# Calving Ground Abundance Estimates of the Beverly and Ahiak Subpopulations of Barren-Ground Caribou (*Rangifer tarandus groenlandicus*) – June 2011

**GOVERNMENT OF NUNAVUT**
**DEPARTMENT OF ENVIRONMENT**

## <u>TECHNICAL</u> <u>SUMMARY</u>

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## ABSTRACT

In June 2011 we estimated the abundance of breeding female barren-ground caribou based on aerial surveys of three calving areas in Nunavut: (1) the Beverly subpopulation calving area extending from the Queen Maud Gulf coastline including the Queen Maud Gulf Migratory Bird Sanctuary (QMGMBS); (2) the more southern historical Beverly subpopulation calving area in the vicinity of the Beverly/Garry Lakes area; and (3) the calving area along the coastline in the eastern portion of the QMGMBS and across Adelaide Peninsula and east to Pelly Bay, utilized by the Ahiak subpopulation.

For the Beverly subpopulation we utilized both a systematic transect visual aerial survey technique for reconnaissance and a stratified systematic aerial transect visual technique to estimate breeding females and adult barren ground caribou within each of the two annual concentrated calving extents. Within the Ahiak annual concentrated calving extents, we used a reconnaissance survey (within Adelaide Peninsula strata) and a supervised pre-stratification technique (East of Adelaide Peninsula to Pelly Bay) based on previous and current year collar locations and June 2010 and 2011 distribution information. This allowed us to focus survey effort towards estimating the number of adult caribou during peak calving. During all aerial visual surveys, we incorporated a double observer visual survey method. We conducted composition surveys within survey strata from both study areas to estimate the proportion of breeding females in each stratum. The estimates of all adult caribou (1+ year old) from visual strata (Yh) was multiplied by the respective breeding proportions to obtain estimates of breeding females for each, within their respective stratum.

The estimate of breeding females is the best indicator of population size since all necessary parameters are estimated directly during the calving ground surveys. However, for management purposes, we also provided total population estimates, which were based on the estimates of breeding females. To estimate

the total population size, the number of breeding females was divided by the proportion of females in the population (as determined during October 2011 composition survey) and the proportion of females that were pregnant (as determined during June 2011 composition surveys). Within the Beverly subpopulation we estimated 124,189 (SE = 13,996; CV = 0.11) adult caribou and yearlings of which 52,825 (SE = 2,638; CV = 0.05) were breeding females. Since the proportion of females pregnant was not estimated directly, we used the pregnancy rates that were estimated for the Qamanirjuaq Herd during past studies. For the Ahiak subpopulation, only breeding females were estimated as fall composition counts were not conducted for this subpopulation. In addition, calving composition counts indicated a general lack of sexual segregation suggesting that the majority of the Ahiak subpopulation was within the survey area during the abundance estimate. Given these assumptions, 71,340 (SE = 3,882; CV = 0.05) adult caribou and yearlings were estimated within the survey area of which 27,729 (SE = 1,579; CV = 0.06) were breeding females.

***Key words:*** Calving ground visual survey, Caribou calving ground, Kitikmeot region, Double observer method, Barren-ground caribou, Beverly Subpopulation, Ahiak Subpopulation, Northeast Mainland, Queen Maud Gulf Bird Sanctuary, Nunavut, *Rangifer tarandus groenlandicus*, population survey, Double observer.

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# 1.0 INTRODUCTION

After the last glaciation, caribou in North America recolonized their range from several refugia and originated several ecotypes (Yannick et al., *in prep.*). While Inuit had been relying on several caribou ecotypes for survival over centuries, the first written reference to barren-ground caribou was likely that of Martin Frobisher in 1576 (Banfield, 1951). The earliest detailed account of migratory behavior, distribution and movements, and the use of caribou by subsistence harvesters was recorded by Hearne in 1795 (Banfield, 1951). Caribou distribution across the mainland in the early 1900's, as determined from reports and resident interviews, seems to have changed little in recent history (Figure 1).

Early observations of mainland barren-ground caribou suggest that all herds moved to the forested belt in winter. Later observations described the winter occurrence of bands of caribou on the tundra (Banfield, 1951). In his review of the available information, Banfield (1951) concluded that although the majority of barren-ground caribou spent their winters within or in proximity to the taiga, small herds and scattered bands remained all winter on the tundra often in the vicinity of the coast or large lakes. Banfield also suggested that during mild winters all the herds might be found near the tree line; a conclusion consistent with more recent scientific findings (Nagy et al., 2011; Nagy, 2011; Nagy and Campbell, 2012). Banfield went on to suggest that the herds do not return to the same areas each winter but rather return to the same general locality over several seasons then abandon it, possibly due to weather and forest fires.

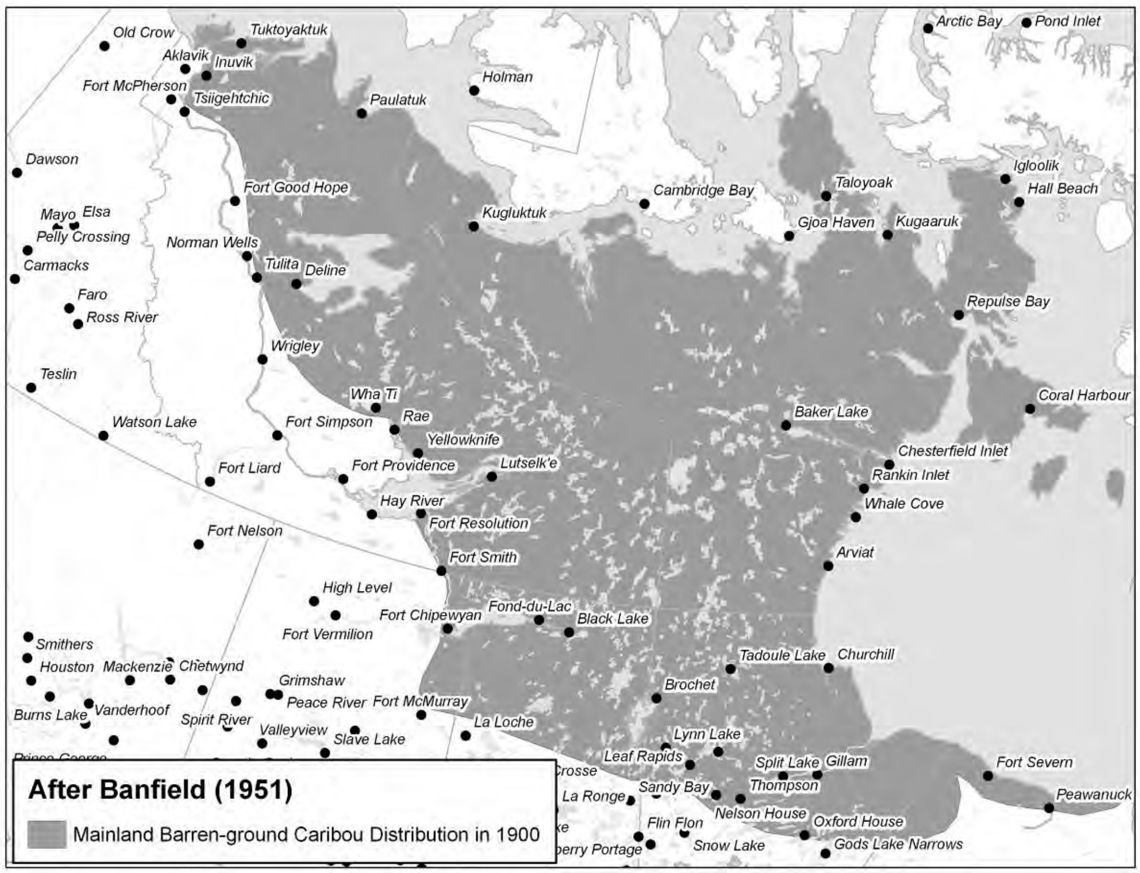



**Figure 1** Mainland barren-ground caribou distribution based on local observations and studies from the early 1900's.

The mid 1900's through the late 1980's saw an increase in demographic studies of barren-ground caribou herds on Canada's western mainland (Calef, 1979). In his status report, Calef (1979) discussed eight major barren-ground caribou herds within the Northwest Territories (NWT), estimated to number in excess of 600,000 animals. The herds described included the Melville Peninsula, Wager Bay and Bluenose herds, thought to be increasing, the Bathurst, Beverly and Porcupine herds, thought to be stable, and the Qamanirjuaq and Baffin herds thought to be declining. During this same period, our understanding of the Beverly caribou herd benefited from a similar acceleration in demographic studies specific to the herd (Calef, 1979; Heard and Jackson, 1990; Thomas, 1969; Rippin, 1971; Moshenko, 1974; Gunn and Decker, 1982; Stephenson et al., 1984; Gunn, 1984; Heard, 1982; Gunn and Sutherland, 1997; Williams and Heard, 1990; Williams et al., 1989; Thomas and Kiliaan, 1985; Thomas and Barry, 1990). In 1994, a photographic survey of the Beverly caribou subpopulation within its Beverly/Garry Lakes annual concentrated calving area estimated 120,000 +/- 43,100 (SE) breeding females from which a total subpopulation estimate of 276,000 +/- 106,600 (SE) adults and yearling caribou was extrapolated using fall composition study results. From 1994 through to 2002 less monitoring and attention was given to the Beverly subpopulation.

The first comprehensive survey of caribou occupying the Northeast Mainland was flown by Heard et al. (1986) in May 1983. An identical survey was flown again by Buckland et al. (2000) in May of 1995. Both surveys used the same study area and identical methods and transects to estimate caribou abundance east of the Perry River as the then Bathurst herd annual concentrated calving area occupied geographic extents west of the Perry River to the eastern shores of Bathurst Inlet (Gunn, 1996; Heard et al., 1986; Sutherland and Gunn, 1996). During the period between these two survey efforts, the Bathurst herd, began a gradual southern then western calving ground distributional shift first documented in 1986, with the completion of the shift likely some time before June 1999 though the exact year remains unclear (Sutherland and Gunn, 1996; Gunn et al., 2000; Gunn, 1996).

The shift resulted in two distinct annual concentrated calving areas on both the west and east side of Bathurst Inlet for a period of time. The total separation of the annual concentrated calving areas was approximately 250 kilometers. An estimated 75% of the current Beverly annual concentrated calving area extends west of Perry River and as a result is within the pre-1986 Bathurst calving extent. Neither the 1983 or 1995 survey efforts covered the western extent of the Beverly's current annual concentrated calving area so a direct comparison of abundance between years is not possible. A survey flown on June 12th and 13th, 1996, observed cow calf pairs on both sides of the Perry River (Gunn et al., 2000). In 2006 the GNWT began systematic calving ground reconnaissance surveys in the vicinity of the Queen Maud Gulf to delineate the extent of calving between Bathurst Inlet and Chantrey Inlet. This survey effort and methodology was repeated June 2007 through 2010. In 2009 and 2010 the survey area was extended east of Chantrey inlet.

During the late 1990's to early 2000, community and government representatives raised concerns over the paucity of information on the Beverly subpopulation status. Of its members, subsistence harvesters from Northern Saskatchewan expressed the greatest concern owing to their greater dependence on Beverly caribou for subsistence (during the winter season) compared to that of neighbouring jurisdictions (InterGroup Consultants Ltd., 2008). Additional concerns were raised by BQCMB members regarding an observed increased harvest of caribou in Northern Saskatchewan as a result of an increased access to the winter range through the construction of all season and winter roads to service mining interests in the area. In response to these concerns and in the absence of data, the NWT Government coordinated a reconnaissance survey of the Beverly caribou subpopulation within its southern annual concentrated calving area in June 2002 in Nunavut. The reconnaissance survey made a number of findings: 1) the area of calving was the lowest recorded since 1979 and approximately 500 $km^2$ smaller than observed in June 1994. 2) The relative densities of adult caribou on the calving ground were lower than most other survey years (except the 1987 and 1988 survey years) (Johnson and Mulders, 2002).

Findings from the 2002 reconnaissance survey raised concerns that the Beverly subpopulation may be in decline. In addition, concerns regarding the start-up of mineral exploration activities on the calving grounds and wintering habitat and the possible negative impacts that they may have had on an already vulnerable subpopulation, compelled the NWT government to initiate a calving ground photo-estimate of the Beverly subpopulation within its more southern calving extent in the vicinity of Beverly and Garry Lakes, in June 2007 (Johnson et al., 2008). Biologists conducting the June 2007 survey found so few breeding females on the more southerly Beverly/Garry Lakes annual concentrated calving area (175 observed on transect; relative density of 0.40 caribou/$km^2$) that they had to cancel the photo-survey. The NWT government found even fewer animals during reconnaissance surveys flown over the same study area in June 2007, 2008, 2009 and 2010 (90 - 100 caribou observed on transect in June 2010; relative density of 0.20 caribou/$km^2$)(unpublished GNWT data). At the time, these findings were attributed to a severe decline in the Beverly subpopulation. This conclusion, however did not sit well with communities in the vicinity. Furthermore, jurisdictional biologists believed there was an alternative explanation for the number of caribou observed on the Beverly/Garry Lakes annual concentrated calving area. This alternative explanation suggests that the Beverly subpopulation began moving out of their previously delineated annual concentrated calving area, prior to the 2002 survey, to the Queen Maud Gulf area known to be partially used for calving by a tundra wintering caribou subpopulation (in this report termed the Ahiak subpopulation).

A quantitative study of caribou collar data across the Canadian arctic east to the shores of Hudson Bay was recently completed by Nagy et al. (2011). The study examined all collar location data from eight barren ground caribou herds west of the Hudson Bay using a technique termed “fuzzy clustering” which examined the spatial affiliation amongst females throughout the calendar year. Nagy et al. (2011) found that the social relationships existing between individuals within a population will determine the degree of interaction/connectivity within a species, subspecies, or ecotype, which in the case of barren ground caribou include two main ecotypes; 1-Tundra wintering and 2- Mainland migratory or Taiga wintering. Behavior as they relate spatially to territories or overlapping home ranges, or to varying degrees of gregariousness and movement ecology (e.g., migratory or sedentary) plays an important role in how populations are structured (Nagy, 2011; Nagy et al., 2011). The results of these studies, coupled with local knowledge within the communities on the northern extent of the range (Baker Lake, Gjoa Haven, and Kugaaruk), suggest that the main driver for the decline in abundance recorded on the Beverly /Garry Lakes annual concentrated calving area was a distributional shift. This shift was to the Queen Maud Gulf geographical area some 250 km north of their Beverly/Garry Lakes annual concentrated calving area. This does not mean that other demographic mechanisms were not active on the subpopulation over the period of the shift, or that the subpopulation had not suffered a concurrent decline of unknown magnitude from these demographic mechanisms. The work does suggest that an active response of the Beverly subpopulation to varying demographic and / or geographic influences (such as predation, anthropogenic disturbance, disease, low productivity, insects, adverse weather conditions; other factors), was a shift in calving distribution away from these influences approximately 250 km north to the vicinity of the Queen Maud Gulf, likely over a period of many years (Nagy et al., 2011). Baker Lake and (other community) HTOs and elders have indicated that they believe that increased exploration and development activities, and an increase in the number of predators within the Beverly/Garry Lake calving ground played a role in the Beverly subpopulation beginning to shift their calving distribution.

In August 2011, the Nunavut Government and regional co-management organizations adopted these new distributions as presented by Nagy et al. (2011)

and Nagy and Campbell, (2012) as the current distribution of the Beverly subpopulation of barren-ground caribou (Figure 2 & 3) because it represents the best available information and is consistent with local and traditional knowledge. Nagy et al. (2011) and Nagy and Campbell (2012) also delineated caribou subpopulations calving east of the Beverly subpopulation and termed the easternmost the Queen Maud Gulf subpopulation. For geographic clarity, this name has been changed in this report to the Ahiak subpopulation of tundra wintering barren ground caribou until a name is decided by local Hunter and Trapper Organization's (HTO) and the Kivalliq and Kitikmeot Regional Wildlife Organizations (Figure 2 & 3). Since June 1994, there has only been sparse data and low sample sizes of collared caribou across both subpopulations. The degree to which demography has affected the observed changes across the Beverly/Garry Lakes annual concentrated calving area
therefore remains uncertain. Additionally, it is important to note that regardless of the temporal scale of the shift and accompanying demographic mechanisms acting on subpopulation abundance, it is clear that some overlap between the Beverly and Ahiak subpopulations does exist. Nevertheless, the degree of overlap, in recent years, as evidenced through the analysis of collar movements between the Beverly and Ahiak subpopulations, appears minimal.

The 2011 June calving ground survey was initiated to estimate caribou calving within the Queen Maud Gulf region of Nunavut east to Pelly Bay, based in part on calving distributions provided in the available scientific literature and unpublished NWT and Nunavut survey data. This objective was further defined through discussions with Regional Wildlife Organizations, co-management partners, and local HTO's, as well as recent spatial analysis of collar data specific to the Beverly and Ahiak subpopulations based on the annual concentrated calving areas made evident through the analysis of current collar data. Current information on the spatial extent of the annual concentrated calving areas of both the Beverly and Ahiak subpopulations, as they are delineated in this report, are required for the management of subsistence and commercial harvesting and land use activities to reduce possible impacts from human activities on calving caribou. Subpopulation estimates generated from survey observations will inform managers as to the sustainability of current harvest estimates and allow for the setting of benchmarks with which to determine subpopulation status and trend.

The general approach of past surveys of calving grounds was the use of a photographic survey plane in areas of high caribou density to minimize sightability and counting bias (Heard, 1985; Gunn et al., 2005; Nishi et al., 2010). For this method, reconnaissance surveys are initially flown to delineate areas of high density followed by optimized resampling of strata areas using the photo plane during times of clear survey weather. However, application of the photographic survey plane was potentially problematic in the Queen Maud Gulf area due to low cloud ceilings. In addition, caribou in the Queen Maud Gulf were most likely distributed in a larger area at lower densities compared to the Bathurst, Bluenose and Qamanirjuaq herds and it was therefore potentially prohibitive to survey the entire Queen Maud Gulf area using the photo plane survey methods given limitations on the number of photos that could be taken during a single survey. For example, the total survey area for the Queen Maud Gulf and Northeast Mainland areas was approximately 73,000 $km^2$ which was approximately nine times larger than the survey area of the Bathurst of 7,984 $km^2$ in 2009 (Nishi et al., 2010) and 11 times bigger than the Qamanirjuaq (6,476 $km^2$) in 2008 (Campbell et al., 2010).

We adapted a previously used calving ground survey methodology to confront the likely challenges of surveying the Queen Maud Gulf and Ahiak. First, we developed a double observer method (Cook and Jacobsen, 1979; Buckland et al., 2010) that corrected visual counts for sightability bias therefore allowing efficient, unbiased estimates without the use of the photo plane. Second, we utilized four survey aircraft to allow efficient survey of large areas during the infrequent times of suitable weather conditions. Finally, we used a hybrid approach of survey design where reconnaissance flying followed by optimized sampling was used in areas of higher caribou density (the Queen Maud Gulf) and one pass survey methods with optimization based upon distribution of collared caribou was used where caribou distribution was more uniform and densities were lower (The Ahiak).

The main objective of the survey was to obtain an estimate of caribou in the geographic areas of the Queen Maud Gulf and Ahiak. Once this estimate was obtained, retrospective analysis and published studies were used to delineate subpopulations from the survey strata. The main contents of this report deal with the reporting of survey results rather than methodologies used to infer subpopulations from the resulting estimates. We emphasize that the estimates from this report should be considered in terms of future management of caribou subpopulations in the region rather than providing an indication of the past histories of caribou populations within the survey area.

Caribou Protection Measures were implemented by Department of Indian Affairs and Northern Development (now Aboriginal Affairs and Northern Development Canada, AANDC) to protect breeding cows during the calving and post-calving periods, but there has been no funding for the caribou monitoring component of the measures since 1991; and Caribou Protection Areas (CPAs) are based on past calving and post-calving information and as a result are outdated. Since the CPAs were established, Beverly caribou have regularly calved outside of the CPAs including at least 4 years in which less than 5% of calving occurred within the CPA (Gunn and Sutherland, 1997; Nagy et al. 2011).

The large geographic scale of the observed spatial shifts and unknown trend made the initiation of this work a priority for the jurisdictions of Saskatchewan, Northwest Territories and Nunavut.

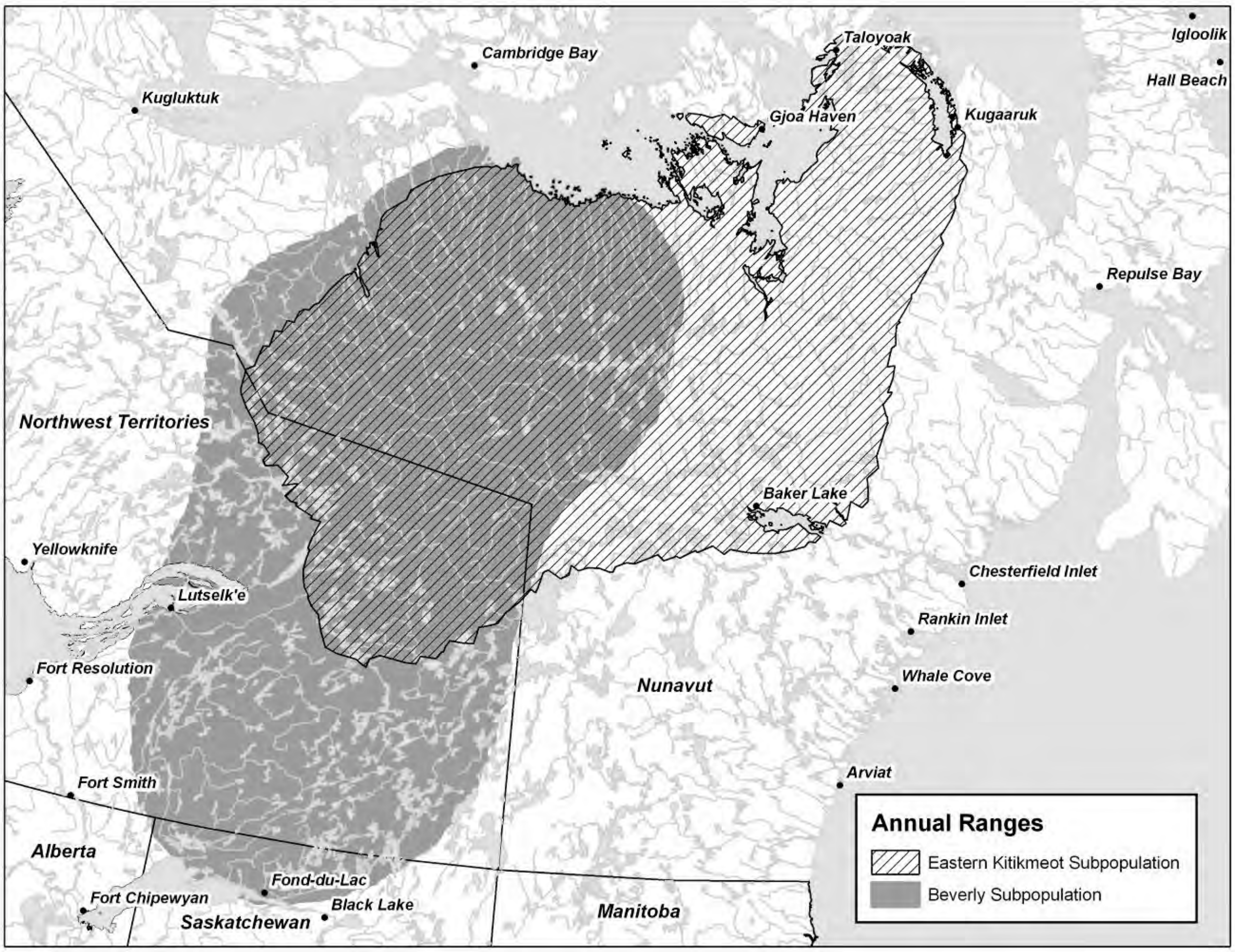



**Figure 2** The current annual ranges of the Beverly mainland migratory barren-ground caribou subpopulation and the Ahiak (formerly Eastern Kitikmeot)* tundra wintering barren-ground caribou subpopulation as described by Nagy et al (2011).

* The figures in this report are currently being updated to reflect the change in subpopulation name noted throughout the report; the "Eastern Kitikmeot subpopulation" will henceforth be known as the Ahiak subpopulation.

