ARCTIC
VOL. 44, NO. 1 (MARCH 1991) P. 57-62

Estimating Bathurst Island Peary Caribou and Muskox Populations

FRANK L. MILLER[1]

(Received 24 May 1989; accepted in revised form 17 August 1990)

ABSTRACT. Peary caribou (*Rangifer tarandus pearyi*) and muskox (*Ovibos moschatus*) numbers were estimated by systematic aerial survey on Bathurst Island and Bathurst's five western major satellite islands of Vanier, Cameron, Alexander, Massey and Marc, Northwest Territories, in 1985 and 1988. The surveys were carried out as part of the Canadian Wildlife Service's most recent evaluation of the status of Peary caribou (1984-88). In July 1985, 727 Peary caribou and 547 muskoxen were estimated on the six-island survey area and in July 1988, 1034 Peary caribou and 522 muskoxen. Post-parturient caribou cows and their newborn calves occurred at significantly greater rates on Massey Island than on the remainder of the survey area in both years. The 1985 and 1988 survey results, plus results from earlier surveys within the area, are used to illustrate how annual inter-island variation in range use within the survey area by varying numbers of caribou could confound population estimates based on aerial surveys of only Bathurst Island that do not also include, at least, the five western major satellite islands.

Key words: Peary caribou, *Rangifer tarandus pearyi*, muskoxen, *Ovibos moschatus*, population estimates, inter-island movements, Canadian High Arctic, south-central Queen Elizabeth Islands

RÉSUMÉ. En 1985 et 1988, on a déterminé, par relevés aériens systématiques, le nombre de caribous de Peary (*Rangifer tarandus pearyi*) et de boeufs musqués (*Ovibos moschatus*) sur l'île de Bathurst et ses cinq grandes îles satellites occidentales (Vanier, Cameron, Alexander, Massey et Marc), dans les Territoires du Nord-Ouest. Ces relevés ont été effectués dans le cadre de la dernière évaluation du Service canadien de la faune sur le statut du caribou de Peary (1984-88). En juillet 1985, le nombre des caribous de Peary a été évalué à 727 et celui des boeufs musqués à 547, dans les six îles formant la zone d'étude et, en juillet 1988, ce nombre a été évalué à 1 034 pour le caribou de Peary et à 522 pour le boeuf musqué. Durant les deux années en question, le taux d'occurrence des femelles caribous venant de mettre bas et de leurs petits était beaucoup plus élevé dans l'île Massey que dans le reste de la zone d'étude. Les résultats des relevés de 1985 et de 1988, ainsi que les résultats de relevés effectués précédemment dans la région, servent à illustrer comment la variation annuelle entre les îles, dans l'utilisation du territoire par des nombres différents de caribous, pourrait fausser les estimations de population qui s'appuient uniquement sur l'île Bathurst, sans tenir compte au moins de ses cinq grandes îles satellites occidentales.

Mots clés: caribou de Peary, *Rangifer tarandus pearyi*, boeuf musqué, *Ovibos moschatus*, estimations de population, mouvements de population entre les îles, Extrême-Arctique canadien, îles centre-sud de la Reine-Élisabeth

Traduit pour le journal par Nésida Loyer.

INTRODUCTION

Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) were well represented in the early 1960s on south-central Queen Elizabeth Islands (QEI), Northwest Territories (NWT), and Bathurst Island was a principal caribou hunting area. In summer 1961, 3565 Peary caribou and 1161 muskoxen were estimated by aerial survey on Bathurst Island and four of its western major satellite islands, Vanier, Cameron, Alexander and Massey (Tener, 1963). Twelve years then passed before numbers of Peary caribou and muskoxen on those islands (including the fifth western major satellite island of Ile Marc) were again estimated by aerial survey. By 1973, Peary caribou on those six south-central QEI had already declined *ca.* 75% and muskoxen *ca.* 40% from their 1961 estimated numbers (Tener, 1963; Miller *et al.*, 1977a). Then, the winter of 1973-74 was disastrous and both Peary caribou and muskoxen apparently experienced calamitous population reductions due to range-wide major die-offs (Parker *et al.*, 1975; Miller *et al.*, 1977a). The population estimates for the six south-central QEI in 1974 for Peary caribou crashed to only *ca.* 10% and for muskoxen to *ca.* 20% of their respective 1961 estimates (Fischer and Duncan, 1976; Miller *et al.*, 1977a).

