# Aerial Abundance Estimates, Seasonal Range Use, and Spatial Affiliations of the Barren-Ground Caribou (*Rangifer tarandus groenlandicus*) on Baffin Island – March 2014

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# ABSTRACT

In late February and March 2014, we estimated the abundance of barren-ground caribou on Baffin Island and ancillary islands, and northern Melville Peninsula using double observer pair and distance sampling methods. The survey was enhanced through the guidance of local knowledge and inclusion of Inuit Qaujimjatuqangit (IQ) from ten Baffin Island communities. With the noted exception of areas on Baffin Island where local Inuit knowledge indicated that no caribou could be found, all of Baffin Island and the northern third of Melville Peninsula were surveyed. In addition, ground surveys were completed in areas around communities where caribou presence was largely unknown but suspected to be very low.

We observed 1,130 individuals across all Baffin Island and ancillary islands and northern Melville Peninsula representing an estimated 571,369 km$^2$. Caribou observed included 63 within the North Baffin grouping survey strata, and 824 within the South Baffin grouping survey strata, and 26 on northern Melville Peninsula. We estimated between 315 caribou (95% CI=159-622 SE=109; CV=0.35) caribou (adults, calves and yearlings) within the north Baffin survey stratum, and 4,337 caribou adults, yearlings and calves (95%CI=3,169-5,935; SE=691.05; CV=0.16) within the south Baffin survey stratum. Over all Baffin Island including the northern Melville Peninsula, we estimated 4,872 caribou (95%CI=3,462-6,484; SE=712.23; CV=0.15) adult, yearling and calf caribou. The estimate for Baffin Island and ancillary islands is 4,652 caribou (95%CI=3,462-6,250; SE=702.79; CV=0.15) adult, yearling and calf caribou.

We re-analyzed a north Baffin survey flown in April 2009 and a South Baffin survey flown in April/May 2012. Neither of these survey estimates displayed a statistically significant change in abundance from the March 2014 survey results. The abundance of caribou on Prince Charles Island displayed a significant

increase (P(t)=0.002) from 709 caribou (95%CI=525-956;SE=104;CV=0.15) in 2012 to 1,603 (95%CI=1158-2220;SE=25;CV=0.16) in 2014.

A review of telemetry data has revealed potential subpopulation structure on Baffin Island within each of the North Baffin survey stratum, South Central Baffin survey stratum, and South East Baffin survey stratum. Daily, seasonal and annual movement rates differed between each of the potential subpopulations. Due to lack of quantitiative data and long-term spatial analysis, the subpopulation structure of caribou on Baffin Island Island remains uncertain. Instead, we use the term "grouping" to describe spatial affiliations until sufficient evidence to support population structure is available. Further studies are required to delineate subpopulation structure and seasonal range fidelity. Generally, South Central caribou displayed much higher movement rates than the South East or North Baffin groupings. North Baffin caribou were the least migratory of all identified groupings showing little differentiation between seasonal movement rates.

***Key words:*** Caribou, Barren-Ground Caribou, Baffin Island, Melville Peninsula, North Baffin Island, South Baffin Island, Aerial Survey, Ground Survey, Late Winter, Visual Survey, Baffin Region, Double Observer Pair Method, Distribution, Movements, Seasonal Range Use, Distance Sampling, Spatial Affiliations, Population Structure, Nunavut, *Rangifer tarandus groenlandicus*, Population Survey, Caribou Late Winter Distribution.

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# 1.0 INTRODUCTION

Caribou are circumpolar in their distribution and occur in northern parts of Eurasia and North America. In Canada, caribou are represented by four subspecies; Peary (*R. t. pearyi*), Woodland (*R. t. caribou*), Grant's (*R. t. granti*), and Barren ground (*R. t. groenlandicus*). Of the four, barren-ground caribou are the most abundant and can be further divided into two ecotypes, the taiga wintering migratory, and the tundra wintering types (Nagy et al. 2011). All Baffin Island caribou groupings fall into the tundra wintering ecotype generally occurring in smaller aggregations, have less dramatic migratory behavior, and are confined to tundra environments. Movements of Baffin Island caribou are not completely understood though limited scientific knowledge and IQ suggest that it varies amoungst the groupings, including but not limited to both altitudinal as well as smaller scale geographically driven migratory behavior when compared with mainland migratory taiga wintering barren-ground caribou.

The Department of Environment, Government of Nunavut, previously recognized three (3) caribou populations across Baffin Island (see Figure 25). These populations included the South, North and Northeast Baffin Populations (Ferguson and Gautier 1992, Department of Environment, 2005). The paucity of demographic and movement studies on Baffin Island over the last 20 years has made divisions that may exist between these populations difficult to verify. Early survey study areas (1940-1970) did not assess subpopulation structure and as a result were unable to provide reliable abundance estimates due to limited coverage. Small, widely dispersed herds, poor weather over the survey period, and rugged terrain over portions of the range further compounded these issues (Hall 1980).

Early survey efforts generally focused on discrete portions of caribou range and were almost exclusively limited to South Baffin. Subsequently, a complete population estimate has never been produced for the island or at the subpopulation level. Williams and Heard (1986) suggested that in excess of 100,000 caribou likely inhabited Baffin Island in 1985. The status was updated in 1991 when it was suggested that populations were stable with 60,000 - 180,000 in South Baffin, greater than 10,000 in Northeast Baffin, and between 50,000-150,000 in North Baffin (Ferguson and Gauthier, 1992). Once again, these estimates were not the result of robust demographic studies but rather best guesses based on qualitative observations and Inuit Qaujimajatuqangit (IQ) of the time and various incidental aerial observation and movement data. Since the mid to late 1990s, local hunters across Baffin Island have reported decreasing caribou numbers, and currently many hunters have to travel further from their communities to locate caribou (Jenkins et al. 2012; Goorts and Ross, 2013).

The most recent demographic studies conducted on Baffin Island examined southern Baffin Island from March through May 2012 (Jenkins et. al. 2012). Though poor weather extended the survey period and made caribou sightability and survey conditions difficult at times, Jenkins reported that an estimated 1,484 yearling and adult caribou occupied the south Baffin study area. These results suggest a dramatic drop from earlier estimates and are consistent with hunter reports of low numbers of caribou across the Island. Though the mechanisms of the observed decline are unclear, Jenkins et al. (2012) suggested that they may be due to a combination of factors not limited to climate change, resource exploration/development, and harvesting (Vors and Boyce 2009, Jenkins 2011, Festa-Bianchet 2011). These factors may limit recovery where population levels are low.

The following report presents the results of a research effort designed to estimate the abundance of barren-ground caribou occupying north, central, and south Baffin Island including northern Melville Peninsula using primarily aerial surveys and secondarily ground surveys (Figure 1). We also examined population trend between surveys, spatial affiliations based on past telemetry studies, migratory behavior, and seasonal range use. The declines identified by Jenkins et al. (2012) in spring 2012, combined with IQ from communities across the Island, have highlighted the urgent need to develop a management strategy aimed at stabilizing the population. The results of these studies will provide baseline information from which the effectiveness of future management efforts can be measured and if necessary, modified to meet identified management goals.

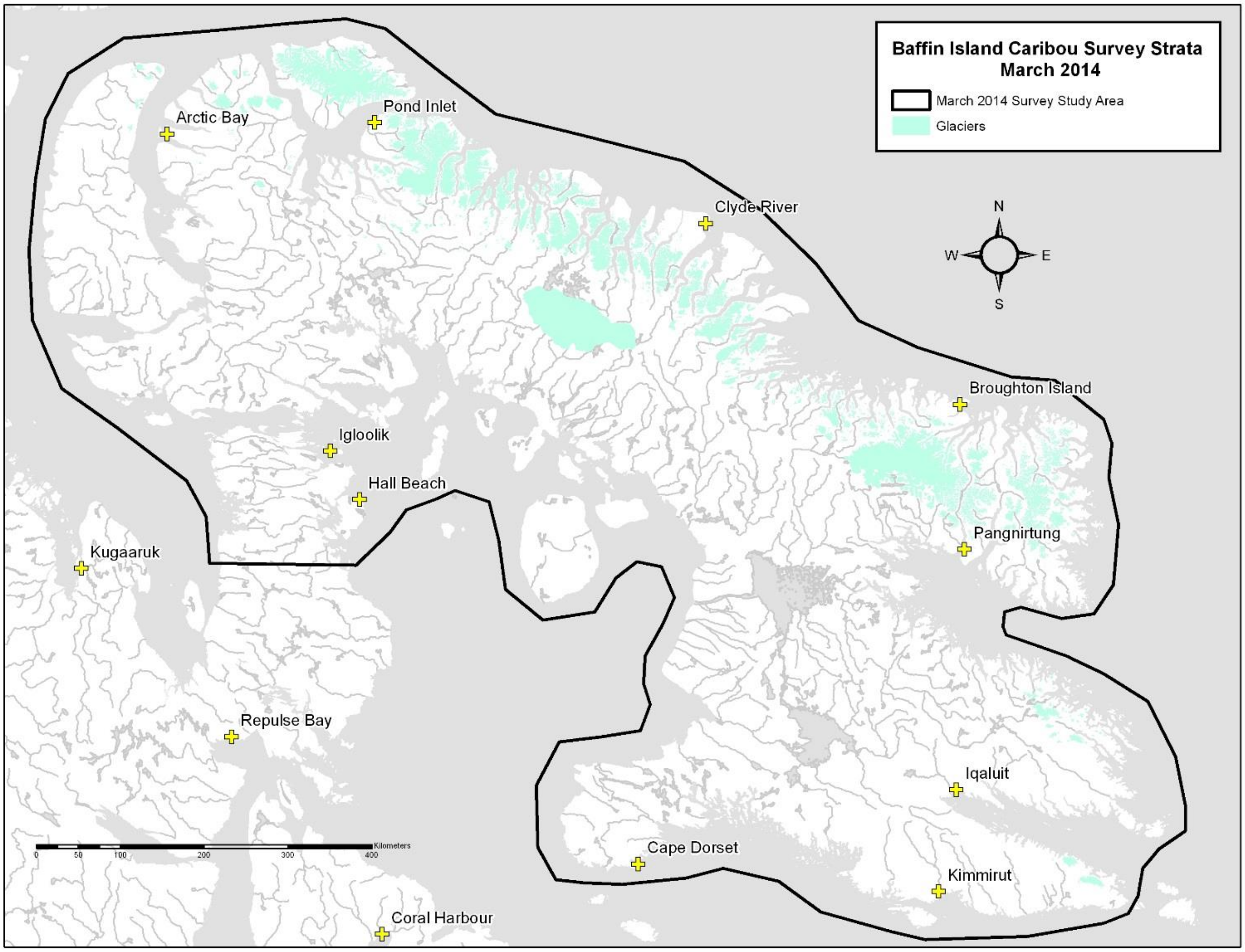


Figure 1. The north and south Baffin Island and northern Melville Peninsula survey study area. Survey area developed through consultation with HTO, RWO and community forums where unanimous requests to survey the entire island were received (Goorts and Ross, 2014).

# 2.0 STUDY AREA

The Baffin Island complex, incorporating all of Baffin Island and proximal islands including Prince Charles Island and excluding the areas of glaciers and ice fields, covers an estimated 543,746 square kilometers. Baffin Island is the largest Island in Canada and fifth largest Island in the world. Relief varies from expansive lowlands near sea level exemplified by the great plain of the Koukdjuak, to the mountains of the North and South Baffin reaching elevations of 1,963 meters and 2,147 meters above sea level respectively. The northeastern fifth of Baffin Island is within the Arctic Cordillera ecozone while the remainder of the Baffin Island complex is wholly within the northern arctic ecozone (Figure 2).

## 2.1 Arctic Cordillera Ecozone

The Arctic Cordillera ecozone is further divided into two ecoregions; 1-The Baffin Mountains and 2- The Baffin Island Coastal Lowland (Figure 3) (Environment Canada, 1995). Rugged mountains and expansive glaciers dominate the Baffin Mountain Ecoregion within the Arctic Cordillera Ecozone. Some of Canada's highest peaks and the world’s highest vertical surface (Mount Thor) are found within this ecozone. The mountain range dominating this zone runs along the northeastern third of Baffin Island dominating Labrador, eastern Baffin, and Devon islands and most of Ellesmere and Bylot islands. On Baffin Island, these mountain ranges belong to the 1.2 billion year old Churchill geological province, typified by a mix of granites, metamorphic gneisses, and ancient sediments of the Canadian Shield. The landscape has been glaciated at least 4 times over its history with the paths of the Pleistocene glaciers being marked by mountain cirques, pyramidal peaks (horns), sharp edged ridges (arêtes) and deep U-shaped valleys, which in coastal areas meet with steep-sided fiords that may rise over a thousand meters above sea level. Within the Baffin Mountain ecoregion, bare bedrock is common, turbic cryosols developed on discontinuous colluvial, alluvial, and morainal deposits are the dominant soils. Within the Baffin Island Coastal Lowland ecoregion, turbic cryosols on sandy colluvial, morainal, and marine deposits are the dominant soils. The extreme cold, high winds and lack of soil make the higher portions of this ecozone encompassed by the Baffin Mountain ecoregion, largely devoid of plants and animals (Figure 4). Ice barrens and extruded and fractured rock cover much of the landscape. Making up only a small portion of this ecozone, the Baffin Island Coastal Lowlands form a flat to rolling landscape along the eastern boundary of the Baffin Mountain Ecoregion. This ecoregion is the most productive within the ecozone displaying the widest range of both plant and animal species. Landforms along coastal flats are dominated by raised beaches, the result of crustal recoil rates of up to 30cm per century.

Pockets of vegetated tundra are most common within the Baffin Island Coastal Lowland ecoregion particularly at lower elevations and along watercourses and coastlines. A sparse vegetative cover of mixed low-growing herbs and shrubs, consisting of moss, purple saxifrage, Dryas spp., arctic willow, kobresia, sedge, and arctic poppy characterizes this ecoregion. Within the more productive wetland sites, species such as wood rush, wire rush, and saxifrage, along with a nearly continuous cover of mosses can cover up to 60% of the landscape, offering important forage to local wildlife. Plant species richness and abundance are much reduced within the Baffin Mountain ecoregion where only a discontinuous cover of mosses, lichens, and cold-hardy vascular plants such as saxifrage, sedge and cottongrass can be found most commonly bordering waterbodies and along watercourses.

Climate within this ecozone is typified by long, cold winters and short, cool summers, with the brief summer growing season enhanced by long periods of daylight. Within the Baffin Mountain ecoregion, estimated mean annual temperature is -11.5°C with mean summer and winter temperatures estimated to be 10°C, and -23°C respectively. Mean annual precipitation is 200-400 mm annually with 400-600 mm centering on the Cumberland Peninsula. The Baffin Island Coastal Lowland ecoregion estimated mean temperature varies little from its south western neighbour with annual means of -11.5°C, while mean summer and winter temperatures are 1°C and -22.5°C respectively. Mean annual precipitation as rain and snow is substantially greater within the Baffin Mountain ecoregion ranging between 200 and 600 mm annually compared with an estimated 200 to 300 mm annually within the Baffin Island Coastal Lowland.

Land mammals are uncommon across much of the Baffin Mountain ecoregion within the Arctic Cordillera ecozone, a direct result of the predominantly sparse vegetation. Caribou, wolf, arctic hare, arctic fox, ermine, and the collared lemming are most commonly observed along coastlines, watercourses and variable patches of vegetation within the Baffin Island Coastal Lowland ecoregion. Polar bears can also be found close to the coast and/or on the sea Ice depending on the season. Though their preferred prey are ringed and bearded seals hunted predominantly on ice flows, following the break up of sea ice, polar bears often come ashore to feed on mussels, starfish, birds' eggs, and carrion within the Baffin Island Coastal Lowland. Mammal abundance generally declines with distance from coastal areas, watercourses and vegetation patches, and generally with increased elevation. A small number of species of songbirds and shorebirds come to the area to breed. Most common are Hoary Redpoll, Little Ringed Plover, and Snow Bunting though other common bird species include gulls, terns and, in association with communities, ravens. The waters surrounding Bylot Island and within Lancaster Sound support large breeding colonies of Northern Fulmars, Thick-billed Murres, and Black-legged Kittiwakes.

Baffin Island communities within the Arctic Cordillera ecozone include Clyde River located within the Baffin Island Coastal Lowlands ecoregion and Qikiqtarjuaq located within the Baffin Mountain ecoregion. Inuit have occupied the Arctic Cordillera ecozone in excess of 1,000 years. The human population within the Baffin Island portion of this ecozone is estimated to be 2,000. Much of the local population depends on subsistence hunting, trapping, and fishing, all contributing to independence, cultural richness, and a healthy lifestyle.

## 2.2 Northern Arctic Ecozone

Over 80% of Baffin Island and proximal islands lie within the Northern Arctic ecozone (Environment Canada, 1995). The northern arctic ecozone covers an estimated 1.5 million square kilometers representing about 14% of Canada forming one of the largest arctic ecosystems in the world (Environment Canada, 1995). The ecozone primarily consists of low rolling plains covered by layers of glacial till and debris. Permafrost lies beneath the entire zone below a thin active layer that freezes in winter and thaws in summer. The constant freezing and thawing sorts the substrate creating cell-like shapes known as patterned ground, which consequently cover much of the ecozone. Expansive flat coastal plains extending many kilometers inland typify many coastlines. Crustal recoil is active in the area and exemplified by inland beach ridges. Within the interior of this ecozone, broad plateaus are common, often showing deep V-shaped cuts along their shoulders where past and existing streams and rivers have cut through the sedimentary substrate on which they flow. Islands of this ecozone often display sheer cliffs along the edges of high plateaus making some coastline inaccessible. On Baffin Island this ecozone can be divided into 10 ecoregions including (after environment Canada, 1995) (Figure 3);

*1- Lancaster Plateau:* Formed on flat-lying Palaeozoic and late Proterozoic sedimentary rocks sloping gently southward and ranging about 300-765 m ASL (above sea level). Within this ecoregion, exposed bedrock is common with regosolic turbic and regosolic static cryosols developed on colluvial, alluvial, morainal, and marine sediments making up the dominant soils;

*2- Gulf of Boothia Plain:* Forming lowland coastal fringes, this ecoregion is dominated by regosolic static cryosols developed on morainal and marine sediments. The region slopes gently southward, ranging from sea level to about 300 m ASL, remaining generally uniform from southern Somerset Island to the Gulf of Boothia.

*3- Borden Peninsula Plateau:* This ecoregion covers the Borden Peninsula of north-central Baffin Island and the southwestern coast of Bylot Island along Navy Board Inlet and forms an inland plateau, shaped on flat-lying Palaeozoic and late Proterozoic carbonate rocks that slope gently southward. Elevation above sea level ranges between 300 and 765 meters. Dominant soils of the region include regosolic turbic cryosols with regosolic static cryosols developed on a variety of undulating glacial deposits.

*4- Melville Peninsula Plateau:* this ecoregion includes the western half of Melville Peninsula and much of northwestern coast of Baffin Island as far south as Nettilling Lake. The ecoregion includes part of the Melville Plateau physiographic region, a broad, gently warped, old erosion surface composed of crystalline Precambrian rocks that rise to about 460-610 meters ASL. This region includes the western portion of the uplands of Baffin Island where drainage begins to flow southwestward towards Foxe Basin. The plateau is divided into the Great Plain of the Koukdjuak with its broad belt of emerged, north-south- trending beaches in the center, and the Soper Highland, north of Koukdjuak River. Bedrock outcroppings are common, and turbic cryosols can be found developed on hummocky, thin, discontinuous sandy moraine. Organic and Static Cryosolic soils also occur in this ecoregion.

*5- Baffin Island Uplands:* Forming the central uplands of Baffin Island, this ecoregion is formed of a broad, gently warped, old erosion surface, shallowly etched by erosion along joint systems and zones of weakness. Its surface slopes gently to the southwest to an elevation of about 915 meters ASL near the Barnes Ice Cap. Bare bedrock is common, and dominant soils include turbic cryosols developed on sparse, thin, colluvial and morainal deposits.

*6- Foxe Basin Plain:* this ecoregion includes the islands and coastal lowlands surrounding Foxe Basin and is formed of flat-lying, Palaeozoic strata that create a very shallow basin like area on the surface of the Precambrian Shield. The Putnam Highland to the south of Koukdjuak River, reaches about 180 meters ASL in elevation. Dominant soils include turbic and static cryosols with some organic cryosols developed on marine, discontinuous glacial drift, and organic deposits.

*7- Pangnirtung Upland:* this ecoregion includes the lower coastal uplands on Baffin Island surrounding Cumberland Sound rising rapidly from sea level. A belt of deeply dissected, crystalline, archean rocks characterizes the region, with its general aspect being one of a broad, gently warped, old erosion surface etched by erosion along joint systems and zones of weakness. Glacier filled sounds or Fjords deeply penetrate the ecoregion characterizing coastal areas. Bare bedrock is common, and static cryosols with some turbic and some organic cryosols developed on discontinuous morainal, organic, and marine deposits, the dominant soils.

*8- Hall Peninsula Upland:* This ecoregion occurs at the upper elevations of the interior portion of Hall Peninsula on southern Baffin Island with a general physiographic aspect of a broad, gently warped, old erosion surface etched by erosion along joint systems and areas of weakness. The ecoregion rises to 1,160 meters ASL sloping southward and eastward towards the Labrador Sea. The region is characterized by dissected, steep-sided, glacier-filled valleys and hummocky surfaces sparsely covered by sandy glacial till. Bedrock outcrops are common, and turbic cryosols dominate.

*9- Meta Incognita Peninsula:* This ecoregion includes the coastal uplands of Baffin Island along Frobisher Bay and Hudson Strait, and stretches inland to include Amadjuak Lake. The ecoregion is characterized by irregular terrain extending westward from Frobisher Bay to Foxe Peninsula reaching elevations of 400 to 500 meters ASL. Rock outcroppings interspersed with sandy morainal veneers and frozen organic deposits dominate surficial materials. Dominant soils of the region include static cryosols with turbic and organic cryosols.

*10- Baffin Upland:* This ecoregion consists of the upper-elevation interior portions of Meta Incognita Peninsula on southern Baffin Island rising abruptly above sea level to 915 meters and draining southward towards Hudson Strait. The surface of the upland is thinly covered with discontinuous, sandy morainal veneers with bedrock outcroppings. Dominant soils include static cryosols with common bare bedrock outcroppings.

Within the Northern Arctic ecozone, summers are short and cold, with mean daily temperatures above freezing only in July and August. Mean annual temperatures vary from lows of -15$^{o}$ C within the Gulf of Boothia Plain ecoregion to -9$^{o}$ C along the coastal areas of the Pangnirtung Upland ecoregion. Mean winter temperatures range between -20$^{o}$ C within the Pangnirtung Upland ecoregion and -29$^{o}$ C within the Gulf of Boothia Plain, while summer mean temperatures range between 0.5$^{o}$ C within the Melville Peninsula Plateau and Gulf of Boothia Plain ecoregions to 2$^{o}$ C within the Foxe Basin Plain and Lancaster Plateau ecoregions. Daily winter temperatures average below -30$^{o}$C in the coldest areas of the ecozone, with persistent snow cover common between September and June. Annual ecozone precipitation is less than 250 mm with the greatest annual precipitation falling within upland sites. Within the Baffin upland ecoregion, mean annual precipitation often exceeds 500 mm, most commonly ranging between 300 and 500 mm. Moisture within this ecozone is plentiful residing within lakes, rivers, wetlands, permafrost, and in snow cover.

Wildlife diversity and abundance within this ecozone is generally low though cyclical for many species. Though more productive and diverse than the Arctic Cordillera ecozone, the northern arctic ecozone is home to an estimated 20 mammal species of the 200 found in Canada. Large mammal species within the Baffin Island portion of this ecozone include caribou, wolf, arctic fox, and polar bear. Other mammals include collared lemming, ermine, and arctic hare. Bird species such as snow, brant, and Canadian geese nest in moist wetlands that line coastal areas and river valleys. Eider and Long-Tailed ducks nest beside small ponds on grassy tundra. Rock Ptarmigan can also be found throughout much of this ecozone along with raptors such as Gyrfalcons and Peregrine falcons. Shorebirds, including the Black-Bellied Plover, Ruddy Turnstone, and Red Phalarope are common in this ecozone as are songbird species including Hoary Redpolls, Horned Larks, and Snow Buntings. Colonies of seabirds such as Thick-Billed Murres and Northern Fulmars are common along the many sheer cliffs found within this ecozone.

About 140 species of plants can be found within the Northern Arctic ecozone compared to the estimated 3,000 species found within southern Canada. Moss and lichen dominate the vegetative cover and are represented by over 600 species. Productive plant communities are most commonly found within coastal lowlands, sheltered valleys, and moist, nutrient-rich corridors along streams and rivers (Figure 4). These areas are known to support thick hummocky carpets of sedges, mosses, and lichens and are important to many species of wildlife. Herb and shrub species such as cranberry (*Vaccinium* spp) purple and three-toothed saxifrage (*Saxifraga* spp.), Mountain Avens, (*Dryas* *integrefolia*), Arctic willow (*Salix* spp.) with graminoide species such as Kobresia (*Kobresi*a spp.) and sedge (*Carex* spp) wood rush (*Hierochloe* spp) and rushes (*Juncus* spp) tend to dominate well-drained sites. Wetland sites of this ecozone tend to be dominated by willow (*Salix* spp) sedge (*Carex* spp.), and cottongrass (*Eriophorum* spp). Higher elevations within this ecozone tend to have very sparse vegetation. Species common within these upland sites include purple and three-toothed saxifrage (*Saxifraga* spp), Mountain avens (*Dryas integrafolia*), wood rush (*Hierochole* spp) and arctic willow (*Salix* spp). The Pangnirtung Upland and Meta Incognita Peninsula ecoregions support a nearly continuous cover of dwarf tundra vegetation consisting of dwarf birch (*Betula* spp), willow (*Salix* spp), northern Labrador tea (*Ledum* spp), mountain avens (*Dryas spp).*, and cranberry and blue berry (*Vaccinium* spp). Dwarf birch, willow, and alder (*Alnus* spp) occur on warm sites; wet sites are dominated by willow (*Salix* spp) and sedge (*Carex* spp). In contrast, the Borden Peninsula Plateau, Lancaster Plateau, and Baffin Islands Uplands ecoregions support very sparse plant cover with mosses dominating those sparse areas with vegetative cover.

Baffin Island communities within the Northern Arctic ecozone include Iqaluit, Kimmirut, Cape Dorset, Pangnirtung, Pond Inlet, and Arctic Bay, and on the northern tip of Melville Peninsula, Igloolik and Hall Beach. The estimated population of this ecozone is 8,000 to 10,000 people. The Inuit, who have occupied the area for a thousand years or more, form over 80% of the population. These communities feature a mixture of traditional and cash economies, largely depending on subsistence hunting, trapping, and fishing activities for the maintenance of independence and healthy lifestyles. The northern arctic ecozone is rich in mineral and hydrocarbon reserves creating conflicts with the long-term viability of wildlife populations both now and into the future. Baffin Land Iron Mines represents one such mining operation where long-term impacts on wildlife remain an ongoing concern.

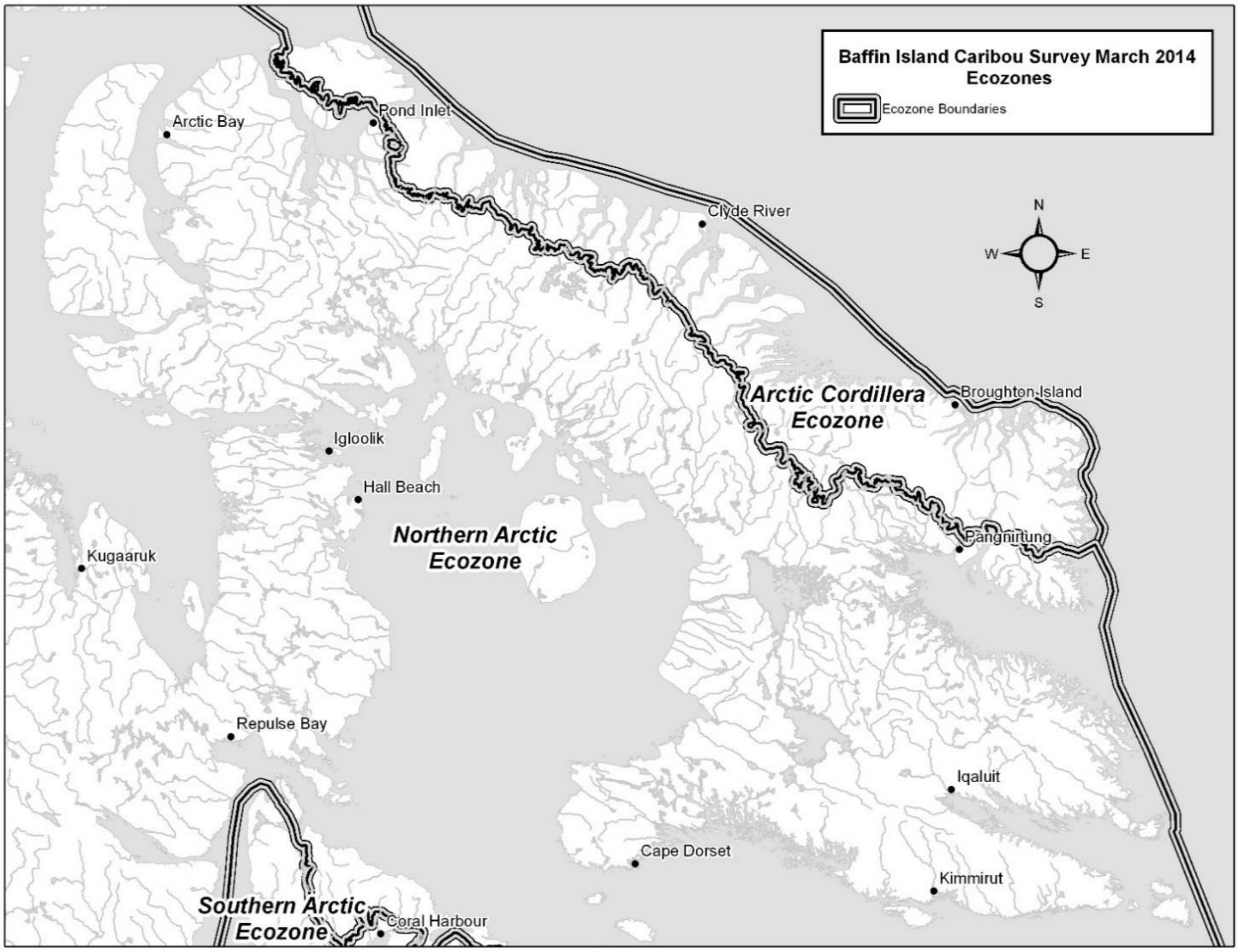


Figure 2. Ecozones of Baffin Island and proximal islands, and northern Melville Peninsula, Nunavut (after Environment Canada, 1995).

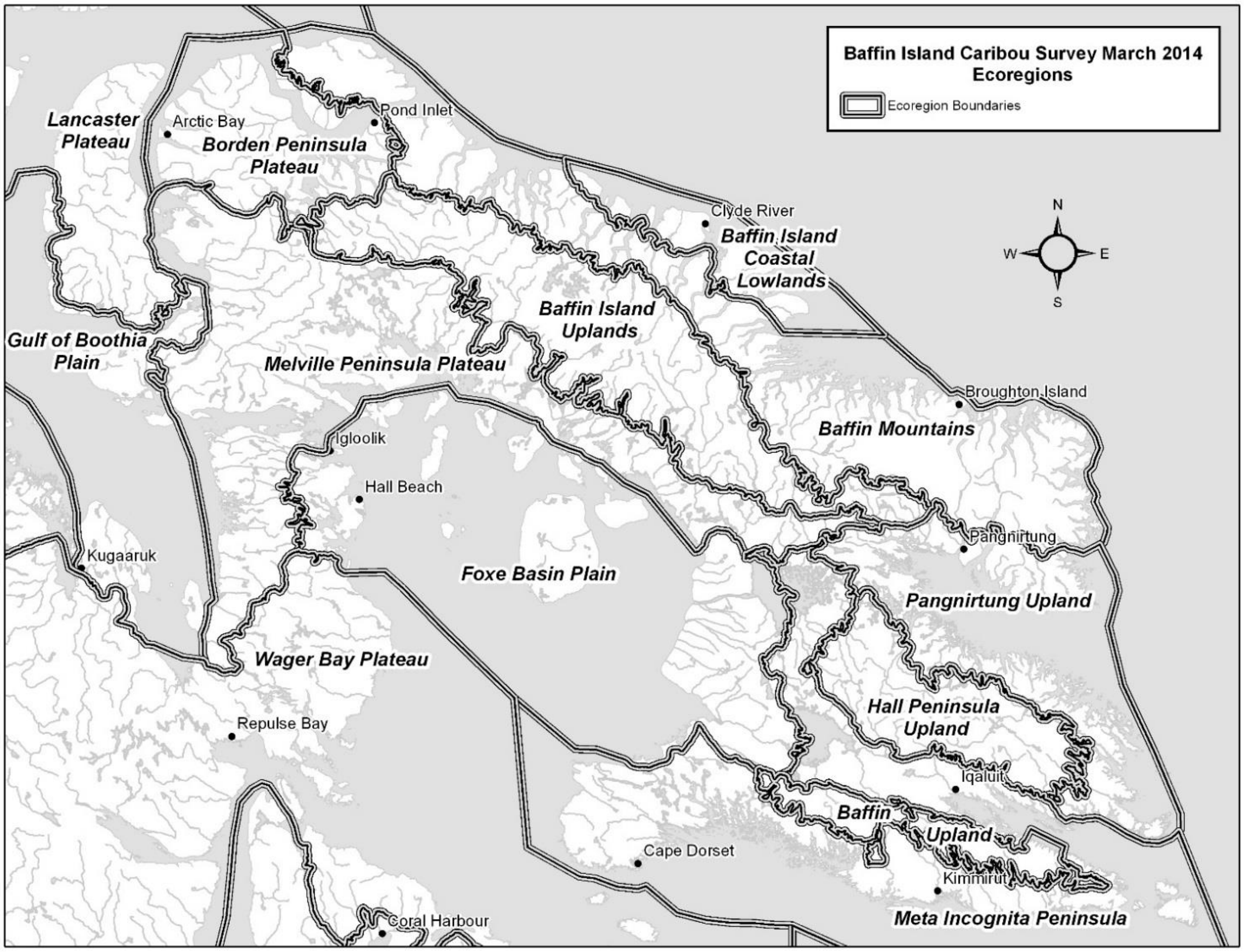


Figure 3. Ecozones of Baffin and proximal islands, and northern Mellville Peninsula, Nunavut (after Environment Canada, 1995).

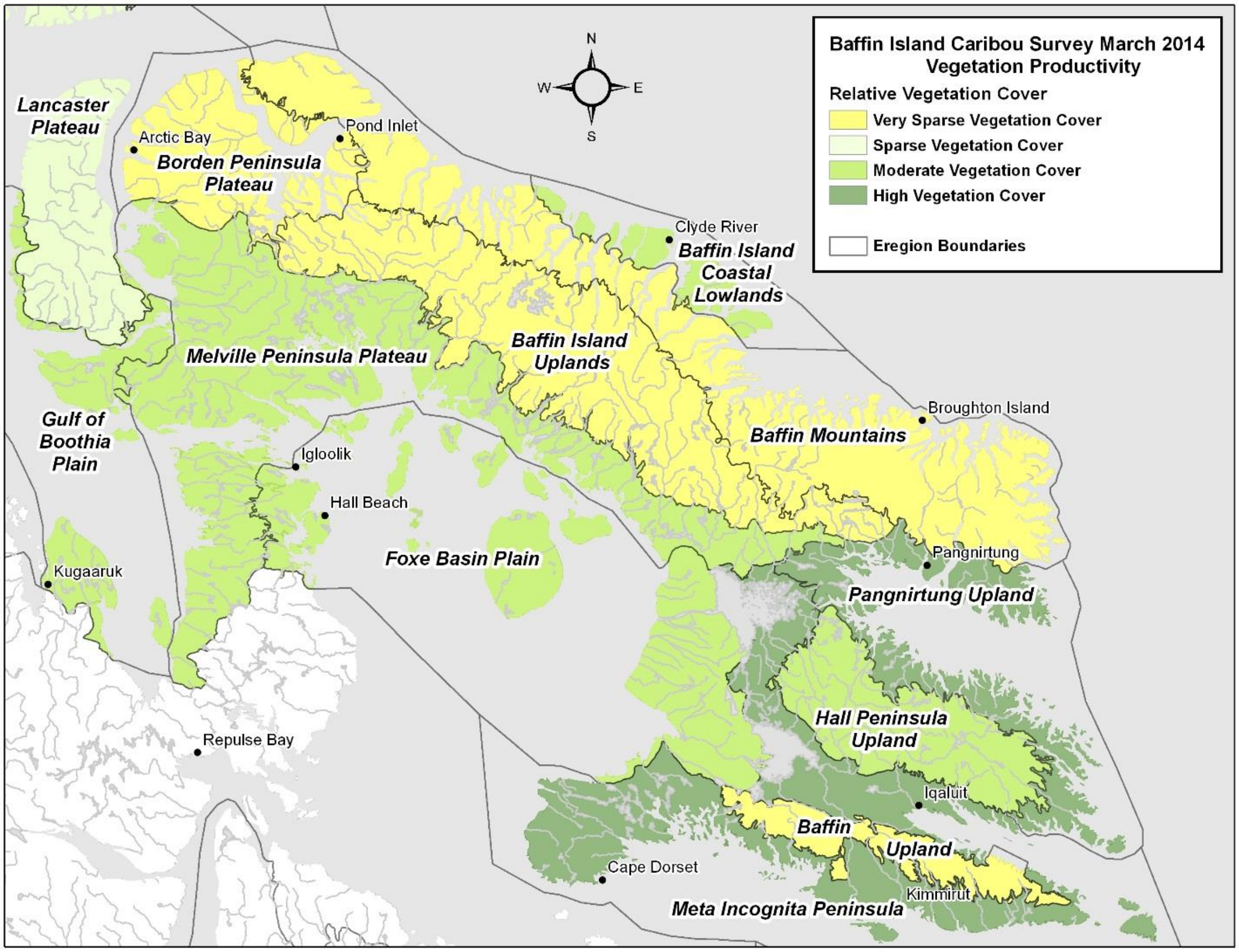


Figure 4. The relative productivity of plant communities within the ecoregions of the Baffin Island complex including northern Melville Peninsula. Productivity based on generalized plant species and cover assessments (after Environment Canada, 1995).

# 3.0 METHODS

The 2014 Baffin Island barren-ground caribou distance sampling, double observer pair visual survey was based out of the communities of Iqaluit, Pangnirtung, Cape Dorset, Clyde River, Pond Inlet, Arctic Bay, Igloolik, and Hall Beach. The survey was structured into two main components: 1) Pre-stratification using telemetry, past survey results and IQ collected during the consultation process, and 2) Distance sampling double observer pair aerial visual surveys and ground survey methods.

