(F)[b]								
94-04(F)	1	1			1			3
94-05(M)[b]								
94-06(F)		2	2		2		2	8
94-07(M)	1	1		1			2	5
93-02(F)[b]								
93-10(F)		3	2				1	6
93-14(F)[b]								
93-17(F)		2			1		1	4

[a] Sex: M equals male and F equals female.
[b] Calves assumed born in June 1995.

Table 17. Sex/age class statistics for Peary caribou in social groupings with telemetry neck-collared caribou present, Bathurst Island complex, Northwest Territories, July 1995

Statistics	Bulls	Cows	1995 calves	Juv.[a] males	Juv. females	Yrl.[a] males	Yrl. females	All observations
Summation of individuals in groups	3	11	4	3	4	8	7	40
Mean number of individuals seen per group	1.0	1.8	2.0	1.0	1.33	8.0	1.4	5.7
± SE of the mean group representation	0.00	0.31	0.00	0.00	0.33	0.00	0.24	0.94
Range of individuals within each group	1-1	1-3	2-2	1-1	1-2	8-8	1-2	3-8
Number of groups with sex/age classes present	3	6	2	3	2	1	5	7

[a] Juv. equals juvenile animals and Yrl. equals yearling animals.

Table 18. Islands used by telemetry neck-collared Peary caribou captured on major western satellite islands of Bathurst Island, Bathurst Island complex, Northwest Territories, July 1993 to July 1995

	Island location[c]							
Animal	Jul	Aug	Apr	May	Jun	Jul	Aug	July
ID #[a] (sex)[b]	1993[d]	1993	1994	1994	1994	1994	1994	1995
93-06(F)	Mass	Marc	Van	Van	Alex	Marc	Marc	Alex
93-07(F)	Mass	Mass	Cam	Mass	Mass	Mass	Mass	?
93-08(M)	Mass	Marc	Paul	Mass	Alex	Marc	Marc	Cam[e]
93-09(F)	Alex	Alex	Bath	Bath	Mass	Alex	Alex	(Alex)[f]
93-10(F)	Alex	Alex	Van	Alex	Alex	Alex	Alex	Alex
93-11(F)	Alex	Alex	Van	Mass	Mass	Alex[g]	Alex	(Alex)[f]
93-12(M)	Van	Mass	Cam[h]					

continued

Table 18. Continued

[a] Numbers 93-06 (94-06) and 93-08 (94-05) were PTT-collared caribou and the remaining five animals were VHF-collared caribou.
[b] Sex: F equals females and M equals males.
[c] Island names: Massey, Mass; Marc, Marc; Vanier, Van; Alexander, Alex; Cameron, Cam; Pauline, Paul; and Bathurst, Bath.
[d] Island where captured.
[e] Animal died sometime in winter 1994/95.
[f] VHF radio telemetry signal detected "close-by" but animal never visually located and identified.
[g] Assumed location, based on 2 August 1994 detection.
[h] Animal was dead before April 1994.

Table 19. Numbers and sex/age composition counts of Peary caribou, Bathurst Island complex, Northwest Territories, 1995

Date (month/day)	Sex/age composition							N	Search effort (min)
	Bulls	Cows	1995 Calves	Juv. males	Juv. females	Yrl. males	Yrl. females		
Bathurst Island									
06/17-06/24	76	158	38	65	66	93	63	559	1142
Alexander Island									
06/24	42	21	9	13	10	18	9	84	87
Ile Marc									
06/24	2	1	1	2	0	1	0	7	28
Massey Island									
06/24	0	21	20	0	3	0	5	49	61
Ile Vanier									
06/24	11	2	2	4	4	7	4	34	78

continued

Table 19. Continued

Date (month/day)	Sex/age composition: Bulls	Cows	1995 Calves	Juv. males	Juv. females	Yrl. males	Yrl. females	N	Search effort (min)
Helena Island									
06/18	9	5	1	12	6	13	3	49	72
Sherard Osborn Island									
06/18	2	2	2	0	0	3	3	12	10
"Bull Island"									
06/20	7	0	0	8	1	4	2	22	49
"Muskox Island"									
06/20	4	1	0	2	1	1	1	10	10
Bathurst Island									
07/07-07/11	133	263	121	120	225	89	133	1084	1107

Table 20 Aerial counts of Peary caribou by 13 search zones on Bathurst Island, south-central Queen Elizabeth Islands, Northwest Territories, 17-24 June 1995

Search zone[a]	Caribou seen		Zone total	% calves[b]	Caribou ($\circ$100 min^{-1})
	1+ yr olds	calves			
NEC***	65	2	67	3.0	39.4
NEI***	151	30	181	16.6	112.4
SEC	21	0	21	0.0	18.8
SEI	1	0	1	0.0	3.1
SC	4	1	5	1/5	13.2
SWC	16	0	16	0/16	16.0
SWI	0	0	0	0/0	0.0
NWC***	38	1	39	2.6	50.0
NWI	0	0	0	0/0	0.0
NCW***	40	1	41	1.8	82.0
NCE***	115	3	118	2.5	59.6
NPBP***	59	0	59	0.0	80.8
SPBP	11	0	11	0/11	24.4

[a] NEC, northeast coast; NEI, northeast interior; SEC, southeast coast; SEI, southeast interior; SC, south coast; SWC, southwest coast; SWI, southwest interior, NWC, northwest coast; NWI, northwest interior; NCW, north coast-west section; NCE, north coast-east section; NPBP, north Polar Bear Pass; and SPBP, south Polar Bear Pass.

[b] Fractions given instead of percentages, when total caribou seen in zone equals <30 animals to avoid possible distortion of proportions.

*** Caribou significantly overrepresented in search zone on a relative landmass basis ($P < 0.005$).

Table 21. Percentage distribution of Peary caribou compared to the relative landmass of each of the 13 search zones, Bathurst Island, south-central Queen Elizabeth Islands, Northwest Territories, 17-24 June 1995

Search zone[a]	% of total caribou	% of total land area	Expected caribou by land area	Observed/ expected index
NEC***	12.0	2.7	15.09	4.44
NEI***	32.4	25.9	144.78	1.25
SEC	3.8	4.9	27.39	0.77
SEI	0.2	9.5	53.10	0.09
SC	0.9	3.3	17.89	0.28
SWC	2.9	4.1	22.92	0.70
SWI	0.0	9.4	52.55	0.00
NWC***	7.0	5.8	32.42	1.20
NWI	0.0	12.9	72.11	0.00
NCW***	7.3	6.6	36.89	1.11
NCE***	21.1	10.4	58.14	2.03
NPBP***	10.5	2.4	13.42	4.40
SPBP	1.9	2.2	12.30	0.89

[a] NEC, northeast coast; NEI, northeast interior; SEC, southeast coast; SEI, southeast interior; SC, south coast; SWC, southwest coast; SWI, southwest interior, NWC, northwest coast; NWI, northwest interior NCW, north coast-west section; NCE, north coast-east section; NPBP, north Polar Bear Pass; and SPBP, south Polar Bear Pass.

*** Caribou significantly overrepresented in search zone on a relative landmass basis ($P < 0.005$).

Table 22. Rate of occurrence of Peary caribou by major land divisions, Bathurst Island, south-central Queen Elizabeth Islands, Northwest Territories, 17-24 June 1995

Major divisions	Number of different caribou sighted	Time spent searching (min)	Rate of occurrence caribou ($\circ$100 min^{-1})
Coastal***vs.	377	864	43.6
Interior	182	278	65.5
North*** vs.	505	745	67.8
South	54	397	13.6
East***vs.	453	784	57.8
West	106	358	29.6

*** Caribou overrepresented within major land division by relative frequency of occurrence in paired comparison ($P < 0.005$).

Table 23. Distribution of 559 Peary caribou by major land divisions, Bathurst Island, south-central Queen Elizabeth Islands, Northwest Territories, 17-24 June 1995

Major divisions	% of total caribou seen	% of total land area	Expected sightings based on land area	Observed/ expected caribou index
Coastal***vs.	67.4	42.3	236.46	1.59
Interior	32.6	57.7	322.54	0.56
North***vs.	90.3	66.7	372.85	1.35
South	9.7	33.3	186.15	0.29
East***vs.	81.0	58.1	324.78	1.39
West	19.0	41.9	234.22	0.45

*** Caribou overrepresented on a relative landmass basis in paired comparison ($P < 0.005$).

Table 24. Aerial counts of Peary caribou by 13 search zones on Bathurst Island, south-central Queen Elizabeth Islands, Northwest Territories, 7-11 July 1995

Search	Caribou seen		Zone	%	Caribou
zone[a]	1+ yr olds	calves	total	calves[b]	(◦100 min^{-1})
NEC***	147	7	154	4.5	205.3
NEI	130	30	160	18.8	89.4
SEC	32	0	32	0.0	53.3
SEI	1	0	1	0/1	1.0
SC	10	2	12	2/12	52.2
SWC	2	0	2	0/2	25.6
SWI	4	0	4	0/4	22.2
NWC	29	4	33	12.1	75.0
NWI	13	0	13	0/13	130.0
NCW***	150	5	155	3.2	95.7
NCE***	403	73	476	15.3	159.7
NPBP	22	0	22	0/22	275.0
SPBP	20	0	20	0/20	37.7

[a] NEC, northeast coast; NEI, northeast interior; SEC, southeast coast; SEI, southeast interior; SC, south coast; SWC, southwest coast; SWI, southwest interior, NWC, northwest coast; NWI, northwest interior; NCW, north coast-west section; NCE, north coast-east section; NPBP, north Polar Bear Pass; and SPBP, south Polar Bear Pass.

[b] Fractions given instead of percentages, when total caribou seen in zone equal < 30 animals to avoid possible distortion of proportions.

*** Caribou significantly overrepresented in search zone on a relative landmass basis ($P < 0.005$).

Table 25. Percentage distribution of Peary caribou compared to landmass of each of the 13 search zones, Bathurst Island, south-central Queen Elizabeth Islands, Northwest Territories, 7-11 July 1995

Search zone[a]	% of total caribou	% of total land area	Expected caribou by land area	Observed/ expected index
NEC***	14.2	2.7	29.23	5.27
NEI	14.8	25.9	280.75	0.57
SEC	3.0	4.9	53.12	0.60
SEI	0.1	9.5	102.98	0.00
SC	1.1	3.2	34.69	0.06
SWC	0.2	4.1	44.44	0.04
SWI	0.4	9.4	101.90	0.04
NWC	3.0	5.8	62.87	0.52
NWI	1.2	12.9	139.84	0.09
NCW***	14.3	6.6	71.54	2.17
NCE***	43.9	10.4	112.74	4.22
NPBP	2.0	2.4	26.02	0.85
SPBP	1.8	2.2	23.85	0.84

[a] NEC, northeast coast; NEI, northeast interior; SEC, southeast coast; SEI, southeast interior; SC, south coast; SWC, southwest coast; SWI, southwest interior, NWC, northwest coast; NWI, northwest interior NCW, north coast-west section; NCE, north coast-east section; NPBP, north Polar Bear Pass; and SPBP, south Polar Bear Pass.

*** Caribou significantly overrepresented in search zone on a relative landmass basis ($P < 0.005$).

Table 26. Rate of occurrence of Peary caribou by major land divisions, Bathurst Island, south-central Queen Elizabeth Islands, Northwest Territories, 7-11 July 1995

Major divisions	Number of different caribou sighted	Time spent searching (min)	Rate of occurrence caribou (◦100 min^{-1})
Coastal***vs.	906	801	113.1
Interior	178	306	58.2
North*** vs.	1013	776	130.5
South	71	331	21.4
East***vs.	858	776	113.2
West	226	349	64.8

*** Caribou overrepresented within major land division by relative frequency of occurrence in paired comparison ($P < 0.005$).

Table 27. Distribution of 1084 Peary caribou by major land divisions, Bathurst Island, south-central Queen Elizabeth Islands, Northwest Territories, 7-11 July 1995

Major divisions	% of total caribou seen	% of total land area	Expected sightings based on land area	Observed/ expected caribou index
Coastal***vs.	83.6	42.3	458.53	1.98
Interior	16.4	57.7	625.47	0.28
North***vs.	93.4	66.7	723.03	1.40
South	6.6	33.3	360.97	0.20
East***vs.	79.2	83.6	629.80	1.36
West	20.8	41.9	454.20	0.50

*** Caribou overrepresented on a relative landmass basis in paired comparison ($P < 0.005$).

Table 28. Distribution of 56 Peary caribou carcasses found within the Bathurst Island complex, Northwest Territories, 17 June to 12 July 1995

Search zone[a]	Caribou carcasses	Search zone	Caribou carcasses
Bathurst Is.	(48)	Major satellite Is.	(7)
NEC	4	Cameron	7
NEI	10	Vanier	0
SEC	3	Massey	0
SEI	5	Marc	0
SC	1	Alexander	0
SWC	8	Helena	0
SWI	5	Sherard Osborn	0
NWC	0	Secondary satellites Is.	(1)
NWI	0	Baker	0
NCW	1	Moore	0
NCE	5	Bradford	0
NPBP	1	"Bull"	1
SPBP	5	"Muskox"	0

[a] NEC, northeast coast; NEI, northeast interior; SEC, southeast coast; SEI, southeast interior; SC, south coast; SWC, southwest coast; SWI, southwest interior, NWC, northwest coast; NWI, northwest interior NCW, north coast-west section; NCE, north coast-east section; NPBP, north Polar Bear Pass; and SPBP, south Polar Bear Pass.

