AN AERIAL SURVEY OF CARIBOU ON

WESTERN VICTORIA ISLAND (5–17 JUNE 1994)

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ABSTRACT

Concerns over the sharp decline in numbers of the Minto Inlet caribou herd on northwest Victoria Island and increased hunting pressure on the Dolphin and Union caribou herd on southwestern Victoria Island prompted a survey of western Victoria Island. We used two fixed-wing aircraft and flew a systematic strip transect survey of western Victoria Island in June 1994. Our objectives were two-fold: 1) to determine the abundance of caribou in northwest Victoria Island (Minto Inlet calving area), and 2) to delineate the calving distribution of caribou on southwestern Victoria Island (Dolphin and Union calving area), re-survey any high density areas, and estimate population size based on the calving ground survey. We conducted the survey from 5–16 June 1994. The area surveyed was 138 185 km^2 in size and accounted for *ca*. 63% of the entire land area of Victoria Island. We estimated a total of 14 539 ± 1015 (SE) caribou on western Victoria Island at an overall density of 0.11 caribou / km^2. Although our survey area included the entire known seasonal range of the Minto Inlet herd, we only observed 4 caribou on-transect in that area. Our results corroborated previous aerial surveys (March 1992, March 1993 and June 1993) where few caribou were observed and added confirmation to the decline of the Minto Inlet herd. We were unable to delineate the entire calving distribution of the Dolphin and Union herd. Calves and caribou were dispersed over a large, extensive area on south central Victoria Island. Unsystematic surveys and opportunistic observations of radio-collared caribou cows on 17 June 1994, confirmed that caribou were also extensively distributed throughout eastern Victoria Island. Given the large area and uniformly low densities of animals on the calving grounds of the Dolphin and Union herd, we suggest that the calving ground survey technique is not a logistically practical method of determining abundance of caribou on Victoria Island. An alternative survey technique to consider is an aerial survey of the fall rut distribution when all age and sex classes are intermixed and caribou aggregate into relatively higher densities along the southern coastline prior to their fall migration to the mainland.

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INTRODUCTION

Arctic-island caribou *(Rangifer tarandus)* on northwest Victoria Island (i.e. the Minto Inlet herd) declined sharply in the early 1990s (Heard 1992, Gunn in prep.), and in April 1993, the Olokhaktomiut Hunters and Trappers Committee (OHTC) in Holman self-imposed a 5-year hunting moratorium for the area north of Minto Inlet (see Appendix A). Because of the hunting moratorium, there was concern that Holman hunters would shift their efforts to the south, thereby increasing the harvest of the Dolphin and Union caribou herd (as defined by Gunn and Fournier's (2000) satellite telemetry).

By 1991, arctic-island caribou on Victoria Island had been classified as "threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). This classification was based on concerns (see Miller 1990) about the level of harvesting compared to the only available population estimate at the time (Jakimchuk and Carruthers 1980). Furthermore, Dolphin and Union caribou were resuming a traditional migration across Coronation Gulf and Dease Strait to overwinter on the mainland (Gunn *et al.* 1997a) and were becoming more accessible to hunters from Kugluktuk, Umingmaktok and Bathurst Inlet. Concomitant with the concern of increased hunting was a concern over increased mortality of Dolphin and Union caribou associated with drownings during the fall migration to the mainland and the potential effects of proposed ship traffic through he Dolphin and Union Strait (Nunavut Planning Commission 1998).

Population estimates for the Minto Inlet herd and the Dolphin and Union herd were required to evaluate the hunting moratorium on the former, and the estimated harvest of the latter[1]. Concerns about the extent of decline in the Minto Inlet herd prompted the OHTC and the Wildlife Management Advisory Council-NWT (WMAC) to request an aerial survey of its entire annual range (Appendix A). The potential for increased hunting and mortality of Dolphin and Union caribou, combined with an outdated population estimate, prompted the Department of Renewable Resources (DRR)[2] to extend the survey, proposed for June 1994, to include southwestern Victoria Island. Objectives for the June 1994 survey were:

1) to determine abundance of caribou in northwest Victoria Island by covering the calving area and known annual distribution of the Minto Inlet herd; and
2) to delineate the calving distribution of Dolphin and Union caribou on southwestern Victoria Island, re-survey any high density areas, and estimate population size based on the calving ground survey.

[1] A fundamental part of the strategy for managing the harvest of caribou in Nunavut and the Northwest Territories is to monitor trend of herd size and ascribe harvest mortalities to those individual herds (see Graf and Heard 1990, Gunn 1998).
[2] DRR is now the Department of Resources, Wildlife and Economic Development.

Review of Caribou Surveys on Victoria Island

The earliest recorded information on Victoria Island caribou dates back to observations by explorers in the early 1850s and again in the early 1900s (see review in Manning 1960, pp. 7–11). Those early observations suggested that there was a migratory and a resident population of caribou on Victoria Island. Manning (1960) referred to the former as the Dolphin and Union Strait herd and guessed that 100 000 caribou was a reasonable estimate for that herd; he predicated this estimate on explorers' observations of caribou densities during spring and fall migrations and extrapolated to the size of Victoria Island. Manning (1960, p.9) also speculated that approximately 8000–9000 caribou were resident on Victoria Island. Using various anthropological and wildlife sources (i.e. elders and hunters), Gunn (1991) sketched a tenable picture of a nadir in abundance of Victoria Island caribou and muskoxen between the 1920s and 1930s and a subsequent recovery in the 1970s (Gunn *et al.* 1997a). Although Manning (1960) argued strongly that over-hunting was the cause of the decline and near extirpation of the Dolphin and Union Strait herd, Gunn (1991) has suggested that severe winters may have also played an important role.

The first attempt at compiling observations of caribou and muskoxen on Victoria Island using an aircraft was co-ordinated by Macpherson (1961) in conjunction with a geological airborne survey of the western Arctic Islands in the summers of 1958–59 (Thorsteinsson and Tozer 1962). Macpherson (1961) compiled observations by geologists on Victoria Island and estimated 670 caribou from observed caribou densities on 18 500 km of transects. Macpherson (1961) reported an average transect width of 540 m, with most of the individual flights occurring at elevations of between 30 and 150 m above ground level.

After Macpherson's (1961) initial efforts, Spencer (1976) and Boxer (1979, 1980) recorded observations of caribou while conducting reconnaissance surveys for muskoxen in the vicinity of Holman and Cambridge Bay in the 1970s. However, it was not until August 1980 that Jakimchuk and Carruthers (1980) used a DHC-2 Turbo Beaver to fly the first systematic aerial survey of Victoria Island to determine distribution and abundance of caribou and muskoxen on an island-wide basis. Jakimchuk and Carruthers (1980) flew the survey as part of an environmental assessment for the proposed Polar Gas Project. They divided Victoria Island into four strata: three strata in the west were flown at 6.25% coverage and a stratum in the southeast was surveyed at 3.13% coverage. Because of inclement weather, they did not fly northeast Victoria Island (Storkerson Peninsula). Jakimchuk and Carruthers (1980) estimated a total of 7936 ∀ 1118 (Standard Error) caribou on Victoria Island.

Subsequent survey efforts then shifted to describe pre-calving and calving distributions. In response to potential shipping activities and the possibility that there was an inter-island population of caribou that calved and summered on eastern Banks Island and then wintered on northwest Victoria Island, Miller (1986) conducted unsystematic helicopter flights in March 1985 to determine whether caribou migrated across the sea ice of Prince of Wales Strait. Miller

(1986) did not observe conclusive evidence to suggest an inter-island migration, and extended his search inland on Victoria Island (and Banks Island) to locate calving caribou. On Victoria Island, Miller (1986) found a coastal concentration of caribou (mostly bulls, juveniles, and yearlings) centered on the Deans Dundas Bay area, but was unable to find evidence for a caribou calving ground within his search area of northwest Victoria Island (i.e. Prince Albert and Diamond Jenness peninsulas). He proposed three possible explanations: 1) the breeding females he observed in the “Jesse Bay calving area” on Banks Island were the missing female segment of the northwestern Victoria Island caribou herd; 2) the calving area for northwestern Victoria Island caribou was actually further east or south on Victoria Island; or 3) his limited search effort was not adequate and he failed to find the calving area (Miller 1986, p. 18).

From 1987–89, Gunn and Fournier (2000) conducted a study to determine the number of caribou herds on Victoria Island and their pattern of seasonal movements. They used ten satellite transmitters to locate areas used by adult cows during calving and rutting, and flew aerial surveys to visually confirm whether collared cows had calved. From this work, Gunn and Fournier (2000) showed that there were two distinct areas of calving and rutting on western Victoria Island. One calving area was found north of Minto Inlet and the other was located south and east of Prince Albert Sound. Collared cows used similarly discrete rutting areas. This corroborated local knowledge of hunters in Holman and Cambridge Bay and suggested that there were two separate herds on western Victoria Island. An aerial survey of northwest Victoria Island in June 1987 resulted in an estimate of 643 ∀ 132 (SE) but delineation of the southern and northern extent of the calving area was incomplete (Gunn and Fournier 2000). A subsequent survey in June 1988 was hampered by inclement weather and was not completed (Gunn and Fournier 2000).

Aerial surveys of northwest Victoria Island were flown again in March 1992, March 1993, and June 1993 (Heard 1992, Gunn in prep.). The rationale for the March 1992 survey (Heard 1992) was twofold. First, the community of Holman was concerned that caribou were scarce in the previous two winters and second, an evaluation of muskox distribution was needed to plan and monitor the effects of a proposed commercial muskox harvest. From 24–27 March 1992, Heard (1992) surveyed an area that included the area surrounding the eastern two thirds of Minto Inlet; the southern extent was the north shore of Prince Albert Sound and the northern extent was approximately 72 degrees north. From his observations of 26 caribou in 8 groups, Heard (1992) estimated 170 ∀ 54 caribou. In 1993, Gunn (in prep.) repeated the survey on 18–20 March using similar methodology to her June 1987 survey and estimated 144 ∀ 22 caribou. Three months later (13–15 June), Morrison (Gunn in prep.) flew an extensive survey of Prince Albert Peninsula that included the known seasonal distribution of caribou in northwest Victoria Island and counted only 15 caribou and 1 calf on 2114 km of transects. Those aerial surveys confirmed the rapid decline of caribou on northwest Victoria Island (Gunn in prep.).

Although the impetus for the June 1994 survey was a request by the OHTC and WMAC to re-evaluate distribution and abundance of caribou in northwest Victoria Island, the aerial survey of western Victoria Island was also designed as part of a larger research program, conceived jointly by DRR and WMAC in October 1993. The research program (DRR 1993) principally consisted of determining population trend through aerial surveys and estimating hunter-kills through a caribou harvest study.

An effective technique of estimating herd size is a prerequisite for determining population trend; the research program was based on the premise that the calving ground survey technique could be effectively used to monitor trends of Dolphin and Union caribou. As a result, a radio-collaring project was also initiated in 1994 to improve our knowledge of calving grounds on Victoria Island (Nishi 2000).

In this report, we present results from the systematic aerial survey of caribou (*Rangifer tarandus*) on western Victoria Island in June 1994. Although 6 years have passed since completion of this survey, results have been presented and discussed with wildlife management boards and Hunters and Trappers Committees / Organizations. We also recognise that additional studies have occurred during this time (Table 1) and refer to them in the discussion.

Table 1. Summary of field studies on arctic-island caribou, Victoria Island, 1994 – 1999.

Timing	Researcher	Survey area	Type
Jun. 1994	Nishi & Buckland (this report)	Caribou on western Victoria Island	Systematic aerial survey
Apr. 1994-Oct. 1997	Nishi (2000)	Dolphin & Union caribou on Victoria Island	VHF radio telemetry (20 cows collared April 1994)
Jul. 1996-1998	WMC International Ltd. (unpubl. data)	Caribou in the Shaler Mountains	Satellite telemetry (4 cows collared July 1996)
Oct. 1997	Nishi and Gunn (in prep)	Dolphin & Union caribou during the rut	Stratified systematic aerial survey
Jul. 1998	Nagy (unpubl. data)	Northwest Victoria Island	Systematic aerial survey
Oct. 1999 & ongoing	Patterson (pers. comm.)	Seasonal movements and mortality of Dolphin and Union caribou	Satellite telemetry (25 cows collared Oct. 1999)

Rationale for Design of Caribou Surveys

Effective survey techniques for caribou are based on a good understanding of the life history and seasonal migration patterns of the herd of interest. With insular herds where ingress and egress are assumed to be minimal, as on Banks, Southampton, and Coats islands, the approach has been to conduct aerial surveys of the entire island (Gates *et al.* 1986, Nagy *et al.* 1996, Heard and Ouellet 1994). With Peary and arctic-island caribou herds that migrate between islands, i.e. the Western Queen Elizabeth Islands and the Prince of Wales Island-Somerset Island-Boothia Peninsula Complex, biologists have surveyed entire island complexes (Miller *et al.* 1977, Gunn and Dragon 1998). With mainland herds of barren-ground caribou, the technique of choice has been aerial photographic surveys of calving grounds (Heard 1985, Williams 1994) or alternatively post-calving aggregations (Valkenburg *et al.* 1985, Russell *et al.* 1996). The prevailing theme in the design of these surveys is an integration of technical and biological considerations that improve the precision and accuracy of the estimate. Stratification of survey effort (Siniff and Skoog 1964, Heard 1987) and aerial photography (Russell *et al.* 1996) are two technical tools frequently used to improve precision and accuracy of caribou surveys, respectively.

Our knowledge of traditional calving grounds (Gunn and Miller 1986) has been a useful model, at a broad landscape level, for describing the likelihood of pregnant female caribou using the same areas for calving (Heard and Stenhouse 1992, but see Valkenburg and Davis 1986). This conceptual model of fidelity of parturient cows to a calving area also provides our current rationale for ascribing herd identity (Kelsall 1968, Thomas 1969). It is a good example of how our biological understanding has led to an efficient and repeatable survey technique for estimating numbers of breeding females on an annual calving ground (Heard 1985).

Similarly, the observed response of barren-ground caribou to biting insects has allowed biologists to design aerial photographic surveys of post-calving aggregations in summer (Valkenburg *et al.* 1985, Russell *et al.* 1996). Although there is debate on the merits of the two census methods (Thomas 1998), an understanding of seasonal movements and behaviour of caribou is a prerequisite for both survey techniques. Most recently, biologists have used radio collars (satellite and/or VHF transmitters) to improve the design and execution of aerial photo-censuses of annual calving grounds (Gunn *et al.* 1997b) and post-calving aggregations (Valkenburg *et al.* 1985, Russell *et al.* 1996, Nagy pers. comm.).

STUDY AREA

Victoria Island is the third largest island in the Canadian Arctic and has a total land area of ca. 220 574 km^2 (Figure 1). Owing to its size, there are regional patterns in geology (Fyles 1963, Thorsteinsson and Tozer 1962), vegetation (Bliss 1981, Edlund 1983), and climate (Maxwell 1981) on Victoria Island.

Vegetation

Edlund (1983) described three broad arctic ecosystems (Low, Mid, and High Arctic) that occur on western Victoria Island. She described the progression from Low to High Arctic ecosystems as characterized by a decrease in species diversity and percent plant cover, and by major changes in the life form of the plant communities, i.e. from erect and semi-erect shrubs to recumbent dwarf shrubs.