## 3.1 Survey Area and Stratification

The establishment of the survey area and the division of that study area into strata of similar relative densities of caribou was achieved prior to the March 2014 survey effort using past aerial survey and telemetry findings merged with local knowledge and/or IQ (Jenkins and Goorts, 2011; Jenkins et al., 2012; Goorts and Ross, 2014). Following a thorough review and spatial plotting of past survey observations across both north and south Baffin Island and satellite islands, including northern Melville Peninsula, an in depth round of HTO and community consultations was undertaken (Table 1). During consultations, all north and south Baffin Island communities as well as northern Melville Peninsula communities were visited with the primary objective of collecting IQ relating to the status of the north and south Baffin Island caribou groupings. Additionally, HTO members and community caribou experts were brought together through HTO and community meetings to discuss and to map relative densities and distributions of caribou across all of Baffin Island and ancillary Islands, and including the northern Melville Peninsula. The merging of past survey observations and telemetry data, with the mapped density distributions from consultations, yielded 5 main survey strata: 1) Zero caribou, 2) Zero to very low densities, 3) Low densities, 4) Low to medium densities, and 5) Medium to High densities of caribou (Figure 5).

Strata delineated as having no caribou (Stratum 1) were not surveyed while strata delineated as having zero to very low densities of caribou (Stratum 2) were ground surveyed by local hunters selected by community HTO's. Community-based HTO's organizing and engaging in ground surveys included Qikiqtarjuaq for north east Baffin, Clyde River for central north east Baffin, and Arctic Bay for north western Baffin Island. The remaining strata including Strata 3, 4 and 5 were surveyed using three fixedwing aircraft and one rotarywing aircraft. In addition, and in the event that ground survey results revealed low to medium (strata 3) relative densities of caribou within Strata 2 delineated areas, an aircraft would be diverted to the strata to conduct aerial observations. In such a circumstance, the strata 2 delineation would be upgraded to strata 3, and added to the aerial strata.

Financial and logistic constraints and weather modeling dictated the survey window and total number of aircraft required to successfully complete the survey. Survey effort, measured as transect spacing, was then allocated across survey strata based on the following constraints. Strata with the highest caribou estimated densities for the survey period would receive the highest level of coverage with survey effort for the remaining strata proportional to relative density of caribou. Stratum 5 received the greatest coverage with transects spaced 7 km apart, followed by 8 and 10 km spacing within strata 4 and 3, respectively. Effective strip width varied depending on sighability, which in turn was dependant on measured co-variates including cloud cover, speed, ruggedness, observer ability and snow cover. Effective strip width of survey transects were calculated for each strata across the survey study area (Table 2). Prince Charles Island was unique due to its greater than 95% snow cover and flat topography yielding conditions of exceptional sightability not encountered within the remaining strata. Effective strip width on Prince Charles Island was 2.44 km yielding 35% coverage (Table 2). The narrowest effective strip width, 0.92 km, was recorded on Foxe Peninsula and represented 9 % strata coverage. All remaining strata produced effective strip widths of between 1.15 km and 1.75 km with respective percent strata coverages of between 12% and 22% (Table 2).

Ground surveys were conducted utilizing caribou experts selected by the HTOs of the nearest community to a delineated strata 2 area. Areas were searched by snowmobile utilizing expert hunting and searching techniques captured within IQ and inherent to the Inuit culture. If caribou and/or their sign were detected within a stratum 2 area at relative densities consistent with stratum 3 delineations (>0.1 caribou/km2) then the stratum area was re-classified as stratum 3 and surveyed at 10 km spaced transects. In the instance where caribou are found, but at levels below 0.1 caribou/km$^2$, then the minimum count of caribou observed would be added to the overall estimate and no further treatment of the area undertaken. If the ground crews did not observe caribou, the stratum 2 area would be assessed as stratum 1, and no further action was taken.

Table 1. Baffin Island and northern Melville Peninsula community consultation schedule and participation.

| Community | Meeting | Date & Time | Attendees |
|---|---|---|---|
| Iqaluit | Amarok HTO | December 10, 2013, 1:00 PM | Joshua Kango (Chair), Methusalah Kunuk, Martha Padluq, Jetaloo Kakee |
| | Public | December 10, 2013, 7:00 PM | 10-15 people |
| | Public | January 18, 2014, 7:00 PM | 15-20 people |
| Cape Dorset | Aiviq HTO | December 12, 2013, 1:00 PM | Quvianatuliaq Tapaungai (Chair), Simigak Suvega, Qjmiataq Nunatsiutuq, Timmy Milikigali, Aningmiuq, Samayualie, Adamie Nuna, Oqituk Ashoona |
| | Public | December 12, 2013, 7:00 PM | 40 people |
| Pangnirtung | HTO | December 13, 2013, 1:00 PM | Noah Mosesee (Chair), Patrick Kilabuk, Jacopie, Maniapik, Andrew Nakashuk, Zebedee Qarpik |
| | Public | December 13, 2013, 7:00 PM | 60 people |
| Qikiqtarjuaq | Nattivak HTO | January 20,2014, 1:00 PM | Loasie Aliqatuqtuq, Robbie Qulluali, Lisa Kooniloosie, (Manager), Joanie Nutarala, Jacopie Nuqinga, Philipuusi, Sangoya, Aimuusi Qutsia |
| | Public | January 20, 2014, 7:00 PM | 35-40 people |
| Clyde River | HTO | January 21,2014, 1:00 PM | Jacobie Kunuk (Chair), Apiusie Apak (Vice-chair), Jaysie Tigullaraq, Mosa Palituq, Levi Palituq |
| | Public | January 21,2014, 7:00 PM | 55-60 people |
| Pond Inlet | HTO | January 22, 2014, 1:00 PM | Gerald Kunuk (Chair), Moses Kunuk, tommy Aglak, Elijah Panipakoocho, Paniloo, |
| | Public | January 22, 2014, 7:00 PM | 40-45 people |
| Arctic Bay | HTO | January 23,2014, 1:00 PM | Qaumayuk Oyukuluk (Acting Chair), Paul Ejaniaq, Koonoo Oyukuluk, Simeonie Olayuk, Andrew Muckpa, Norman Pauloosie, Levi Barnabas, Koona'rk Enoogoo, I key Kigutukajuk, |
| | Public | January 23,2014, 7:00 PM | 50-55 people |
| Igloolik | HTO | January 24, 2014, 1:00 PM | David Irngaut (Chair), Daniel Katalik, Judah Sarpinak, Jacob Maliki, David Aqqiaruq, Simonie Issigaitok, Natilino Piugattuk |
| | Public | January 24, 2014, 7:00 PM | 25-30 people |
| Hall Beach | HTO | Januaury 27,2014, 1:00 PM | Manasie Naullaq (Chair), Levi Kaunak, Sam Arnarjuaq, Daniel Arvaarluk, Luba Nangmalik (Manager) |
| | Public | January 27,2014, 7:00 PM | 15-20 people |
| Kimmirut | HTO | January 28, 2014, 1:00 PM | Pitseolak Qimiqpi, Kolola Pitseolak (Manager), Malikto Lyta, Joannie Ikillua, Palanga Lyta, Josepi Palluq, Joe Arluktuq (Chair) |
| | Public | January 28,2014, 7:00 PM | 20-25 people |

Table 2. Effective strip width and associated strata coverage for the nine (9) Baffin Island caribou survey strata (MRDS = mark-recapture distance sampling).

| ***Strata*** | ***MRDS Coverage (%)*** | ***Area ($km^2$)*** | ***Effective Strip Width (Km)*** | ***Half Strip Width (Km)*** |
|---|---|---|---|---|
| *Prince Charles Island* | 35 | 3289.80 | 2.44 | 1.22 |
| *Meta Incogneta Peninsula* | 17 | 6582.95 | 1.26 | 0.63 |
| *Hall Peninsula* | 20 | 13,020.30 | 1.51 | 0.75 |
| *Central Baffin* | 18 | 13,128.27 | 1.40 | 0.70 |
| *Mary River* | 22 | 8,609.37 | 1.75 | 0.88 |
| *Foxe Peninsula* | 9 | 3,349.16 | 0.92 | 0.46 |
| *North Central Baffin* | 15 | 6,289.85 | 1.53 | 0.77 |
| *Borden Peninsula* | 17 | 10,690.79 | 1.66 | 0.83 |
| *Melville Peninsula* | 12 | 3,264.53 | 1.15 | 0.58 |

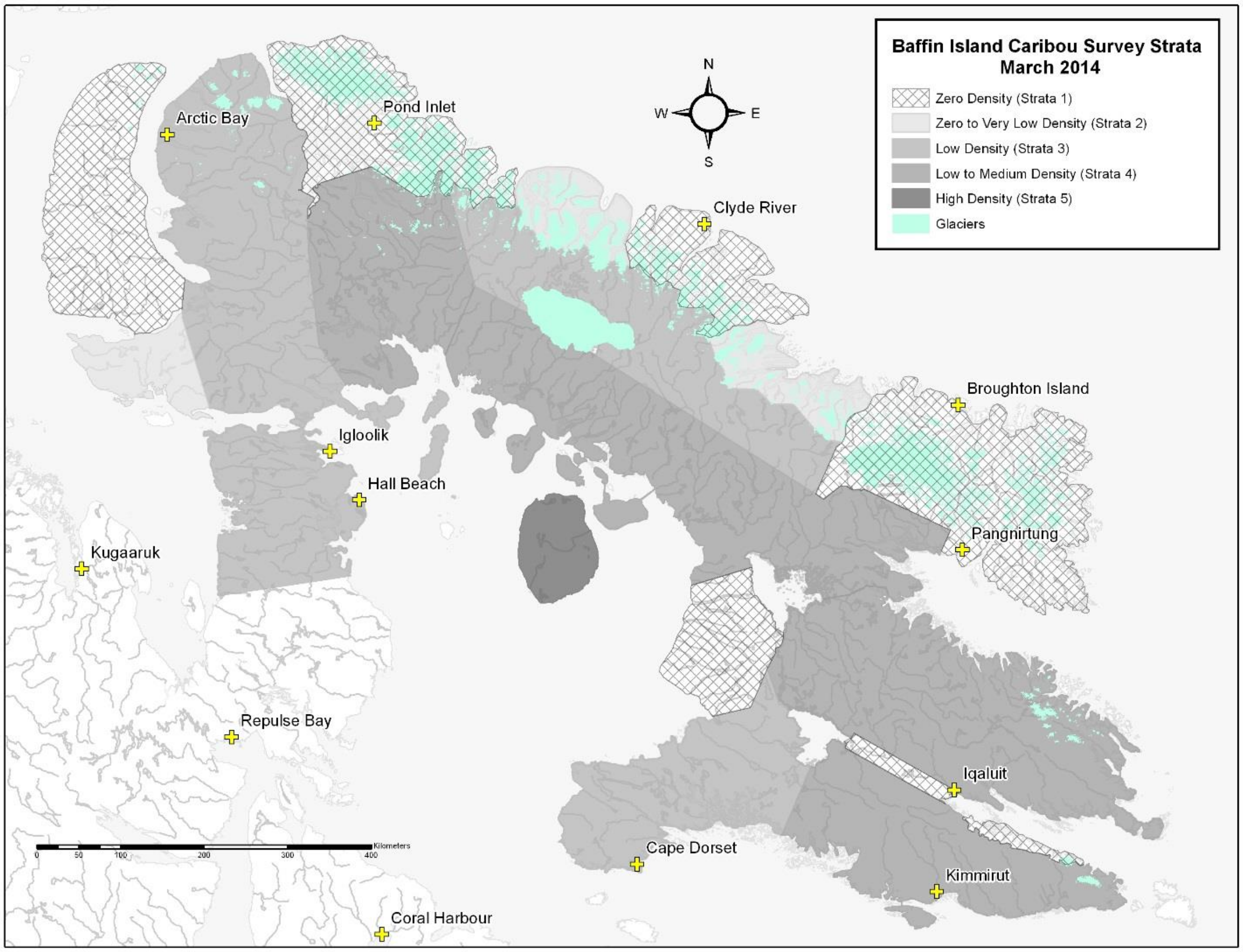


Figure 5. Strata representing relative densities of caribou across Baffin Island, satellite islands and northern Melville Peninsula. Strata derived through a synthesis of past aerial survey observations, telemetry results, and IQ collected during Baffin-wide HTO and community consultations.

## 3.2 Aerial Abundance Survey

The March 2014 Baffin Island and northern Melville Peninsula survey utilized a random, stratified, visual method, employing both distance sampling and double observer pair techniques. Transect spacing was allocated based on proportional densities as described in section 3.1 and flying effort allocated based on total available flying time (Heard, 1987). 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 (Figure 6). The entire aerial survey study area covered 398,016 $km^2$ and encompassed the known late winter extents of caribou across the survey area. In total, 419 transects with a mean transect length of 112 km were flown, yielding 53,548 line kilometers not including positioning and de-positioning. Transects were created using Environmental Systems Research Institute (ESRI) ArcMap Geographic Information System (GIS) software and were based on the World Geographic System (WGS) 1984 coordinate system projected into Canada Lambert conformal conic.

Three Cessna Grand Caravans and one Eurocopter A-star helicopter were used for all aspects of the visual survey across the study area. The rotary wing aircraft was used for the more rugged mountainous areas within the North Central and north Borden Peninsula strata 3 survey areas, while the fixed wing aircraft were utilized for all remaining survey strata and portions of strata. The visual observations were recorded using distance sampling, where five observational strips or bins, were marked out on left and right fixed wing struts. The 5 distance bins were divided across the strut into 0 to 200 meter, 200 to 400 meter, 400 to 600 meter, 600 to 1,000 meter, and 1,000 to 1,500 meter strips and based on analysis of previous south Baffin survey data (Jenkins et al.

2012) and guidelines for bin intervals for aerial surveys (Buckland et al. 1993) . Strip widths were marked using attached streamers at 0 meter, 1,000 meter, and 1,500 meter strut marks, while 1/8 inch wide black bungee cords were used against a white strut background to visually separate the remaining bins. Strip widths (w) were calculated using the formula from Norton-Griffiths (1978) (Figure 7).

$$w = W * h/H$$

*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 at survey altitude. For the rotary wing aircraft, observation distance from transect was recorded directly by flying to the location of the observation and recording a waypoint. Perpendicular distance from the transect was later calculated and the resultant value binned for consistency with fixed wing observation details. All aircraft were equipped with radar altimeters to ensure an altitude of 400 feet above ground level (AGL) was maintained precisely. Off-transect observations were avoided for the purposes of ensuring a more focused observation of the demarked distance bin visual strips. Observed caribou were classified where and when possible as adult cow, adult bull, calf and yearling.

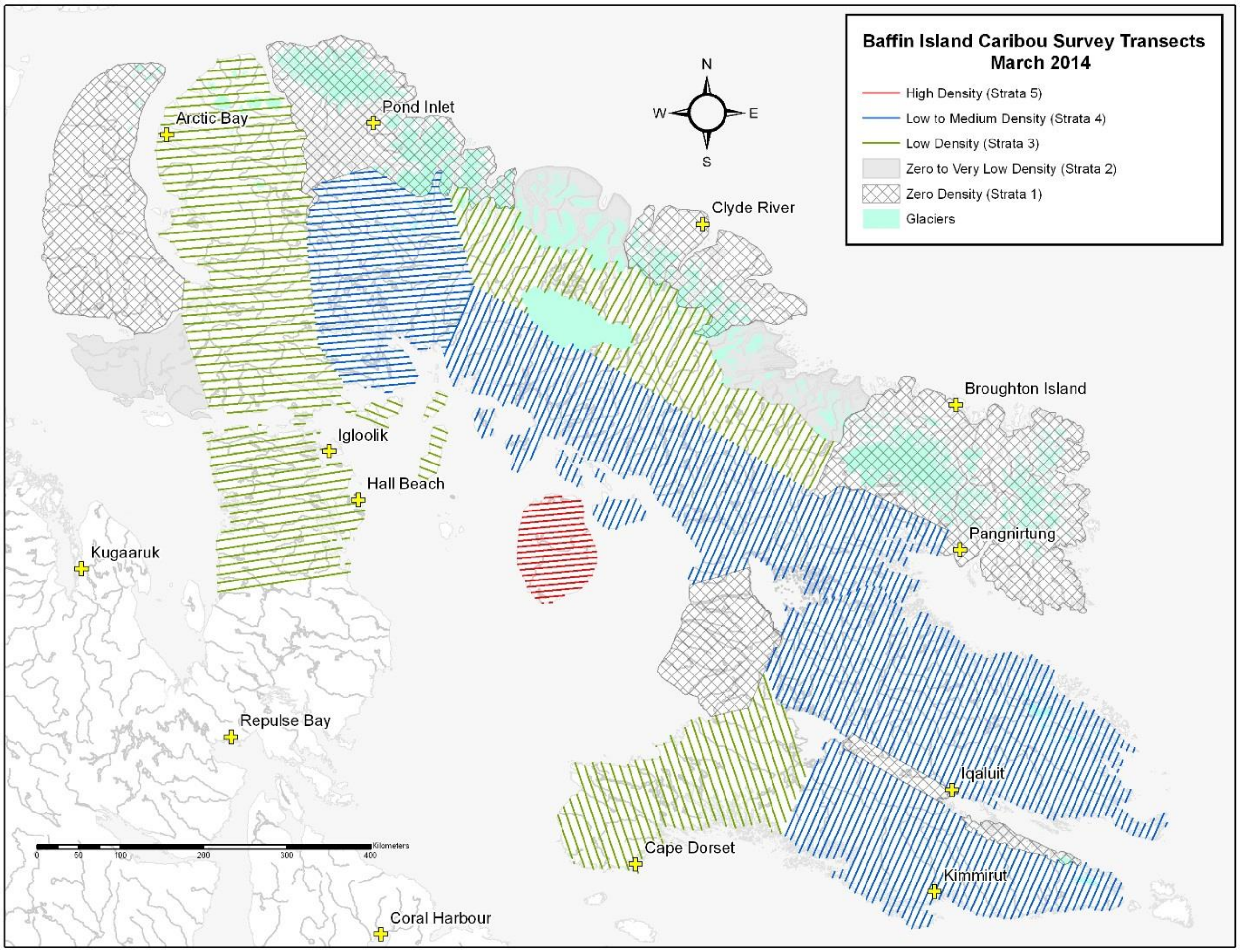


Figure 6. Survey transects systematically placed from a random starting point and flown late February and March 2014. Transect spacing based on strata representation of caribou relative densities (Strata 3 = 10 km; Strata 4 = 8 km; and Strata 5 = 7 km spacing).

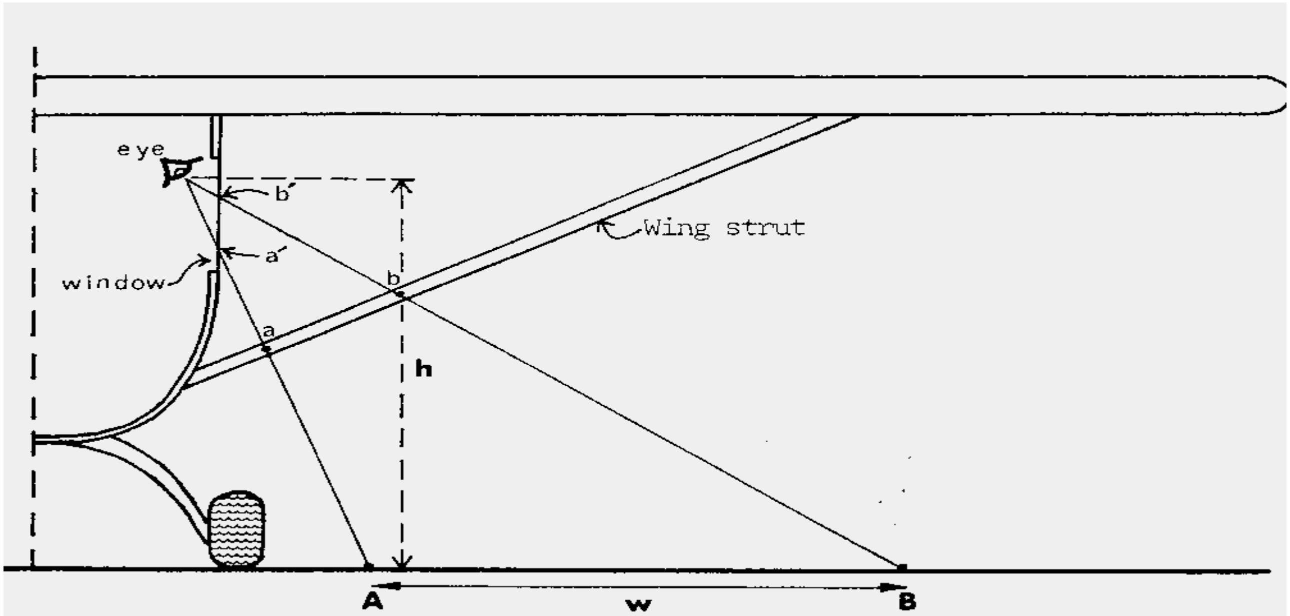


Figure 7. Schematic diagram of aircraft configuration for strip width sampling (Norton-Griffiths, 1978). W is marked out on the tarmac, and the two lines of sight a' – a – A and b' – b – B established. The streamers are attached to the struts at *a* and *b*, whereas a' and b' are the window marks.

$$w = W * h/H$$

*<u>Where</u>:*

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

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

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

Within the fixed wing platform a double observer method, using two dedicated observers on each side of the aircraft and two additional observer/data recorders on each side of the aircraft, were utilized throughout the survey. The rotary wing aircraft utilized a standard configuration of two dedicated observers, one on each of the left and right side of the aircraft and one observer/data recorder on the left side of the aircraft, and one Pilot/observer on the right. For the fixed wing strip transect survey, all caribou called by the observers included the bin/strip number in which they were seen, an assessment of composition where possible, and an index of snow cover. The observer/recorder recorded the species and number, the observation waypoint, airspeed, percent cloud cover, visibility, and an index of ruggedness. Observation elevations were added following the survey using an elevation model within spatial software.

The topography index was a general assessment of terrain ruggedness and slope. Observers and/or data recorders assessed the overall degree of slope within the immediate area of observed individuals/ groups, and recorded these observations numerically as flat (1), moderate (2), or steep (3). Ruggedness was assessed using a visual sweep across the entire survey strip on the side the observation was made. Ruggedness assessments were also recorded numerically as flat (1), rolling (2), and mountainous (3). By way of example, a ruggedness index of 1 / 2 would indicate the observation was made in a flat area within rolling terrain.

A snow patchiness index was assessed numerically by the observers within an estimated 100 meter buffer around the observation. Observations made in areas characterized by checkerboard patches of snow and open ground estimated to be 1 to 2 meters in size or less, were given a value of 1. Areas with checkerboard like patches 2 to 10 meters in size were recorded as a 2, while observations made within areas representing checkerboard patches 10 to 50 meters in size were given a value of three. Finally, observations made within areas of either contiguous snow cover or exposed ground, were assessed as a 4. Observations yielding a patchiness index of 4 (indicating a continuous background) would be further assessed using snow cover estimates recorded by the recorder/observer.

## 3.3 Double Observer Pair Visual Method

The double-observer pair configuration was utilized within all fixed wing aircraft to maximize sightability out of each of the left and right side of the aircraft by adding additional observers to each side (Campbell and Lee 2012 in prep; Campbell et al. 2014). Additionally the double observer pair configuration allowed each aircraft to maintain a minimum of two experienced wildlife observers on each of the left and right side of the aircraft throughout the survey. The method as applied to the present work involved two pairs of observers on each of the left and right hand sides of the aircraft in addition to one recorder/observer on each side of the aircraft. Of the dedicated observers, one "primary" observer sat in the front seat of the plane with a second "secondary observer" seated immediately behind the primary (**Error! Reference source not found.**8). The method as it applied to the Baffin Island survey effort adhered to five basic steps:

***1)*** The primary observer called out all groups of caribou (number of caribou and location) including the observation bin number he/she saw within each of the 0 to 200, 200 to 400, 400 to 600, 600 to 1000, and 1000 to 1500 meter distance bins. Primary observers were instructed to call observations before they passed the three o'clock (right) or nine o'clock (left) positions 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 (**Error! Reference source not found.**). The main instruction to observers 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 <u>additional</u> 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 recorders, 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". 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. As the data recorders were also experienced observers, data recorder observations would also be recorded.

The method used a combined distance sampling and mark-recapture approach to estimate abundance for survey stratum on Baffin Island. The basic approach involved using mark-recapture to estimate the probability of detection of caribou at 0 distance from the survey plane and distance sampling methods to estimate the decrease in probability of detection at greater distances from the plane. This approach ensured a more robust estimate than using distance sampling methods alone which assume that the probability of detection of caribou groups at 0 distance from the plane is 1 (Borchers et al. 1998, Buckland et al. 2004, Laake et al. 2008a, Laake et al. 2008b, Buckland et al. 2010, Laake et al. 2012). The Huggins (Huggins 1991) mark-recapture model in program MARK (White and Burnham 1999) was used for initial model selection of dominant covariates that affect sightability in the vicinity of the survey plane. For this analysis, observations were restricted to those that occurred within 400 meters of the survey plane.  A removal model formulation of parameters was used to account for the dependence of primary and secondary observers.

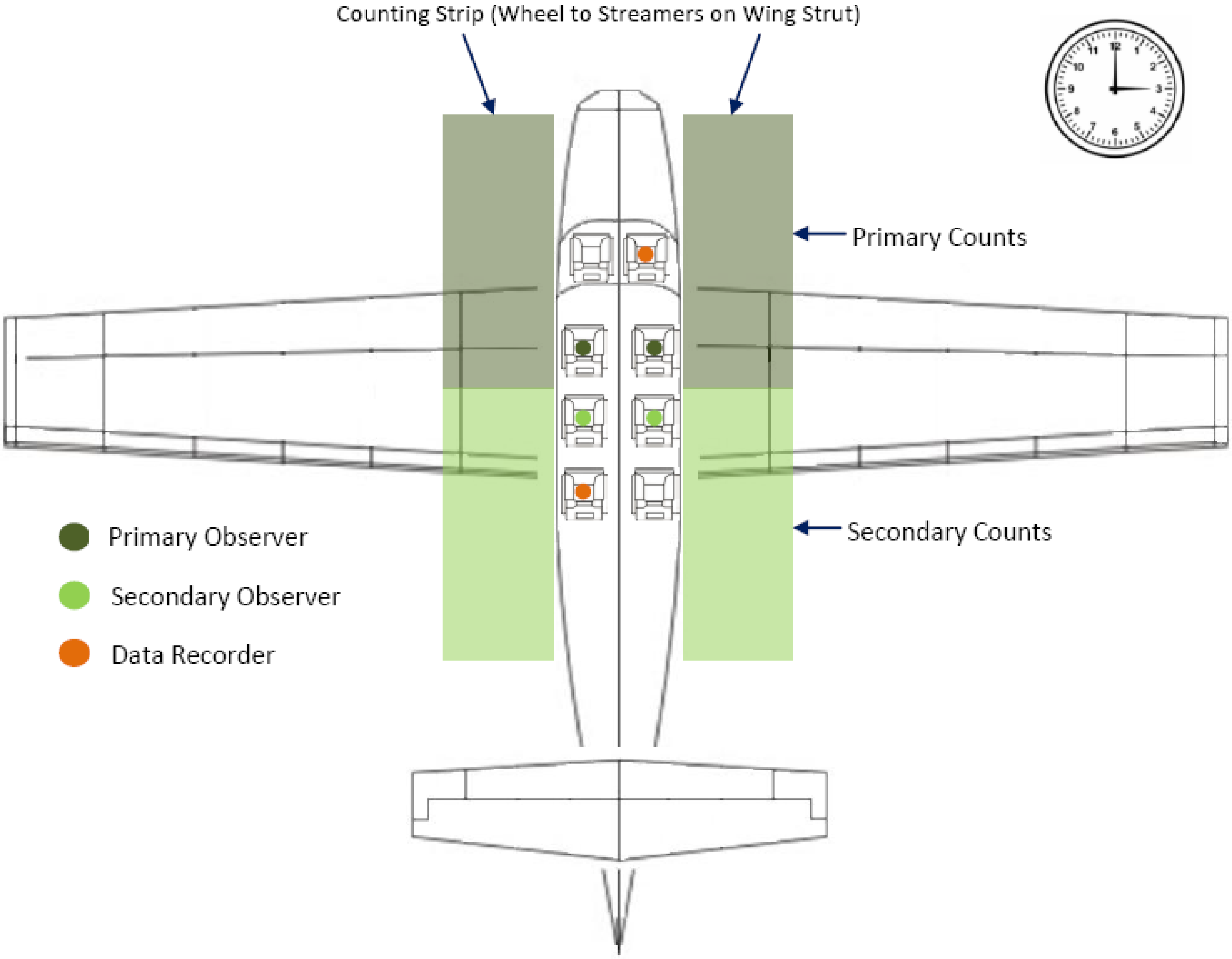


Figure 8. Observer position for the double observer pair method employed on this survey. The secondary observer calls caribou not seen by the primary observer after the caribou have passed the main field of vision of the primary observer. The small hand on a clock is used to reference relative locations 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 main covariates used in the analysis are listed in Table 3. The observer covariate corresponded to each primary observer in the survey (as detailed later in results). The distance covariate was mainly used in the mark-recapture analysis given that it is explicitly considered in the distance analysis. In addition, cosine and polynomial adjustment terms were used in the *DISTANCE* sampling analysis to generalize the shape of half-normal or hazard rate detection functions (Buckland et al. 2004). Information theoretic methods were used to compare candidate models (Burnham and Anderson 1992) and covariate predictions were assessed graphically to assess biological validity and model fit.

The most supported distance sampling and mark-recapture models were then used, combining the data sources into a single mark-recapture distance sampling analysis in R (R Development Core Team 2009) program MRDS (Laake et al. 2012). Combinations of the most supported models from each data type were tested in terms of relative model fit. The removal mark-recapture model in MRDS was used under the assumption of point independence of mark-recapture and distance sampling observations.

Alternative estimates for the survey area were derived in MRDS to explore the relative magnitude of estimates using different estimation methods. Estimates were produced from a model that used distance sampling methods with no mark-recapture component (assumed sightability on the survey line was 1). Estimates were also produced from a double observer pair mark-recapture removal model without a distance sampling component using observations of caribou that occurred less than 400 meters from the plane. This estimate emulated double observer pair strip transects methods used in other caribou surveys (Buckland et al. 2004, Buckland et al. 2010, Campbell et al. 2012, Boulanger et al. 2014). Finally, strip transect estimates assuming sightability of one in the 0-400 meter survey strip were generated in program *DISTANCE* using a uniform detection function.

Estimates of abundance and density for survey strata were produced from the most-supported MRDS model. Variance estimates for sub-regions were derived from the variance-covariance matrix of stratum estimates from the MRDS model. Log-based confidence limits were estimated using formulas from Buckland et al. (1993). Degrees of freedom for confidence limits for sub-regions were estimated using the variance and degrees of freedom of each stratum (Buckland et al. 1993).

Table 3. Covariates used in distance and mark-recapture analyses.

| ***Covariate*** | ***Acronym*** | ***Type*** |
|---|---|---|
| observer | ob1-7 | binary |
| distance bin from plane | distance | ordinal |
| group size | caribou | continuous |
| snow | snow | ordinal |
| cloud | cloud | continuous |
| snow patchiness | patch | ordinal |
| mountain terrain | mtn | binary |
| rolling terrain | rolling | binary |
| flat terrain | flat | binary |
| slope | slope | ordinal |
| airplane speed | speed | continuous |
| Prince Charles Island | PCI | binary |

## 3.4 2012 South Baffin Survey Re-Analysis

Within this report, we summarize a re-analysis of the 2012 Baffin Island caribou survey. The primary objective of these analyses was to use similar strata and distance sampling model formulations to allow direct comparison of the 2012 and 2014 abundance estimates. In addition, calves or short-faced yearlings were excluded from the original Baffin 2012 analyses, whereas they were included in the 2014 analysis. Therefore, this analysis was done with calves (34 total) included in modeling and estimates.

The primary field methods used in this survey are summarized in Jenkins et al. (2012). The main difference between the analysis conducted in the 2012 survey and the re-analysis was that strata were redefined so that the Prince Charles Island was a stand-alone strata and other strata were comparable to those sampled in 2014. We considered this a necessary adjustment to the 2012 analysis as sightability on Prince Charles Island was much greater than within any other strata in both 2012 and 2014, largely due to the near complete snow cover and flat terrain. The strata used in this analysis and how they compare with the 2012 and 2014 strata are summarized (Table 4**)**.

As with Jenkins et al. (2012), program *DISTANCE* was used for modeling and estimating strata abundance (Thomas et al. 2009). Similar methods to the 2014 survey were also used for this analysis with the exception that the 2012 survey used helicopters for surveys with single observers and delineated exact rather than binned distances. Unlike the 2014 survey, only slope and terrain ruggedness were recorded as covariates in 2012 (snow and cloud cover were not recorded). Multiple covariate distance sampling methods are listed, and were used to model sightability and distance distributions (Buckland et al., 2004) (Table 5). Strata-specific estimates and variances were obtained using the MRDS (Laake et al. 2012) module in program *DISTANCE*. This program uses variance estimates of Innes et al. (2002) for strata (with cluster size as a covariate) therefore avoiding the use of bootstrap methods for variance estimates when cluster size is a covariate.

Table 4. Summary of Baffin 2012 strata. All transects were spaced at 10 kilometers.

| ***Strata*** | ***Acronym 2012*** | ***Acronym 2014*** | ***Area ($km^2$)*** | ***Transect n*** | ***Total length (km)*** |
|---|---|---|---|---|---|
| *Central Baffin* | CB | CBI | 72705.26 | 51 | 6,841 |
| *Foxe Peninsula* | FP | CD | 36170.93 | 19 | 3,354 |
| *Hall Peninsula* | HP | HP | 65620.87 | 44 | 6,552 |
| *Meta Incogneta Peninsula* | MI | MI | 38991.32 | 32 | 3,986 |
| *Prince Charles Island* | PC | PCI | 9467.77 | 13 | 968 |

Table 5. Covariates used in the 2012 analysis.

| ***Covariate*** | ***Description*** |
|---|---|
| *Caribou* | number of caribou in group |
| *Slope* | ordinal value from 1 (flat) to 3 (steep) |
| *Topo* | flat, rolling, or mountainous |
| *Stratum* | stratum surveyed |
| *PCI* | PCI (vs Non PCI) stratum |

## 3.5 2009 North Baffin Reconnaissance Survey Analysis

The primary field methods used in this survey are summarized in Jenkins et al. (2012). Only one stratum was surveyed in 2009. The area of the stratum was 74,989 $km^2$, which was surveyed with 43 transects for a total transect length of 7,392 km. In comparison the 2014 North Baffin survey area, including the Borden Peninsula and Mary River strata, covered 106,000 $km^2$ with 93 transects for a total transect length of 11,651 km.

As with Jenkins et al (2012), program *DISTANCE* was used for modelling and estimates (Thomas et al. 2009). Similar methods to the 2014 survey were also used for this analysis with the exception that the 2009 survey used helicopters configured for two dedicated single observers and delineated exact rather than binned distances. Unlike the 2014 survey, no covariates were recorded during the survey.

Multiple covariate distance sampling methods were used to model sightability and distance distributions (Buckland et al. 2004). Covariates used are described in Table 5. Strata-specific estimates and variances were obtained using the MRDS module in program *DISTANCE* (Laake et al. 2012).

## 3.6 Subpopulation Delineation and Distribution

To date the only reported analysis of Baffin Island caribou telemetry data was made by Jenkins and Goorts (2011) within what they referred to as the north Baffin Island population. During their analysis, they used minimum convex polygons to delineate seasonal ranges for the North Baffin Caribou subpopulation (Jenkins and Goorts, 2011). This same telemetry data has never been used to report on possible caribou subpopulation delineation across Baffin Island. In this report, we utilized the telemetry data from two different caribou collar telemetry programs: 1) the North Baffin GPS telemetry program running between April 2008 and April 2011, and 2) the South Baffin satellite telemetry program running between April 1987 and April 1994. No reported analysis was found for the 1987 through 1994 data set. In the present work we re-analyzed the telemetry data collected by Jenkins and Goorts (2011) using kernel analysis techniques and daily movement rates to define seasonal use. For both data sets, we utilized the spatial analyst extension for Arc View 10, GIS (Geographic Information Systems) software.

A series of density maps based on a kernel analysis were developed to identify locations key to six major life cycles or seasons including: spring migration (April 5$^{th}$ to May 28$^{th}$), calving (May 29$^{th}$ to June 25$^{th}$), post-calving (June 26$^{th}$ to August 12$^{th}$), late summer and fall migration (August 13$^{th}$ to October 22$^{nd}$), rut and early winter (October 23$^{rd}$ to December 15$^{th}$), and winter (December 16$^{th}$ to April 4$^{th}$). Using a kernel analysis, seasons were delineated for each of the three delineated groupings within Baffin Island (North, South Central, and South East groupingss).

### 3.6.1 Utilization Distribution

The seasonal density data sets were analyzed to identify seasonal home ranges (the area each grouping occupies within a specified date range) and are based on a modified 100% utilization distribution boundary. The results of each of the density analyses were classified to yield a utilization distribution defined as the probability of finding a caribou within the range within the specified season or time period. The utilization distribution was grouped into 100%, 95%, 90%, 80% and 50% probability classes representing the utilization distribution within the seasonal home range. The 100% class encompasses the full extent of all caribou locations for the season/ time period of interest. The classes with lower percentage values are all nested within the higher classes (i.e., the 100% class contains the full extent of the 90% class, which in turn contains the full extent of all classes beneath it).

Areas with a higher utilization distribution are less critical because they encompass a larger extent of the landscape. For example, within a home range there is a 100% probability of caribou being present but much of the range is not being heavily utilized at any given time. Key habitats are those with higher densities of caribou as indicated by collar frequency. Key habitats represent a smaller proportion of the landscape and, as a result, have lower utilization distribution values when compared to the entire home range. The 50% class (the area where there is a 50% probability of the herd being found during the analysis period) represents the highest density class with half of the collar locations being found within these smaller areas over the period of study.

### 3.6.2 Spatial Analysis

Telemetry points were initially analysed (see Grouping Delineation) to identify which grouping annual range they maintained throughout the life of the collars. These assigned points were then used to generate kernel densities for each grouping using previously defined seasons derived through an analysis of daily movement rates over an analagous multi-year telemetry program extending onto southern Melville Peninsula (Nagy and Campbell, 2012). Seasons were assigned based on a seasonal movement analysis of the Wager Bay tundra wintering barren-ground caribou subpopulation as defined through previous studies (Nagy et al., 2011; Nagy and Campbell, 2012). The derived database was then utilized within a density analysis.

The density analysis used a search radius of 11 kilometres based on an identified zone of influence for barren-ground caribou within taiga environments (Boulangier et al. 2007). Due to the limited amout of spatial data points, seasonal ranges were delineated based on a modified version of the 100% utilization distribution developed to connect small individual patches of habitat, yielding contiguous polygons. During this process polygons, together with the 11 kilometre buffer zone, were dissolved and a negative buffer of 11 kilometres was then applied to reduce the size of the polygon to yield the range polygon. The resulting ranges were subsequently clipped to the land base to remove areas that extended into the ocean. Each of the six seasonal ranges were then merged together to develop the annual range for each grouping.