In August 1981, Ferguson (1987) determined the status of Peary caribou and muskox populations on only Bathurst Island by aerial survey. He concluded that neither species had shown any marked overall recovery since 1974 and, therefore, the prohibition of harvesting of Peary caribou and muskoxen on Bathurst Island should continue. The Inuit hunters of Resolute Bay, Cornwallis Island, have maintained a voluntary ban on hunting of caribou on Bathurst Island since 1975. The hunting of muskoxen on Bathurst Island is prohibited by regulations under the Government of the NWT Wildlife Act.

The Canadian Wildlife Service aerially surveyed Peary caribou and muskoxen on western and central QEI during July 1985 (Miller, 1987a), July 1986 (Miller, 1987b) and July 1987 (Miller, 1988), as part of a program to evaluate the status of Peary caribou on the Canadian Arctic Archipelago (Miller, 1990b). The overall trend for all Peary caribou was one of apparently continual decline from at least 1961 to 1987. Muskoxen exhibited various rates of recovery in all areas from 1974 to 1985-87. The only inconsistency in these regional findings was an apparent increase in the number of Peary caribou on south-central QEI, which includes Bathurst Island and several of its satellite islands. Therefore the Canadian Wildlife Service resurveyed Bathurst and its five major western satellite islands by air in July 1988 to further evaluate the current status of Peary caribou and muskox populations within that south-central QEI complex.

If all caribou and reindeer had to be characterized by one common trait, it would be their seemingly almost continual movement while engaged in daily foraging activities and seasonal movements (e.g., Heape, 1931; Bergerud, 1974). Yet, this well-known trait of *Rangifer* is not always adequately addressed when estimating population sizes by surveys, usually because of limited funds. This condition has been especially true for aerial surveys on the Canadian Arctic Archipelago. Caribou on the Arctic Archipelago have the unique tradition of often involving two or more different islands in their seasonal migrations and also when making sporadic environmentally forced movements in response to widespread forage unavailability (e.g., Miller *et al.*, 1977b,

[1]Canadian Wildlife Service, Western and Northern Region, Room 210, 4999 - 98 Avenue, Edmonton, Alberta, Canada T6B 2X3

1982; Miller, 1990a). The most accurate estimation of the size of a population of such caribou should be obtained when the entire probable inter-island area occupied by the population is included in the survey. This ecologically sound survey approach has, unfortunately, not prevailed among studies because of limited fiscal resources. The data from the 1985 and 1988 surveys of Bathurst Island and some of the surrounding satellite islands are used to illustrate this problem.

STUDY AREA

The islands within the study area lie between 74 and 77°N latitude and 96 and 105°W longitude (Fig. 1). Bathurst Island is both the largest and the principal "game" island within the survey area. All of the islands are low lying and are mainly below 150 m above mean sea level in elevation. Geology, topography and vegetation within the study area have been described in some detail (e.g., Dunbar and Greenaway, 1956; Thorsteinsson, 1958; Savile, 1961; Fortier *et al.*, 1963; Tener, 1963; Edlund, 1983).

In 1985 the survey area included six islands of the south-central QEI, with a collective landmass of *ca.* 19 266 km^2 (Miller, 1987a): Bathurst (16 090 km^2), Vanier (1130 km^2), Cameron (1060 km^2), Alexander (490 km^2), Massey (440 km^2) and Marc (56 km^2). In 1988, all six were again systematically surveyed along the same line transects as in 1985.