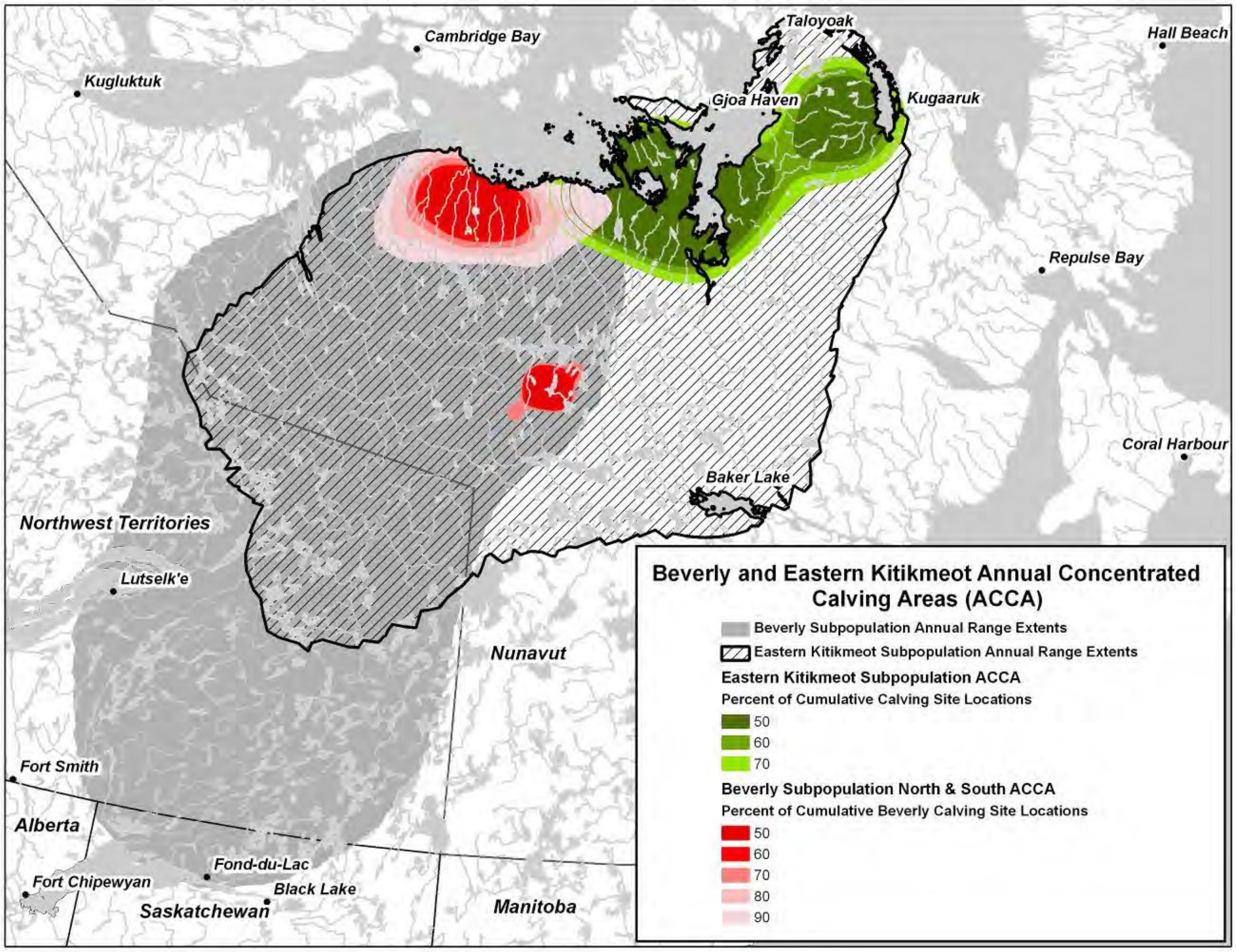



**Figure 3** The annual concentrated calving areas of the Beverly and Ahiak barren-ground caribou subpopulations based on a multi-year fuzzy cluster analysis of barren-ground caribou collar locations (Via significant changes in movement rates) calving sites (After Nagy and Campbell, 2012).

# 2.0 STUDY AREA

Using annual location data collected from satellite and Global Positioning Satellite (GPS) collars between 2000 and 2011 (Beverly caribou subpopulation) and 2008 through 2011 (Ahiak caribou subpopulation previously named the Queen Maud Gulf subpopulation) Nagy et al. (2011), Nagy (2011) and Nagy and Campbell (2012) estimated the Beverly and Ahiak subpopulations annual ranges to occupy 426,160 $km^2$ and 413,301 $km^2$ respectively (Figure 2). A kernel analysis using calving site locations estimated the annual concentrated calving areas of these subpopulations to be 38,491 $km^2$
(Beverly northern concentrated calving area = 34,100 $km^2$; Beverly southern concentrated calving area = 4,391 $km^2$) and 70,934 $km^2$ respectively (Figure 3). The annual range of the Beverly subpopulation covers three jurisdictions; Saskatchewan, NWT and Nunavut, and nine communities including Black Lake and Fond-du-lac in Saskatchewan, Lutselk'e in the North West Territories, and Baker Lake, Gjoa Haven, Taloyoak and Kugaaruk in Nunavut. For the Beverly subpopulation, the entire annual concentrated calving area extents (both north and south) and much of the post calving extents lie completely within Nunavut. Approximately half of the spring and fall migratory corridors lie within Nunavut while the remaining corridors lie within NWT as do the largest proportions of fall, winter and spring ranges. For the Ahiak subpopulation over 80% of the entire annual range lies within Nunavut of which all of the calving, post calving habitat and fall, and spring migratory corridors lie completely within Nunavut.

The June 2011 survey study area delineated for these two subpopulations covered an estimated 288,312 $Km^2$. The area extended from the community of Baker Lake, west along the Thelon River to longitude $106^0$ west; north to the shores of the Queen Maud Gulf; east along the coast of mainland Nunavut to the southern extents of Committee Bay; south to the western extents of Repulse Bay; west to $96^0$ longitude; then south to the community of Baker Lake (Figure 4).

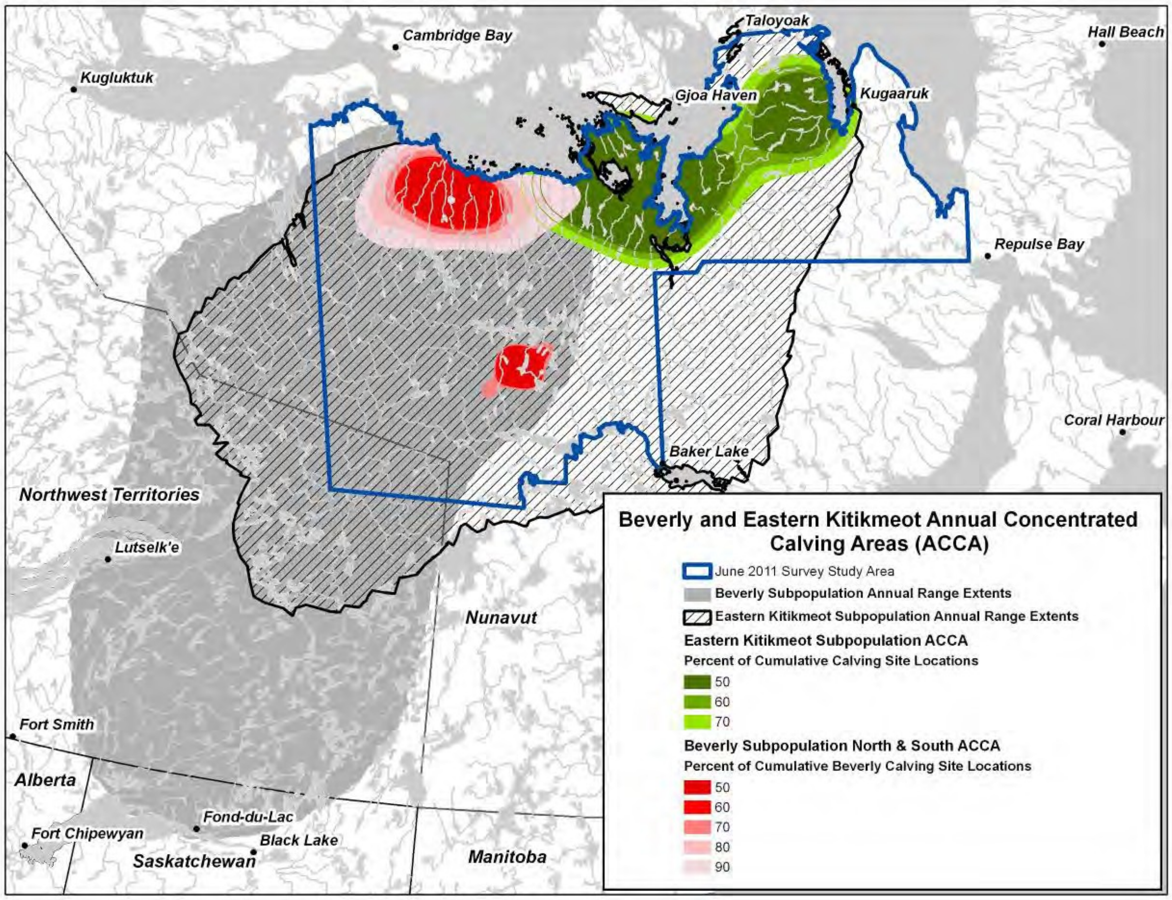



**Figure 4** The June 2011 Beverly and Ahiak calving ground survey study area extents.

# 3.0 METHODS

## *3.1 Reconnaissance and Abundance Surveys*

The 2011 Beverly and Ahiak barren-ground caribou double observer visual surveys were based out of the communities of Baker Lake, Cambridge Bay, Kugaaruk, Gjoa Haven and Taloyoak. The survey was structured into four main components: 1) Systematic reconnaissance surveys, 2) Double observer visual surveys, 3) density stratum based composition surveys and 4) fall composition surveys. The systematic reconnaissance surveys were designed to determine the timing and distribution of calving as well as to stratify effort based on observed relative densities. The double observer visual surveys and the composition surveys were used to estimate the number of breeding females on the annual calving grounds while the fall composition survey of the Beverly subpopulation was used to extrapolate the breeding female estimates to subpopulation estimates by estimating the male to female ratio.

Potential reconnaissance survey transects were distributed systematically across the northern mainland from Bathurst Inlet east to Committee Bay. The entire study area covered 288,312 km$^2$ and encompassed the known extents of caribou calving in the area of Beverly and Garry Lakes, the Queen Maud Gulf and Chantrey Inlet east to Committee Bay (Johnson and Mulders, 2002; Johnson et al. 2008; Johnson and Williams, 2008; Kelly in prep., 2010; Nagy et al., 2011) (Figure 5). This yielded 89 reconnaissance transects oriented north-south and spaced 10 kilometers apart and varying in length from 160 to 530 km. Each transect had associated transect station points that were located at 10 kilometer intervals along the lines. Each station had an alphanumeric identifier (i.e., S22) allowing each location to be easily referenced. The 10 kilometer segment between any two transect stations is termed a transect segment. Each transect segment was named after its northern transect station. Transects were created using Environmental Systems Research Institute (ESRI) ArcMap Geographic Information System (GIS) software and were based on the UTM zone 15 World Geodetic System (WGS) 1984 coordinate system. The starting coordinate for the first transect was 200,000 easting and 7,140,000 northing.

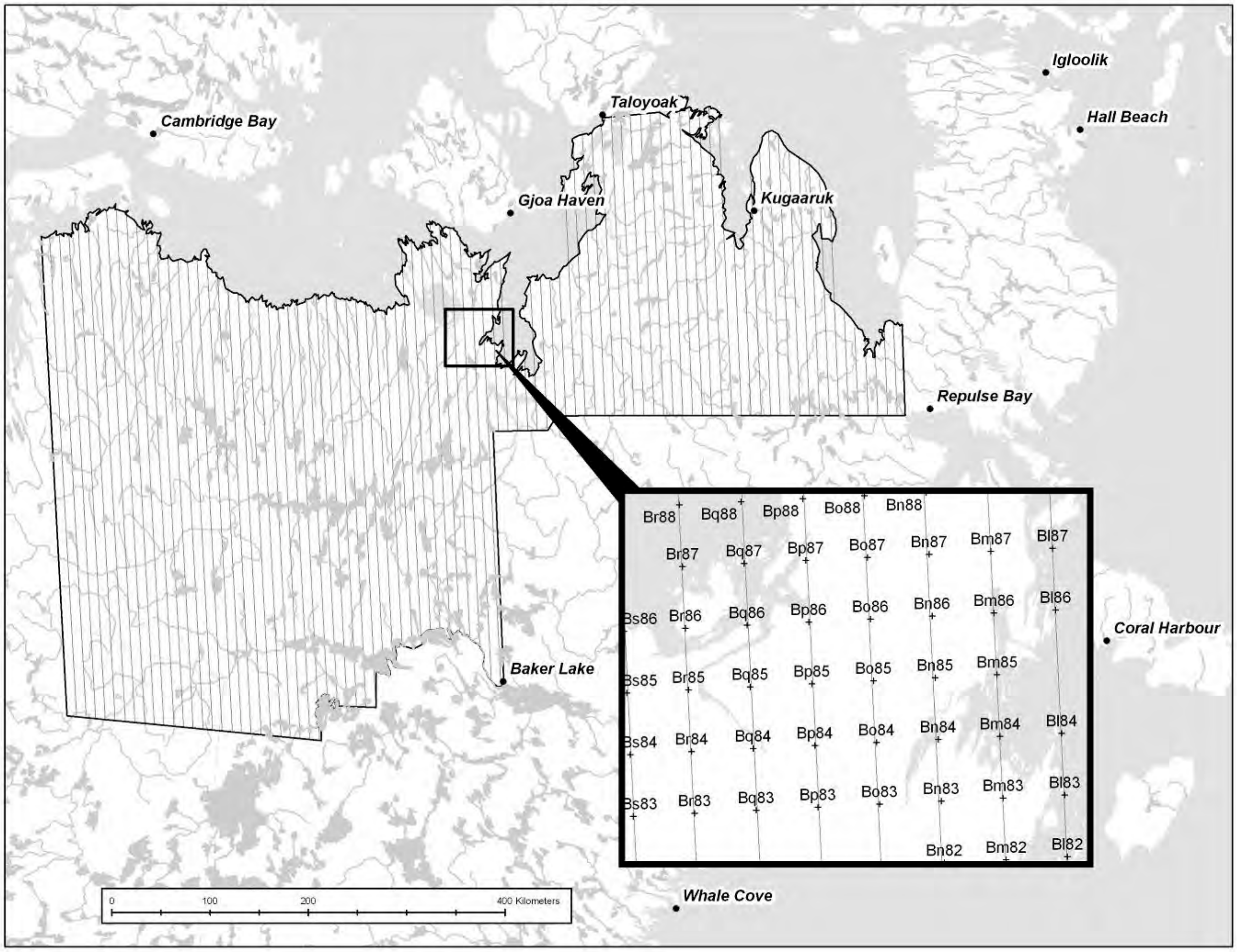



**Figure 5** Potential reconnaissance transects and transect stations designed to cover the known extent of calving for the Beverly and Ahiak subpopulations of barren ground caribou. Not all transects were flown during the June 2011 survey.

Three Cessna Grand Caravans and one Dehavalland Turbo Otter were used for all aspects of the visual surveys across the study area. Strip widths were established using streamers attached to the wing struts (Figure 6). Strip width (w) was calculated using the formula of Norton-Griffiths (1978):

$$w = W * h/H$$

*Where:*

***W** = the required strip width;*

***h** = the height of the observer's eye from the tarmac; and*

***H** = the required flying height*

Strip width calculations were confirmed by flying perpendicularly over runway distance markers. The strip width was 400 m out each side of the aircraft, for a total transect width of 800 m. All aircraft were equipped with radar altimeters to ensure an altitude of 400 feet above ground level (AGL) was maintained accurately. Off-transect observations were optional during the abundance phase of the survey so that observers could focus on indicated strips. During the reconnaissance survey, caribou were classified as much as possible as adult with or without antlers, adult with or without calf, and yearling or bull.

For this survey, a double observer method utilizing two observers on each side of the aircraft was developed. The double observer method implemented during all phases of the June 2011 survey was very similar to the strip transect method used in previous calving ground surveys. For strip transect surveys, caribou that are observed within the strip width (as defined by the wheel of the plane and the indicator on the wing strut) are recorded. The double observer method uses the same strip transect method, but also collects additional information to estimate caribou sightability.

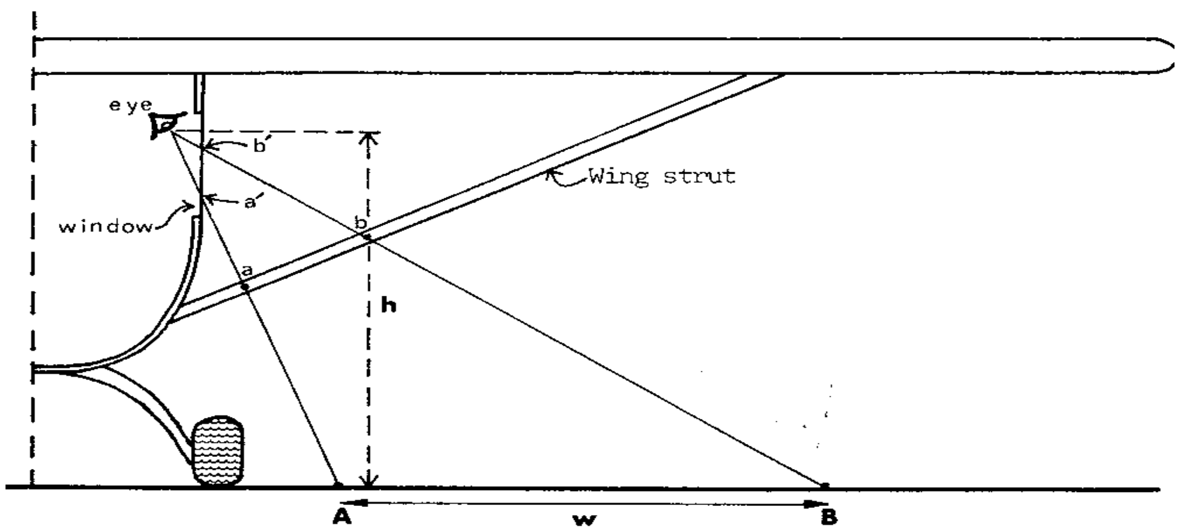



**Figure 6** Schematic diagram of aircraft configuration for strip width sampling (Norton-Griffiths, 1978). W is marked out on the tarmac, and the two lines of sight a' – a – A and b' – b – B established. The streamers are attached to the struts at a and b, whereas a' and b' are the window marks.

The systematic reconnaissance surveys over breeding female distributions allowed us to delineate high, medium and low strata in the Queen Maud Gulf and Chantry Inlet areas. The reconnaissance of the Beverly/Garry Lakes annual concentrated calving area revealed numbers too low for any further survey effort (a more detailed analysis of this reconnaissance will be discussed in the replacement report). Following the systematic reconnaissance but prior to the initiation of the visual survey, all observations were entered into ESRI GIS software to calculate relative densities of breeding females using a tool utility. The relative density tools were built in ESRI's Model Builder (v9.1) utility and loaded into ArcToolbox. The tools allowed us to calculate the relative density of observed caribou locations along the sample transects and display these results on a map. We used vector-based analysis methods based on the following steps:

1. The survey transect segments were buffered by a user-specified width (1000 m in this survey; i.e., 800 meter strip width and 200 m blind spot under the aircraft) yielding polygons that were 1 $km^2$ (i.e., 1.0 km wide x 10 km long).
2. The survey observation points were intersected with the derived buffer polygons.
3. The density was calculated for each polygon by dividing the number of 1+ year-old caribou by the area of the buffer polygon (# of 1+ year old caribou/$km^2$).
4. The relative density (#obs/$km^2$) was then thematically displayed on a map based on pre-defined classes or bins.

The resulting graphics were then used to stratify the breeding female distribution into High, Medium and medium/low-density strata.

The partitioning of survey resources were generally based on relative densities whereby the highest relative densities detected during the reconnaissance stage

received the highest allocation of survey time during the abundance stage. The allocation of effort was in part based on the following formula (after Heard, 1987):

$$N_i = \frac{M\,Y_i}{TL_i\sqrt{TL_i}\sum\left(\frac{Y_i}{\sqrt{TL_i}}\right)}$$

***Where:***

$N_i$ *= number of transects in stratum i*

$Y_i$ = Population estimate in stratum i.

$M$ = Total number of fixed wing hours available for abundance transects.

$TL_i$ = Mean length of transect in stratum i .

Transects within each stratum were aligned at right angles to the longitudinal axis of the stratum to maximize the total number of transects (N). In each abundance stratum an initial transect was randomly placed perpendicular to the longest stratum boundary and the remaining transects systematically placed at regular intervals according to the allocation of survey effort. Transect spacing was allocated based on proportional densities and available resources (Heard, 1987). Within the Beverly subpopulation medium density stratum, transects were placed five kilometers apart providing approximately 15% coverage while in the high density stratum transects were placed 3.4 kilometers apart yielding approximately 23% coverage of the stratum. Transect spacing for the medium/low density stratum was nine kilometers providing coverage of approximately 9% in the stratum. Within the Ahiak subpopulation abundance strata received coverage varying from 20% within higher density strata to 9% within low density strata.

### *3.2 Double Observer Visual Method*

The double-observer method was designed to replace the need of a photo plane for surveys encountering more moderate densities of wildlife as was the case (based on 2009 and 2010 reconnaissance survey observations) within the 2011 survey area. This method involves two pairs of observers on each of the left and right hand sides of the aircraft. One "primary" observer who sits in the front seat of the plane and a "secondary observer" who sits behind the primary observer on the same side of the plane (Figure 7). The method adhered to five basic steps:

***1 -*** The primary observer called out all groups of caribou (number of caribou and location) he/she saw within the 400 meter wide strip transect before they passed halfway between the primary and secondary observer (approximately at the wing strut). This included caribou groups that were between approximately 12 and 3 o'clock for right side observers and 9 and 12 o'clock for left side observers (see figure 7). The main requirement was that the primary observer be given time to call out all caribou seen before the secondary observer called them out;

***2 -*** The secondary observer called out whether he/she saw the caribou that the first observer saw and observations of any additional caribou groups. The secondary observer waited to call out caribou until the group observed passed half way between observers (between 3 and 6 o'clock for right side observers and 6 and 9 o'clock for left side observer);

***3 -*** The observers discussed any differences in group counts to ensure that they had called out the same groups or different groups and to ensure accurate counts of larger groups;

***4 -*** The data recorder, one in the right seat beside the pilot and the other on the rearmost seat on the left side of the aircraft, categorized and recorded counts of each caribou group into "primary only", "secondary only", and "both";

***5 -*** The observers switched places approximately half way through each survey day (i.e. at lunch or within a stratum) as part of the survey methods to address observer fatigue. Each of the two pair combinations for half of the transects within a stratum) to monitor observer ability. The recorder noted the names of the primary and secondary observer for all observations.

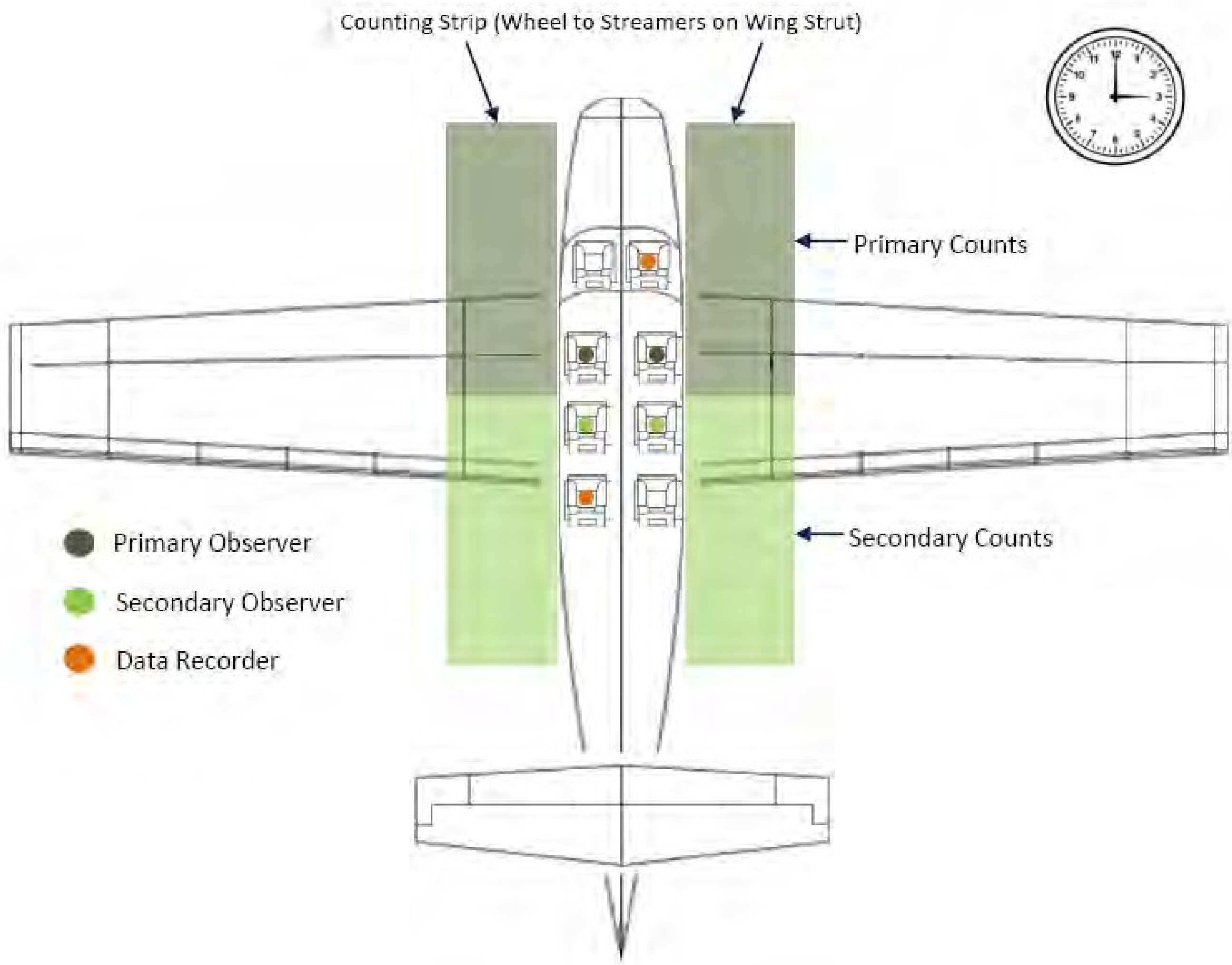



**Figure 7** Observer position for the double observer method employed on this survey. The secondary observer calls caribou not seen by the primary observer after the caribou have passed the main field of vision of the primary observer. The small hand on a clock is used to reference relative locations of caribou groups (e.g. "Caribou group at 3 o'clock" would suggest a caribou group 90$^{o}$ to the right of the aircrafts longitudinal axis.).