Table 29. Distribution of 48 Peary caribou carcasses found on Bathurst Island, Northwest Territories, June-July 1995

Search zone[a]	% of island's landmass	Proportion of carcasses	Mean density of carcasses (• 100 km^{-2})	Statistical significance[b]
NEC[c]	2.7	0.083	0.933	P<0.025
NEI	25.9	0.208	0.240	P>0.1
SEC	4.9	0.062	0.378	P>0.5
SEI	9.5	0.104	0.326	P>0.5
SC	3.2	0.021	0.194	P>0.9
SWC[c]	4.1	0.167	1.214	P<0.005
SWI	9.4	0.104	0.332	P>0.5
NWC	5.8	0.000	0.000	P>0.5
NWI	12.9	0.000	0.000	P>0.01
NCW	6.6	0.021	0.093	P>0.1
NCE	10.4	0.104	0.299	P>0.9
NPBP	2.4	0.021	0.258	P>0.5
SPBP[c]	2.2	0.104	1.413	P<0.005

[a] Search zones on Bathurst Island equal northeast coast (NEC), northeast interior (NEI), southeast coast (SEC), southeast interior (SEI), south coast (SC), southwest coast (SWC), southwest interior (SWI), northwest coast (NWC), northwest interior (NWI), north coast, western section (NCW), north coast, eastern section (NCE), north Polar Bear Pass (NPBP), and south Polar Bear Pass (SPBP).

[b] Statistical significance tested by comparison of the number of carcasses found in each search zone vs. the collective number of carcasses found on the remainder of the island (the other 12 search zones), where the expected values are derived on the relative landmass basis for each of the search zones (df = 2).

[c] Significant overrepresentation of carcasses within search zone.

Table 30. Group statistics for Peary caribou social formations, Bathurst Island complex, Northwest Territories, 17-24 June 1995 (data obtained from nonsystematic helicopter searches)

		Group statistics				
Island	Group type	N	Mean	± SD	Range	95% CI
Bathurst	Male-only groups	56	3.6	1.75	2-12	3.1-4.0
	All mixed sex/age groups	98	3.4	1.89	2-12	3.0-3.8
	Mixed sex/age groups with calves	33	2.8	1.18	2-6	2.4-3.2
	calves included	33	2.8	1.18	2-6	2.4-3.2
	calves excluded	33	1.7	0.89	1-4	1.4-2.0
	Mixed sex/age groups without calves	65	3.7	2.11	2-12	3.2-4.2
	solitary individuals	28				

continued

Table 30. Continued

Island	Group type	Group statistics N	Mean	± SD	Range	95% CI
Alexander	Male-only groups	5	6.6	2.88	4-11	3.0-10.2
	All mixed sex/age groups	12	4.1	2.39	2-10	2.6-5.6
	Mixed sex/age groups with calves	4	5.8	3.10	3-10	0.8-10.7
	calves included	4	5.8	3.10	3-10	0.8-10.7
	calves excluded	4	3.5	2.38	2-7	-0.3-7.3
	Mixed sex/age groups without calves	8	3.3	1.58	2-6	1.9-4.6
	solitary individuals	2				

continued

Table 30. Continued

Island	Group type	Group statistics N	Mean	± SD	Range	95% CI
Marc	Male-only groups	2	5.0	0.00	5-5	5.0-5.0
	All mixed sex/age groups	1	2.0	0.00	2-2	2.0-2.0
	Mixed sex/age groups with calves	1	2.0	0.00	2-2	2.0-2.0
	calves included	1	2.0	0.00	2-2	2.0-2.0
	calves excluded	1	1.0	0.00	1-1	1.0-1.0
	Mixed sex/age groups without calves	0				
	solitary individuals	0				

continued

Table 30. Continued

Island	Group type	Group statistics N	Mean	± SD	Range	95% CI
Massey	Male-only groups	0				
	All mixed sex/age groups	9	5.4	4.10	2-14	2.3-8.6
	Mixed sex/age groups with calves	8	5.6	4.34	2-14	2.0-9.2
	calves included	8	5.6	4.34	2-14	2.0-9.2
	calves excluded	8	3.1	2.47	1-8	1.1-5.2
	Mixed sex/age groups without calves	1	4.0	0.00	4-4	4.0-4.0
	solitary individuals	0				

continued

Table 30. Continued

Island	Group type	Group statistics N	Mean	± SD	Range	95% CI
Vanier	Male-only groups	6	3.3	1.51	2-6	1.8-4.9
	All mixed sex/age groups	5	2.6	0.89	2-4	1.5-3.7
	Mixed sex/age groups with calves	2	2.0	0.00	2-2	2.0-2.0
	calves included	2	2.0	0.00	2-2	2.0-2.0
	calves excluded	2	1.0	0.00	1-1	1.0-1.0
	Mixed sex/age groups without calves	3	3.0	1.00	2-4	0.5-5.5
	solitary individuals	1				

continued

Table 30. Continued

		Group statistics				
Island	Group type	N	Mean	± SD	Range	95% CI
Helena	Male-only groups	9	3.4	1.01	2-5	2.7-4.2
	All mixed sex/age groups	4	3.3	1.89	2-6	0.2-6.3
	Mixed sex/age groups with calves	1	2.0	0.00	2-2	2.0-2.0
	calves included	1	2.0	0.00	2-2	2.0-2.0
	calves excluded	1	1.0	0.00	1-1	1.0-1.0
	Mixed sex/age groups without calves	3	3.7	2.08	2-6	-1.5-8.8
	solitary individuals	5				

continued

Table 30. Continued

Island	Group type	Group statistics N	Mean	± SD	Range	95% CI
Sherard Osborn	Male-only groups	1	5.0	0.00	5-5	5.0-5.0
	All mixed sex/age groups	3	2.3	0.58	2-3	0.9-3.8
	Mixed sex/age groups with calves	2	2.0	0.00	2-2	2.0-2.0
	calves included	2	2.0	0.00	2-2	2.0-2.0
	calves excluded	2	1.0	0.00	1-1	1.0-1.0
	Mixed sex/age groups without calves	1	3.0	0.00	3-3	3.0-3.0
	solitary individuals	0				

continued

Table 30. Continued

Island	Group type	Group statistics N	Mean	± SD	Range	95% CI
"Bull"	Male-only groups	5	3.8	0.84	3-5	2.8-4.8
	All mixed sex/age groups	1	3.0	0.00	3-3	3.0-3.0
	Mixed sex/age groups with calves	0				
	calves included	0				
	calves excluded	0				
	Mixed sex/age groups without calves	1	3.0	0.00	3-3	3.0-3.0
	solitary individuals	0				

continued

Table 30. Continued

Island	Group type	Group statistics N	Mean	± SD	Range	95% CI
"Muskox"	Male-only groups	2	3.5	0.71	3-4	-2.9-9.8
	All mixed sex/age groups	1	3.0	0.0	3-3	3.0-3.0
	Mixed sex/age groups with calves	0				
	calves included	0				
	calves excluded	0				
	Mixed sex/age groups without calves	1	3.0	0.00	3-3	3.0-3.0
	solitary individuals	0				

Table 31. Group statistics for Peary caribou social formations, Bathurst Island, Northwest Territories, 7-11 July 1995

		Group statistics				
Island	Group type	N	Mean	± SD	Range	95% CI
Bathurst	Male-only groups	70	4.1	2.15	2-11	3.6-4.6
	All mixed sex/age groups	142	5.4	3.73	2-24	4.8-6.0
	Mixed sex/age groups with calves	61	7.3	4.50	2-24	6.2-8.5
	calves included	61	7.3	4.50	2-24	6.2-8.5
	calves excluded	61	5.3	3.74	2-24	4.4-6.3
	Mixed sex/age groups without calves	81	3.9	2.10	2-24	3.5-4.4
	solitary individuals	32				

Table 32. Percentage representation of breeding cows, 2+ yr-old females, 1+ yr-old females, and associated "calf:female ratios" for Peary caribou, Bathurst Island complex, Northwest Territories, 17-24 June 1995

		Females as % of N			Calves:100	Calves:100	Calves:100
Island	N[a]	Breeding cows	2+ yr-old females	1+ yr-old females	breeding cows	2+ yr-old females	1+ yr-old females
June							
Bathurst							
	521	30.3	43.0	55.1	24.0	17.0	13.2
Four[b] western major satellite islands							
	142	31.7	43.7	55.1	71.1	51.6	40.0
Two[c] northern major satellite islands							
	58	12.1	22.4	32.7	3/7[d]	3/13	3/19

continued

Table 32. Continued

Island	N	Females as % of N: Breeding cows	Females as % of N: 2+ yr-old females	Females as % of N: 1+ yr-old females	Calves:100 breeding cows	Calves:100 2+ yr-old females	Calves:100 1+ yr-old females
Two[e] secondary satellite islands							
	32	3.3	9.4	18.8	0/1	0/3	0/6
July							
Bathurst							
	963	27.3	50.7	64.5	46.0	24.8	19.5

[a] "N" equals 1+ yr-old caribou only (excludes calves of the year).
[b] Caribou were seen only on the four western major satellite islands of Alexander, Marc, Massey, and Vanier in 1995.
[c] Caribou were seen on the two northern major satellite islands Helena and Sherard Osborn islands in 1995.
[d] Fractions given instead of percentages, when total caribou seen in zone equals <30 animals to avoid possible distortion of proportions.
[e] Caribou were seen only on the two secondary satellite islands of "Bull" and "Muskox" in l995.

Table 33. Observed representations and estimates of number of newborn calves among all Peary caribou, Bathurst island complex, Northwest Territories, June-July 1995

Land division by date	Observed 1+ yr-old females	Observed % calves	Adjusted N[a]	Adjusted % calves	% of theoretical max. r[b]
17-24 June 1995					
Bathurst					
	287	6.8	516	7.4	24.7
Four western major satellite islands					
	80	18.4	165	19.4	64.7
Two northern major satellite islands					
	19	4.9	35	8.6	28.7
Two secondary satellite islands					
	6	0.0	10	0.0	0.0
17-24 June 1995					
Bathurst Island Complex					
	392	8.8	726	10.0	33.3
7-11 July 1995					
Bathurst Island					
	621	11.2	1156	10.5	35.0

[a] Adjusted on the assumption that 1+ yr-old females should equal 60% of the 1+ yr-old caribou in the sample (i.e., 40 males:60 females).
[b] Assumed to be "0.30", based on the literature (e.g, Bergerud 1978, 1980).