Edlund (1983) characterized the northern coast and higher elevations in the Shaler Mountains, Prince Albert Peninsula, and Diamond Jenness Peninsula as inclusive to the High Arctic ecosystem. She found flora of this ecosystem to be the least diverse (less than 100 vascular species); continuous plant cover was limited by moisture and consequently restricted to lower slopes and wetlands. Excluding lower wet areas, vascular plant communities were dominated by dwarf shrubs (less than 25% cover): mountain avens (*Dryas integrifolia)* were

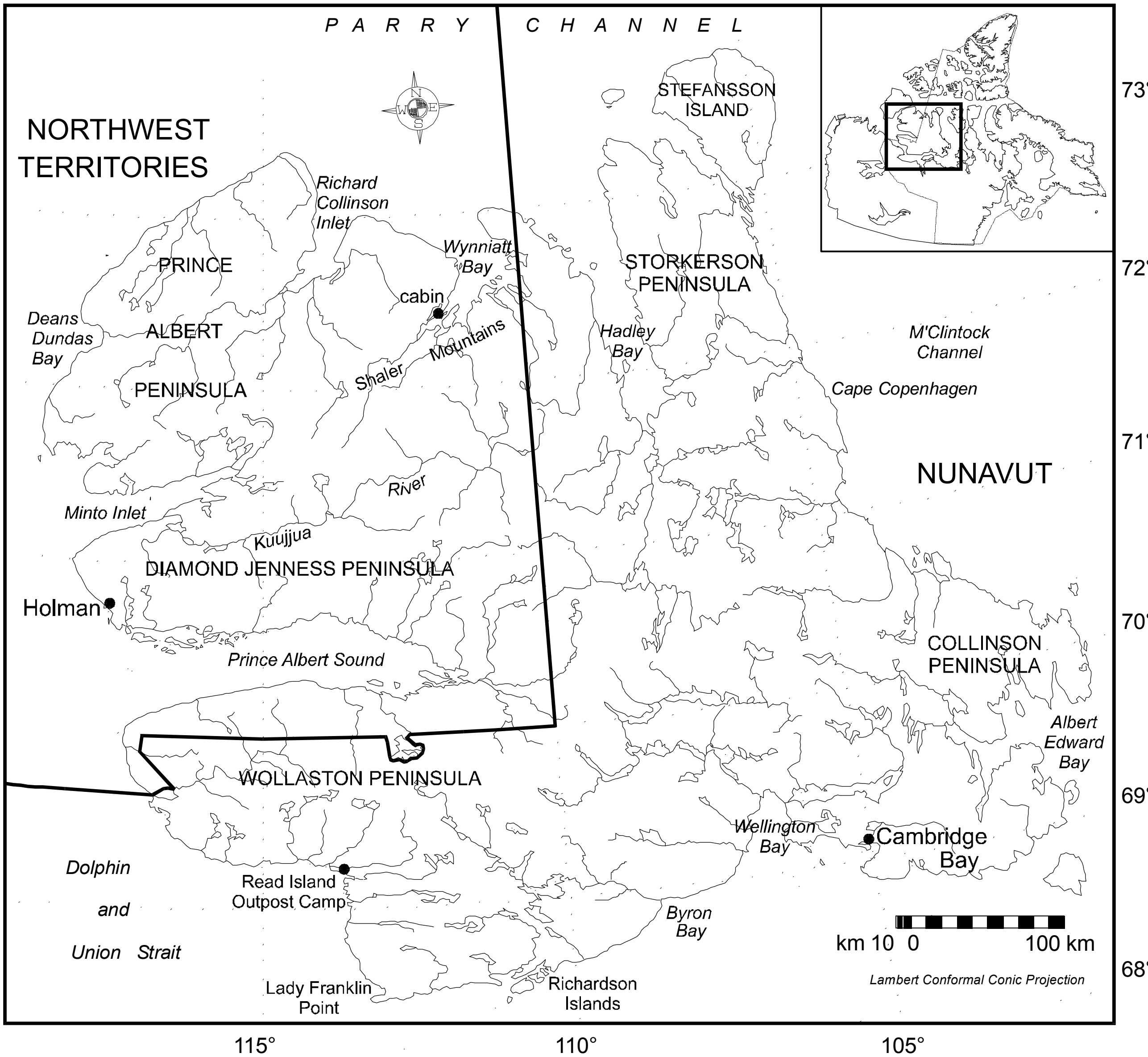

Figure 1. Place names and locations on Victoria Island, Canada.

dominant, with Arctic willow (*Salix arctica*) being common. Wet sedge meadows were relatively low in graminoid abundance and general diversity.

Edlund (1983) described the Mid Arctic ecosystem as occurring on central Prince Albert Peninsula, at moderate elevations in the Shaler Mountains and on Diamond Jenness Peninsula, and in a small area of northern Wollaston Peninsula. The Mid Arctic ecosystem was intermediate in plant species diversity with less than 150 species described (Edlund 1983). Dwarf shrubs, particularly *Dryas* spp., dominated all but the wettest areas. The woody component of wetlands consisted of prostate shrubs, mostly *Salix arctica*. However, *Cassiope* spp. was found in sheltered sites.

Edlund (1983) described the Low Arctic ecosystem on Wollaston Peninsula and northwards along the coast to southern Prince Albert Peninsula. The flora was richest in diversity with up to 200 vascular species identified. *Dryas* spp. was a major component of communities that had nearly continuous ground cover. Arctic willow was a common dwarf shrub associate, with herbaceous associates including a variety of legumes, forbs, and graminoids. The shrub component of wetlands included several dwarf shrub species as well as thickets of erect shrubs, commonly willows. Dwarf birch (*Betula* spp.) also occured in sheltered locations. The presence of sites with tree-sized willows (*Salix* spp.) ranging from 1–5 m high (depending on species) in the Minto Inlet area was a unique and unusual feature of this Low Arctic ecosystem (Edlund 1983, p.77).

Climate

In her comprehensive review of climate of the Canadian Arctic Islands, Maxwell (1981) identified five climatic regions and showed that Victoria Island was covered by three of those five regions. Climatic characteristics in northern Victoria Island are influenced predominantly by the Arctic Ocean (Table 2). However, as Parry and M'Clintock Channels are dominated by multi-year ice, the maritime effect is reduced to the extent that mean annual temperature range is still very high (38-40°C) (Maxwell 1981).

The climate in central and eastern Victoria Island possesses many characteristics of the continental regime of the adjacent mainland. This is due to the massive size and proximity of adjacent land areas and the fact that inter-island waterways are narrow and shallow (Maxwell 1981). This region of the island has very low precipitation amounts with a large mean annual temperature range (42-45°C) (Maxwell 1981).

The climate in western Victoria Island is mainly influenced by maritime air masses moving into the Mackenzie Valley and southern Beaufort Sea from the west (Maxwell 1981). Although northwest Victoria Island is considered a polar semi-desert (Bliss 1981), the southwest coast of Victoria Island receives increased amounts of net radiation with more precipitation and cloudiness due to the maritime influences (Maxwell 1981). The mean annual temperature range is 36°C and summer conditions are relatively warmer (Table 2).

Table 2. General climatic characteristics of Victoria Island (from Maxwell 1980 and 1981).

Region	**Winter**[a] (B: Begins E: Ends)	**Mean annual**[b] **thawing degree-days**	**Mean annual**[c] **growing degree-days**
Northwestern – Western Parry Channel (Ia)	B: Aug 20-25 E: June 10-25	400-600	50-100
South-central – Victoria Island-Boothia Peninsula (IIa)	B: Aug 25- Sep 15 E: June 5-15	500-600+	100-200+
Western (III)	B: Aug 30- Sept 5 E: May25	500-600	100-200

[a] Winter is defined as time when mean daily temperature is below 0°C.
[b] Mean annual totals of degree-days above 0°C based on the period 1941-1970. A degree-day is defined as a unit of measurement equal to a difference of one degree between the mean outdoor temperature on a certain day and a reference temperature.
[c] Mean annual totals of degree-days above 5°C based on the period 1941-1970 (an indicator of total heat available for plants in the growing season).

METHODS

A Systematic Survey of Western Victoria Island

We largely based our survey design on available summaries of the 1987–88 satellite telemetry data since Gunn and Fournier's (2000) aerial survey results from June 1987 and 1988 were unavailable to us prior to the survey (A. Gunn was away from Canada). We delineated western Victoria Island into five strata (Figure 2) based on general topography of the island and expected distribution of calving caribou. Stratum II included the calving area south and southeast of Prince Albert Sound (Figure 4 in Gunn and Fournier 2000). Stratum IV was delineated to include the calving area and known annual range of the Minto Inlet herd (Gunn and Fournier 2000). We used Universal Transverse Mercator (UTM) gridlines to space transects at 10-km intervals, which was 10% coverage of the survey area, and we applied uniform coverage in all strata. To reduce sampling bias, we oriented transects such that they were perpendicular to major rivers and drainage valleys.

The large size of the survey area necessitated the use of two aircraft: a Helio-Courier H-295 on tundra tires and a Cessna 185 on wheel-skis. For both aircraft, we used a total strip width of 1000 m (500 m per side). Survey altitude and speed were 120 m above ground level and 140–160 km per hour (km/h), respectively. We positioned transect markers on the aircraft using the method outlined by Norton-Griffiths (1978). On the Helio-Courier, we attached a length

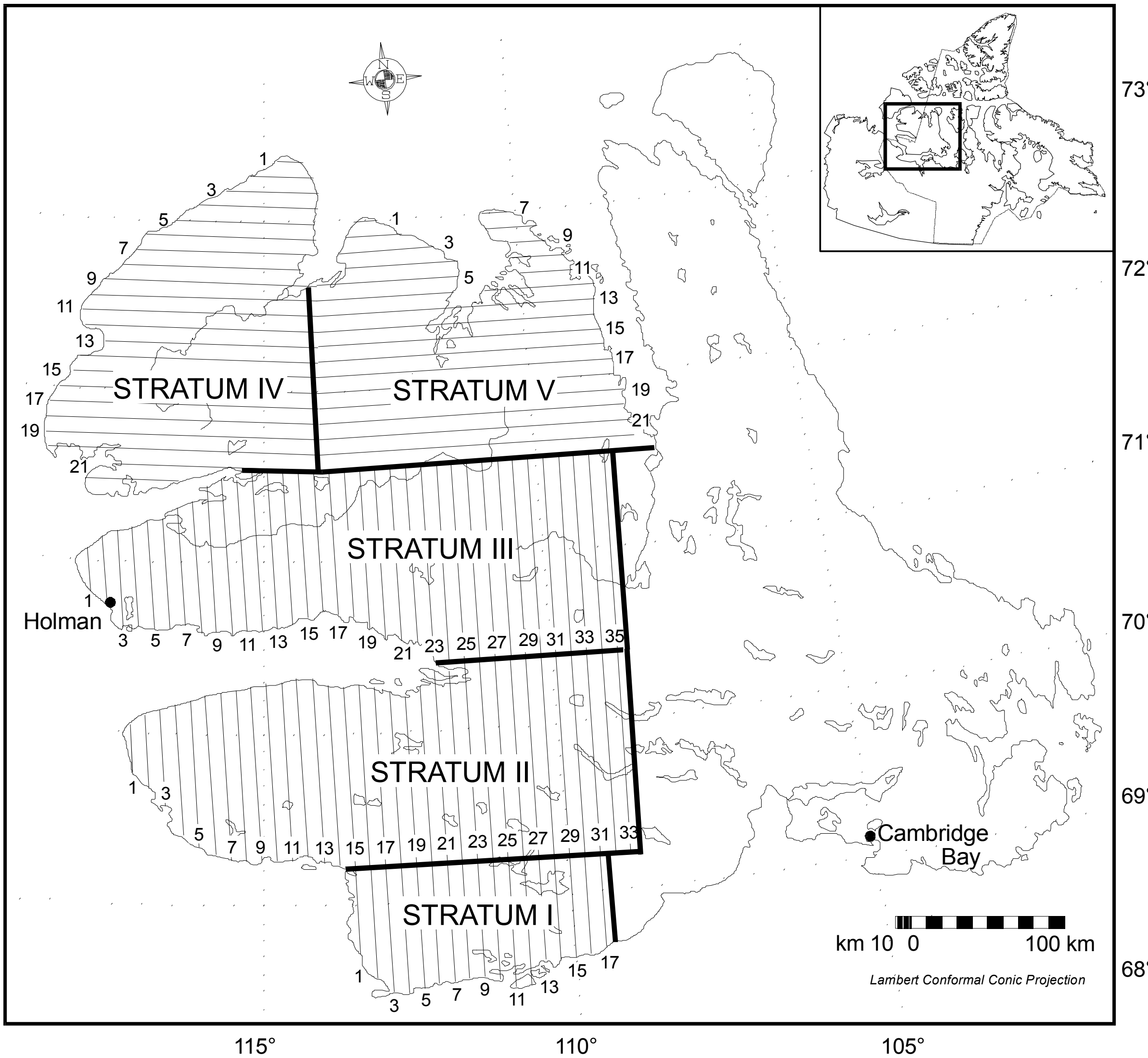

Figure 2. Stratum boundaries and transect lines for an aerial survey of western Victoria Island, 5-14 June 1994 (note: only odd-numbered transects are labelled for display here).

of nylon cord from an eyebolt on the underside of each wing to a bracket on the fuselage behind and below the rear doors. A short length of black tape was wrapped around each cord to visually delineate the outer boundary of the strip transect. On the Cessna 185, we marked the outer transect boundaries with a 30-cm length of wooden doweling (7-mm diameter) attached to each of the wing struts. We verified strip width from the air using the runway at the Kugluktuk and Holman airports by positioning a half-ton truck or empty fuel drum 500 m from one end of the runway. We checked the transect markers against the known distance on the ground by flying perpendicularly to the runway axis at survey altitude.

In the Helio-Courier, all observations of caribou and muskoxen were plotted on 1:250 000 scale maps by the pilot-navigator, and recorded on data sheets by the right observer. Observers in the Cessna called out their observations into the intercom system and micro-cassette recorders. The navigator plotted all muskox and caribou observations on 1:250 000 scale maps, and recorded those observations on data sheets. At the end of each day, cassette recordings were played back to verify hand-recorded data. Distribution and abundance of muskoxen will be described in a separate report.

Both crews left Kugluktuk on 5 June to start surveying their respective strata (Appendices B and C). The survey crew in the Helio-Courier consisted of a pilot-navigator (P. Linton), right observer (L. Buckland), and left observer (J. Kuneyuna). That crew surveyed northwest Victoria Island (strata III, IV, and V)

(Figure 2) and was based out of Holman and a cabin at Wynniatt Bay (DRR, Polar Bear Project). The general order of strata flown by the Helio-Courier was stratum IV, V, and then III (Appendix D). Variable weather (Appendix E) in the survey area required that transects 16–20 in stratum IV and transects 13–17 in stratum V be flown in western and eastern portions.

The second survey crew used the Cessna 185 to survey the southwest region of the island (strata I, II, and III) (Figure 2). Crewmembers included a pilot (K. Williams), navigator (J. Nishi), right observer (K. Niptanatiak with J. Nishi as alternate), and left observer (P. Panegyuk). That crew was based out of Kugluktuk and an outpost camp at Read Island (Figure 1). The general order of surveying was stratum II, I, and then the eastern portion of stratum III (Appendix D). Because of variable weather (Appendix E) and poor visibility on transects 17, 18, and 30 in stratum II, those transects were re-flown in subsequent days. To extend the survey area and better delineate the eastern distribution of calving caribou in the southern strata, we added two and four additional transect lines to strata I (transects 16 & 17) and II (transects 30–33), respectively (Figure 2). Upon completion of strata I and II, and transects 27–35 in stratum III, the Cessna crew worked out of Holman to assist the Helio-Courier crew in the completion of stratum III.

Strata I–V were completed on 14 June and both aircraft subsequently flew to Kugluktuk, with the Cessna 185 then returning to Norman Wells. Upon completion of those five strata, our initial assessment of survey observations showed a clumped distribution of caribou and the presence of calves in the Shaler Mountains. Observations also suggested that there was a break in distribution of caribou south of the Kuujjua River in the northern portion of stratum III (Figures 3 and 4).

To sample this distribution of cows and calves and to improve precision of the estimate, we delineated and surveyed two additional strata, VI and VII (Figure 5), in the Shaler Mountains within stratum V. We surveyed those two additional strata on 15 and 16 June with the Helio-Courier and a three-person crew: pilot-navigator (P. Linton), left observer (L. Buckland), and right observer (J. Nishi). We spaced the transects at 3-km intervals and flew at an airspeed of 140–160 km/h at 120 m above ground level. Transect width was 1000 m (500 m per side).

Unsystematic Reconnaissance of Eastern Victoria Island

After finishing the survey of the Shaler Mountains, we allocated remaining budgeted hours on the Helio-Courier to conduct an unsystematic reconnaissance flight of eastern Victoria Island. We flew the unsystematic survey flight to determine whether calving caribou were distributed along the eastern part of Victoria Island. We classified caribou into the following age and sex classes: bulls, yearlings, antlered cows, antlerless cows, calves, and unknown. We flew from the Shaler Mountains towards the southern extent of Hadley Bay. Survey altitude was variable, from 80 m to 120 m above ground,

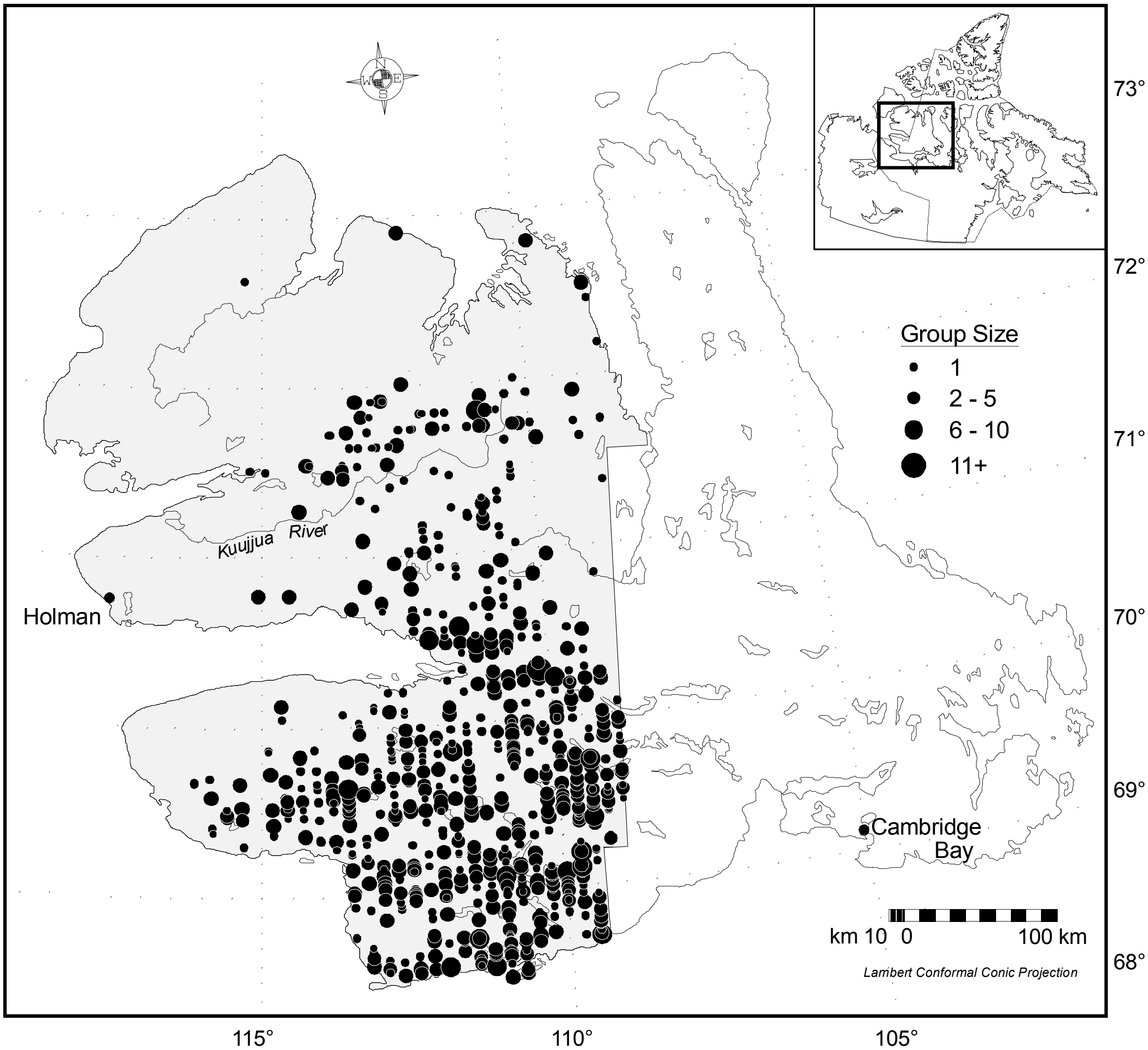

Figure 3. Caribou observed on transect during an aerial survey of western Victoria Island, 5-14 June 1994 (surveyed area shown in grey).