The sample unit for the survey was "*groups of caribou*" not individual caribou. Recorders and observers were instructed to consider individuals to be those caribou that were observed independent of other individual caribou and/or groups of caribou. If sightings of individuals were within close proximity to other individuals then the caribou were considered a group.

The Huggins closed mark-recapture model (Huggins 1991) was used to estimate and model sighting probabilities. In this context, double observer sampling can be considered a 2-sample mark-recapture trial in which some caribou are seen ("marked") by the ("session 1") primary observer of which some are also seen by the second observer ("session 2"). The second observer may also see caribou that the first observer did not see. This process is analogous to mark-recapture except that caribou are sighted and resighted rather than marked and recaptured. A group of caribou rather than the individual caribou was the sample unit given that the sighting probabilities of caribou within a group were not independent. In the context of dependent observer methods, the sighting probability of the second observer was not independent of the primary observer. To accommodate this, removal models were used which estimated $p$ (the initial probability of sighting by the primary and secondary observer) and $c$ (the probability of sighting by the second observer given that it had been already sighted by the primary observer). Note that resighting probability ($c$) is not equivalent to the initial sighting probability of a caribou ($p$). Also, the removal model assumed that the initial sighting probability of the primary and secondary observers was equal. Models were built and compared in program MARK (White and Burnham 1999). The effect of covariates on sightability such as group size, observer order, snow cover, cloud cover, terrain ruggedness, and observation frequency were assessed.

### *3.3 Composition Surveys - Calving*

Composition surveys were conducted concurrently with visual surveys following the abundance completion within targeted strata. During surveys, caribou were classified as yearlings (1+ year olds), bulls, cows with calves (< one month old), cows with udders, udderless cows with antlers, and udderless cows without antlers. We also recorded whether antlered cows had either 1 or 2 antlers. Breeding cows were tallied as cows with calves, cows with udders, and udderless cows with antlers. Non-breeders were tallied as udderless cows with no antlers, yearlings and bulls. The proportion of breeders was then determined using these two categorizations. Bootstrap methods were used to obtain variance estimates. In this case, 1000 resamplings of the data were used and the mean and standard deviation from resampling were used as point estimates of proportion of breeders and the associated standard error (Manly, 1997).

Composition survey effort was allocated consistently within each stratum. Selection of flight paths were based on fuel cache locations and caribou aggregations but consistently used the reconnaissance transect station locations to maintain consistent coverage throughout the strata being sampled. GPS waypoints were recorded for all groups of caribou where they were first sighted.

June composition surveys were timed to begin concurrently with visual surveys to ensure minimal movement. Sampling was structured to begin at a fuel cache then proceeded to a predetermined transect station within a maximum of two (2) kilometers of the strata corner/boundary. From this station the aircraft would proceed to the next nearest transect station to the north and/or south priority sampling the next nearest caribou group (including individuals) encountered in a zigzag pattern using the proximity of transect stations to equally distribute composition effort (Figure 8). At times, observed groups of caribou “pulled” the aircrew from the pre-planned flight path. When sampling caused deviation from the preplanned flight path the aircrew would stop sampling caribou groups that were seen greater than 5 kilometers perpendicular to the original flight path.

From this point, only caribou groups observed within this five-kilometer buffer would be sampled and an attempt to rejoin the original flight path made. During re-positioning flights from the stratum to the fuel caches, caribou encountered within a maximum of 2 km inside of target stratum boundaries were classified opportunistically and variation of flight paths was held to within 2 km to reduce deviation from the planned flight paths and fuel caches.

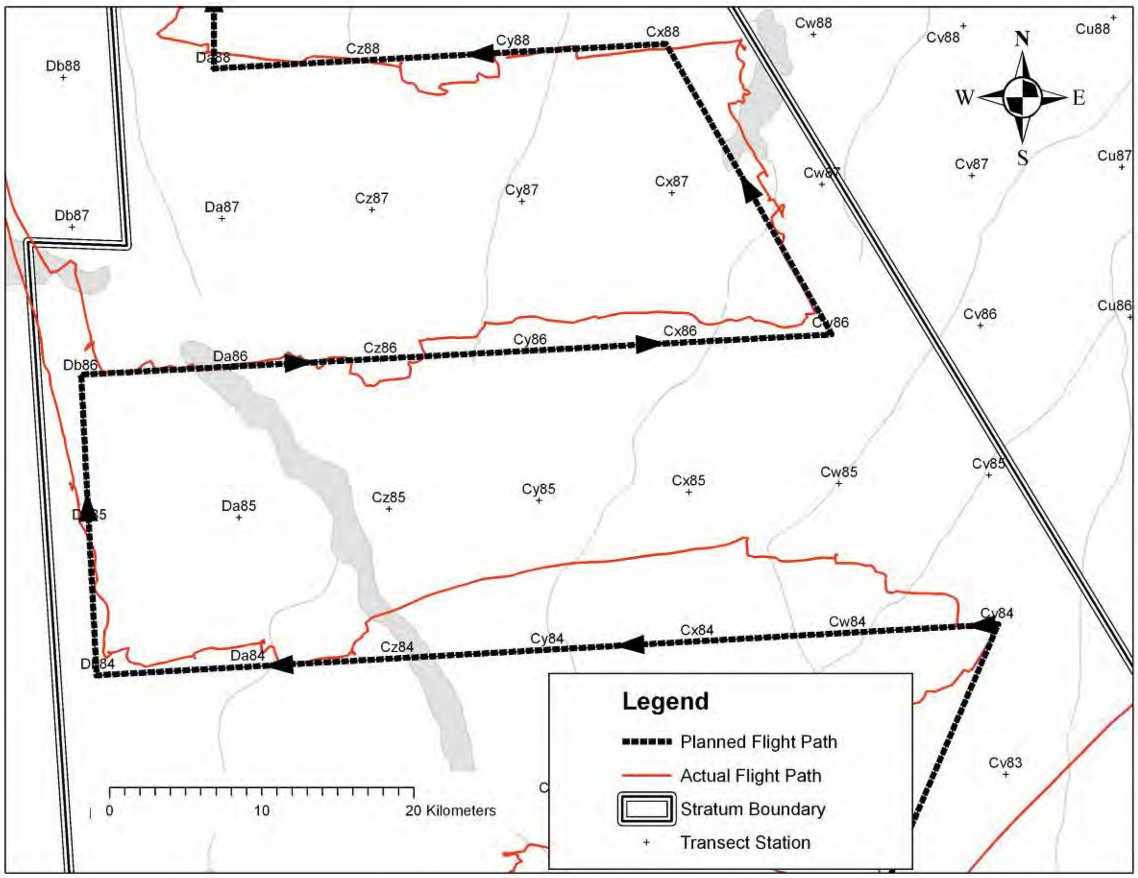



**Figure 8** Strata composition flight lines vs. planned routes. Deviations due to observed caribou groups away from flight path. The next nearest group would be classified up too a maximum of 5 km perpendicular to the planned flight path.

Estimates of the proportion of breeding females were then multiplied by the double observer estimate of all adult caribou and yearlings for each stratum to obtain an estimate of the number of breeding females. Variances were obtained for the combined estimate using the delta method (Seber, 1982; Williams et al., 2002) assuming no correlation between the two estimates.

### *3.4 Composition Surveys - Fall*

The NWT Government conducted composition surveys in the fall of 2011, to determine bull-cow ratios on this range and for the respective subpopulation. A bull-cow ratio is needed for extrapolated subpopulation population estimates from the calving ground survey by dividing the estimate of the total number of breeding females on the calving ground by the sex ratio of the population. Over time and across population cycles, adult sex ratios can change with a bias to either sex. Because bulls and cows are spatially segregated at certain times of the year, the survey is conducted during the rut when caribou are in mixed-sex groups.

A 3-person crew conducted the composition surveys: front seat observer, rear seat data recorder, and pilot. Caribou were classified from the helicopter as cows, prime bulls, young bulls or calves (less than 1 year old) and yearlings (greater than 1 but less than 2 years old). A female was classified based on the presence of a dark vulva patch and calves were identified based on their small body size and rounded skull profile. Bulls were classified as either prime bull or young bulls based on large body size and height of antlers. Classifications were recorded with tally counters and recorded into a notebook as an observation point. Each observation point was accompanied by a GPS waypoint. Cochran's (1977) Jackknife technique was used to calculate age and sex ratios and their associated variances. This estimate was reported but extrapolated population estimates were not conducted pending further refinement of populations and pregnancy rates needed for the extrapolation procedure.

Sampling areas were determined using the location of collared cows during the survey as well as the geographic areas used by collared Beverly cows during the rut season since 2006 (Nagy et al., 2011). In 2011, prior to the composition survey, a fixed-wing reconnaissance survey was conducted to determine the relative density and distribution of caribou in the study area. Collars were radio-tracked to determine the relative numbers of caribou associated with each collar. This information was used to finalize the sampling design so that information from a representative portion of the subpopulation could be obtained.

The bull-cow ratio as derived in this report was simply the count of bulls divided by the count of cows whereas the proportion of adult cows was the number of cows divided by the number of adult cows and adult bulls. As with the calving ground composition survey data, a bootstrap procedure was used for point estimates, standard error, and percentile-based confidence limits. For this,1000 bootstrap resamplings were conducted on the original data set (Manly, 1997).

### *3.5 Aerial Wildlife Survey-Observation Collector (AWS-OC)*

To increase data entry speed, accuracy/precision, and reduce the time required to perform preliminary analysis of reconnaissance data for abundance stratification, a digital data entry system, termed the "Aerial Wildlife Survey – Observation Collector" (AWS-OC) was developed specifically for this survey. The AWS-OC software operates with Windows 7 professional and was developed specifically for use in double-observer aerial caribou surveys to facilitate the collection of field data and the subsequent management of the resultant observation dataset. This tablet-based system allows for the instantaneous entering of caribou group waypoints (observations) directly into a digital database. Data entry time was cut by approximately 50% over standard hand written datasheets, with the added benefits of continuous back up onto a USB drive into a digital database with no additional data entry required. The application includes two modules:

***1***-The ***AWS-OC Field Collection Module*** utilized ESRI ArcGIS version 9.3.1 and is designed for collecting observation data while airborne. The application is spatially enabled to connect with a Global Positioning System (GPS) and displays the current location on maps in ESRI's ArcGIS software. Limited GIS experience is required to operate the system;

***2***- The ***AWS-OC Data Manager Module*** is designed for use on the ground or in the office for data management and field planning tasks. Advanced user functionality is focused on tabular data accessible with MS Access database software and ESRI ArcGIS version 9.3.1.

The AWS-OC is designed for use on a touch screen tablet PC. Version 2.0 has been developed and tested on a Dell Latitude XT2. For added durability and stability in severe turbulence, the tablets have been equipped with solid-state hard drives. The Latitude XT2 tablets have a standard keyboard allowing it to function as a traditional notebook computer or the screen can be rotated to convert the unit to a touch screen, tablet computer. Additional components making up a complete AWS-OC field kit included an AC adapter and power cord for the tablet PC, a spare battery, a Garmin GPSMap 78s Global Positioning System (GPS), a USB to serial adapter cable, a 4-pin data cable and RS-232 Serial (9-pin) to USB converter serial cable to connect the GPS to the tablet, and a tablet mounting board to protect the security of cable attachments (Figure 9). Both the AWS-OC settings and GPSMap 78s settings were configured to NMEA in/out, the correct time zone, to metric units, and set to the WGS 84 datum.

To ensure uninterrupted power for two AWS-OC tablets over a 12-hour period, two 12-volt marine batteries and a Motomaster Eliminator 400 watt digital power converter was set up within each aircraft. All running time capabilities were tested in advance of the systems field deployment. All depleted batteries were charged using a standard 12-volt battery charger at the end of each survey day.

The data entry page of the *AWS Transect Settings* form allowed the entry of common details that were recorded for all observations (Figure 10). The transect numbers were auto-completed when the GPS was connected and online.

**Figure 9** Hardware components of the Aerial Wildlife Survey - Observation Collector (AWS-OC) software and illustration of the Garmin GPSmap 78s cable setup.

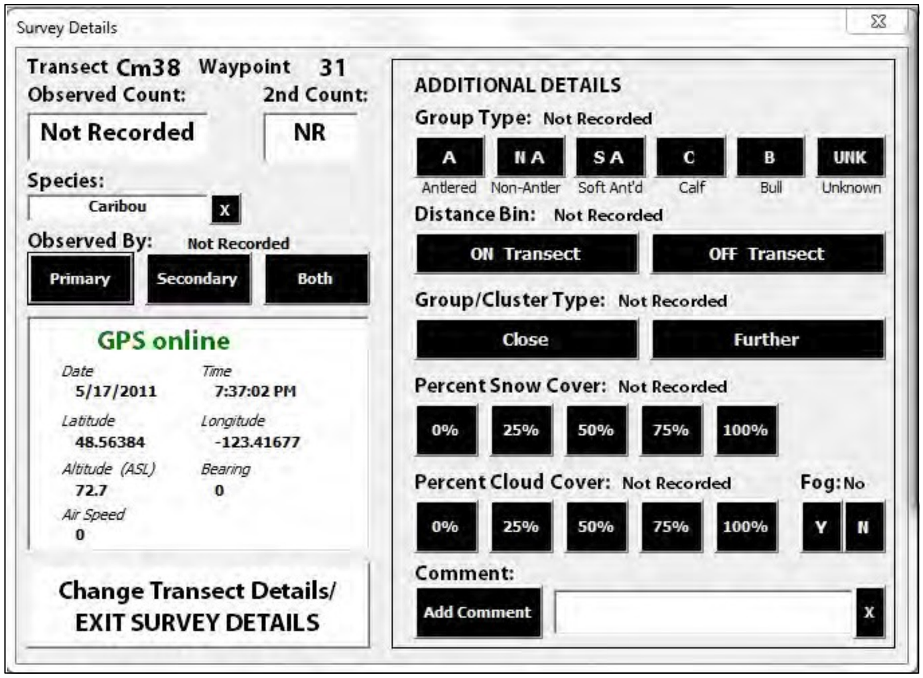




**Figure 10** The data entry screens of the AWS-OC tablet interface including the dropdown number pad for numerical entries under “additional details”.

### *3.6 Collar Reconnaissance*

To identify collared caribou associations with breeding females on the Beverly annual concentrated calving area, a flight to collared Beverly caribou locations was conducted prior to the reconnaissance survey (Figure 11). The establishment of these breeding female aggregations and their representation by deployed collars is important to assessing timing and annual proportions of females reaching the calving grounds (Heard, 1985; Russell et al. 2002). Extensive reconnaissance surveys combined with movement rates and movements of radio-collared cows provided useful information to determine the spatial distribution of breeding females relative to peak of calving in any one year.

There were 24 active Telonics GPS Generation IV GPS collars attached to adult female caribou over the 2011 spring migration and calving periods for both the Ahiak and Beverly subpopulations (Figure 11). All collars were deployed between 2006 and 2011, while the deployment seasons varied from early winter, late winter spring and post-calving. Of the 24 active collars, 11 were deployed to the north and west of Baker Lake (10 in November 2009 and 1 in April 2011). All collars deployed in this region were termed the Ahiak subpopulation. Ten of the 11 collars deployed on these caribou ended up within the Ahiak annual concentrated calving area in June 2011. The remaining 13 of the 24 active collars were deployed on or near the Beverly winter range. Of the 13 active Beverly collars, 1 was deployed in March 2006, 3 deployed in July 2007, 7 deployed in April 2008, and 2 deployed incidentally in April of 2009 during a Bathurst caribou herd deployment.

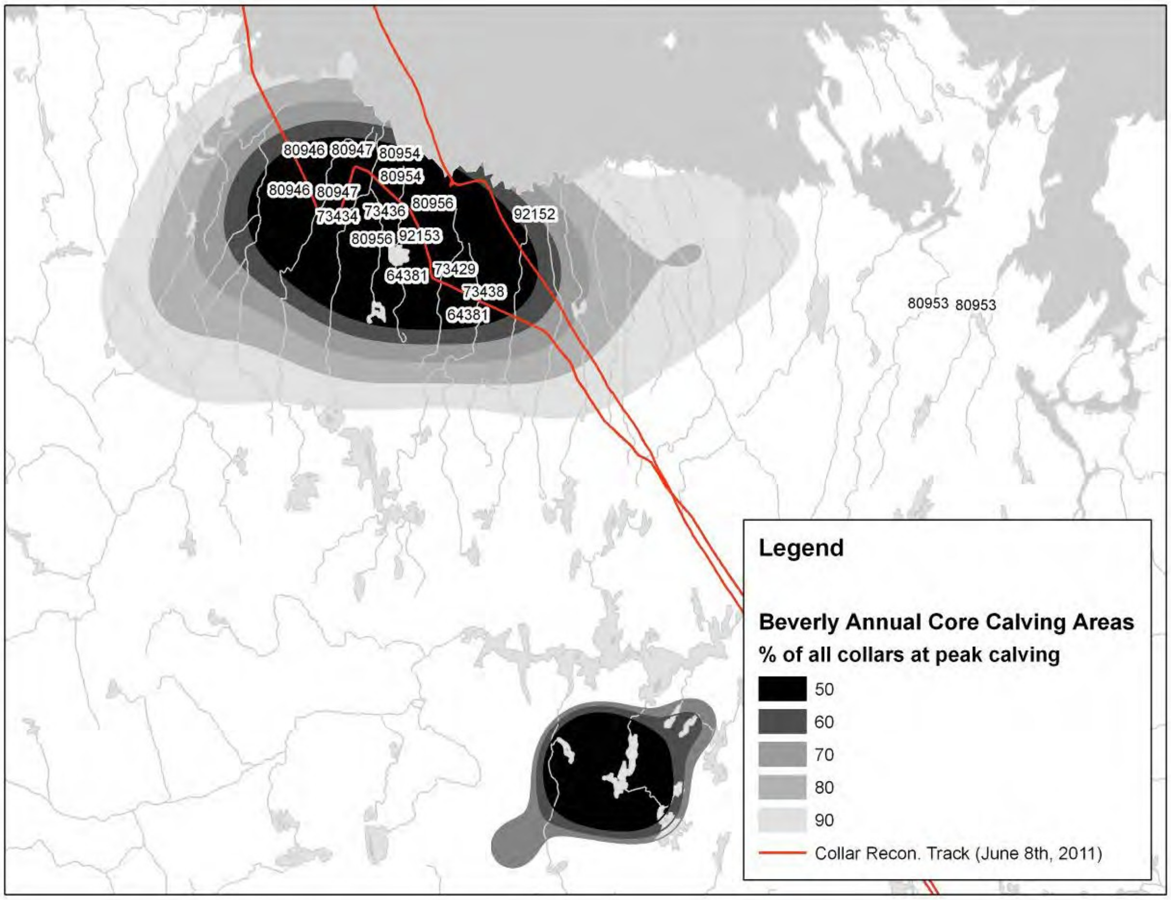



**Figure 11** The reconnaissance of collared cow aggregations on the Beverly subpopulation annual concentrated calving area on June 8th, 2011. Reconnaissance flown using 2 Cessna 208 Grand Caravan fixed wing aircraft.

# 4.0 RESULTS

The June 2011 Beverly (BEV) and Ahiak (EK) annual concentrated calving area surveys began with a Beverly collar reconnaissance survey on June 8$^{th}$, followed by the Beverly reconnaissance survey of both the northern and southern annual concentrated calving areas from June 9$^{th}$ to 12$^{th}$. The reconnaissance phase was followed by an abundance survey of only the northern annual concentrated calving area flown from June 13$^{th}$ to 17$^{th}$ and composition surveys in all strata from June 15$^{th}$ to 18$^{th}$, 2011 (Table 1). Within the EK subpopulation, an adaptive reconnaissance / abundance survey was initiated on June 18$^{th}$ and completed on June 21$^{st}$, 2011. In addition, a reconnaissance survey of the Simpson Peninsula was carried out June 21$^{st}$, for the purposes of delineating the eastern extents of the Northeast Mainland (NEM) subpopulation and western extents of the EK subpopulation. Composition surveys were flown from June 19$^{th}$ to 23$^{rd}$ within 7 of the 12 surveyed strata based on observed densities. No composition surveys were conducted within the NEM strata.

**Table 1** Survey Initiation and completion dates for the June 2011 Beverly and EK Calving Ground visual abundance Surveys including NEM reconnaissance survey stratum.

| Survey Activity | Month and Day (2011) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jun-08 | Jun-09 | Jun-10 | Jun-11 | Jun-12 | Jun-13 | Jun-14 | Jun-15 | Jun-16 | Jun-17 | Jun-18 | Jun-19 | Jun-20 | Jun-21 | Jun-22 | Jun-23 |
| Collar Reconnaissance | X | | | | | | Ice Fog & Freezing Rain | | | | | | | | | |
| Systematic Reconnaissance | | X | X | X | X | | | | | | | | | | | |
| Beverly Abundance | | | | | | X | | X | X | X | | | | | | |
| Beverly Composition | | | | | | | | X | X | X | X | | | | | |
| EK Abundance | | | | | | | | | | | X | X | X | X | | |
| NEM Reconnaissance | | | | | | | | | | | | | | X | | |
| EK Composition | | | | | | | | | | | | X | X | X | X | X |

## 4.1 Pre-Survey Collar Assessment

Using position data collected from adult cows affixed with Telonics Inc. Generation 3 and 4 GPS collars, we estimated peak calving for the June 2011 Beverly and Ahiak subpopulation surveys to be between June 13 and June 15 for Beverly and between June 12 and 14 for EK (Figure 12, Figure 13). Also of interest were the mean annual movement rates for May, which were calculated to be 18 km/day for the Beverly subpopulation and 12 km/day for the EK subpopulation.

By June 1, 2011, all but two of the 13 active collars on Beverly cows were within the northern annual concentrated calving area while no Beverly collars were located in or near the southern annual concentrated calving area (Figure 12). At no time during the June 2011 calving period were collared cows observed on the southern concentrated calving area. By peak of calving, all Beverly collars were within the northern annual concentrated calving area extents.

By June 1, all but two collared cows were within the EK annual concentrated calving area of which one was within the northern Beverly concentrated calving area. By peak calving all but one EK collared cow was in the EK annual concentrated calving extents, while that one collar was within the eastern extents of Beverly annual concentrated calving area. Over all, little movement within or outside of the calving areas was observed during the survey period (Figure 14 & 15).

Beverly cows displayed the least amount of movement between June 8$^{th}$ and 20$^{th}$, remaining within the annual concentrated calving area, seemingly held between river systems draining into the Queen Maud Gulf. Ahiak caribou displayed greater movement during this same period although remained within identified calving extents. The greatest amount of movement occurred within the northeastern extents of the EK annual concentrated calving areas where higher altitudes and frozen rivers likely provided for greater mobility across the landscape. Within the Beverly annual concentrated calving area, elevations were close to sea level and all of the rivers fast flowing, likely reducing the mobility of cow calf pairs eastward and westward (Figure 16).