METHODS

Methodology for carrying out the aerial surveys and calculating the population estimates is detailed in Miller (1987a,b, 1988). The surveys were flown in a Bell-206B turbo-helicopter at an airspeed of about 160 km·h^{-1} and an altitude of about 90 m above ground level. A four-person survey crew was used: pilot-spotter, right front seat; navigator-spotter, left front seat; and two rear-seat observers. The observers measured the angle of depression with hand-held clinometers when the helicopter was abeam of the animals for calculation of horizontal right-angle distance to animal(s) sighted along line transects and recorded the data for the sightings on their respective sides of the aircraft (Fig. 2). Then, all caribou were classified by designated sex/age classes: bulls, cows, calves, juveniles and yearlings. Muskoxen were segregated as bulls or calves and others as cows, juveniles or yearlings (Miller 1987a,b, 1988). When necessary the animals were circled and all four crew members participated in the segregation by sex/age classes of all individuals in each group.

The surveys were carried out along systematically spaced transect lines. The mean density and population estimates were calculated using standard procedures for systematic transect surveys (Cochran, 1963; Kingsley and Smith, 1981). The estimates and their associated variances were obtained by using only those sightings of animals for which the measured angle of depression from the helicopter to the animals was greater than 5° (6° or greater). This practice meant that all "on-transect" animals were within about 850 m of either side of the aircraft or within a strip transect width of 1700 m ("maximum feasible strip width" — based on field testing and evaluation of results, using strip transects of 15 different widths flown at three different altitudes [N = 45 combinations of analyses], Prince of Wales and Melville islands, NWT, spring and summer 1984 [F.L. Miller, unpubl. data]). In this way, surveys flown along line transects at 6.4 km intervals were equivalent to 27% coverage and those flown at 3.2 km intervals equalled 54% coverage.

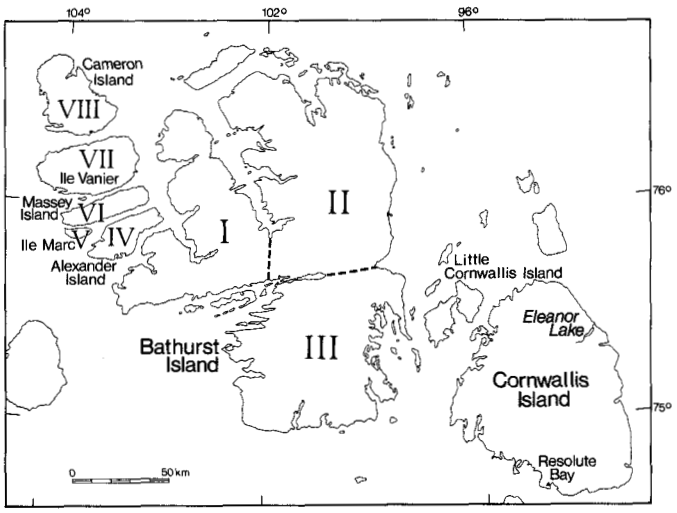

FIG. 1. Locations of eight survey strata used in July 1985 and July 1988 aerial surveys of six south-central Queen Elizabeth Islands, Canadian High Arctic.