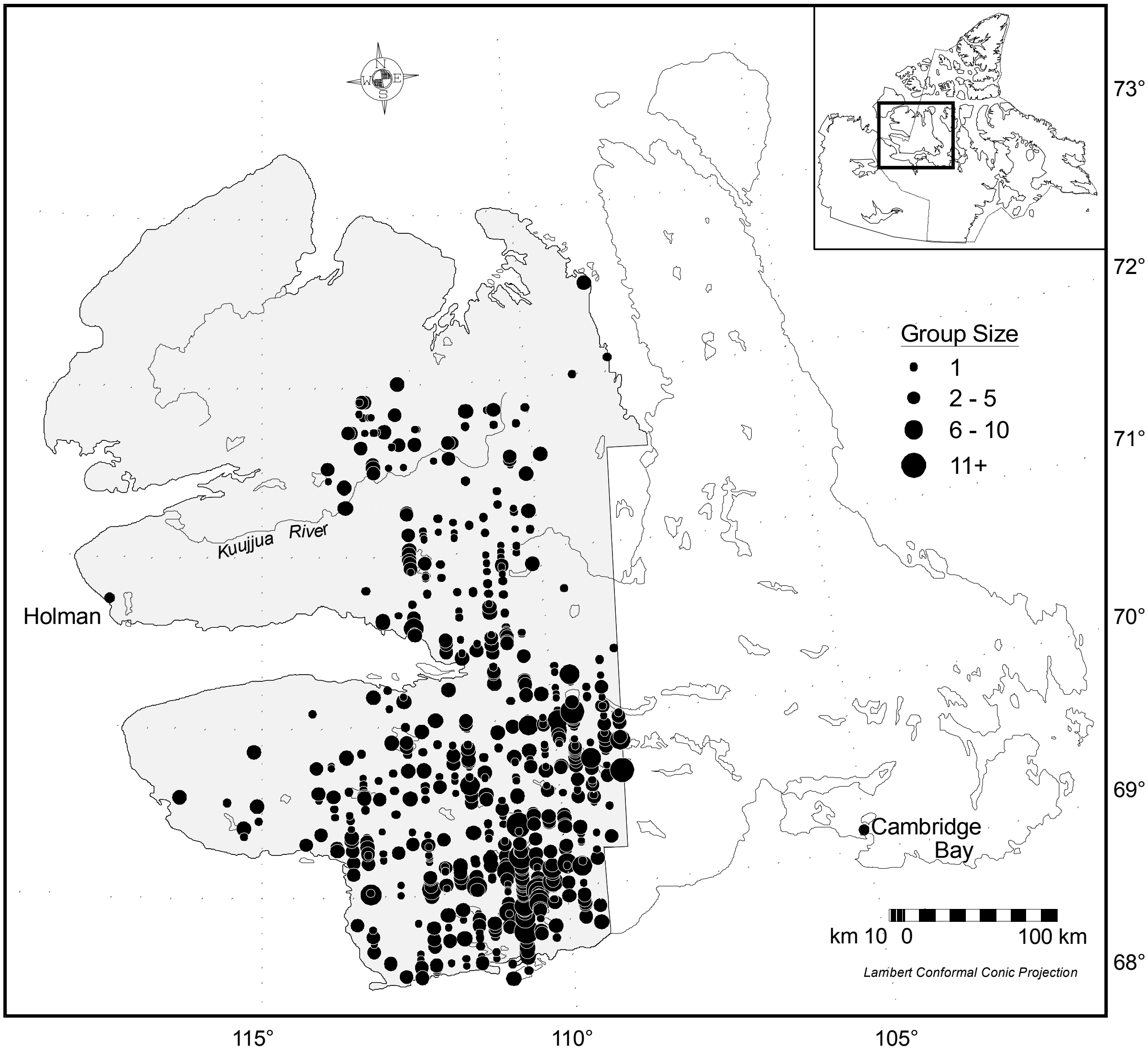

Figure 4. Caribou observed off transect during an aerial survey of western Victoria Island, 5-14 June 1994 (surveyed area shown in grey).

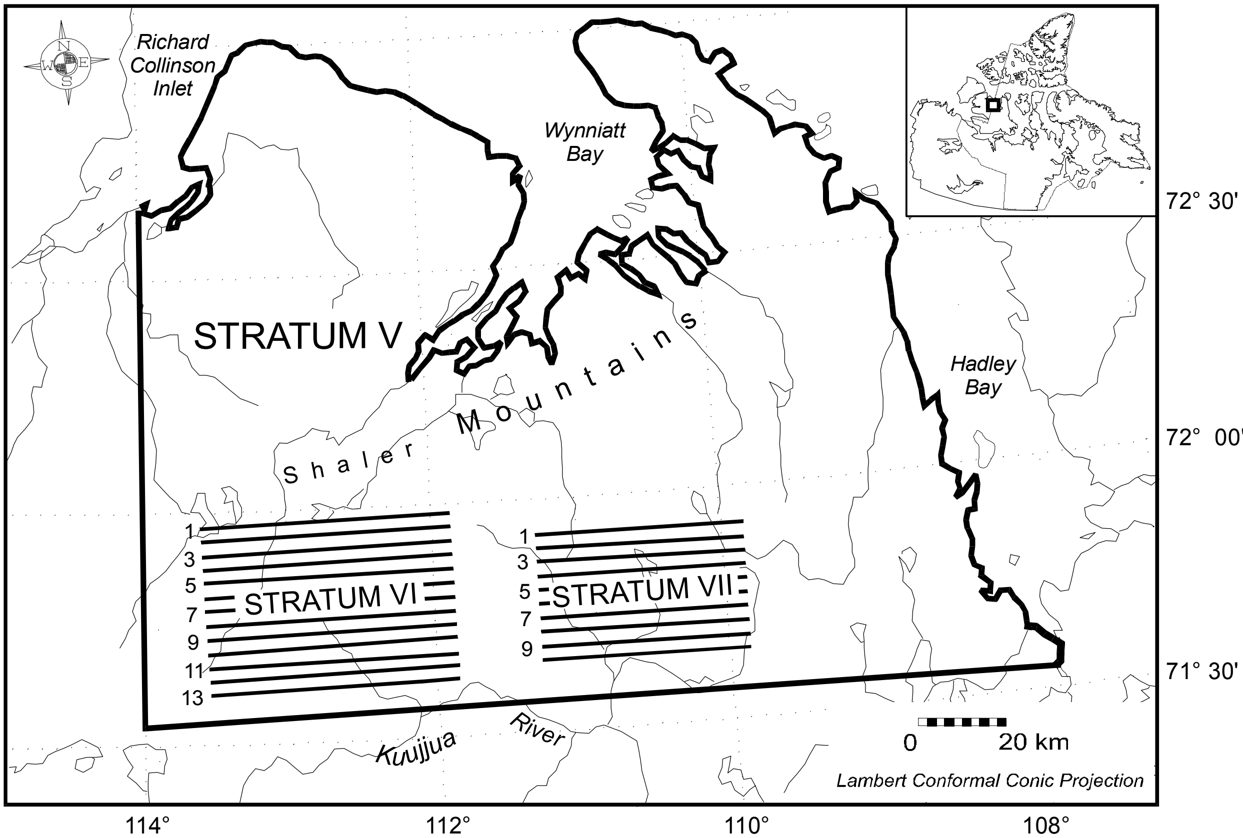

Figure 5. Strata and transects lines for an aerial survey of the Shaler Mountains on northern Victoria Island, 15-16 June 1994.

with an air speed of 130–160 km/h. Following a refuelling stop at Hadley Bay, we then flew east towards Cape Copenhagen and then south along the east coast to Collinson Peninsula with Cambridge Bay as our final destination.

Data Analyses

We used Jolly's (1969) Method 2 (strata I–V) and Method 1 (strata VI and VII) to calculate population estimates of caribou from observations on transect (Krebs 1992, Program 3.5 – Program Aerial). All mean values are presented with a standard error (SE) unless otherwise indicated.

Differences between left and right observers were tested using a two-tailed Wilcoxon signed ranks test. We adjusted sample sizes for occurrences when there was no difference between left and right observers, and we used the large sample test statistic adjusted for tied ranks (Siegel and Castellan 1988, pp. 91–94). Significant differences are reported at $p \leq 0.05$.

In compiling all on-transect observations of caribou group size during the systematic survey, we treated simultaneous observations by left and right observers as separate samples. However, in 89 cases where observers called out the number of caribou both on and off transect in a single observation, we recorded group size as the sum for that occurrence. We used a Kruskal Wallis one-way ANOVA on ranks to compare median group size of caribou observed during the systematic survey versus the low-level unsystematic reconnaissance.

For geographic analysis of survey data from strata I–VII, we used the

SPANS GIS software package (SPANS version 6.0, TYDAC 1997). We determined caribou densities along each transect by summing all on-transect observations at 10-km intervals. Since strip width was 1 km, density estimates were calculated for contiguous quadrats of 10 km^2 along a transect. Because total transect length was not evenly divisible into 10-km lengths, we used density samples from quadrats that were 10 ∀ 0.5 km^2; this range allowed for ∀ 5% variability in area. Based on this criterion, the number of density samples used in analysis of data in strata I–V was reduced from 1481 to 1262. We show densities from strata I–V separately from the data of strata VI and VII because they were surveyed at different sampling intensities, i.e. 10% versus 30% coverage.

RESULTS

Systematic Survey of Western Victoria Island, June 1994

Between the two survey aircraft, we flew 157.5 hours from 5–16 June 1994 to complete the systematic survey of western Victoria Island (Appendices B and C). An additional 39.8 hours were used to ferry aircraft between communities and/or field camps. In total, we flew 14 673 km of strip transects and counted 1563 caribou (excluding 50 calves) on transect (Appendix F). Our estimate for the entire survey area was 14 539 ∀ 1015 non-calf caribou (Table 3).

The highest densities of caribou (0.39 caribou / km^2) occurred on southern Victoria Island in stratum I (Table 3, Figure 6). Relative to other strata in the survey area, we observed a higher proportion of bulls (recognized by velvet antlers) in the immediate area of the Richardson Islands and more generally within about 100 km of the southern coastline. Caribou density was lower in the western portions of stratum II and III and declined north from stratum II (0.19 caribou / km^2) to III (0.05 caribou / km^2) (Figure 6). Along the northern end of stratum III, there was a break in the distribution of caribou associated with the Kuujjua River drainage (Figure 6). On north-central Victoria Island (stratum V, Figure 3), 66% of the caribou were found in the Shaler Mountains (stratum VI and VII, Figure 4). Caribou densities in stratum VI (0.13 caribou / km^2) and VII (0.11 caribou / km^2) were considerably higher than in the rest of

Table 3. Analysis of data from an aerial survey of caribou *(Rangifer tarandus)* on western Victoria Island, 5–16 June 1994. (Areas calculated using a 1: 8 000 000 scale base map on SPANS EXPLORERJ)

	Strata							
	I	II	III	IV	V	VI	VII	Total
Maximum number of transects (N)	170	325	376	208	158	43	33	
Number of transects surveyed (n)	17	33	35	22	22	13	10	
Stratum area, km^2 (Z)	12 515	37 063	36 165	26 992	21 220	2580	1650	
Transect area, km^2 (z)	1261	3705	3611	2738	2078	780	500	
Number of caribou counted (y)	496	685	193	4	26	104	55	
Caribou density, caribou / km^2 (R)	0.393	0.185	0.053	0.002	0.013	0.133	0.110	
Population estimate (Y)	4923	6852	1933	39	266	344	182	14 539
Population variance (Var Y)	249 300	604 457	170 739	775	3716	1517	611	1 031 115
Standard error (SE Y)	499	777	413	28	61	39	25	1015
Coefficient of variation (CV)	0.101	0.113	0.214	0.706	0.23	0.113	0.137	0.070
95% Confidence interval	1 059	1 584	840	58	127	85	56	
% Coverage	10.1	10.0	10.0	10.1	9.8	30.2	30.3	

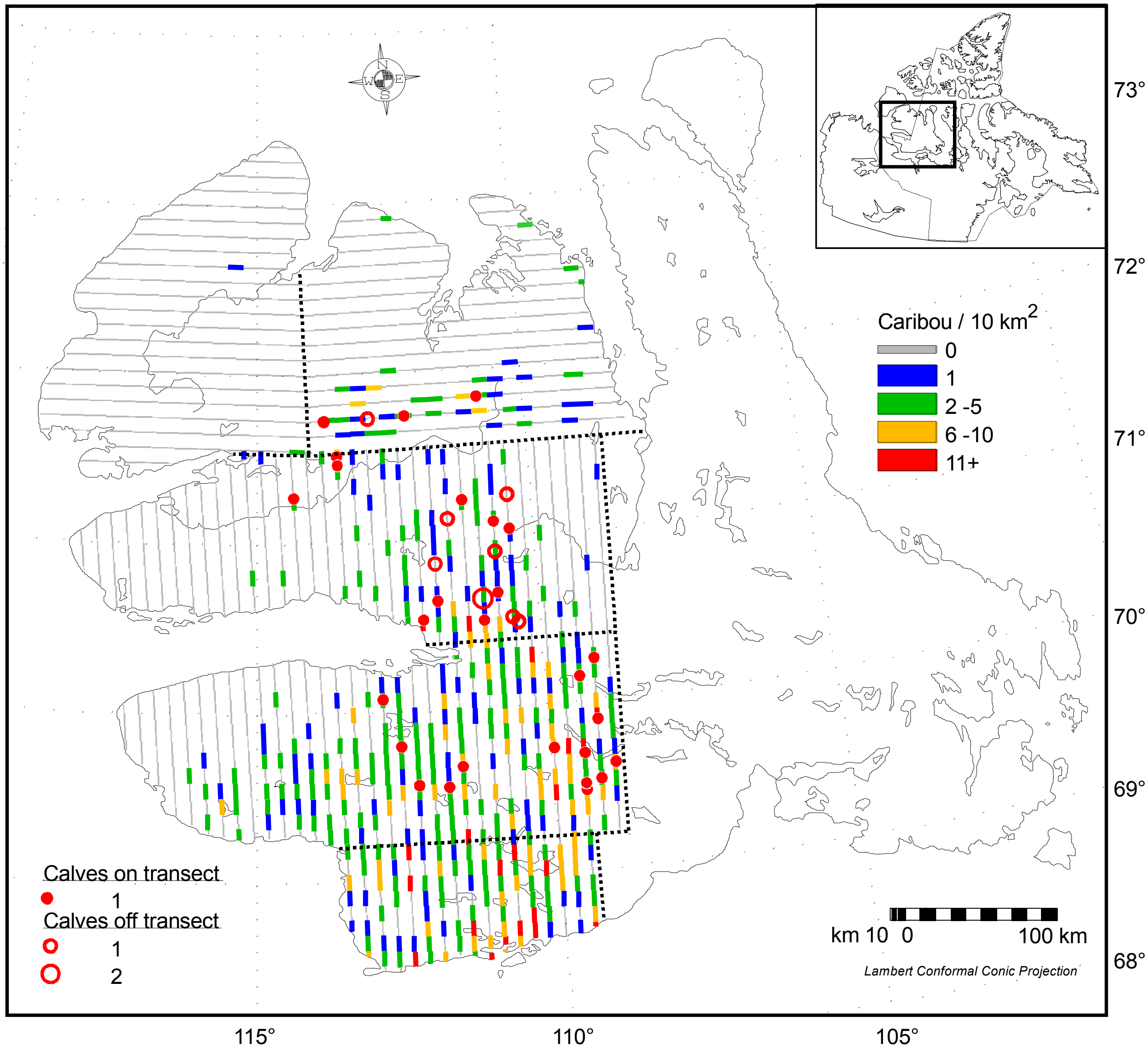

Figure 6. Observed densities of caribou (≥1 year old) from a systematic survey of western Victoria Island, 5-14 June 1994. Densities were calculated from observations of caribou within a 1-km-wide strip transect sectioned at 10-km intervals. Portions adjacent to the coast or another stratum may be ≤10 km^2. All observations of calves are shown with reference made to whether they were on or off transect.

stratum V (0.01 caribou / km^2) (Table 3). We recorded fewest caribou in stratum IV, the northwest portion of Victoria Island (Figure 6).