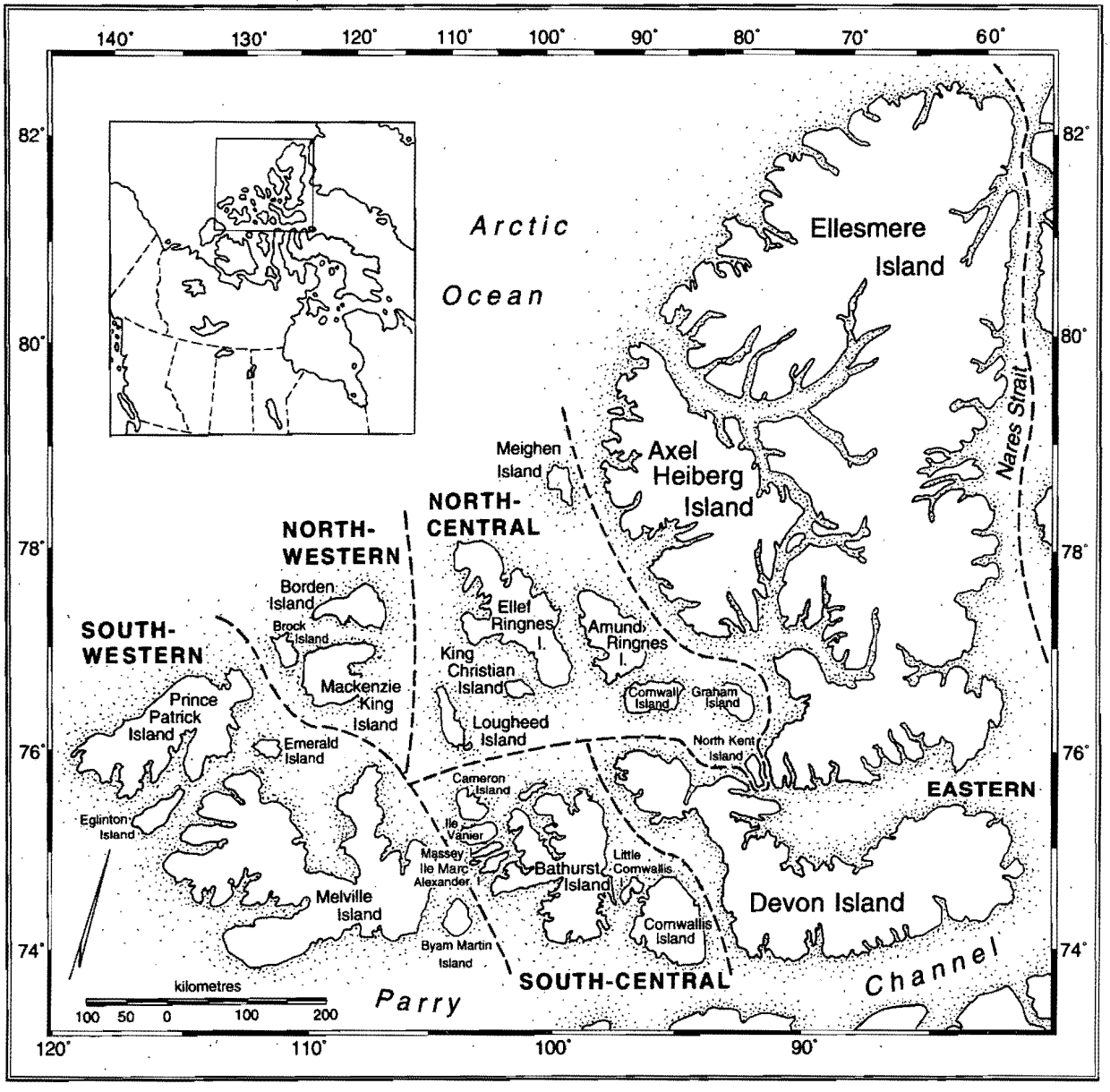

Fig. 1. Queen Elizabeth Islands of the Canadian Arctic Archipelago

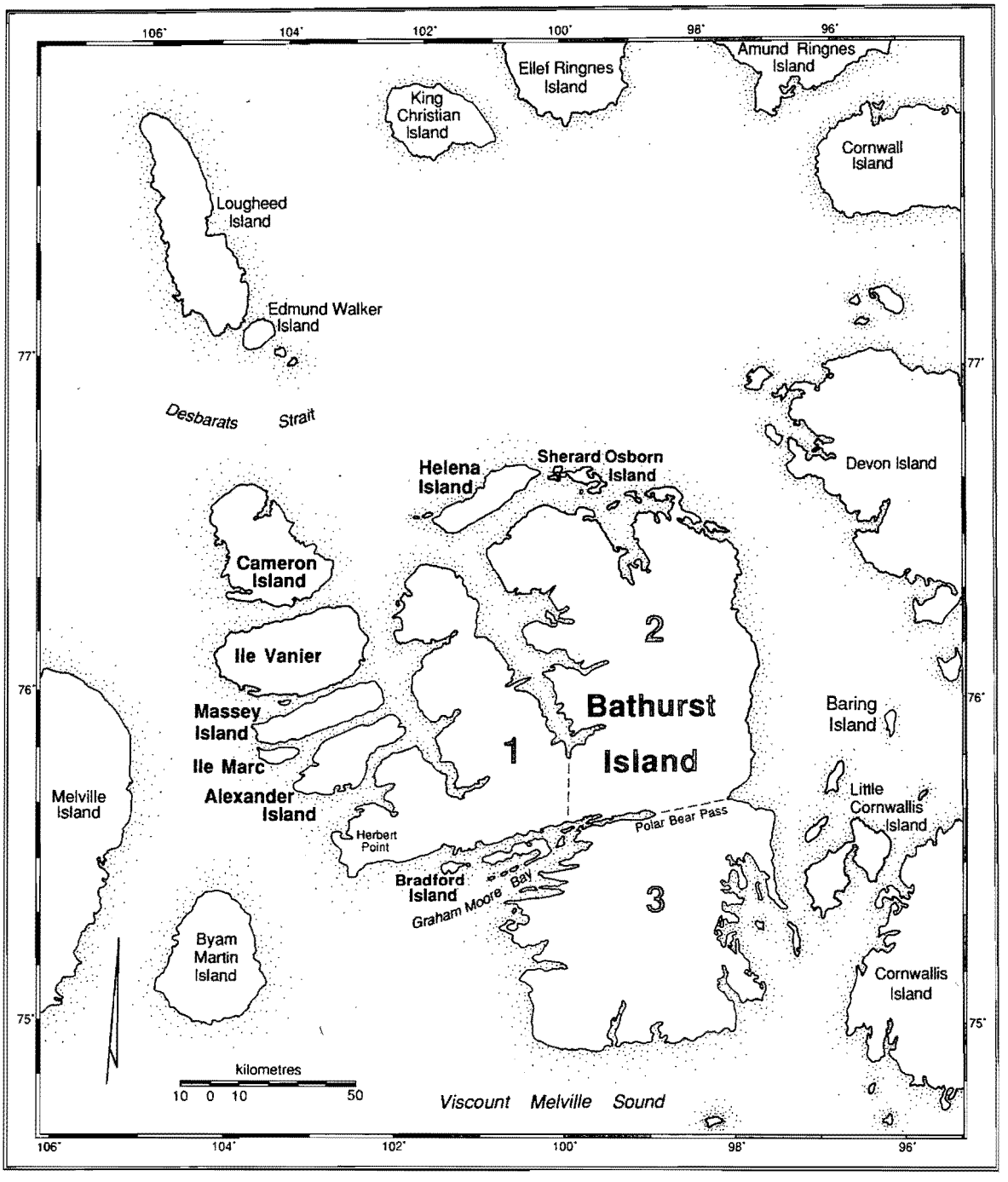

Fig. 2. Locations of nine of the 30 islands within the Bathurst Island complex, south-central Queen Elizabeth Islands , Northwest Territories: the principal island, Bathurst; the five western major satellite islands, Alexander, Marc, Massey, Vanier, and Cameron; the two northern major satellite islands, Helena and Sherard Osborn; and one of the two secondary satellite islands in Queens Channel, Baring

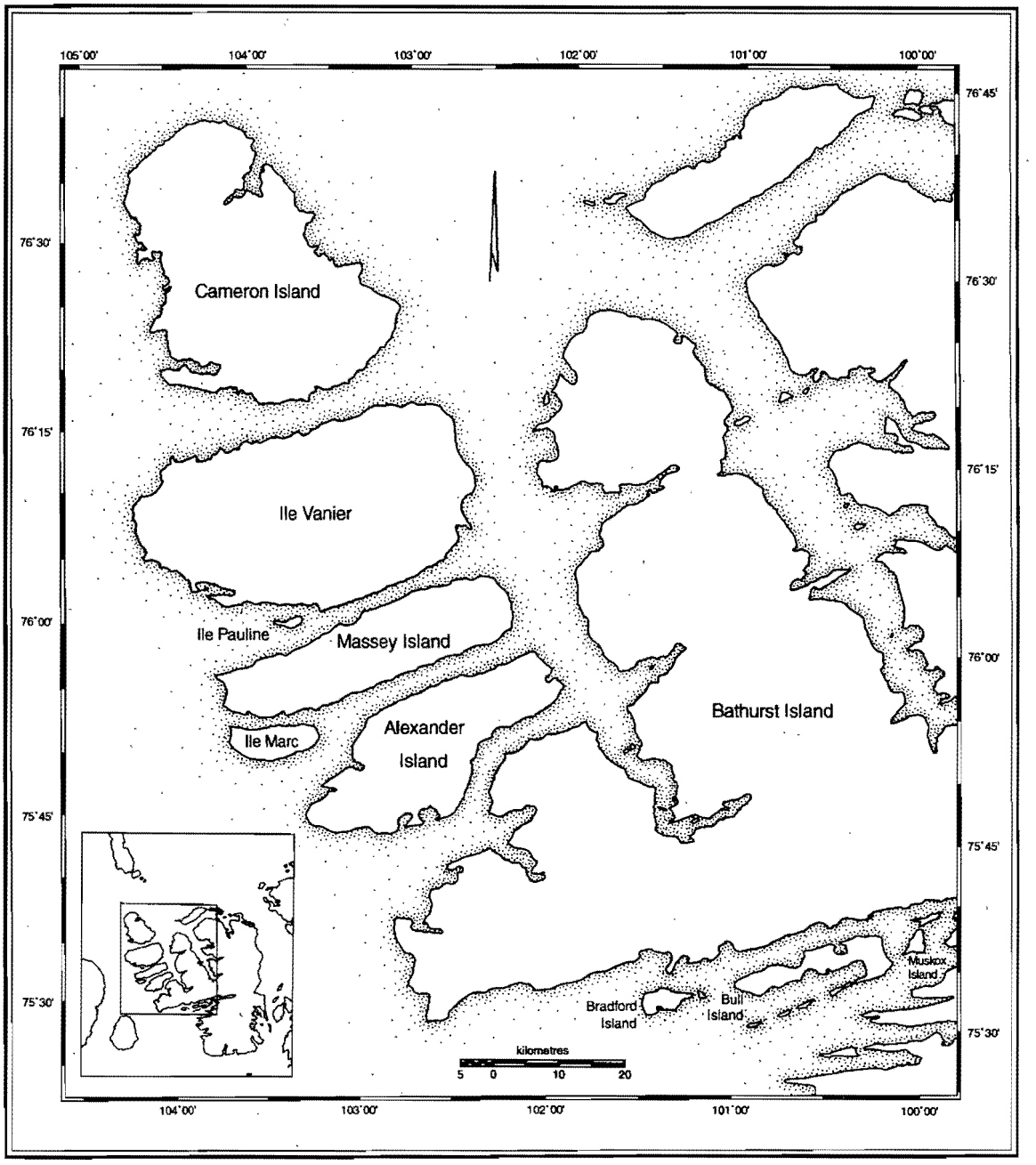

Fig. 3. Locations of nine of the 30 islands within the Bathurst Island complex, south-central Queen Elizabeth Islands , Northwest Territories: the five western major satellite islands, Alexander, Marc, Massey, Vanier, and Cameron; the one western secondary satellite island, Ile Pauline; and the three west-central secondary satellite islands, Bradford, "Bull", and "Muskox"

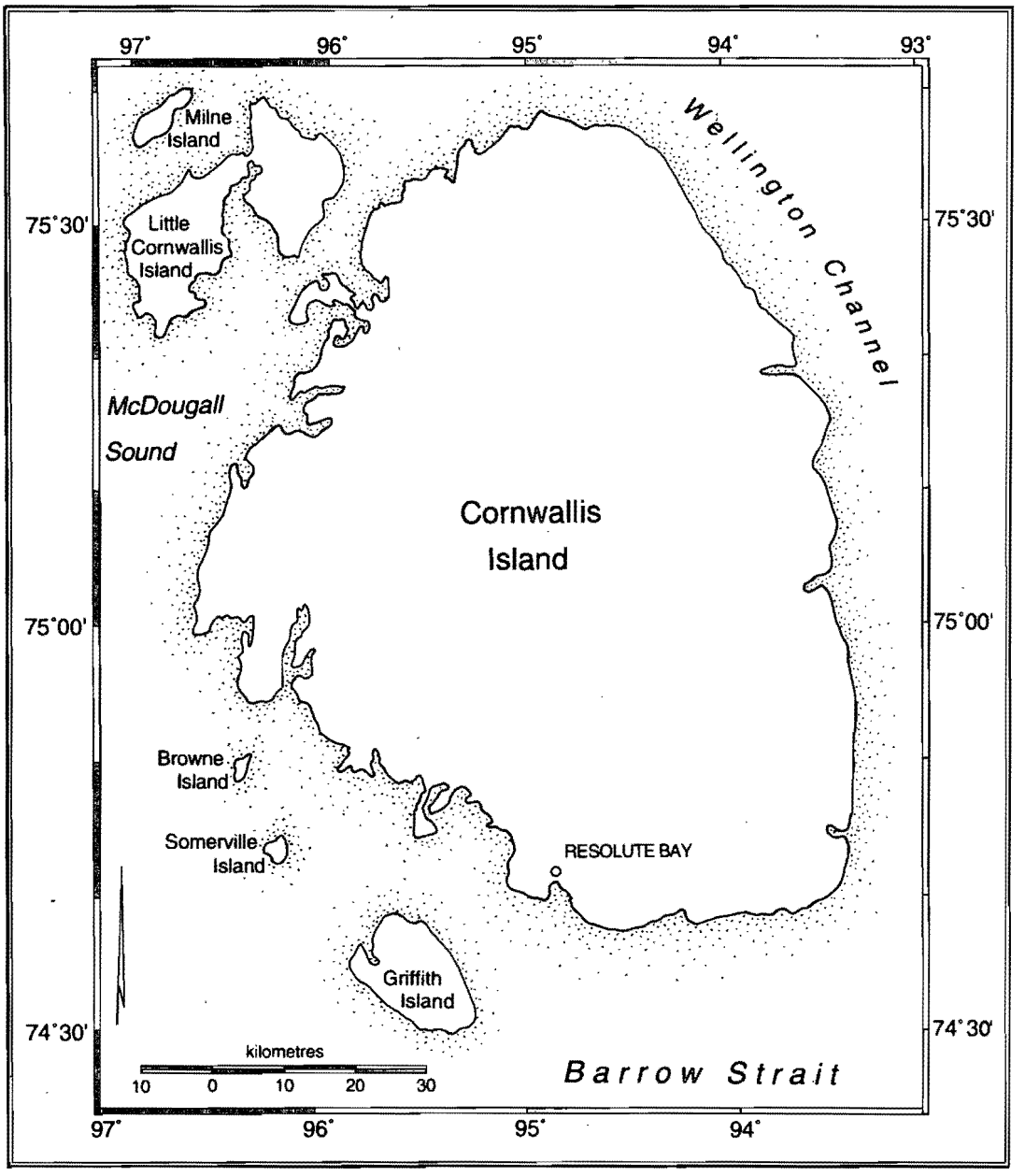

Fig. 4. Locations of two of the 30 islands within the Bathurst Island complex, south-central Queen Elizabeth Islands, Northwest Territories: the two eastern major satellite islands, Cornwallis and Little Cornwallis