### 3.6.3 Grouping Delineation

Grouping associations were identified based primarily on annual rather than seasonal collar affiliations. We weighted collar affiliations most heavily on the rutting and calving periods. Finally, we examined movements of individual caribou through their collar life between calving and rutting areas to determine reproductive fidelity along with annual and seasonal range fidelity. Individual collars identified as sharing common annual and seasonal extents with fewer than 10% of that collar group utilizing more than one consistent calving and/or rutting area would be delineated as a grouping.

# 4.0 RESULTS

## 4.1 2014 Abundance Estimates

In total, 1,157 caribou were observed within the Baffin Island and northern Melville Peninsula March 14, 2014 survey study area (Table 6). We observed 50 caribou on transect in 8 groups within north Baffin strata, 347 caribou in 104 groups within South Baffin strata (not including Prince Charles Island), 557 caribou in 164 groups on Prince Charles Island, and 31 caribou in 7 groups on northern Meville Peninsula. In total, 1,157 caribou were observed within 289 groups across the entire 2014 survey area.

Table 6. Summary of observations and group sizes of caribou observed on transect during the 2014 Baffin Island survey. An observation is defined by a caribou group sighted within a single distance bin.

| Groupings | Stratum | ID | Observations | | Group size | | | |
|---|---|---|---|---|---|---|---|---|
| | | | n | caribou | mean | std | min | max |
| South East Baffin | Meta Incognita Peninsula | MI-4 | 23 | 102 | 4.43 | 2.59 | 1 | 10 |
| | Foxe Peninsula | CD-3 | 2 | 20 | 10.00 | 5.66 | 6 | 14 |
| | Hall Peninsula | HP-4 | 41 | 187 | 4.56 | 3.42 | 1 | 12 |
| South Central Baffin | Central Baffin | CBI-4 | 38 | 197 | 5.18 | 4.05 | 1 | 15 |
| North Baffin | Mary River | MR-4 | 7 | 49 | 7.00 | 4.12 | 2 | 13 |
| | Borden Peninsula | BP-3 | 1 | 1 | 1.00 | | 1 | 1 |
| | Miscellaneous Islands | IS-3 | 0 | 0 | 0.00 | 0.00 | 0 | 0 |
| North East Baffin | North East Baffin | NCB-3 | 6 | 13 | 2.17 | 0.75 | 1 | 3 |
| Prince Charles Island | Prince Charles Island | PCI-5 | 164 | 557 | 3.40 | 2.27 | 1 | 14 |
| Supplementary survey | Melville Peninsula | MP-3 | 7 | 31 | 4.43 | 1.81 | 2 | 7 |
| **Totals** | | | **289** | **1,157** | | | | |

## 4.2 Mark-recapture estimation of detection

Inspection of the configuration of observers revealed that in most cases observers did not switch places during the survey (Appendix 1). In general, the strongest observer was given the primary position. Therefore, the number of primary observers was reduced to 8 (Table 7). In one plane, the data recorder recorded a relatively large number (17) of caribou groups that the primary and secondary observers missed. To allow inclusion of these observations, the data recorder was assigned as the secondary observer in this plane and the primary and secondary observers were assigned as primary observers. This revised formulation revealed that the naïve sighting probabilities of this group (0.72) were lower than any of the other primary observers. Therefore, this observer pairing (observer number 4) was considered explicitly in the mark-recapture analysis. Recorders did not record caribou observations consistently in other planes and therefore these observations (6 observations of 27 caribou total) were not included in analyses. A very low number of observations (3) was made from the helicopter. This sample size was too low to allow estimation of helicopter-specific sighting probabilities.

As discussed later, the dependent observer estimation method only allows estimation of the primary observer and assumes equal detection probabilities between observers (Buckland et al. 2004, Buckland et al. 2010). Therefore, not switching observers makes the assumption that sighting probabilities of the primary observer equals the secondary. If the primary has a higher probability of seeing a caribou then sighting probabilities will be overestimated, which will lead to a negatively biased abundance estimate.

The number of observations were roughly equal for each distance bin (Table 6). The larger number of observations in the bins that were further from the plane was partially due to the larger distance interval (and larger area) sampled by these bins. However, naïve detection probabilities of the primary observer did not decline appreciably with distance (Table 8). This lack of decrease was presumably caused by increased heterogeneity of detection rates at further distances, as demonstrated in other distance sampling studies (Laake et al. 2008a).

Model selection initially focused on evaluating the influence of each of the covariates that might affect sightability (Table 9). Many of the covariates had less support than a constant model (Table 9: Model 19) suggesting that they did not affect sightability as indicated by the double observer pair data. Of the covariates considered, a covariate that had unique detection probabilities for observer 4 (ob4), observations on Prince Charles Island (PCI), and different slopes (slope) and cloud cover, were most supported as indicated by delta AICc values of less than 2.

Table 7. Primary observers and numbers of observations seen only by the secondary, primary, and both observers. Naïve estimates of detection for the primary observer (p(primary)=secondary/both) are also displayed.

| ***Obn*** | ***Primary observer*** | ***Secondary Only*** | ***Primary Only*** | ***Both Observers*** | ***p(primary)*** |
|---|---|---|---|---|---|
| *1* | L I | 3 | 3 | 73 | 0.96 |
| *2* | J I | 1 | 10 | 14 | 0.93 |
| *3* | R K | 3 | 13 | 40 | 0.93 |
| *4* | C S /2nd | 20 | 0 | 72 | 0.72 |
| *5* | L K | 1 | 1 | 5 | 0.80 |
| *6* | Miscellaneous observers | 1 | 2 | 6 | 0.83 |
| *7* | J | 0 | 2 | 10 | 1.00 |
| *8* | Helicopter | 0 | 0 | 3 | 1.00 |

Table 8. A summary of frequencies of observations seen by secondary, primary and both observers by distance from plane bin. Naïve estimates of detection for the primary observer (p(primary)=secondary/both) are also displayed.

| ***Distance bin.*** | ***Secondary Only*** | ***Primary Only*** | ***both*** | ***p(primary)*** |
|---|---|---|---|---|
| *0-200 m.* | 5 | 4 | 50 | 0.90 |
| *200-400 m.* | 2 | 6 | 46 | 0.96 |
| *400-600 m.* | 13 | 1 | 42 | 0.69 |
| *600-1000 m.* | 6 | 10 | 35 | 0.83 |
| *1000-1500 m.* | 3 | 10 | 50 | 0.94 |
| ***Totals*** | ***29*** | ***31*** | ***223*** | ***0.87*** |

Table 9. Mark-recapture analysis of factors affecting sightability within 400 meters of the survey plane. Ob(4) indicates unique estimates for observer 4 (Table 6). The noPCI indicates a unique detection rate or slope for stratum other than Prince Charles Island. Akaike Information Criteria ($AIC_c$), the difference in $AIC_c$ values between the *i*th model and the model with the lowest $AIC_c$ value ($\Delta_i$), Akaike weights ($w_i$), number of parameters ($K$) and log-likelihood of the model are presented.

| # | Model | AICc | ΔAICc | $w_i$ | K | Deviance |
|---|---|---|---|---|---|---|
| 1 | ob(4)+PCI | 112.38 | 0.00 | 0.273 | 3 | 106.34 |
| 2 | ob(4)+PCI+slope | 113.01 | 0.64 | 0.199 | 4 | 104.94 |
| 3 | ob(4)+PCI+cloud | 113.26 | 0.88 | 0.176 | 4 | 105.19 |
| 4 | ob(4)+PCI+noPCI*snow | 114.40 | 2.02 | 0.099 | 4 | 106.33 |
| 5 | ob(4)+PCI+slope+snow | 115.05 | 2.67 | 0.072 | 5 | 104.94 |
| 6 | ob(4)+PCI+noPCI*slope+noPCI*snow | 115.05 | 2.67 | 0.072 | 5 | 104.94 |
| 7 | ob(4)+PCI+slope+snow+cloud | 116.56 | 4.18 | 0.034 | 6 | 104.41 |
| 8 | ob(4)+PCI+slope+snow+snow*patch | 117.02 | 4.64 | 0.027 | 6 | 104.87 |
| 9 | ob(4)+slope | 118.46 | 6.08 | 0.013 | 4 | 110.39 |
| 10 | ob(4)+caribou | 120.62 | 8.24 | 0.004 | 4 | 112.55 |
| 11 | caribou | 120.83 | 8.45 | 0.004 | 3 | 114.79 |
| 12 | caribou+ob(1,2,3,4) | 121.58 | 9.21 | 0.003 | 6 | 109.43 |
| 13 | Ob(123)+ob(4)+ob(567) | 122.13 | 9.76 | 0.002 | 3 | 116.09 |
| 14 | Ob(123)+ob(4) | 122.13 | 9.76 | 0.002 | 3 | 116.09 |
| 15 | ob(4)+flat | 122.24 | 9.86 | 0.002 | 4 | 114.17 |
| 16 | ob(4)+mtn+rolling+flat | 122.24 | 9.86 | 0.002 | 4 | 114.17 |
| 17 | distance+caribou | 122.25 | 9.87 | 0.002 | 4 | 114.18 |
| 18 | ob(4)+ob(567) | 122.36 | 9.98 | 0.002 | 3 | 116.32 |
| 19 | constant | 122.76 | 10.38 | 0.002 | 2 | 118.74 |
| 20 | distance+caribou+dist*caribou | 123.31 | 10.93 | 0.001 | 5 | 113.20 |
| 21 | ob(4) | 123.61 | 11.23 | 0.001 | 3 | 117.57 |
| 22 | distance | 123.64 | 11.26 | 0.001 | 3 | 117.60 |
| 23 | ob(4)+patch | 124.18 | 11.80 | 0.001 | 4 | 116.11 |
| 24 | ob(4)+snow+caribou+snow*patch | 124.48 | 12.10 | 0.001 | 6 | 112.33 |
| 25 | ob(4)+snow+patch+caribou | 124.49 | 12.11 | 0.001 | 6 | 112.34 |
| 26 | ob(4)+distance | 124.54 | 12.16 | 0.001 | 4 | 116.47 |
| 27 | ob(4)+snow | 124.78 | 12.41 | 0.001 | 4 | 116.71 |
| 28 | ob(4)+speed | 125.59 | 13.21 | 0.000 | 4 | 117.52 |
| 29 | ob(4) cloud | 125.63 | 13.25 | 0.000 | 4 | 117.56 |
| 30 | ob(4)+snow+snow*patch | 126.01 | 13.63 | 0.000 | 5 | 115.90 |
| 31 | ob(4)+snow+patch | 126.04 | 13.66 | 0.000 | 5 | 115.93 |
| 32 | Ob(1)+ob(2)+ob(3)+ob(4) | 126.05 | 13.67 | 0.000 | 5 | 115.95 |
| 33 | ob(4)+snow+patch+cloud | 128.07 | 15.69 | 0.000 | 6 | 115.92 |

## 4.3 Distance sampling estimation of detection function

Distance sampling analyses focused on finding a parsimonious model for the scale of the detection function that fit the observed detection frequencies. As with the mark-recapture analysis, model selection initially focused on evaluating the strengths of individual covariates. In addition, the overall goodness of fit of distance models was assessed using chi-square tests that compared observed and expected frequencies for each of the distance interval bins. Preliminary estimates of abundance for all the strata combined were also generated to assess the relative sensitivity of abundance estimates to different distance model parameterizations (Table 10). We note that these abundance estimates assumed similar encounter rates and caribou group sizes for all stratum and therefore are not as reliable of an estimate with stratum-specific parameterization. Therefore, estimates should be interpreted in a relative fashion. Abundance and density estimates with stratum-specific encounter rates and cluster sizes were generated as part of the MRDS analysis. One challenge was that the number of degrees of freedom available to test overall goodness of fit was limited to three (3) given the finite number of distance interval bins. Therefore, goodness of fit could not be tested for the more complex distance models.

The most supported covariates for the scale of the detection function were observations conducted on Prince Charles Island (PCI), observer 4 (ob(4) ), snow, and snow with a cosine adjustment terms as indicated by ΔAIC of less than 2. Lack of fit was suggested for all of the models (with 3 or less parameters) as indicated by p-values from the chi-square test of less than 0.05. One model (19) with 2 cosine adjustment terms did fit the data but also displayed some detection probability estimates of greater than 1, making the overall validity of the model questionable. The lack of fit was assessed graphically (next section) and assessed further in the MRDS analysis.

Estimates of abundance for all strata ranged from 4,711-5,156 for the most supported models.

Inspection of predicted detection probabilities relative to histograms of the distance bins revealed reasonable fit to the first 3 distance bins and the last distance bin but poor fit to the 600-800 meter bin (Figure 9). This was also reflected in the chi-square test where the score for the 600-800 meter bin was 5.8 and the total chi-square for all bins was 8.9. Therefore, the main lack of fit for the model was caused by the 600-800 meter bin. Predicted detection probabilities were greater than 0.2 for all bins which reduced risk of bias with the covariate models (Buckland et al. 2004).

Inspection of observed detection frequencies and predicted probabilities of detection revealed a large difference in detection probabilities and shape of the detection function for Prince Charles Island compared to other stratum (Figure 10). Caribou were seen at further distances on Prince Charles Island which resulted in high detection probabilities (>0.5) for all distance bins. For other strata, detections declined to lower levels and probabilities at the further distance bins. In both cases, the main lack of fit occurred at the 600-800 meter bin. The effect of cloud cover was to reduce the detection probabilities at further distances which was presumably due to reduced visibility.

Table 10. Model selection of Distance covariate models. Base detection functions (DF) are given for each model; HR infers a hazard rate detection model and HN symbolizes a half-normal detection function. Covariates are listed in Table 2. Akaike Information Criteria ($AIC_c$), the difference in $AIC_c$ values between the *i*th model and the model with the lowest $AIC_c$ value ($\Delta_i$), Akaike weights ($w_i$), number of parameters ($K$), number of parameters of adjustment terms ($K_{adj}$), and log-likelihood of the model are presented. In addition p-values for goodness of fit tests ($P(\chi^2)$) and pooled abundance estimates (N) and coefficient of variation of pooled estimates CV( $\hat{N}$) is given.

| No | DF | covariates | AICc | $\Delta AIC_i$ | K | $K_{adj}$ | LogL | $P(\chi^2)$ |
|---|---|---|---|---|---|---|---|---|
| 1 | HN | PCI cloud | 906.0 | 0.00 | 3 | 0 | -450.0 | 0.003 |
| 2 | HN | PCI cloud ob(4) | 906.4 | 0.36 | 4 | 0 | -449.1 | |
| 3 | HN | PCI cloud snow | 906.7 | 0.70 | 4 | 0 | -449.3 | |
| 4 | HR | PCI cloud cosine | 907.9 | 1.89 | 5 | 1 | -448.8 | |
| 5 | HN | PCI cloud caribou | 908.0 | 2.01 | 4 | 0 | -449.9 | |
| 6 | HN | cloud | 909.5 | 3.50 | 2 | 0 | -452.7 | 0.009 |
| 7 | HN | PCI cosine | 910.2 | 4.23 | 3 | 1 | -452.1 | 0.011 |
| 8 | HR | PCI cloud | 911.1 | 5.04 | 4 | 0 | -451.5 | |
| 9 | HN | PCI polynomial | 911.5 | 5.49 | 3 | 1 | -452.7 | 0.007 |
| 10 | HN | cloud snow | 911.5 | 5.52 | 3 | 0 | -452.7 | 0.002 |
| 11 | HN | PCI | 912.3 | 6.25 | 2 | 0 | -454.1 | 0.008 |
| 12 | HN | cloud snow patch | 913.1 | 7.07 | 4 | 0 | -452.5 | |
| 13 | HN | PCI recorderob | 913.2 | 7.21 | 3 | 0 | -453.6 | 0.002 |
| 14 | HN | PCI slope | 913.7 | 7.67 | 3 | 0 | -453.8 | 0.002 |
| 15 | HR | cloud | 913.7 | 7.70 | 3 | 0 | -453.8 | 0.006 |
| 16 | HR | cloud snow patch | 915.3 | 9.28 | 5 | 0 | -452.5 | |
| 17 | HR | cloud cluster | 915.8 | 9.82 | 4 | 0 | -453.8 | |
| 18 | HN | slope | 916.4 | 10.38 | 2 | 0 | -456.2 | 0.005 |
| 19 | HN | Cos(2adj terms)[A] | 916.5 | 10.50 | 3 | 2 | -455.2 | 0.326 |
| 20 | HN | Topography (pool) | 917.5 | 11.47 | 2 | 0 | -456.7 | 0.006 |
| 21 | HN | topo | 919.5 | 13.51 | 3 | 0 | -456.7 | 0.001 |
| 22 | HN | Cosine adjust | 919.9 | 13.90 | 2 | 1 | -457.9 | 0.034 |
| 23 | HR | Cosine adjust | 920.3 | 14.32 | 3 | 1 | -457.1 | 0.025 |
| 24 | HR | | 920.5 | 14.54 | 2 | 0 | -458.3 | 0.030 |
| 25 | HR | cluster | 922.5 | 16.50 | 3 | 0 | -458.2 | 0.007 |
| 26 | HR | snowpatch | 922.5 | 16.51 | 3 | 0 | -458.2 | 0.007 |
| 27 | HR | recorderob | 922.6 | 16.61 | 3 | 0 | -458.3 | 0.007 |
| 28 | HR | snow | 922.7 | 16.64 | 3 | 0 | -458.3 | 0.008 |
| 29 | HR | ob(4) | 922.7 | 16.69 | 3 | 0 | -458.3 | 0.004 |
| 30 | HN | | 923.2 | 17.20 | 1 | 0 | -460.6 | 0.012 |
| 31 | HN | primobn | 933.3 | 27.25 | 8 | 0 | -458.4 | |

[A]Model not suitable due to predicted values>1.

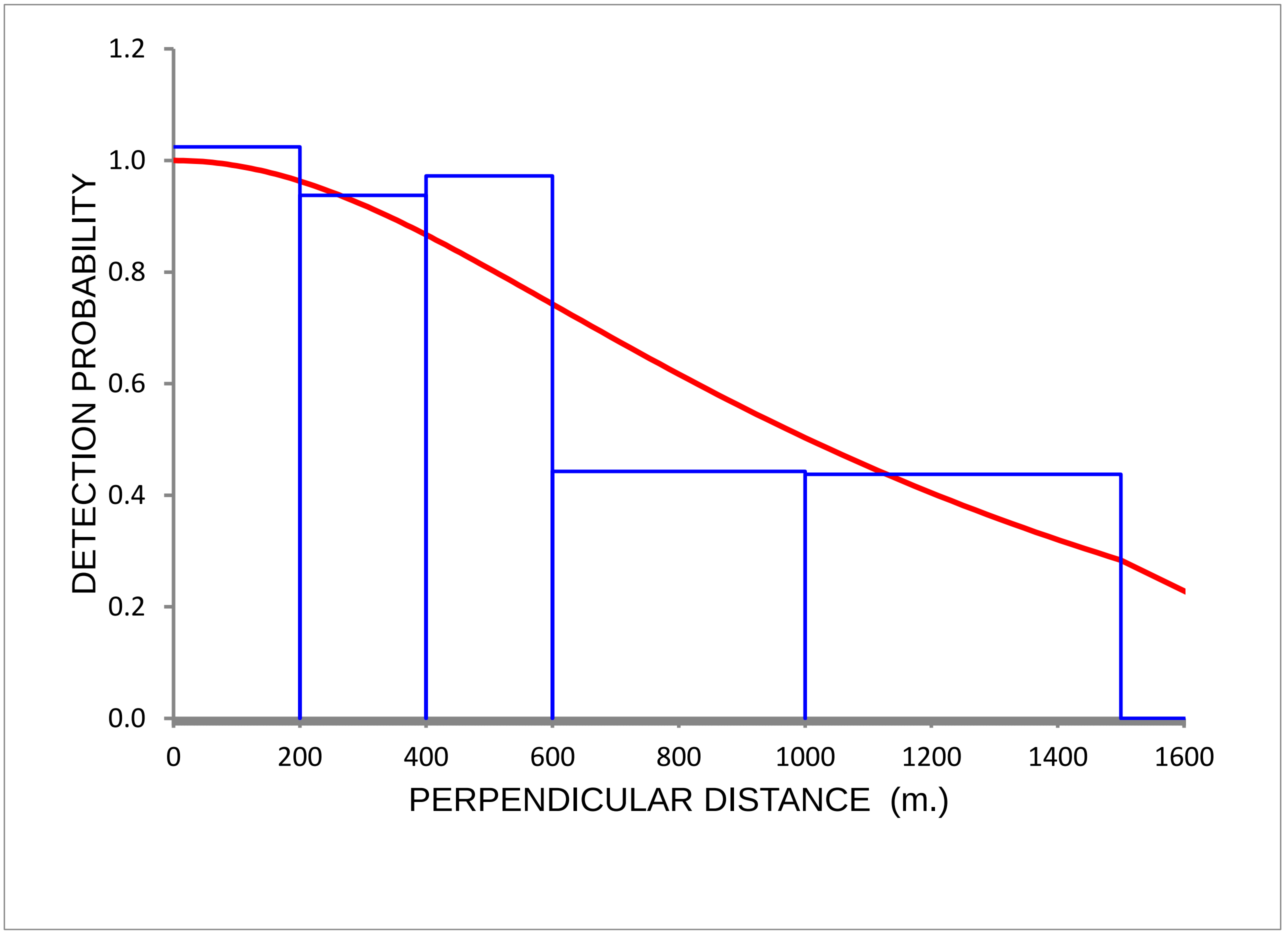


Figure 9. Fit of detection function from model 1 (Table 9). Fit is from model 1 in Table 1.

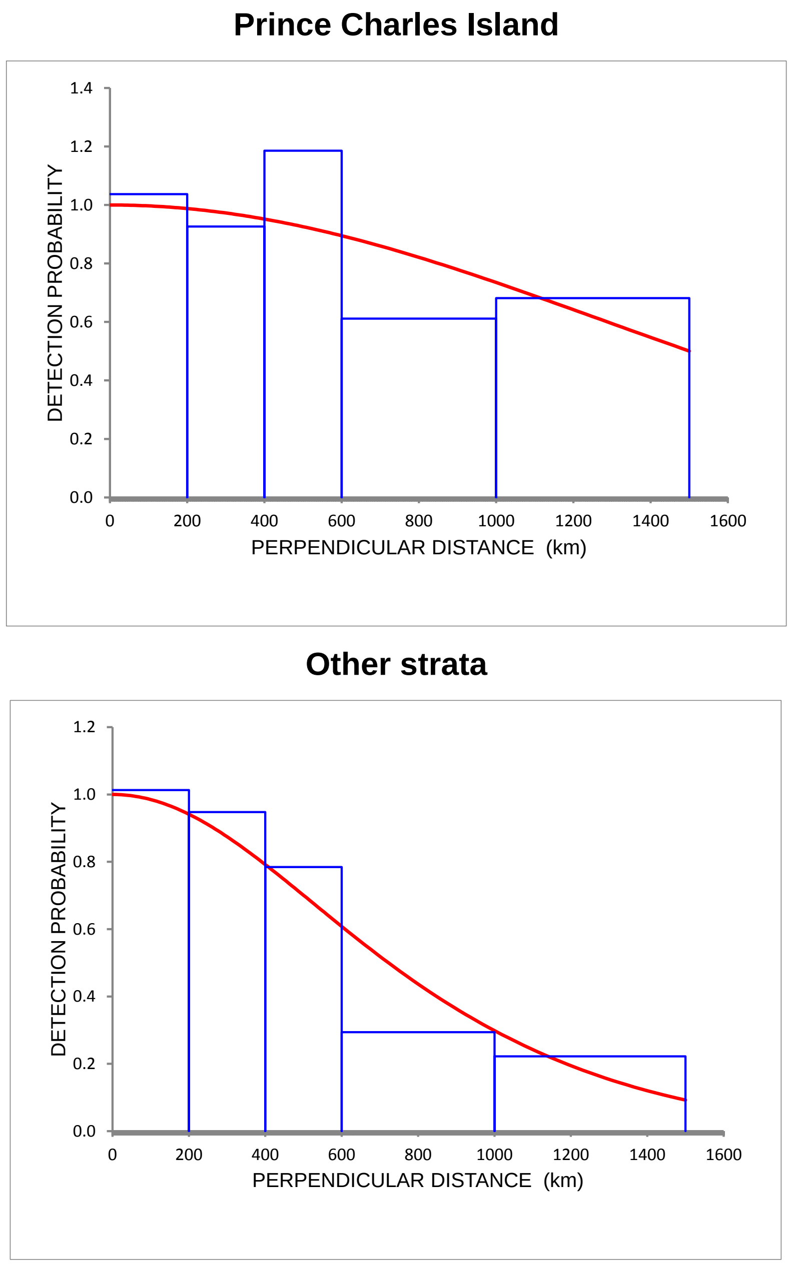


Figure 10. Frequencies of detection for each distance bin and predicted probabilities of detection from model 1 (Table 9).

## 4.4 Combined Distance and Mark-Recapture Model

The combined mark-recapture and distance sampling analysis suggested that the covariates supported in individual analyses were also supported in the joint analysis. Overall model complexity was limited with more complex models not converging (Table 11). A model that contained unique terms for observer 4 observations on Prince Charles Island for both the mark-recapture and distance sampling component was most supported (Model 1). In addition, Model 1 assumed observer detection probabilities varied with slope, and that cloud cover affected the scale of the distance detection function. A model with group number of caribou was retested for the joint model (given that group-sizes can bias line transect estimates if not accounted for) and it was not supported (Model 8). A model that forced the data to fit the 600-800 meter bin but without covariates (Model 10) was less supported than models with covariates. Models with covariates and adjustment terms of greater than 2$^{nd}$ order did not produce reliable estimates with detection probabilities being greater than 1 for some combinations of covariates and distance bin category. Abundance estimates varied minimally for the most supported models ($\Delta AIC_c<2$), suggesting minimal variation in estimates due to model selection uncertainty. The model averaged estimate of abundance was 4,867 (CV=14.6%) which was 7 caribou less than the estimate of model 1.

The average detection probability at the transect line from model 1 was 0.94 (SE=0.07) suggesting reasonably high sightability on the line. Detection plots with mark-recapture model estimates included suggested reasonable fit for the first 3 detection bins from combined observer and primary observer only data (Figure 11). Conditional detection probabilities were constant with distance, given that distance was not a covariate in the MR model. Regardless, there was minimal indication of change in detection probabilities with distance as estimated by the mark-recapture component of the analysis, a finding also supported by naïve estimates (Table 6).

The most supported MRDS model (Table 11, Model 1) still had marginal fit to the data ($\chi^2$=21.8, df=6, p<0.01) which as before was due to the lack of fit of the 600-800 meter bin. In detail, the total chi-square for the distance portion of the MRDS model was 10.4 with a chi-square score of 9.1 for the 600-800 meter bin. The Chi-square score for the mark-recapture component was 12.2 with 6 degrees of freedom suggesting acceptable fit for the mark-recapture portion (p=0.06). Therefore the lack of fit was primarily caused by lower frequencies of observations than predicted in the 600-800meter bin.

Lack of fit for the 600-800 meter distance bin would not be expected to significantly affect estimates given that the shoulder area of the distance curve is primarily used to estimate detection probabilities. We produced estimates for model 10 which used adjustment terms to fit the detection function as a means of testing the sensitivity of estimates to lack of fit to the 600-800 meter bin. The detection function from this model did fit the observed bin frequencies ($\chi^2$=2.06, df=1,p=0.15) as seen in a plot of the data (Figure 12). Estimates from this model (given next) provided a comparison with the covariate models that were more directly related to attributes of the data, but did not fit the 600-800 meter bin.

Table 11. Akaike Information Criteria ($AIC_c$), the difference in $AIC_c$ values between the *i*th model and the model with the lowest $AIC_c$ value ($\Delta_i$), Akaike weights ($w_i$), number of parameters ($K$), and log-likelihood of the model are presented.

| No | MR Covariates | DF | Distance Covariates | $AIC_c$ | $\Delta AIC_c$ | $w_i$ | K | LogL | $\widehat{N}$ | CV |
|---|---|---|---|---|---|---|---|---|---|---|
| ***1*** | ob(4)+PCI+slope | HN | PCI+cloud+ob(4) | 1040.1 | 0.0 | 0.36 | 8 | -516.5 | 4,872 | 0.15 |
| ***2*** | ob(4)+PCI+slope | HN | PCI+cloud+snow | 1040.4 | 0.3 | 0.26 | 8 | -516.7 | 4,871 | 0.14 |
| ***3*** | ob(4)+PCI+slope | HN | PCI+cloud | 1041.0 | 0.9 | 0.14 | 7 | -517.5 | 4,841 | 0.15 |
| ***4*** | ob(4)+PCI+slope+ snow | HN | PCI+cloud | 1041.8 | 1.7 | 0.06 | 8 | -517.4 | 4,841 | 0.15 |
| ***5*** | ob(4)+PCI+slope+ distance | HN | PCI+cloud | 1042.0 | 1.9 | 0.05 | 8 | -517.5 | 4,789 | 0.15 |
| ***6*** | ob(4)+PCI+slope | HR | PCI+cloud | 1042.0 | 1.9 | 0.05 | 7 | -517.9 | 4,972 | 0.16 |
| ***7*** | ob(4)+PCI | HN | PCI+cloud | 1042.2 | 2.1 | 0.04 | 6 | -518.5 | 4,826 | 0.14 |
| ***8*** | ob(4)+PCI+slope | HN | PCI+cloud+ob(4) +caribou | 1042.6 | 2.5 | 0.03 | 9 | -517.4 | 4,933 | 0.15 |
| ***9*** | ob(4)+PCI+slope | HN | PCI+ cosine (2) | 1045.1 | 5.1 | 0.00 | 7 | -519.5 | 5,435 | 0.16 |
| ***10*** | Ob(4)+PCI+slope | HN | Cosine order (2,3) | 1053.3 | 13.2 | 0.00 | 8 | -523.1 | 4,812 | 0.17 |
| ***11*** | ob(4)+PCI+slope | HN | constant | 1060.4 | 20.3 | 0.00 | 5 | -528.0 | 4,310 | 0.14 |
| ***12*** | ob(4)+slope | HN | cloud | 1061.9 | 21.9 | 0.00 | 5 | -528.8 | 4,573 | 0.13 |
| ***13*** | PCI | HN | PCI | 1072.7 | 32.6 | 0.00 | 4 | -534.6 | 4,514 | 0.12 |
| ***14*** | constant | HN | PCI+cloud | 1090.9 | 50.8 | 0.00 | 4 | -543.7 | 4,569 | 0.13 |
| ***15*** | constant | HN | constant | 1110.3 | 70.2 | 0.00 | 2 | -554.3 | 4,131 | 0.12 |

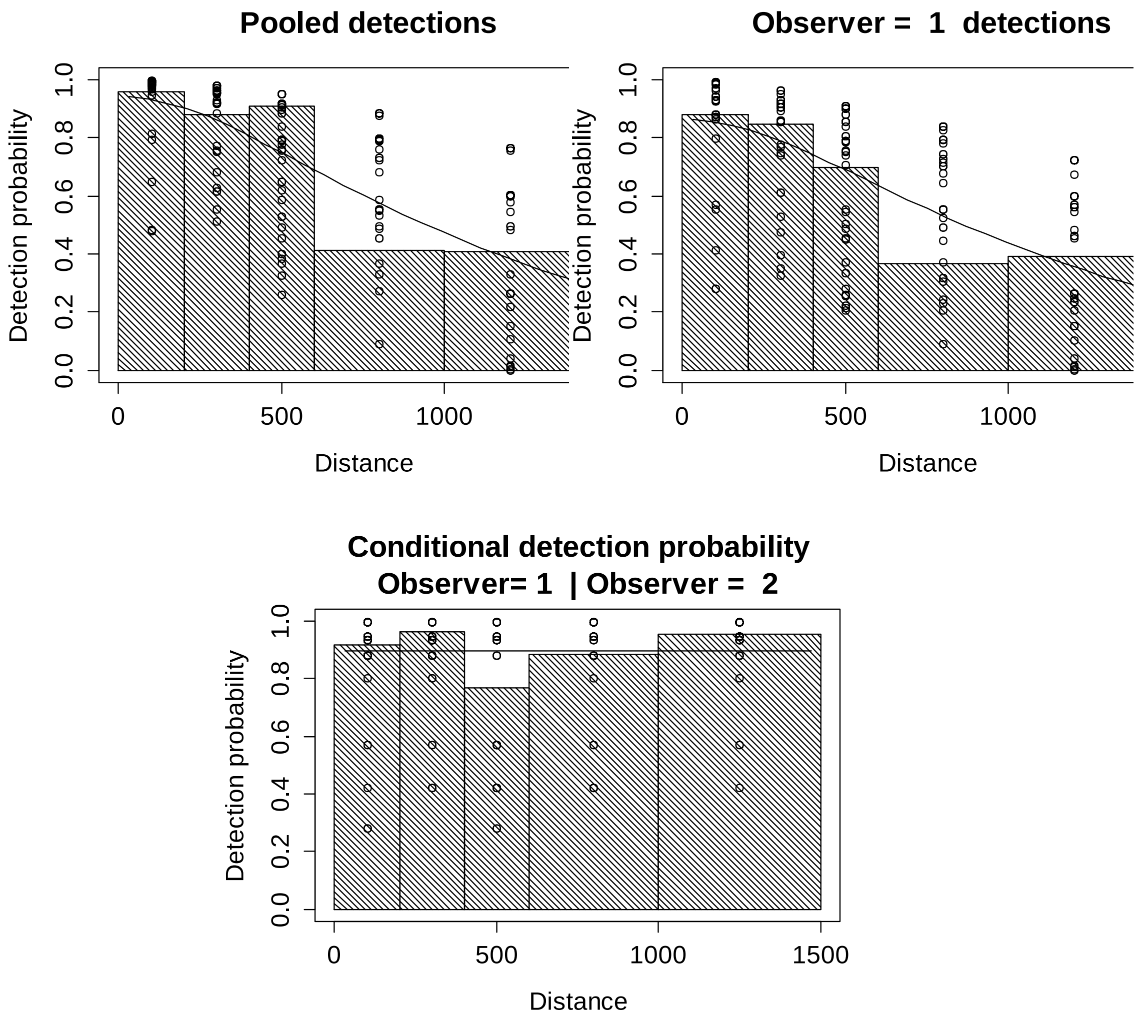


Figure 11. Estimates of detection probabilities from the joint mark-recapture distance sampling model 1 (Table 9) for pooled, primary observer detection. The conditional detection probability of the primary observer is estimated from the mark-recapture component of the model.

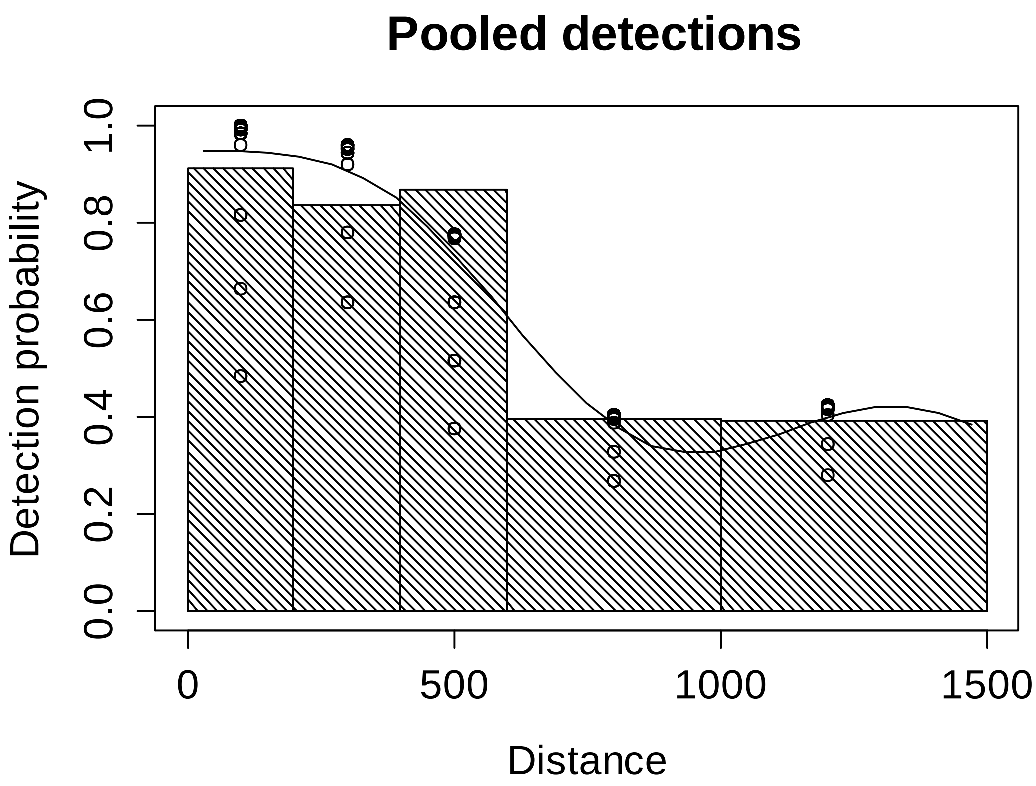


Figure 12. Detection function of half normal model with 2nd and 3rd order cosine terms added to force it to fit observed detections in the 600-1000 meter bin (Model 10, Table 7).

## 4.5 Abundance Estimates from the MRDS Models

The most robust estimation was the joint mark-recapture distance sampling model 1 (Table 11) which incorporated variation in detection probabilities from all the available data sources (Table 12, Model 1). Estimates from this model were compared to this model with adjustment terms (to force fitting of the 600-800 meter bin) (Model 2), a model with distance sampling only terms (which assumed sighting=1 at 0 distance from the aircraft) (Model 3) a double observer pair MR model that only used the MR model to estimate sightability (Model 4), and a strip transect model (that assumed sighting probabilities=1 for the 0-400 meter bins) (Model 5). The estimates from each model were reasonably close with the MRDS covariate model having the highest estimate and the strip transect model having the lower estimate. The minimal difference in estimates for the model with adjustment terms is not surprising given that the fit of the further distance bins has less influence on overall estimates. The higher coefficient of variation for this model suggested that the adjustment terms did not describe variation within the data set as efficiently as the covariates. It is likely the dip in detection at the 600-800 meter bin was a sparse data issue rather than a true source of variation. The lower estimate of the strip transect makes sense given that the strip transect model made the most restrictive assumption of sightability=1 for the entire=0-400 meter strip. This is further supported by the higher estimate of the double observer pair MR only model (Model 4) which estimated a detection probability of 0.98 (SE=0.021).

From this comparison, we concluded that the best estimate for Baffin Island was the MRDS model with covariates (Tables 11 and 11; Model 1). Estimates for grouping and stratum from this model are given in Table 13. In general, estimates for most stratum were imprecise except for Prince Charles Island where the most caribou were observed. The pooled estimate from the entire survey area and estimate for grouping was relatively precise though. Estimates of density revealed that densities of caribou on survey stratum were low, with the exception of Prince Charles Island (Table 14).