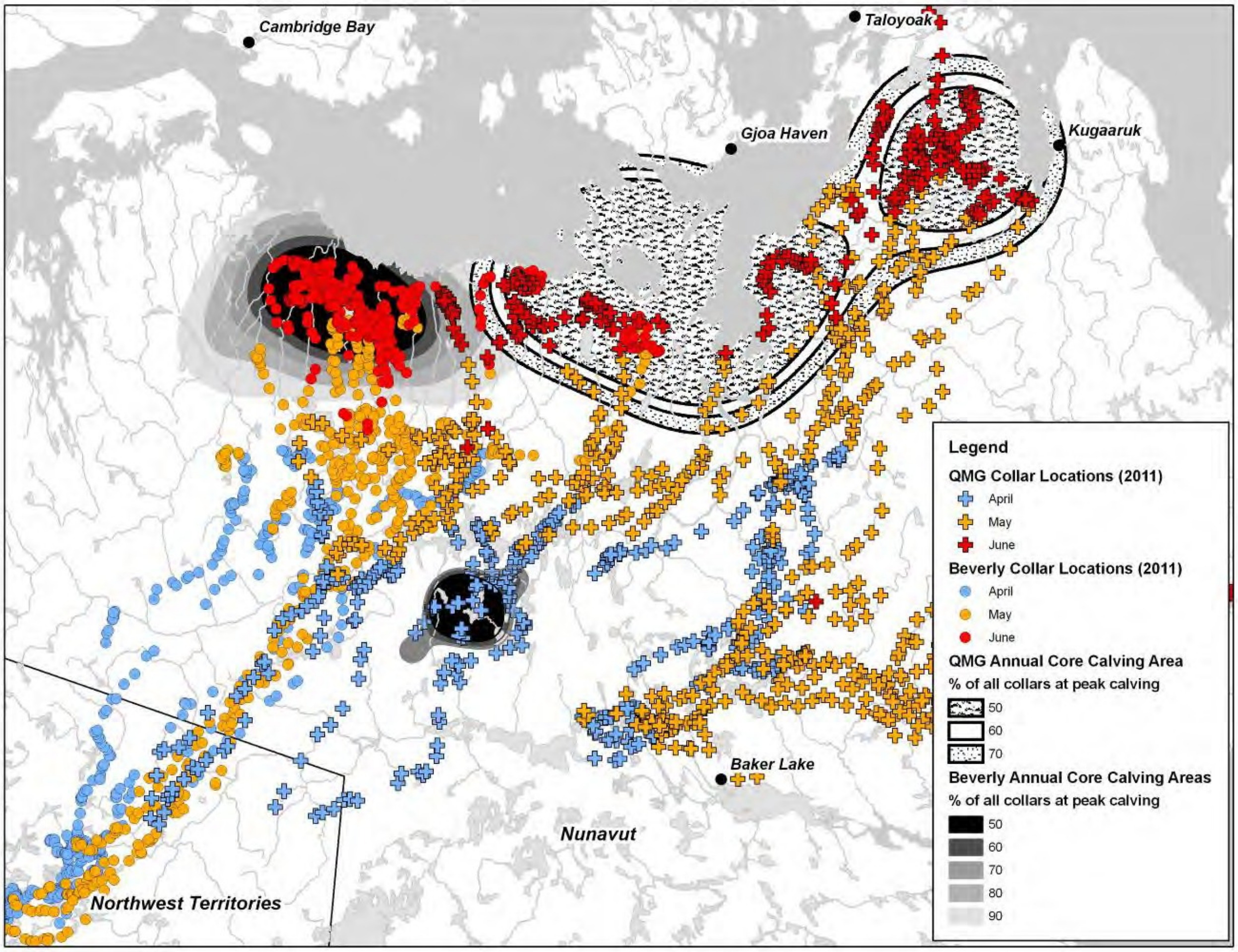
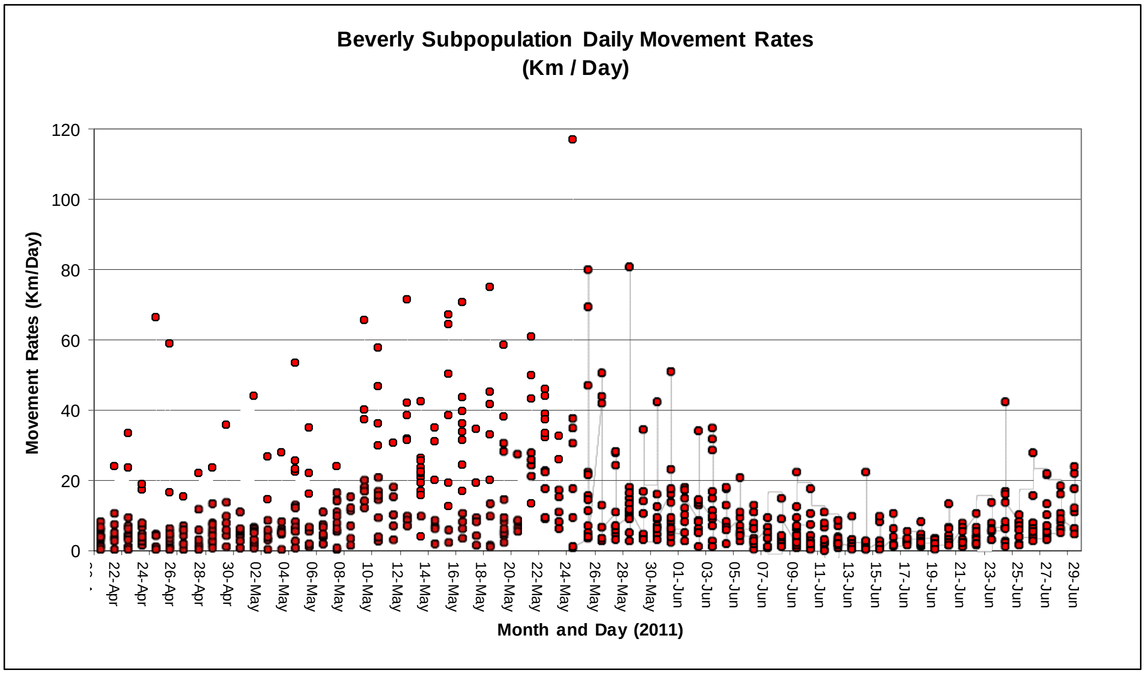



**Figure 12** Monthly movements of collared Beverly and Ahiak (EK) caribou up to and including June 2011. Note that only 3 of 24 collars active during this period were not within the annual concentrated calving areas of both subpopulations by June 1st. Annual concentrated calving area extents based on a kernel analysis of cumulative collar locations at peak calving (Nagy and Campbell, 2012).



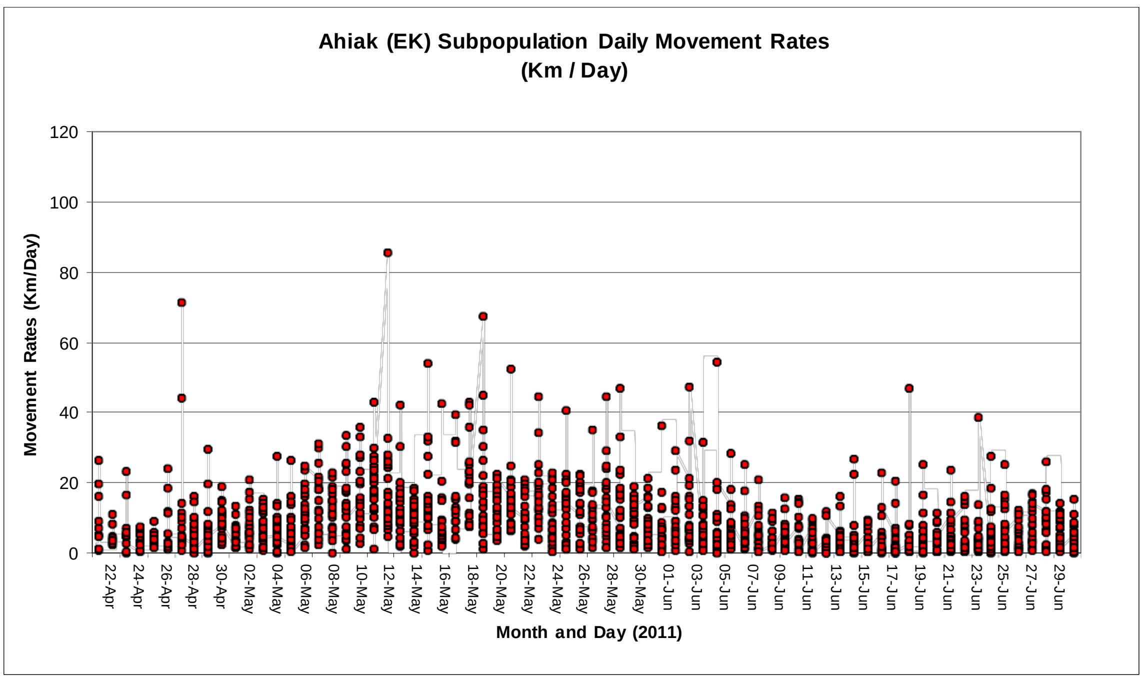




**Figure 13** Mean daily movement rates in kilometers per day for the Beverly and Ahiak (EK) barren-ground caribou subpopulations for April, May and June 2011. Note the higher migratory movement rates in April and May for the Beverly subpopulation. All movement rates based on Telonics GPS 3 and 4 daily collar position data.

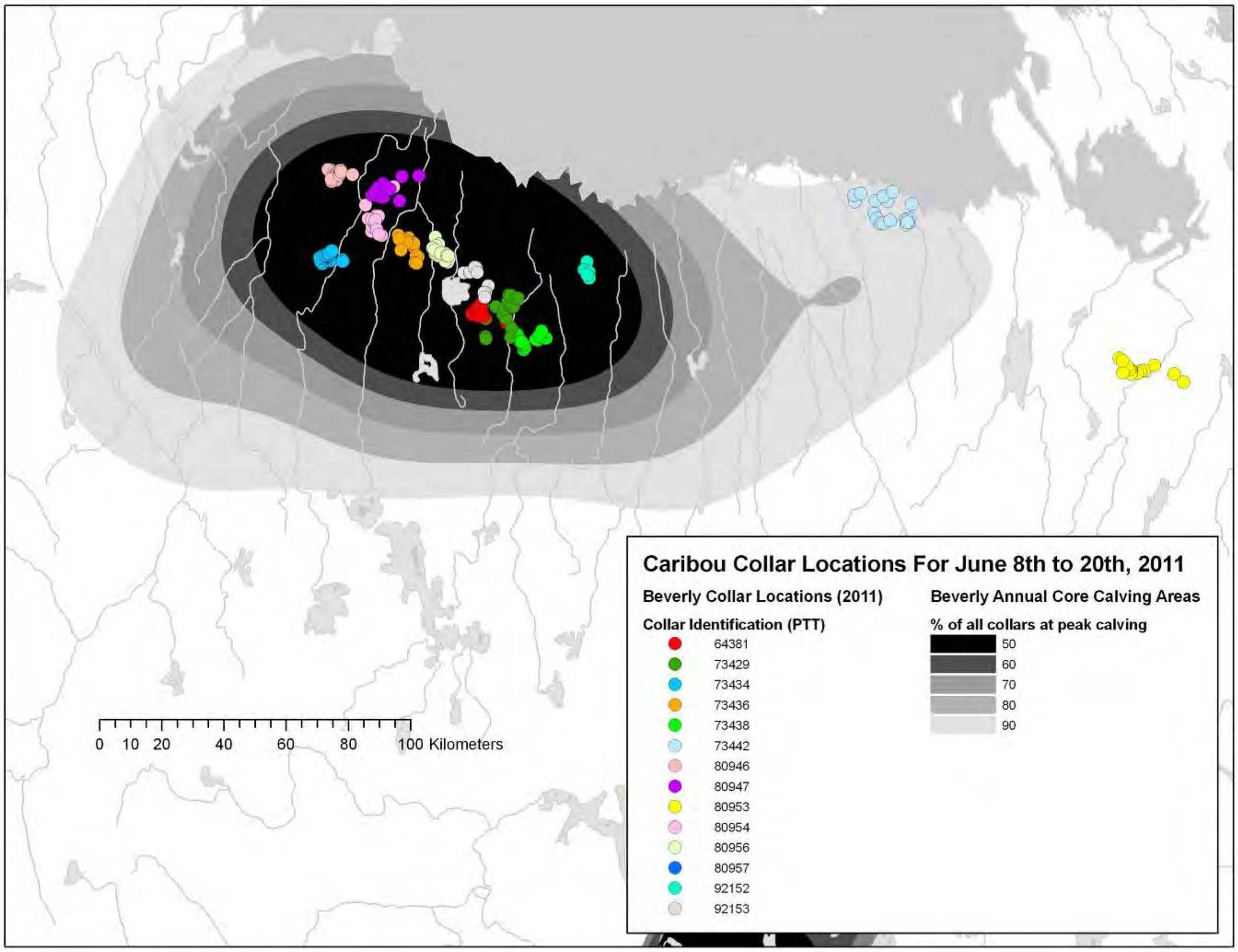



**Figure 14** Collared Beverly cow movements between June 8th and 20th, 2011.

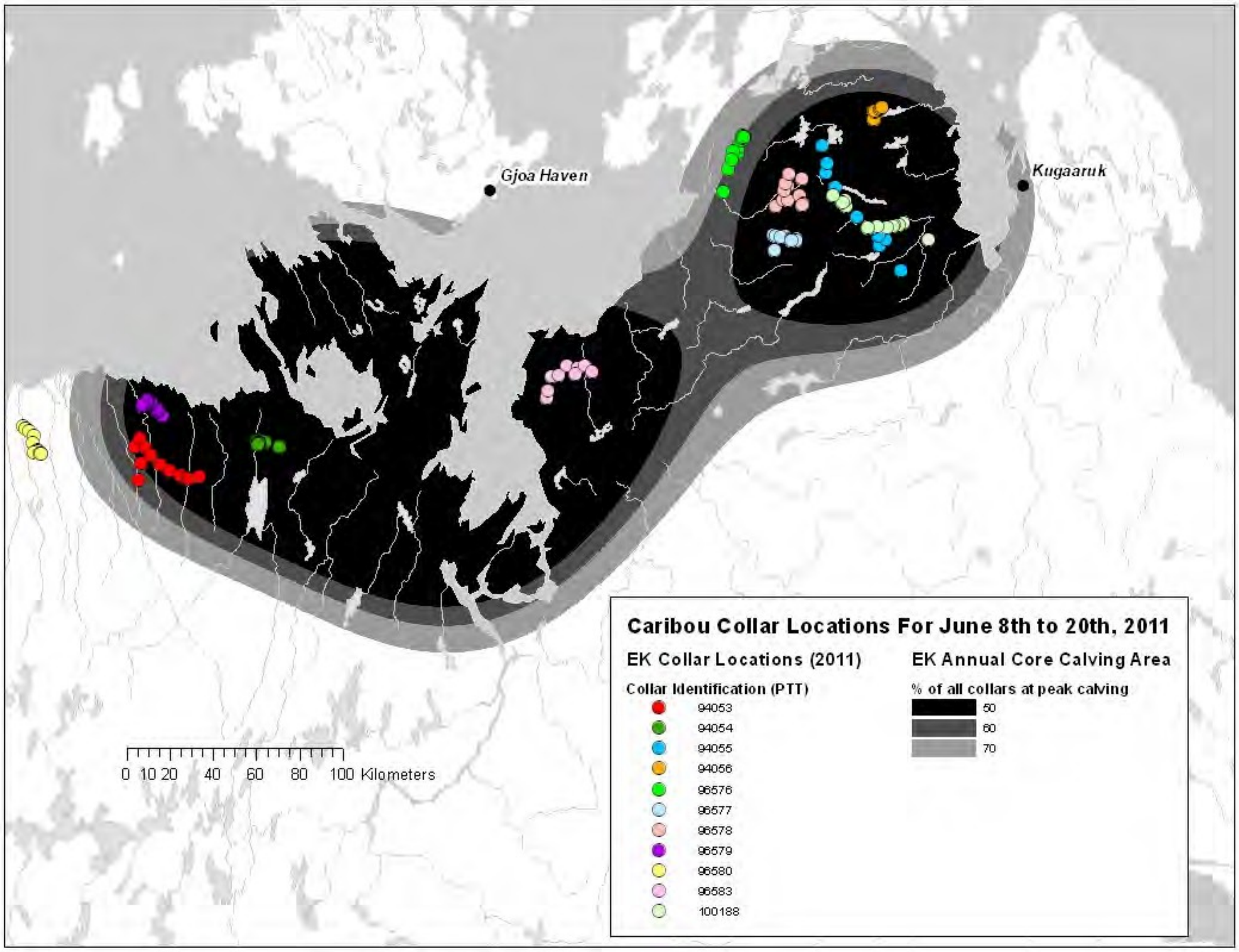



**Figure 15** Collared Ahiak (EK) cow movements between June 8th and 20th, 2011.

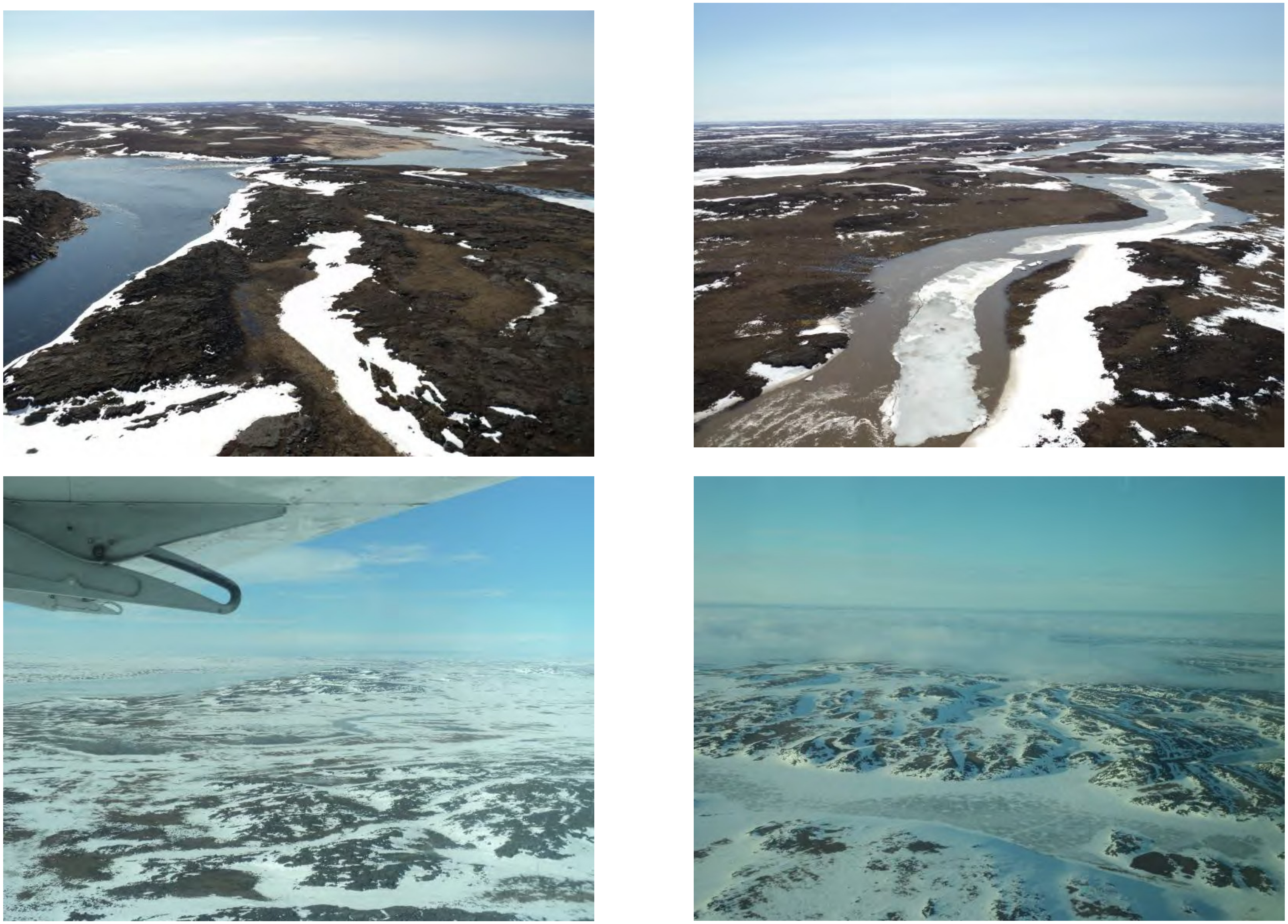


**Figure 16** Timing of spring thaw based on elevation. Upper photo pair of the low elevation Beverly calving area June 12th / 2011. Bottom photo pair of the higher elevation of the Ahiak (EK) calving area, northeastern extents, June 16th / 2011.

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## 4.2 Reconnaissance Surveys

### 4.2.1 Beverly Subpopulation

The collar reconnaissance was flown on June 8, 2011 for the Beverly subpopulation only. The collar reconnaissance indicated that peak calving was quickly approaching and that the Beverly subpopulation reconnaissance could start immediately. The Beverly caribou subpopulation systematic reconnaissance survey was initiated on June 9 and completed by June 12, 2011 surveying an area of 80,113 $km^2$ covering both the northern and southern annual concentrated calving extents (Figure 17). Reconnaissance surveys of the Beverly's southern annual concentrated calving area in the vicinity of Beverly/Garry Lakes, revealed densities of breeding females too low to survey further. A full write up on the findings from this reconnaissance will be provided in the more comprehensive file report meant to replace this report. The systematic reconnaissance survey delineated a distinct area within the known annual concentrated calving area composed mainly of breeding females. The systematic reconnaissance covered all aggregations of breeding females west of Chantrey Inlet including the Adelaide Peninsula. In an effort to ensure aggregations of breeding females were not missed, the survey continued with the last reconnaissance transects being flown June 12$^{th}$, 2011. A total of 6,946 adult and yearling caribou were observed on transect between June 9$^{th}$ and 12$^{th}$ of which an estimated 2,907 (42 %) were breeding females (Figure 18). Using breeding female distributions determined during the reconnaissance, we then stratified the Beverly annual concentrated calving area, including one strata east of the concentrated calving extents, into Low, Medium A, B, and C, and High breeding female density strata (Figure 19).

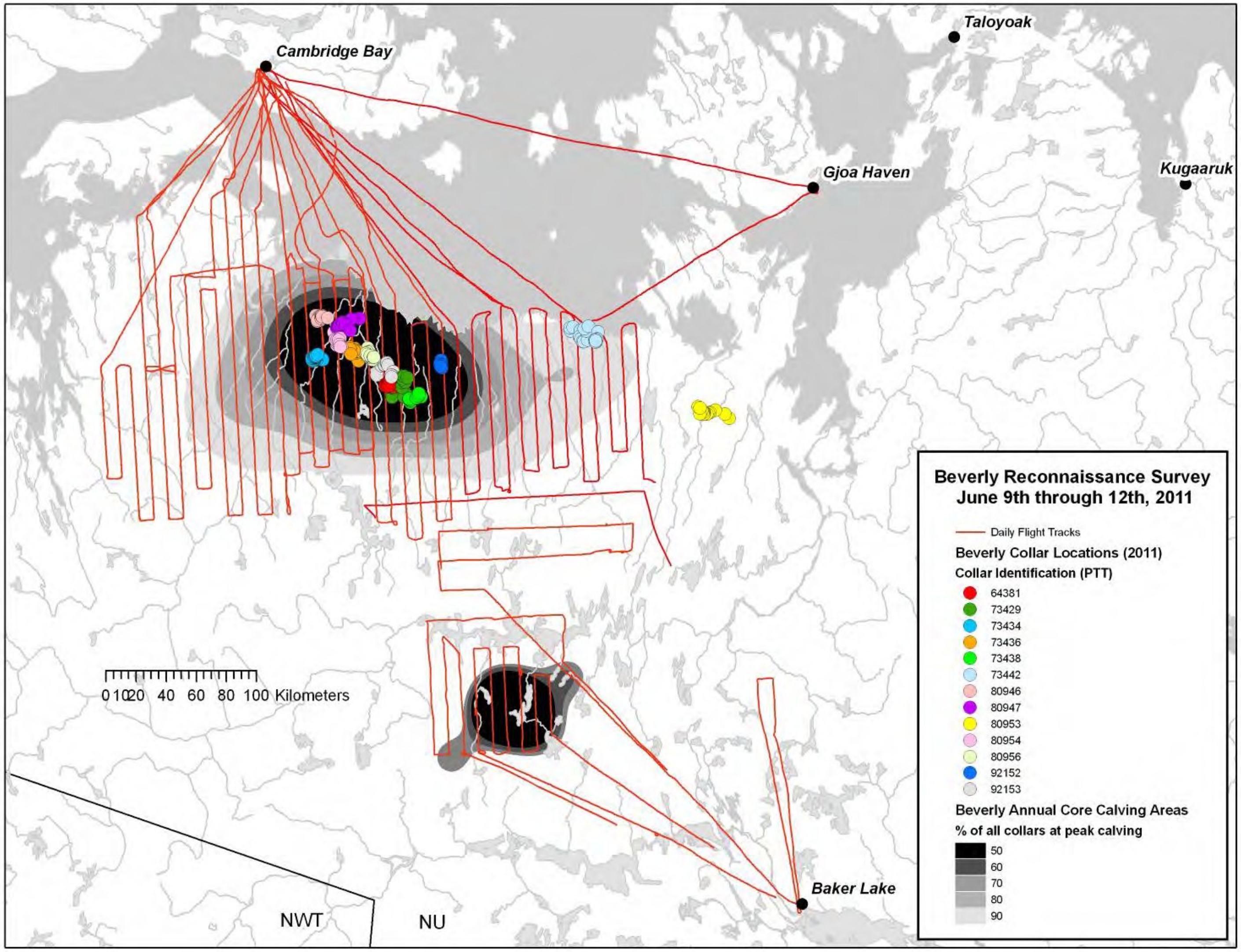


**Figure 17** The Beverly subpopulation reconnaissance survey flight tracks June 9th through 12th, 2011. Included are collared Beverly cow locations (Platform Transmitter Terminals) for the period between June 8th and 20th, 2011.

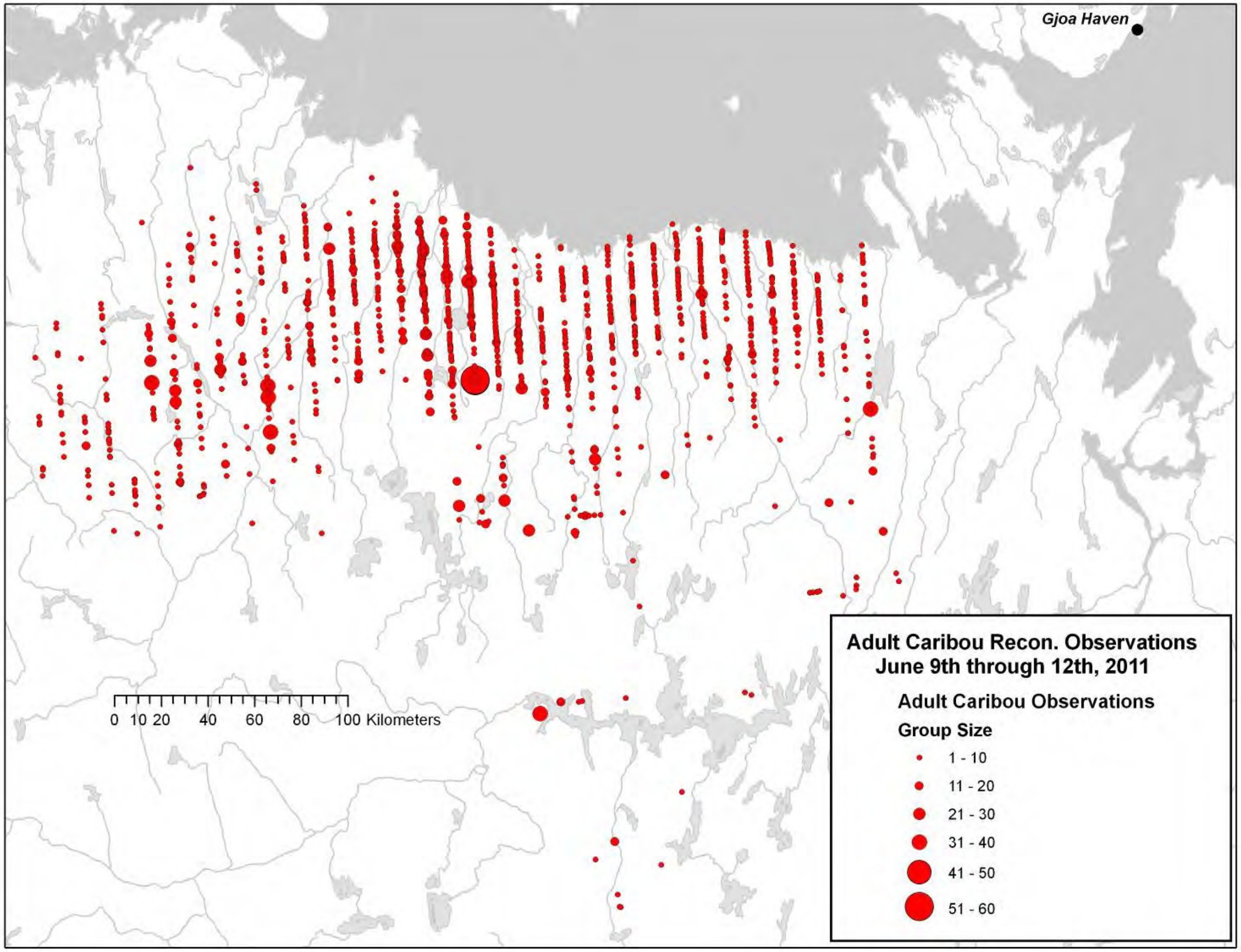


**Figure 18** Observations from the 2011 June 9th to 12th Beverly caribou subpopulation reconnaissance survey. Groups displayed include both breeding and non-breeding animals.