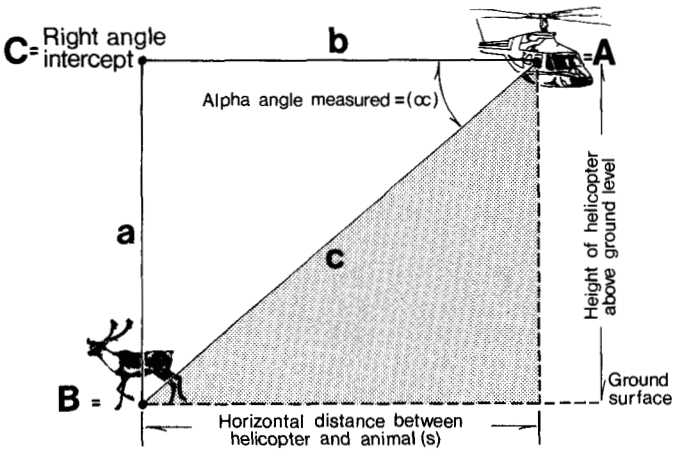

FIG. 2. Schema of angle of depression measured with hand-held clinometer when helicopter was abeam of animals for calculation of horizontal right-angle distance to animal(s) sighted along line transects.

RESULTS

The six-island complex was surveyed between 10 and 25 July 1985 and 11 and 21 July 1988 (Tables 1-4). Weather conditions were generally favourable during both years and the range was essentially snow free.

In 1985, 352 Peary caribou were counted on and off transect (Table 1). The overall mean density estimate of caribou on the six islands was 3.8 (± 0.72 S.E.) caribou·100 km^{-2}. Nearly one-third of those estimated caribou occurred collectively on the five western satellite islands, at a mean density of 7.3 (± 1.76 S.E.) caribou·100 km^{-2}. Mean density of caribou for the five western satellite islands was 2.4 times greater than the mean density of 3.1 (± 0.75 S.E.) caribou·100 km^{-2} on Bathurst Island. The overall proportion of calves among observed caribou on all six islands was 26.1%: 26.3% on Bathurst Island and 25.9% collectively on the five western satellite islands.

In 1988, 602 Peary caribou were counted during the aerial survey (Table 1). The overall mean density estimate of caribou

TABLE 1. Numbers counted and population sizes estimated for Peary caribou on six south-central Queen Elizabeth Islands, NWT, 10-25 July 1985 and 11-21 July 1988

	Number of caribou counted[a]								Estimated number of caribou[b]	
	Off transect				On transect				Tot. ± S.E.	Tot. ± S.E.
Island	1985		1988		1985		1988		1985	1988
Bathurst	55	(15)	121	(52)	96	(39)	166	(57)	495 ± 121.0	821 ± 138.0
Vanier	23	(11)	24	(7)	16	(2)	34	(12)	67 ± 37.0	85 ± 26.2
Cameron	1		3		13	(1)	5		51 ± 32.9	9 ± 4.4
Alexander	12	(2)	11		7	(3)	14	(3)	38 ± 38.0	31 ± 13.2
Massey	22	(9)	24	(14)	12	(9)	30	(16)	76 ± 20.5	84 ± 21.5
Marc	3	(1)	7		0		2		0	4 ± 2.1
Totals	116	(38)	190	(73)	144	(54)	251	(88)	727 ± 137.7	1034 ± 142.8

[a]Number of calves in parentheses.
[b]1985 and 1988 population estimates are not significantly different (t-test, $P>0.05$) for all islands or combination of islands.

on the six islands was 5.4 (±0.74 S.E.) caribou·100 km^{-2}. More than one-fifth of the estimated caribou occurred collectively on the five western satellite islands, at a mean density of 6.7 (±1.2 S.E.) caribou·100 km^{-2}. The collective mean density of caribou on the five satellite islands was still 1.3 times greater than the mean density of 5.1 (±0.74 S.E.) caribou·100 km^{-2} on Bathurst Island. The overall proportional representation of calves among caribou on all islands was 26.7%: 27.5% on Bathurst Island and 25.2% collectively on the five satellite islands.