During the systematic survey, we first observed newborn calves on 9 June in stratum II (Table 4a, Appendix D). Over the next five days, we continued to see more calves, with the highest proportions on 15 and 16 June in strata VI and VII (Table 4a, Appendix D), where most of the cows with calves still had antlers.

During the first stage of the survey, we saw no calves in either stratum I or IV (Table 4b) and calves observed in strata II, III and V were concentrated in two areas. Of the 27 calves observed on transect, 21 (78%) occurred in the eastern portions of strata II and III over an extensive area east of Prince Albert Sound (Figure 6, Table 4b). The other 6 (22%) calves were observed north of the Kuujjua River and in the Shaler Mountains area (Figure 6). During the subsequent survey of strata VI and VII in the Shaler Mountains, we observed an additional 16 and 7 calves, respectively (Figure 7, Table 4b). This translated into the highest proportion of calves observed for all strata surveyed (Table 4b).

There were no significant differences in caribou density associated with the presence or observed abundance of newborn calves (Figure 8). Caribou density was not a good indicator for the presence of calves, and parturient females did not gather into high-density aggregations.

Observed group sizes of caribou on transect were not normally distributed (Kolmogorov-Smirnov Distance =0.269; $p<0.001$). Group size ranged from 1 to 12 (Figure 9). For comparative purposes we present the mean and median

Table 4. Calf and non-calf caribou observed during aerial surveys of Victoria Island, 5–17 June 1994.

a) Observations of caribou summarized by date.

Date	Survey type	Calves	Caribou	% calves
5-Jun-94	Strip transect	0	37	0
6-Jun-94	Strip transect	0	83	0
7-Jun-94	Strip transect	0	421	0
8-Jun-94	Strip transect	0	79	0
9-Jun-94	Strip transect	3	278	1
10-Jun-94	Strip transect	3	153	2
11-Jun-94	Strip transect	4	76	5
12-Jun-94	Strip transect	11	219	5
13-Jun-94	Strip transect	3	80	4
14-Jun-94	Strip transect	3	46	7
15-Jun-94	Strip transect	5	23	22
16-Jun-94	Strip transect	18	136	13
17-Jun-94	Low-level reconnaissance	76	282	27
SUM		**126**	**1913**	

b) Observations of caribou summarized by survey stratum.

Stratum	Survey dates	Survey type	Calves	Caribou	% calves
I	7,8, 11 June	Strip transect	0	496	0
II	5,6,9-12 June	Strip transect	14	685	2
III	7,11-14 June	Strip transect	10	193	5
IV	5-8,10 June	Strip transect	0	4	0
V	6,10,12,13 June	Strip transect	3	94	3
VI	15,16 June	Strip transect	16	104	15
VII	16 June	Strip transect	7	55	13
--	17 June	Low-level reconnaissance	76	282	27
SUM			**126**	**1913**	

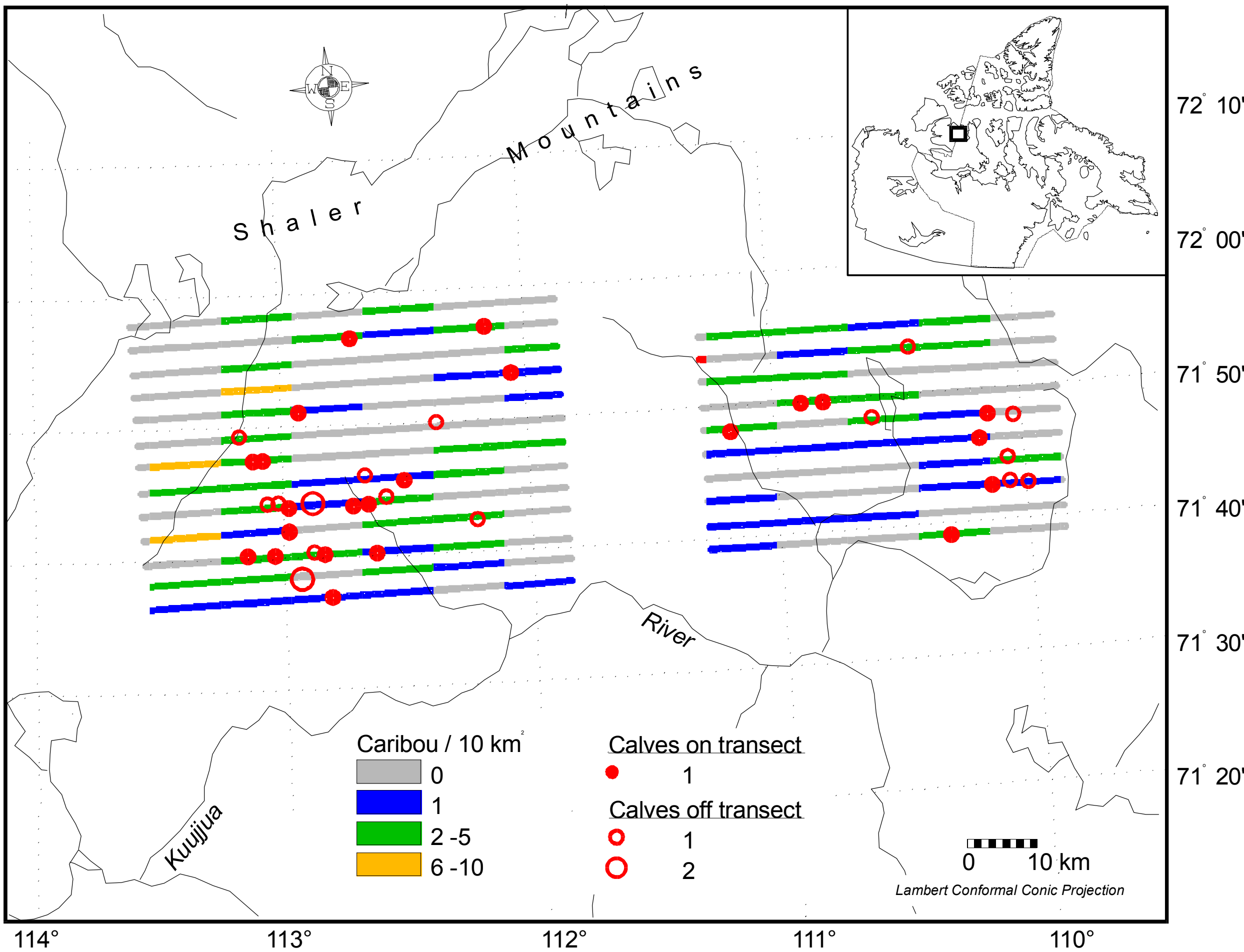

Figure 7. Observed densities of caribou (> 1 year old) from a systematic survey of the Shaler Mountains on Victoria Island, 15-16 June 1994. Densities were calculated from observations of caribou within a 1-km-wide transect sectioned at 10-km intervals. Portions at ends of transect lines may be < 10 km2. All observations of calves are shown with reference to whether they were on or off transect.

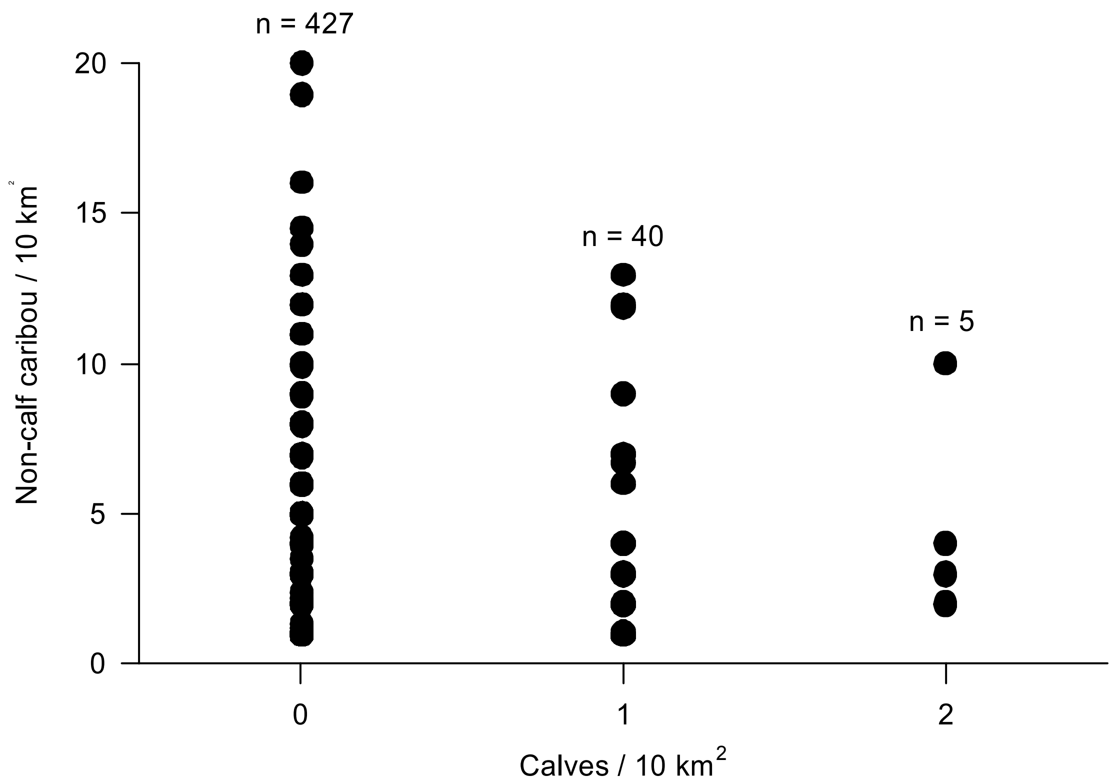

Figure 8. Kruskal Wallis one-way analysis of variance between on-transect observations of calf caribou and associated densities of non-calf caribou (n=472, H=1.499, P=0.473, df = 2). Observations paired within 10-km segments of an aerial survey transect (10 km long x 1 km wide). Sample size restricted to 472 10 km2 contiguous quadrats along a transect in which at least one non-calf caribou was observed (see Figures 6 and 7). Mean quadrat size = 10.0 km2 (0.01 SE), range = 7.5 10.2 km2.

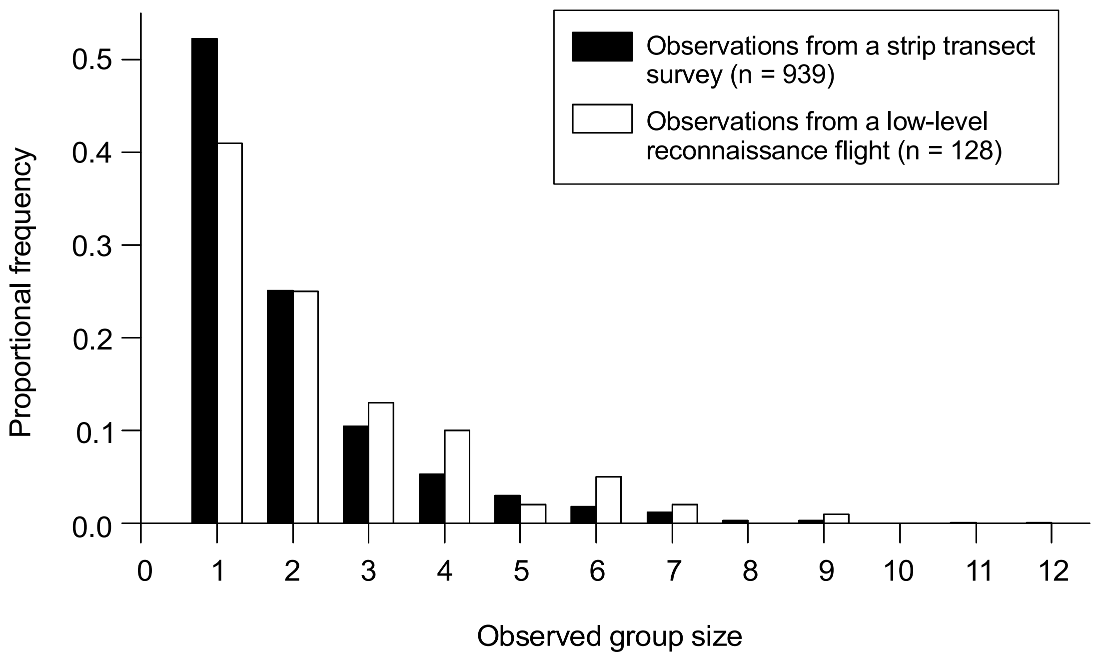

Figure 9. Frequency distribution of caribou group size during aerial surveys of Victoria Island in June 1994. Transect data were collected during a systematic survey of western Victoria Island, 5-16 June 1994. Transect width for right and left observers was 500 m. Survey altitude was 120 m above ground and airspeed was 140-160 km/h. Observations of caribou during the low-level reconnaissance flight of eastern Victoria Island were recorded on 17 June 1994. Airspeed was 140-160 km/h with height above ground varying from 60-100 m.

values of observed group size as 2.0 ∀ 1.5 (SD) and 1.0, respectively (n = 939). Comparison of the number of caribou counted on transect by left and right observers revealed significant differences for some portions of the survey (Table 5).

Table 5. Comparisons between left and right observers using a two-tailed Wilcoxon signed ranks test.

Strata	Observers	Caribou on transect		No. of transects	n[a]	T^+	z[b]	p
		Left	Right					
I, II	PP / KN	536	507	46	34	264.0	-0.59	0.69
III, IV, V	JK / LB	109	35	60	21	49.0	-2.57	*0.01
II, III	PP / JN	117	168	23	19	147.5	2.22	*0.03
VI, VII	JN / LB	86	73	23	22	99.0	-0.98	0.38
I - VII	All Observers	848	783	152	96	2063.0	-1.00	0.40

[a] Sample size: adjusted for occurrences when there was no difference between left and right observers.
[b] Large sample test statistic adjusted for tied ranks (Siegel and Castellan 1988, p. 91).
* Significant difference ($p \leq 0.05$) between left and right observers.

Weather conditions that may have affected visibility of caribou against a patchy snow-covered background were variable (Appendix E). We occasionally had to delay or re-fly portions of transects because of low fog, isolated snow showers and freezing drizzle. In the northern portion of Victoria Island (strata IV and V), snow cover was patchy and ranged from 50% to 100%. The higher elevation of the Shaler Mountains made it difficult to survey because of snow showers and consistently low ceilings. There was less snow cover on southern Victoria Island (strata I, II, and the east portion of III) than in the northern strata. In the southern portion of the survey area (strata I–III), the area along the coastline was essentially snow-free. This snow-free band extended inward from the coast for approximately 20–30 km. Snow cover over the rest of the inland area varied between 10%–50%.

Observer fatigue may have also affected survey results. In order to complete the survey within a 2-week period, we flew some long days in both the Cessna 185 (5 days >9.0 hrs) and the Helio-Courier (7 days >9.0 hrs) (Appendix E).

Unsystematic Reconnaissance of Eastern Victoria Island

On 17 June 1994, we left the Wynniatt Bay research cabin and flew 7.6 hours in the Helio-Courier during an unsystematic low-level reconnaissance of eastern Victoria Island. Flying was restricted to fog free areas in the southern part of Storkerson Peninsula. The northern area was enveloped in heavy fog;

fog was thick (visibility less than 150–200 m) and patchy in distribution and the ceiling ranged from 60–100 m above sea level. Weather conditions improved as we continued south; visibility became excellent as cloud and fog dissipated.

We observed a total of 382 caribou occurring in 128 separate groups, and classified 358 animals according to six age/sex categories (Table 6, Appendix H). Observed group size of caribou ranged from 1 to 9 and was not normally distributed (KS Distance = 0.247; $p < 0.001$) (Figure 9). Mean and median group size observed during the reconnaissance flight were 2.4 ± 1.7 (SD) and 2.0, respectively. This was significantly different than the median group size of 1 observed during the systematic survey (H=9.218, df=1, p=0.002).

Table 6. Sex and age composition of Victoria Island caribou observed during a low-level reconnaissance flight of eastern Victoria Island, 17 June 1994.

Cows				Bulls	Yearlings	Unknown[a]
Antlered no calf	Antlered with calf	Antlerless with calf	Antlerless no calf			
7	7	69	110	56	33	24

[a] Caribou identified as “Unknown” were those animals that were too far away from the aircraft to be classified.

During the reconnaissance flight, we observed eight caribou on the west side of Hadley Bay, with the remaining animals found along the flight path from southeast Hadley Bay, across Storkerson Peninsula, and southeast along the coast to Collinson Peninsula (Figures 10 to 13). There was no apparent spatial segregation by age and sex classes along the flightline. However, most antlered cows (with and without calves) were observed on the flight across Storkerson Peninsula (Figure 10). Similarly, antlerless cows accompanied by calves were mostly distributed across the base of Storkerson Peninsula and on Collinson Peninsula (Figure 11). Distribution of antlerless cows, bulls, and yearlings followed a similar pattern (Figures 12 and 13).