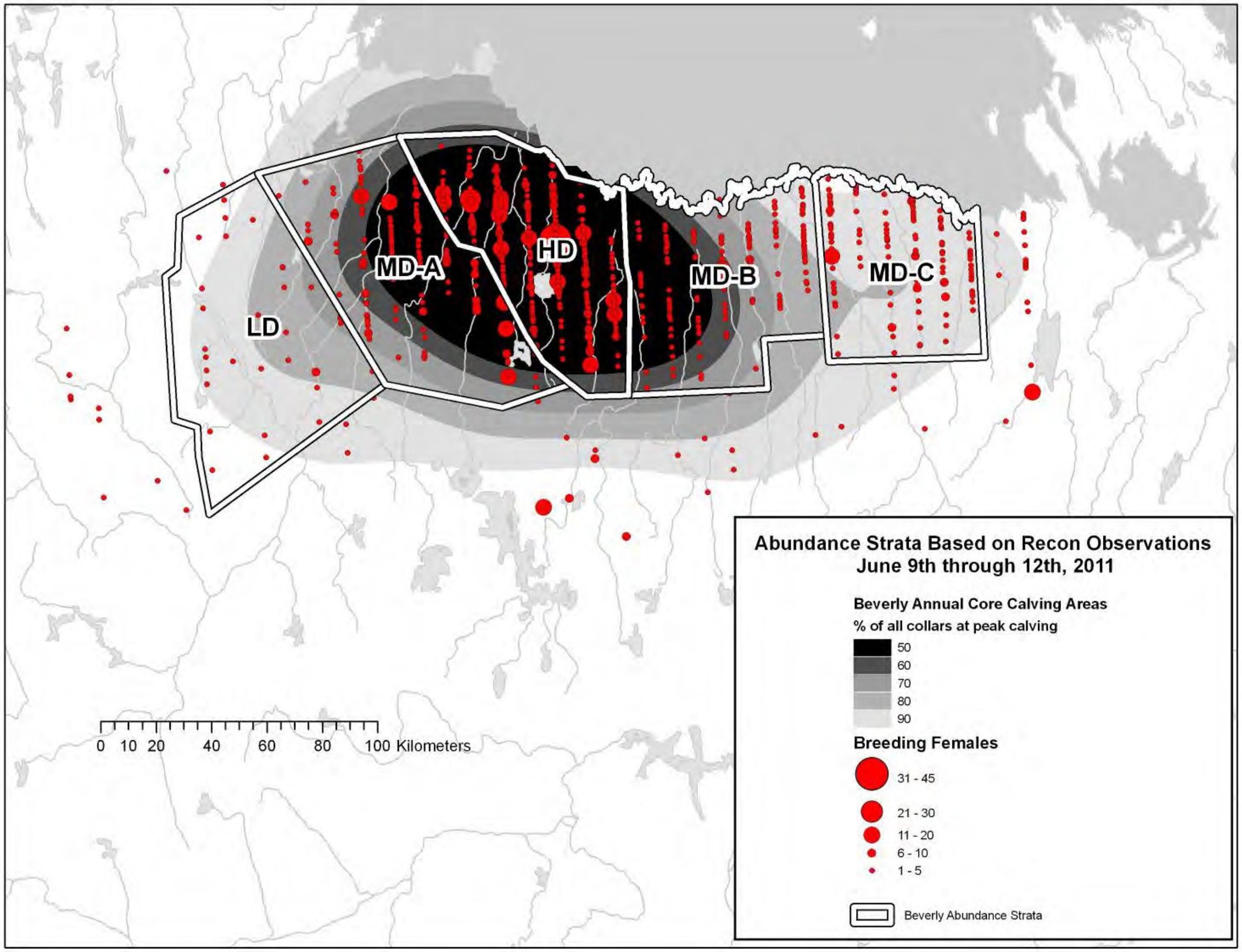


**Figure 19** June 9th through 12th reconnaissance observations of breeding females and abundance strata placement for the Beverly subpopulation of barren-ground caribou, June 2011.

### 4.2.2 Ahiak Subpopulation

Due to time constraints related to the advancing calving season, a full systematic aerial reconnaissance survey was not undertaken within the Ahiak (EK) annual concentrated calving area. Instead, we used information on distribution from a previous reconnaissance survey conducted in 2010 (Figure 20 and 21), and the distribution of collared caribou (Figure 15) to pre-stratify visual surveys based upon likely gradients in caribou density in the Adelaide Peninsula and Northeast Mainland. For this approach, we determined the amount of coverage that was possible for the area given the likely number of survey days available for each of the three survey aircraft. From this, we assigned strata with coverage varying from base reconnaissance levels (8%) to higher levels for areas with higher densities of caribou (20%). To delineate the eastern extents of the EK abundance survey we flew a reconnaissance survey over the Simpson Peninsula east of the known extents of the EK annual concentrated calving area. Based on the findings of Nagy et al (2011) and Nagy and Campbell (2012), the Simpson Peninsula area represents the northwestern extents of the Wager Bay tundra wintering subpopulation of Barren-ground caribou, though no spatial information exists for caribou occupying the northern extents of the Simpson Peninsula.

Observed distributions changed little from the 2010 results. Collar movements monitored throughout the survey verified that caribou moved little during the abundance survey and occupied much the same areas across both years. Additional reconnaissance to the south, east and west were flown to insure large aggregations were not overlooked. Reconnaissance of the western extents of the EK core calving area utilized the overlap from the 2011 Beverly reconnaissance survey to capture the western calving extents within this area of overlap (Figure 18 & 19).

Of the 11 active EK collars, only one was calving outside the western extents (Figure 15). In total, an area of 79,768 km$^2$ was surveyed between 2010 and 2011. Reconnaissance observations used to stratify for the abundance survey represent

a synthesis of observations from June 2010 and 2011 (Figure 21). All overlapping 2010 observations were removed and the resultant distribution used to place abundance strata (Figure 22). All observations recorded for the reconnaissance survey were of adult caribou rather than breeding females as 2011 observations were made based on abundance survey criteria, whereby observers were instructed not to differentiate between antlered and non-antlered to increase observer accuracy and precision. All 2011 reconnaissance observations were used in abundance estimates.

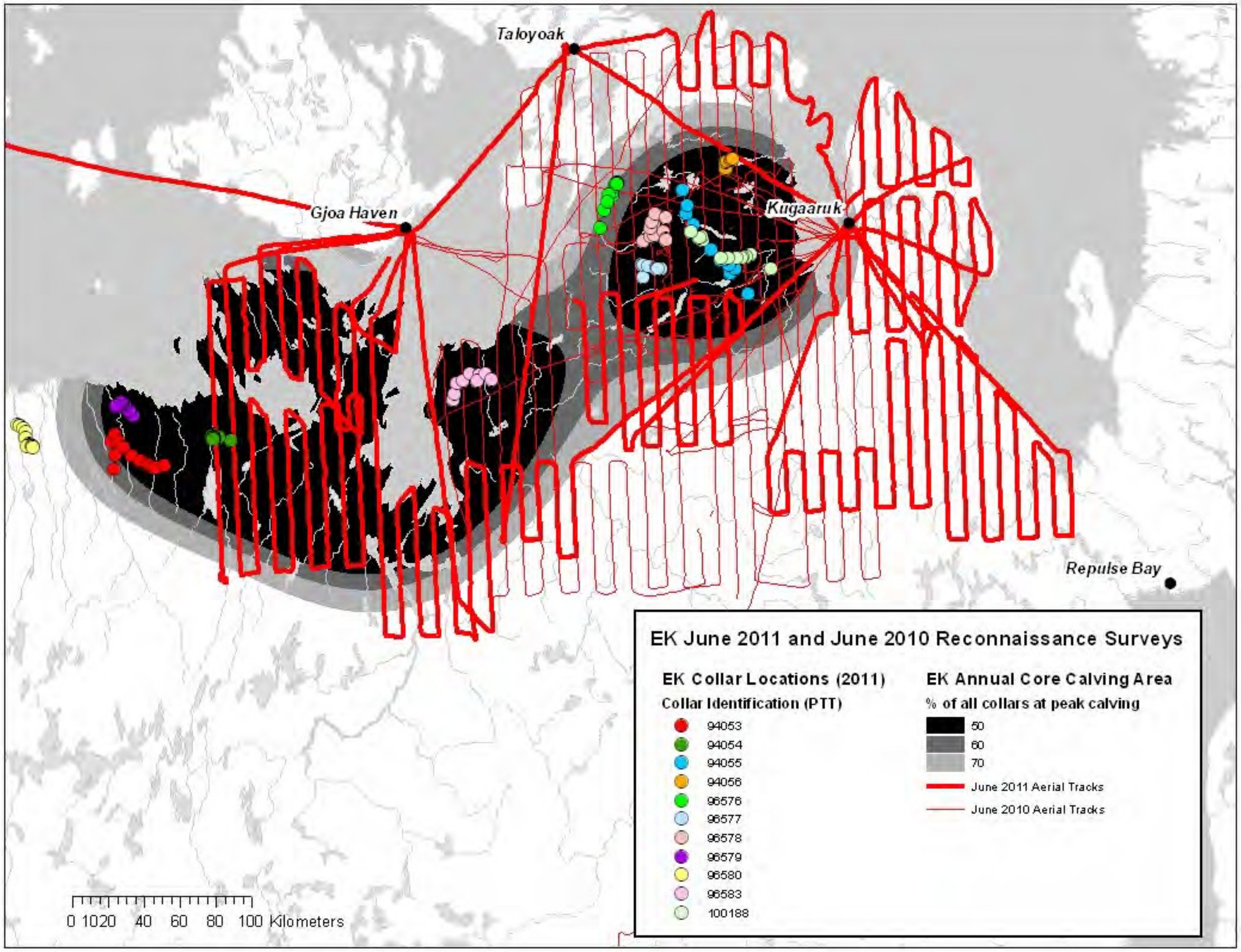


**Figure 20** A synthesis of the aerial survey track logs from the June 2010 and 2011 Ahiak (EK) reconnaissance surveys used to stratify the Ahiak survey area. Included are collared Ahiak (EK) cow locations (Platform Terminal Transmitters) for the period between June 8th and 20th, 2011. Along the eastern extents, reconnaissance transects covered the western extents of NEM caribou distribution.

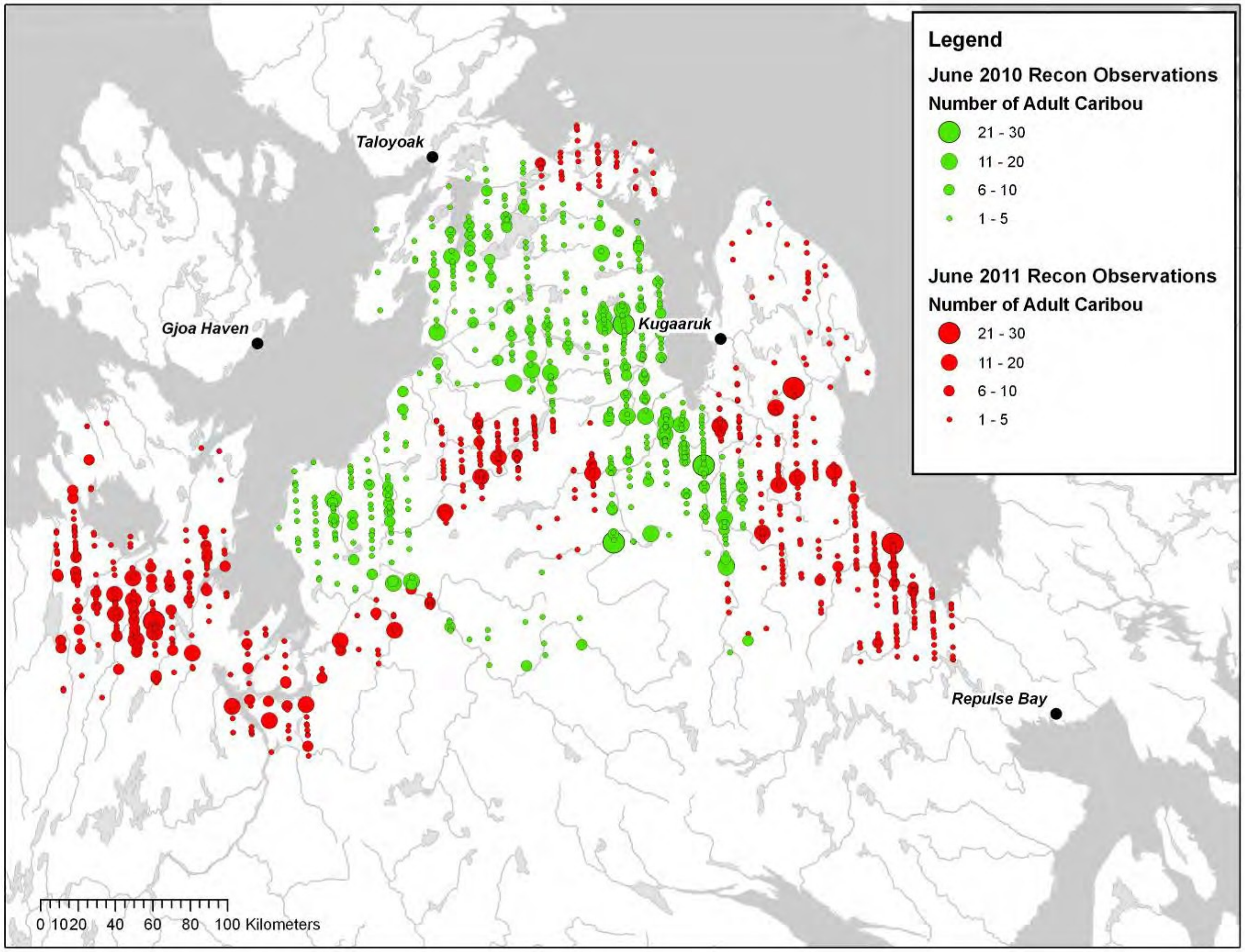


**Figure 21** Observations from the 2011 June Ahiak (EK) caribou subpopulation reconnaissance survey. Groups displayed include both breeding and non-breeding animals and represent a synthesis of observations reported in June 2010 and 2011.

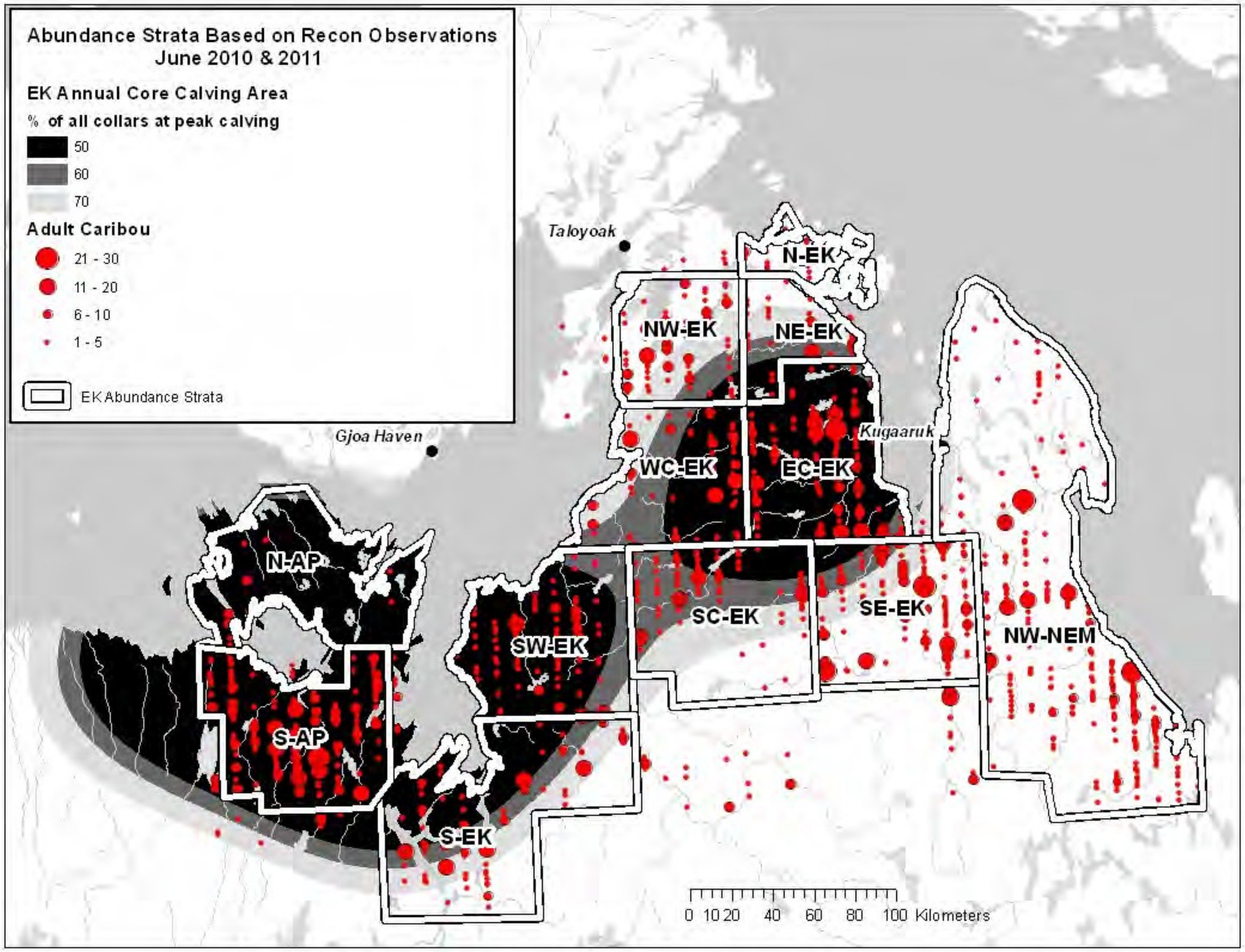


**Figure 22** June 15th through 20th 2010 & 2011 reconnaissance observations of adult breeding females and June 2011 abundance strata placement for the Ahiak subpopulation of barren-ground caribou. N-AP=North Adelaide Peninsula; S-AP=South Adelaide Peninsula; S-EK=South Ahiak; SW-EK=Southwest Ahiak; WC-EK=West Central Ahiak; NW-EK=Northwest Ahiak; N-EK=North Ahiak; NE-EK=Northeast Ahiak; EC-EK=East Central Ahiak; SC-EK=South Central Ahiak; SE-EK=Southeast Ahiak; and NW-NEM=Northwest Northeast Mainland reconnaissance stratum made up of the Wager Bay subpopulation.

### *4.3 Composition Studies*

#### *4.3.1 Beverly Subpopulation*

#### *June Composition*

We found that caribou had moved very little over the time between the reconnaissance and composition surveys. Aggregations of caribou waypointed for the abundance were in all cases consistent with those encountered during the composition across both subpopulations. Composition studies were undertaken within all of the Beverly abundance strata between June 15th and 18th, 2011 (Figure 23). A total of 1,112 groups representing 15,216 caribou of various age and sex were classified as encountered (Table 2). Mean group size across all strata was 13 and ranged from 1 to 165 caribou per group. Mean group size was the lowest within both the westernmost and easternmost strata (9 caribou) and was the highest within the HD stratum (21 caribou).

**Table 2** Beverly June 2011 composition survey sampling effort and summary observations for all abundance strata.

| Sampling Details | Stratum Sampled | | | | | Totals |
|---|---|---|---|---|---|---|
| | High | Medium A | Medium B | Medium C | Low | |
| **Mean Group Size** | 21 | 10 | 12 | 9 | 9 | **13** |
| **Total Number of Groups Classified** | 351 | 177 | 224 | 190 | 170 | **1,112** |
| **Total Number of Caribou Classified** | **7,438** | **1,806** | **2,677** | **1,792** | **1,503** | **15,216** |

From west to east across abundance strata, composition was observed to move from primarily bulls and yearlings in the western extents to predominantly cows and calves within the central or high density stratum to a mixture of breeding and non-breeding females and yearlings towards the eastern extents (Figure 24). The “High Density” (HD) stratum contained the highest numbers of breeding females

(88%) while non-breeders were only 12% across the stratum. The “Medium Density B” (MD-B) stratum located directly to the east of the High density stratum displayed the second highest proportions of breeding females (70%) while non-breeders were roughly twice that observed in the HD stratum (30%). Both the “Medium Density A” (MD-A) and “Medium Density C” (MD-C) strata displayed similar compositions of breeding females (64% and 60% respectively) and non-breeders (37% and 40% respectively) while these same strata differed mainly in the numbers of yearlings observed within each strata (6% and 18% respectively). The “Low Density” (LD) stratum making up the southwestern most extents of the Beverly annual concentrated calving area displayed the most obvious divergence from the other abundance strata displaying obvious sexual segregation more typical of migratory caribou. Within this stratum bulls made up the dominant single category (72%) with total non-breeders recorded to be 96%. Yearlings made up 16% of this stratum similar only to MD-C the most eastern of the abundance strata, where yearlings made up 18% of that stratum.