There were 83 caribou calves seen at heel per 100 breeding cows in both years (Table 2). Caribou bulls ranged from 60 to 37 and juvenile/yearlings from 74 to 91 per 100 breeding cows in 1985 and 1988 respectively. Caribou were observed more frequently than expected by chance alone on a relative landmass basis on the five western satellite islands collectively (16.5% of the 19 266 km^2) *vs.* Bathurst Island (83.5% of 19 266 km^2) in both years (Table 1: 1985, $X^2 = 162.41$, df = 1; $P<0.005$ *vs.* 1988, $X^2 = 135.89$, df = 1; $P<0.005$). In both 1985 and 1988 post-parturient caribou cows and their newborn calves occurred in samples of observed caribou at rates about as expected by chance alone (Table 2). Caribou bulls were, however, overrepresented and juvenile/yearlings underrepresented in 1985 and vice versa in 1988 (Table 2: $X^2 = 10.75$, df = 3; $P<0.025$). There was no significant difference in the observed frequency of caribou by designated sex/age classes on Bathurst Island *vs.* the five satellite islands collectively in either year (Table 2: 1985, $X^2 = 1.32$, df = 2; $P>0.5$ *vs.* 1988, $X^2 = 2.17$, df = 2; $P>0.1$). Both post-parturient cows and newborn calves were, however, significantly overrepresented on Massey Island *vs.* the remainder of the survey area in both years (Table 2: 1985, $X^2 = 9.18$, df = 2; $P<0.025$ *vs.* 1988, $X^2 = 20.11$, df = 2; $P<0.005$).

In 1985, 318 muskoxen were counted during the aerial survey (Table 3). The overall mean density estimates of muskoxen on the six islands was 2.8 (±0.76 S.E.) muskoxen·100 km^{-2}. Only 4.8% of the estimated muskoxen occurred on Alexander Island, and none was seen on the other four satellite islands. The overall proportion of calves among observed muskoxen on all six islands was 17.0%: 16.7% on Bathurst Island and 4 of 19 muskoxen on Alexander Island.

In 1988, 331 muskoxen were counted during the aerial survey (Table 3). The overall mean density estimate of muskoxen on the six islands was 2.7 (±0.56 S.E.) muskoxen·100 km^{-2}. Only 3.5% of all the estimated muskoxen occurred collectively on Cameron, Vanier and Alexander, and none was seen on Massey or Marc islands. The mean density of muskoxen for all satellite islands was 5.2 times less than the mean density of muskoxen on Bathurst Island. The overall proportion of calves among observed muskoxen on all islands was 11.8%: 12.2% on Bathurst Island and none on any of the satellite islands.

Muskoxen were seen more frequently than expected by chance alone on a relative landmass basis on Bathurst Island *vs.* the five satellite islands collectively in both years (Table 3: 1985, $X^2 = 25.98$, df = 1; $P<0.005$ *vs.* 1988, $X^2 = 42.04$, df = 1; $P<0.005$). Muskox bulls represented about one-fifth and two-fifths of all the 1+ year-old muskoxen seen in 1985 and 1988 respectively (Table 4). No attempt was made to segregate muskox cows from juveniles or yearlings (Table 4). Muskox bulls were underrepresented and all other sex/age classes overrepresented among all muskoxen seen in 1985 and vice versa in 1988 (Table 4: $X^2 = 33.10$, df = 2; $P<0.005$).

DISCUSSION

Peary caribou recolonized or colonized essentially the entire Canadian Arctic Archipelago (except, apparently, Baffin, Bylot and other immediately adjacent smaller islands) by free movement over the sea ice after the Wisconsin-Weichelian period of glaciation. Homogeneous characteristics of specimens of Peary caribou from the QEI indicate

TABLE 2. Frequency distribution of Peary caribou on south-central Queen Elizabeth Islands, NWT, July 1985 and July 1988

			% sex/age classes			
Island	Year	*n*	Cows	Calves	Bulls	Juv./yrl.[a]
Bathurst	1985	205	29.3	26.3	21.0	23.4
	1988	396	30.1	27.5	9.6	32.8
Massey	1985	52	42.3	34.6		23.1
	1988	84	45.2	35.7		19.1
Vanier	1985	52	32.7	25.0	19.2	23.1
	1988	77	40.2	24.7	16.9	18.2
Alexander	1985	24	29.2	20.8	16.7	33.3
	1988	28	17.8	10.7	28.6	42.9
Cameron/Marc[b]	1985	19	26.3	10.6	52.6	10.5
	1988	17			76.5	23.5
All six islands	1985	352	31.6	26.1	19.0	23.3
	1988	602	32.1	26.7	12.0	29.2