Table 12. Estimates of caribou for combined strata from various mark-recapture (MR) and distance sampling (DS) models.

| No | Analysis type | MR model | DS model | $\hat{N}$ | SE | CV | Conf. Limit | |
|---|---|---|---|---|---|---|---|---|
| 1 | MRDS (Model 1)[A] | ob4+pci+slope | PCI+cloud+ob4 | 4,872 | 712.2 | 14.6% | 3,661 | 6,484 |
| 2 | MRDS (Model 10) | ob4+pci+slope | cosine adj (2,3 order) | 4,812 | 836.7 | 17.4% | 3,426 | 6,757 |
| 3 | DS only | No MR model | PCI+cloud+ob4 | 4,590 | 596.0 | 13.0% | 3,559 | 5,921 |
| 4 | MR only (0-400m)[B] | ob4+pci+slope | No DS model | 4,577 | 619.3 | 13.5% | 3,510 | 5,968 |
| 5 | Strip (0-400m) [B] | No MR model | No DS model | 4,494 | 588.7 | 13.1% | 3,474 | 5,812 |

[A]As listed in Table 10

[B]Only observations within 400 meters of the plane were used for estimates and detection within the strip was assumed to equal 1.

Table 13. Estimates of abundance for groupings and survey stratum from the 2014 Baffin Island survey from Model 1 (Table 11). The number of individuals observed in each stratum is also given for reference.

| ***Strata*** | ***individuals*** | $\hat{N}$ | ***SE*** | ***CV*** | ***95% Conf. Limit*** | |
|---|---|---|---|---|---|---|
| ***North Baffin*** | | | | | | |
| *Borden Peninsula* | 1 | 6 | 5.7 | 99.5% | 1 | 30 |
| *Mary River* | 49 | 224 | 97.1 | 43.3% | 96 | 521 |
| *North Central Baffin* | 13 | 85 | 45.0 | 53.0% | 31 | 230 |
| ***Total*** | **63** | **315** | **108.8** | **34.6%** | **159** | **622** |
| ***South Baffin*** | | | | | | |
| *Central Baffin* | 197 | 1,091 | 278.4 | 25.5% | 662 | 1,798 |
| *Foxe Peninsula* | 20 | 216 | 183.4 | 84.9% | 48 | 972 |
| *Hall Peninsula* | 176 | 887 | 292.9 | 33.0% | 467 | 1,686 |
| *Meta Incognita Peninsula* | 91 | 539 | 207.5 | 38.5% | 256 | 1,138 |
| *Prince Charles Island (PCI)* | 557 | 1,603 | 249.8 | 15.6% | 1,158 | 2,220 |
| **Total** | **824** | **4,337** | **691.1** | **15.9%** | **3,169** | **5,935** |
| **Total (-PCI)** | **267** | **2,734** | **606.7** | **22.2%** | **1,777** | **4,207** |
| ***Other areas*** | | | | | | |
| *Melville Peninsula* | 26 | 220 | 101.3 | 46.0% | 88 | 551 |
| ***Total*** | ***1,130*** | ***4,872*** | ***712.2*** | ***14.6%*** | ***3,661*** | ***6,484*** |
| ***Total-MP (Melville Peninsula)*** | ***1,104*** | ***4,652*** | ***702.8*** | ***15.1%*** | ***3,462*** | ***6,250*** |

Table 14. Estimates of density for survey stratum from model 1 (Table 10). Density is expressed in caribou per 1000 km$^2$.

| *Strata* | *Area (km$^2$)* | $\hat{D}$ | *SE* | *CV* | *95% Conf. limit* | |
|---|---|---|---|---|---|---|
| ***North Baffin*** | | | | | | |
| *Borden Peninsula* | 64144.7 | 0.09 | 0.09 | 99.9% | 0.0 | 0.5 |
| *Mary River* | 39357.1 | 5.69 | 2.50 | 43.8% | 2.4 | 13.3 |
| *North Central Baffin* | 41126.0 | 2.07 | 1.10 | 53.3% | 0.8 | 5.6 |
| ***Total/Average*** | **144627.8** | **2.18** | **0.75** | **34.6%** | **1.1** | **4.3** |
| | | | | | | |
| ***South Baffin*** | | | | | | |
| *Central Baffin* | 72,705.3 | 15.01 | 4.09 | 27.2% | 8.8 | 25.5 |
| *Foxe Peninsula* | 36,170.9 | 5.97 | 5.09 | 85.1% | 1.3 | 27.0 |
| *Hall Peninsula* | 65,620.9 | 13.52 | 4.91 | 36.3% | 6.7 | 27.2 |
| *Meta-Incognita Peninsula* | 38,991.3 | 13.83 | 6.31 | 45.7% | 5.8 | 32.8 |
| *Prince Charles Island* | 9,467.8 | 169.30 | 28.95 | 17.1% | 119.4 | 240.0 |
| ***Total/Average*** | **222,956.2** | **19.45** | **3.09** | **15.9%** | **14.3** | **26.5** |
| ***Total/Average-PCI*** | **213,488.4** | **12.81** | **2.84** | **22.2%** | **8.3** | **19.7** |
| | | | | | | |
| ***Other areas*** | | | | | | |
| *Melville Peninsula* | 27,622.99 | 7.98 | 3.68 | 46.2% | 3.18 | 20.00 |
| | | | | | | |
| ***Total/Average*** | **395,206.9** | **12.33** | **1.80** | **14.6%** | **9.3** | **16.4** |
| ***Total/Average-MP*** | **367,584.0** | **12.65** | **1.91** | **15.1%** | **9.4** | **17.0** |

## 4.6 March 2014 HTO Led Ground Surveys

The HTO led ground surveys were carried out by the HTOs of Qikiqtarjuaq, Clyde River and Arctic Bay. The surveys were conducted by snowmobile over the course of six to seven days in early March 2014 in four ‘Strata 2’ delineated areas on Baffin Island (Figure 13). In total, approximately 32 caribou were observed in five groups (2 in Arctic Bay strata 2, over 30 in Clyde River North strata 2, 0 in Clyde River South strata 2, and 0 in Qikiqtarjuaq stata 2) (Table 15). Unfortunately, extensive harvesting of observed caribou occurred within all observed groups. Total harvest was unclear within the Clyde River strata and one of the 2 caribou observed within the Arctic Bay strata was reported harvested. Because of this harvesting activity the observed caribou were considered removed from the population and not included within the estimate. A breakdown of the individual ground survey results is provided.

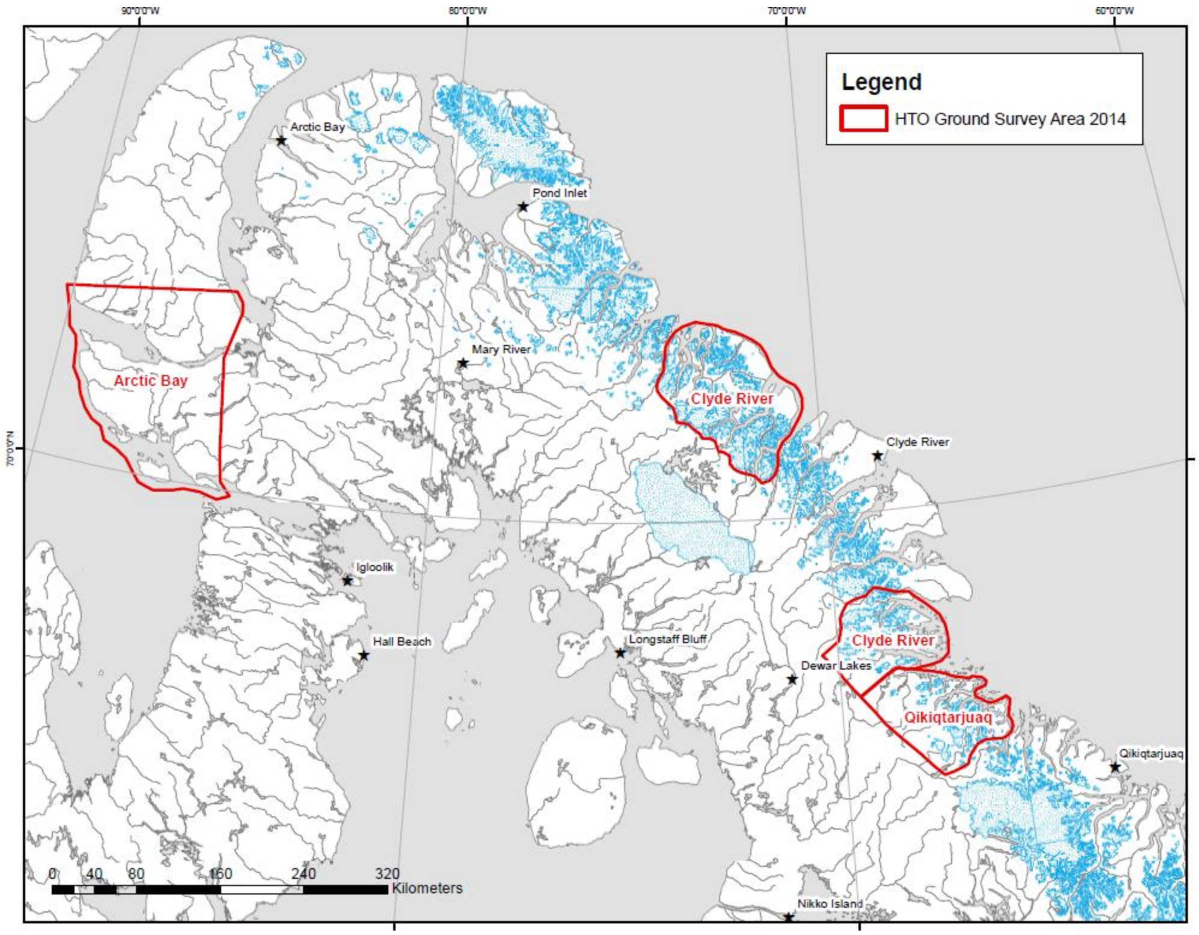


Figure 13. Strata 2 ground survey areas surveyed by snowmobile by the Qikiqtarjuaq (QIK-2), Clyde River (CR(S)-2 and CR(N)-2), and Arctic Bay HTOs (AB-2) in early March 2014. Strata 2 areas were delineated using input gathered during Baffin-wide community and HTO consultations, as well as past aerial survey and telemetry data.

Table 15. Summary of observations and group sizes of caribou observed during the HTO-led ground surveys in early March 2014. An observation is defined as a group of caribou within the immediate vicinity of each other.

| Grouping | HTO Ground Survey | Strata ID | Observations | | Group Size |
|---|---|---|---|---|---|
| | | | n | Total Caribou | |
| Northeast Baffin | Qikiqtarjuaq | QIK-2 | 0 | 0 | 0 |
| | Clyde River South | CR(S)-2 | 0 | 0 | 0 |
| | Clyde River North | CR(N)-2 | 4 | 30+ | 9 |
| | | | | | 21 |
| | | | | | unk* |
| | | | | | unk* |
| North Baffin | Arctic Bay | AB-2 | 1 | 2 | 2 |
| **Totals** | | | **5** | **32+** | |

*exact number of caribou observed in the group could not be determined by ground surveyors.

### 4.6.1 Qikiqtarjuaq HTO Led Ground Survey

The ground survey led by four Qikiqtarjuaq HTO appointed surveyors ran from March 3rd to 9th, 2014 in the southern-most 'Strata 2' centering on Nadlung Fiord and the area north of Auyuittuq National Park. No caribou or caribou sign were observed during the 6 day survey (Figure 14).

### 4.6.2 Clyde River HTO Led Ground Survey

The ground surveys led by the six Clyde River HTO appointed surveyors were conducted in early March 2014. Surveyors were split into two teams (three surveyors per team). One team surveyed the 'Stata 2' area located along the northeast coast of Baffin Island south of Clyde River (Figure 15). No caribou were observed in this area during the survey; however 'old' caribou tracks were observed in three separate locations, though an estimate of the number of caribou represented by the observed sign was not determined. The second team surveyed the 'Strata 2' area located along the northeast coast of Baffin Island, north of Clyde River around Remote Peninsula (Figure 16). Approximately 30 caribou (observations provided were not exact) were observed in four separate groups/ locations and caribou tracks (but no caribou) were observed in one location within the survey area. Exact numbers of caribou were recorded for two observations; however, there were two observations where caribou were seen but the exact number could not be determined. Surveyors reported that there were 'many' caribou seen at each of these observations but the caribou ran away before they could be counted and a definition for "many" was not provided. Surveyors were unable to limit these observations to a range or estimate of caribou that might have been present, therefore we report the number of animals seen in this ground survey area to be approximately 30. In total, only 30 caribou were accurately counted and reported by surveyors.

### 4.6.3 Arctic Bay HTO Led Ground Survey

The ground survey led by six Arctic Bay HTO appointed surveyors was conducted in early March 2014 in the northern-most ‘Strata 2’ located south of the Brodeur Peninsula and north of the Fury and Hecla Strait (Figure 17).  Caribou sign was observed at seven separate locations, and only 2 caribou in one group were observed on Crown Prince Frederik Island.

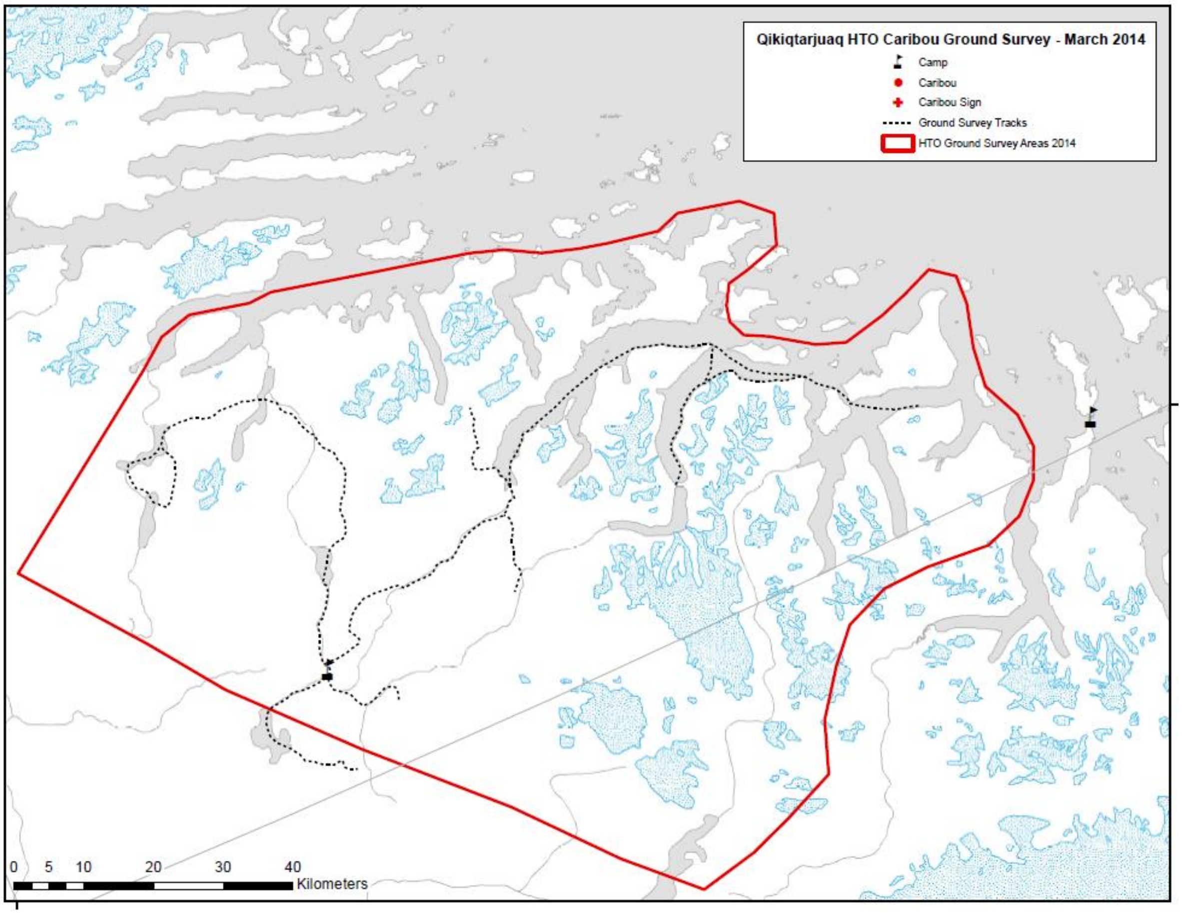


Figure 14. Track logs and camp locations from the Qikiqtarjuaq HTO-led ground survey conducted on March 3rd to 9th, 2014. The track logs identify the specific areas within the QIK-2 Strata travelled by ground surveyors to search for caribou.

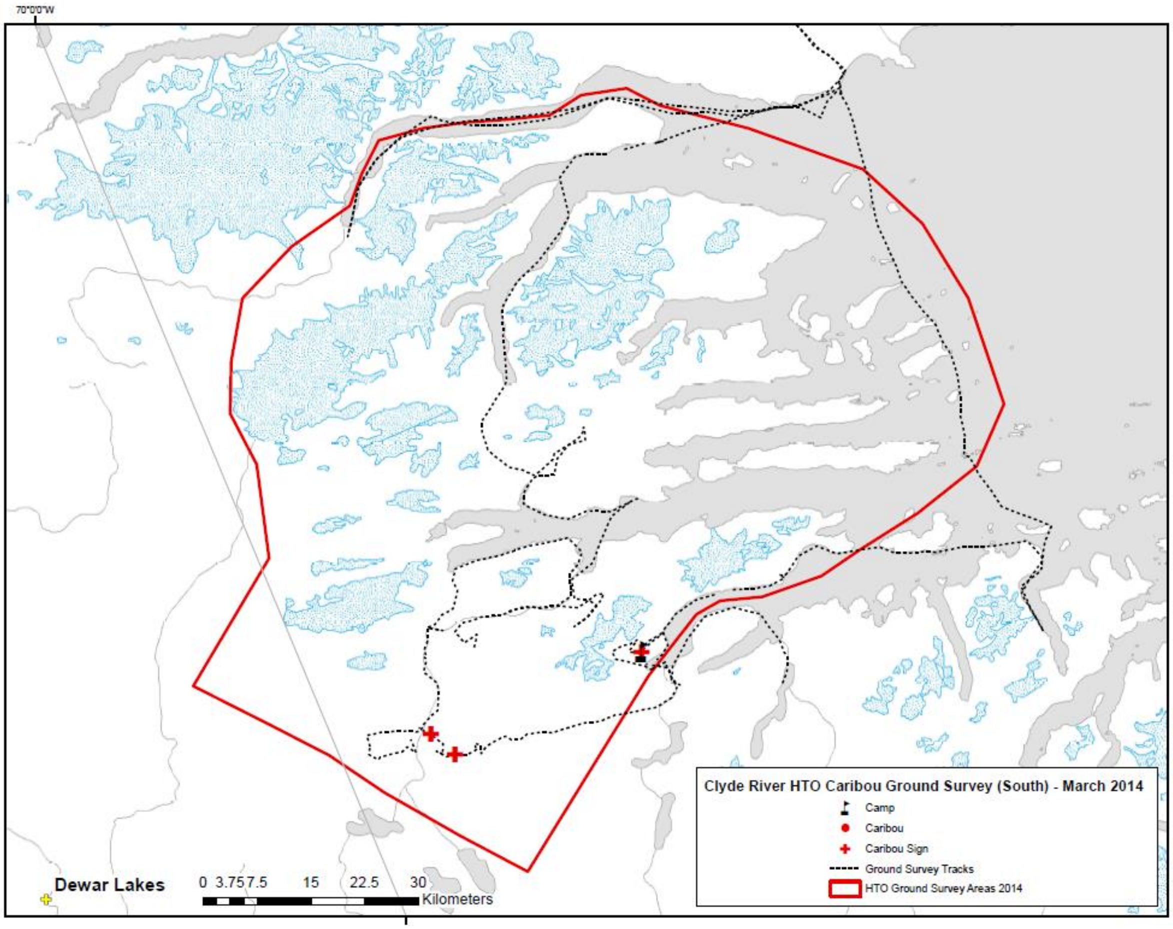


Figure 15. Track logs and locations of observed caribou sign (tracks) from the Clyde River HTO-led ground survey conducted in early March in the CR(S)-2 Strata. Track logs identify the specific areas covered by ground survey crews within the CR(S)-2 Strata.

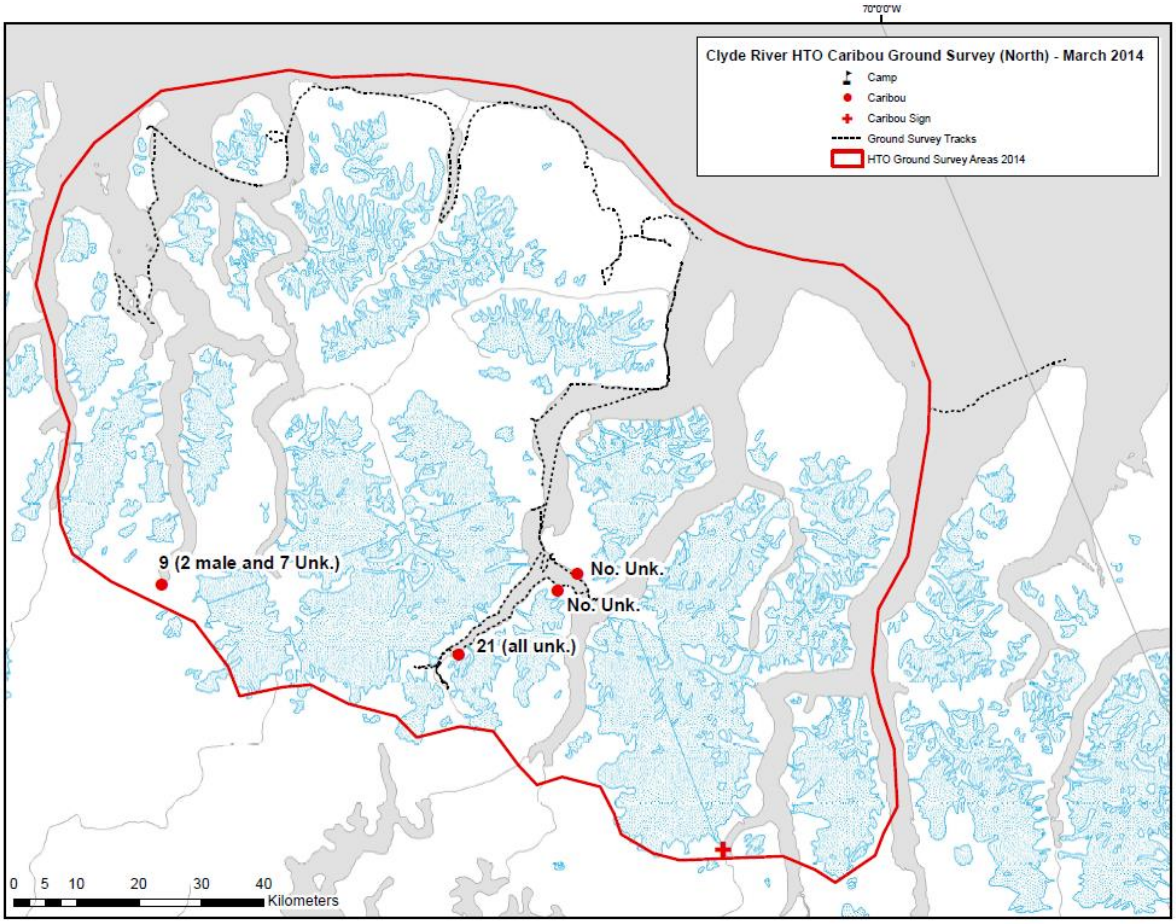


Figure 16. Track logs and locations of observed caribou groups and caribou sign (tracks) from the Clyde River HTO-led ground survey conducted in early March in the CR(N)-2 Strata. Track logs identify the specific areas covered by ground survey crews within the CR(N)-2 Strata.

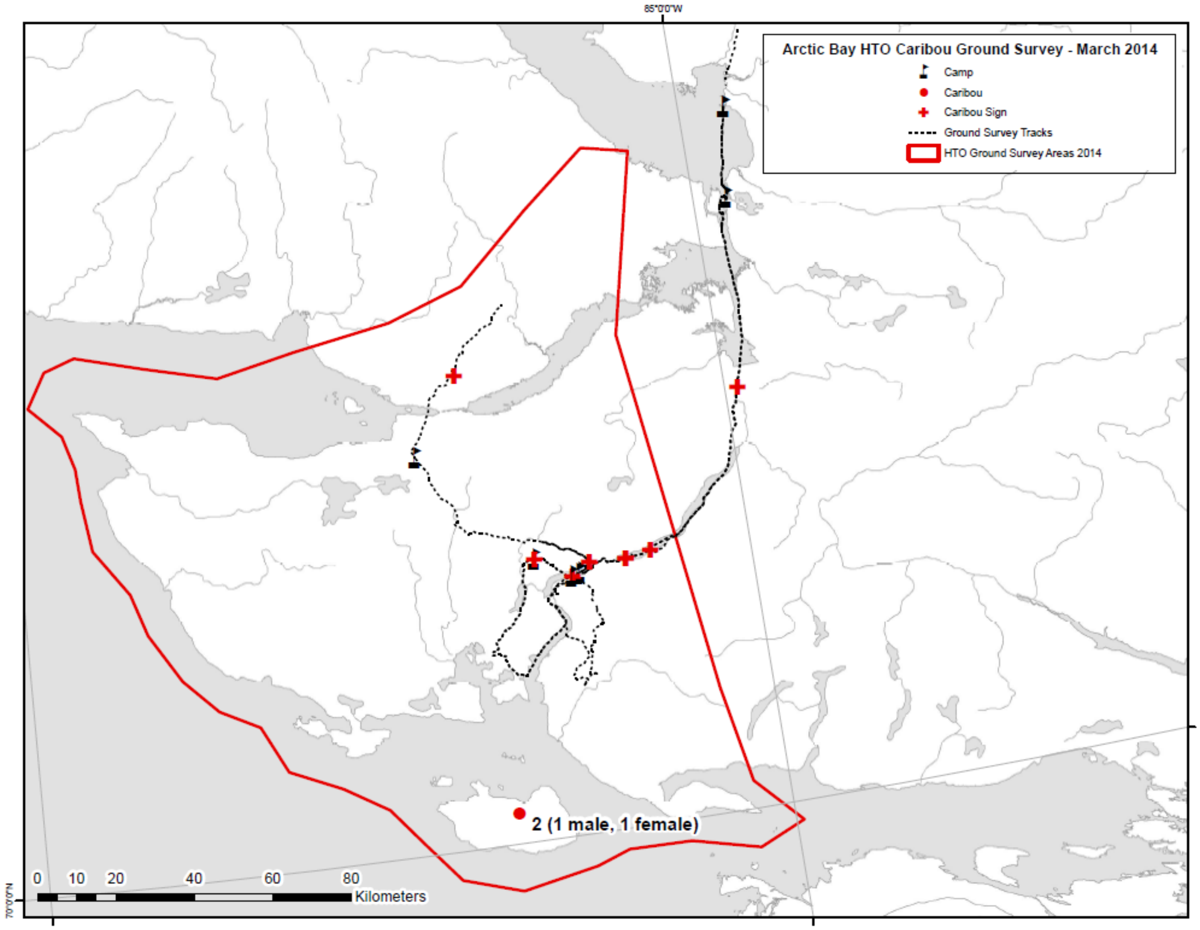


Figure 17. Track logs and locations of observed caribou groups and caribou sign (tracks) from the Arctic Bay HTO-led ground survey conducted in early March in the AB-2 Strata. Track logs identify the specific areas covered by ground survey crews within the AB-2 Strata.

## 4.7 2012 South Baffin Survey Re-Analysis

Unlike the analysis conducted by Jenkins et al. (2012), both adult caribou and calves (also called short-faced yearlings) were used for this re-analysis of the 2012 survey data. Group sizes varied from one (1) to eight (8) caribou for all stratum with average group sizes of 2.5 caribou (Table 15). In total, 358 caribou were observed on transect in all strata. Jenkins et al (2012) excluded calves from analyses and estimates, and numbers of calves observed are shown for reference purposes (Table 16). We note that the total number of caribou (358) is equal to the total number of caribou on transect in Table 3 of Jenkins et al (2012) verifying that the data sets used for analyses are similar.

Table 16. Summary of observations in each of the 2012 strata. Adults and calves were used in analyses.

| ***Strata*** | ***Observations Groups*** | ***Mean group size*** | | | | ***Total numbers observed*** | | |
|---|---|---|---|---|---|---|---|---|
| | | *mean* | *std* | *min* | *max* | *Adults/ yearlings* | *calves* | ***Total*** |
| *Central Baffin* | *18* | 3.78 | 2.02 | 1 | 8 | 57 | 11 | ***68*** |
| *Foxe Peninsula* | *2* | 5.00 | 1.41 | 4 | 6 | 8 | 2 | ***10*** |
| *Hall Peninsula* | *13* | 3.31 | 2.25 | 1 | 8 | 39 | 4 | ***43*** |
| *Meta Incogneta Peninsula* | *6* | 2.50 | 1.52 | 1 | 5 | 15 | 0 | ***15*** |
| *Prince Charles Island* | *104* | 2.13 | 1.33 | 1 | 7 | 205 | 17 | ***222*** |
| ***Total*** | ***143*** | ***2.50*** | ***1.66*** | ***1*** | ***8*** | ***324*** | ***34*** | ***358*** |

### 4.7.1 Right Truncation of Data

Summaries of the number of observations as a function of distance from the transect line revealed observations that occurred as far as 3.2 kilometers from the survey line (Figure 18). However, the further observations mainly occurred on Prince Charles Island, which was relatively flat with a near continuous snow cover, therefore allowing longer sighting distances. As with Jenkins et al. (2012), observations that were greater than 2.8 kilometers from the survey plane were right truncated which eliminated two (2) observations in the PCI stratum (8 caribou total eliminated).

### 4.7.2 Left Truncation of Data

Distance sampling assumes that sightability on the transect line is equal to one (1), or that all caribou are observed. For aerial surveys, it is possible that caribou directly under the helicopter or survey plane have a lower sightability due to obscured vision of the side observers and only partial attention of the pilot and data recorder. For this reason, a "blind spot" is delineated for fixed wing surveys of 100 meters on either side of the survey plane. For fixed-wing aircraft this blind spot is recognized, however due to enhanced forward visibility through the front and chin bubbles in rotary wing aircraft, 100 percent visibility of animals with a trajectory directly ahead and/or under the aircraft is often assumed.

One way to assess potential blind spots is to assess frequencies of observations at shorter (50 meter) intervals near the survey vehicle. If no blind spot is occurring, the frequencies should be higher or at least even for closer intervals compared to further intervals (assuming sightability decreases at further intervals) given that each 50 meter strip is of equal area. We plotted observation frequencies at 50 meter intervals and found that observation frequencies at the 0-50 and 50-100 meter intervals were lower than other intervals up to 400 meters suggesting that a blind spot was present for the helicopter surveys at distances of less than 100 meters that would represent the area immediately under the aircraft (Figure 19).

We primarily analyzed the data with the data truncated at 100 meters under the assumption that sightability would be more likely to be equal to 1 at 100 meters from the helicopter compared to on the transect line which would run immediately under the center of the aircraft. For comparison, we also provide the re-analysis results with no left truncation. Note that program *DISTANCE* explicitly accounts for left truncation by not including the observations or transect area within 100 meters of the aircraft in estimates. Jenkins et al. (2012) did not left truncate the data.

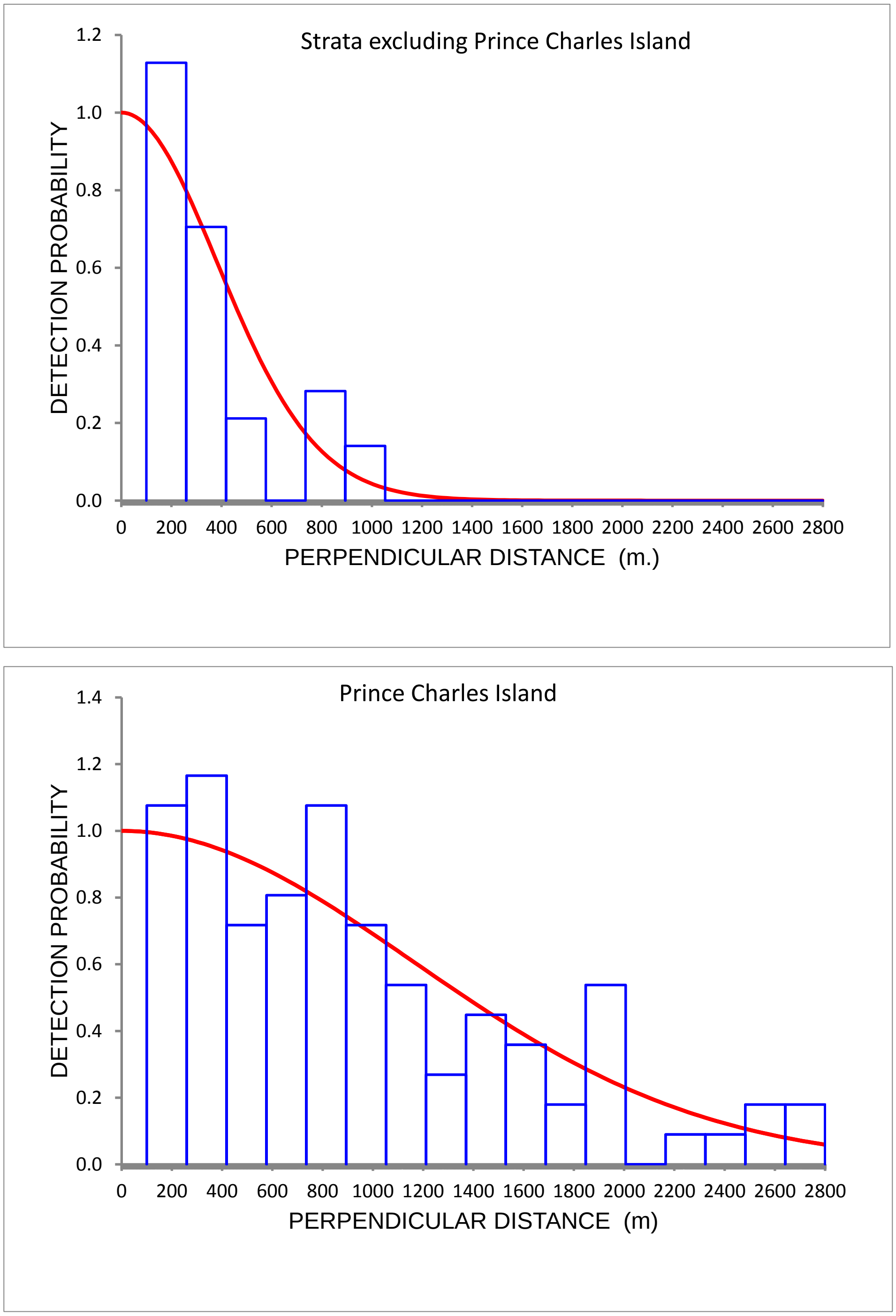


Figure 18. Detection functions (from model 1 (Table 17) and histograms of observations for Prince Charles Island and non-Prince Charles Island strata with left truncation of the data at 100m.

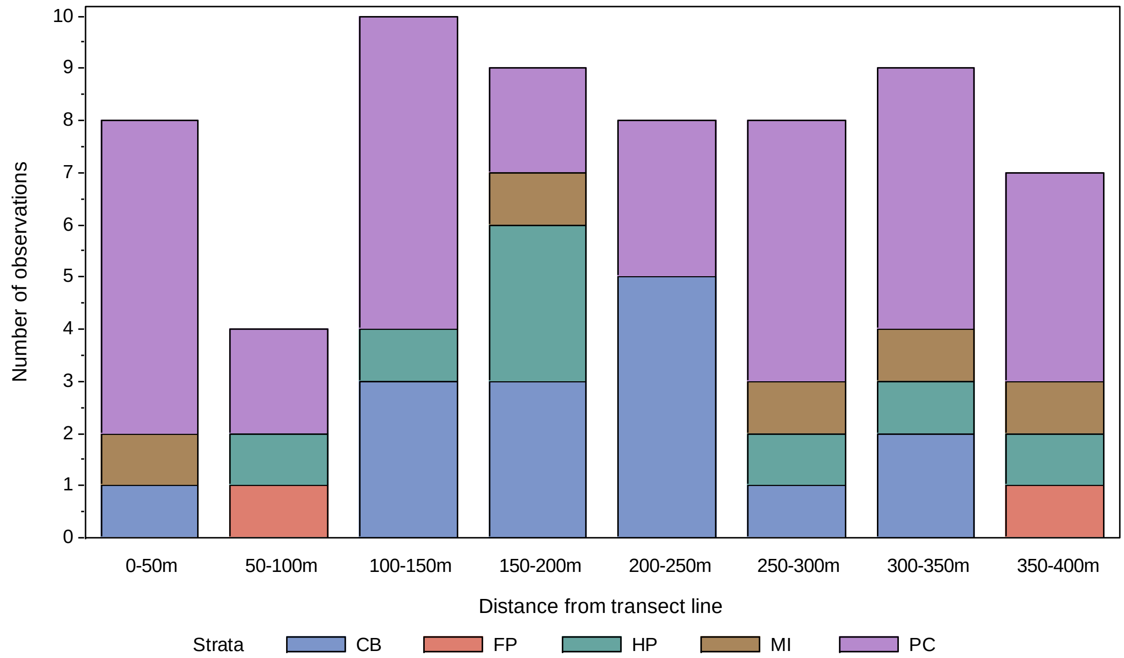


Figure 19. Summary of observations within 400 meters of the transect line to evaluate left truncation

### 4.7.3 Distance Analysis – Left Truncation

Model selection results suggested that the detection of caribou varied by observations that occurred on Prince Charles Island (PCI), and by group size of caribou (Table 17, Model 1). This model was tied for support with a model that did not have sightability varying by group size of caribou, suggesting that the group size effect on sightability was weak. However, the difference of overall estimates between model 1 and 2 was negligible (99 caribou). Both models 1 and 2 displayed adequate fit to the data. Models without covariates (Models 8 and 9) generally had lower estimates than covariate models. Models with stratum specific sightability or with both slope and topography failed to converge due to low sample sizes and correlation of covariates respectively. All of the supported models fit the data as indicated by non-significant goodness of fit tests (at $\alpha=0.05$).

### 4.7.4 Differential Sightability

The influence of differential sightability on Prince Charles Island PCI on total estimates can be seen by comparing the estimates of model 1 and model 8 which both included caribou as a covariate but model 8 does not include PCI observations (assumes similar sightability across all strata). The estimate is 685 caribou lower which is presumably due to the assumption of similar sightability across all strata. A plot of detection functions overlaid on histograms of detections displayed marked differences in detection between Prince Charles Island and other strata as also found in the 2014 survey (Figure 19). Estimates of abundance from model 1 (Table 18) were relatively imprecise for all stratum except Prince Charles Island. The overall estimate of abundance was reasonably precise (Table 18).