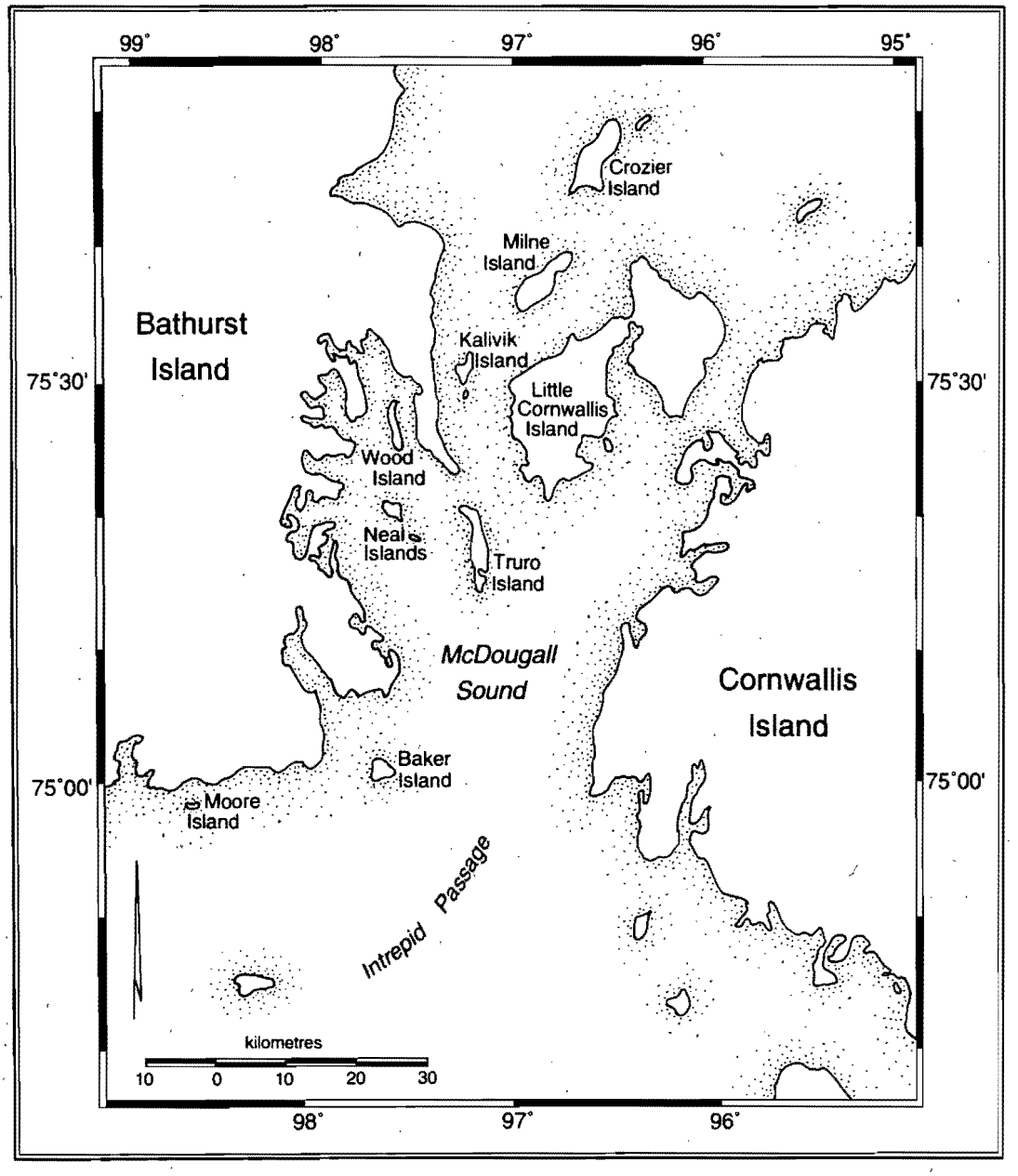

Fig. 5. Locations of eight of the 30 islands within the Bathurst Island complex, south-central Queen Elizabeth Islands, Northwest Territories: the two secondary satellite islands in Intrepid Passage, Baker and Moore; the three secondary satellite islands in McDougall Sound, Neal, Truro, and Wood; the two secondary satellite islands in Crozier Strait, Kalivik and Milne; and one of the two secondary satellite islands in Queens Channel, Crozier

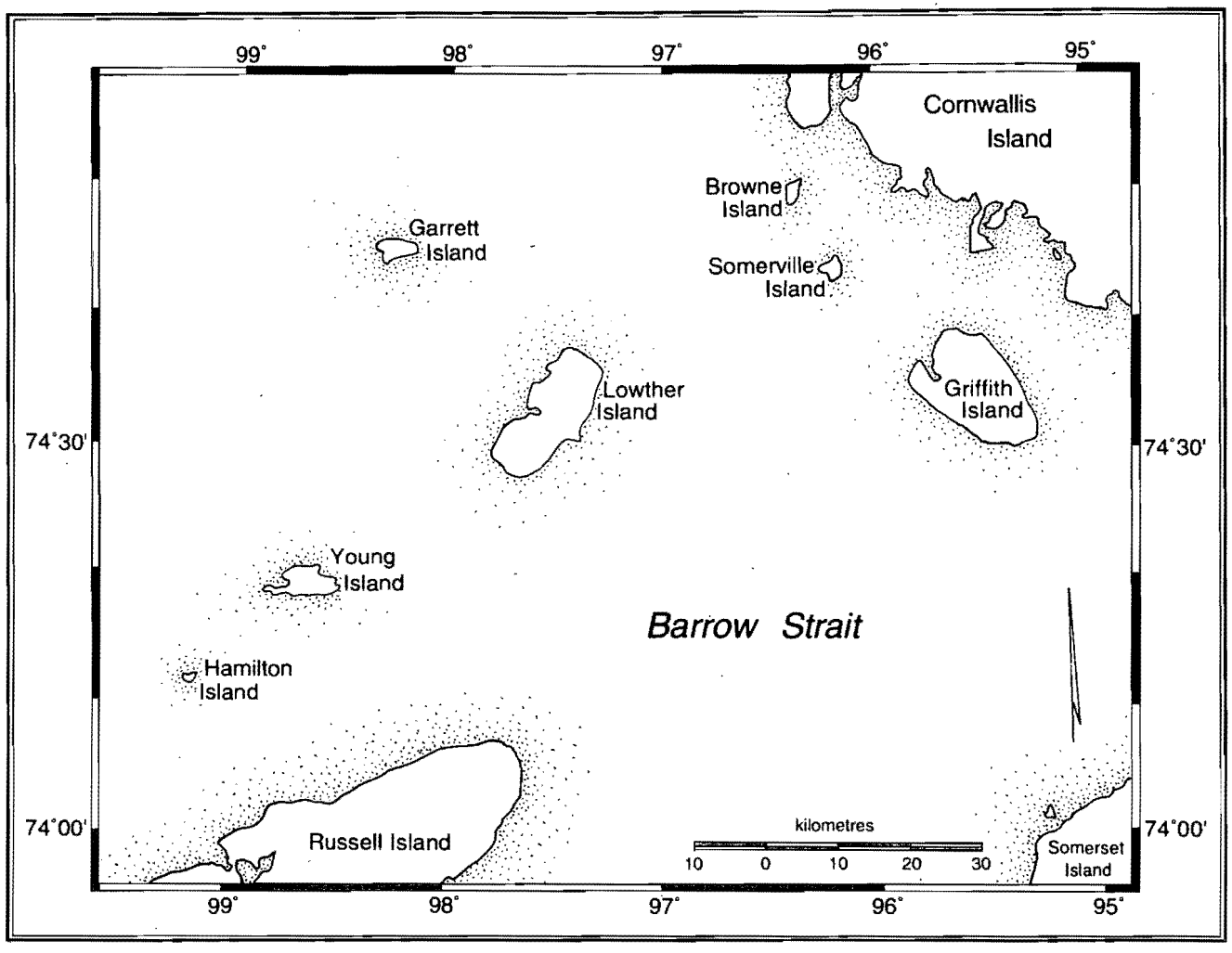

Fig. 6. Locations of seven of the 30 islands within the Bathurst Island complex, south-central Queen Elizabeth Islands, Northwest Territories: the seven secondary satellite islands in Barrow Strait, Browne, Garrett, Griffith, Hamilton, Lowther, Somerville, and Young

Appendix 1. Past and present conditions for Service Argos Inc. "Location Class" determinations

Old system (through May 1994)		New system (from June 1994)	
Classes	Conditions	Classes	Conditions
Standard		Standard	
3	- 5 messages received in 402 s - good geometric conditions - low residual error	3, 2, 1, 0	- 4 messages received - location result passes at least 2 of the 4 plausibility tests (for location to be made available) - location accuracy is estimated for all classes
2	- 5 messages received in 420 s		
1	- 4 messages received in 420 s		
Non-standard		Service Plus[a]	
0	- any locations rejected by the other classes	A	- 3 messages - 2 plausibility tests are done

continued

Appendix 1. Continued

Old system (through May 1994)		New system (from June 1994)	
Classes	Conditions	Classes	Conditions
	- less than 4 messages		- accuracy is not estimated - frequency is calculated
		B	- 2 messages
			- 2 plausibility tests are done
			- accuracy and frequency are not estimated
		Z	- location not validated

[a] Location-data for "Service Plus" is called "Auxiliary Processing" in North America.

Appendix 2. Sizes and percentage representations of search zones and major land areas of Bathurst Island (16 090 km^2), south-central Queen Elizabeth Islands, Northwest Territories

No.	Zone	Size (km^2)	% of stratum	% of island
Search zones No. 1-12 (16 090 km^2)				
01	NEC	428.6	-	2.66
02	NEI	4163.5	-	25.88
03	SEC	793.7	-	4.93
04	SEI	1533.8	-	9.53
05	SC	515.7	-	3.20
06	SWC	659.2	-	4.10
07	SWI	1503.8	-	9.35
08	NWC	933.6	-	5.80
09	NWI	2076.4	-	12.91
10	NCW	1070.0	-	6.65
11	NCE	1669.6	-	10.38
12	NPBP	388.3	-	2.41
13	SPBP	353.8	-	2.20
Stratum I (4080 km^2)				
08	NWC	933.6	22.88	5.80
09	NWI	2076.4	50.89	12.91
10	NCW	1070.0	26.23	6.65
		4080.0	100.0	25.36

Continued

Appendix 2. Continued

No.	Zone	Size (km^2)	% of stratum	% of island
Stratum II (6650 km^2)				
1	NEC	428.6	6.44	2.66
02	NEI	4163.5	62.61	25.88
11	NCE	1669.6	25.11	10.38
12	NPBP	388.3	5.84	2.41
		6650.0	100.00	41.33
Stratum III (5360 km^2)				
03	SEC	793.7	14.81	4.93
04	SEI	1533.8	28.61	9.53
05	SC	515.7	9.62	3.20
06	SWC	659.2	12.30	4.10
07	SWI	1503.8	28.06	9.35
13	SPBP	353.8	6.60	2.20
		5360.0	100.00	33.31
NE Bathurst Is. (6650 km^2 = St. II)				
01	NEC	428.6	-	2.66
02	NEI	4163.5	-	25.88
11	NCE	1669.6	-	10.38
12	NPBP	388.3	-	2.41
		6650.0		41.33
NW Bathurst Is. (4080 km^2 = St. I)				
08	NWC	933.6	-	5.80
09	NWI	2076.4	-	12.91
10	NCW	1070.0	-	6.65
		4080.0		25.36

Continued

Appendix 2. Continued

No.	Zone	Size (km^2)	% of stratum	% of island
SE Bathurst Is. (2694.5 km^2)				
03	SEC	793.7	-	4.93
04	SEI	1533.8	-	9.53
05 (30%)	SC	154.7	-	0.96
13 (60%)	SPBP	212.3	-	1.32
		2694.5		16.74
SW Bathurst Is. (2665.5 km^2)				
06	SWC	659.2	-	4.10
07	SEI	1503.8	-	9.35
05 (70%)	SC	361.0	-	2.24
13 (40%)	SPBP	141.5	-	0.88
		2665.5		16.57
N Bathurst Is. (10 730.0 km^2)				
01	NEC	428.6	-	2.66
02	NEI	4163.5	-	25.88
08	NWC	933.6	-	5.80
09	NWI	2076.4	-	12.91
10	NCW	1070.0	-	6.65
11	NCE	1669.6	-	10.38
12	NPBP	388.3	-	2.41
		10 730.0		66.69