[a]Juv./yrl. equals juvenile or yearling caribou.
[b]Small samples from Cameron Island and Ile Marc were combined to allow Chi-square Goodness-of-fit tests where the hypothetical distribution equaled the overall sample from all six islands in each year.

TABLE 3. Numbers counted and population sizes estimated for muskoxen on six south-central Queen Elizabeth Islands, NWT, 10-25 July 1985 and 11-21 July 1988

Island	Number of muskoxen counted[a]								Estimated number of muskoxen[b]	
	Off transect				On transect				Tot. ± S.E.	Tot. ± S.E.
	1985		1988		1985		1988		1985	1988
Bathurst	114	(28)	138	(22)	135	(22)	143	(17)	521 ± 145.6	503 ± 106.9
Vanier	0		0		0		3		0	6 ± 2.9
Cameron	0		0		0		4		0	7 ± 3.5
Alexander	8	(4)	1		7		3		26 ± 23.1	6 ± 3.8
Totals	122	(32)	139	(22)	142	(22)	153	(17)	547 ± 147.2	522 ± 108.0

[a]Number of calves in parentheses.
[b]1985 and 1988 population estimates are not significantly different (t-test, $P>0.05$) for all islands or combination of islands; no muskoxen were seen on Ile Marc or Massey Island in 1985 or 1988.

that maintenance of regular inter-movements had persisted over time (Manning, 1960; Banfield, 1961). Some inter-island populations of caribou on the Canadian Arctic Archipelago have been well documented (e.g., Miller *et al.*, 1977b, 1982). Also, additional fragmentary evidence for inter-island movements by caribou on the Canadian Arctic Archipelago, both direct and indirect observations, has been reported and summarized in terms of ecological importance in Miller (1990a). At least two basic types of inter-island movements are perpetuated by caribou on the Arctic Archipelago: 1) periodic seasonal migrations, and 2) sporadic, environmentally forced inter-island movements due to widespread forage unavailability brought on by unfavourable snow/ice conditions (e.g., Miller *et al.*, 1977a,b, 1982; Miller, 1990a,b). Both periodic inter-island migrations and sporadic inter-island movements serve to allow maximal use of the best available ranges (in terms of quality, quantity or availability of forage). Such inter-island movements also provide a continuing means by which Peary caribou can eventually repopulate islands where caribou herds have been annihilated through prolonged or rapid major die-offs.

Indirect evidence for inter-island movements of Peary caribou among Bathurst Island and adjacent islands is available in the form of changing numbers (both annually and seasonally) and markedly distorted representations of caribou by sex/age classes (e.g., Bissett, 1968; Freeman, 1975; Miller *et al.*, 1977b; Miller and Gunn, 1978; Miller, 1987a, 1990a,b).

Ferguson (1987) did not survey Bathurst's five major western satellite islands in August 1981, because of prior commitments for the use of the aircraft at that time (M.A.D. Ferguson, pers. comm. 1988). If he had been able to systematically survey those five islands (at least at 25% aerial coverage), I believe he would have detected an early stage of the increase in the number of caribou within the six-island, south-central QEI complex in 1981.

The results from all aerial surveys except 1974 indicate a marked preference by caribou for some ranges on the satellite islands, especially Massey Island, over those on Bathurst Island (Table 5). Thus, it appears that any population estimate of Peary caribou on Bathurst Island made in summer is likely to be an underestimate of as much as nearly one-third (Table 5) of the total number of caribou within the six-island complex. Population estimates made during extreme lows in 1974 and 1975 would not have markedly influenced those estimates of Bathurst Island, if the five satellite islands had not been surveyed (Table 5). Therefore, survey results from satellite islands are desirable for better evaluation of the biological soundness of any necessary management decisions.