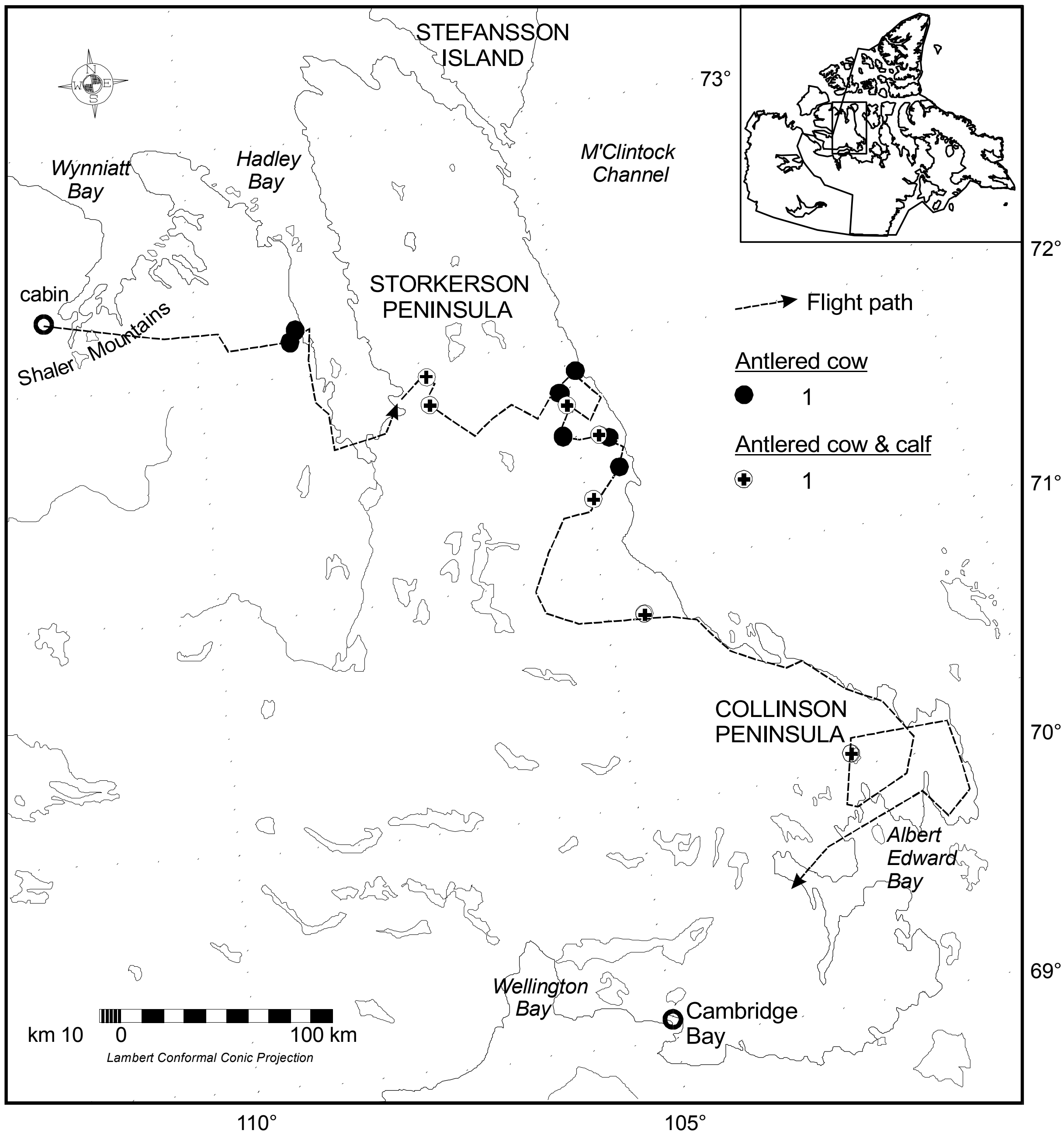

Figure 10. Antlered caribou cows with and without newborn calves observed during an unsystematic reconnaissance survey of eastern Victoria Island, 17 June 1994.

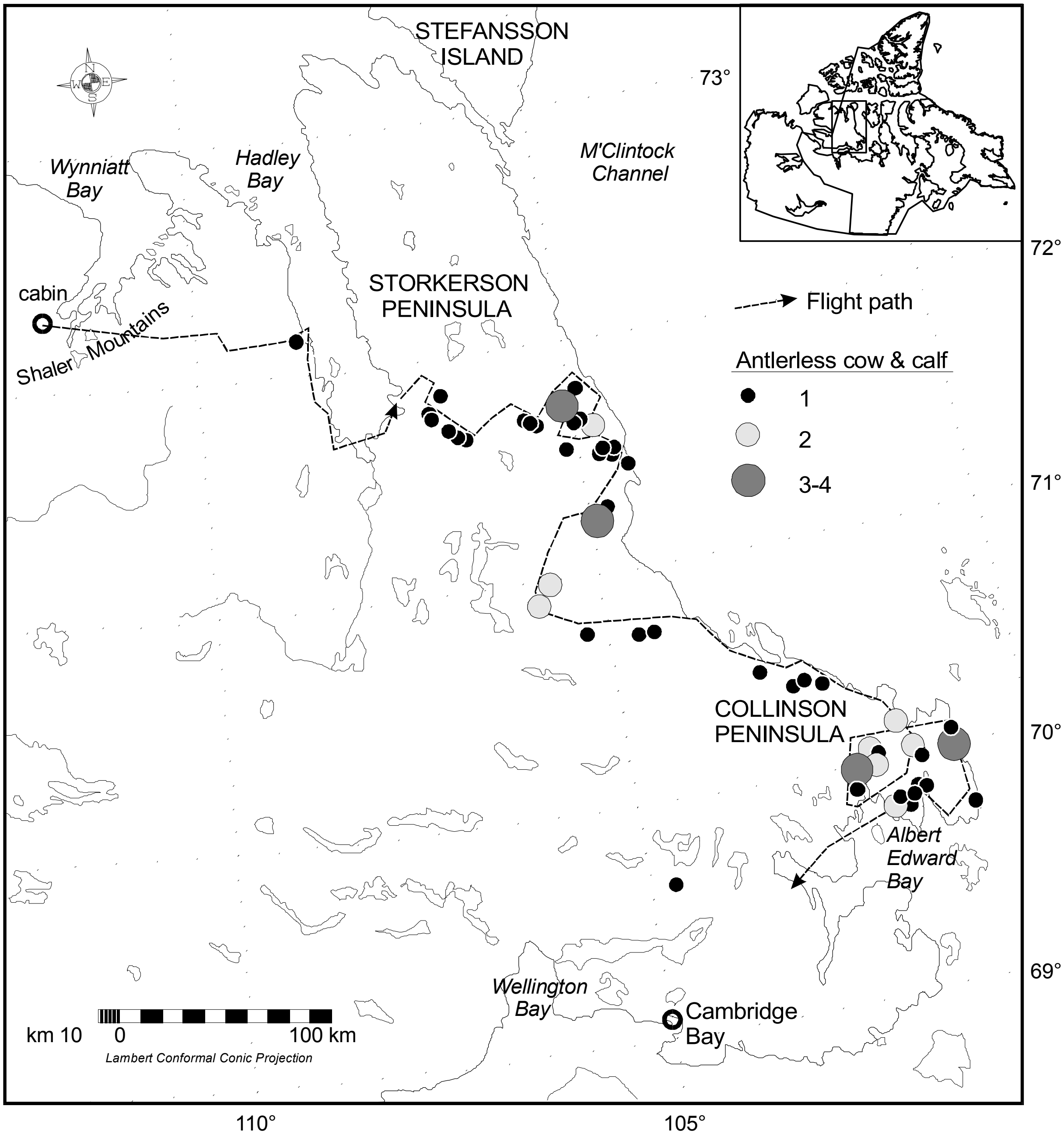

Figure 11. Antlerless caribou cows with calves observed during an unsystematic reconnaissance survey of eastern Victoria Island, 17 June 1994.

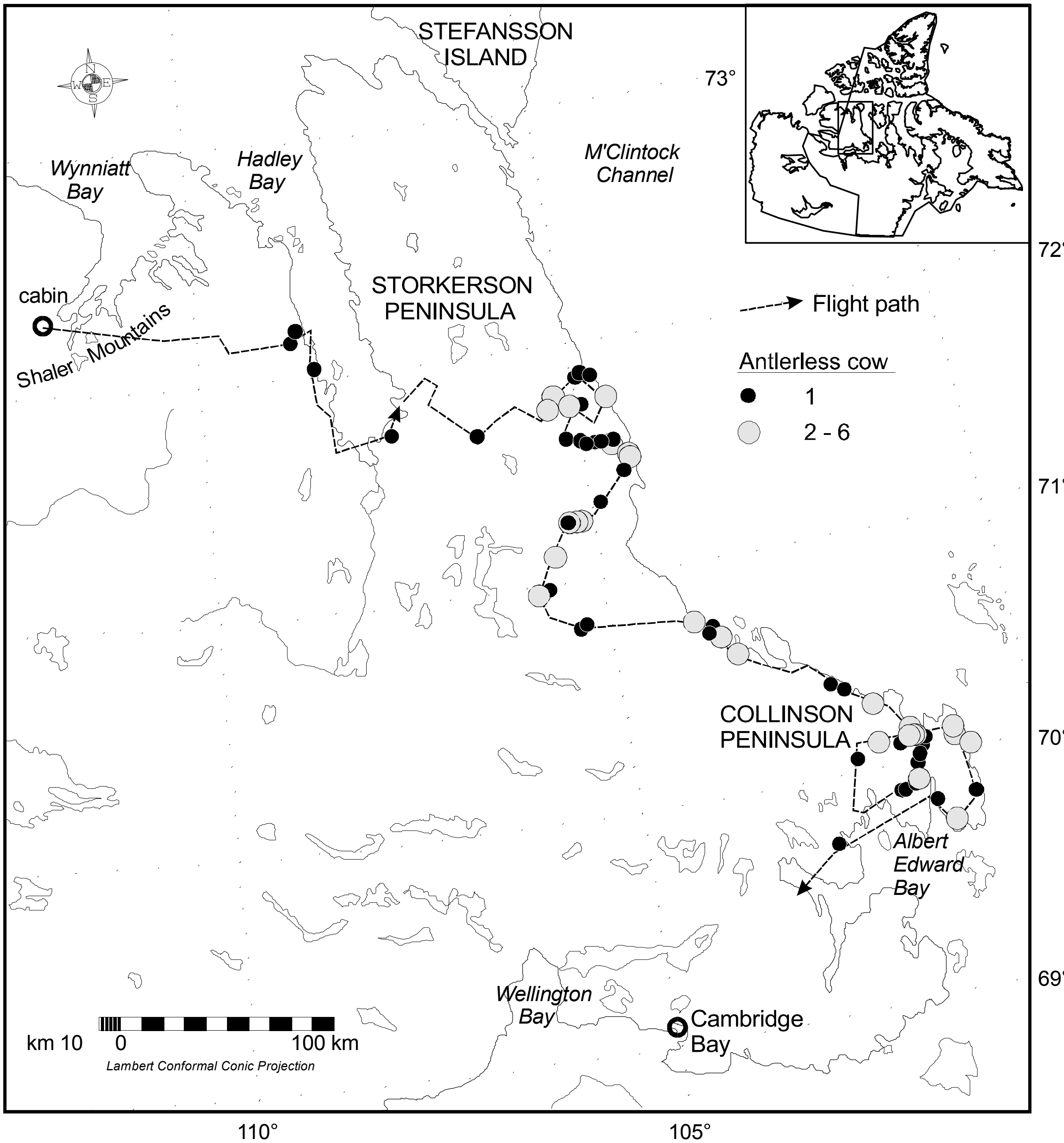

Figure 12. Antlerless caribou cows observed during an unsystematic reconnaissance survey of eastern Victoria Island, 17 June 1994.

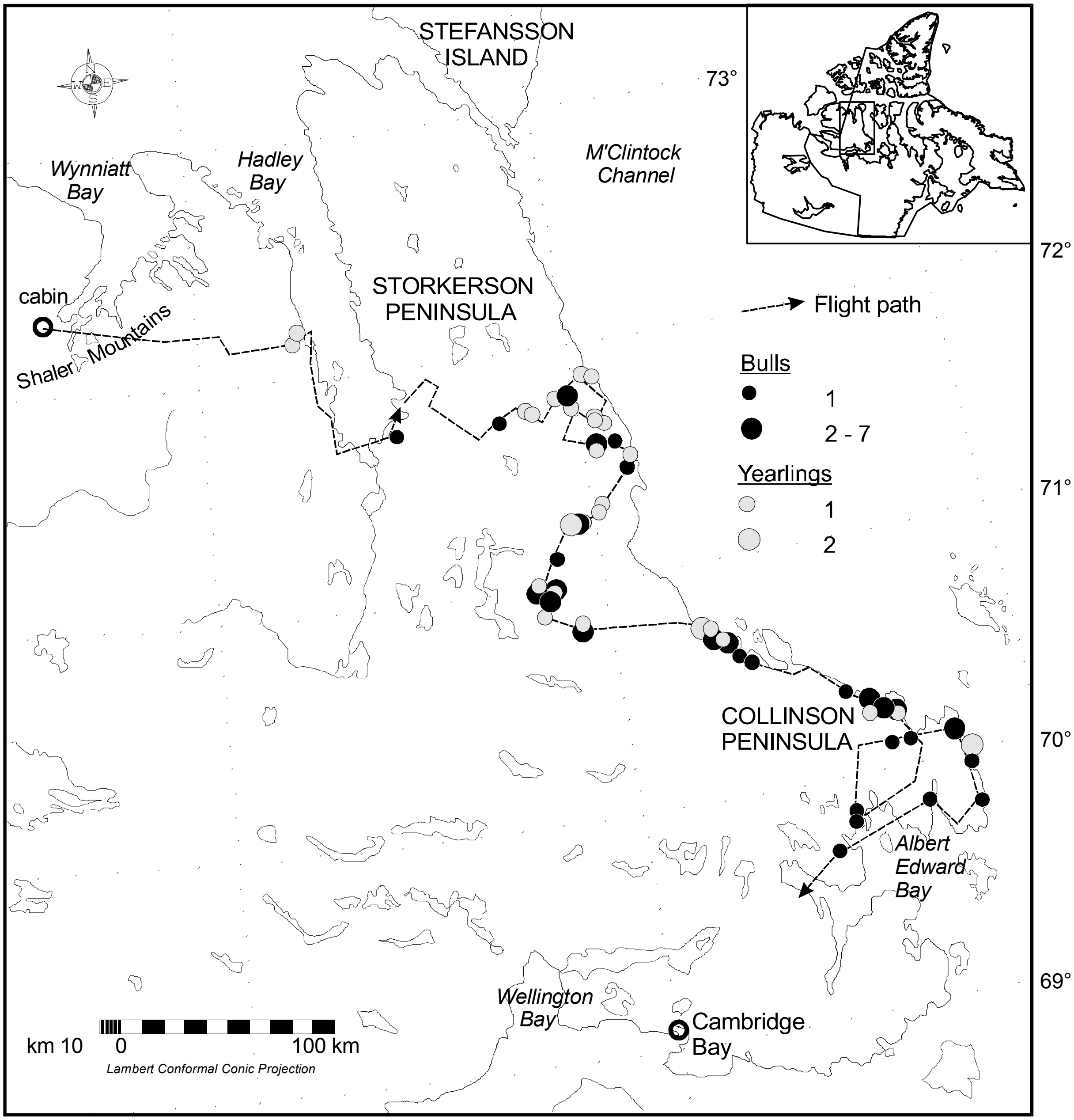

Figure 13. Bull and yearling caribou observed during an unsystematic reconnaissance survey of eastern Victoria Island, 17 June 1994.

DISCUSSION

Population Estimate

We only observed 4 caribou on 2738 km of transects within the known seasonal range of the Minto Inlet herd. Consequently, the main implication of this survey pointed to a continued conservative approach of minimizing the harvest of Minto Inlet caribou in northwest Victoria Island. Although we did observe caribou on north central Victoria Island – the Shaler Mountains area – the total estimate for strata V, VI, and VII, was only 792 ± 76. The suggestion that those caribou represented an eastward range shift of the Minto Inlet herd was speculative.

Our total estimate of 14 539 (∀ 1015) caribou on western Victoria Island was precise, but not accurate. Observer bias usually results in animals being missed (Caughley 1974, Norton-Griffiths 1978), but more importantly, the distribution of caribou was not sampled adequately to generate a population estimate. Our intention was to determine the size of the Dolphin and Union herd by extrapolation from a calving ground survey. Since the distribution of caribou and calves extended east beyond our survey area and we did not have enough flight hours to adequately sample the eastern distribution, we missed an unknown yet substantial number of caribou. The non-systematic survey clearly showed that caribou and calves were also present on Storkerson and Collinson peninsulas.

Our total survey area of western Victoria Island was 138 185 km^2, which was approximately 63% of the entire island. Given that we did not survey the other 37% of the island (i.e. 82 389 km^2), it was not possible to accurately estimate the total number of caribou on Victoria Island. Nevertheless, survey results underscored the continued need to conservatively manage the harvest of Dolphin and Union caribou.

Following the survey, extensive consultation took place (Appendix A) to discuss survey results and management options. Consensus was reached on the following recommendations:

1) Two caribou management areas within the Inuvialuit Settlement Region (ISR) were established. One area was in the northwest part (Minto Inlet area) and the other was in the southwest part of Victoria Island (Prince Albert Sound area).