### 4.7.5 Sensitivity to Left Truncation

Analyses were also run at other left truncation distances to assess overall sensitivity of analyses to this assumption. A half-normal model with PCI and cluster size as a covariate was used for all model runs. The overall estimate was then plotted as a function of left truncation distance (Figure 20). The resulting estimates suggested a slight increase in estimates at moderate (i.e. 100-150 meter) distances and then a decrease at larger left truncation distances (presumably due to sightability decreasing at further distances from the transect line).

Table 17. Program *DISTANCE* model selection results for the 2012 Baffin Island data set with data left truncated at 100 meters. Base detection functions (DF) are given for each model; HR infers a hazard rate detection model and HN symbolizes a half-normal detection function Akaike Information Criteria ($AIC_c$), the difference in $AIC_c$ values between the *i*th model and the model with the lowest $AIC_c$ value ($\Delta_i$), Akaike weights ($w_i$), number of parameters ($K$), number of parameters of adjustment terms ($K_{adj}$), and log-likelihood of the model are presented. In addition p-values for goodness of fit tests ($P(\chi^2)$) and pooled abundance estimates (N) are given.

| ***No*** | ***Model*** | | ***Model selection*** | | | | | ***Abundance*** | | ***GOF*** |
|---|---|---|---|---|---|---|---|---|---|---|
| | **DF** | **Name** | **AICc** | $\Delta_i$ | $w_i$ | **K** | **LogL** | $\hat{N}$ | **CV(N)** | $P(\chi^2)$ |
| ***1*** | HN | PCI caribou | 1911.8 | 0.00 | 0.45 | 3 | -952.8 | 2,193 | 17.6% | 0.11 |
| ***2*** | HN | PCI | 1911.8 | 0.00 | 0.45 | 2 | -953.8 | 2,292 | 16.8% | 0.14 |
| ***3*** | HN | PCI caribou topo | 1913.8 | 2.09 | 0.06 | 4 | -952.8 | 2,191 | 17.5% | 0.07 |
| ***4*** | HN | PCI caribou slope | 1913.9 | 2.13 | 0.05 | 4 | -952.8 | 2,193 | 17.6% | 0.07 |
| ***5*** | HN | caribou topo | 1927.4 | 15.69 | 0.00 | 4 | -959.6 | 1,968 | 18.0% | 0.09 |
| ***6*** | HR | PCI caribou | 1931.1 | 19.33 | 0.00 | 4 | -961.4 | 2,370 | 22.9% | 0.07 |
| ***7*** | HR | constant | 1940.2 | 28.48 | 0.00 | 2 | -968.1 | 2,263 | 22.9% | 0.18 |
| ***8*** | HN | constant | 1942.6 | 30.83 | 0.00 | 2 | -969.2 | 1,437 | 12.4% | 0.15 |
| ***9*** | HN | caribou | 1944.2 | 32.45 | 0.00 | 3 | -969.0 | 1,507 | 14.3% | 0.11 |

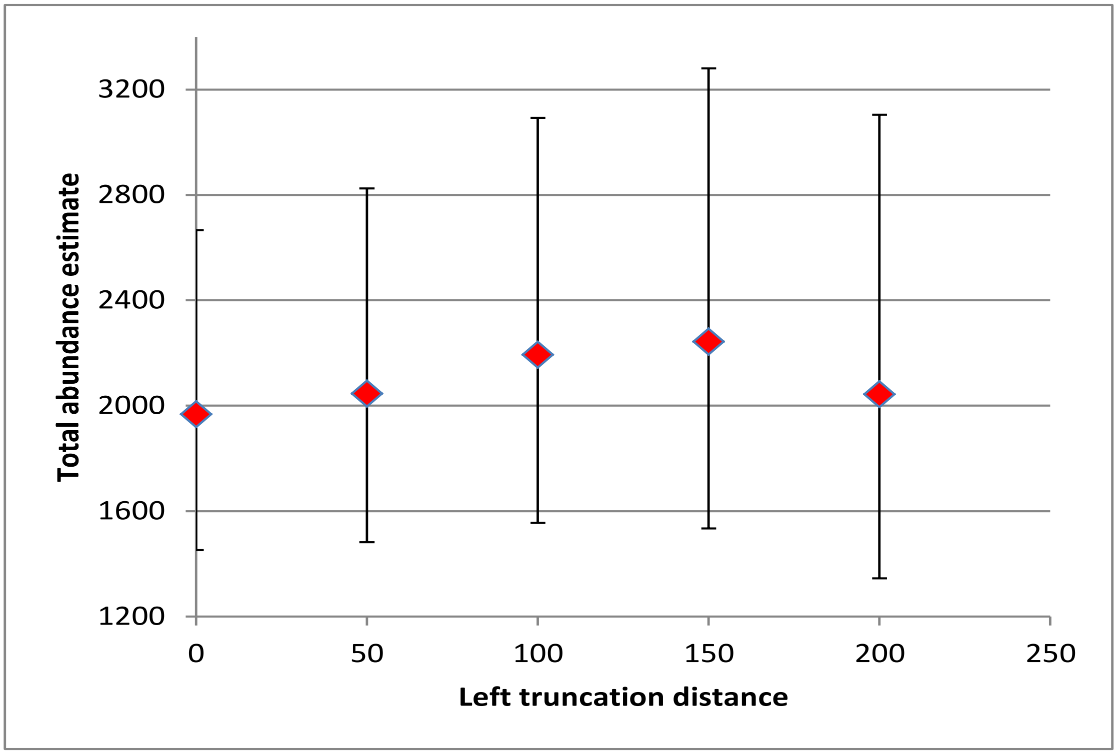


Figure 20. Sensitivity of estimates to left truncation of observations in the data set.

Table 18. Estimates of caribou abundance from March-May 2012 using Model 1 (with left truncation) (Table 17). The number of individual caribou seen on transect within the distances from transect considered (100-2800 meters) is given for reference.

| ***Strata*** | ***Caribou*** | $\hat{N}$ | ***SE*** | ***CI*** | | ***CV*** | ***df*** |
|---|---|---|---|---|---|---|---|
| *Central Baffin* | 62 | 773 | 253.4 | 410 | 1,460 | 32.8% | 78.9 |
| *Foxe Peninsula* | 6 | 69 | 68.5 | 12 | 389 | 99.5% | 19.6 |
| *Hall Peninsula* | 41 | 480 | 161.9 | 250 | 925 | 33.7% | 65.5 |
| *Meta Incognita Peninsula* | 13 | 162 | 88.1 | 57 | 455 | 54.5% | 34.7 |
| *Prince Charles Island* | 202 | 709 | 103.5 | 525 | 956 | 14.6% | 25.3 |
| ***Totals*** | ***324*** | ***2,193*** | ***385.7*** | ***1,555*** | ***3,093*** | ***17.6%*** | ***232.4*** |

### 4.7.6 Distance Analysis – No Left Truncation

Model selection results were similar to the left truncation distance analysis. A model that assumed that the detection of caribou varied by observations that occurred on Prince Charles Island (PCI), and by group size of caribou (Table 19, model 1) was most supported. In addition, models with slope and topography were supported as indicated by AICc values of less than two (2). Pooled estimates of abundance varied from 1,697 to 2,010 caribou (all ages) for the most supported models. Models without covariates (Models 9 and 10) generally had lower estimates than covariate models. All of the supported models fit the data as indicated by non-significant goodness of fit tests.

The influence of differential sightability on Prince Charles Island (PCI) on total estimates can be seen by comparing the estimates of model 1 and model 11 which both included caribou as a covariate but model 11 does not include PCI (assumes similar sightability across all strata). The estimate is 480 caribou lower which is presumably due to the assumption of similar sightability across all strata. A plot of detection functions overlaid on histograms of detections displayed marked differences in detection between Prince Charles Island and other strata as also found in the 2014 survey (Figure 21). Note that the 0-100 meter bin has fewer observations than the 100-200 meter bin for the non-PCI stratum in Figure 4 in comparison to the left truncated analysis which eliminates this bin (Figure 3) to ensure that sightability is equal to 1 for the first bin. Estimates of abundance from model 1 (Table 19) were relatively imprecise for all stratum except Prince Charles Island. The overall estimate of abundance was reasonably precise (Table 20).

Table 19. Program DISTANCE model selection results for the 2012 Baffin Island data set. Base detection functions (DF) are given for each model; HR infers a hazard rate detection model and HN symbolizes a half-normal detection function Akaike Information Criteria ($AIC_c$), the difference in $AIC_c$ values between the *i*th model and the model with the lowest $AIC_c$ value ($\Delta_i$), Akaike weights ($w_i$), number of parameters ($K$), number of parameters of adjustment terms ($K_{adj}$), and log-likelihood of the model are presented. In addition p-values for goodness of fit tests ($P(\chi^2)$) and pooled abundance estimates (N) are given.

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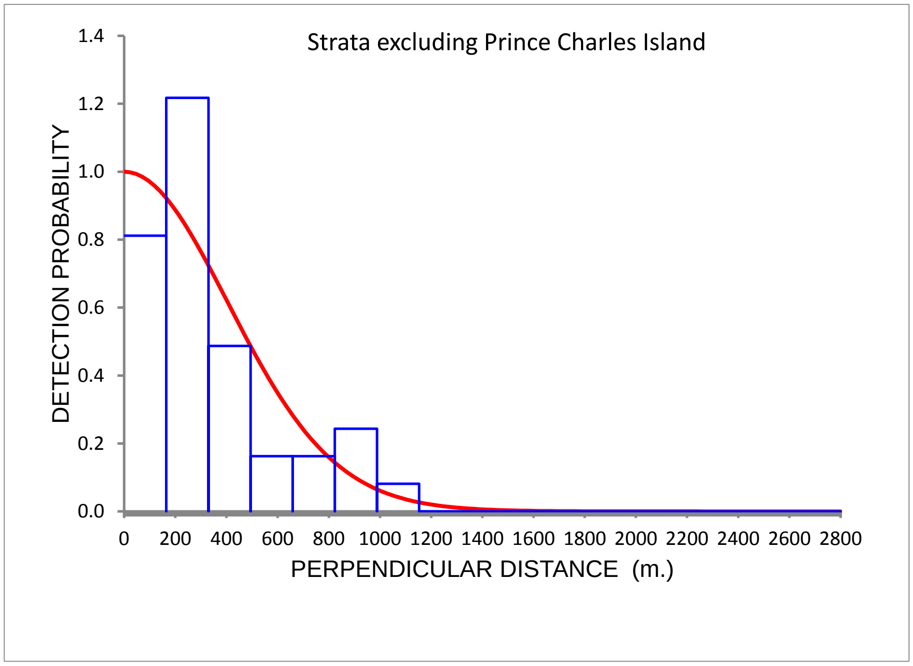
| ***No*** | ***Model*** | | ***Model selection*** | | | | | ***Abundance*** | | ***GOF*** |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***DF*** | ***Name*** | ***AICc*** | $\Delta_i$ | $w_i$ | ***K*** | ***LogL*** | $\hat{N}$ | ***CV(N)*** | $P(\chi^2)$ |
| ***1*** | HN | PCI caribou | 2106.3 | 0.00 | 0.45 | 3 | -1050.1 | 1,968 | 0.16 | 0.151 |
| ***2*** | HN | PCI | 2106.6 | 0.23 | 0.36 | 2 | -1051.2 | 2,052 | 0.15 | 0.194 |
| ***3*** | HN | PCI caribou slope | 2108.1 | 1.79 | 0.08 | 4 | -1049.9 | 1,983 | 0.16 | 0.109 |
| ***4*** | HN | PCI caribou + topo | 2108.4 | 2.10 | 0.06 | 4 | -1050.1 | 1,970 | 0.16 | 0.107 |
| ***5*** | HN | PCI stratum + caribou | 2108.5 | 2.13 | 0.05 | 6 | -1047.9 | 2,081 | 0.17 | 0.058 |
| ***6*** | HN | caribou+ topo | 2119.1 | 12.77 | 0.00 | 4 | -1055.4 | 1,841 | 0.16 | 0.122 |
| ***7*** | HR | PCI caribou | 2119.3 | 12.97 | 0.00 | 4 | -1055.5 | 1,970 | 0.17 | 0.092 |
| ***8*** | HN | caribou topo slope | 2119.6 | 13.27 | 0.00 | 5 | -1054.6 | 2,218 | 0.31 | 0.089 |
| ***9*** | HR | constant | 2134.2 | 27.86 | 0.00 | 2 | -1065.1 | 1,923 | 0.17 | 0.259 |
| ***10*** | HN | constant | 2135.6 | 29.29 | 0.00 | 2 | -1065.8 | 1,431 | 0.11 | 0.181 |
| ***11*** | HN | caribou | 2137.4 | 31.06 | 0.00 | 3 | -1065.6 | 1,478 | 0.13 | 0.136 |



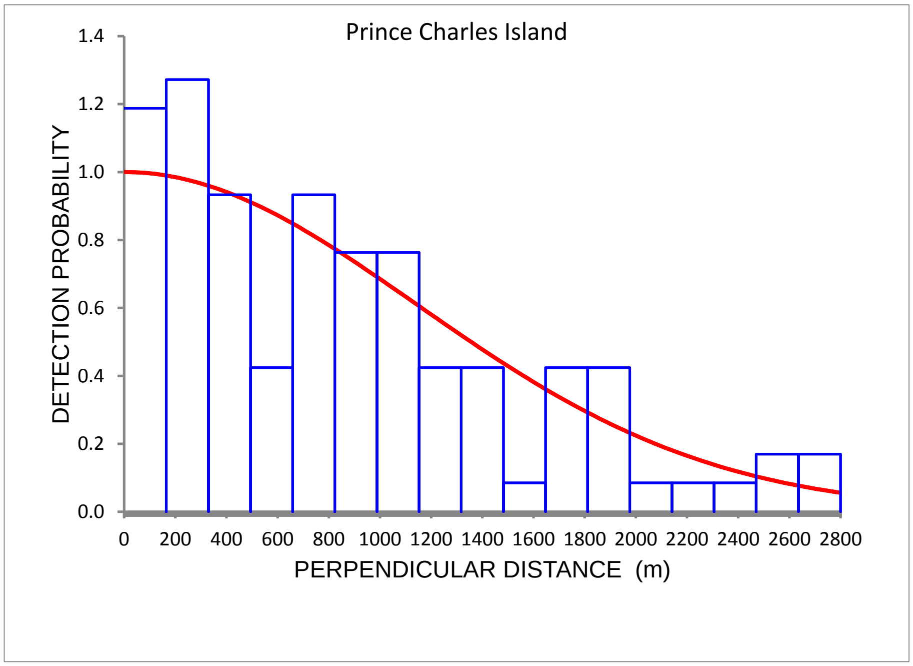




Figure 21. Detection functions (from model 1 (Table 19) and histograms of observations for Prince Charles Island and non-Prince Charles Island strata.

Table 20. Estimates of abundance from Model 1 (no left truncation) (Table 19). The number of individual caribou seen on transect (0 m to 2800 m from transect line) is given for reference.

| Strata | Caribou sighted | $\hat{N}$ | SE | CI | | CV | df |
|---|---|---|---|---|---|---|---|
| *Central Baffin* | 68 | 641 | 198.0 | 352 | 1,169 | 30.9% | 77.7 |
| *Foxe Peninsula* | 10 | 93 | 62.7 | 26 | 334 | 67.4% | 20.1 |
| *Hall Peninsula* | 43 | 386 | 122.7 | 208 | 718 | 31.8% | 62.3 |
| *Meta Incognita Peninsula* | 15 | 142 | 68.2 | 56 | 358 | 48.0% | 34.5 |
| *Prince Charles Island* | 214 | 705 | 92.9 | 538 | 923 | 13.2% | 25.8 |
| **Totals** | **350** | **1,968** | **305.5** | **1,452** | **2,667** | **15.5%** | **239.0** |

## 4.8 2009 North Baffin Survey Distance Re-Analysis

Group sizes varied from one (1) to eight (8) caribou with a mean group size of 3.6 caribou (std=2.34) observed in 12 groups (on transect). The total number of caribou observed on transect was 44. Observations of caribou occurred between 65 and 1,476 meters from the transect line (Figure 22). Calves (short-faced yearlings), yearlings, and adults were used in the analyses.

### 4.8.1 Distance Analysis

The data was not left truncated under the assumption that there was no blind spot so that the sightability of caribou from the helicopter on the survey line was one (1). There were no visible outliers and therefore the data was not right truncated.

Model selection suggested that sightability was described by a half-normal detection function with group size as a covariate (Table 5). This model fit the data adequately as determined by chi-square and KS goodness of fit tests. Estimates of abundance were very imprecise due to low sample sizes of caribou in the analysis. A plot of the detection function for model 1 (Table 21) demonstrates reasonable fit of the half-normal detection function to the observed data (Figure 23). Model two (2) (Table 21) estimated the number of 2009 North Baffin caribou occupying the survey area to be 673 animals (95% CI = 285 to 1,591; CV = 0.45).

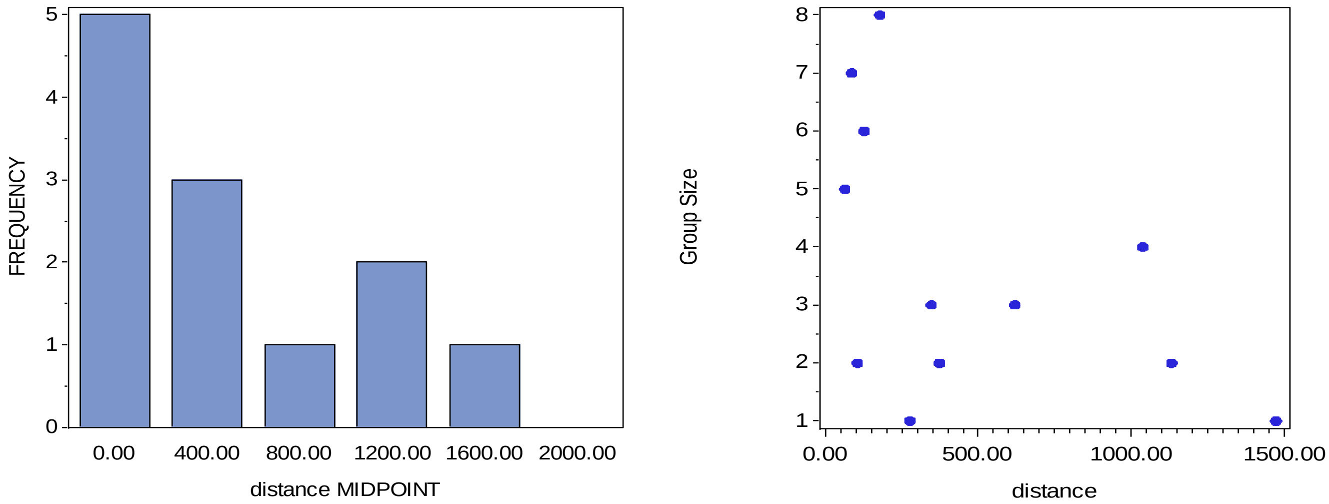



Figure 22. Frequency of observations (left) and group size (right) as a function of distance from the survey line.

Table 21. Distance model selection results for 2009 North Baffin Survey. Base detection functions (DF) are given for each model; HR infers a hazard rate detection model and HN symbolizes a half-normal detection function Akaike Information Criteria ($AIC_c$), the difference in $AIC_c$ values between the *i*th model and the model with the lowest $AIC_c$ value ($\Delta_i$), Akaike weights ($w_i$), number of parameters ($K$), number of parameters of adjustment terms ($K_{adj}$), and log-likelihood of the model are presented. In addition p-values for goodness of fit tests ($P(\chi^2)$) and pooled abundance estimates (N) are given.

| No | Model | | $AIC_c$ | $\Delta_i$ | $w_i$ | K | LogL | GOF | K-S | Abundance | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DF | Covariates | | | | | | $P(\chi^2)$ | p | $\hat{N}$ | 95% CI | | CV |
| **1** | HN | caribou | 170.4 | 0.00 | 0.93 | 2 | -82.5 | 0.37 | 0.60 | 645 | 153 | 2728 | 81.8% |
| **2** | HN | | 173.2 | 2.80 | 0.06 | 2 | -83.9 | 0.48 | 0.99 | 673 | 285 | 1591 | 44.8% |
| **3** | HR | | 174.8 | 4.41 | 0.01 | 3 | -84.7 | 0.34 | 0.98 | 789 | 160 | 3894 | 86.6% |
| **4** | HR | caribou | 179.5 | 9.13 | 0.00 | 4 | -85.3 | 0.07 | 0.81 | 701 | 148 | 3322 | 89.4% |

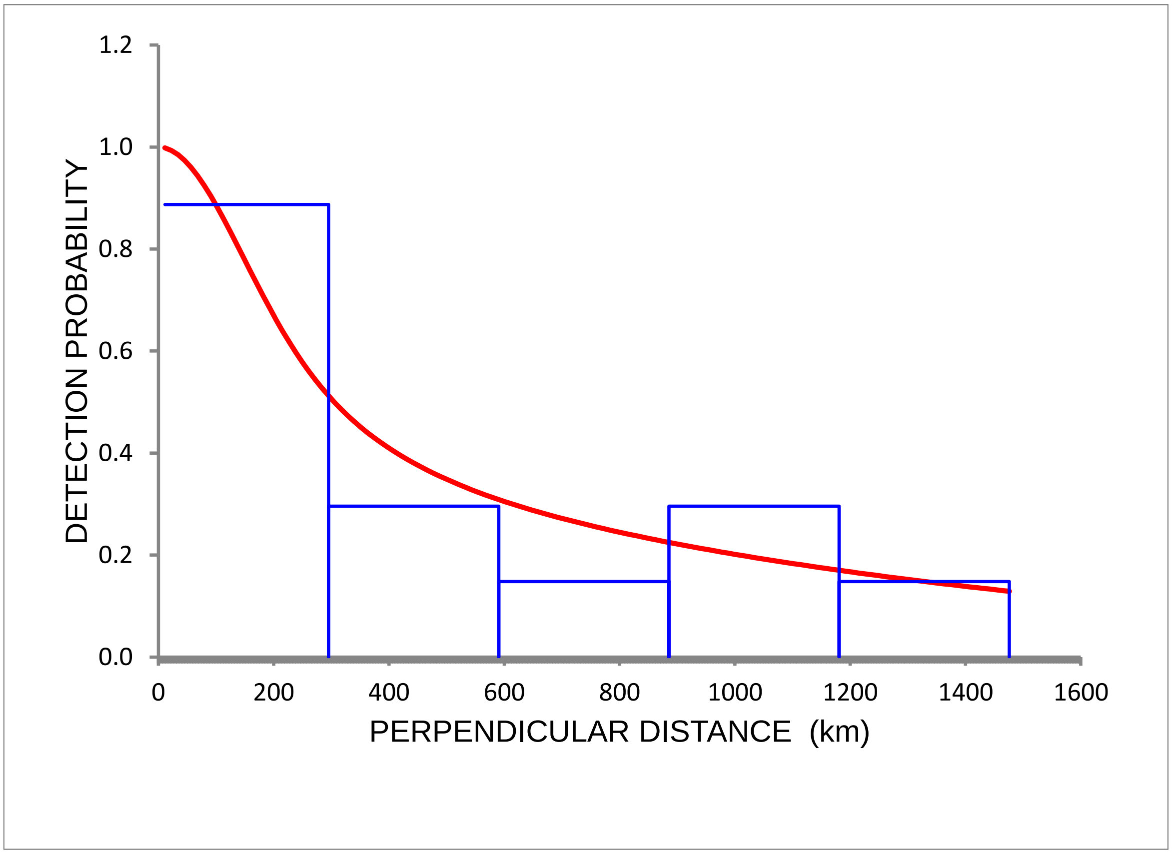



Figure 23. Detection function and observed distribution of observations for the 2009 North Baffin survey from model 1 (Table 5).

## 4.9 Spatial Affiliations

We re-analyzed caribou telemetry data collected by M Ferguson from 1987 to 1994 and by Jenkins and Goorts (2011) from 2008 to 2011. We utilized Arc View 10.0 spatial analyst software to analyze all spatial data. From 1987 through 1994, 71 satellite collars were successfully deployed on Baffin Island caribou cows during a reported period of high caribou abundance within the historically defined south Baffin population with an additional two (2) collars being deployed on caribou cows during a period of reported high caribou abundance within the historically defined North Baffin caribou population (Table 22). Additionally we analyzed the raw data from 31 GPS collars deployed on caribou cows during a period of reported low caribou abundance within the North Baffin historically defined Population between 2008 and 2011 (Jenkins and Goorts, 2011).

Though temporally deficient, the results of these analysis, when combined, strongly suggest a division of Baffin Island caribou into three (3) separate spatial affiliations which we define here as groupings. These groupings include the North Baffin, the South Central Baffin, and the South East Baffin caribou groupings (Figure 24). The North Baffin grouping is within what was previously described as the North Baffin Population, and the South Central and South East grouping within what was previously described as the South Baffin caribou Population. Unfortunately, no collars have been deployed within what had previously been described as the Northeast Baffin population by Ferguson (1993), and as a result, no determination of the demography and spatial affiliations of caribou occupying that historically defined range can be made at this time.

Though the data collection period was limited, the telemetry results displayed very little mixing between groupings. In the case of the north Baffin grouping, this lack of mixing was present within both high and low abundance phases.

North Baffin collared caribou cows displayed no tendency to switch with 100% of all collars captured within the defined north Baffin annual range, both between the 1987 to 1994 deployment and 2008 to 2011 deployment, remaining within that annual range (Figure 25).

The South East Baffin grouping also maintained fidelity to their annual range with only one (1) collared animal out of 56 (1.8%) utilizing both the delineated South East and South Central annual ranges.  Rutting exclusively within the South East Baffin annual range extents, this same animal spent its first calving season within the South East Baffin range extents and its second and final calving season within the northern extents of the South Central grouping annual range.

The South Central Baffin grouping displayed less fidelity with 3 out of 17 collars (17.6%) deployed within the South Central Baffin annual range, sharing a range with neighbouring groupings, two (2) with the North Baffin grouping and one with the South Baffin grouping.  In the case of the caribou utilizing both the South Central and South East Baffin annual range extents, this collared caribou returned each year to calve within the South Central Baffin grouping annual range, while spending the rut exclusively within the South East Baffin grouping annual range.  The two collared caribou caught within the northern extents of the South Central Baffin grouping annual range left the area immediately following capture and spent the remainder of their deployment including all calving and rutting periods, completely within the North Baffin grouping annual range extents (Figure 25).  This calving fidelity suggests that the two caribou captured may have been from the North Baffin grouping, which if correct would suggest that only 5.9% of collared South Central caribou displayed a lack of fidelity to their annual range.

Table 22. A summary of the 1987 to 1994 satellite collar deployment details and the 2008 to 2011 GPS collar deployment details. Note that an annual range use differing from the capture location indicates a collar that had switched annual ranges during deployment.

| Capture Location by Grouping | Annual Range Used | Deployment Year | Collar Type | # Collars Deployed | Proportion Switching Ranges (%) | Total Collars |
|---|---|---|---|---|---|---|
| ***North Baffin*** | North Baffin | 2008-2011 | GPS | 31 | 0.0 | ***33*** |
| | North Baffin | 1988-1990 | Satellite | 2 | | |
| ***Central Baffin*** | Central Baffin | 1990-1994 | Satellite | 14 | 17.6 | ***17*** |
| | North Baffin | 1991-1993 | Satellite | 2 | | |
| | South Baffin | 1991-1993 | Satellite | 1 | | |
| ***South Baffin*** | South Baffin | 1987-1994 | Satellite | 55 | 1.8 | ***56*** |
| | Central Baffin | 1991-1992 | Satellite | 1 | | |
| ***Total Collars*** | | | | | | ***106*** |

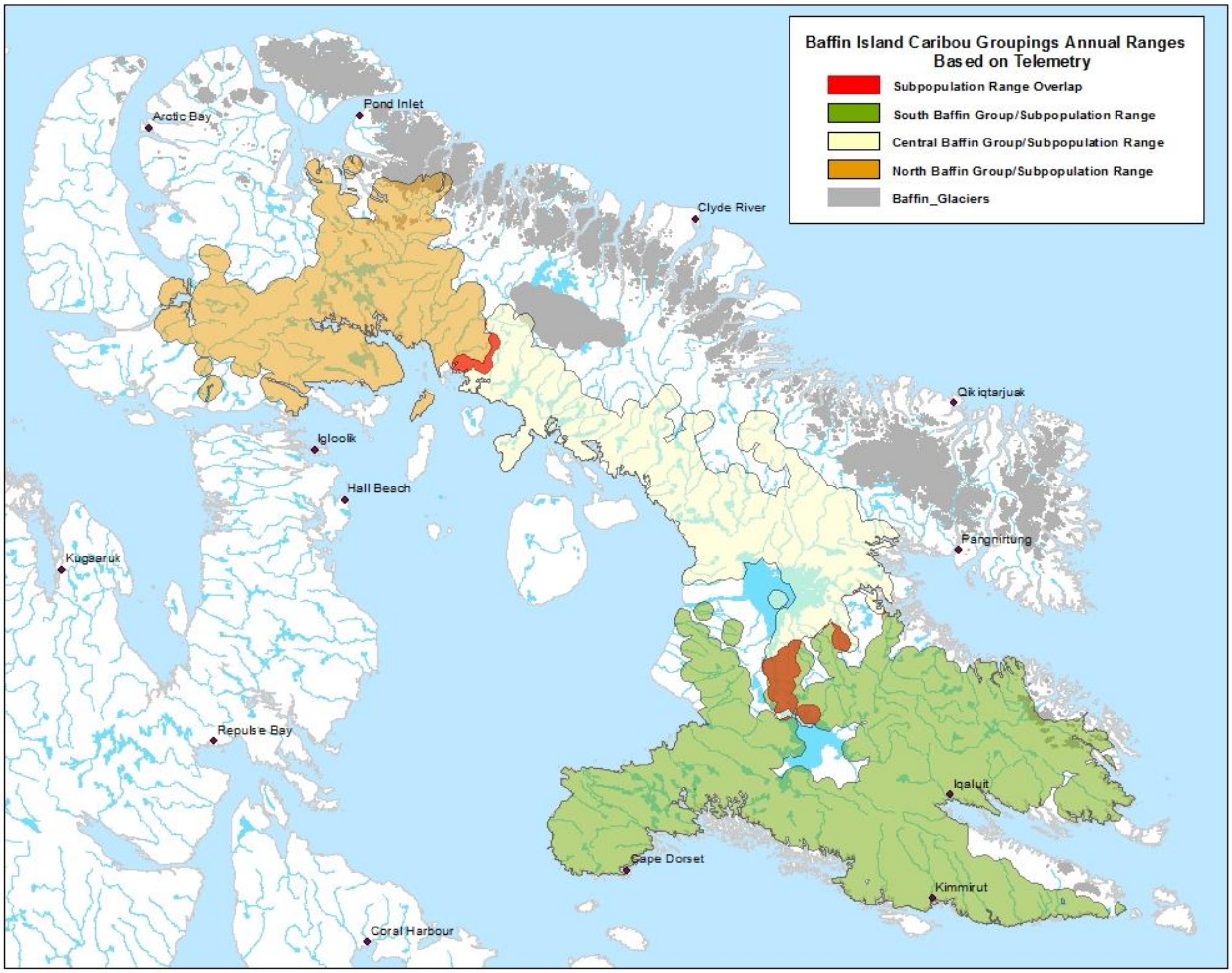



Figure 24. Caribou grouping annual range delineation based on telemetry studies from 1987 to 1994 (primarily South Baffin), and 2008 to 2011 (North Baffin). Polygons created utilizing a kernel analysis (See methods) of telemetry point data collected for 107 collars (North=35; Central = 17; South = 55).

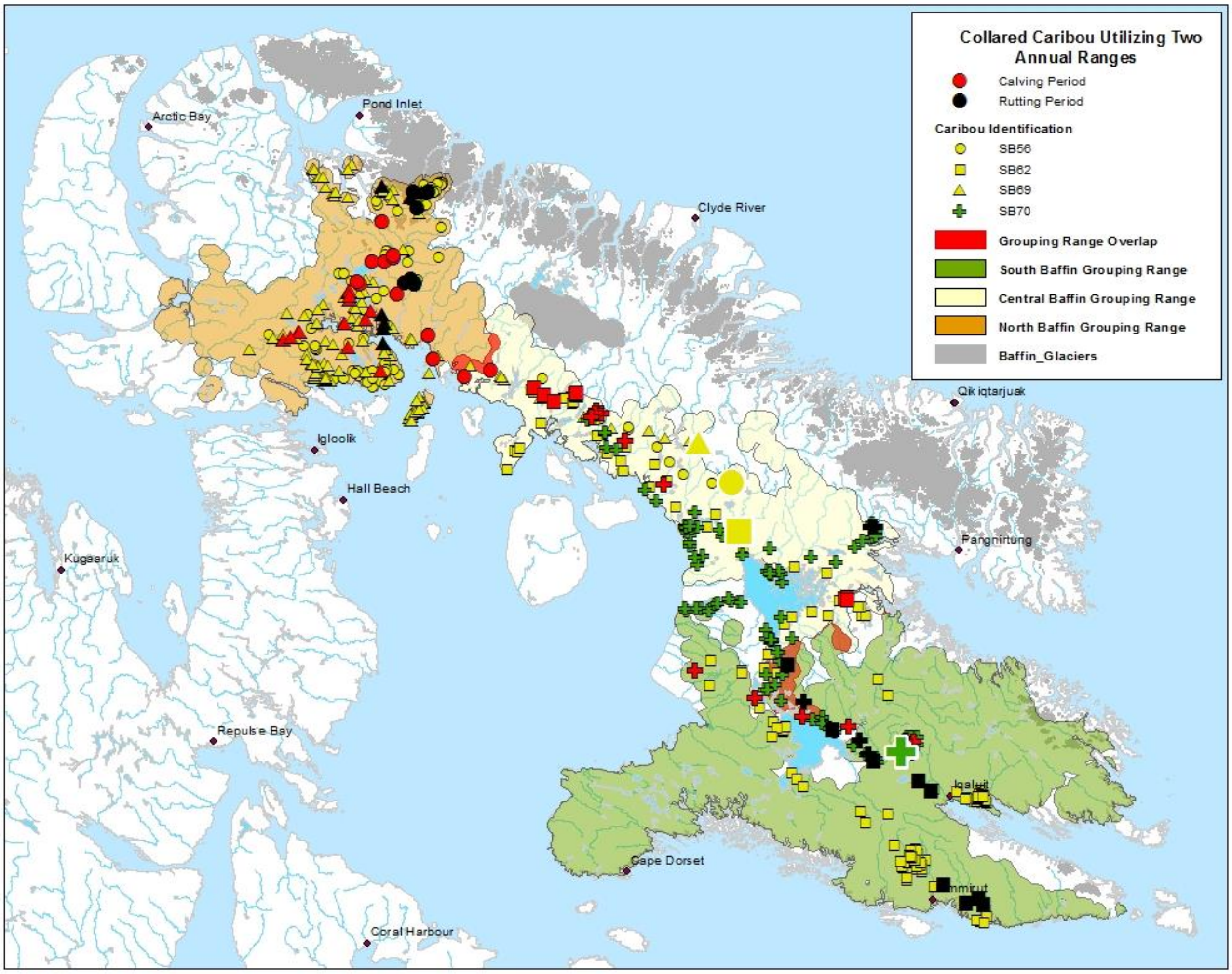



Figure 25. The locations of individual caribou utilizing more than one annual range. Calving (red) and rutting (black) periods are highlighted. Capture locations of each animal are expressed as larger white bordered symbols.

## 4.10 Seasonal Distribution

During the analysis of telemetry data, caribou position data specific to each of the three identified groupings, were broken down into seasons based on an analysis of daily movement rates for each of 6 seasonal periods: 1-Spring Migration (April 1st to May 29th), 2- Calving (May 30th to June 25th), 3- Post-calving and summer (June 26th to August 12th), 4- Late Summer and Fall Migration Pre-breeding (Aug 13th to October 22nd), 5- Breeding/Fall Migration post-breeding (Oct 23rd to December 15th), and 6- Winter (December 16th to April 4th) (Campbell et al, in prep; Nagy and Campbell, 2012) (Figure 26, 27, & 28). Seasonal breakdowns were initially drawn from a similar analysis of tundra wintering barren-ground caribou within the Wager Bay caribou subpopulation (Nagy and Campbell, 2012; Nagy et al., 2011; Campbell et al., in prep). Due to the limited amount of Baffin telemetry data we modified the seasons from the nine utilized in the Wager Bay subpopulation analysis to the six seasonal ranges listed above (Figure 29, 30, 31, 32, 33,& 34). The reduction in seasonal classes was the result of the combination of a post-calving class with a summer class, a late summer class with a fall migration class, and a breeding/rut class with an early winter class. Combining these seasonal classes sacrificed detail for for a more robust summary of movement rates due to the greater number of data points. The Wager Bay population is the closest spatially analyzed tundra wintering barren-ground caribou subpopulation to Baffin Island and being a tundra wintering population, likely shares some similarities to Baffin Island caribou.

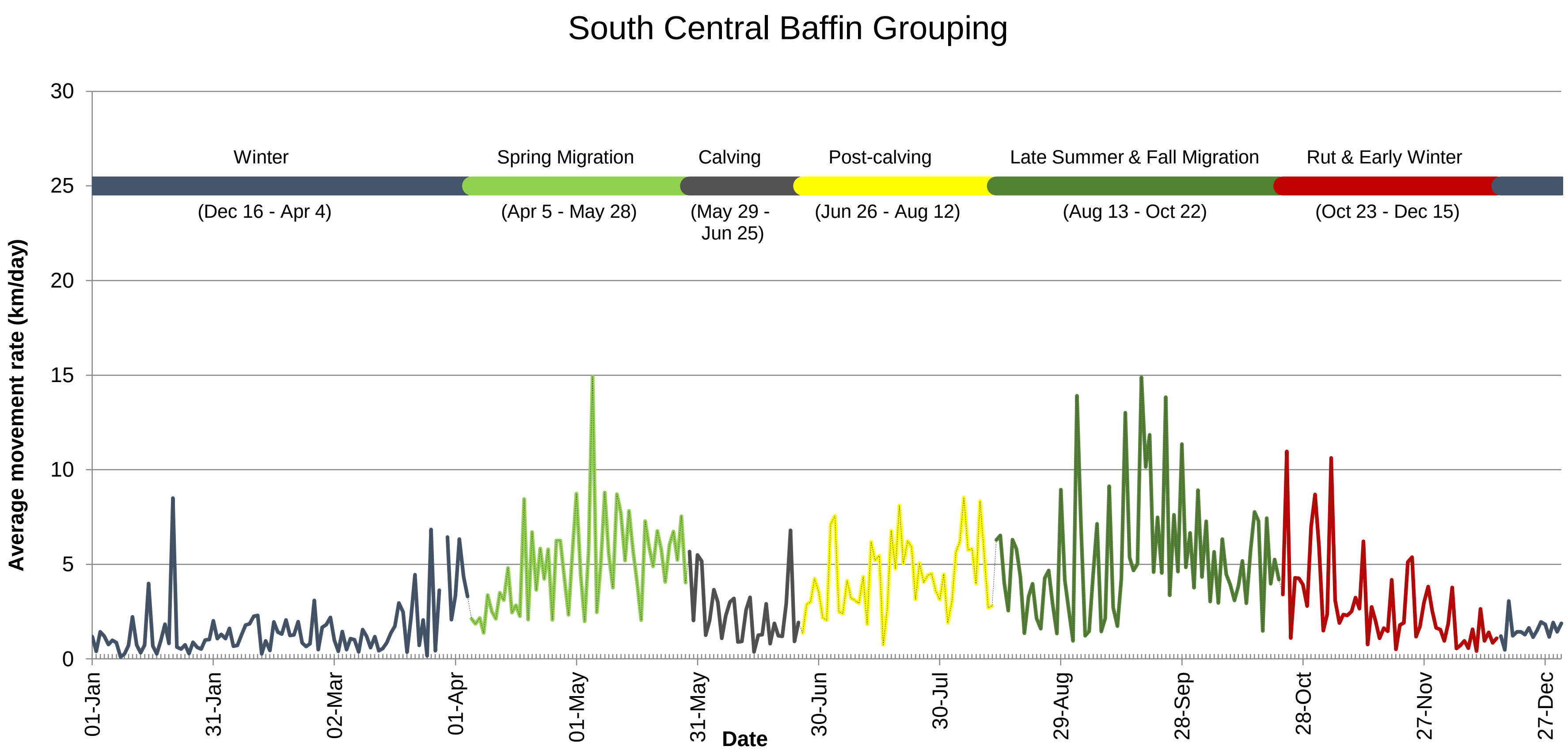



Figure 26. Average daily movement rates of the Central Baffin caribou grouping (1987-1996). Movement rates calculated utilizing telemetry locations for 17 collared caribou cows captured within the central Baffin grouping annual range.