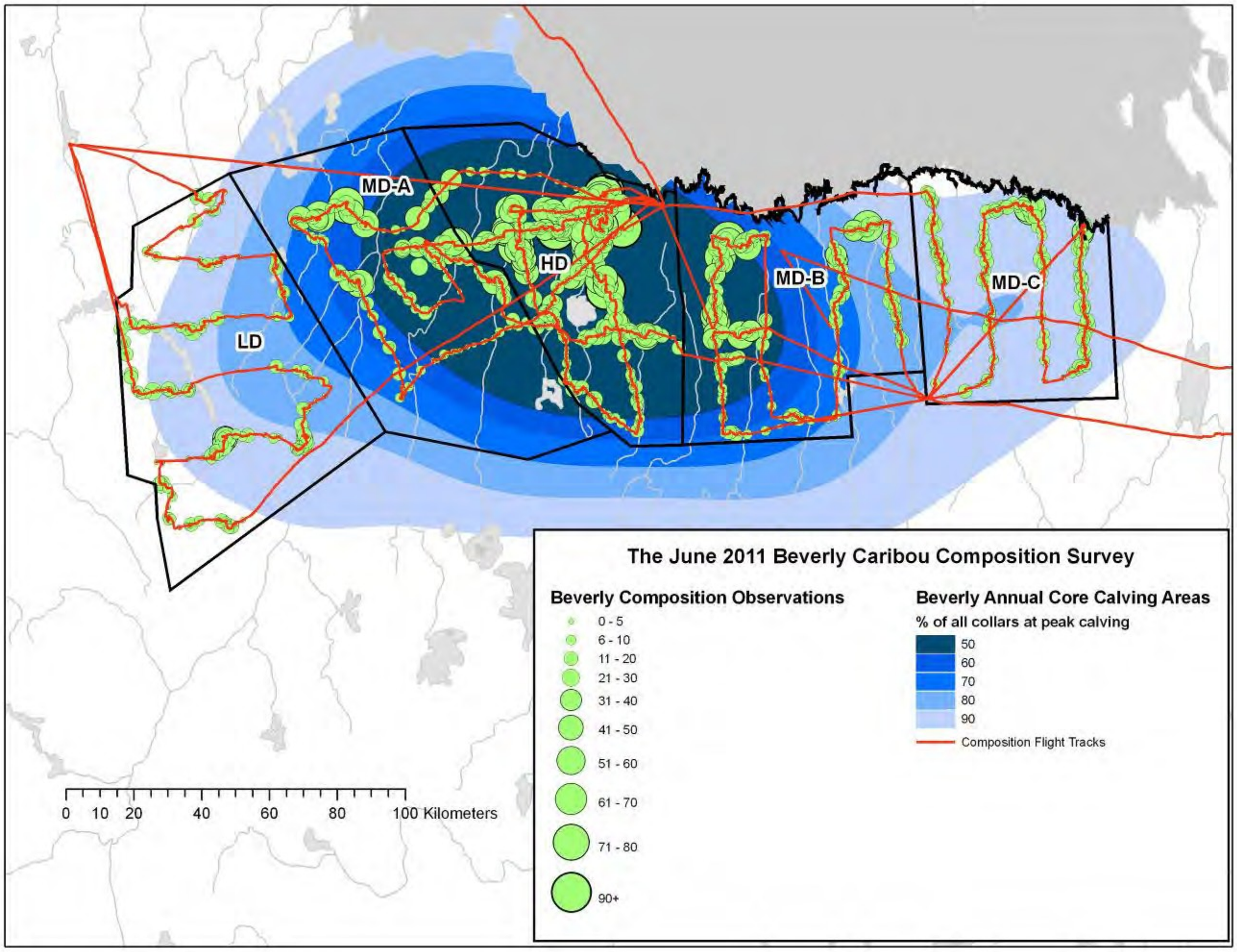


**Figure 23** The June 2011 Beverly composition survey flight tracks and observations of all ages and sexes.

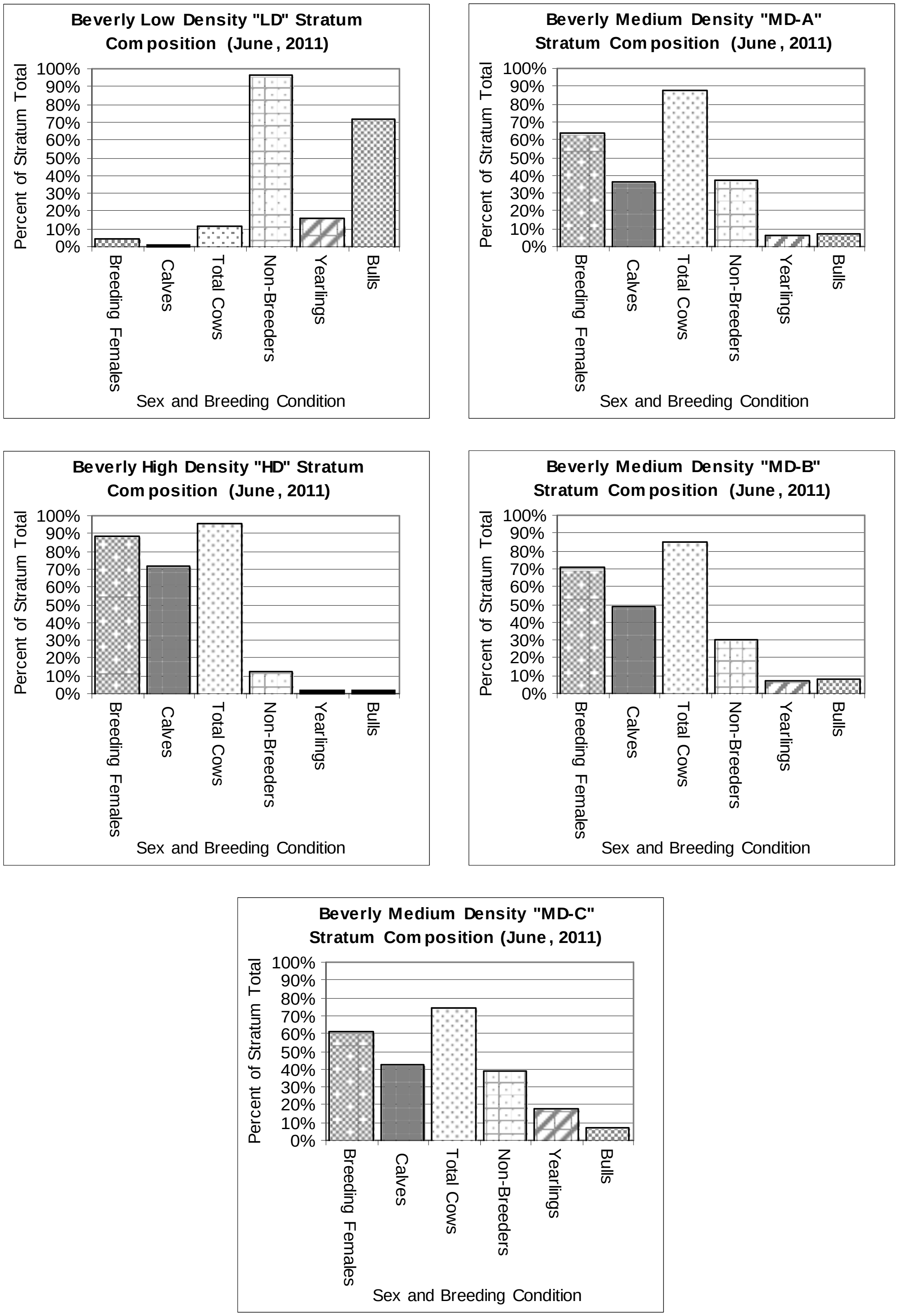


**Figure 24** Beverly abundance strata classification results, June 2011. Results displayed from westernmost strata through to easternmost strata (LD = Low Density; MD-A = Medium Density “A”;HD = High Density; MD-B = Medium density “B”; and MD-C = Medium Density “C”).

### *Fall Composition*

In October 2011, 8 Beverly collars managed by the Government of the Northwest Territories (GNWT) and 5 Ahiak collars managed by the Government of Nunavut (GN) were within the fall study area. A fixed wing reconnaissance survey was flown from 22-28 October, 2011 during which 3 collars were successfully radio-tracked. No caribou were observed in the northern portion of the reconnaissance study area. Caribou were concentrated between Mary Frances Lake and the Thelon River, and in the area around Whitefish and Lynx Lakes (Figure 25).

The composition survey followed the reconnaissance survey and was flown from the 25$^{th}$ to the 29$^{th}$ of October 2011. In total 12,421 caribou were classified in 252 groups within the southern extents of the Reconnaissance area (Table 3, Figure 26). The overall bull:cow ratio was 69 bulls to 100 cows, with group composition varying across the study area from a high of 99 to100 in the area around Zucker/Whitefish/Lynx Lakes to a low of 40 to 100 east of Thelon River. We were not able to cover the East Kitikmeot caribou distribution around Baker Lake but may have classified a small number of EK caribou in the Thelon River area.

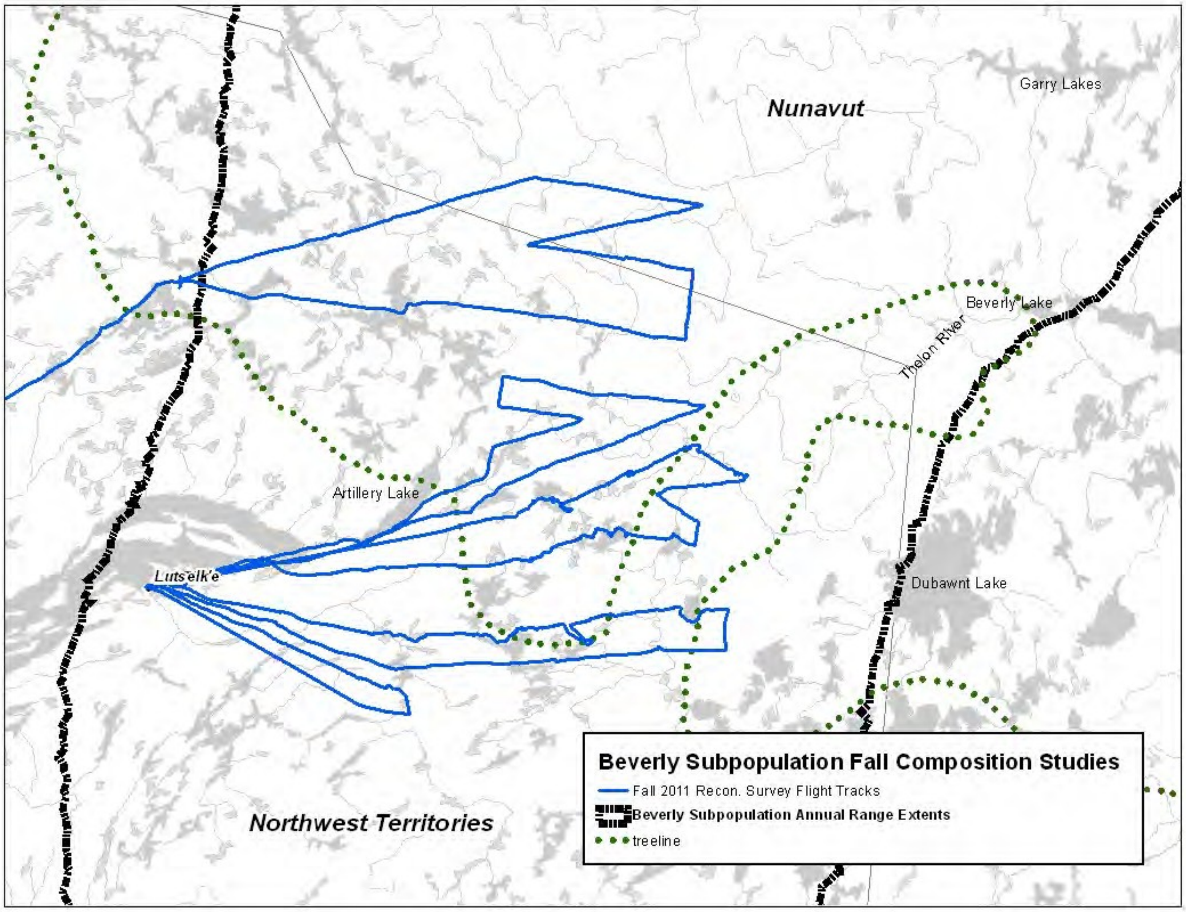


**Figure 25** Fall composition reconnaissance flight tracks flown between the 22 and 28th of October, 2011.

**Table 3** Beverly 2011 fall composition survey sampling effort and summary statistics.

| Sampling Details | Summary Statistics |
|---|---|
| **Mean Group Size** | 49 |
| **Median Group Size** | 29 |
| **Total Number of Groups Classified** | 252 |
| **Total Number of Cows Classified** | 5,570 |
| **Total Number of Calves Classified** | 3,004 |
| **Total Number of Bulls Classified** | 3,847 |
| **Total Number of Yearlings Classified** | 0 |
| **Total Number of Caribou Classified** | 12,421 |
| **Bull: Cow Ratio** | 69.0 bulls:100 cows (SE 3.6) |

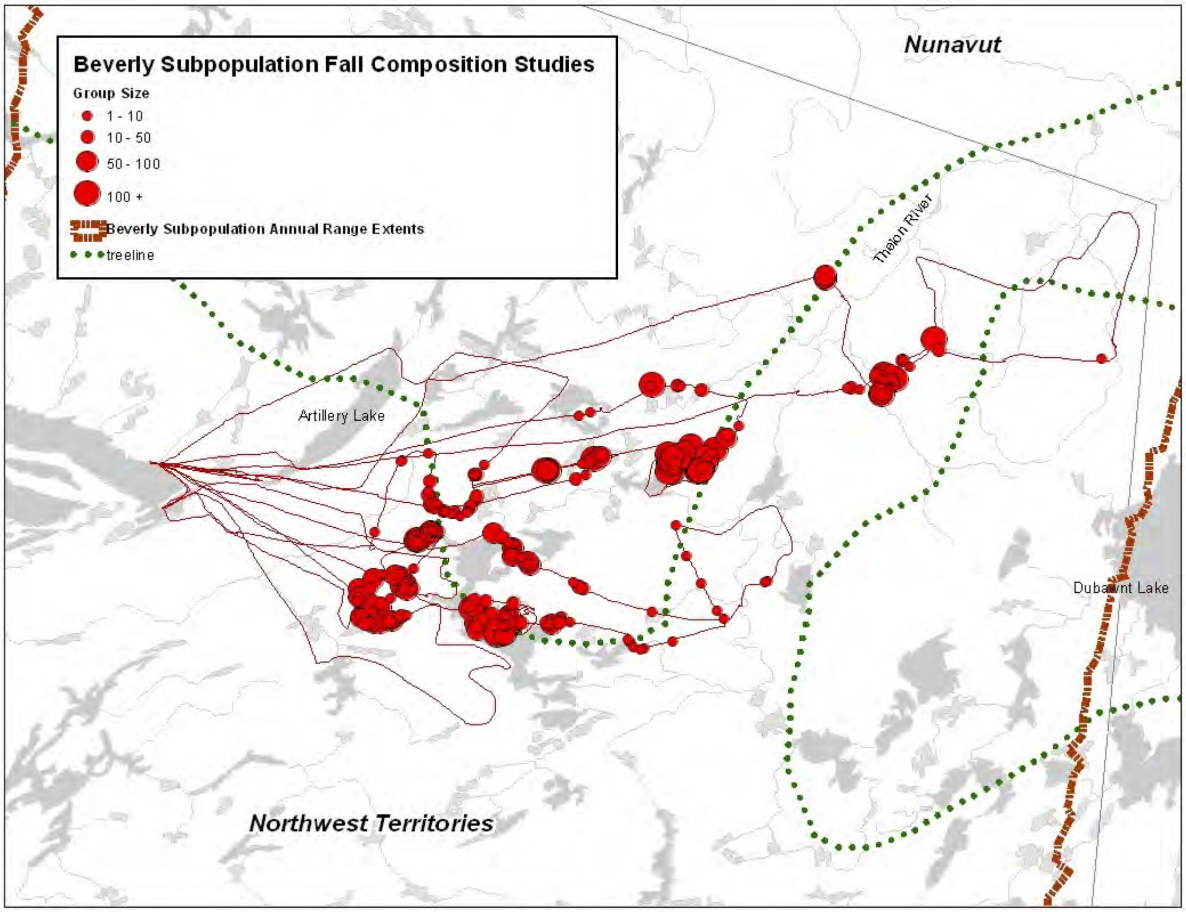


**Figure 26** October 25th through 29th 2011, composition flight tracks and observations of barren-ground caribou.

### *4.3.2 Ahiak Subpopulation*

Composition studies were undertaken within all strata with evidence of breeding female aggregations. Of the 11 strata surveyed for abundance only 7 fitted these criteria and were marked for composition studies (Figure 27). In total 1,159 groups representing 8,332 caribou were sampled across the EK survey area (Table 4).

**Table 4** Ahiak (EK) June 2011 composition survey sampling effort and summary observations for all abundance strata.

| Sampling Details | Stratum Sampled | | | | | | | Totals |
|---|---|---|---|---|---|---|---|---|
| | Adelaide South | West-Central EK | East-Central EK | South-Western EK | South-Eastern EK | North-Eastern EK | North-Western EK | |
| **Mean Group Size** | 11 | 7 | 6 | 5 | 8 | 5 | 4 | **7** |
| **Total Number of Groups Classified** | 231 | 216 | 164 | 163 | 220 | 50 | 115 | **1,159** |
| **Total Number of Caribou Classified** | **2,594** | **1,531** | **955** | **845** | **1,711** | **253** | **443** | **8,332** |

Mean group size of caribou across all strata was seven caribou per group with a range of 1 to 90 caribou per group. Mean group size was the highest within the western extents of the EK annual concentrated calving area (11 caribou/group) followed by the SE-EK (Southeast Ahiak) strata (8 caribou/group). Both mean group size and all abundance strata east of the AP-S (Adelaide Peninsula South) strata were below the lowest values observed within Beverly strata.

With the exception of the “Adelaide Peninsula South” (AP-S) strata, on the extreme western extents of the EK annual concentrated calving area, no strata indicated large concentrations of breeding females, rather all abundance strata east of the AP-S strata showed little variation amongst the age, sex and breeding condition classes (Figure 28 & 29). Note worthy was the AP-S stratum with a recorded 64% breeding females and 36% non-breeders of which 15% were yearlings and 8% bulls. Of the eastern strata, the Northeast Ahiak (NE-EK) strata held the highest proportion of breeding females though proportions of bulls and yearlings (14% and 9% respectively) were higher than observed within the high concentration breeding female strata within Beverly strata. In fact all other EK strata showed proportions of yearlings ranging from 13% to 22% within the East Central Ahiak (EC-EK) and Northwest Ahiak (NW-EK) strata respectively, and similarly bull proportions ranging widely between 14% and 35% within the NE-EK and Southeast Ahiak (SE-EK) strata respectively. All strata within the EK survey area displayed bull and yearling proportions consistently and substantially higher than those recorded for all but the LD Beverly strata suggesting a differing migratory strategy from the more segregated Beverly subpopulation. Of all the strata within the EK, the AP-S stands out as a more concentrated calving area than its more eastern counterparts adding confusion in assessing the level of mixing between the two subpopulations within this stratum.

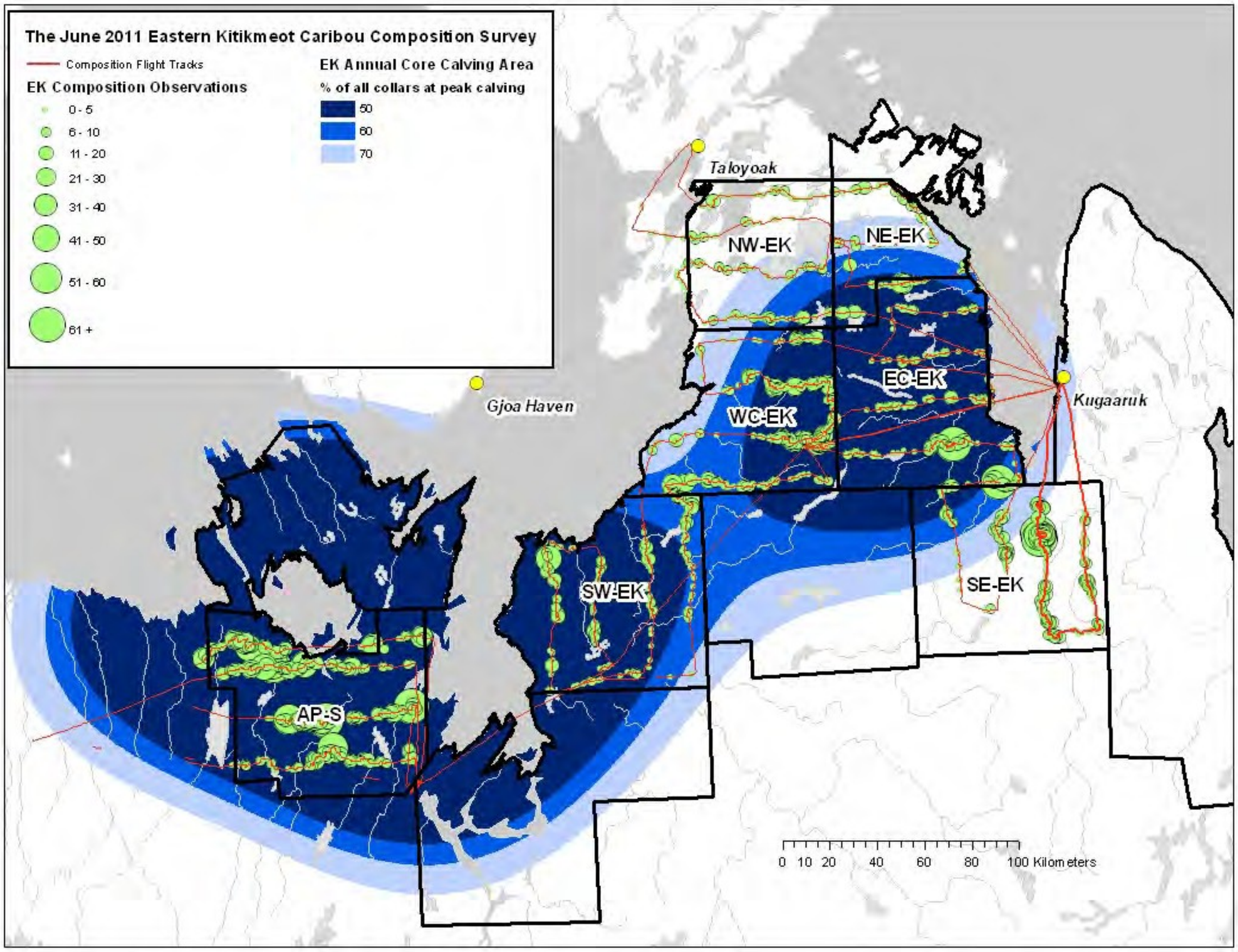


**Figure 27** June 2011 Ahiak (EK) composition survey flight tracks and caribou observations of all ages and sexes.

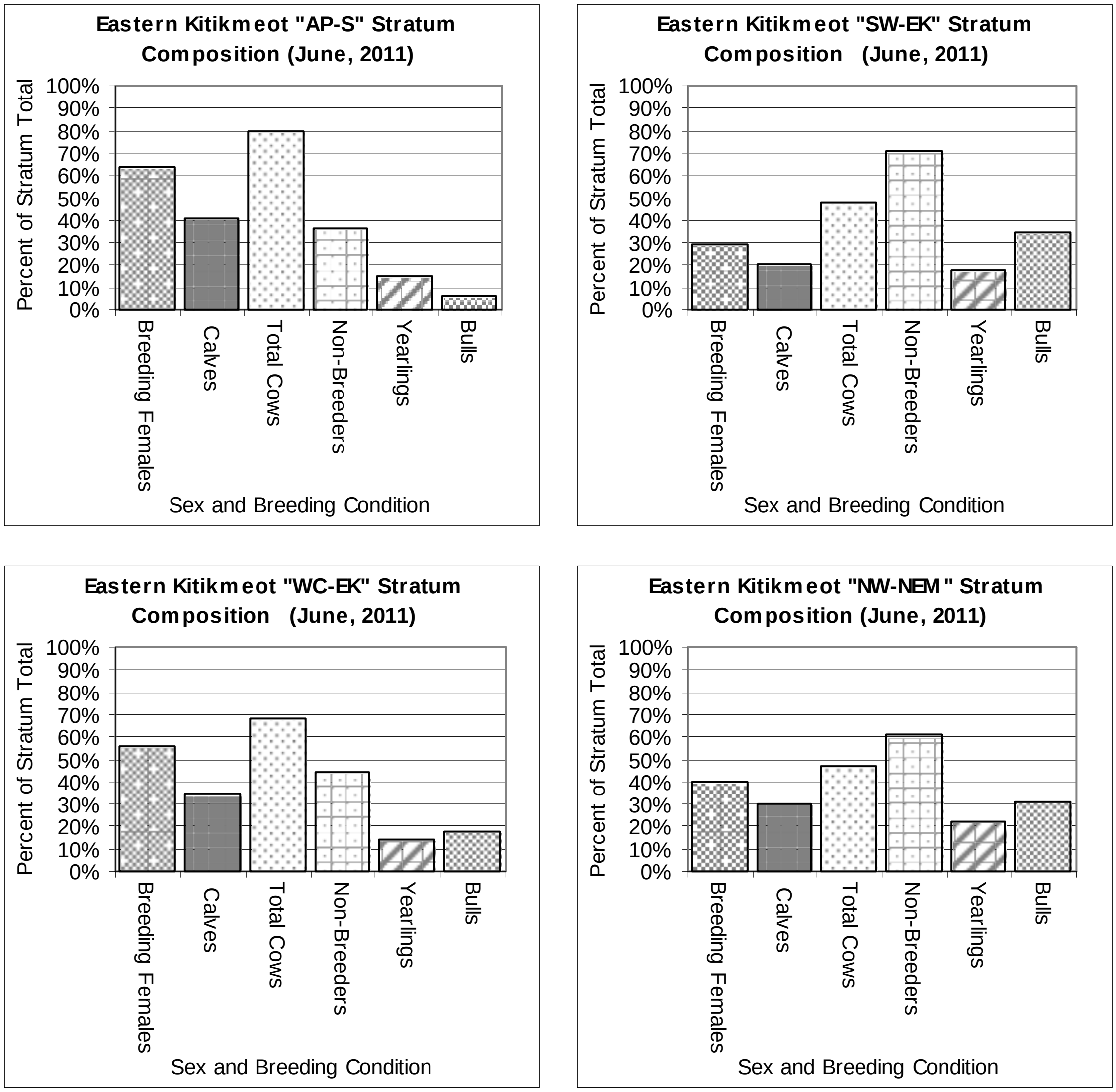


**Figure 28** Westernmost abundance strata of the Ahiak (EK) subpopulation classification results, June 2011.

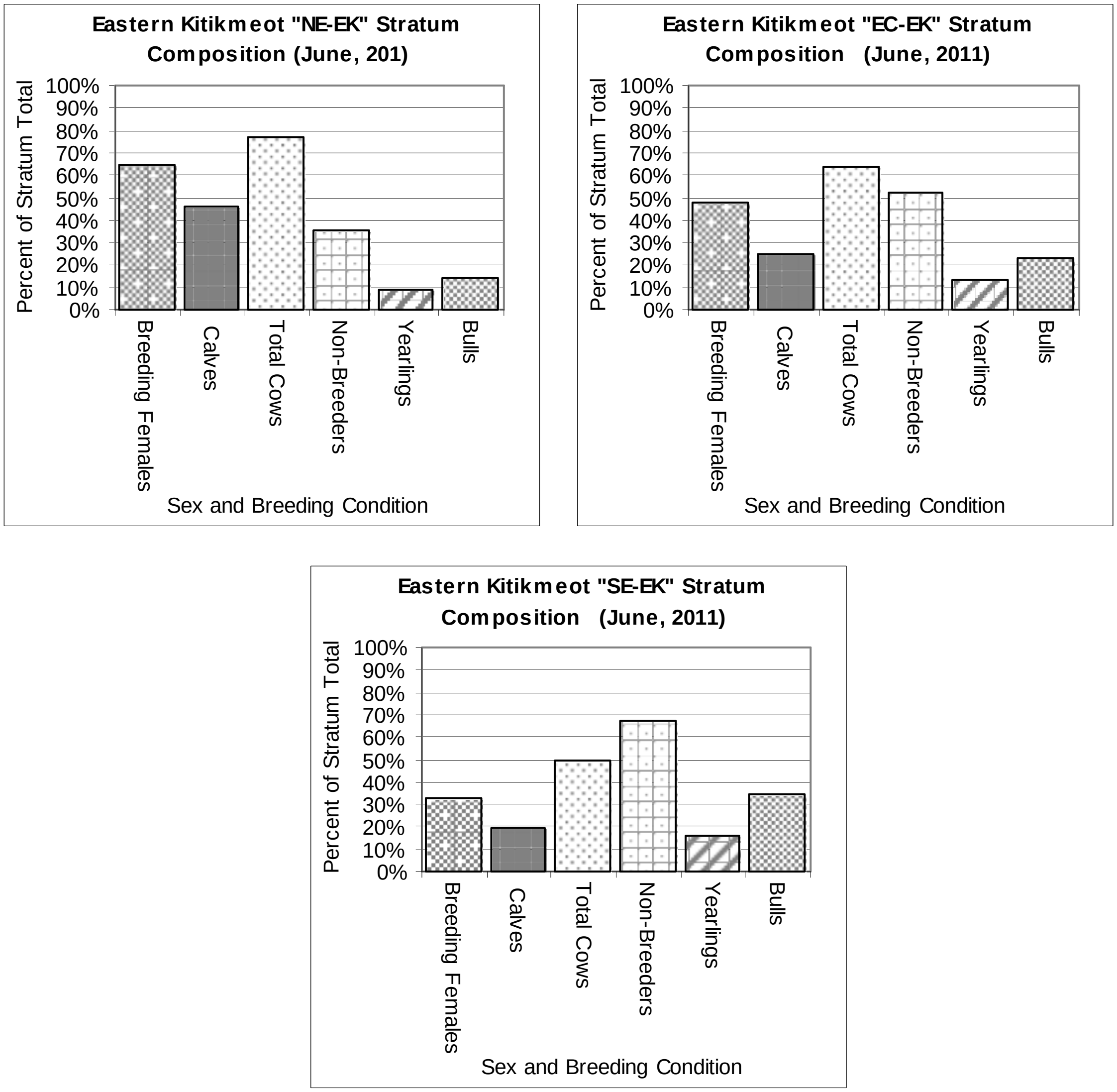


**Figure 29** Easternmost abundance strata of the Ahiak (EK) subpopulation classification results, June 2011.

### *4.4 Abundance Surveys*

Strata for the Beverly visual abundance survey were delineated according to the observed relative densities determined during the systematic reconnaissance of breeding females (Figure 30). In total, 5 abundance strata were delineated and surveyed including from west to east, a Low Density strata (LD), Medium Density A strata (MD-A), a high Density strata (HD), a Medium Density B (MD-B) and finally making up the easternmost extents a Medium Density C (MD-C) stratum. Transects were spaced based on density assessment. The highest percent cover falling within the HD stratum and the lowest within the LD stratum (Table 5, Figure 30). We assessed that it would be possible to fly 3,500 km of transect within the likely short window of reasonable survey weather. We estimated the number of total caribou in each strata, and number of breeding caribou in each stratum, based upon the reconnaissance survey data. The LD strata had a relatively large number of caribou, but the density of breeding caribou was low. Based on caribou densities, the allocation formula suggested the highest amount of effort be placed in the high strata with successively less effort placed into the LD, MD-A, MD-B, and MD-C strata. The highest observed densities on transect were found within the High Density (HD) stratum (6.0 caribou/$km^2$), followed by MD-B (3.9 caribou/$km^2$) with a mean relative density for all Beverly strata of 3.5 caribou/$km^2$ (Figure 31) (Table 5).