Continued

Appendix 2. Continued

No.	Zone	Size (km^2)	% of stratum	% of island
S Bathurst Is. (5360.0 km^2)				
03	SEC	793.7	-	4.93
04	SEI	1533.8	-	9.53
05	SC	515.7	-	3.20
06	SWC	659.2	-	4.10
07	SWI	1503.8	-	9.35
13	SPBP	353.8	-	2.20
		5360.0		33.31
E Bathurst Is. (9344.5 km^2)				
01	NEC	428.6	-	2.66
02	NEI	4163.5	-	25.88
03	SEC	793.7	-	4.93
04	SEI	1533.8	-	9.53
05 (30%)	SC	154.7	-	0.96
11	NCE	1669.6	-	10.38
12	NPBP	388.3	-	2.41
13 (60%)	SPBP	212.3	-	1.32
		9344.5		58.07

continued

Appendix 2. Continued

No.	Zone	Size (km^2)	% of stratum	% of island
W Bathurst Is. (6745.5 km^2)				
05 (70%)	SC	361.0	-	2.24
06	SWC	659.2	-	4.10
07	SWI	1503.8	-	9.35
08	NWC	933.6	-	5.80
09	NWI	2076.4	-	12.91
10	NCW	1070.0	-	6.65
13 (40%)	SPBP	141.5	-	0.88
		6745.5		41.93

Appendix 3. Canadian Wildlife Service report on an investigation of muskoxen within the Bathurst Island complex, Northwest Territories, June-July 1995

MUSKOX INVESTIGATION, BATHURST ISLAND COMPLEX, NORTHWEST TERRITORIES, JUNE-JULY 1995

1. INTRODUCTION

I met with the Government of the Northwest Territories (GNWT), Department of Renewable Resources (DRR), Resource Officer and members of the Resolute Bay Hunters & Trappers Organization (HTO) in Resolute , Northwest Territories (NWT), on 12 June 1995. We discussed the evidence that they had found for a high rate of winter deaths among muskoxen *(Ovibos moschatus)* in the Eleanor Lake area of Cornwallis Island (specimens had been collected by the Resolute, GNWT, DRR, Resource Officer from several dead muskoxen and sent for analyses to the Western College of Veterinary Medicine at Saskatoon). The Resource Officer and the members of the HTO appraised me of their findings and their concern for the possibility that the muskox deaths could have been caused by infectious disease. They knew of the reported Yersiniosis (*Yersinia pseudotuberculosis*) in muskoxen on Banks Island and that Yersiniosis is a disease communicable from animals to humans under natural conditions (Blake *et al.* 1989). They expressed concern for the possibility of tainted water supplies being used by summer field parties, and wanted more information on the extent of the apparent muskox winter die-off. I agreed with them that the matter should be investigated further. Therefore, I volunteered to shift some of my resources into a more intensive and extensive aerial search for muskox carcasses and to cursorily assess the status of the muskox population within the Bathurst Island complex. The following is a report of my field activities and findings related to muskoxen within the Bathurst Island complex, south-central Queen Elizabeth Islands, in June and July 1995.

2. PROCEDURES

A Bell 206L ("Jet Long Ranger") turbo-helicopter on high skid gear and equipped with an onboard Global Positioning System (GPS) was used as the search aircraft. The helicopter was flown mainly at 30 to 90 m above ground level and at airspeeds of *ca.* 96 to 160 km per hour but at lower altitudes and slower airspeeds, including hovering, for brief periods when making some sex/age segregation and when examining

carcasses, carcass sites, and areas immediately adjacent to them. I used a 3-person search crew: pilot-navigator-spotter (right front seat); spotter-observer-recorder (left front seat); and spotter-observer (right rear seat). The crew maintained voice contact by use of an internal intercommunication system. Whenever a carcass was spotted, the helicopter was set down next to it, and we made a brief visual inspection of the death site and the remains. The inspection was done either from the helicopter or on foot, if the remains were sufficient to warrant closer inspection. The location of the carcass was read from the onboard GPS and recorded in a field notebook along with the species involved; sex/age category of carcass, if discernible; and whatever other particulars of note that could be gleaned during the brief visual inspection. When we encountered live muskoxen the observation was recorded by species, group size, and sex/age composition of all animals involved in each sighting. Each sighting included either a solitary individual or a social grouping of two or more individuals.

The Bathurst Island complex was divided into "search zones" to evaluate findings on a spatial basis. I divided Bathurst Island into 13 search zones for the purpose of nonsystematic aerial searches: (1) northeast coast (NEC); (2) northeast interior (NEI); (3) southeast coast (SEC); (4) southeast interior (SEI); (5) south coast (SC); (6) southwest coast (SWC); (7) southwest interior (SWI); (8) northwest coast (NWC); (9) northwest interior (NWI); (10) north coast, western section (NCW); (11) north coast, eastern section (NCE); (12) north Polar Bear Pass (NPBP); and (13) south Polar Bear Pass (SPBP). Additionally, each of Bathurst Island's major and secondary satellite islands was treated as a separate search zone. Zones 12 and 13 Polar Bear Pass (PBP), include all of the lowlands from the middle of the valley north to the crest of high ground and a nearly equal distance to the south from near the head of Goodsir Inlet through the pass to near the head of Bracebridge Inlet. All coastal search zones consist of strips of land that extend about 5 km inland from the sea coast, with the one exception of PBP. For comparisons of major land divisions, PBP is considered as a "coastal site" in the "Coastal vs. Interior" comparison because of the "shoreline effect" created by the river-lake system passing through the wet central lowlands of the pass. The middle lowlands of PBP, through central Bathurst Island, was used to divide Bathurst into north and south sections (Miller 1995: the common boundary of survey Stratum (St.) II and St. III, Fig. 2). The northern portion of Bathurst Island was divided into eastern and western

halves along the common land and water boundaries of St. I and St. II (Miller 1995: Fig. 2). The southern portion of Bathurst Island was divided in half on an east and west basis along the 99° 00' W meridian (passing just west of the head of Bracebridge Inlet at the north end to just west of Dyke Ackland Bay on the south coast. Also, in the "East vs. West" comparison, all of the NPBP and 60% of the SPBP are included in the "East" and 40% of the SPBP is included in the "West"; and 30% of the SC is included in the East and 70% of the SC in the West.

We had continual helicopter support between 17 June and 12 July 1995 and only then, when weather permitted. We carried out two sets of low-level (l00 m or less above ground level) nonsystematic aerial searches to obtain sex/age composition counts (the results also could be used as "minimal population counts"): 17-24 June, 27 hours; and 7-11 July, 18 hours (Table 1). Muskoxen, and caribou *(Rangifer tarandus pearyi),* were counted and segregated during the 1st set of searches (but only caribou during the 2nd set of searches). We also searched for muskox (and caribou) carcasses during the above two periods. In addition, we expended an additional 20 hours searching for carcasses, primarily in habitats or sections of Bathurst Island preferred by muskoxen (the remainder of the airborne time, 15 hours, was devoted to high-level, 900-1800 m above sea level, radio telemetry tracking flights for satellite-collared caribou).

3. FINDINGS

In general, weather and background conditions were not conducive to aerial searches during June 1995 (and high-level flights essentially were not possible in the helicopter during that time period). The mottled background (snow-covered vs. snow-free patches) in the last half of June 1995 hindered the detection of carcasses (particularly caribou carcasses). Continual low overcast and frequent fog prevented any aerial searches from 25 June until 2 July 1995. Sunny periods prevailed throughout the day on only 6 days from 17 June to 12 July 1995.

3.1. Muskox Carcasses

We found 50 muskox carcasses between 17 June and 12 July 1995 (Tables 2, 3). The 50 carcasses were classified as 21 bulls, 18 yearlings, 9 juveniles, 1 cow, and 1 calf (1994 calf , 4-6 months old). The 21 bulls made up the largest single portion of the sample of 50

muskox carcasses and their "observed/expected" ratio was 1.16, based on the frequency of occurrence of bulls in the sample of 868 live muskoxen. The rate of occurrence for bulls in the sample of 50 carcasses could be expected by chance alone ($P > 0.30$), however, when compared to all other sex/age groupings at their proportional representation in the count of live muskoxen made in late June 1995. The 18 yearlings in the sample of 50 muskox carcasses do occur, however, at a rate greater than expected by chance ($P < 0.02$), when their maximum probable representation in the population is considered to be 20% (which is a reasonable assumption, as 20% slightly exceeds the maximum rate reported in previous years, and any percentage less than 20% would also result in an overrepresentation of yearlings). It is likely that juveniles are also overrepresented among the 50 muskox carcasses (but nonsignificantly so, when their representation in the population is assumed to be 10% or more; $P > 0.05$). At 9% or less representation in the population, juveniles would be significantly overrepresented among the 50 carcasses ($P < 0.05$). Any assumption about the likely representation of juveniles in the population is, however, more tenuous. Most 1994 calves that died between the ages of 4 and 6 months in early winter 1994/95 would have been so completely utilized by predators/ scavengers by summer 1995 that either there would be no evidence of their deaths left or their sparse remains would have gone undetected (also, 1994 calves technically should be classified as yearlings in the 1995 sample). Only cows are obviously markedly underrepresented in the sample of 50 muskox carcasses ($P < 0.005$).

We know that 36% of the 832 1+ yr-old live muskoxen counted in late June 1995 were 3+ yr-old bulls (see Table 4). We reasonably can assume (based on our observations of the mixed sex/age herds) that at least 50% of the 530 animals classified as "others" were 3+ yr-old cows (32% of the 832). We can further assume that the remaining 265 "others" could be divided evenly among 2-yr olds (132 = 16% of 832) and yearlings (133 = 16% of 832), based on data from Spencer and Lensink (1970: as detailed below). The resultant sex/age composition for a hypothetical muskox population within the Bathurst Island complex compares closely with Spencer and Lensink's (1970: 7; Table 2) sex/age composition calculations for the Nunivak Island muskox population obtained in April 1968: where a hypothetical population was extrapolated that yielded 37.5% 3+ yr-old bulls; 30% 3+ yr-old cows; 16.1% 2-yr olds; and 16.4% yearlings. The resultant sex/age composition

for the hypothetical muskox population within the Bathurst Island complex can be used as the "expected" sex/age composition of the sample of 50 muskox carcasses. When we do so, we find that in this collective consideration of the four sex/age groupings, the majority (51%) of the contribution to the Chi-square value (χ^2 = 27.66, 3df; P <0.005) is made by the underrepresentation of cows in the carcass sample; followed relatively closely by the 45% that is contributed by the overrepresentation of yearlings in the carcass sample; and that only the remaining 4% of the Chi-square value is actually contributed by the low overrepresentation of juveniles (2%) and bulls (2%). Thus, only cows remain distinctly underrepresented and yearlings markedly overrepresented in the sample of 50 muskox carcasses.

We found 45 of the 50 carcasses on Bathurst Island; 4 additional ones on Alexander Island; and the remaining one was on Cameron Island. The overall proportional distribution of the 50 carcasses on a relative landmass basis was as expected by chance alone (P >0.20), when the number of carcasses found on each island was compared to the land area of each of the three islands (i.e., Bathurst, 16 090 km^2, 45 carcasses; Alexander, 490 km^2, 4 carcasses; and Cameron, 1060 km^2, 1 carcass). A similar nonsignificant relationship (P >0.30) pertained, when the proportional number of carcasses found on each island was compared to the relative amount of time expended in the searches on each island. The distribution of the 45 carcasses on Bathurst Island was significantly different (P <0.005), however, when the 22 carcasses found in the PBP area on central Bathurst were compared to the 16 carcasses found on northern Bathurst (north of PBP), and to the 7 carcasses found on southern Bathurst (south of PBP). The same pattern existed with a greater than expected rate (P <0.005) for the frequency of occurrence of carcasses in the PBP area, when based on a comparison among the number of carcasses found in each of the three major land divisions of Bathurst Island and the relative amount of time expended in searches in each of those divisions.

No muskox carcasses were found within 5 of the 13 search zones on Bathurst Island, which represented over half (56%) of the islands' land area (Tables 2, 3). On the remainder of the island, where muskox carcasses were found, the carcasses occurred at greater rates than expected by chance alone in 3 of the 8 zones (Table 3). The preponderance of muskox carcasses in the PBP area suggests that either

a greater proportion of the muskoxen wintering in PBP died during winter 1994/95 than elsewhere on the island or, more likely, that proportionally more (perhaps, the majority) of the muskoxen then on Bathurst Island tried to winter in PBP sometime during late winter 1994/95 and spring 1995.

No strong pattern could be discerned from the visual inspection of the actual death sites. Carcasses were found in wet sedge meadows (typical muskox habitat), on elevated knolls and slopes in or immediately adjacent to lowlands (areas that could have served as late winter range), and on, seemingly, marginal sites on windblown, exposed ridges at intermediate and at relatively high elevations (where then prevailing environmental conditions likely forced the muskoxen to go). There appeared to be a weak tendency for relatively close associations of carcasses ("clustering" or "clumping") within larger land divisions, seemingly, suggesting that those animals in each cluster or clump might all have been members of the same herd or that they were from different herds and simply seeking out isolated and restricted pockets of favourable habitats (available forage).