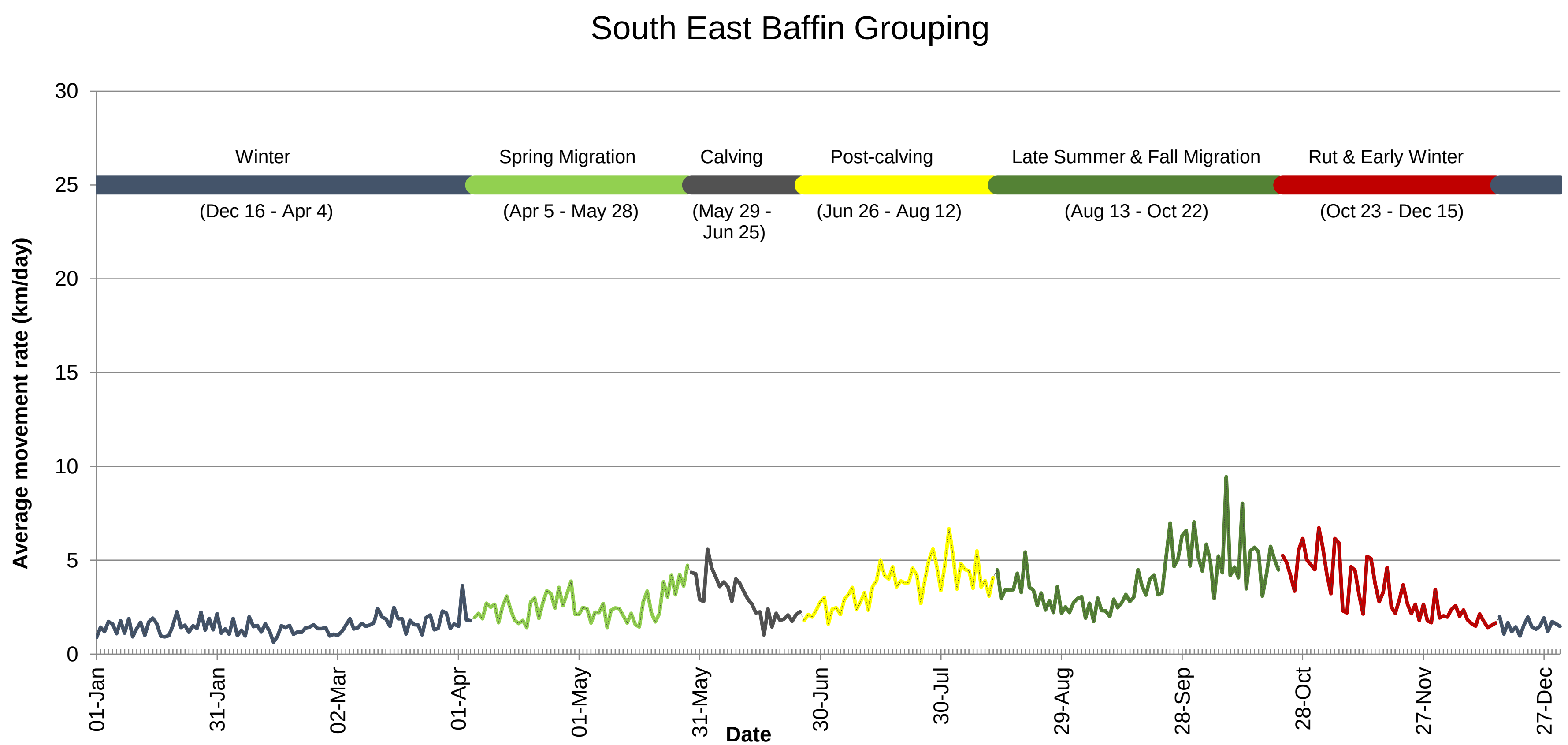



Figure 27. Average daily movement rates of the South Baffin caribou grouping (1987-1996). Movement rates calculated utilizing telemetry locations for 55 collared caribou cows captured within the south Baffin grouping annual range.

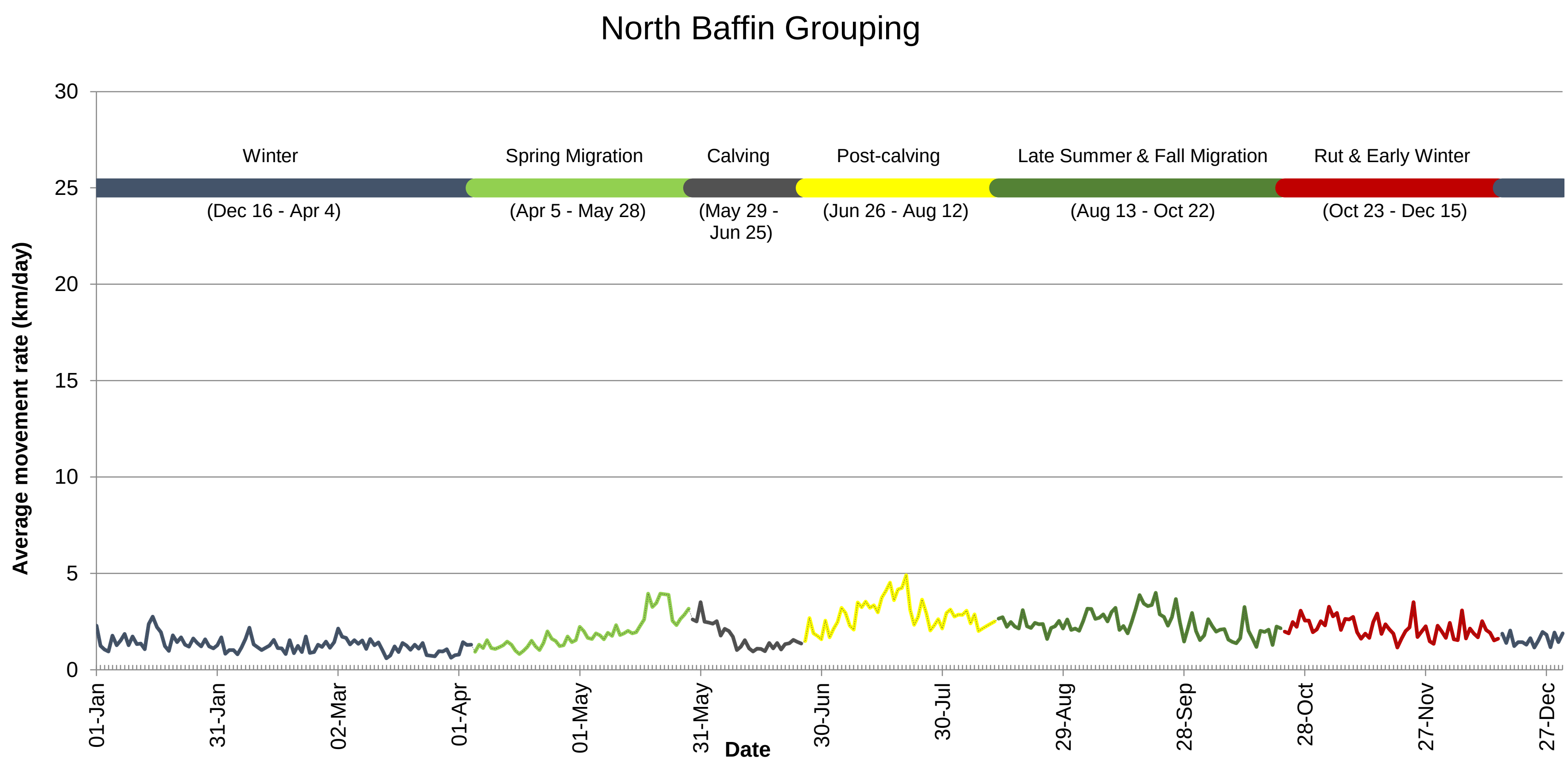



Figure 28. Average daily movement rates of the North Baffin caribou grouping (1987-1996 & 2008-2011). Movement rates calculated utilizing telemetry locations for 31 collared caribou cows observed between 2008 and 2011, and 4 collared caribou cows observed between 1987 & 1996 within the north Baffin grouping annual range.

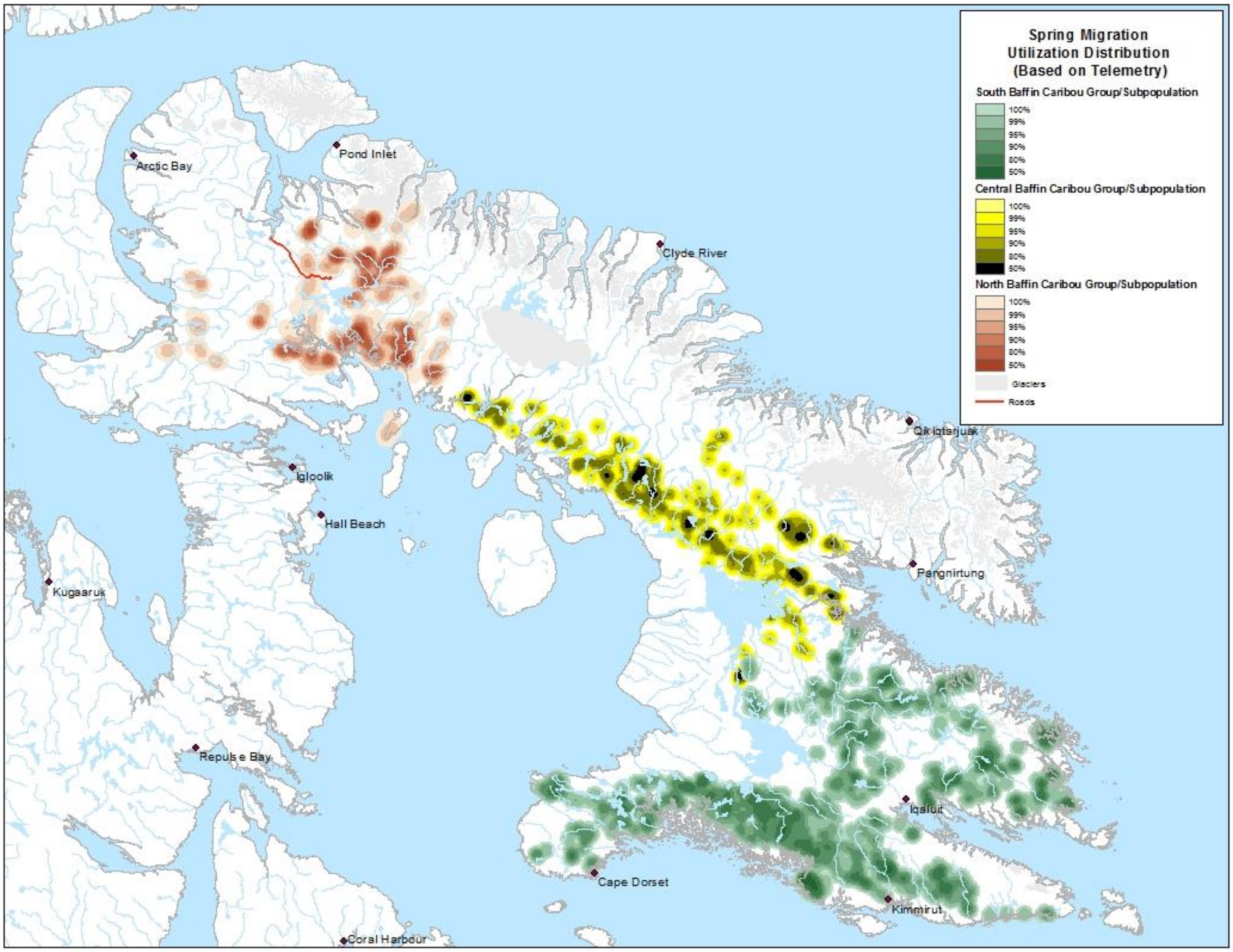



Figure 29. Spring migration range use based on utilization distributions utilizing a Kernel analysis with an 11 km search radius. Darker colors indicate higher use.

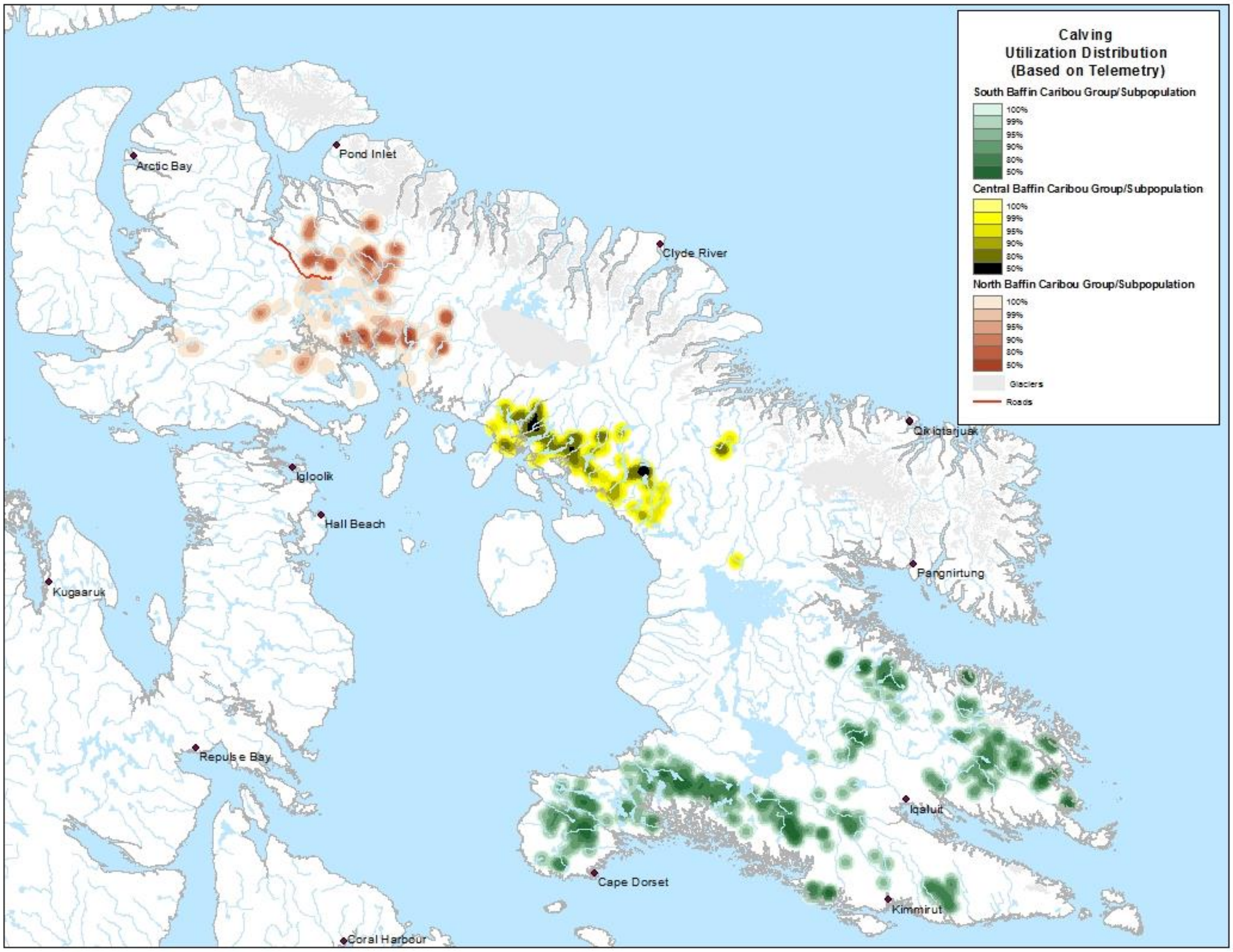



Figure 30. Calving range use based on utilization distributions utilizing a Kernel analysis with an 11 km search radius. Darker colors indicate higher use.

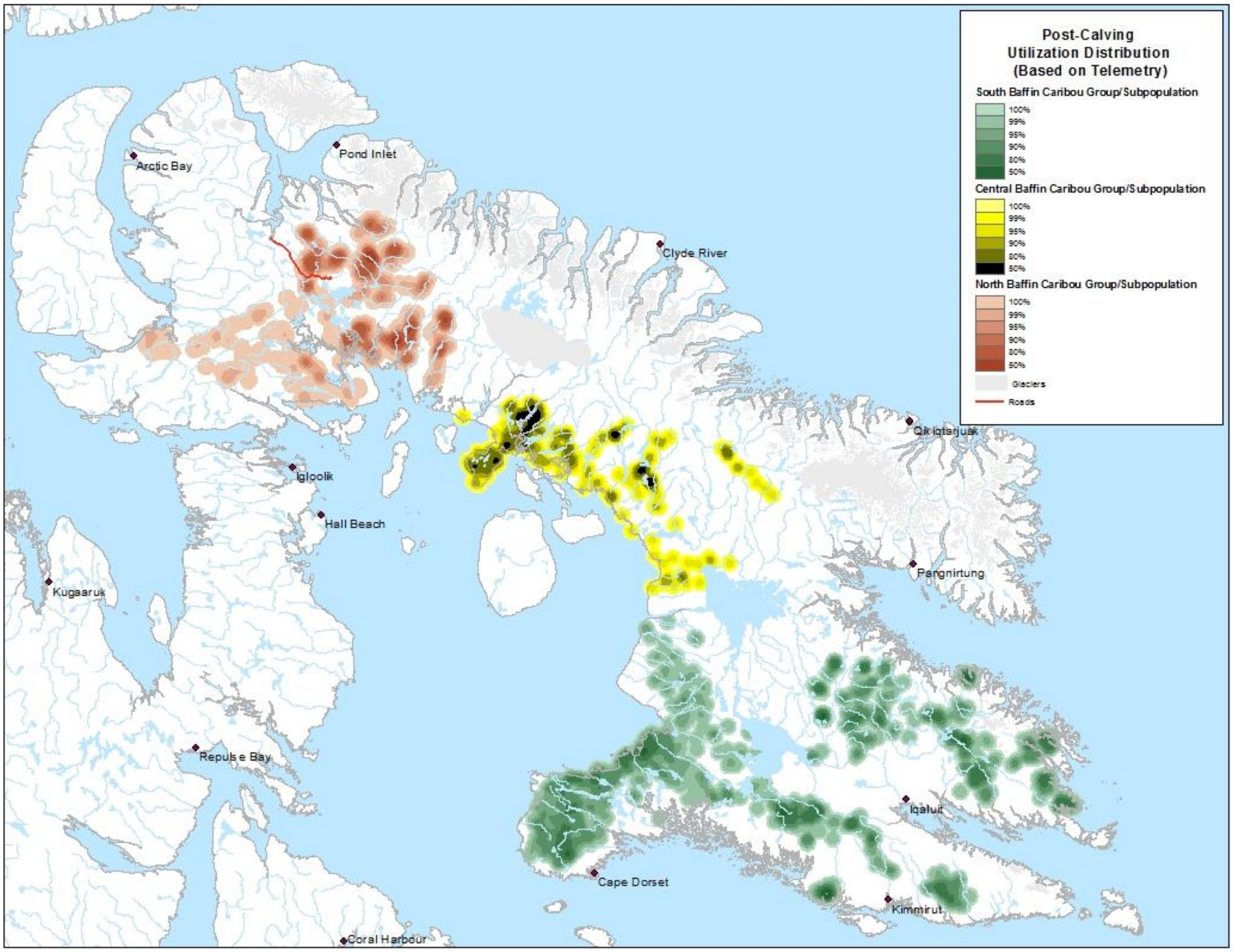



Figure 31. Post-Calving range use based on utilization distributions utilizing a Kernel analysis with an 11 km search radius. Darker colors indicate higher use.

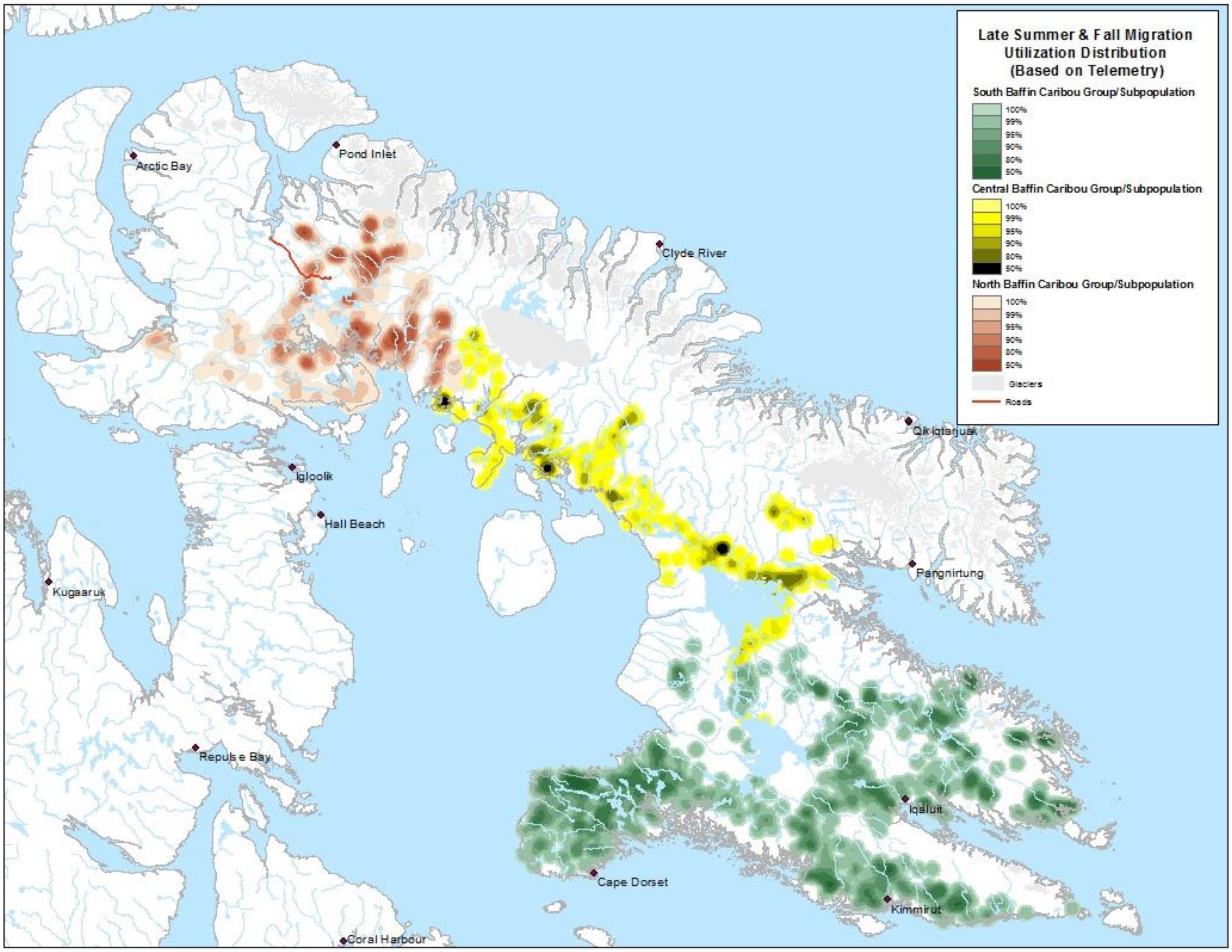



Figure 32. Late Summer and Fall Migration range use based on utilization distributions utilizing a Kernel analysis with an 11 km search radius. Darker colors indicate higher use.

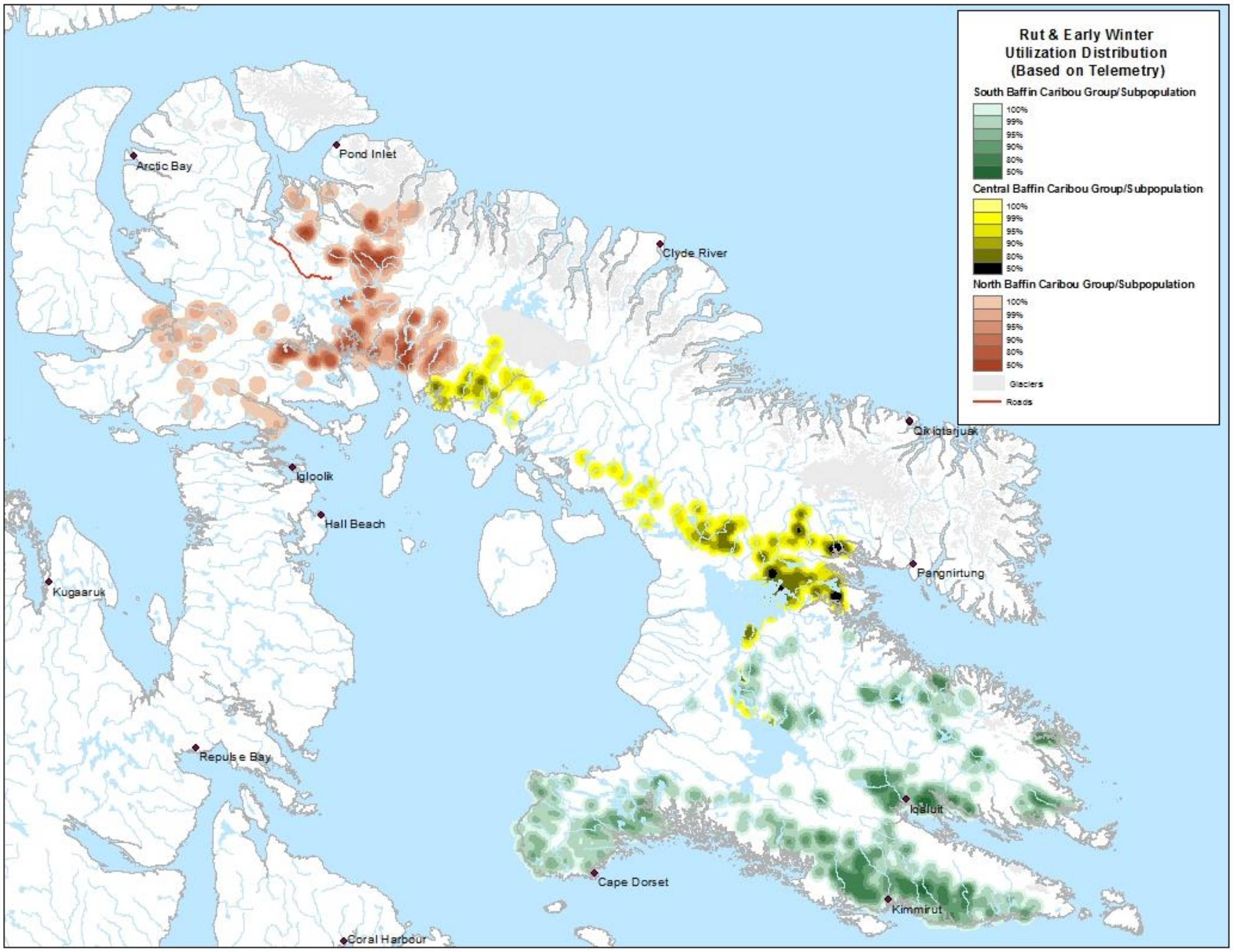



Figure 33. Rut and Early Winter range use based on utilization distributions utilizing a Kernel analysis with an 11 km search radius. Darker colors indicate higher use.

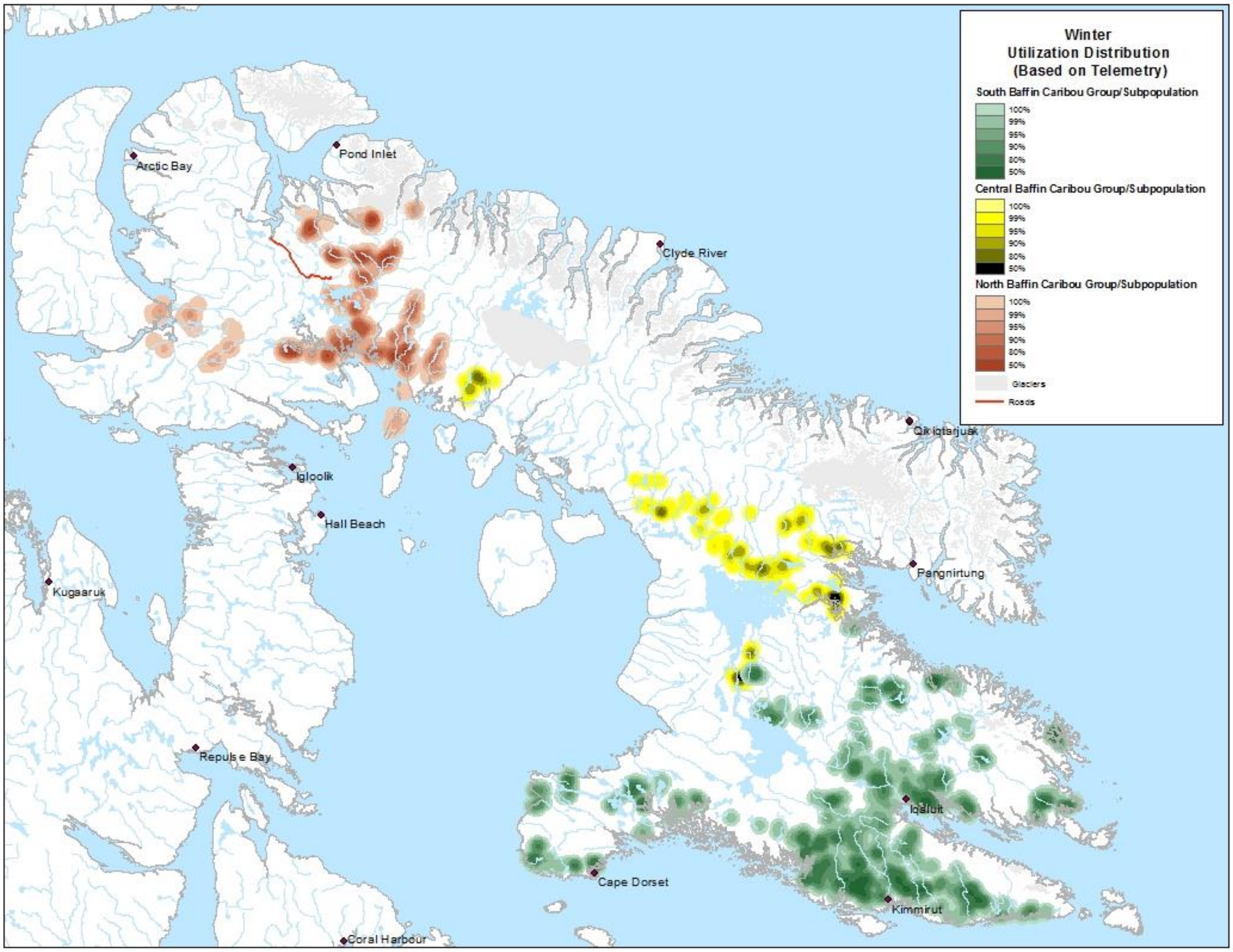



Figure 34. Winter range use based on utilization distributions utilizing a Kernel analysis with an 11 km search radius. Darker colors indicate higher use.

# 5.0 DISCUSSION

Little is known about the abundance, number or dispersement of caribou populations across Baffin Island. From the earliest field reports and limited scientific investigations, caribou subpopulations have often been discussed in terms of North and South Baffin caribou herds, groups or populations (Ferguson, 1993; Chowns, 1979; Elliott and Elliott, 1974; Elliott, 1972; Clement, 1978; Chowns and Popko, 1980; Redhead and Land, 1979; Ferguson and Gauthier, 1992; Redhead, 1979; Tener, 1961; Ferguson et al. 1998). Ferguson (1993), provided boundaries between what were described as Baffin Island caribou populations. In Ferguson's description, the Baffin Island complex is divided into North Baffin, Northeast Baffin and South Baffin Island caribou populations (Ferguson, 1993).

Though it is clear that the complexities of caribou subpopulations are many, and more delineation work is required before we can fully understand them, it is useful to examine existing spatial data and associated geographic divisions that have some support within the existing literature, contemporary IQ, and data from past telemetry studies. Though it is unclear how many subpopulations make up Baffin Island, the description provided by Ferguson, (1998) represents the most recent geographic description of caribou demographic units on Baffin Island. Additionally, position data from a collaring program led by Ferguson between 1987 and 1993 within the south Baffin area, and a more recent telemetry study led by Jenkins and Goorts (2011), run between April 2008 and July 2011, though temporally specific, display at least a general separation between north and south Baffin caribou spatial affiliations.

## 5.1 Baffin Island Populations/Subpopulations

No quantitative assessment of caribou population and/or subpopulation structure has been reported for Baffin Island. Ferguson was the first to report three populations across Baffin Island; the North Baffin population, the South Baffin population and the Northeast Baffin population (Ferguson, 1993; Ferguson and Gauthier, 1992;Ferguson et al., 1998). The delineation of these populations was based largely on Inuit knowledge with the first published boundaries released in 1992 (Ferguson and Gauthier, 1992; Ferguson, 1993) (Figure 35). Ferguson also described differing ecotypes and/or migratory types within the defined south Baffin population, suggesting that three subpopulations make up the south Baffin caribou population (Ferguson, 1993; Ferguson et al., 1998).

We modified Ferguson's boundaries utilizing the height of land between drainage systems to separate the Northeast Baffin from the South Baffin previously delineated range extents in combination with telemetry data to estimate population geographic divisions (Figure 36). We used a contemporary spatial analysis of caribou telemetry data collected between 1987 and 1996 for South Baffin (72 collars), and North Baffin (4 collars) as well as caribou telemetry data collected between 2008 and 2011 for North Baffin (31 collars), to determine annual associations between individual collared caribou during the two collaring periods. We estimated maximum possible range with glaciers removed to assess the maximum possible land base potentially available to caribou (Table 23). Further telemetry and range studies will be required to specify maximum available range to caribou as it is likely that at least a small proportion of the historic range identified here would not have supported caribou.

Though these hypothesized populations were utilized in recent years to describe the dispersement of caribou populations across Baffin Island for the purposes of management, more research is required prior to assigning firm population and/or subpopulation structure on a geographic and temporal scale. Using modern spatial techniques, we attempted to further classify caribou cow telemetry data into groupings over a very limited temporal scale to gain insight into two cyclic phases, a population high (1987-1996) and a population low (2008-2011).

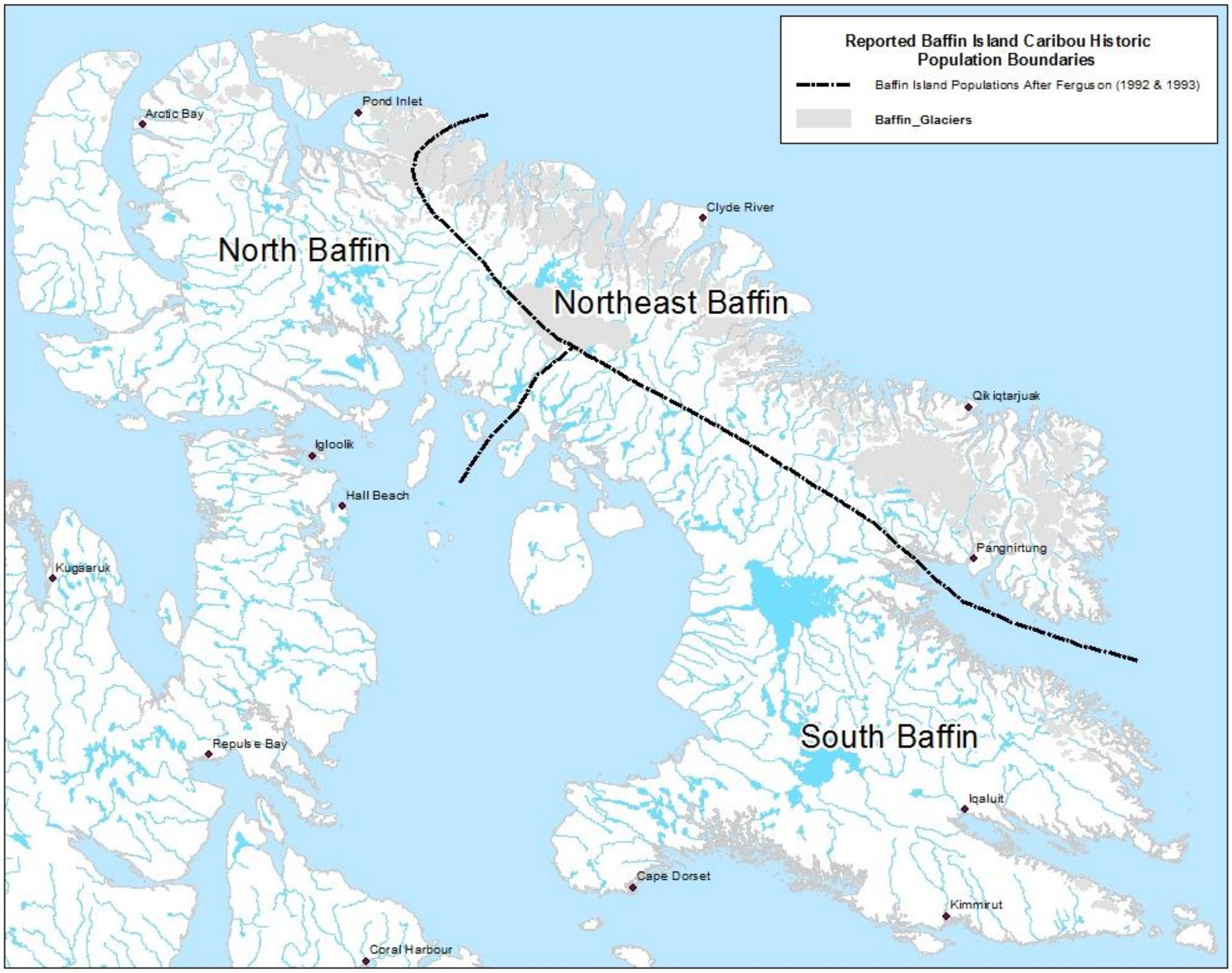



Figure 35. Caribou population divisions on Baffin Island after Ferguson (1993) and Ferguson and Gauthier (1992). Divisions based largely on IQ and not substantiated with genetic analysis and/or long-term spatial affiliations based on telemetry.