The double observer method estimated that from 3-12% of caribou on transect were not counted due to sightability (Table 5). The actual proportion missed was a function of the covariates for each stratum such as the observers that were used as well as survey conditions (snow, cloud cover, terrain). Estimates were considered for all strata for both barren-ground caribou subpopulations including strata within the Ahiak annual concentrated calving area where only reconnaissance transects were flown (approximately 8%) coverage. The use of reconnaissance transects for abundance estimates was considered justified as all such strata contained greater than 10 transects (the usual threshold of replicate lines needed to estimate variances), however, we suggest that any estimates from these strata be interpreted cautiously with careful attention to estimate standard errors.

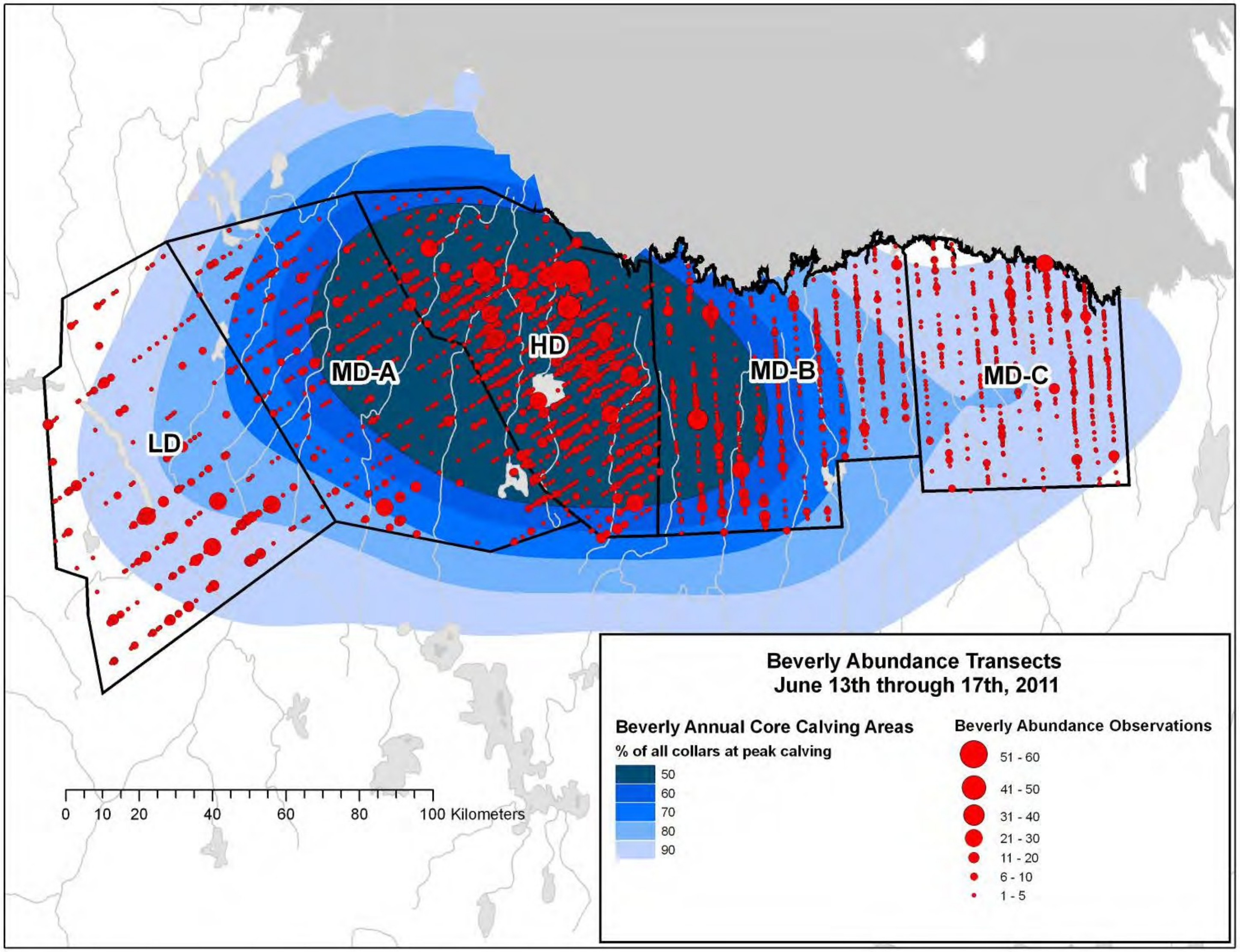


**Figure 30** June 2011 Beverly subpopulation abundance survey observations across the annual concentrated calving area.

**Table 5** Summary of sampling and count-based results by subpopulation and geographic region of survey and strata. The strata used on survey and subpopulation based strata are given. The number of adult caribou (adults and yearlings 1 year of age and/or older) counted on transect, the double observer estimate of caribou counted on transect, the relative density of the transect area, the estimated number of caribou missed, and proportion of caribou counted (p*) are given. We note that these are counts of caribou observed on strata as opposed to estimates of total caribou on the strata.

| Sub- Population | Strata | Sampling Summary | | | | Results | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Strata Area ($km^2$) | Transect Area ($km^2$) | Transect Count | Coverage (%) | Total Count | 2x Observer Estimates | Relative Density (Caribou / $Km^2$) | Estimated Caribou Missed | Proportion Counted (p*) |
| Beverly | LD | 5710.4 | 494.8 | 10 | 8.7 | 1,213 | 1,250 | 2.5 | 37.4 | 0.97 |
| | MD-A | 5390.6 | 779.8 | 22 | 14.5 | 1,634 | 1,685 | 2.2 | 50.6 | 0.96 |
| | MD-B | 4771.4 | 625.8 | 12 | 13.1 | 2,382 | 2,471 | 3.9 | 89.4 | 0.88 |
| | MD-C | 3584.4 | 547.8 | 11 | 15.3 | 1,498 | 1,706 | 3.1 | 207.7 | 0.90 |
| | HD | 4521.6 | 1037.7 | 34 | 23 | 6,041 | 6,265 | 6.0 | 223.5 | 0.97 |
| Ahiak | N-AP | 4398.5 | 397.9 | 10 | 9 | 221 | 271 | 0.7 | 49.6 | 0.96 |
| | S-AP | 5893 | 679.5 | 14 | 11.5 | 1,530 | 1,702 | 2.5 | 171.7 | 0.96 |
| | WC-EK | 4885.9 | 880.2 | 19 | 18 | 2,048 | 2,225 | 2.5 | 177.1 | 0.92 |
| | EC-EK | 5675 | 992.7 | 17 | 17.5 | 1,547 | 1,637 | 1.6 | 89.5 | 0.95 |
| | SW-EK | 5912.6 | 943.4 | 17 | 16 | 811 | 881 | 0.9 | 70.2 | 0.92 |
| | SE-EK | 5599.8 | 904 | 16 | 16.1 | 2,101 | 2,139 | 2.4 | 37.7 | 0.98 |
| | N-EK | 1427.8 | 143.1 | 7 | 10 | 81 | 81 | 0.6 | 0[A] | 1.00 |
| | S-EK | 7433.4 | 653.3 | 12 | 8.8 | 391 | 456 | 0.7 | 64.9 | 0.86 |
| | NE-EK | 2355.4 | 364.3 | 11 | 15.5 | 157 | 165 | 0.5 | 7.8 | 0.95 |
| | SC-EK | 6226.6 | 527.1 | 9 | 8.5 | 352 | 357 | 0.7 | 4.7 | 0.99 |
| | NW-EK | 3667.2 | 598.4 | 12 | 16.3 | 282 | 300 | 0.5 | 17.8 | 0.94 |
| NEM | E-NEM | 17913.7 | 1469.1 | 15 | 8.2 | 990 | 1,032 | 0.7 | 42.4 | 0.96 |

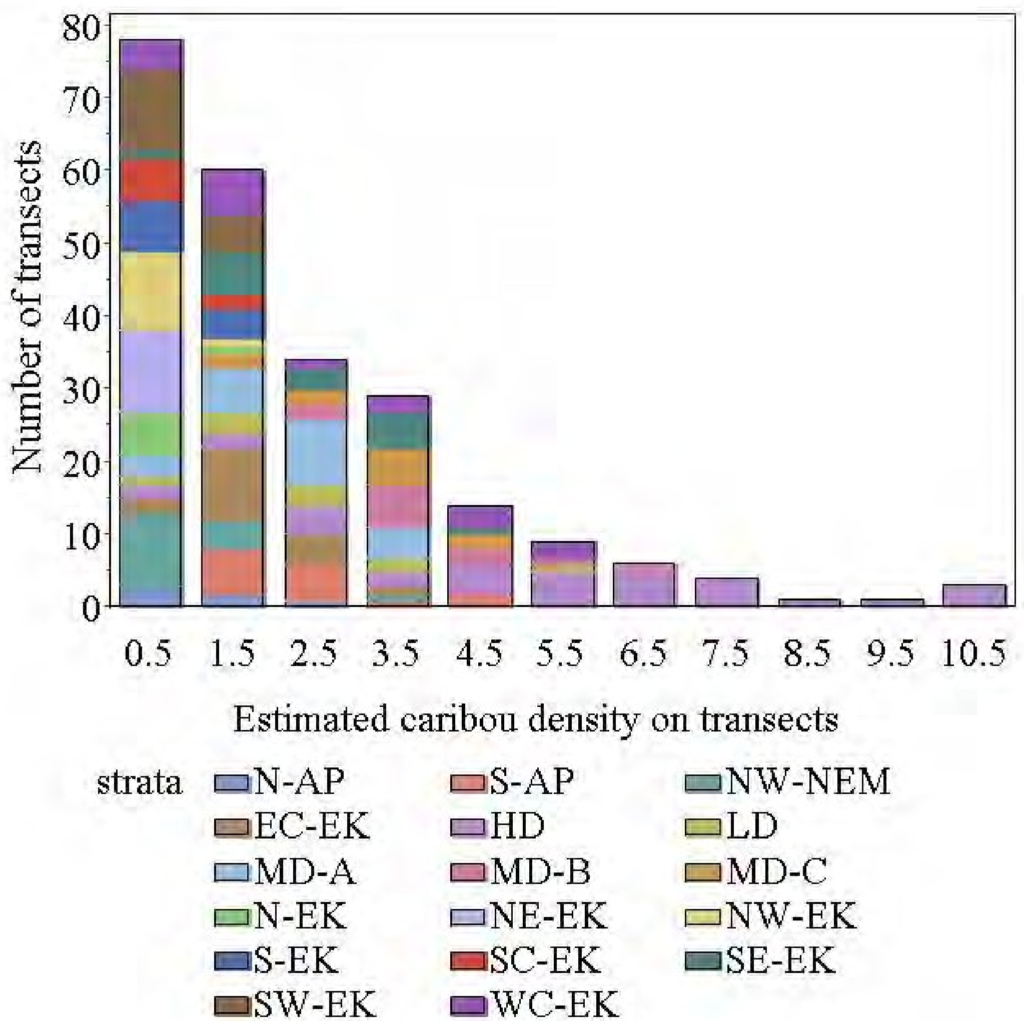


**Figure 31** Estimated transect densities of caribou on strata.

Strata for the EK visual abundance survey were delineated according to the observed relative densities determined during the systematic reconnaissance of breeding females for the Adelaide North and South strata, and based on a synthesis of pre-stratification observations recorded during a June 2010 reconnaissance survey. During the June 2011 survey, strata and transects served as reconnaissance and abundance surveys for the purposes of completing the survey within the peak calving period (Figure 32). In total, 11 abundance strata were delineated within the Ahiak subpopulation occupying an area of 71,389 km$^2$ within the known calving extents and 1 abundance strata delineated within the western extents of the Wager Bay population of NEM caribou termed the northwest NEM or NW-NEM (Table 5). The westernmost EK strata separated from the easterly strata by Chantrey Inlet and the Back River are the North and South Adelaide Peninsula stratum (AP-N & AP-S). East of The Back River and Chantrey Inlet were the South Ahiak (S-EK), Southwest Ahiak (SW-EK), South Central Ahiak (SC-EK), West Central Ahiak (WC-EK), Northwest Ahiak (NW-EK), North Ahiak (N-EK), Northeast Ahiak (NE-EK), East Central Ahiak (EC-EK), Southeast Ahiak (SE- EK) and East Ahiak (E-EK). Transects were spaced based on density assessment.

A total of 1,751 adult and yearling (12 months of age or greater) caribou were observed over 1,304 km of transect within the South Adelaide Peninsula (AP-S) and North Adelaide Peninsula (AP-N) (Figure 32). A total of 7,770 adult and yearling caribou were observed over 7,529 km of transect flown east of Chantrey Inlet and the Back River to the western shore of Pelly Bay. A total of 1,032 adult and yearling caribou over 1,836 km of transect flown were observed within the area of the Simpson Peninsula east of Pelly Bay. The highest relative densities were observed within AP-S (2.5 caribou/km$^2$), West Central Ahiak (WC-EK) (2.5 caribou/km$^2$), South East Ahiak (SE-EK) (2.4 caribou/km$^2$) and East Central Ahiak (EC-EK) (1.6 caribou/km$^2$) (Table 5, Figure 31).

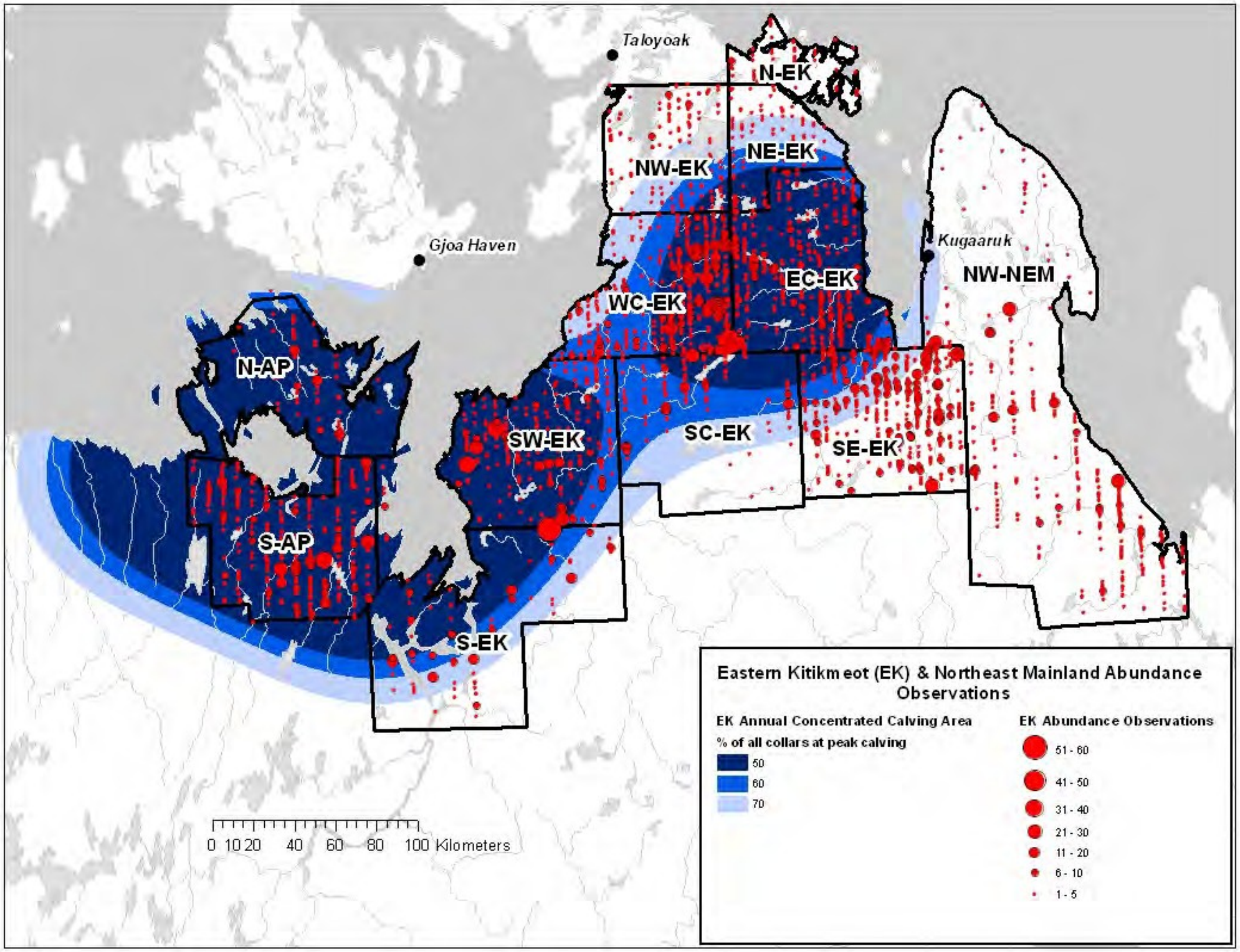


**Figure 32** June 2011 Ahiak (EK) subpopulation abundance survey observations across the annual concentrated calving area.

As detailed earlier in this report, all survey strata were grouped based on the relative densities observed during the reconnaissance phase over specific geographic areas surveyed from the Adelaide Peninsula to the Eastern shores of Pelly Bay belonging to the Ahiak subpopulation. All areas east of Pelly Bay were considered part of the Wager Bay subpopulation of NEM tundra wintering barren-ground caribou (Nagy and Campbell, 2012). Therefore, strata estimates are grouped accordingly. Estimates were considered for all strata including strata with reconnaissance (approximately 8%) coverage (only in the Ahiak). In many cases, the actual number of lines in reconnaissance strata was greater than 10 (the usual threshold of replicate lines needed to estimate variances); however, we remind the reader that any estimates from these strata be interpreted cautiously with careful attention to estimate standard errors.

It was also possible to estimate the density of caribou on each transect surveyed by using double observer estimate divided by each transect area. The result of the double observer analysis further illustrates that the main type of potential observer bias in the area is due to sightability of small groups of caribou rather than counting bias of larger groups of caribou. The resulting distribution of densities demonstrates that caribou in the Queen Maud Gulf and Northeast Mainland area are distributed in relatively low densities over a wide area. Only some transects on the Beverly high-density stratum stand out as they approached 10 caribou per square kilometer.

### *4.4.1 Stratum Estimates*

Initial estimates utilized pooled results from each of the left and right primary and secondary observers, where the largest count of the same group of caribou was included in the analysis and the lower count discarded. This procedure was equivalent to the uncorrected count based methods used on previous calving ground surveys. The double observer and count based estimates were then multiplied by the ratio of the area surveyed (strata area/transect area) to obtain estimates of total caribou on each stratum (Buckland et al., 2010). Bootstrap methods (using transect lines as the sample unit) that included the estimation of double observer sighting probabilities, were then used to obtain standard errors on population estimates. A parametric bootstrap method with 250 resamplings of the data was used for an estimate of the standard error. Standard errors for uncorrected counts were also estimated using the asymptotic formulas of Jolly (1969) for comparison with the bootstrap estimates (Table 6).

Using Jolly's Method 1 and 2 (Jolly 1969 *in* Norton-Griffiths, Krebs 1989) an estimate of adults and yearlings within all Beverly Strata was made for the count based estimates (Table 6). An estimated 79,577 (SE = 3,961.9; CV= 0.05) caribou adults and yearlings occupied the Beverly subpopulation annual concentrated calving area with 26,322 (SE=1508; CV=0.08) adults and yearlings estimated within the high-density strata alone. Using the double observer method over the same Beverly strata, we estimated 83,373 (SE = 4089; CV = 0.05) adults and yearlings occupying the Beverly annual concentrated calving area, an estimated 3,796 caribou more than when using Jolly's method 1 and 2 above. Double observer estimates for the high density strata were 974 (less than 4% of the jolly method) caribou greater that Jolly's method 1 and 2.

Similarly for the Ahiak strata, the double observer estimates of adults and yearlings were 71,340 (SE = 3882; CV = 0.05), 5,160 caribou greater than estimates using Jolly's method 1 and 2 (Table 6). Estimates of the NW-NEM strata were 12,589 (SE = 3130; CV = 0.25), 517 caribou greater than Jolly's method 1 and 2. This estimate however, does not represent an estimate of the calving distribution of the Wager subpopulation and should at no time be used as such. We provide the estimate of the Wager strata (NW-NEM) to inform readers of the relative abundance of caribou adjacent to target subpopulations.

Clearly, the double observer methodology worked well over the conditions encountered, maximizing sightability and more effectively and precisely estimating the abundance of caribou in the survey area. In general, the levels of precision for the double observer and uncorrected count-based estimates were similar. This was presumably because high double observer sighting probabilities minimized the amount of extra variation added into the estimates by sightability (given that the bootstrap procedure included variation caused by estimation of sighting probabilities). In some cases, adjustment of counts for sightability potentially reduced variation between lines by eliminating caribou missed in some lines due to factors such as snow conditions or observer-based variation.

The Beverly strata had lower coefficients of variation especially for strata that had optimized coverage (HD, all MD strata). The LD stratum had a high coefficient of variation due to the relatively low coverage (8.7%) that this stratum received. As discussed, this stratum was primarily composed of non-breeders and therefore the primary survey effort in this area was directed towards the HD and MD strata that had higher proportions of breeders. The resulting CV for the Beverly subpopulation was 5.0%. Coefficients of variation for individual strata within the Ahiak subpopulation that received greater than reconnaissance coverage (strata WC-EK, EC-EK, SW-EK, and SE-EK) were ranging from 12.2 to 16.1%. The NW-EK and NE-EK strata also had higher coverage (approximate 16%) and had resulting coefficients of variation of 15.3% and 20.7% respectively. The reconnaissance coverage strata had coefficients of variation greater than 20%. The combined coefficient of variation of all estimates for the Eastern Kitikmeot strata was 5.2%.