On the other hand, there is no evidence, direct or indirect, of regular inter-island movements of muskoxen among the south-central QEI. There is, however, evidence of muskoxen moving during a period of widespread forage unavailability in winter 1973-74 from Bathurst Island to at least Little Cornwallis and Cornwallis islands (Miller *et al.*, 1977a). Also, Inuit hunters from Resolute Bay, Cornwallis Island, believe that muskoxen (and caribou) commonly move back and forth between Bathurst Island and Little Cornwallis or Cornwallis islands (G. Eckalook, T. Manik, L. Nungag, pers. comm.

TABLE 4. Frequency distribution of muskoxen on south-central Queen Elizabeth Islands, NWT, July 1985 and July 1988

Island	Year	*n*	% sex/age classes		
			Bulls	Calves	Cows/juv./yrl.[a]
Bathurst	1985	299	19.1	16.7	64.2
	1988	320	38.4	12.2	49.4
Alexander	1985	19	21.1	21.1	57.8
	1988	4	50.0		50.0
Cameron	1988	4	100.0		
Vanier	1988	3	100.0		
Totals	1985	318	19.2	17.0	63.8
	1988	331	39.9	11.8	48.3

[a]No attempt was made to segregate cows from juveniles or yearlings, because of the difficulty of constantly doing so while the observers were airborne.

TABLE 5. Proportional distributions of Peary caribou on Bathurst Island *vs.* the five western major satellite islands (Vanier, Cameron, Alexander, Massey and Marc), NWT

Year	Estimated total population for all six islands	% of estimated population occurring on five western satellite islands	Annual Chi-square contributions (df = 1)
1988[a]	1034	20.6[d]	12.8
1985[a]	727	31.9[d]	123.4
1975[b]	361	3.3[d]	45.8
1974[b]	228	16.7	0.1
1961[c]	3565	23.6[d]	132.9

[a]Data source, Miller (1987a) and this study.
[b]Data source, Fischer and Duncan (1976).
[c]Data source, Tener (1963).
[d]Annual contribution of caribou on a relative landmass basis estimated on the five western major satellite islands was significantly ($P<0.005$) greater in 1988, 1985 and 1961 and less in 1975 than the estimated number on Bathurst Island (where respective landmass areas are Bathurst Island [83.5%] *vs.* the five major western satellite islands [16.5%]).

1988). Thus, there is no evidence to even suggest that any range on the five western major satellite islands has been or currently is important to muskoxen within the south-central QEI (Table 6). Only a few muskoxen have been found on any of the five western satellite islands (Tener, 1963; Fischer and Duncan, 1976; Miller *et al.*, 1977a; Miller, 1987a). Even in summer 1961, when the highest number of muskoxen (n = 1161) was estimated within the six-island, south-central QEI complex (Tener, 1963), only 2.2% were on the five western satellite islands (Table 6).

For management purposes a decision most often has to be made between the costs of obtaining highly accurate data and the need for collecting less accurate information at a lower cost. For Peary caribou and muskox populations within this south-central QEI complex, I conclude the following. 1) When obtaining accurate estimates of numbers and satisfactory samples of sex/age composition, it will be necessary to aerial survey at least Bathurst and the five major western satellite islands at minimum coverages of at least 25% and 50% respectively. Extrapolation of the number of animals seen on each set of alternate line transects (odd *vs.* even) on each of the satellite islands, when surveyed at 50% coverage, gives two additional population estimates for the satellite islands (at 25% coverage each) to compare directly with the results from the 25% coverage of Bathurst Island. 2) Ideally, spot checks should be carried out on the other satellite islands of Bathurst Island, on Little Cornwallis Island and on, at least, northeastern (Eleanor Lake drainage) and southwestern Cornwallis Island. This extra effort is particularly important if environmental stress during the previous winter is suspected. 3) If funding permits, subsequent intensive resurvey of caribou or muskox concentrations should be carried out, as recommended by Ferguson (1987). To date, however, no agency has been forthcoming with the additional funds necessary to do so. I recommend 50% coverage of the satellite islands because it is only an additional small cost and is necessary to better evaluate the sex/age composition of the caribou on those small islands and to further document the apparent annual preference by breeding caribou cows for postcalving and probably calving areas on Massey Island. I believe detailed knowledge of sex/age composition is necessary, along with reliable data about trends in numbers, for low-density populations of caribou or muskoxen to be adequately managed on a biologically sound basis.