Utilization of the 50 muskox carcasses by predators or scavengers varied extremely. More than half (52%, 26) of them had been completely utilized, or nearly so, by predator(s) or scavenger(s). An additional 6% (3) had received only moderate to light utilization. For unknown reasons, however, 42% (21) of the 50 muskox carcasses had not been fed on and remained essentially entirely intact, except for three of them that each had their rumen opened up but still in place. Why these 21 carcasses still were essentially unused by predators or scavengers, when found in summer 1995, cannot be explained with confidence. Also, for reason(s) unknown, the proportion of carcasses utilized vs. those that were unused was roughly comparable among the search zones where carcasses were found on Bathurst Island: NPBP, 6 utilized/6 unused; SPBP, 8/4; NCW , 3/3; NCE, 3/3; SWC, 2/3; NEC, 2/1; SWI, 1/1; and NWC, 1/0. It is possible that all or many of them had been buried in the snow cover during late winter and had only recently melted out. It also is possible that many or all of the animals whose carcasses were unused when found had died in spring 1995, not too long before our finding them. Thus, we would have found them before they were detected by individuals of the low-density populations of would-be scavengers within the Bathurst Island complex. For the most part, when a muskox carcass was fed on, it

was utilized extensively. I judge that a wolf or wolves were involved in all 29 cases where the carcass was markedly utilized, based on the amount of removal and degree of damage to the skeleton: rib cage, leg bones, vertebrae, or skull. Among the 21 bulls, 11 were considered "Completely Utilized," 2 "Heavily Utilized," 2 had only their rumens opened up, and 6 remained essentially intact. Only 5 of the 18 yearling carcasses were "Completely Utilized," 1 was "Heavily Utilized," 1 was "Lightly Utilized," 1 had only the rumen opened up, and 10 were essentially intact. Only 3 of the 9 juveniles were "Completely Utilized," 2 were "Heavily Utilized," 1 was "Moderately Utilized," 1 was "Lightly Utilized," and 2 were essentially intact. The one cow and the one 1994 calf were "Completely Utilized."

3.2. Muskox observations

We counted 868 live muskoxen and segregated them by sex/age groupings between 17 and 24 June 1995: 88% (760) of them were seen on Bathurst Island; and the remaining 12% (108) animals were seen collectively on five of the small islands immediately to the west of central and northern Bathurst (Table 4). We classified 35% (302) of the live muskoxen as bulls, only 4% (36) were calves of the year, and the remaining 61% (530) were classed as "others," which included all females 1+ year-old and all juvenile and yearling males, and probably some 3-yr-old males.

We made 144 sightings of muskoxen: 62% (89) of those observations were of muskoxen in mixed sex/age herds; an additional 33% (47) were of "bull-only" herds; and the remaining 5% (8) were of single bulls (Tables 5, 6). The number of muskoxen seen per sighting averaged 6.0 ± 4.51 SD and ranged from 1 to 22 individuals. Eighty-five percent of the sightings were made on Bathurst Island and the other 15% were on five satellite islands to the west and northwest of Bathurst (Table 5-8).

On average, about 54 muskoxen were seen per 100 min of aerial search effort. Muskoxen were most common on the PBP lowlands of central Bathurst Island, 43% (328) of the 760 muskoxen seen on Bathurst Island. Muskoxen also were more common on coastal sites and in the south and the west of Bathurst Island than on interior sites and the north and the east of Bathurst Island (Tables 9, 10: 2.3:1, 2.2:1, and

2.4:1, respectively; P<0.005) as was found in August 1993 (Miller 1995: 1.7:1, 2.8:1, and 3.5:1).

Both the number of sightings made and the number of muskoxen seen were significantly overrepresented (P <0.005) in the PBP area of central Bathurst Island, when compared to the remainder of the island on a relative landmass basis or by frequency of occurrence (Tables 7, 8). Nearly 38% of all the sightings and 43% of all muskoxen seen on Bathurst island were in the PBP area during only 10% of the aerial search effort on Bathurst Island. Although there was no significant difference between the number of sightings made or the number of muskoxen seen in the NPBP search zone vs. the SPBP search zone (Table 7, 8), there were some significant differences among contributions made by some of the social groupings seen in the NPBP zone vs. the SPBP zone. The number of bull-only herds and the number of bulls in those herds were both significantly overrepresented in the NPBP zone compared to in the SPBP zone (P <0.05 and P <0.005, respectively). The number of mixed sex/age herds with calves present was not significantly different (P >0.5) between NPBP and SPBP, but the number of muskoxen in those herds in the NPBP was significantly greater (P <0.005) than those within the SPBP. However, the number of calves present in mixed sex/age herds in NPBP did not vary significantly from the number in mixed sex/age herds in SPBP (P >0.1). The number of mixed sex/age herds with no calves present was also nonsignificantly different (P >0.1) in NPBP vs. SPBP, but the number of muskoxen present in those herds was significantly greater (P <0.005) in the SPBP zone than in the NPBP zone. This is the opposite condition of that found for the number of muskoxen in mixed sex/age herds with calves present.

Observations of muskoxen were made more frequently than expected by chance alone (P < 0.005) in the PBP area, when compared to southern Bathurst Island, the five satellite islands, and northern Bathurst Island. This same pattern of relative importance pertains to the distribution of muskox herds on a proportional landmass basis (P <0.005), suggesting that muskoxen were exhibiting a strong preference for the PBP lowlands in June 1995. The relatively large number of carcasses in the PBP area also supports the possibility of disproportionally high use of the area during, at least, late winter 1994/95 and spring 1995, when most muskoxen likely died (cf. Miller *et al.* 1977, Lent 1978, Gunn 1982).

The 23 mixed sex/age herds with calves present averaged significantly larger than the 66 mixed sex/age herds with no calves present (Table 6: $P < 0.05$). The larger mean herd size of the 23 mixed sex/age herds with calves present cannot be explained by the relative contribution that bulls or calves made to all of those herds. The average rate of bulls present in mixed sex/age herds with calves present was similar to the mean rates of bulls present in mixed sex/age herds with no calves present and in all mixed sex/age herds (2.2 with calves vs. 1.8 without calves vs. 1.9 in all mixed sex/age herds: $P > 0.20$). When all the calves are excluded from every herd and the mean herd sizes are calculated based only on 1+ yr-old animals, the mean size of the 23 mixed sex/age herds remains significantly larger than the mean herd size for the 66 mixed sex/age herds that never had any calves in them when seen (Table 6: $P < 0.005$). Therefore, the calves do not account for the significant contribution to the larger mean herd size for 23 mixed sex/age herds that had calves in them vs. the 66 mixed sex/age herds with no calves present when seen. It is those animals that fall into the "others" classification that make the significant contribution to the larger mean herd size for the 23 herds with calves present vs. the 66 herds without calves present: ("others": in the 23 herds with calves, mean equals 9.3 ± 0.81 SE vs. the 66 herds with no calves, where the mean equals 4.8 ± 0.32 SE; $P < 0.05$). Unfortunately, we have no exact measure of cows, yearlings, and juveniles within the "others" category; so, we cannot refine this consideration to a more useful level.

Bull-only herds averaged significantly smaller than all mixed sex/age herds (Table 6: $P < 0.05$). Sixty-four percent of the 47 bull-only herds occurred as pairs, 17% as groups of 3, 13% as groups of 4, 4% as groups of 5, and 2% as one group of 6. Nearly half (49%) of the 124 muskoxen seen in the 47 bull-only herds were represented by the 30 pairs, 19% by the 8 groups of 3, 19% by the 6 groups of 4, 8% by the 2 groups of 5, and 5% by the 1 group of 6. The sighting of only 8 solitary bulls among 868 muskoxen in late June of the year seems to represent a rather low rate of solitary bulls in the muskox population at that time of the year. This condition possibly could be a reflection of any one or more of several environmentally-forced events: disproportionately heavy mortality among single bulls during winter 1994/95 (cf. Gunn *et al.* 1989); solitary bulls joining together with other single bulls to form bull-only herds; and solitary bulls joining already established bull-only or mixed sex/age herds.

3.3. Muskox Calves

We saw only 36 (4%) calves among the 868 muskoxen that we segregated (Table 4). Those calves occurred in 23 discrete mixed sex/age herds at a mean rate of 1.6 ± 0.66 SD and ranged from 1 to 3 calves per herd (Table 11). All but three of the 36 calves were seen on Bathurst Island; therefore, no between- or among-island breakdown is warranted. There were no calves present in 74% (66) of the 89 mixed sex/age herds seen, indicating that on average, cows in 3 out of every 4 herds had failed to produce or rear a viable offspring in 1995.

Although we made no exact count of the number of cows within the sample of 530 "others" (Table 4), I believe from my brief observation of each herd, that there was at least one cow present (and usually more than one) in every one of the 89 mixed sex/age herds. Thus, when we assume that 50% of the 214 "others" seen in the 23 herds with calves present were cows, we find that on average, even when calves were present, only 1 in 3 of the cows had a calf at heel in late June 1995. If we assume that cows represented as much as two-thirds (67%) of the animals classified as "others", the yield drops to only 1 in every 4 cows with a calf at heel. This speculation suggests that only 25-33% of the expected 1995 muskox calf production was still alive in late June 1995. We could take an opposite approach and assume that 20% calves among all muskoxen segregated should be the maximum representation of calves. That means that 174 calves should have been produced by cows in the sample of 868 muskoxen. This approximate same value also can be reached by assuming that 50% of the muskoxen classified as "others" were cows but only 70% of them were bred (530 x 50% x 70%). That would yield 21% calves. In either case (20% or 21%), only 1 cow in 5 would still had a calf at heel in late June 1995, suggesting that as little as 20% of the expected 1995 calf crop remained alive.

4. DISCUSSION

The cause(s) of death was not determined with confidence for any of the 50 muskoxen whose carcasses were found by us within the Bathurst Island complex. The working assumption is, however, that the primary cause of death in all or most cases was extreme malnutrition brought on by prolonged undernutrition caused by unfavourable snow/ice conditions during winter 1994/95. High proportional representation of carcasses from bulls and yearlings in this sample is consistent with two other samples of muskoxen where most apparently died from extreme

malnutrition (cf. Parker *et al.* 1975, Gunn *et al.* 1989). Whether wolves preyed on any significant number of these muskoxen either before or when the muskoxen were in an advanced weakened state from prolonged undernutrition is unknown. The assumption of environmentally-induced malnutrition is strengthened by the following findings: evidence for malnutrition in the samples examined by staff at the Western College of Veterinary Medicine (E. Doig, A. Gunn, Dep. Renewable Resources, pers. commun.,1995); the high proportional rates for yearlings, and to lesser extents, for bulls and juveniles among the 50 muskox carcasses, and the extreme lack of cows in that sample; and the low proportional representation of calves in the count of live muskoxen obtained in late June 1995 (only 36 calves among 868 muskoxen). The poor representation of calves emphasizes, however, that although most cows apparently were able to survive the rigours of winter 1994/95, their deteriorated nutritional state did not allow many of them to bring their fetuses to full-term or to produce and rear a viable offspring (the possibility exists, although seemingly much less likely, that many cows did not even breed or they did not conceive in autumn 1994).

The low 4% contribution by calves in the sample of live muskoxen during late June 1995 indicates either extremely poor initial calf production or exceptionally high early calf mortality or a combination of both in 1995. These conditions together with the high carcass count indicate that the muskox population within the Bathurst Island complex has suffered a depression in its potential population growth from June 1994 to July 1995. The general evidence of an apparent widespread lethal state of extreme malnutrition among muskoxen in winter 1994/95 supports mainly the lack of initial calf production in 1995. This condition could have resulted from any or all of the following events: failure of bulls to enter into the rut, or more likely, cows being unreceptive to advances by rutting bulls and a resultant low rate of pregnancy among breeding age cows; failure of many cows to carry viable fetuses to full-term; production by many cows of nonviable neonates; or failure of many cows to rear viable offspring through the first days or weeks of life.

Although 4% calves is indicative of a poor calf crop or a subsequent low rate of survival of newborn calves, it is not the worst annual contribution of calves that has ever been reported for the muskox population within the Bathurst Island complex. Poor performance in calf production or unsuccessful rearing of the calves is relatively well-known

for the Bathurst Island muskox population. That is, Gray (1973) saw no calves, yearlings, or 2-yr olds from summer 1968 to 1970, nor did he observe any rutting behaviour during those years while studying muskoxen in the PBP area. Initial calf production and early survival was nil in 1974 (Fischer and Duncan 1976, Miller *et al.* 1977). Only 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). Intermediate rates have been reported at 9.0% among 111 muskoxen in 1961 (Tener 1963), 10.1% among 69 muskoxen in 1975 (Fischer and Duncan 1976), and 11.8% among 331 muskoxen in 1988 (Miller 1989). The highest rates for newborn calves within the Bathurst Island complex muskox population were 18.1% among 370 muskoxen in 1985 (Miller 1987), 17.8% among 923 muskoxen in 1993 (Miller 1995), and 16.2% among 222 muskoxen in 1981 (Ferguson 1987: on Bathurst Island only).