**Table 6** Double observer estimates of adult and yearling caribou in each subpopulation strata (Including the Northeast Mainland (NEM) stratum) and uncorrected count-based estimates for comparison purposes. The standard error of the count-based estimate using the formulas of Jolly (1969) is given. The bootstrap-based estimate is provided for comparison.

| Sub-Population | Strata | 2x observer N estimate | | | Count-based N estimate | | | |
|---|---|---|---|---|---|---|---|---|
| | | Estimate | Std. Err | CV | Estimate | Std. Err | SE (Jolly) | CV |
| Beverly | LD | 14,429 | 2505.1 | 17.1% | 13,998 | 2539.2 | 2871.0 | 18.1% |
| | MD-A | 11,645 | 1013.7 | 8.6% | 11,295 | 1030.5 | 867.2 | 9.1% |
| | MD-B | 18,843 | 1633.7 | 8.7% | 18,161 | 1614.0 | 1677.1 | 8.9% |
| | MD-C | 11,160 | 1411.9 | 12.4% | 9,801 | 1197.2 | 1271.5 | 12.2% |
| | HD | 27,296 | 2181.2 | 8.0% | 26,322 | 2062.0 | 1507.5 | 7.9% |
| **Totals** | | **83,373** | **4089** | **4.9%** | **79,577** | **3974.9** | **3,961.9** | **5.0%** |
| Ahiak | N-AP | 2,991 | 1172.4 | 36.0% | 2,443 | 869.9 | 1768.1 | 35.0% |
| | S-AP | 14,758 | 1600.9 | 10.7% | 13,269 | 1454.0 | 1428.0 | 11.0% |
| | WC-EK | 12,352 | 2000.6 | 16.1% | 11,369 | 1981.9 | 1933.6 | 17.3% |
| | EC-EK | 9,355 | 1110.2 | 11.5% | 8,844 | 878.9 | 856.0 | 10.0% |
| | SW-EK | 5,523 | 549.5 | 10.0% | 5,083 | 529.1 | 565.1 | 10.4% |
| | SE-EK | 13,248 | 1602.4 | 12.2% | 13,014 | 1557.3 | 1552.0 | 12.1% |
| | N-EK | 808 | 196.8 | 24.8% | 808 | 196.8 | 251.0 | 24.8% |
| | S-EK | 5,187 | 1471.5 | 26.8% | 4,449 | 849.2 | 568.9 | 20.4% |
| | NE-EK | 1,065 | 219.8 | 20.7% | 1,015 | 206.4 | 214.6 | 20.6% |
| | SC-EK | 4,214 | 830.8 | 19.7% | 4,158 | 813.3 | 885.6 | 19.6% |
| | NW-EK | 1,837 | 288.1 | 15.3% | 1,728 | 267.0 | 240.1 | 15.3% |
| **Totals** | | **71,340** | **3881.7** | **5.4%** | **66,180** | **3881.7** | **3436.8** | **5.2%** |
| NEM | E-NEM | 12,589 | 3129.5 | 24.6% | 12,072 | 2958.1 | 3284.2 | 24.3% |

### 4.4.2 Breeding Female Estimates

Though total subpopulation size provides useful information to managers and is commonly regularly requested by communities, this survey effort was designed to estimate breeding females within the annual concentrated calving areas of the Beverly and Ahiak subpopulations of barren-ground caribou. To this end, breeding female estimates offer the highest precision and accuracy when monitoring abundance trends. Strata based composition data recorded immediately following abundance surveys of specific strata were collected for this purpose. All strata based composition data including estimates of mean proportions and their associated standard errors of breeding and non-breeding females and other age and sex characteristics of the caribou occupying the target strata were calculated. The composition data was analyzed further using a bootstrap procedure to estimate unbiased proportions of breeders and associated standard errors. One thousand bootstrap replications were conducted which resulted in robust standard error estimates and percentile-based confidence limits. These estimates were then multiplied by the double observer based strata estimates of caribou to obtain estimates of breeding females (Table 7). A total of
52,825 (SE = 2638; CV = 0.05) breeding females were estimated within the Beverly subpopulation strata and 27,729 (SE = 1579; CV = 5.7) within the Ahiak. Only strata that had composition data were used for estimates.

**Table 7** Estimates of breeding female from composition data and double observer estimates. Estimates are only given for strata that had composition surveys.

| Sub-Population | Strata | 2x observer N estimate | | Proportion Breeders | | Breeding Female N Estimates | | |
|---|---|---|---|---|---|---|---|---|
| | | Estimate | SE | Estimate | SE | Estimate | SE | CV |
| Beverly | LD | 14,429 | 2505.1 | 0.048 | 0.011 | 698 | 203.7 | 29.2% |
| | MD-A | 11,645 | 1013.7 | 0.682 | 0.026 | 7,939 | 753.4 | 9.5% |
| | MD-B | 18,843 | 1633.7 | 0.709 | 0.030 | 13,362 | 1289.5 | 9.7% |
| | MD-C | 11,160 | 1411.9 | 0.613 | 0.032 | 6,844 | 938.1 | 13.7% |
| | HD | 27,296 | 2181.2 | 0.879 | 0.013 | 23,982 | 1950.6 | 8.1% |
| **Totals** | | | | | | **52,825** | **2637.6** | **5.0%** |
| Ahiak | N-AP | 2,991 | 1172.4 | | | | | |
| | S-AP | 14,758 | 1600.9 | 0.639 | 0.026 | 9,424 | 1091.5 | 11.6% |
| | WC-EK | 12,352 | 2000.6 | 0.561 | 0.032 | 6,932 | 1190.6 | 17.2% |
| | EC-EK | 9,355 | 1110.2 | 0.461 | 0.044 | 4,317 | 658.1 | 15.2% |
| | SW-EK | 5,523 | 549.5 | 0.297 | 0.038 | 1,638 | 266.5 | 16.3% |
| | SE-EK | 13,248 | 1602.4 | 0.312 | 0.040 | 4,135 | 729.8 | 17.7% |
| | N-EK | 808 | 196.8 | 0.697 | 0.050 | 563 | 143.1 | 25.4% |
| | S-EK | 5,187 | 1471.5 | | | | | |
| | NE-EK | 1,065 | 219.8 | | | | | |
| | SC-EK | 4,214 | 830.8 | | | | | |
| | NW-EK | 1,837 | 288.1 | 0.392 | 0.040 | 720 | 134.4 | 18.7% |
| **Totals** | | | | | | **27,729** | **1578.9** | **5.7%** |
| NEM | E-NEM | 12,589 | 3129.5 | | | | | |

## *4.5 Estimates of Total Subpopulation Size*

### 4.5.1 Ahiak and Northeast Mainland Subpopulations

No fall composition data were available for the Ahiak or Northeast Mainland subpopulations to allow an estimate of the proportion of cows needed for an extrapolated population estimate. In the case of the Northeast mainland subpopulation only the northeastern extents of their spring distribution was surveyed so the estimates provided do not in any way represent a subpopulation estimate but rather an estimate of only that portion of their range.

June composition data was only available for a proportion of the Ahiak survey area. It is evident from calving composition surveys that both breeders and non- breeders were more consistently interspersed in this survey area (as indicated by lower proportions of breeders in all strata) (Figure 28 and 29). The Ahiak clearly did not show the age and sex segregation seen within the Beverly migratory subpopulation and evident within other Mainland migratory caribou populations such as
the Qamanirjuaq (Campbell et al., 2008). As a result, we considered the estimate of total adult caribou in the Ahiak subpopulation (Table 6) of 71,340 adult (1+ year old caribou), (SE=3881.7) as the best estimate of caribou in this geographic area. Using
the formulas presented in Gunn et al. (1997) we estimated the degrees of freedom for the combined strata surveyed of 86.5 with a corresponding t-statistic of 1.98. This was used to estimate a parametric confidence interval of 63.623-79,056 for an abundance estimate of 71,340 (SE = 3882) adults and yearlings for the Ahiak subpopulation of tundra wintering barren-ground caribou.

We believe that all major aggregations of caribou within the Ahiak study area were captured; however, small groups of caribou were sparsely distributed outside of abundance strata suggesting that a portion of the subpopulation would not have been included within the final estimate.

### *4.5.2 Beverly Subpopulation*

Total subpopulation size was estimated in a two-step process. First, the total number of adult (1.5+ year old) females in the subpopulation was estimated by dividing the estimate of breeding females by the assumed pregnancy rate. The estimate of total females was then divided by the estimated proportion of females in the subpopulation as estimated from fall composition surveys to provide an estimate of total adult caribou in the subpopulation (Heard and Williams 1991). Note that this estimate corresponds to adult caribou and will not include calves of the previous year (that were yearlings on the calving ground). Pregnancy rates for this estimate were taken from (Dauphine 1976, Heard and Williams 1991). All of the estimates associated with subpopulation size have standard errors and therefore the delta method (Buckland et al. 1993) was used to combine variance for the entire subpopulation estimate.

Fall composition studies were successfully completed for the Beverly subpopulation in late October 2011. Estimates of the bull-cow ratio and the proportion of cows were 0.693 (SE=0.0250, CI=0.648-0.742) and 0.5908 (SE=0.008527, CI=0.574-0.607) respectively. The confidence limits were percentile and based on 1000 bootstrap resampling's. When subpopulations are defined, and pregnancy rates determined, this information can be used to estimate the total number of adult caribou in survey areas (Table 7).

For the Beverly subpopulation (Queen Maud Gulf area), we used an extrapolation method to estimate total subpopulation size where the estimate of breeding females is divided by the proportion of adult females pregnant to estimate total adult females (Table 8) (Heard, 1985). This estimate is then divided by the proportion of adult cows in the population (collected in the fall 2011) to estimate total subpopulation size (of caribou that are 1+ years old) on the calving ground. This method assumes that a proportion of non-breeding caribou were not in the survey area (most likely in areas south of the survey area). We estimated degrees of freedom of 45.5 for the strata surveyed that were used for breeding female estimation with a resulting t-statistic of 2.014. From this, a parametric confidence interval (for the estimate of 124,189 within the Beverly subpopulation) was estimated as 95,999-152,378.

Table 8 Extrapolated subpopulation estimates for the Beverly subpopulation in the vicinity of the QMG.

| Survey data | Estimate | Variance | Std. Error | CV |
|---|---|---|---|---|
| Total (adult 1+ yr old) caribou (all strata) | 83,373 | 16723143.5 | 3881.7 | 5.4% |
| Number of breeding females | 52825.1 | 6956751.3 | 2637.6 | 5.0% |
| Proportion females in the entire subpopulation | 0.59078 | | 0.0085 | 1.4% |
| Proportion 1+ yr. females pregnant | 0.72 | | | 10.0% |
| **Total pop. estimate (1+ yr old caribou)** | **124,189** | **195890818.5** | **13996.1** | **11.3%** |

# 5.0 DISCUSSION

## *5.1 Double Observer Method*

The double observer method used in this survey provided an efficient way to correct visual counts for sightability bias. Analysis results demonstrated that sightability of caribou varies by observer, snow cover, cloud cover, terrain features, and the relative rate of observation occurrence (these results are detailed and discussed in the file report). Therefore, it is very likely that raw counts of caribou underestimates the true number of caribou on transect. However, results also demonstrated that in general, sighting probabilities are usually reasonably high, and the use of two observers can substantially reduce sightability bias. It is known that unequal sightability can potentially cause negative biases in estimates (Buckland et al., 2004; Laake et al., 2008a; Laake et al., 2008b; Buckland et al., 2010), however, the effect of unequal sightability is lessened as sighting probabilities increase (Pollock et al., 1990). In our case, single observer sighting probabilities were usually above 0.5, and resulting double observer probabilities were above 0.85 (Figure 33). Therefore, in most cases the actual estimates were only 6% higher than uncorrected count based estimates, and levels of precision were similar to uncorrected count based estimates.

The MARK Huggins model provided an efficient way to model variation in sightability and therefore ensure robust estimates. Traditional dependent double observer methods (Cook and Jacobsen, 1979) do not readily allow the use of covariates to model sighting probability variation. The Huggins removal model analysis demonstrated the large range of covariates that affected sightability and provided a parsimonious method to model sighting probability variation. If sighting probabilities were lower we suspect that the effect of unequal sightability would become more pronounced. This scenario is possible if survey conditions such as mixed snow cover and mixed cloud cover (that reduce sightability) occurred over wider ranges of the study area. Therefore, we suggest that high sightability cannot always be assumed and that methods should be employed to test and account for sighting probability bias. In all cases we recommend the use of 2 observers to offset lower single observer sighting probabilities.

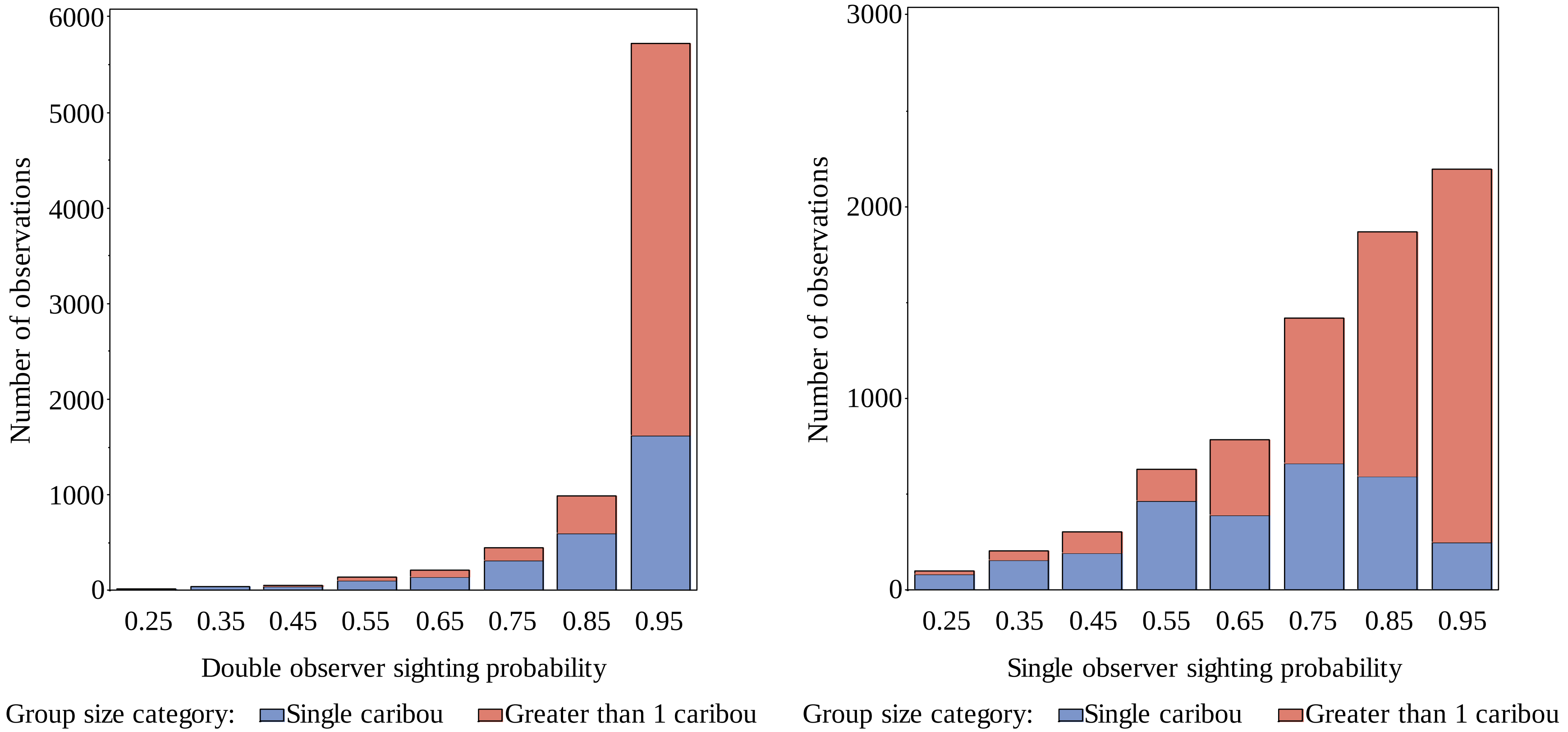


**Figure 33** Overall distribution of single and double observer sighting probabilities.

### *5.2 Ahiak Subpopulation*

Survey data for areas east of the Perry River (which would include Beverly strata MD-B and C and the entire Ahiak strata) suggest that between 28,050 -37,950 caribou and 26,677-36,435 caribou occupied the eastern extents of the Queen Maud Gulf up to the western shore of Chantrey Inlet in May 1983 and 1995 respectively (Heard, 1986; Buckland et al., 2000). Though continued analysis of survey data is underway and will be presented in the full survey report, there is little evidence at present that the abundance of the Ahiak subpopulation has changed substantially from these earlier reports. Only incomplete studies and information and fragmented survey work has been conducted in the Ahiak between 1996 and 2006 when the NWT began comprehensive reconnaissance surveys of the entire Queen Maud Gulf area. Continued monitoring using telemetry along with periodic reconnaissance and abundance surveys are recommended. With declines apparent for other subpopulations, managers will need to understand the status and trend of this subpopulation for effective harvest management into the future. In addition, resource use and development issues must occur in a sustainable fashion in order to support the subsistence harvest of communities (Baker Lake, Gjoa Haven, Kugaaruk, Taloyoak, Repulse Bay, and in some years Lutselk'e) utilizing Ahiak tundra wintering caribou. This survey and recent collaring program represent the most comprehensive information collected for this subpopulation to date, providing much needed information with which to manage sustainably this important natural resource.

### *5.3 Beverly Subpopulation*

Barren-ground caribou vary through population highs and lows. The Beverly subpopulation estimates have varied between 124,000 and 164,000 adult caribou in the 1970s to between 189,000 (SE 70,961) and 276,000 (SE 106,600) adult caribou in the mid-1980s to mid-1990s at which time calving occurred on the traditional calving ground (Table 9, Figure 34). The current Beverly subpopulation estimate of about 124,000 adult caribou (on the northern QMG calving ground) indicates that the number of caribou using this landscape is at the lower end of the known population size range of the Beverly subpopulation, especially since caribou that utilized the Traditional Beverly calving ground probably combined with caribou that already occurred in the northern QMG calving ground for the 2011 estimate. Due to overlap in calving extents of the two subpopulations in the eastern Queen Maud Gulf area, the current estimate includes some East Kitikmeot caribou (similarly, the East Kitikmeot estimate may include some Beverly caribou).

Initial trend analyses of GNWT calving ground reconnaissance data across the Queen Maud Gulf from 2006 to 2010 suggest that the population of adult female caribou in this area (which includes calving areas used by Beverly and by East Kitikmeot subpopulations) declined from 2006 to 2008 and increased from 2008 to 2010: however it was at lower levels in 2010 compared to 2006. (J. Boulanger unpublished analysis,); these trends will be further explored in the File Report

The estimate in this report provides critical information to help managers assess whether this subpopulation can meet sustenance needs, to evaluate the harvest pressure on this subpopulation, and to consider the ability of this subpopulation to withstand stochastic events and other natural and anthropogenic pressures that may be anticipated on its range.

Given the subpopulation structure of migratory barren-ground caribou provided by Nagy et al., further exploration with respect to the movement and demographics of Beverly caribou in relation to their previous annual concentrated calving area should be investigated as this may have implications on the sustainability and management of this subpopulation (Thompson 1998). Based on results, it is likely that the Beverly subpopulation has declined in abundance. The magnitude of this decline is uncertain due to a lack of consistent monitoring effort. Therefore, it is critical that we continue to monitor this subpopulation in order to mitigate impacts and to manage for this subpopulation to be vital, healthy and capable of sustaining harvesting needs and/or be restored from a depleted status.

**Table 9** The history of calving-ground visual and photographic surveys of the Beverly barren ground caribou subpopulation. Where both visual and photographic surveys were completed in the same year, photo survey results were used. (S-B&G Lakes = South - Beverly and Garry Lakes; N-QMG = North - Queen Maud Gulf).

| Year | Location of Calving Ground | Breeding Females | | | Total Subpopulation Size | | | Source |
|---|---|---|---|---|---|---|---|---|
| | | $Y_h$ | SE | CV | $Y_h$ | SE | CV | |
| 1967 | S-B&G | | | | 159,000 | | | Thomas, 1969 *(Spring Migration Visual Survey)* |
| 1971 | S-B&G | | | | 164,000 | | | Rippin, 1971 *(Calving-ground Visual Survey)* |
| 1974 | S-B&G | | | | 124,000 | | | Moshenko, 1974 *(Calving-ground Visual Survey)* |
| 1982 | S-B&G | 73,597 | 30,672 | 0.4178 | 164,338[b] | 72,332 | 0.440 | Heard and Jackson, 1990 *(Calving-ground Photo-Survey)* |
| 1984 | S-B&G | 114,484 | 31,047 | 0.271 | 263,691[b] | 80,652 | 0.306 | Heard and Jackson, 1990 *(Calving-ground Photo-Survey)* |
| 1987 | S-B&G | 32,491 | 3,719 | 0.115 | 93,546[b] | 19,423 | 0.208 | Heard and Jackson, 1990 *(Calving-ground Visual-Survey)* |
| 1988 | S-B&G | 82,300 | 28,529 | 0.347 | 189,561[b] | 70,961 | 0.374 | Heard and Jackson, 1990 *(Calving-ground Photo-Survey)* |
| 1993 | S-B&G | 37,654 | 5,682 | | 86,728 | 17,943 | 0.207 | Williams, 1995 (Calving-ground Photo-Survey) |
| 1994 | S-B&G | 119,927 | 43,061 | 0.359 | 276,000 | 106,600 | 0.386 | Williams, 1995 (Calving-ground Photo-Survey) |
| 2011 | N-QMG | 52,825 | 2,638 | 0.05 | 124,189 | 13,996 | 0.11 | This report *(Calving-ground Double Observer Visual Survey)* |

[b] = Total Population = # of parturient females / proportion of females in the population / proportion of females pregnant X a sightability correction factor for visual surveys only (Heard and Jackson, 1990). CV = SE/Total Population (Heard, 1987).

$Y_h$ = point estimate

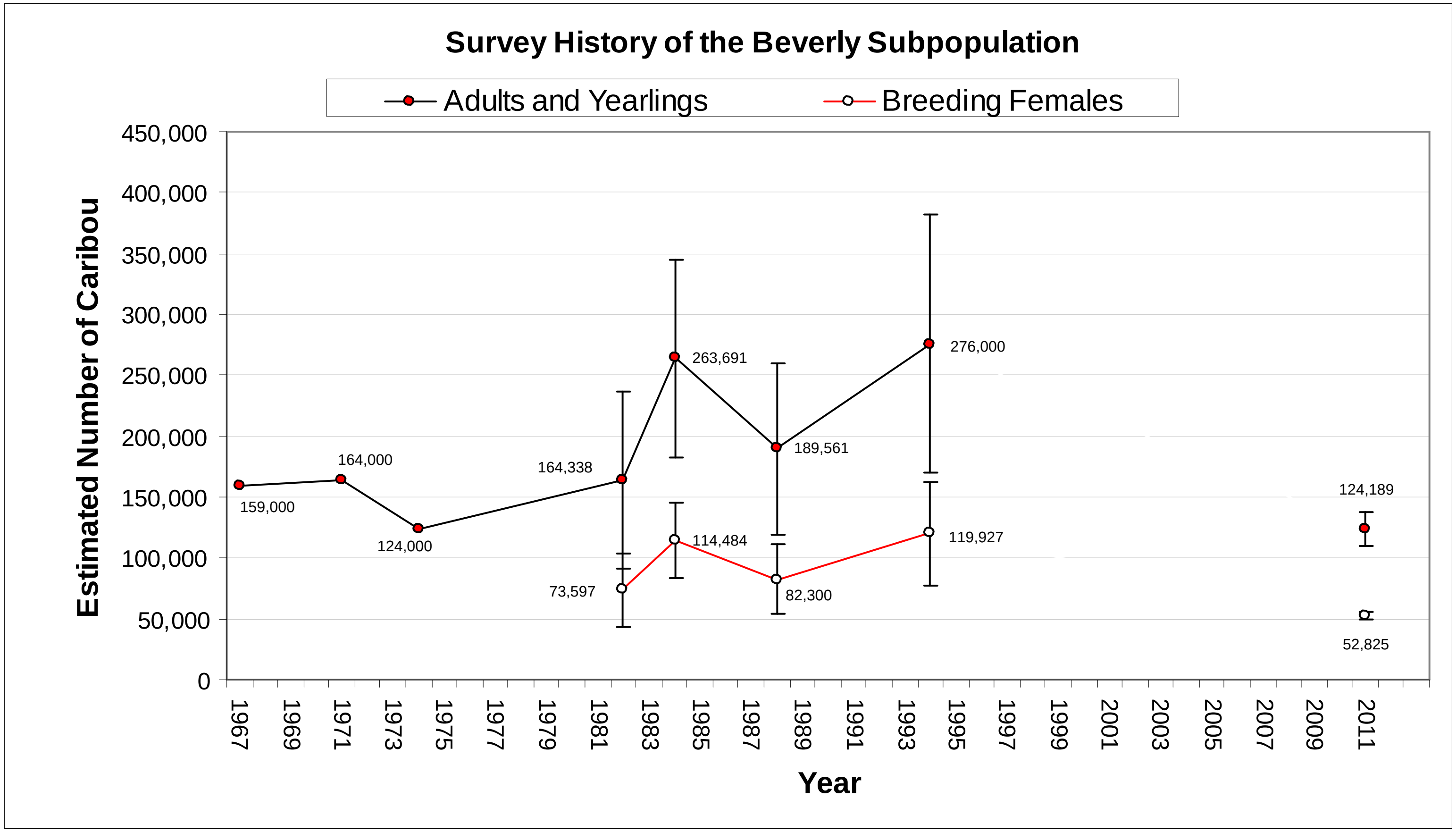


**Figure 34** Survey histories of abundance estimates of adults and yearlings (1+ years of age) and breeding females for the Beverly subpopulation of taiga wintering mainland migratory barren-ground caribou on their southern annual concentrated calving area (1967 to 1994) and on their northern annual concentrated calving area (this report). Error bars indicate Standard Error of estimates.

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| Nunavut Department of Economic Development & Transportation (GN-ED&T) | |
| Nunavut Department of Environment (GN-DoE) | |
| Nunavut General Monitoring Program (NGMP) | |
| Nunavut Inuit Wildlife Secretariat (NIWS) | |

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| Nunavut Tunngavik Incorporated (NTI) |
| Nunavut Wildlife Management Board (NWMB) |
| Repulse Bay HTO |
| Taloyoak HTO |