2) No one, including ISR beneficiaries, would be allowed to hunt caribou in the Minto Inlet area.

3) ISR beneficiaries would be able to hunt Dolphin and Union caribou in the Prince Albert Sound area in summer and fall (1 July – 15 November).

4) The summer/fall season would also apply to residents hunting Dolphin and Union caribou in the Prince Albert Sound area.

5) There would be no trophy hunts (NR/NRA) of Dolphin and Union caribou in the Prince Albert Sound area.

6) Commercial quotas for Dolphin and Union caribou on Victoria Island would be eliminated.

7) Wildlife management zone boundaries would be amended in the Cambridge Bay area to protect Dolphin and Union caribou that wintered on Kent Peninsula and Melbourne Island from commercial harvesting.

In addition to legislative changes, the Ekaluktutiak Hunters and Trappers Association (EHTA) undertook two additional measures to further reduce the harvest of Dolphin and Union caribou. The first was a voluntary reduction of their number of caribou sport hunts on Victoria Island. The second was to halt the commercial harvest of Dolphin and Union caribou wintering on the mainland.

Despite elimination of the commercial harvest of caribou on Victoria Island and extension of wildlife management areas to protect Dolphin and Union caribou wintering on Kent Peninsula and Melbourne Island, a majority of the 289 tags used for Cambridge Bay=s commercial quota for Bathurst caribou were still used to harvest Dolphin and Union caribou on the mainland during winter in the mid 1990s (G. Corey pers. comm.). In the interest of halting the commercial harvest of Dolphin and Union caribou, the EHTA recommended that commercial hunters travel further inland to harvest barren-ground caribou. In fall 1997, the EHTA stopped distributing commercial caribou tags until a hunt could be organized in a mainland location that would ensure only barren-ground caribou were being harvested (see Gunn *et al.* 2000).

Location of Calving Grounds

We were unable to find caribou on an annual calving ground on northwest Victoria Island. The fact that we only observed 4 caribou on transects in stratum IV (Figure 6) strongly suggested that caribou were virtually absent from within the known seasonal range of the Minto Inlet herd as determined by satellite telemetry studies in the late 1980s (Gunn and Fournier 2000). Our findings corroborated previous surveys (Heard 1992, Gunn in prep.) where very few caribou were observed within the seasonal distribution of caribou in northwest Victoria Island and added further credence to the observed decline of the Minto Inlet herd[3].

Our observations of caribou calving in the Shaler Mountains area suggested an extension of what was known as the traditional caribou calving grounds of Dolphin and Union caribou (Gunn and Fournier 2000). This was the most parsimonious explanation, although the strength of this inference was weakened by our subjective assessment of the timing of calving and a lack of current data (in 1994) on seasonal distribution and movements of caribou in north-central Victoria Island[4]. However, given the clumped distribution of cows and calves in the higher elevations of the Shaler Mountains and the break in

[3] An aerial survey of northwest Victoria Island was subsequently flown in summer 1998, and the result was an estimate between 433 and 583 non-calf caribou (J. Nagy, unpub. data).
[4] In July 1996, WMC International Limited (in cooperation with DRR), deployed 4 satellite collars on caribou cows in the Shaler Mountains, an area within WMC International Ltd.'s mineral exploration area. Those collared cows confirmed that the Shaler Mountains were part of the annual range of Dolphin and Union caribou (WMC International Limited unpublished data).

distribution of caribou associated with the Kuujjua River valley (Figures 3 and 6), we could not reject possible alternate explanations: 1) this calving ground and herd had not yet been described; or 2) this observation represented an eastward shift of the annual calving ground of the Minto Inlet herd.

Within the survey area, we observed the main distribution of caribou and newborn calves on south-central Victoria Island around the eastern arm of Prince Albert Sound. The calving area was extensive with caribou dispersed throughout the central and southern portions of the survey area. Our southern distribution of calving was generally consistent with Gunn and Fournier's (2000) results, which showed a calving area that extended south and east of Prince Albert Sound. However, we observed a calving distribution that extended further north than what Gunn and Fournier (2000) described in the late 1980s. The northern extent of the large continuous distribution of caribou appeared to occur south of the Kuujjua River (Figure 6). The northern extent slipped southward as the survey of central Victoria Island progressed eastward. However, we were unable to delineate the eastern boundary of the Dolphin and Union calving ground with confidence, as there was still a calf observed on the eastern-most transect (#33) in stratum II (Figures 3 and 6, Appendix F).

Our difficulty in delineating the annual calving ground for the Dolphin and Union herd was a function of the relatively low densities of caribou and newborn calves dispersed over a large geographic area. This difficulty was complicated by the time required to cover the survey area, and by the fact that our observations on the timing of calving were confounded by spatial and temporal sampling issues[5].

We found that pregnant caribou on Victoria Island did not aggregate within a distinct annual calving ground; cows and calves were dispersed throughout much of the surveyed area. We also observed bulls and yearlings interspersed throughout the study area. Unlike barren-ground caribou (see Heard and Jackson 1990, Gunn *et al.* 1997b), caribou calving grounds on Victoria Island (identified by the presence of newborn calves) were not associated with a density gradient. Calving areas on Victoria Island (defined roughly as the survey areas within the bounds of calf observations in strata II and III and strata VI and VII) were not characterized by discernible increases in caribou density.

Gunn and Fournier (2000) showed that there were two caribou calving grounds on Victoria Island and suggested that eastern Victoria Island (Collinson Peninsula) may represent a third calving area. Our non-systematic observations of calving caribou on Collinson and Storkerson Peninsulas extended the known calving distribution and also supported the observations of calving on Collinson Peninsula in 1987–88 (Gunn and Fournier 2000).

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[5] Our aerial survey was not an appropriate method to determine timing of calving because observations varied in both space and time; an accurate method would control for spatial variability. This would require sampling only a portion of the calving ground and observing mature cows repeatedly during the calving season (see Caughley and Caughley 1974).

Monitoring Flights for Radio-collared Caribou Cows

During the June 1994 aerial survey, we equipped the Cessna 185 with radio-tracking equipment and used the survey as an opportunity to monitor radio-collar Dolphin and Union caribou[6] in the southwest region of Victoria Island. We monitored collar frequencies during all survey flights of transects in strata I and II, and transects 23–35 in stratum III, and attempted to get visual confirmations of any active collars. We obtained observations of six radio-collared cows after detecting their radio signals during the aerial survey (Table 7, Figure 14). We were not able to locate one collar (#50) despite a seemingly strong radio-signal.

Immediately following the low-level reconnaissance flight on 17 June, we flew back to Collinson Peninsula to monitor radio-collar frequencies. On the following day (18 June) we monitored collar frequencies during flights from Cambridge Bay to the Wynniatt Bay cabin and southeast over the Shaler Mountains before returning to Kugluktuk (Figure 14, Appendix C). We were able to acquire visual relocations of an additional five radio-collared cows, and radio signals from two cows (Table 7, Figure 14). The cows were distributed over an extensive area from Collinson Peninsula midway up Storkerson Peninsula.

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[6] In late April 1994, 20 Victoria Island caribou cows were captured and fitted with VHF radio collars in the area south of Cambridge Bay (Kent Peninsula, Melbourne and Minto islands, and southeast Victoria Island). Deployment of those 20 collars was part of a project to determine where Victoria Island caribou go to calve. Nishi (2000) reports complete results from radio-telemetry work (1994–1997).

Table 7. Observations of radio-collared female caribou, Victoria Island, June 1994.

Collar ID	Date Observed	Observation Type	Comments
60	10 June	visual	antlered no calf at heel
50	11 June	radio signal only	stratum III, transect 35,
70	13 June	visual	bald no calf at heel
30	15 June	visual	antlered with calf at heel
130	15 June	visual	antlered with calf at heel
150	15 June	visual	antlered no calf at heel
120	17 June	visual	antlerless with calf at heel
110	17 June	radio signal only	Cape Adelaide
192	18 June	visual	antlerless with calf at heel
160	18 June	visual	antlerless with calf at heel
180	18 June	visual	antlerless with calf at heel
170	18 June	visual	antlerless with calf at heel
140	18 June	radio signal only	no observation

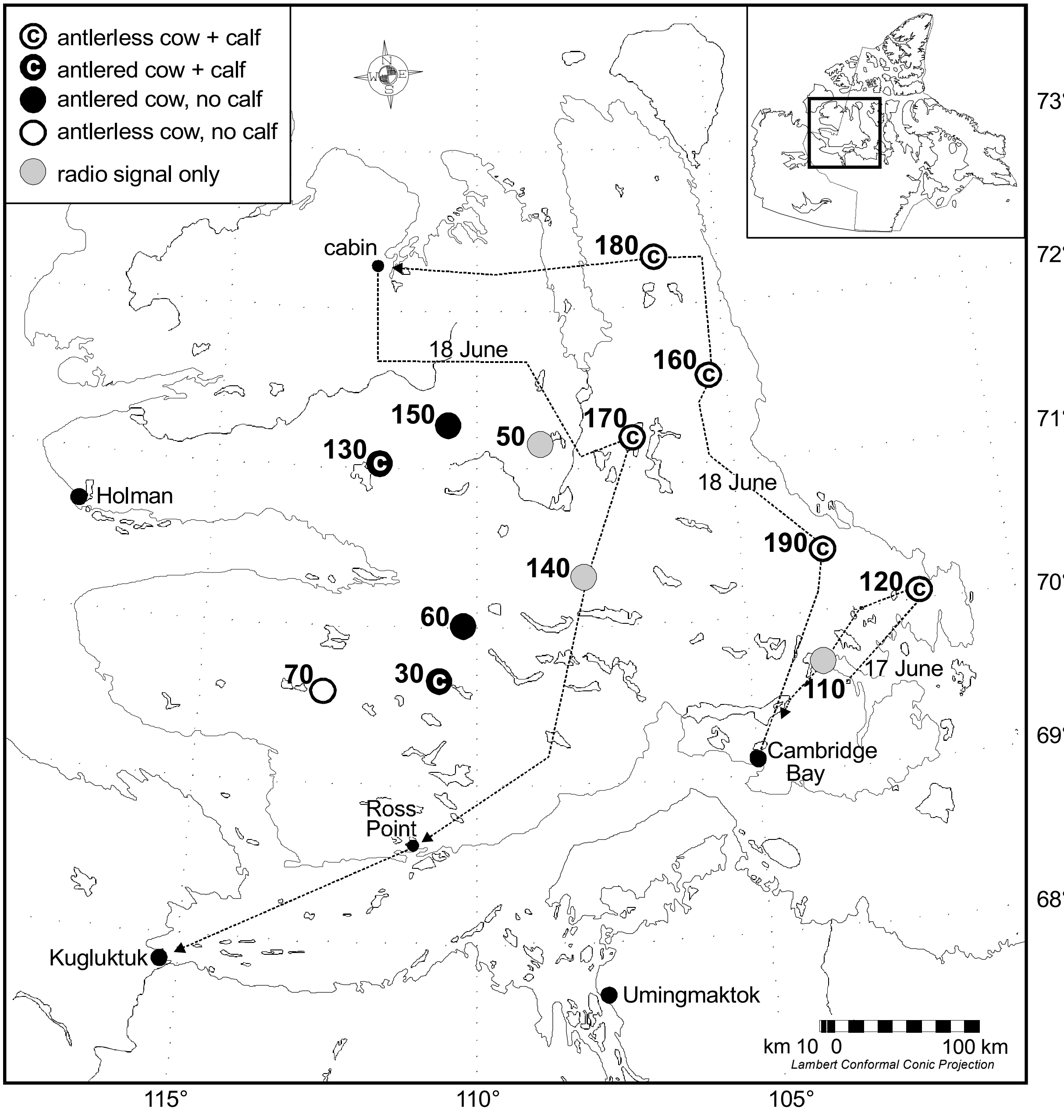

Figure 14. Flight lines and locations of seven radio-collared caribou cows on Victoria Island, 17 and 18 June 1994. The six collared cows not on the flight path were located during a systematic aerial survey of Victoria Island, 10-15 June 1994.

All five cows observed were antlerless and accompanied by newborn calves. Those observations confirmed that Dolphin and Union caribou were also calving east outside of the survey area.

Timing of Calving

We suggested that the peak of calving (i.e. the date when $\geq$ 50% of calves are born) likely occurred between the 11 and 17 June 1994. We based our consideration on: 1) observations of calves throughout the survey (Tables 4a); 2) proportion of radio-collared cows (observed on the 17 and 18 June) that had lost their hard antlers and had a calf at heel (Table 7); and 3) the following crude estimate of the proportion of calves born. A comparison of the proportion of calves to non-calf caribou observed during the non-systematic survey on 17 June suggested that of the 358 caribou identified, 21.2% were calves (Table 6). Adjusting for the missing male segment of the population (given the assumption that a reasonable split between the sexes of 1^+-year-old animals in a caribou population is 40:60 or 66.7 males : 100 females (see Miller 1997, p. 46)), the proportion of calves was further reduced to 17.5%. Relative to the theoretical maximum of 30% newborn calves in a barren-ground caribou population (Bergerud 1980) and assuming minimal early calf mortality, the non-systematic data implied that calving was already 58% complete by 17 June 1994.

Research Implications

An aerial survey is a snapshot in time of the abundance and distribution of animals in a defined space. The challenges in executing an aerial census of an annual caribou calving ground are to define the spatial (geographic) extent of pregnant cows and conduct a systematic survey of that area within a narrow temporal window at the peak of calving. There are at least three important factors that limit effectiveness of a calving ground survey technique on Victoria Island. First, the geographic area in which calving caribou are found during the calving season is large and extensive. Second, the temporal envelope of the calving season limits survey time and consequently limits spatial extent of the survey area. And third, caribou density – the most repeatable measure obtained from an aerial survey under standardised conditions – does not seem to be a useful field correlate for defining an annual calving ground. Thus, when considering the dynamic nature of a geographically extensive calving ground with relatively uniform density, such as on Victoria Island, the practical utility of the calving ground census technique is marginal.

Gunn and Fournier (2000) showed that there were two caribou calving grounds and two discrete caribou herds on Victoria Island – the Minto Inlet herd and the Dolphin and Union herd. Based on data from one satellite-collared cow and hunters' observations, they also suggested that eastern Victoria Island (i.e. Collinson Peninsula) represented a third calving area. Our observations of calving caribou and radio-collared cows on Collinson and Storkerson peninsulas confirmed Gunn and Founier's preliminary results, and extended the known calving distribution to eastern Victoria Island.

One alternative to a calving ground survey is to survey the entire island, but the costs and logistics would be prohibitive. The option of a whole-island survey gives little consideration to sampling discrete populations and would not enable managers to understand the trends and dynamics of individual herds. This would be akin to surveying two or more herds of caribou and assessing overall trend on the pooled survey results. The resultant estimate would be ambiguous, as it would be difficult to determine herd discreteness and herd-specific trends.

Improved design of aerial surveys for Dolphin and Union caribou requires further confirmation of seasonal movements and additional work on describing herd discreteness. Based on our survey results (this report), hunters' observations (D. Kaomayok, and G. Angohiatok pers. comm.), and Gunn and Fournier's (2000) earlier telemetry studies, we knew that caribou calved on eastern Victoria Island. Whether the distribution of caribou between south-central and southeast Victoria Island was continuous remains an important question with implications to future survey design and understanding herd discreteness (see Nishi 2000).

Another alternative is to survey Dolphin and Union caribou during their fall rut distribution when all age and sex classes are intermixed and when caribou aggregate along the southern coastline prior to their fall migration to the mainland. As the distribution of collared cows during October 1987, 1988 (Gunn and Fournier 2000), 1994 and 1996 (Nishi 2000) was mostly along the southern coastline, Nishi and Gunn (in prep) used this approach in October 1997 and estimated 27 786 ± 3366 (SE) caribou. The fall rut survey technique will require further confirmation on the proportion of the Dolphin and Union herd that is present along the coastline in fall.

Caribou calving grounds are dynamic over several spatial and temporal scales (Russell *et al*. 1993, Sutherland and Gunn 1996, Gunn and Sutherland 1997, Gunn 1999, Wolfe *et al.*1999, Nagy unpublished data on Bluenose caribou). Our survey results point out the need for additional research[7] as it will take many more years of data to describe and understand the spatial and temporal variability of calving grounds on Victoria Island. This need is highlighted by the 'Caribou Protection Measures' proposed to guide industrial activity in the West Kitikmeot (Nunavut Planning Commission 1998). We suggest that those 'protection measures' will require ongoing research and revision to reflect our increasing understanding of the dynamics that are characteristic of caribou calving grounds on Victoria Island.

[7] In October 1999, 25 satellite collars were deployed on Dolphin and Union cows along the southern coastline of Victoria Island to address ongoing concerns of harvest sustainability (B. Patterson, pers. com.).

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APPENDIX A. Chronology of Victoria Island caribou management issues, 1987-1994.

1987-1989: herd delimitation and seasonal movements of caribou on Victoria Island using satellite telemetry (Gunn and Fournier 2000).

1991: Arctic-island caribou classified as “threatened” by COSEWIC.

March 1992: 170 caribou estimated in northwest Victoria Island (Heard 1992)

March 1993: 144 caribou estimated in northwest Victoria Island (Gunn in prep.)

April 1993: Holman self-imposed a ban on hunting of caribou in northwest Victoria Island.

13-15 June 1993: Aerial survey by Morrison (Gunn in prep.) confirmed lack of caribou in northwest Victoria Island.