The alternative approach would be to conduct aerial surveys of Bathurst Island only (but still at least at 25% coverage) and base all management decisions on the resultant estimates as measures of "minimum populations." If this lower cost approach is employed, apparent increases in population sizes could occur over time (possibly even between surveys) at rates that would be well beyond the populations' maximum reproduction potential. These erroneously perceived increases could be solely or partially due to annual variations in summer occupation of the various islands within the south-central QEI complex. Also, with the alternative lower cost approach it will not be possible to accurately evaluate the apparent impact of various levels of annual harvests, because no measure will be known of the possible exchange of animals and the associated annual variation in such exchanges due to inter-island movements resulting from traditions or environmentally forced events. Thus, management decisions relating to harvest of especially Peary caribou will have to be ultra-conservative, in order to be safe over the long term until it can be demonstrated without doubt that the herd can sustain high rates of annual harvests.

These findings support the position that harvesting of muskoxen and especially Peary caribou on Bathurst Island should be carried out only at low rates and strictly controlled by Inuit of Resolute Bay. Also, to promote population growth, any limited harvest that is considered should exclude female individuals, especially those of breeding age.

TABLE 6. Proportional distributions of muskoxen on Bathurst Island *vs.* the five western major satellite islands (Vanier, Cameron, Alexander, Massey and Marc), NWT

Year	Estimated total population for all six islands	% of estimated population occurring on five western satellite islands	Annual Chi-square contributions (df = 1)
1988[a]	547	95.2[e]	54.45
1985[a]	522	86.5[e]	62.21
1975[b]	69[c]	100.0[e]	13.68
1974[b]	189	100.0[e]	38.29
1961[d]	1161	97.8[e]	173.01

[a]Data source, Miller (1987a) and this study.
[b]Data source, Fischer and Duncan (1976).
[c]No muskoxen were seen "on transect" by Fischer and Duncan (1976) in 1975; therefore, none was estimated (69 = actual number of muskoxen seen "off-transect").
[d]Data source, Tener (1963).
[e]Annual contribution of muskoxen on a relative landmass basis estimated on Bathurst Island was significantly ($P < 0.005$) greater in all years than the estimated number on the five major western satellite islands collectively.

ACKNOWLEDGEMENTS

The study was supported by the Canadian Wildlife Service (CWS), Environment Canada, and Polar Continental Shelf Project (PCSP), Energy, Mines and Resources Canada. I am grateful to G.D. Hobson, past director, PCSP, for his long-time support of my caribou studies. S.J. Barry, CWS, kindly provided statistical assistance; S.M. MacEachran, CWS, drafted the figures. I thank J.R.W. McGillis and A. Westcott for their assistance as observers and pilots Dave White (1985) and Len Martin (1988), Associated Helicopters Ltd., for their flying skill and for their assistance as navigator-spotter on the survey and searches. I thank Dr. A. Gunn, Department of Renewable Resources (DRR), Government of the Northwest Territories (GNWT), and Dr. R.G.W. Edwards, CWS, for critically reading the manuscript. I also thank M.A.D. Ferguson, DRR, GNWT, and two anonymous reviewers for their reviews of the manuscript.

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