The poor performance of the 1995 muskox calf crop is not in itself a catastrophic event. It would require several years of such losses in close succession to cause a serious setback to the muskox population within the Bathurst Island complex at the current level of permitted annual harvest. This condition would be especially severe in terms of population dynamics, however, if the population experienced several consecutive years of high calf loss. From a management standpoint the end result of the 1994/95 losses is, however, still favourable. When the mortality of 1+ yr-old muskoxen is accounted for, there is still a net gain of 73 or more 1+ yr-old animals in the muskox population within the Bathurst Island complex, based on apparent changes from summers 1993 to 1995. That is, we saw 759 1+ yr-old muskoxen within the Bathurst Island complex in summer 1993 (Miller 1995) and we saw 832 1+ yr-old muskoxen in summer 1995. Therefore, the known harvestable muskox base is actually at least *ca.* 10% larger after heavy losses in winter 1994/95 than it was calculated at in summer 1993. There likely will be a decline in overall production in the muskox population within the Bathurst Island complex several years hence, however, as a result of the poor contribution of the female component of the 1995 calf crop to future breeding stock in the population. This condition will be reflected only in a slower rate of population growth and will not meaningfully influence the level of future harvestable stock, unless the population suffers future, frequent, and especially consecutive-year setbacks in initial production or rearing of newborn calves. At present, the muskox population within the Bathurst

Island complex, at about 1000 animals (1+ yr-old), can more than sustain the current allowable rate of annual harvest and at the same time the population can continue to grow in size.

Unfortunately, it was not possible due to limited project resources and the lack of any other potentially forthcoming support to materialize, to carry out this investigation at a level of detail that would have provided much more insight into the cause(s) of mortality among muskoxen in the Bathurst Island complex in winter 1994/95. The detection of major events, such as this one, that markedly influences, or which could potentially markedly influence, the population dynamics of muskoxen in the High Arctic is difficult because of the region's isolation and remoteness. Therefore, this instance of trying to investigate an apparent high level of mortality among muskoxen, serves best as one more example to demonstrate the true need for flexibility in reallotment of funds or providing an in-place source of funding to fully investigate such potentially important contingency events. Otherwise, this undesirable situation will continue into the foreseeable future: where there is a failure to collect all of the facts that are necessary for a biologically meaningful evaluation of the event, when given unpredictable, often sporadically occurring, special and specific opportunities to do so.

SUMMARY

After discussing the evidence that was found for a high rate of winter deaths among muskoxen *(Ovibos moschatus)* in the Eleanor Lake area of Cornwallis Island with the GNWT, DRR, Resource Officer and members of the Resolute HTO, I volunteered to shift some of my resources into a more intensive and extensive aerial search for muskox carcasses and to cursorily assess the status of the muskox population within the Bathurst Island complex in June and July 1995. A Bell 206L turbo-helicopter was used as the search aircraft. The helicopter was flown mainly at 30 to 100 m above ground level and at airspeeds of *ca.* 96 to 160 km per hour but at lower altitudes and slower airspeeds, including hovering, for brief periods when making some sex/age segregation and when examining carcasses, carcass sites, and areas immediately adjacent to them.

We had helicopter support between 17 June and 15 July 1995 and carried out two sets of low-level (l00 m or less above ground level) nonsystematic aerial searches to obtain sex/age composition

counts, 17-24 June and 7-11 July. Muskoxen were counted and segregated during the 1st set of searches (but only caribou (*Rangifer tarandus pearyi*) during the 2nd set of searches). We also searched for muskox (and caribou) carcasses during the above two periods. In addition, we expended an additional 20 hours searching for carcasses, primarily in habitats or sections of Bathurst Island preferred by muskoxen.

We found 50 muskox carcasses between 17 June and 12 July 1995. The 50 carcasses were classified as 21 bulls, 18 yearlings, 9 juveniles, 1 cow, and 1 calf. Only cows are obviously distinctly underrepresented and yearlings markedly overrepresented in the sample of 50 muskox carcasses ($P < 0.005$).

We found 45 of the 50 carcasses on Bathurst Island; 4 additional ones on Alexander Island; and the remaining one was on Cameron Island. The distribution of the 45 carcasses on Bathurst Island was significantly different ($P < 0.005$), when the 22 carcasses found in the Polar Bear Pass (PBP) area on central Bathurst were compared to the 16 carcasses found on northern Bathurst (north of PBP), and to the 7 carcasses found on southern Bathurst (south of PBP). The same pattern existed with a greater than expected rate ($P < 0.005$) for the frequency of occurrence of carcasses in the PBP area, when based on a comparison among the number of carcasses found in each of the three major land divisions of Bathurst Island and the relative amount of time expended in searches in each of those divisions.

No strong pattern could be discerned from the visual inspection of the actual death sites. Carcasses were found in wet sedge meadows (typical muskox habitat), on elevated knolls and slopes in or immediately adjacent to lowlands (areas that could have served as late winter range), and on, seemingly, marginal sites on windblown, exposed ridges at intermediate and at relatively high elevations (where then prevailing environmental conditions likely forced the muskoxen to go). There appeared to be a weak tendency for relatively close associations of carcasses ("clustering" or "clumping") within larger land divisions, seemingly, suggesting that those animals in each cluster or clump might all have been members of the same herd or that they were from different herds and simply seeking out isolated and restricted pockets of favourable habitats (available forage).

Utilization of the 50 muskox carcasses by predators or scavengers varied extremely. More than half (52%, 26) of them had been completely utilized, or nearly so, by predator(s) or scavenger(s). An additional 6% (3) had received only moderate to light utilization. For unknown reasons, however, 42% (21) of the 50 muskox carcasses had not been fed on and remained essentially entirely intact, except for three of them that each had their rumen opened up but still in place.

The cause(s) of death was not determined with confidence for any of the 50 muskoxen whose carcasses were found by us within the Bathurst Island complex. The working assumption is, however, that the primary cause of death in all or most cases was extreme malnutrition brought on by prolonged undernutrition caused by unfavourable snow/ice conditions during winter 1994/95. Whether wolves preyed on any significant number of these muskoxen either before or when the muskoxen were in an advanced weakened state from prolonged undernutrition is unknown. The assumption of environmentally-induced malnutrition is strengthened by the following findings: evidence for malnutrition in the samples examined by staff at the Western College of Veterinary Medicine; the high proportional rates for yearlings, and to lesser extents, for bulls and juveniles among the 50 muskox carcasses, and the extreme lack of cows in that sample; and the low proportional representation of calves in the count of live muskoxen obtained in late June 1995. The poor representation of calves emphasizes, however, that although most cows apparently were able to survive the rigours of winter 1994/95, their deteriorated nutritional state did not allow many of them to bring their fetuses to full-term or to produce and rear a viable offspring (the possibility exists, although seemingly much less likely, that many cows did not even breed or they did not conceive in autumn 1994).

We counted 868 live muskoxen and segregated them by sex/age groupings between 17 and 24 June 1995: 88% (760) of them were seen on Bathurst Island; and the remaining 12% (108) animals were seen collectively on five of the small islands immediately to the west of central and northern Bathurst Island. We classified 35% (302) of the live muskoxen as bulls, only 4% (36) were calves of the year, and the remaining 61% (530) were classed as "others," which included all females 1+ year-old and all juvenile and yearling males, and probably some 3-yr-old males.

Both the number of sightings made and the number of muskoxen seen were significantly overrepresented ($P < 0.005$) in the PBP area of central Bathurst Island, when compared to the remainder of the Island on a relative landmass basis or by frequency of occurrence. Nearly 38% of all the sightings and 43% of all muskoxen seen on Bathurst island were in the PBP area during only 10% of the aerial search effort on Bathurst Island.

Observations of muskoxen were made more frequently than expected by chance alone ($P < 0.005$) in the PBP area, when compared to southern Bathurst Island, the five satellite islands, and northern Bathurst Island. This same pattern of relative importance pertains to the distribution of muskox herds on a proportional landmass basis ($P < 0.005$), suggesting that muskoxen were exhibiting a strong preference for the PBP lowlands in June 1995. The relatively large number of carcasses in the PBP area also supports the possibility of disproportionally high use of the area during, at least, late winter 1994/95 and spring 1995, when most muskoxen likely died.

We saw only 36 (4%) calves among the 868 muskoxen that we segregated. Those calves occurred in 23 discrete mixed sex/age herds at a mean rate of 1.6 ± 0.66 SD and ranged from 1 to 3 calves per herd. There were no calves present in 74% (66) of the 89 mixed sex/age herds seen, indicating that on average, cows in 3 out of every 4 herds had failed to produce or rear a viable offspring in 1995.

The low 4% contribution by calves in the sample of live muskoxen during late June 1995 indicates either extremely poor initial calf production or exceptionally high early calf mortality or a combination of both in 1995. These conditions together with the high carcass count indicate that the muskox population within the Bathurst Island complex has suffered a depression in its potential population growth from June 1994 to July 1995. The general evidence of an apparent widespread lethal state of extreme malnutrition among muskoxen in winter 1994/95 supports mainly the lack of initial calf production in 1995. This condition could have resulted from any or all of the following events: failure of bulls to enter into the rut, or more likely, cows being unreceptive to advances by rutting bulls and a resultant low rate of pregnancy among breeding age cows; failure of many cows to carry viable fetuses to full-term; production

by many cows of nonviable neonates; or failure of many cows to rear viable offspring through the first days or weeks of life.

The poor performance of the 1995 muskox calf crop is not in itself a catastrophic event. It would require several years of such losses in close succession to cause a serious setback to the muskox population within the Bathurst Island complex at the current level of permitted annual harvest. This condition would be especially severe in terms of population dynamics, however, if the population experienced several consecutive years of high calf loss, particularly when the losses also are associated with high levels of annual mortality among 1+ yr-old muskoxen.

From a management standpoint the end result of the 1994/95 losses is, however, still favourable. When the mortality of 1+ yr-old muskoxen is accounted for, there is still a net gain of 73 or more 1+ yr-old animals in the muskox population within the Bathurst Island complex, based on apparent changes from summers 1993 to 1995. That is, we saw 759 1+ yr-old muskoxen within the Bathurst Island complex in summer 1993 and we saw 832 1+ yr-old muskoxen in summer 1995. Therefore, the known harvestable muskox base is actually at least *ca.* 10% larger after heavy losses in winter 1994/95 than it was calculated at in summer 1993.

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Appendix 3. Table 1. Summaries of nonsystematic aerial search efforts for muskoxen and caribou, Bathurst Island complex, Northwest Territories, 17-24 June and 7-11 July 1995

Search zone[a]	June[b] search time (min)	July[c] search time (min)	Search zone	June[b] search time (min)
Bathurst Is.	(1142)	(1107)	Major satellites	(400)
NEC	170	75	Cameron	64
NEI	161	179	Vanier	78
SEC	112	60	Massey	61
SEI	32	99	Marc	28
SC	38	23	Alexander	87
SWC	100	78	Helena	72
SWI	70	18	Sherard Osborn	10
NWC	78	44	Secondary satellites	(74)
NWI	15	10	Baker	7
NCW	50	162	Moore	4
NCE	198	298	Bradford	4
NPBP	73	8	"Bull"	49
SPBP	45	53	"Muskox"	10

Appendix 3. Table 1. Continued

[a] Search zones on Bathurst Island equal northeast coast (NEC), northeast interior (NEI), southeast coast (SEC), southeast interior (SEI), south coast (SC), southwest coast (SWC), southwest interior (SWI), northwest coast (NWC), northwest interior (NWI), north coast, western section (NCW), north coast, eastern section (NCE), north Polar Bear Pass (NPBP), and south Polar Bear Pass (SPBP).

[b] June 1995 aerial searches were for both live muskoxen and live caribou as well as for muskox or caribou carcasses.

[c] July 1995 aerial searches were for only live caribou and muskox or caribou carcasses.

Appendix 3. Table 2. Distribution of 50 muskox carcasses found within the Bathurst Island complex, Northwest Territories, 17 June to 12 July 1995

Search zone[a]	Number carcasses	Search zone	Number carcasses
Bathurst Is.	(45)	Major satellites	(5)
NEC	3	Cameron	1
NEI	0	Vanier	0
SEC	0	Massey	0
SEI	0	Marc	0
SC	0	Alexander	4
SWC	5	Helena	0
SWI	2	Sherard Osborn	0
NWC	1	Secondary satellites	(0)
NWI	0	Baker	0
NCW	6	Moore	0
NCE	6	Bradford	0
NPBP	12	"Bull"	0
SPBP	10	"Muskox"	0

[a] Search zones on Bathurst Island equal northeast coast (NEC), northeast interior (NEI), southeast coast (SEC), southeast interior (SEI), south coast (SC), southwest coast (SWC), southwest interior (SWI), northwest coast (NWC), northwest interior (NWI), north coast, western section (NCW), north coast, eastern section (NCE), north Polar Bear Pass (NPBP), and south Polar Bear Pass (SPBP).