14-16 June 1993: WMAC meeting

- Discussed the status of Holman's self-imposed ban on hunting of Minto Inlet caribou. Recommendation by OHTC and WMAC to conduct another survey of northwest Victoria Island.

Fall 1993:

- A. Gunn submitted draft file report entitled "The decline of caribou on northwest Victoria Island: A review" (Gunn in prep.)
- Critique of Gunn's draft file report: DRR Inuvik Region use a harvest model to argue hunting may have been a more important factor in decline of Minto Inlet caribou.

October 1993: Research Proposal drafted for 5-year study on Victoria Island caribou (DRR 1993).

12 - 14 October 1993: KHTA Meeting in Cambridge Bay to discuss research proposal.

December 1993: Inuvialuit Harvest Study from July to November 1993 shows that Holman residents killed 74 caribou of which 73 were considered Peary-type.

20 December 1993: WMAC meeting

- motion: The WMAC (NWT) shall recommend to the community of Holman that they voluntarily cease all hunting of Minto Inlet “Peary” caribou until further notice.

- motion: The WMAC (NWT) shall recommend to the Minister of DRR that he request the communities of Kugluktuk and Cambridge Bay to cease all hunting of Peary-type (Minto Inlet) caribou on Victoria Island until further notice.

13 January 1994: DRR conference call regarding communities' (Holman, Cambridge Bay, and Kugluktuk) support of hunting ban on Minto Inlet “Peary” caribou.

- reviewed plans for community consultation on WMAC's recommendations
- planned a meeting with OHTC in February 1994 to discuss caribou management

2 February 1994: Public Meeting at Holman to discuss ban on hunting Minto Inlet “Peary” caribou.

- poor turnout, decision to reconvene on 4 March 1994, to ensure greater turnout and awareness of management concerns.

13 February 1994: Public meeting in Cambridge Bay to discuss caribou management (poor turnout).

4 March 1994: Public Meeting at Holman to discuss ban on hunting Minto Inlet “Peary” caribou.

- decision to be made by OHTC on 16 April 1994

28 March 1994: Public Meeting in Cambridge Bay to discuss caribou management on Victoria Island (poor turnout).

16 April 1994: OHTC decides to ban all hunting of caribou by Holman until survey completed in June 1994.

23-28 April 1994: 20 radio collars deployed on Victoria Island caribou (Kent Peninsula, Melbourne and Minto Islands, and southeast of Cambridge Bay)

1 June 1994: Funding request and presentation made at NWMB meeting. NWMB agreed to partially fund survey.

5-18 June 1994: Extensive survey of western Victoria Island. Surveyed area was about 63% of total land area. Estimate a total of 14 539 $\pm$ 1015 caribou on western Victoria Island. 10 radio collars relocated.

29 June 1994: DRR Meeting in Yellowknife to discuss survey results and management options.

8 July 1994: DRR teleconference with WMAC to discuss management options for Victoria Island caribou with general consensus on recommendations.

11-12 July 1994: KHTA Annual General Meeting: support for all recommendations

18 July 1994: Cambridge Bay HTA and Public Meeting: support for all recommendations.

21 July 1994: Holman HTC and Public Meeting. Request summer hunting season extended into fall (15 November).

29 July 1994: Letter to NWMB regarding management recommendations for Victoria Island caribou.

APPENDIX B. Daily flight log of Cessna 185 on wheel skis, Victoria Island, June 1994.

Date	Purpose	Hours flown
3 June	Ferry[a]: YVQ[b] - YCO	2.7
4 June	Ferry: YCO - Read Island - YCO	2.9
5 June	Ferry: YCO - Read Island	1.2
	Systematic survey[c]: Read Island	6.4
6 June	Systematic survey: Read Island	9.8
7 June	Systematic survey: Read Island	9.9
8 June	Systematic survey: Read Island	4.6
9 June	Systematic survey: Read Island	9.1
10 June	Systematic survey: Read Island	6.8
	Ferry: Read Island - YCO	0.9
11 June	Ferry: YCO - Read Island	1.2
	Systematic survey: Read Island	5.8
12 June	Systematic survey: Read Island	13.4
13 June	Ferry: Read Island - YHI	1.0
	Survey: YHI	6.3
	Survey: YHI	5.1
14 June	Ferry: YHI - Read Island	1.2
	Ferry: Read Island - YCO	1.0
	Ferry: YCO - YVQ	3.2
TOTAL	Ferry: 16.3	
	Systematic survey: 76.2	
		92.5

[a] "Ferry" time includes placement of aircraft between communities and/or field camps (fuel caches).
[b] Canadian Location Identifiers: YHI is Holman, YCO is Kugluktuk, YCB is Cambridge Bay, and YVQ is Norman Wells.
[c] "Survey" time includes: a) time on transect, b) ferry time between transects, and c) ferry time between field camps and transects.

APPENDIX C. Daily flight log of Helio-Courier H-295 on tundra tires, Victoria Island, June 1994.

Date	Purpose	Hours flown
4 June	Ferry[a]: YVQ[b] to YCO	3.5
5 June	Ferry: YCO to YHI	2.5
	Systematic survey[c]: YHI to Walker Bay	5.8
	Ferry: Walker Bay - YHI	0.7
6 June	Systematic survey: YHI - Wynniatt Bay	7.1
	Ferry: Lake - YHI	2.8
7 June	Systematic survey: YHI - NW Victoria Island	6.9
		3.3
8 June	Systematic survey: YHI - NW Victoria Island	5.4
		3.3
9 June	Ferry: YHI - Wynniatt Bay (fuel cache)	1.8
		1.6
10 June	Systematic survey: YHI - Wynniatt Bay	4.4
11 June	Ferry: Wynniatt Bay (move fuel cache)	1.2
12 June	Systematic survey: Wynniatt Bay	4.7
	Systematic survey: Wynniatt Bay	5.7
13 June	Systematic survey: Wynniatt Bay	2.7
	Systematic survey: Wynniatt Bay	5.5
	Ferry: Wynniatt Bay - YHI	1.8
14 June	Survey: YHI - Kuuk River	7.1
	Survey: Kuuk River - YHI	3.0
	Ferry: YHI - YCO	2.0
15 June	Ferry: YCO - Wynniatt Bay	1.0
	High-altitude radio telemetry (HART):	3.3
	Survey: Wynniatt Bay - Shaler Mtns	5.3
16 June	Systematic survey: Wynniatt Bay - Shaler Mtns.	5.8
	Systematic survey: Wynniatt Bay - Shaler Mtns.	3.7
17 June	Unsystematic recon: Wynniatt Bay - Hadley Bay	1.5
	Unsystematic recon: Hadley Bay - Albert Edward Bay	6.1
	High-altitude radio telemetry (HART): Albert Edward Bay - YCB	2.7

Appendix C. *continued*

Date	Purpose	Hours flown
18 June	High-altitude radio telemetry (HART): YCB - Shaler Mtns. / Wynniatt Bay	7.2
	HART: Wynniatt Bay - Fort Ross	3.7
	Ferry: Fort Ross - YCO	1.1
19 June	Ferry: YCO - YVQ	3.0
TOTAL	Ferry: 21.4 Systematic survey: 81.3 Unsystematic reconnaissance: 7.6 High-altitude radio-tracking: 16.9	127.2

[a] "Ferry" time includes placement of aircraft between communities and/or field camps (fuel caches).
[b] Canadian Location Identifiers: YHI is Holman, YCO is Kugluktuk, YCB is Cambridge Bay, and YVQ is Norman Wells.
[c] "Survey" time includes: a) time on transect, b) ferry time between transects, and c) ferry time between field camps and transects.

APPENDIX D. Summary of transects flown and caribou observed during an aerial survey of Victoria Island, 5–17 June 1994.

Date	Aircraft[a]	Stratum: Transects	Caribou	Calves
5 June	C185	II: 1–10	37	0
5 June	HC	IV: 1–6	0	0
6 June	C185	II: 11–16	78	0
6 June	HC	IV: 7-9, V: 1–6	5	0
7 June	C185	II: 17, 18, I: 4–15	418	0
7 June	HC	IV: 16–22, III: 1–4	3	0
8 June	C185	I: 1–3, 16, II: 30,17	79	0
8 June	HC	IV: 10–15, 16–19	0	0
9 June	C185	II: 21–26, 29, 30	278	3
10 June	C185	II: 27–28,17–20	153	3
10 June	HC	IV: 16–20, V: 16	0	0
11June	C185	I: 17, II: 31, III: 34–35	76	4
12June	C185	II: 32–33, III: 7–33	146	8
12June	HC	V: 18–21	73	3
13June	C185	III: 23–26, 8–13	63	3
13June	HC	V: 7–12,13–17, 22	17	0
14June	HC	III: 5–7, 14–22	46	3
15June	HC	VI: 1–3	23	5
16June	HC	VI: 4–13, VII: 1–10	136	18
17June	HC	Unsystematic reconnaissance	282	76
SUM			**1913**	**126**

[a] C185 is a Cessna 185; HC is a Helio-Courier H-295.

APPENDIX E. Daily weather conditions for aerial survey of Victoria Island, June 1994.

Date	Total hours flown[a]	Clouds[b], visibility, light & contrast, temperature
3 June	C185: 2.7h	Clear, high scattered
4 June	C185: 2.9h HC: 3.5h	Broken, est. 1000' with variable fog patches; 5°C
5 June	C185: 7.6h HC: 9.0h	Scattered, est. 5000'; fog in morning; 10°C Scattered, est. 1000'; good visibility; 8°C
6 June	C185: 9.8h HC: 9.9h	Fog until afternoon; Variable ceiling, scattered est. 1000'; 2°C Broken, est. 7000';clear, sunny with good visibility; 7°C
7 June	C185: 9.9h HC: 10.2h	Broken-overcast, est. 1000'; 12°C Scattered, est. 2000' and variable; occasional fog; 6°C
8 June	C185: 4.6h HC: 8.7h	Overcast, light rain and fog; 8°C Scattered-broken, est. 2000' and occasional fog at 500', 6°C
9 June	C185: 9.1h HC: 3.4h	Overcast, est. 1000 -2000'; visibility excellent, contrast fair; 2°C Overcast-fog patches
10 June	C185: 7.7h HC: 4.4h	Overcast, est. 2000'; visibility excellent, contrast fair; 2°C Broken-overcast, and patches of low fog; -1°C
11 June	C185: 7.0h HC: 1.2h	Variable broken 1000 - 2500', patches of freezing rain; 0°C Broken-overcast, low fog
12 June	C185:13.4h HC:10.4h	Scattered, est. 2000 - 3000'; intermittent snow showers, Scattered, 2°C
13 June	C185:12.4h HC:10.0h	Scattered, est. 2000'; excellent visibility; 5°C Overcast; light rain; 0°C
14 June	C185: 5.4h HC:12.1h	Scattered and bright, est. 5000', 8°C Clear; 5°C
15 June	HC: 6.3h	Clear - high scattered; excellent visibility; 5°C
16 June	HC: 9.6h	Scattered, est. 5000'; excellent visibility; 5°C
17 June	HC: 9.4h	Overcast, est. 2000', variable with fog; 5°C
18 June	HC: 12.0h	Overcast with variable fog patches; 6°C
19 June	HC: 3.0h	Scattered

[a] C185 is a Cessna 185; HC is a Helio-Courier H-295.

[b] We report estimated ceiling heights to the nearest 1000 feet as this is still the standard format used by Transport Canada for their Aviation Routine Weather Report (METAR) and International Aerodrome Forecast (TAF).

APPENDIX F. Caribou observed on transect during an aerial survey of western Victoria Island, 5–16 June 1994.

STRATUM I (7– 8, and 11 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed on transect					
		Left observer		Right observer		Total	
		Non-calf	Calf	Non-calf	Calf	Non-calf	Calf
1	57	9	0	1	0	10	0
2	72	0	0	16	0	16	0
3	82	12	0	14	0	26	0
4	83	5	0	10	0	15	0
5	81	28	0	13	0	41	0
6	79	8	0	13	0	21	0
7	78	13	0	12	0	25	0
8	76	7	0	7	0	14	0
9	76	28	0	7	0	35	0
10	78	11	0	20	0	31	0
11	84	30	0	29	0	59	0
12	84	16	0	35	0	51	0
13	68	25	0	23	0	48	0
14	68	12	0	14	0	26	0
15	67	18	0	10	0	28	0
16	66	11	0	16	0	27	0
17	62	8	0	15	0	23	0
SUM	**1261**	**241**	**0**	**255**	**0**	**496**	**0**

Appendix F. *continued*

STRATUM II (5–6, and 9–12 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed on transect: Left observer Non-calf	Left observer Calf	Right observer Non-calf	Right observer Calf	Total Non-calf	Total Calf
1	29	0	0	0	0	0	0
2	48	0	0	0	0	0	0
3	63	0	0	0	0	0	0
4	86	0	0	0	0	0	0
5	94	1	0	1	0	2	0
6	104	5	0	0	0	5	0
7	107	2	0	6	0	8	0
8	110	6	0	5	0	11	0
9	113	0	0	0	0	0	0
10	114	6	0	5	0	11	0
11	115	2	0	10	0	12	0
12	116	7	0	4	0	11	0
13	119	4	0	5	0	9	0
14	118	12	0	9	0	21	0
15	118	14	0	11	0	25	0
16	119	16	0	8	0	24	0
17	116	6	0	3	0	9	0
18	113	14	1	11	0	25	1
19	109	13	0	14	1	27	1
20	115	9	1	9	0	18	1
21	125	12	0	10	0	22	0
22	124	20	0	7	1	27	1
23	130	17	1	14	0	31	1
24	130	4	0	4	0	8	0
25	130	15	0	19	0	34	0
26	130	23	0	23	0	46	0
27	130	13	0	13	0	26	0
28	130	18	0	30	0	48	0
29	130	36	1	18	0	54	1
30	130	28	0	28	0	56	0
31	130	16	2	35	2	51	4
32	130	21	2	20	1	41	3
33	130	9	1	14	0	23	1
SUM	**3705**	**349**	**9**	**336**	**5**	**685**	**14**

Appendix F. *continued*

STRATUM III (7, 11–14 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed on transect: Left observer Non-calf	Left observer Calf	Right observer Non-calf	Right observer Calf	Total Non-calf	Total Calf
1	27	0	0	0	0	0	0
2	44	0	0	0	0	0	0
3	63	0	0	0	0	0	0
4	65	0	0	0	0	0	0
5	69	0	0	0	0	0	0
6	72	0	0	0	0	0	0
7	77	0	0	0	0	0	0
8	86	0	0	0	0	0	0
9	95	0	0	0	0	0	0
10	103	0	0	0	0	0	0
11	99	0	0	0	0	0	0
12	106	0	0	3	0	3	0
13	103	0	0	1	0	1	0
14	101	0	0	2	0	2	0
15	97	0	0	2	1	2	1
16	93	0	0	0	0	0	0
17	95	0	0	3	0	3	0
18	97	4	1	6	1	10	2
19	103	6	0	0	0	6	0
20	109	4	0	0	0	4	0
21	113	6	0	0	0	6	0
22	115	11	0	2	0	13	0
23	119	4	0	11	1	15	1
24	130	4	0	5	1	9	1
25	130	7	0	9	0	16	0
26	130	15	1	4	0	19	1
27	130	9	0	22	1	31	1
28	130	9	2	11	0	20	2
29	130	8	0	7	1	15	1
30	130	4	0	2	0	6	0
31	130	1	0	6	0	7	0
32	130	1	0	0	0	1	0
33	130	0	0	2	0	2	0
34	130	0	0	1	0	1	0
35	130	1	0	0	0	1	0
SUM	**3611**	**94**	**4**	**99**	**6**	**193**	**10**

Appendix F. *continued*

STRATUM IV (5–8, and 10 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed on transect: Left observer Non-calf	Left observer Calf	Right observer Non-calf	Right observer Calf	Total Non-calf	Total Calf
1	17	0	0	0	0	0	0
2	41	0	0	0	0	0	0
3	60	0	0	0	0	0	0
4	77	0	0	0	0	0	0
5	90	0	0	0	0	0	0
6	110	0	0	0	0	0	0
7	110	0	0	0	0	0	0
8	116	0	0	0	0	0	0
9	139	1	0	0	0	1	0
10	148	0	0	0	0	0	0
11	153	0	0	0	0	0	0
12	151	0	0	0	0	0	0
13	139	0	0	0	0	0	0
14	155	0	0	0	0	0	0
15	160	0	0	0	0	0	0
16	169	0	0	0	0	0	0
17	175	0	0	0	0	0	0
18	178	0	0	0	0	0	0
19	178	0	0	0	0	0	0
20	177	0	0	0	0	0	0
21	134	3	0	0	0	3	0
22	61	0	0	0	0	0	0
SUM	**2738**	**4**	**0**	**0**	**0**	**4**	**0**

Appendix F. *continued*

STRATUM V[a] (6, 10, and 12–13 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed on transect					
		Left observer		Right observer		Total	
		Non-calf	Calf	Non-calf	Calf	Non-calf	Calf
1	15	0	0	0	0	0	0
2	37	0	0	0	0	0	0
3	62	2	0	0	0	2	0
4	73	0	0	0	0	0	0
5	94	0	0	0	0	0	0
6	89	0	0	2	0	2	0
7	17	0	0	0	0	0	0
8	34	0	0	0	0	0	0
9	24	0	0	0	0	0	0
10	35	0	0	0	0	0	0
11	34	0	0	0	0	0	0
12	72	2	0	0	0	2	0
13	181	0	0	1	0	1	0
14	181	0	0	0	0	0	0
15	186	0	0	0	0	0	0
16	188	0	0	1	0	1	0
17	193	0	0	0	0	0	0
18	196	5	0	0	0	5	0
19	199	16	0	2	0	18	0
20	199	19	0	5	1	24	1
21	203	21	1	5	1	26	2
22	206	9	0	4	0	13	0
SUM	**2518**	**74**	**1**	**20**	**2**	**94**	**3**

[a] Results prior to stratification and survey of strata VI and VII.