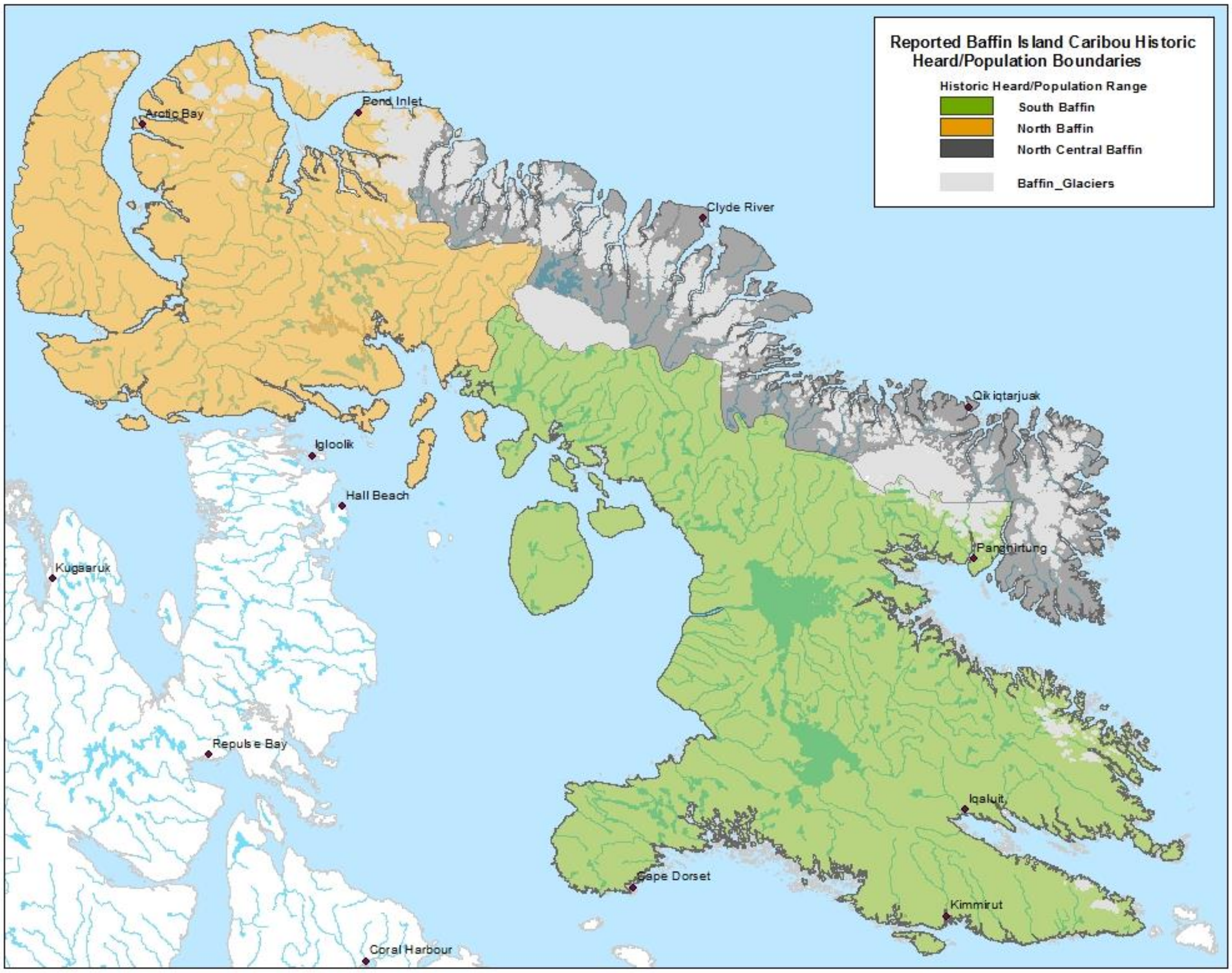



Figure 36. Reported herd/groupings/population delineations based on historic observations, survey work and IQ after Ferguson (1993) and Ferguson and Gauthier (1992). Boundaries adjusted based on telemetry studies and watershed boundaries. Boundaries are speculative and not to be used as definitive herd, population or subpopulation divisions.

Table 23. Summary statistics for estimated possible historic caribou range on Baffin Island and caribou range based on the more contemporary telemetry of 106 adult caribou cows collared between 1987 and 1994 (South and North Baffin) and 2008 and 2011 (North Baffin). Historic range estimates based on boundaries drawn after Ferguson (1993) with merged contemporary boundary corrections based on telemetry results and watershed divisions. Caution should be used when utilizing these figures due to the small sample size of collared caribou.

| ***Population Grouping*** | ***Estimated Land Area ($km^2$)*** | | ***Glacier Area ($km^2$)*** | | ***Total Area ($km^2$)*** | | ***Proportion of Maximum Available Habitat*** |
|---|---|---|---|---|---|---|---|
| | *Possible Historic Range* | *Telemetry Based Range* | *Within Historic Range* | *Within Telemetry Based Range* | *Possible Historic Range* | *Telemetry Based Range* | |
| ***All Baffin Island*** | 543,746 | N/I | 42,765 | N/I | 500,981 | N/I | N/I |
| ***North Baffin Island*** | 166,607 | 59,842 | 5,800 | 0 | 160,807 | 59,842 | 0.37 |
| ***North East Baffin Island*** | 92,928 | N/I | 18,676 | N/I | 74,252 | N/I | N/I |
| ***South Baffin Island*** | 260,492 | 200,657 | 988 | 0 | 259,504 | 200,657 | 0.77 |

## 5.2 Subpopulation Delineation

Recent local knowledge and IQ collected during a consultation tour of all Baffin Island communities in December and January 2013/14, and a follow-up workshop in November 2014, was inconclusive regarding the status and boundaries of subpopulation division across Baffin Island (Goorts and Ross, 2013; DOE consultation report, 2014). In contrast, a more rigorous published collection of IQ from the 1970's, 1980's and 1990's utilizing the collective knowledge of many Inuit elders, described multiple populations, ecotypes and/or subpopulations of caribou across Baffin Island (Ferguson, 1993; Ferguson et al, 1998,; Elliott, 1972; Elliott and Elliot, 1974). Earlier scientific sources and IQ studies indicated that the caribou of Baffin Island were composed of three main populations/groups which can be further divided into different ecotypes or migratory types.

Due to some conflicting perceptions, and lack of sufficient quantitative data typically derived from genetic and long-term spatial analysis, the subpopulation structure of caribou on Baffin Island Island remains uncertain. Instead, we use the term "grouping" to describe spatial affiliations until more information is collected to delineate population structure.

The use of the term "population" to describe observed spatial affiliations between caribou is problematic due to the small levels of mixing observed between these groupings, apparent during the analysis of available telemetry data. The information and knowledge collated during the 2014/15 consultations, suggests that the possibility that Baffin Island is made up of one caribou population should be considered, and as a result raises concerns over the applicability of earlier "population" designations. The hypothesis that Baffin Island is composed of various subpopulations is supported by some available reports and literature as well as by available spatial data.

The spatial analysis of existing telemetry data was consistent with Ferguson's earlier IQ findings yielding some support to the existence of caribou subpopulation divisions across Baffin Island. During this analysis, unique spatial associations and differing migratory characteristics were expressed within three distinct geographic areas (the North Baffin, South Central Baffin, and South East Baffin) within what was previously termed the North and South Baffin Island caribou populations by Ferguson and Gauthier (1992), and Ferguson (1993). These same divisions were also described within several scientific reports up to the mid to late 1990s (Rippin, 1972; Ferguson et al. 1998; Chowns and Popko, 1980; Elliott, 1972; Soper, 1928; Clement, 1978,; Jenkins and Goorts, 2011). With respect to these results, it appears that temporally specific subpopulation structure did exist on Baffin Island in the late 1980's to early 1990s, and within the north Baffin between 2008 and 2011 (Jenkins and Goorts, 2011).

Elliott, (1972) was the first to report multiple subpopulations in the late 1960s when he described at least four distinct groups of caribou within the South Central Baffin area including the Dewar Lakes Herd, the Ice Lakes Herd, the Dewar-Ice Lakes Herd, and the Foxe Basin Herd. Rippin, (1972) separated Baffin Island caribou into four main groups including the Amadjuak-Nettilling Lake Caribou group, the Steensby Inlet-Inuktorfik Lake Caribou group, The Tessik Lake Caribou group, and a general grouping which included small scattered independent herds of unknown number or distribution. Ferguson, (1998) reported that Inuit recognized one population/subpopulation of caribou in north Baffin Island, a second in northeast Baffin Island, and a third population/subpopulation in South Baffin Island (Figure 35). Within the historically defined South Baffin population, Ferguson (1993) describes three ecotypes or subpopulations of caribou, two different migratory upland-lowland caribou, and resident mountain plateau caribou. Ferguson also reported two seasonal patterns of movement identified by Inuit within the south Baffin, the first connected to caribou migrating between low and high elevations, and the second relating to resident caribou remaining in the mountains.

#### 5.2.1 Spatial Affiliations Summary

Unfortunately, no other annual or seasonal delineations for Baffin Island caribou have been reported. Therefore, the kernel analysis of the existing data provides important information to help better understand potential caribou subpopulation structure on Baffin Island. Though the data is limited, these preliminary analyses will provide insights into the dispersement of caribou during periods of high abundance, and in the case of the 2008 to 2011 North Baffin telemetry study, low abundance, as well as help recommend future research and management direction.

The initiation of a collaring program within the three possible groups identified using available telemetry data, would be an important next step towards the delineation and quantification of demographic affiliations. This would be particularly true for the northeast Baffin range extents where no telemetry information exists and the only survey data on record is from the present study. To maximize effectiveness, such a program should begin soon following the 2014 survey effort. The distribution and affiliations derived from such a program would provide a critical benchmark to our understanding of the population dynamics of Baffin Island caribou, helping all co-management partners make more informed decisions related to the impacts of development and various land-based activities on the long-term viability of the Baffin Island population of caribou.

## 5.3 Distribution and Movements

Though the spatial analysis of existing Baffin Island caribou telemetry data indicated strong spatial affiliations within each of the identified groupings over the period of the respective collar deployments, further examination of daily movement rates added additional support to this separation.  Caribou daily movement rates differed considerably when examined based on collared caribou captured and spending their deployment within each of the three groupings annual range extents identified earlier in this report.  In summary, the central Baffin grouping displayed the greatest annual movements, recording an average of 1,244 km/year, the south Baffin grouping the second highest at 1,022 km/year, and the north Baffin grouping the least amount of movement averaging 719 km/year (Table 24).

### 5.3.1 Spring and Fall Movements

The South Central Baffin grouping displayed the most extensive movements with mean daily movement rates of 5.0 kilometers per day during the spring period (April 5th to May 28th) and 5.3 kilometers per day during the fall period (August 13th to October 32nd) (Figure 26).  The largest single daily movement rate by any individual caribou was 14.9 km/day during the spring movement period and 13.9 km/day during fall, with total annual average movement rates of 265 km/year in spring and 378 km/year in fall (Table 24).  Aannual spring and fall movements within the South Central Baffin grouping, at their greatest extents, stretched from the southern shore of Nettilling Lake northwest to the Lake Gillian area (Figure 29 & 32).

South East Baffin caribou were less migratory during the spring and late summer/fall movement periods, displaying mean daily movement rates of 2.5 and 4.0 kilometers per day respectively (Figure 27).  The largest daily movement rate by any individual was 4.7 km/day in spring and 9.5 km/day in fall. The average annual distance travelled during spring was 137 km, while distances travelled during fall were considerably greater at 282 km/year. South Baffin movement extents were predominantly between Foxe Peninsula in summer and Meta Incognita Peninsula during winter. Caribou collared on Hall Peninsula generally remained within the peninsula throughout the year.

The north Baffin grouping displayed no extensive movements during the spring and fall periods (Figure 28). Daily movement rates for the spring and fall periods were 1.9 and 2.4 kilometers per day respectively (Figure 29 & 32). The largest daily movement rate of any individual caribou was 4.0 km/day for both the spring and fall migratory period. The average annual distance traveled was 103 km during spring and 170 km during fall. North Baffin movement extents were minimal with little seasonal movement and/or exchange between collared cows occupying the northern extents of this groupings range in the vicinity of Mary River, and the southern extents, in the vicinity of Steensby Inlet.

### 5.3.2 Calving Season

Mean daily movement rates during the calving period are typically low as caribou are encumbered by the late stages of pregnancy, the birthing process, and the nursing of newborn calves. The North Baffin grouping movement rates during calving of 1.7 km/day, differed little from spring migratory rates, further emphasizing the reduced migratory behavior of this grouping (Figure 28). Peak calving was difficult to analyze for the North Baffin grouping due to the limited data and little difference in daily movement rates observed between seasons. Generally, all years for all three groupings displayed the most reduced daily movement rates between the 13$^{th}$ and 18$^{th}$ of June with the North Baffin grouping tending toward the lower end of the range and the South Central and South East groupings tending toward the upper end of the range. The highest overall daily movement rates during the calving period were recorded within the

South East Baffin grouping at 3.0 kilometers per day followed by the South Central Baffin grouping at 2.5 kilometers per day.  Average annual movement rates during the calving season reflected daily averages with the South East Baffin grouping displaying the highest rates of movements of the three groupings at 83 km/year (Table 24).  The South Central and North Baffin groupings followed with 69 and 47 km/year respectively.

Calving extents for the North Baffin groupings were well dispersed across the annual range.  The most concentrated calving sites were within nine general areas, four within the southern extents of this groupings annual range, and five within the central and northern extents (Figure 30).  The four main calving aggregations observed within the southern extents included the area of Tariujaq Arm of Steensby Inlet, an area west of Cockburn Lake, the Separation Lake area, the northern extents of the Isortoq Lake area, and an area in the vicinity of the headwaters of Freshney River.  Calving aggregations within the central and northern extents of the North Baffin grouping were located in an area just south of Tay Sound, an extended area northwest of Nuluujaak mountain and the Mary River drainage, the Ravn River drainage, and an area east of the north Arm of Paquet Bay.

Within the South Central Baffin grouping annual range, calving aggregations were less spread out than those of the North and South East Baffin groupings, concentrated almost entirely within the northwestern extents of the South Central Baffin annual range (Figure 30).  Two large, relatively continuous calving areas were delineated within the South Central Baffin annual range. The first of these aggregations was located within an area running from Flint Lake, southeast to Nadluardjuk Lake.  The second calving aggregation was spread across the southern extents of Dewar Lakes area, running southwest to Wordie Bay.

South East Baffin calving extents were largely concentrated within a relatively continuous area across the Foxe Peninsula and western extents of the Meta Incognita Peninsula (Figure 30). On the Foxe Peninsula, calving aggregations ran between an area southwest of Nukvuk Lake to the Kingnait Range in the west, and from the vicinity of Keeka Lake to the northern reaches of Keltie Inlet and Mingo Lake in the eastern extents. On the western extents of the Meta Incognita Peninsula, calving areas ran from the vicinity of Mingo Lake (Eastern shore) inland to the northeast, to an area north of the northern tip of Ava Inlet. Further east along the southern coast a calving area was also delineated within a river valley running north of Barrier Inlet.

The Hall Peninsula portion of the South East Baffin grouping annual range displayed the most dispersed calving distributions, forming a patchwork of medium collar density clusters primarily across the upper plateau and more eastern extents of Hall Peninsula. In total, five main calving aggregations were delineated across the Hall Peninsula. These areas included an area in the vicinity of the mid to northern extents of Beekman Peninsula, an area including multiple river valleys draining into Smith Channel, an upper plateau area marking the center of the eastern extents of Hall Peninsula, an area extending east of the McKeand river drainage half way along its length to the western extents of Robert Peel Inlet, and an area in the vicinity of the head waters of the McKeand River system.

### 5.3.3 Post-Calving

Post-calving movement rates for the North Baffin grouping were the highest of any period within this grouping's annual cycle at 2.8 kilometers per day. Of the three groupings, post-calving movements were again the highest within the South Central grouping at 4.3 km/day, followed by the South East grouping at 3.7 km/day. Movement rates between all three groupings were similar during the post-calving period with the North Baffin grouping averaging 136 km/year, the South Central grouping 208 km/year, and the South East grouping 175 km/year.

Post-calving extents were similar to those described for calving though generally more spread out within their respective grouipings annual ranges (Figure 31). Once again, the South Central grouping displayed the most defined post-calving range with the most concentrated groups of post-calving caribou being found across Baird Peninsula to the northern tip of Flint Lake. Post-calving aggregations within the South East Baffin grouping annual range displayed the highest and most continuous distributions across the northwestern half of the Foxe Peninsula, east central Meta Incognita Peninsula, and the central plateau area across Hall Peninsula. North Baffin post-calving extents were scattered across the annual range showing little tendency to aggregate in any one area.

### 5.3.4 Rut/Early Winter and Winter

Little difference in daily movement rates were observed between the three groupings during the rut and early winter period and the winter period. However, the North Baffin grouping displayed lower daily movement rates over these two periods at 2.2 and 1.3 kilometers per day respectively, than that recorded for the South East and South Central groupings (Figure 28, 27 and 26). The South East Baffin grouping underwent higher mean daily movement rates during the rut and early winter period then recorded for the South Central grouping, at 3.3 and 2.9 kilometers per day respectively. Both the South East Baffin and South Central Baffin groupings displayed the same mean daily movement rates over the winter period at 1.5 kilometers per day. Average annual movement rates for the three groupings during the rut/early winter period was greatest for the South East Baffin grouping at 178 km/year, followed by the central grouping at 154 km/year, with the lowest annual movement rates indicated for the North Baffin grouping at 116 km/year (Table 24). The winter period showed similar movement rates across all groupings with the South Central at 167 km/year, with the lowest annual movement rates recorded within the North Baffin grouping at 148 km/year.

Rutting and winter aggregations within the North Baffin grouping were similar to those of the calving and post calving season with a general eastern shift across the annual range (Figure 33, 34, 31 & 30). Both rutting and winter range was spread across the annual range with the greatest use apparent within the eastern extents of the North Baffin annual range. The South Central Baffin grouping displayed the most concentrated and continuous use of rutting and early winter range of the three groupings, displaying a well-defined wintering area along the northeast and eastern shores of Nettilling Lake to the Ranger River drainage. Rut and winter aggregations in the South East Baffin grouping annual range concentrated along most of the southern half of the Meta Incognita Peninsula with a second smaller aggregation within the southwestern extents of Hall Peninsula in a broad area stretching between Burton Bay and Anna Maria Port. Foxe Peninsula displayed less concentrated rut and early winter aggregations across its southeastern half.

Winter aggregations within the southeast annual range were similar to fall and early winter distributions, but less concentrated, with patchy aggregations located across Hall Peninsula within the more rugged country bordering the central plateau area.

Table 24. Annual movement rates of the North, Central and South Baffin caribou groupings as delineated using telemetry data.

| ***Caribou Grouping*** | ***Annual Movement Rates (km/year)*** | ***Seasonal Movement Rates (km/year)*** | | | | | |
|---|---|---|---|---|---|---|---|
| | | ***Spring Migration*** | ***Calving*** | ***Post-Calving & Early Summer*** | ***Late Summer & Fall Migration*** | ***Rut & Early Winter*** | ***Winter*** |
| ***North Baffin*** | 719 | 103 | 47 | 136 | 170 | 116 | 148 |
| ***Central Baffin*** | 1,244 | 265 | 69 | 208 | 377 | 153 | 171 |
| ***South Baffin*** | 1,022 | 137 | 83 | 175 | 282 | 178 | 167 |

## 5.4 Seasonal Range Fidelity

To enhance the temporal assessment of seasonal range for the three Baffin Island groupings, we overlaid historical delineations of seasonal range to provide a sense of multi-year fidelity. It is important to note that the seasonal ranges generated in this report are based on very limited information and data sources over very specific time periods, and as a result, are almost certainly underestimates of the extent of range required to sustain a healthy caribou population/populations on Baffin Island. Unfortunately, reports of seasonal range utilized by north Baffin caribou are few, and none substantiated through quantitative assessment and reporting techniques, making a comparison with the more contemporary telemetry spatial analysis difficult. For these reasons, the resulting spatial analysis of the North Baffin grouping will be based solely on telemetry. Similarly there is only limited IQ available for what was historically defined as the Northeast Baffin population. No scientific reports addressing northeast Baffin demography have been uncovered. As a result, no assessment of seasonal range can be undertaken on this historically delineated population of caribou. Further studies are required to delineate subpopulation structure and seasonal range fidelity.

### 5.4.1 Calving

The calving period on Baffin Island is poorly understood as it is based on limited telemetry conducted between 1987 and 1994, and 2008 and 2011 (Table 22), with historic assessments of the calving period being based on only two aerial survey-based assessments. The first of these assessments was made by Elliott in 1974, and the second by Chowns and Popko in 1979 (Elliott, 1974; Chowns and Popko, 1980) (Figure 37). Individual high-density core calving areas varied between assessment periods though in all cases calving occurred in the same general geographic areas, particularly within the South

East Baffin grouping. Calving areas within the South Central Baffin grouping tended to be more coastal (based on 1987-1994 telemetry) than those reported by Elliott (1974).

### 5.4.2 Post-Calving

Post-calving sites documented by Elliott (1974) were much less extensive than those produced through the present telemetry analysis, though there was good overlap between the two information sources confirming at least some consistency over the two periods for South Central Baffin Island grouping post-calving areas (Figure 38). Though there was good overlap between historically defined South Baffin telemetry based post-calving areas and Elliott and Redheads respective 1974 and 1976 delineated post-calving areas, South East Baffin grouping postcalving sites displayed much more extensive activity to the northeast and south of these delineated areas. Of interest is the high activity on the northern extents of the Foxe Peninsula indicated through the analysis of telemetry data from 1987 through 1994. As the Foxe peninsula was well outside of Elliotts and Redheads collective study areas, we cannot eliminate the possibility that the Foxe Peninsula area was also in use for post-calving caribou over the same period of these two research programs. Unfortunately, no seasonal delineation work prior to the present analysis of telemetry data has ever been reported for the Meta Incognita Peninsula or for seasons other than calving on the Hall Peninsula.

### 5.4.3 Rut and Early Winter

The only historical report of delineated caribou aggregations during the rut and early winter period (October 23$^{rd}$ to December 15$^{th}$) is provided by Chowns (1979). During this period, Chowns set out to estimate the historically defined South Baffin caribou population utilizing stratified aerial survey techniques in November 1978. The geographic area of the reconnaissance used to delineate high density strata did not extend onto the Hall or Meta Incognita Peninsulas, nor did it extend north of Nettilling Lake. When compared with telemetry data from the 1987 through 1994 deployment, overlap between the two time periods was apparent though the 1987-1994 telemetry data suggests that rutting areas had changed over the decade between the two studies (Figure 39). The telemetry analysis indicated the southcentral Meta Incognita Peninsula was being favored by caribou during that period, suggesting a shift in caribou distribution, similar to that described by Ferguson (1991) from his interviews with Inuit hunters and elders.

Though a distributional shift explains these differences in preferred rut and early winter range, of greater interest is Chowns northern most strata, a strata that overlaps heavy collared caribou use over the same season but a decade later. If a similar structure as that described using the available telemetry data was in existence over the period of Chowns (1979) study, it would appear that he may have been estimating only a portion of two groupings, the South East Baffin and the South Central Baffin groupings. This observation suggests that Chowns may have underestimated the range and abundance of the caribou occupying both the South East and South Central groupings of Baffin Island caribou, which at the time were collectively termed the South Baffin population (Chowns, 1979).

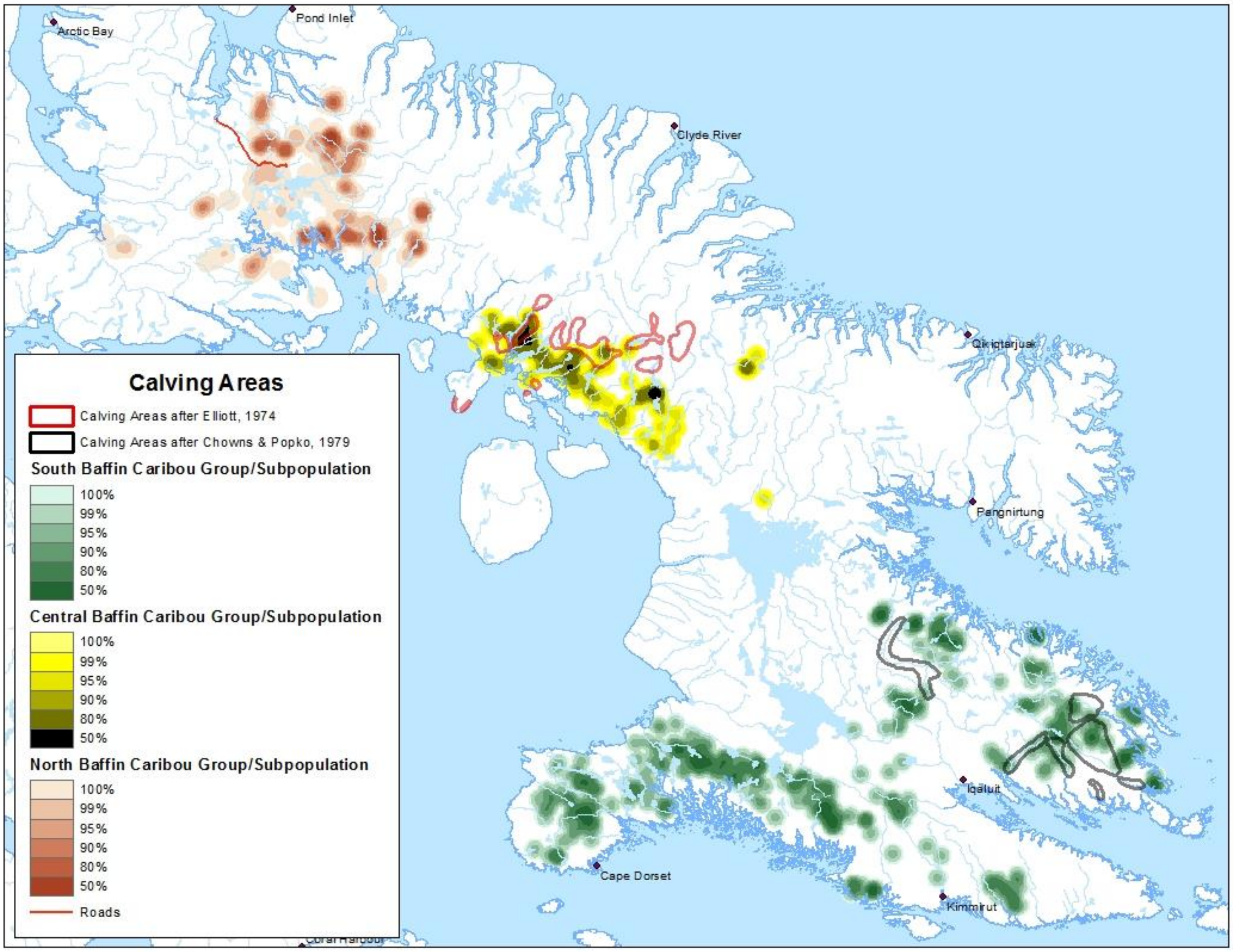



Figure 37. The calving period (May 29th to June 25th). Outlined areas represent delineated caribou calving areas after Elliott (1974), and Chowns and Popko (1979). Telemetry derived calving range of the North Baffin, Central Baffin and South Baffin caribou groupings are indicated.

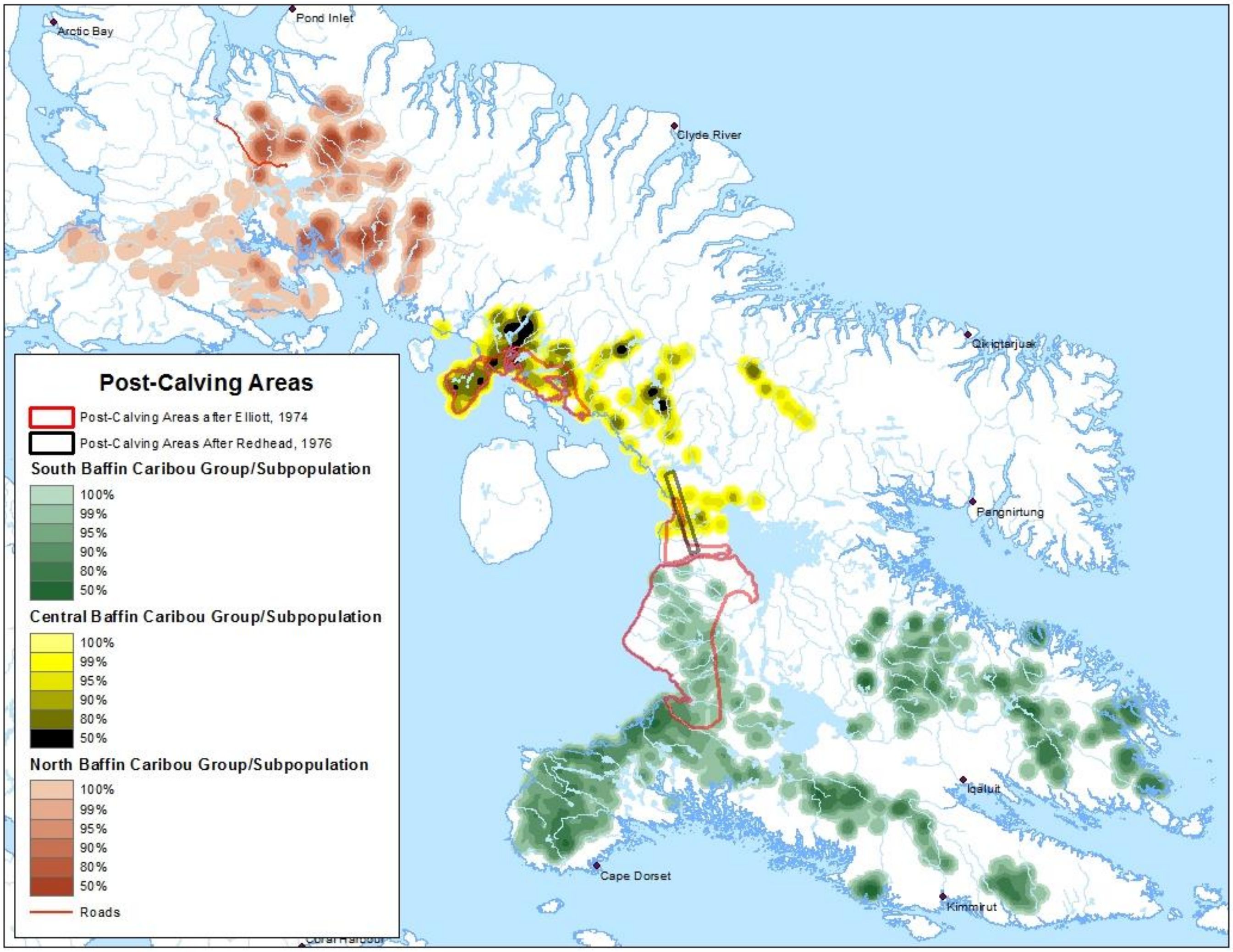



Figure 38. The post-calving and summer period (June 26th to Aug. 12th). Outlined areas represent delineated caribou post-calving areas after Elliott (1974), and Redhead, (1976). Telemetry derived post-calving range of the North Baffin, Central Baffin and South Baffin caribou groupings are indicated.

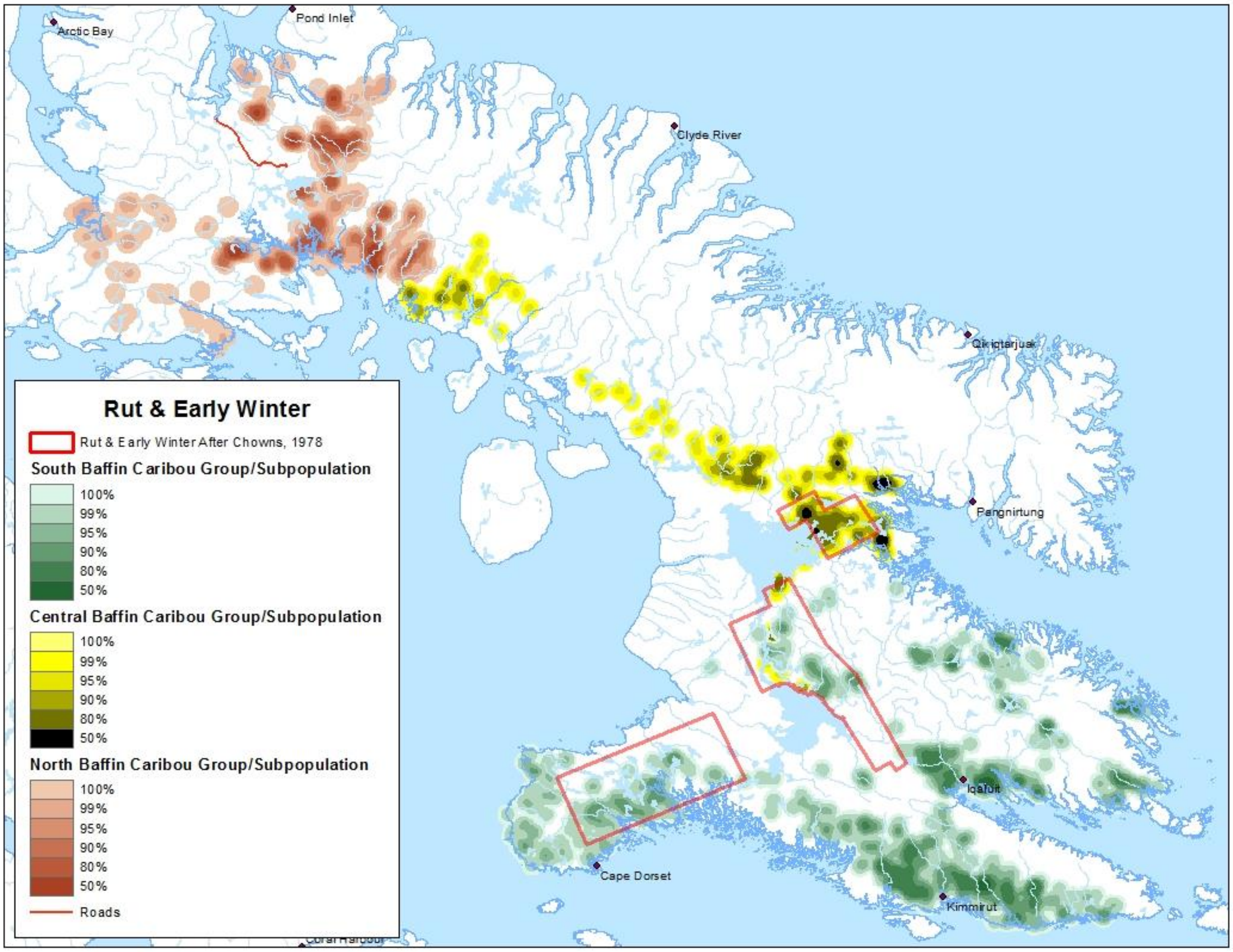



Figure 39. The Rut and Early Winter period (Oct. 23rd to Dec. 15th). Outlined areas represent delineated caribou post-calving areas after Elliott (1974), and Redhead, (1976). Telemetry derived post-calving range of the North Baffin, Central Baffin and South Baffin caribou groupings are indicated.

## 5.5 Baffin Island Caribou Abundance and Trend

The earliest records describing the caribou of Baffin Island in any scientific detail were made by Soper (1928) and again by Manning (1943). In these two accounts, observations of caribou and caribou harvests were recorded during the author's exploratory travels across Baffin Island. However, despite both authors making observations of local abundance, productivity, and temporally specific movements, no analysis of abundance was or could be undertaken as only a very small portion of the caribou range across Baffin Island was investigated. These early investigations, however, did provide baseline information from which more contemporary investigations could be built.

Kelsall (1949), Loughrey, (1954), Tener and Solman (1960) and Tener, (1961), undertook the first series of attempts at surveying the island by air. All of these principal investigators utilized Sopers (1928) and Manning's (1943) qualitative observations to design their surveys and to interpret their results. Of the four aerial surveys attempted over this period, only Kelsall (1949), and Tener and Solman (1960), successfully completed their aerial survey programs. Weather delays eventually cancelled Teners (1961) attempts to re-survey the island in March 1961. Though Tener and Solman (1960) discuss a survey estimate of Baffin Island derived by Loughrey (1954), the report has never been found (Hall, 1980). With no means of critically reviewing Loughrey's (1954) survey details, we have removed these results from our discussion.

Though Kelsall (1949) and Tener and Solman (1960) completed much of their planned surveys, both efforts were fraught with the methodological difficulties characteristic of many aerial survey programs of the time (Hall, 1980). Survey altitudes in April 1949 varied between 60 and 610 meters with airspeeds varying between 193 and 225 km/hour. Additionally Kelsall (1949) surveyed an estimated 8,029 $km^2$ representing 1.6 percent of Baffin Island excluding all glaciers (500,981 km$^2$) (Table 23). This level of coverage was inadequate to determine abundance or even to provide an index with which to determine trend as massive expanses of potential caribou habitat were not assessed (Hall, 1980). Though their survey effort was more intensive, Tener and Solman (1960) ran into similar difficulties during their aerial program. Altitudes in March 1960 were maintained as close as possible to 305 meters while airspeeds were the same as those reported by Kelsall. Survey coverage was similar at 8,016 km$^2$ or 1.6 percent of non-glaciated habitat across Baffin Island. However, the altitudes used by Tener and Solman were consistently lower and their effective strip width considerably more narrow than that of Kelsall, suggesting improved sightability of caribou. Regardless of the dependability of these surveys, a key factor to consider is their lack of representation of caribou habitat across Baffin Island (Figure 40). Both survey study areas did not include any Northeast Baffin or Cumberland Peninsula caribou habitat. Much of Foxe, Hall and Meta-Incognita Peninsula's and North Baffin were not surveyed. Though both Kelsall (1949) (4,500 to 6,500 caribou) and Tener and Solman (1960) (7,725 caribou) generated abundance estimates, the methodological issues and lack of coverage make these estimates unreliable and likely far lower than the actual population at that time. The lack of comparable study areas disqualifies any attempt to use these survey estimates to determine trend.

### 5.5.1 South East and South Central Baffin

Though the Kelsall, and Tener and Solman aeral surveys were the fist attempts to assess caribou abundance on Baffin Island, many other surveys were attempted between the late 1960's and late 1970s. These survey efforts were restricted to the southern Baffin Island population as defined in these earlier reports (Rippin, 1972; Elliott, 1972; Elliott and Elliott, 1974A; Elliott and Elliott, 1974B; Redhead, 1979; Chowns, 1979; Clement, 1978). Though survey methods improved substantially over that period, the problem of inadequate survey coverage persisted (Table 25). Scientists were now facing the difficulty of assessing population structure/dispersment across which to lay aerial abundance assessment study areas that would be representative of this same structure.