Appendix 3. Table 3. Distribution of 45 muskox carcasses found on Bathurst Island, Northwest Territories, June-July 1995

Search zone[a]	% of island's landmass	Proportion of carcasses	Mean density of carcasses (• 100 km^{-2})	Statistical significance[b]
NEC	2.7	0.067	0.700	P>0.05
NEI	25.9	0.000	0.000	P<0.005
SEC	4.9	0.000	0.000	P>0.1
SEI	9.5	0.000	0.000	P<0.05
SC	3.2	0.000	0.000	P>0.1
SWC**	4.1	0.111	0.758	P<0.025
SWI	9.4	0.044	0.133	P>0.1
NWC	5.8	0.022	0.107	P>0.1
NWI	12.9	0.000	0.000	P<0.01
NCW	6.6	0.133	0.561	P>0.05
NCE	10.4	0.133	0.359	P>0.5
NPBP***	2.4	0.267	3.090	P<0.005
SPBP***	2.2	0.222	2.826	P<0.005

continued

Appendix 3. Table 3. Continued

[a] Search zones on Bathurst Island equal northeast coast (NEC), northeast interior (NEI), southeast coast (SEC), southeast interior (SEI), south coast (SC), southwest coast (SWC), southwest interior (SWI), northwest coast (NWC), northwest interior (NWI), north coast, western section (NCW), north coast, eastern section (NCE), north Polar Bear Pass (NPBP), and south Polar Bear Pass (SPBP).

[b] Statistical significance tested by comparison of the number of carcasses found in each search zone vs. the collective number of carcasses found on the remainder of the island (the other 12 search zones), where the expected values are derived on the relative landmass basis for each of the search zones (df = 2).

** Overrepresentation of carcasses in search zone equals $P < 0.025$.

*** Overrepresentation of carcasses in search zone equals $P < 0.005$.

Appendix 3. Table 4. Distribution of muskoxen by island and sex/age grouping, Bathurst Island complex, Northwest Territories, 17-24 June 1995

	Sex/age composition			Total
Island	Bulls	Calves	Others[a]	muskoxen
Bathurst	267	33	460	760
Alexander	16	0	30	46
"Bull"	11	2	14	27
Cameron	2	0	12	14
Vanier	4	0	7	11
Massey	2	1	7	10
Totals	302	36	530	868

[a] "Others" include all females 1+ years old and all juvenile and all yearling males, and probably some 3-yr-old males.

Appendix 3. Table 5. Number of observations of muskoxen by their representation in each type of social grouping, Bathurst Island complex, Northwest Territories, 17-24 June 1995

	Social grouping			
Island	Single bulls	Bull-only	Mixed sex/age	All observations
Bathurst	5	42 (113)[a]	75 (642)	122 (760)
Alexander	1	4 (8)	7 (37)	12 (46)
"Bull"	1	1 (3)	2 (23)	4 (27)
Cameron	0	0	2 (14)	2 (14)
Vanier	1	0	2 (10)	3 (11)
Massey	0	0	1 (10)	1 (10)
Totals	8	47 (124)	89 (736)	144 (868)

[a] Values in parentheses equal the number of muskoxen seen in those observations

Appendix 3. Table 6. Statistics for muskox sightings by type of social grouping in which muskoxen were seen, Bathurst Island complex, Northwest Territories, 17-24 June 1995

	Herd statistics				
Social group	N	Number muskoxen	Mean	±SD	Range
Mixed sex/age herds					
all sightings	89	736	8.3	4.35	3-22
Mixed sex/age herds with calves					
including calves	23	300	13.0	4.71	5-22
excluding calves	23	264	11.5	4.44	4-21
Mixed sex/age herds without calves	66	436	6.6	2.69	3-18
Bull-only herds	47	124	2.6	1.01	2-6
Single bulls	8	8	1.0	0.00	1-1

Appendix 3. Table 7. Distribution of the number of groups of muskoxen seen by social group classifications, Bathurst Island, Northwest Territories, June 1995

Search	Solitary	Bull-only	Mixed sex/age herds		
zone[a]	bulls	herds	With calves	Without calves	All
NEC	1	4	0	2	2
NEI	0	1	0	2	2
SEC	1	5	2	0	2
SEI	0	0	0	0	0
SC	0	2	1	2	3
SWC	1	3	3	9	12
SWI	1	7	2	4	6
NWC	0	0	0	3	3
NWI	0	0	1	0	1
NCW	0	1	2	3	5
NCE	1	5	2	5	7
NPBP	0	11	5	10	15
SPBP	0	3	3	15	18

[a] Search zones on Bathurst Island equal northeast coast (NEC), northeast interior (NEI), southeast coast (SEC), southeast interior (SEI), south coast (SC), southwest coast (SWC), southwest interior (SWI), northwest coast (NWC), northwest interior (NWI), north coast, western section (NCW), north coast, eastern section (NCE), north Polar Bear Pass (NPBP), and south Polar Bear Pass (SPBP).

Appendix 3. Table 8. Distribution of the number of individual muskoxen seen in the different social groupings, Bathurst Island, Northwest Territories, June 1995

Search zone[a]	Solitary bulls	Bull-only herds	Mixed sex/age herds			All obs.[b]
			With calves	Without calves	All	
NEC	1	10	0	12	12	23
NEI	0	2	0	9	9	11
SEC	1	19	23	0	23	43
SEI	0	0	0	0	0	0
SC	0	4	10	19	29	33
SWC	1	7	42	62	104	112
SWI	1	19	28	19	47	67
NWC	0	0	0	15	15	15
NWI	0	0	15	0	15	15
NCW	0	3	16	20	36	39
NCE	1	12	29	32	61	74
NPBP	0	29	73	73	146	175
SPBP	0	8	37	108	145	153

[a] Search zones on Bathurst Island equal northeast coast (NEC), northeast interior (NEI), southeast coast (SEC), southeast interior (SEI), south coast (SC), southwest coast (SWC), southwest interior (SWI), northwest coast (NWC), northwest interior (NWI), north coast, western section (NCW), north coast, eastern section (NCE), north Polar Bear Pass (NPBP), and south Polar Bear Pass (SPBP).

Appendix 3. Table 9. Rate of occurrence of 760 muskoxen by major land divisions, Bathurst Island, Northwest Territories, June 1995

Major divisions	Number of different muskoxen sighted	Time spent searching (min)	Rate of occurrence muskoxen (• 100 min^{-1})
Coastal*** vs.	667	864	77.2
Interior	93	278	33.4
North vs.	352	745	47.2
South***	408	397	102.8
East vs.	348	770	45.2
West***	412	372	110.8

*** Muskoxen overrepresented within major land division by relative frequency of occurrence in paired comparison ($P < 0.005$).

Appendix 3. Table 10. Distribution of 760 muskoxen by major land divisions, Bathurst Island, Northwest Territories, June 1995

Major divisions	% of total muskoxen seen	% of total land area	Expected sightings based on land area	Observed/ expected muskox index
Coastal*** vs	87.8	42.3	864	77.2
Interior	12.2	57.7	278	33.4
North vs.	46.3	66.7	745	47.2
South***	53.7	33.3	397	102.8
East vs.	45.8	58.1	770	45.2
West***	54.2	41.9	372	110.8

*** Muskoxen overrepresented on a relative landmass basis in paired comparison ($P < 0.005$).

Appendix 3. Table 11. Distribution of muskox calves by the number of calves seen in each of the 23 mixed sex/age herds with calves present, Bathurst Island complex, Northwest Territories, 17-24 June 1995

	Number of calves/herd			
Herd statistics	1	2	3	1-3
N	12	9	2	23
Mean				
with calves	11.5	13.5	20.0	13.0
without calves	10.5	11.6	17.0	11.5
± SD				
with calves	4.89	3.36	2.83	4.71
without calves	4.89	3.36	2.83	4.44
Range				
with calves	5-22	8-18	18-22	5-22
without calves	4-21	6-16	15-19	4-21
No. 1+ yr olds	126	104	34	264
Tot. muskoxen	138	122	40	300

Appendix 4. Caribou aerial sex/age composition counts by survey date, Bathurst Island, Northwest Territories, June 1995

	Caribou								Search
June 1995	Bulls	Cows	Calves	Juvenile males	Juvenile females	Yearling males	Yearling females	Totals	time (min)
17	8	99	21	12	29	17	19	205	270
18	19	48	15	17	21	43	19	182	239
19	17	8	1	11	4	26	11	78	189
20	30	4	1	22	5	19	11	92	148
23	24	7	3	25	15	9	12	95	331
24	17	45	32	19	17	26	18	174	3187
Totals	115	211	73	106	91	140	90	826	1616

Appendix 5. Sex/age composition, numbers, and distributions of Peary caribou by search zones, Bathurst Island, Northwest Territories, 17-24 June 1995 (data obtained by nonsystematic helicopter searches)

Search zone[a]	Time (min)	Sex/age composition							Total caribou	Caribou (•100 min^{-1})
		Bull	Cow	Calf	Juv.[b] male	Juv. female	Yrl.[b] male	Yrl. female		
NEC	170	11***[c]	5	2	8***	4	34***	3	67***	39.4
NEI	161	3	98***	30***	5	22	5	18	181***	112.4
SEC	112	8*	1	0	4	0	6	2	21	18.8
SEI	32	0	0	0	0	1	0	0	1	3.1
SC	38	0	1	1	1	0	2	0	5	13.2
SWC	100	6	0	0	5	0	5	0	16	16.0
SWI	70	0	0	0	0	0	0	0	0	0
NWC	78	14***	1	1	14***	6	0	3	39	50.0
NWI	15	0	0	0	0	0	0	0	0	0
NCW	50	7	3	1	6	9*	4	11***	41	82.0
NCE	198	7	43***	3	10	31***	19***	15***	118***	59.6

continued

Appendix 5. Continued

Search zone[a]	Time (min)	Sex/age composition								
		Bull	Cow	Calf	Juv.[b] male	Juv. female	Yrl.[b] male	Yrl. female	Total caribou	Caribou (•100 min^{-1})
NPBP	73	15***	6	0	12***	3	12***	11***	59***	80.8
SPBP	45	5**	0	0	0	0	6**	0	11	24.4

[a] NEC, northeast coast; NEI, northeast interior; SEC, southeast coast; SEI, southeast interior; SC, south coast; SWC, southwest coast; SWI, southwest interior; NWC, northwest coast; NWI, northwest interior; NCW, north coast, western section; NCE, north coast, eastern section; NPBP, north Polar Bear Pass, and SPBP, south Polar Bear Pass.

[b] Juveniles (Juv.) and yearlings (Yrl.).

[c] Caribou were significantly overrepresented in search zone: *** P <0.005; ** P <0.01; and * P <0.05.

Appendix 6. Caribou aerial sex/age composition counts by survey date, Bathurst Island, Northwest Territories, July 1995

	Caribou								Search
July 1995	Bulls	Cows	Calves	Juvenile males	Juvenile females	Yearling males	Yearling females	Totals	time (min)
7	24	130	58	42	120	31	61	466	
8	3	0	0	6	1	4	1	15	16
9	7	3	2	17	2	16	2	49	189
10	38	12	4	22	14	13	5	108	271
11	61	118	57	33	88	25	64	446	346
Totals	133	263	121	120	225	89	133	1084	1107

Appendix 7. Sex/age composition, numbers, and distributions of Peary caribou by search zones, Bathurst Island, south-central Queen Elizabeth Islands, Northwest Territories, 7-11 July 1995 (data obtained by nonsystematic helicopter searches)

		Sex/age composition								
Search zone[a]	Time (min)	Bull	Cow	Calf	Juv.[b] male	Juv. female	Yrl.[b] male	Yrl. female	Total caribou	Caribou (•100 min^{-1})
NEC	75	18***[c]	22***	7*	33***	30***	23***	21***	154***	48.7
NEI	179	3	47	30	3	45	4	28	160	89.4
SEC	60	6	0	0	14***	0	12***	0	32	53.3
SEI	99	0	0	0	1	0	0	0	1	1.0
SC	23	0	3	2	1	2	2	2	12	52.2
SWC	78	2	0	0	0	0	0	0	2	2.6
SWI	18	1	1	0	1	1	0	0	4	22.2
NWC	44	6	11	4	4	5	0	3	33	75.0
NWI	10	1	0	0	5	2	4	1	13	130.0
NCW	162	46***	24	5	17***	30***	16***	17***	155***	95.7

continued

Appendix 7. Continued

Search zone[a]	Time (min)	Sex/age composition							Total caribou	Caribou (•100 min^{-1})
		Bull	Cow	Calf	Juv.[b] male	Juv. female	Yrl.[b] male	Yrl. female		
NCE	298	28***	155***	73***	30***	110***	19***	61***	476***	149.7
NPBP	8	12***	0	0	6	0	4	0	22	275.0
SPBP	53	10***	0	0	5	0	5*	0	20	37.7

[a] NEC, northeast coast; NEI, northeast interior; SEC, southeast coast; SEI, southeast interior; SC, south coast; SWC, southwest coast; SWI, southwest interior; NWC, northwest coast; NWI, northwest interior; NCW, north coast, western section; NCE, north coast, eastern section; NPBP, north Polar Bear Pass, and SPBP, south Polar Bear Pass.

[b] Juveniles (Juv.) and yearlings (Yrl.).

[c] Caribou were significantly overrepresented in search zone: *** P <0.005; ** P <0.01; and * P <0.05.