Appendix F. *continued*

STRATUM V[a] (6, 10, and 12–13 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed on transect: Left observer Non-calf	Left observer Calf	Right observer Non-calf	Right observer Calf	Total Non-calf	Total Calf
1	15	0	0	0	0	0	0
2	37	0	0	0	0	0	0
3	62	2	0	0	0	2	0
4	73	0	0	0	0	0	0
5	94	0	0	0	0	0	0
6	89	0	0	2	0	2	0
7	17	0	0	0	0	0	0
8	34	0	0	0	0	0	0
9	24	0	0	0	0	0	0
10	35	0	0	0	0	0	0
11	34	0	0	0	0	0	0
12	72	2	0	0	0	2	0
13	181	0	0	1	0	1	0
14	181	0	0	0	0	0	0
15	186	0	0	0	0	0	0
16	188	0	0	1	0	1	0
17	193	0	0	0	0	0	0
18	196	5	0	0	0	5	0
19	89	4	0	0	0	4	0
20	89	1	0	0	0	1	0
21	93	4	0	3	1	7	1
22	96	0	0	1	0	1	0
SUM	**2078**	**18**	**0**	**8**	**1**	**26**	**1**

[a] Results following stratification and survey of strata VI and VII. These results were used in the final survey analyses.

Appendix F. *continued*

STRATUM VI (15–16 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed on transect: Left observer Non-calf	Left observer Calf	Right observer Non-calf	Right observer Calf	Total Non-calf	Total Calf
1	60	5	1	0	0	5	1
2	60	5	0	4	0	9	0
3	60	3	1	6	3	9	4
4	60	6	0	7	1	13	1
5	60	3	2	3	1	6	3
6	60	7	1	6	0	13	1
7	60	7	1	5	1	12	2
8	60	4	0	1	0	5	0
9	60	3	0	2	1	5	1
10	60	7	1	3	0	10	1
11	60	1	0	3	0	4	0
12	60	5	2	3	0	8	2
13	60	3	0	2	0	5	0
SUM	**780**	**59**	**9**	**45**	**7**	**104**	**16**

Appendix F. *continued*

STRATUM VII (16 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed on transect					
		Left observer		Right observer		Total	
		Non-calf	Calf	Non-calf	Calf	Non-calf	Calf
1	50	4	1	0	0	4	1
2	50	2	0	1	0	3	0
3	50	2	0	1	1	3	1
4	50	0	0	3	0	3	0
5	50	1	0	3	1	4	1
6	50	2	1	4	1	6	2
7	50	3	0	5	2	8	2
8	50	3	0	4	0	7	0
9	50	4	0	5	0	9	0
10	50	6	0	2	0	8	0
SUM	**500**	**27**	**2**	**28**	**5**	**55**	**7**

APPENDIX G. Caribou observed off transect during an aerial survey of western Victoria Island, 5–16 June 1994.

STRATUM I (7–8, and 11 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed off transect					
		Left observer		Right observer		Total	
		Non-calf	Calf	Non-calf	Calf	Non-calf	Calf
1	57	6	0	3	0	9	0
2	72	1	0	15	0	16	0
3	82	3	0	0	0	3	0
4	83	0	0	6	0	6	0
5	81	8	0	1	0	9	0
6	79	7	0	34	0	41	0
7	78	12	0	3	0	15	0
8	76	2	0	23	0	25	0
9	76	32	0	2	0	34	0
10	78	2	0	20	0	22	0
11	84	26	0	19	0	45	0
12	84	17	0	119	0	136	0
13	68	44	0	41	0	85	0
14	68	14	0	33	0	47	0
15	67	14	0	2	0	16	0
16	66	5	0	23	0	28	0
17	62	3	0	8	0	11	0
SUM	**1261**	**196**	**0**	**352**	**0**	**548**	**0**

Appendix G. *continued*

STRATUM II (5–6, and 9–12 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed off transect: Left observer Non-calf	Left observer Calf	Right observer Non-calf	Right observer Calf	Total Non-calf	Total Calf
1	29	0	0	0	0	0	0
2	48	0	0	0	0	0	0
3	63	0	0	0	0	0	0
4	86	2	0	0	0	2	0
5	94	0	0	0	0	0	0
6	104	0	0	0	0	0	0
7	107	0	0	1	0	1	0
8	110	3	0	0	0	3	0
9	113	3	0	3	0	6	0
10	114	0	0	0	0	0	0
11	115	0	0	0	0	0	0
12	116	2	0	0	0	2	0
13	119	3	0	7	0	10	0
14	118	0	0	15	0	15	0
15	118	8	0	4	0	12	0
16	119	4	0	22	0	26	0
17	116	3	0	4	0	7	0
18	113	4	0	5	0	9	0
19	109	19	0	3	0	22	0
20	115	5	0	10	0	15	0
21	125	1	0	8	0	9	0
22	124	12	0	0	0	12	0
23	130	24	0	18	0	42	0
24	130	4	0	9	0	13	0
25	130	7	0	21	0	28	0
26	130	16	0	21	0	37	0
27	130	6	0	33	0	39	0
28	130	28	0	13	0	41	0
29	130	33	0	14	0	47	0
30	130	8	0	53	0	61	0
31	130	15	0	11	0	26	0
32	130	10	0	20	0	30	0
33	130	17	0	24	0	41	0
SUM	**3705**	**237**	**0**	**319**	**0**	**556**	**0**

Appendix G. *continued*

STRATUM III (7, 11–14 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed off transect: Left observer Non-calf	Left observer Calf	Right observer Non-calf	Right observer Calf	Total Non-calf	Total Calf
1	27	0	0	0	0	0	0
2	44	0	0	0	0	0	0
3	63	0	0	0	0	0	0
4	65	0	0	0	0	0	0
5	69	0	0	0	0	0	0
6	72	0	0	0	0	0	0
7	77	0	0	0	0	0	0
8	86	0	0	0	0	0	0
9	95	0	0	0	0	0	0
10	103	0	0	0	0	0	0
11	99	0	0	0	0	0	0
12	106	0	0	0	0	0	0
13	103	0	0	0	0	0	0
14	101	0	0	0	0	0	0
15	97	0	0	0	0	0	0
16	93	0	0	0	0	0	0
17	95	3	0	0	0	3	0
18	97	7	0	0	0	7	0
19	103	1	0	0	0	1	0
20	109	15	0	0	0	15	0
21	113	0	0	2	0	2	0
22	115	45	0	4	0	49	0
23	119	7	0	4	0	11	0
24	130	6	0	8	1	14	1
25	130	4	0	6	1	10	1
26	130	2	0	6	0	8	0
27	130	11	0	16	2	27	2
28	130	17	1	10	0	27	1
29	130	1	0	14	3	15	3
30	130	5	0	4	0	9	0
31	130	2	0	0	0	2	0
32	130	0	0	1	0	1	0
33	130	0	0	0	0	0	0
34	130	0	0	0	0	0	0
35	130	0	0	0	0	0	0
SUM	**3611**	**126**	**1**	**75**	**7**	**201**	**8**

Appendix G. *continued*

STRATUM IV (5–8, and 10 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed off transect					
		Left observer		Right observer		Total	
		Non-calf	Calf	Non-calf	Calf	Non-calf	Calf
1	17	0	0	0	0	0	0
2	41	0	0	0	0	0	0
3	60	0	0	0	0	0	0
4	77	0	0	0	0	0	0
5	90	0	0	0	0	0	0
6	110	0	0	0	0	0	0
7	110	0	0	0	0	0	0
8	116	0	0	0	0	0	0
9	139	0	0	0	0	0	0
10	148	0	0	0	0	0	0
11	153	0	0	0	0	0	0
12	151	0	0	0	0	0	0
13	139	0	0	0	0	0	0
14	155	0	0	0	0	0	0
15	160	0	0	0	0	0	0
16	169	0	0	0	0	0	0
17	175	0	0	0	0	0	0
18	178	0	0	0	0	0	0
19	178	0	0	0	0	0	0
20	177	0	0	0	0	0	0
21	134	0	0	0	0	0	0
22	61	0	0	0	0	0	0
SUM	**2738**	**0**	**0**	**0**	**0**	**0**	**0**

Appendix G. *continued*

STRATUM V[a] (6, 10, and 12–13 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed off transect					
		Left observer		Right observer		Total	
		Non-calf	Calf	Non-calf	Calf	Non-calf	Calf
1	15	0	0	0	0	0	0
2	37	0	0	0	0	0	0
3	62	0	0	0	0	2	0
4	73	0	0	0	0	0	0
5	94	0	0	0	0	0	0
6	89	0	0	0	0	0	0
7	17	0	0	0	0	0	0
8	34	0	0	0	0	0	0
9	24	0	0	0	0	0	0
10	35	0	0	0	0	0	0
11	34	0	0	0	0	0	0
12	72	2	0	0	0	2	0
13	181	0	0	0	0	0	0
14	181	0	0	0	0	0	0
15	186	0	0	0	0	0	0
16	188	0	0	0	0	0	0
17	193	1	0	0	0	1	0
18	196	3	0	0	0	3	0
19	199	3	0	2	0	5	0
20	199	9	0	5	0	14	0
21	203	12	1	2	0	14	1
22	206	8	0	4	0	12	0
SUM	**2518**	**38**	**1**	**13**	**0**	**51**	**1**

[a] Results prior to stratification and survey of strata VI and VII.

Appendix G. *continued*

STRATUM VI (15–16 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed off transect					
		Left observer		Right observer		Total	
		Non-calf	Calf	Non-calf	Calf	Non-calf	Calf
1	60	10	0	2	0	12	0
2	60	4	2	7	0	11	2
3	60	4	1	2	0	6	1
4	60	8	0	6	2	14	2
5	60	14	2	8	3	22	5
6	60	1	1	4	0	5	1
7	60	3	0	0	0	3	0
8	60	0	0	7	2	7	2
9	60	9	0	2	0	11	0
10	60	1	0	6	0	7	0
11	60	2	0	1	0	3	0
12	60	1	0	0	0	1	0
13	60	2	0	4	0	6	0
SUM	**780**	**59**	**6**	**49**	**7**	**108**	**13**

Appendix G. *continued*

STRATUM VII (16 June 1994)

Transect no.	Transect area (km^2)	No. of caribou observed off transect					
		Left observer		Right observer		Total	
		Non-calf	Calf	Non-calf	Calf	Non-calf	Calf
1	50	6	0	4	0	10	0
2	50	3	1	6	0	9	1
3	50	5	0	11	0	16	0
4	50	5	0	10	0	15	0
5	50	15	2	3	0	18	2
6	50	10	0	2	0	12	0
7	50	5	1	4	0	9	1
8	50	3	2	1	0	4	2
9	50	0	0	0	0	0	0
10	50	3	0	2	0	5	0
SUM	**500**	**55**	**6**	**43**	**0**	**98**	**6**

APPENDIX H. Observations of caribou during low-level reconnaissance flights of eastern Victoria Island, 17 June 1994.

Obs. no.	Time	Lat	Long	Ant_Cw	Bld_Cw	Calf	Yrl	Bull	Unk
dep[a]	1030	7218	11205	Wynniatt Bay Research Cabin					
wpt[b]	1050	7214	11043						
wpt	1054	7212	11024						
wpt	1101	7213	10948						
1	1103	7210	10936					1MX	
2	1113	7309	10843	1	1		1		
3	1118	7212	10838	1	2	1	1		
wpt	1120	7213	10823						
wpt	1131	7208	10825						
3b	1136	7202	10826		1				1
wpt	1144	7150	10814						
arrv[c]	1158	7142	10745	Hadley Bay (71E42.71’ 107E44.79’) for fuel and lunch					
dep	1242	7142	10745	Hadley Bay					
4	1244	7143	10730		1				
5	1246	7143	10727					1	
6	1255	7151	10714						1
7	1302	7156	10655	1		1			
8	1308	7154	10646		1	1			
9	1309	7150	10657		1	1			
9b	1310	7149	10655	1	1	2			
wpt	1313	7147	10645						
10	1314	7145	10643		1	1			
11	1315	7143	10637		1	1			
12	1317	7143	10636		1	1			
13	1321	7140	10622		1				
14	1326	7143	10604					1	
15	1331	7145	10542		1	1	1		
16	1333	7144	10537		1	1	1		
17	1334	7143	10533		1	1			
18	1338	7147	10510		3	3	1	2	
19	1341	7147	10517		2		1		
20	1344	7147	10509	1					
21	1348	7151	10457		2	1			
22	1349	7152	10453	1	1		1		
23	1355	7151	10445		1		1		
24	1401	7145	10435		2				
25	1406	7139	10441				1		
26	1408	7140	10448				1		
27	1409	7141	10448		2	2	1		
28	1411	7143	10457		1	1			
29	1412	7144	10456		1				
30	1413	7143	10501		1	1			
31	1414	7144	10505	1	2	1	1		
32	1420	7144	10523		4				
33	1423	7142	10529						1
34	1429	7136	10512	1	2	1			
35	1432	7135	10501		1				

[a] Departure; [b] Waypoint; [c] Arrival

Appendix H. *continued*

No.	Time	Lat	Long	Ant_Cw	Bld_Cw	Calf	Yrl	Bull	Unk
36	1434	7134	10457		1				
37	1435	7134	10450		1		1	2	
38	1436	7134	10445		2	1			
39	1437	7135	10443	1	1	2			
40	1440	7133	10437		4	1			
41	1441	7134	10435	1	2	1		1	
42	1442	7133	10429						3
43	1445	7130	10425		3	1	1		
44	1445	7129	10424		2				
45	1448	7127	10429					1	
46	1449	7126	10431	1	1				
47	1451	7124	10437						1
48	1456	7119	10453		2	1	1		
49	1457	7119	10456	1		1			
50	1459	7117	10458						1
51	1500	7117	10457		4	4	1		
52	1503	7115	10510		2		1	1	2
53	1504	7115	10514		2		2		
54	1508	7115	10521		1				
55	1511	7115	10520		2		2	1	
56	1518	7107	10535		2			1	
57	1523	7103	10541		2	2			
58	1525	7106	10546						1
59	1526	7059	10543		1			2	
60	1529	7059	10552				1	2	
60b	1530	7058	10552		6	2	1	2	
61	1534	7053	10551		1		1		
62	1542	7048	10524		1		1	2	
63	1544	7049	10519		2	1			
64	1548	7048	10505						
65	1551	7047	10440		1	1			
66	1554	7048	10432	1		1			
67	1556	7047	10428		1	1			1
68	1605	7045	10358		6				
69	1606	7043	10346		1		2	3	
70	1607	7043	10345		1		1		
71	1609	7041	10342						2
72	1610	7040	10340		2		1	1	
73	1611	7039	10337					7	
74	1614	7035	10330		2			1	
75	1616	7033	10322					1	1
76	1617	7033	10310		1	1			
77	1625	7027	10252		1	1			
78	1627	7028	10243		1	1			3
79	1630	7025	10232						1
80	1634	7026	10230		1	1			
81	1636	7023	10226		1				
82	1638	7021	10217		1			1	

Appendix H. *continued*

No.	Time	Lat	Long	Ant_Cw	Bld_Cw	Calf	Yrl	Bull	Unk
83	1639	7018	10206						1
84	1642	7018	10201					3	
85	1644	7016	10158		4		1		
86	1645	7015	10152					6	
87	1649	7014	10143					2	
88	1650	7013	10142		2	2	1		
89	1651	7010	10138						1
90	1653	7008	10135		2				
91	1654	7006	10132		4				
92	1700	7706	10118		2			1	
93	1704	7004	10104		6	4			
94	1705	7006	10104		4			3	
95	1710	7005	10059		1	1			
96	1714	7001	10054		5		2		
97	1717	6957	10857					1	
98	1722	6949	10058		2	1			
99	1724	6947	10056					1	
100	1731	6943	10116		2				
101	1735	6949	10127		1				
102	1736	6950	10133					1	
103	1743	6952	10156		2	2			
104	1745	6953	10151		2	1			
105	1746	6953	10148		2	1			
106	1748	6954	10140		2	1			
107	1749	6955	10137		3	1			
108	1749	6955	10137		1	1			
109	1750	6959	10135		1				
110	1752	7001	10132		1				
110b	1753	7003	10129		2	1			
111	1755	7005	10126		1				
112	1758	7006	10134		4	2			
113	1759	7006	10137		2			1	
114	1801	7006	10141		1				
115	1803	7006	10151					1	
115	1803	7006	10151					1	
116	1805	7006	10200		3	1			
117	1806	7006	10204		2	2			
118	1808	7007	10205		2	2			
119	1815	7003	10218	1	5	5			
120	1819	6958	10221		1	1			
121	1820	6956	10224						1
122	1824	6952	10626						1
123	1826	6951	10227					1	
124	1826	6950	10227					1	1
125	1833	6943	10444		2	1			
126	1834	6942	10245					1	
End	1846	6932	10320					2	
SUM				14	179	76	33	56	24