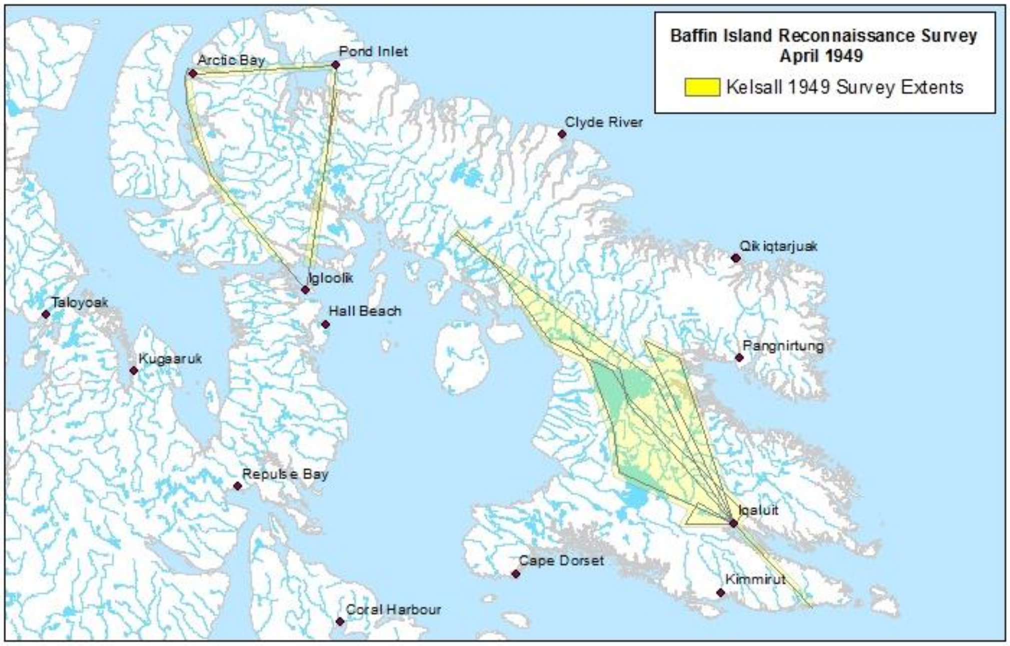
Aerial assessments of the historically delineated South Baffin Island caribou population between 1961 and 1978 were flown by Redhead (1979) in July 1976, and Chowns (1979) in November 1978 (Figure 41). Both surveys utilized reconnaissance surveys to further stratify their study areas. Both surveys utilized altitudes of 120 meters and strip widths of 400 meters on each side of the aircraft, methods which are well accepted today as effective ways to maximize sightability for any given background. Additionally, both surveys covered a high proportion of their reconnaissance study areas with 55% coverage for Redheads July 1976 survey study area and 29% coverage of Chowns November 1978 survey study area. Again, as in past surveys, the problem with these surveys lies in their representation of the historically delineated South Baffin population where Redhead covered less than one percent of potential South Baffin caribou habitat and Chowns just over seven percent. Clearly, given the historical reports in addition to our more contemporary understanding of caribou distribution across Baffin Island, neither of these surveys were able to fully assess caribou abundance on southern Baffin Island. Of the two, however, Chowns 1978 survey effort represented the most extensive and reliable data to date, estimating 35,291 (+/- 5,417 95% CI) caribou, the highest estimate ever quantified on Baffin Island using modern aerial census techniques. A review of the historic data, IQ and more contemporary studies examining that period, strongly suggests that this result was an underestimate of South Baffin caribou abundance though to what degree will remain unknown (Hall, 1980; Clement, 1978; Ferguson, 1993; Ferguson and Gauthier, 1992;Soper, 1928; Elliott and Elliott, 1974; Rippin, 1972).

Though Ferguson discusses aerial surveys flown in March 1982, November 1984, and again in April 1991 and 1992, no reports, analysis and/or details of these surveys/analysis have been found (Ferguson, 1991; Ferguson et al., 1998). Though

Ferguson did report an estimate of 36,000 caribou occupying the Foxe Peninsula with the exception of the coastal lowlands south of Foxe Basin, in November 1984, the estimate cannot be substantiated as no survey details, analysis or report is available to examine (Ferguson, 1991). Ferguson did report that during the April 1991 survey, no sign of caribou was seen on eastern Cumberland Peninsula though Inuit knowledge predicted that this area would soon be occupied (Ferguson et al., 1998). Following Chowns survey efforts the next aerial survey to assess the south Baffin caribou subpopulation took place 34 years later.

The first attempt to estimate the abundance of entire groupings was made by Jenkins et al. (2012) (Figure 42). Jenkins et al survey effort covered both the South Central and South East Baffin groupings annual ranges historically termed the South Baffin population (Ferguson and Gauthier, 1992). The survey duration, however, was lengthy, beginning March 27$^{th}$ and terminating May 27$^{th}$ (62 days), a result of poor weather throughout the period. The excessive duration, due in part to poor weather caused multiple, substantial temporal gaps between adjacent transects ranging between 5 and 8 days in some instances, exacerbating the possibilities of either double counting and/or missing groups of caribou moving within these localized geographic areas. Further complicating this potential error was the increasing daily movement rates characteristic of the spring period. Average daily movement rates for the Central and South Baffin groupings over the survey period were 5.0 and 2.5 km/day, respectively, with annualized totals over the survey period of 265 km/year and 137 km/year, respectively.

Additionally, as the survey proceeded into late April and May, snow cover became patchy in all but the most flat environments making sightability of caribou more difficult. The combination of these potential issues had raised concerns over the reliability of the estimates generated, a concern voiced by Baffin Island communities in January 2014 (Goorts and Ross, 2014). Despite these issues, Jenkins et al. (2012) generated an estimate of 1,484 (95% CI = 1,065–2,067; SE = 252.3; CV = 0.17) caribou one year of age or older. The resultant estimate from the 2012 survey was far lower than any of the co-management partners had expected, and the potential issues encountered likely could not account for the overall lack of caribou observed in spring 2012.



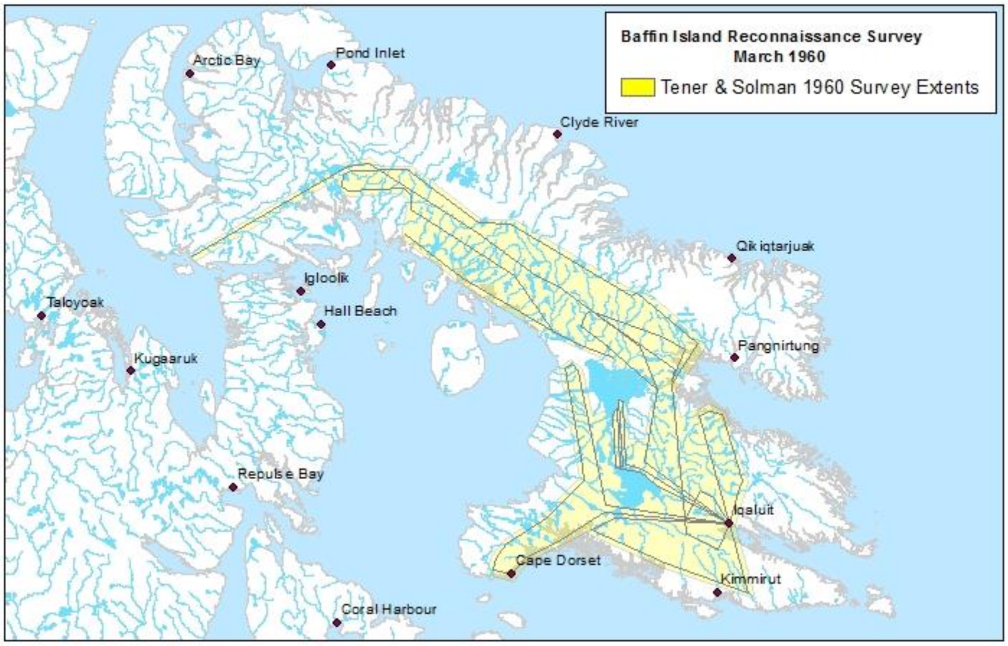




Figure 40. Early reconnaissance level surveys of Baffin Island after Kelsall (1949) and Tener and Solman, (1960) (Note transect placement based on report figures and should be considered approximate.).

Table 25. Summary results of reported aerial caribou surveys flown between the mid-1960s through 1970.

***BAFFIN ISLAND SURVEYS 1965 - 1980***

| **Year** | **Month** | **Baffin Subpopulation** | **Summary Statistics** | | | **Mean *Altitude (m)*** | **Strip *Width (km)*** | **Survey Study Area *(km2)*** | **Coverage *(km2)*** | **Survey Area Coverage *(%)*** | **Subpopulation Range Area *(km2)*** | **Proportion of Range *Surveyed (%)*** | **Visual Method (*SO = Single Observer*)** | **Source** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ***Yh*** | ***SE*** | ***CV (%)*** | | | | | | | | | |
| ***1949*** | April | All | 5,500 | NA | NA | 533 | 1.6 | 83,271 | 8,029 | 9.6 | 500,984 | 1.6 | SO | *J.P. Kelsall, 1949* |
| ***1960*** | March | All | 7,725 | NA | NA | 305 | 3.2 | 178,741 | 8,016 | 4.5 | 500,984 | 1.6 | SO | *J.S. Tener & V.E.F. Solman. 1960.* |
| ***1976*** | July | SB | 3,750 | 344.1 | | 120 | 0.4 | 1,476 | 816 | 55.3 | 252,711 | 0.3 | SO | *R. Redhead, 1979* |
| ***1978*** | November | SB | 35,291 | 2,652.8 | 15.3 | 120 | 0.4 | 65,425 | 18,765 | 28.7 | 252,711 | 7.4 | SO | *T. Chowns, 1979* |

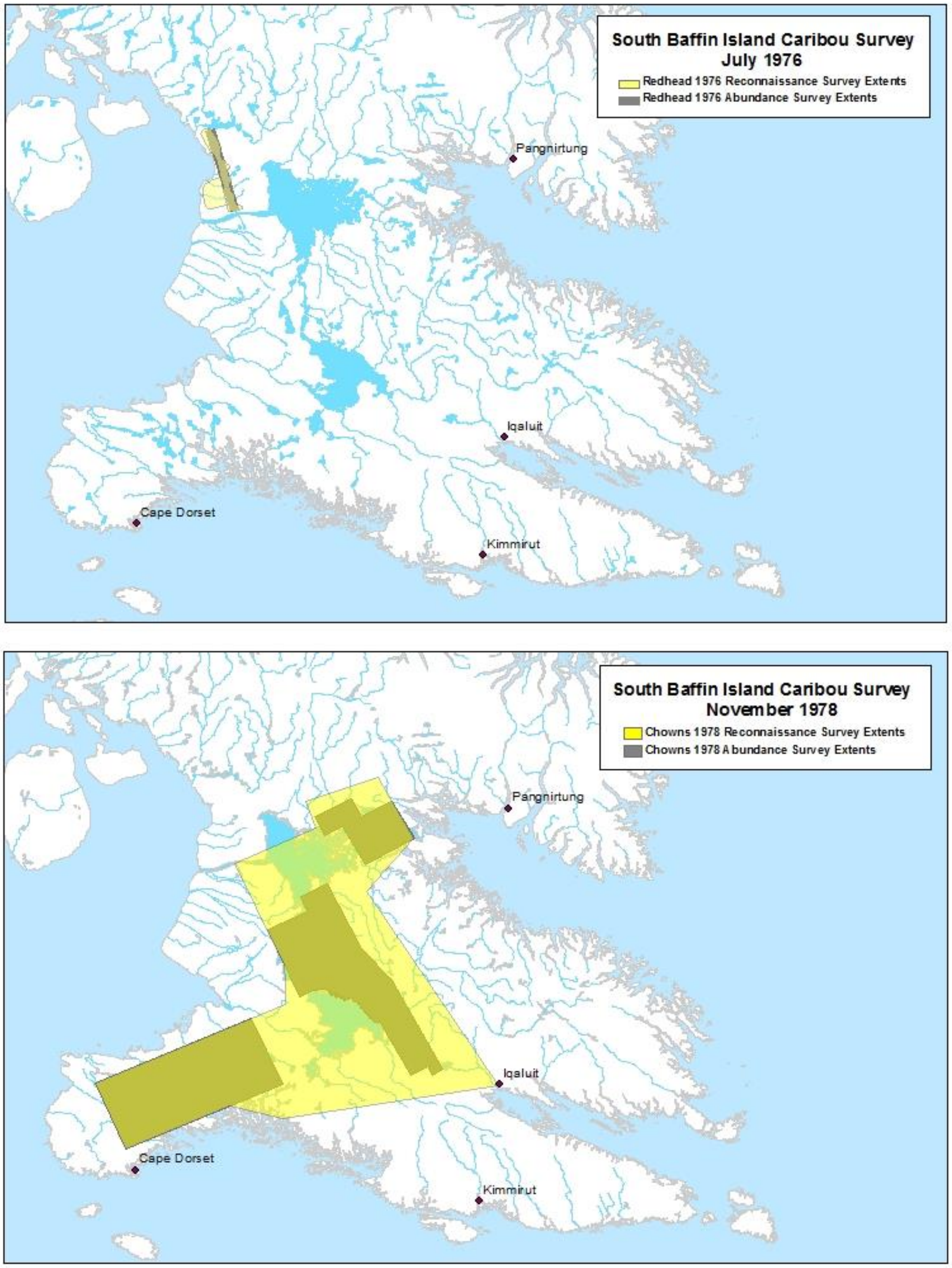



Figure 41. Caribou survey reconnaissance and abundance strata after Redhead (1979) and Chowns (1979) (survey areas illustrated are approximate).

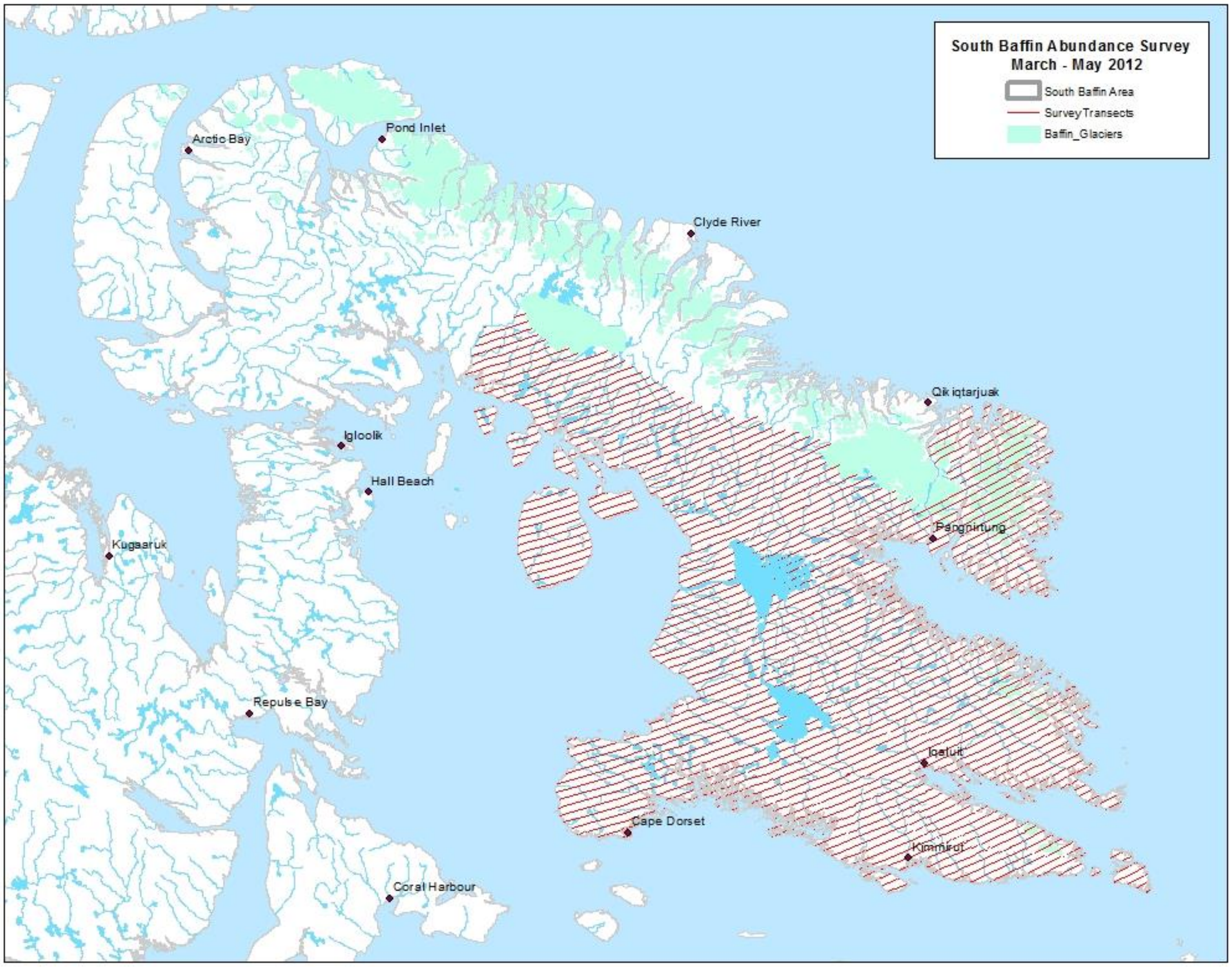



Figure 42. The March/April/May 2012 south Baffin Island caribou survey transects and extents. South Baffin area based on telemetry studies between 1987 and 1995.

### 5.5.2 Comparison of 2012 and 2014 Survey Estimates

We compared the left truncated (at 100 meter) estimates from the 2012 survey (Table 26) with the 2014 survey estimates for paired stratum (Figure 43). Estimates were higher for all stratum in 2014, however, confidence limits overlapped for all stratum except PCI.

We also compared the estimates using a two-tailed t-test ($t = (\hat{N}_{2014} - \hat{N}_{2012}) / \sqrt{SE^2_{2014} + SE^2_{2012}}$) to determine if differences between the 2012 and 2014 aerial abundance survey estimates were significant (Table 26). Degrees of freedom as estimated by program *DISTANCE* were used for each yearly stratum estimate. The combined estimation of degrees of freedom used for the t-test were based on combined variances and degrees of freedom from each stratum (Gasaway et al. 1986). A two-tailed hypothesis test and associated p-value was generated for each t-statistic. The difference between 2012 and 2014 estimates, both by strata, groupings, and island-wide, was not significantly different (at α=0.05) with the single exception of the PCI strata in which instance the 2014 abundance estimate of 1,603 (95% CI=1,158-2,220;SE=103.5;CV=0.16) was significantly higher than the 709 (95%CI=525-956;SE=104;CV=0.15) caribou observed in 2012 (p=0.002).

The estimate of 2,193 (95% CI=1,555-3,093) derived from the re-analysis of 2012 data (Table 18) was higher overall than the estimate of Jenkins et al (2012) of 1,484 (95% CI=1065-2067). It is hard to completely evaluate whether the difference in estimates is due to lack of precision or actual factors influencing estimates. One of the main differences between this analysis and the analysis of Jenkins et al (2012) is that this analysis has directly accounted for differences in sightability on Prince Charles Island and other stratum and left truncated the data at 100 meters. Pooling data from other stratum with PCI within the 2012 analysis potentially reduced the estimates of other stratum since it was assumed that sightability was greater for these stratum. For example, the overall abundance estimate from model 9 (Table 17) was 1,507 (CI=1123-1836).

The analysis of Jenkins et al (2012) excluded calves whereas the analysis in this paper included calves. The most supported distance model (Model 1, Table 17) was re-run with calves excluded to explore the effect of exclusion of calves on estimates from this analysis. The resulting estimate for all stratum was 1,952 (CI=1378-2763) which was 241 caribou less than the total estimate of 2,193 (CI=1,555-3,093). We believe the inclusion of calves is justified given the difficulties in classifying calves or short-faced yearlings at further distances from the transect line during the 2014 survey. In addition, the actual group sizes sighted by observers included calves, and therefore use of this number for modelling group size as a sightability covariate is more justified than group size with calves excluded. In addition, the short-faced yearlings observed had survived almost to the next calving season and therefore should be considered part of the biological population. The actual inclusion of calves did not greatly influence estimates.

One additional difference in the 2014 analyses was that the effect of cluster size on sightability was modelled using cluster size as a covariate whereas Jenkins et al (2012) used a regression-based approach to account for cluster size bias. Using cluster size as a covariate provides a direct method to estimate cluster size that is fully integrated into model selection and estimates (Buckland et al 2004).

Table 26. Comparison of 2012 and 2014 estimates using a two-tailed t-test.

| Stratum | 2012 | | | 2014 | | | T-test for difference | | |
|---|---|---|---|---|---|---|---|---|---|
| | $\hat{N}$ | SE | df | $\hat{N}$ | SE | df | $t$ | df | P($t$) |
| *Central Baffin* | 773 | 253.4 | 78.9 | 1,091 | 278.4 | 103.2 | 0.84 | 181.8 | 0.400 |
| *Foxe Peninsula* | 69 | 68.5 | 19.6 | 216 | 183.4 | 30.4 | 0.75 | 38.3 | 0.457 |
| *Hall Peninsula* | 480 | 161.9 | 65.5 | 887 | 292.9 | 96.0 | 1.21 | 143.9 | 0.227 |
| *Meta Incognita Penninsula* | 162 | 88.1 | 34.7 | 539 | 207.5 | 96.2 | 1.67 | 122.9 | 0.097 |
| *Prince Charles Island* | 709 | 103.5 | 25.3 | 1,603 | 249.8 | 26.0 | 3.31 | 34.7 | 0.002 |

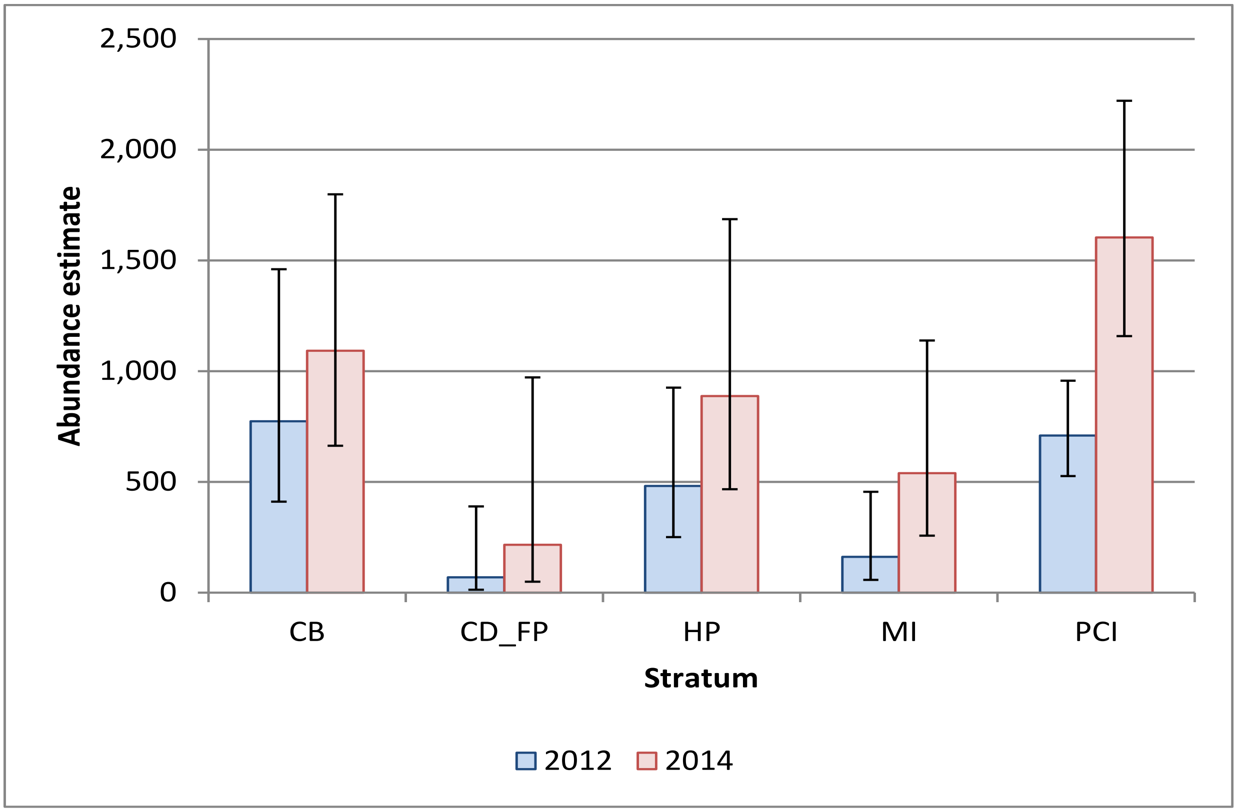



Figure 43. Estimates of abundance from 2012 and 2014 surveys. See Table 4 for acronyms for each stratum. Note the overlapping error bars representing the 95% confidence intervals for all strata except the Prince Charles Island (PCI) strata.

## 5.7 North Baffin

Including Kelsall (1949), and Tener and Solman (1960) survey efforts, aerial population assessment techniques were never effectively administered on the North Baffin groupings until April 2008 and 2009. During this period, Jenkins and Goorts (2011) utilized visual reconnaissance level surveys in support of a North Baffin caribou telemetry program (Figure 44). During these reconnaissance surveys, Jenkins and Goorts employed distance-sampling techniques within a rotary wing platform, and though the survey goals were not to assess abundance, they did effectively capture relative density and spring distribution. Of the two reconnaissance survey efforts, the April 2009 survey covered the largest portion (54%) of the north Baffin study area while the 2008 reconnaissance survey covered 33% of potential caribou habitat within the north Baffin study area (Table 27). During the years of these surveys at least, relative densities were extremely low with estimated relative densities of caribou being below 0.01 caribou/km$^2$ or 1 caribou / 100km$^2$. These more contemporary survey results clearly pointed to a scarcity of caribou within the North Baffin grouping study area as early as 2008 and 2009. Additionally, IQ from Hunters and Trappers Organizations representing all Baffin Island communities had been reporting declining caribou abundance across the entire island for close to a decade.

### 5.7.1 Comparison of 2009 and 2014 Survey Estimates

The 2009 Baffin Island survey had little available data on snow conditions, cloud conditions, topography, and other covariate values and therefore the options to analyze this data set were limited compared with the 2014 data set over the same general area. For example, one approach that might improve precision would be to combine this data as a stratum with the 2012 survey data. However, this option is risky without knowledge of the similarity of survey conditions. Without covariates to describe the potential differences in survey conditions, it would be difficult to assess if survey conditions between the two survey years were similar. Combining the two data sets could create bias in either estimate. The best option was to analyze the 2009 data as a separate data set.

The 2014 Baffin Island caribou abundance estimate is the first of its kind within the North Baffin study area estimating a mean of 315 caribou (95% CI=159-622; SE=109; CV=0.35) within this area. In contrast, the April 2009 survey data analysis assessed over twice the mean number of the 2014 survey estimate, estimating 673 caribou (95% CI=285-1,591; CV=0.45). Though the mean values differed between surveys, variability within each estimate was too high to conclude whether the observed decline between survey periods had occurred and was significant.

It is clear that the scarcity of caribou reported in both 2008 and 2009 did not improve over the five-year period between surveys. Though the data is insufficient to demonstrate a statistically significant trend, relative densities observed in March 2014 when compared to those observed in March/April 2009, dropped by a factor of 10 from 0.011 caribou / km$^2$ recorded in March/April 2009, to 0.002 caribou / km$^2$ recorded in March 2014 (Figure 45). This drop is consistent with hunter reports of greater difficulty in finding caribou in the North Baffin study area. Unfortunately, harvesting records over this same period were incomplete reducing our understanding of the harvesting pressure on this group of caribou over the same period. Jenkins and Goorts (2011) provided some insight into the effects of harvest in the north Baffin area. Jenkins and Goorts reported that of the 32 adult caribou cows collared over the 2008 to 2011 deployment period, local hunters harvested 13 caribou or 41%. This high harvest ratio of collared cows is indicative of a high harvesting rate on a low population size of the North Baffin caribou grouping.

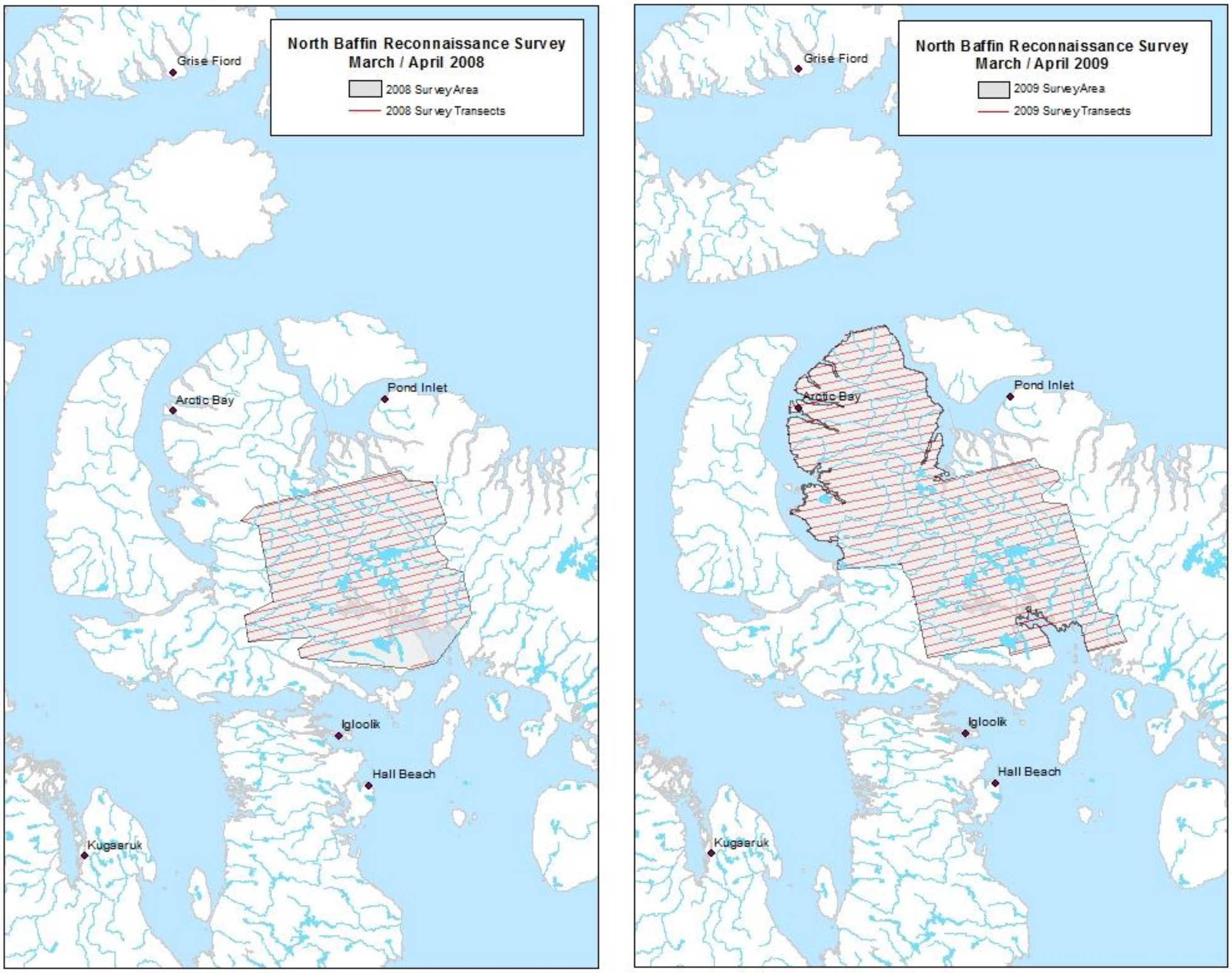



Figure 44. Reconnaissance surveys flown by Jenkins and Goorts (2011) in April of 2008 and 2009. The surveys were flown in support of a caribou collaring program to determine the distribution and movements of North Baffin caribou.

Table 27. The 2008 and 2009 North Baffin caribou grouping reconnaissance survey summary statistics. Brodeur Peninsula area subtracted from North Baffin study area based on strong IQ that the Peninsula was not caribou habitat during the period of these surveys (Goorts and Ross, 2013 Consultation Report).

NORTH BAFFIN RECONNAISSANCE SURVEYS

| Year | Month | Transect Spacing (km) | Altitude (m) | Grouping | Summary Statistics | | | | | | | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Kilometers Flown | Area Observed (km2) (based on an estimated 1.5 km strip width) | Number Observed | Relative Density (Caribou/km2) | Survey Area (Estimated) ($Km^2$) | Range Area (km2) | Proportion of Range Surveyed (%) | |
| **2008** | March/April | 10 | 120 | NB | 4,587 | 6,881** | 47 | 0.007 | 45,021 | 137,857* | 32.7 | *D.A. Jenkins & J. Goorts, 2011* |
| **2009** | March/April | 10 | 120 | NB | 7,186 | 10,779** | 119 | 0.011 | 74,989 | 137,857* | 54.4 | *D.A. Jenkins & J. Goorts, 2011* |

* = estimated possible caribou habitat minus Brodure Peninsula (based on North Baffin wide IQ and hunter reports) corrected for Baffin Island area. Baffin Island estimated potential area occupied by caribou = 329,267 km2.

** = Distance sampling strip width varies with sightability (terrain /environmental conditions) A 750 meter strip total was estimated based on actual observation distances.

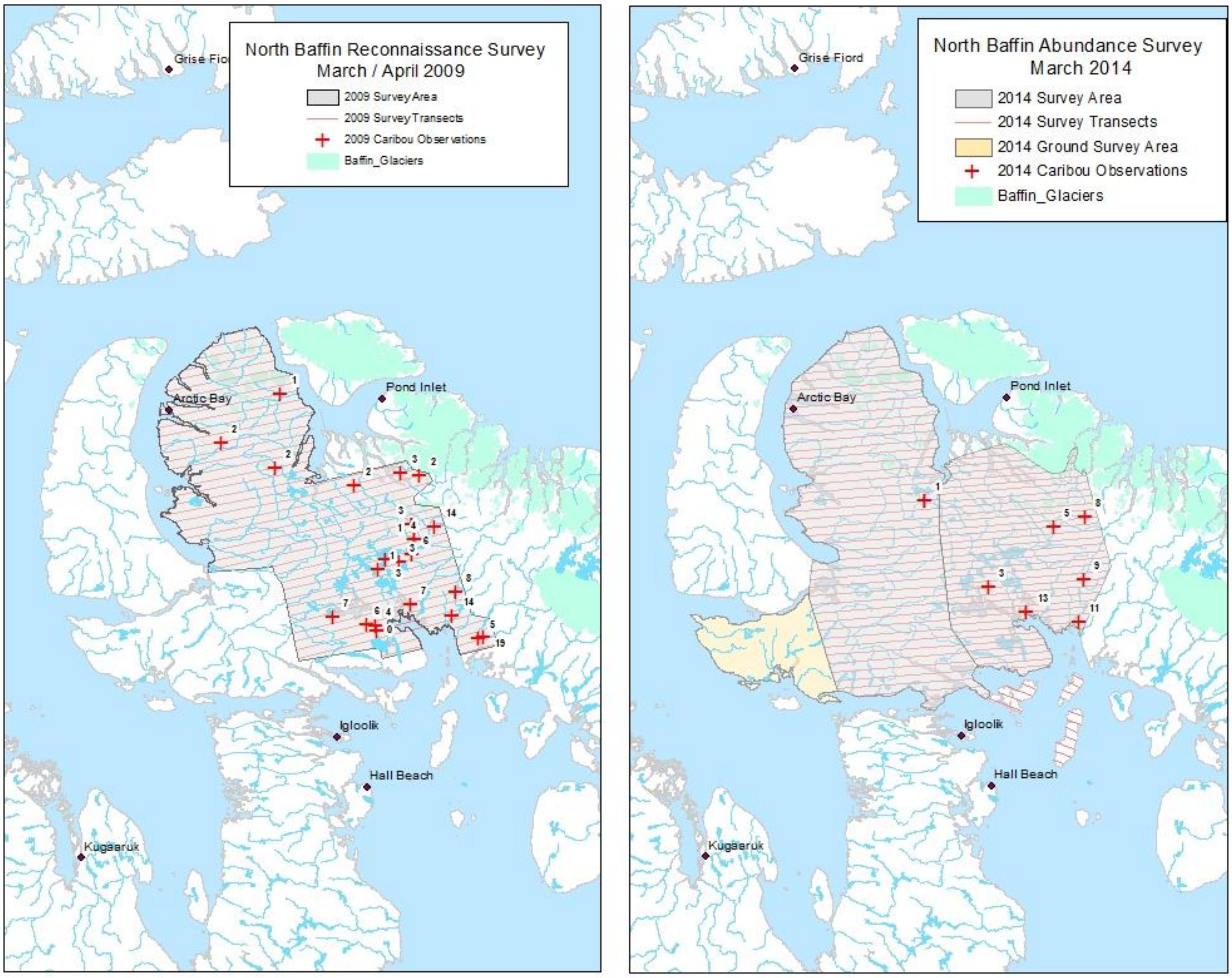



Figure 45. The 2009 reconnaissance survey (Jenkins and Goorts (2011) and 2014 abundance survey areas, transects, and observations.

## 5.8 Northern Melville Peninsula

Though the caribou occupying northern Melville Peninsula are not considered part of the Baffin Island population, historical records and IQ have indicated that movement of caribou between northern Melville Peninsula and the North Baffin grouping annual ranges may have occurred in the past and/or may be ongoing (Goorts and Ross, 2014; Manning, 1943). Additionally, consultations following the 2013 survey workshop listed migration across the Fury and Hecla Strait as a possible cause for the declines being detected on Baffin Island (Goorts and Tyler, 2014). The 2014 Baffin Island survey program took this possible movement corridor into consideration during the design phase. We addressed this concern through a systematic aerial abundance estimate of the caribou occupying northern Melville Peninsula during the March 2014 survey period, when ice formation across the Fury and Hecla Strait could make such movement possible.

We surveyed the northern extents of Melville Peninsula between March 16$^{th}$ and 17$^{th}$, 2014 utilizing two fixed wing aircraft. We estimated 220 caribou (95% CI=88-551; SE=101; CV= 0.46) within the northern Melville survey area (Figure 46). Caribou distributions across the study area were restricted to the northwestern and western extents of the study area where only 26 caribou were observed on transect.

Few caribou studies have been completed within the northern Melville study area, and those that have, were flown in May and June, outside of the March 2014 survey period. The first completed survey of Northern Melville Peninsula was reported by Ferguson and Vincent (1992). The survey was flown in June 1982, and covered the same area as that reported in the present work, though 3 months later (Figure 47). The survey covered 8.5% of the survey area counting a total of 561 caribou on transect, estimating 2,871 caribou (95%CI=1993 to3749; SE=435; CV=0.15) (Ferguson and Vincent, (1992).

Heard et al., (1997) and Heard et al. (1986) flew the same area a year later though a month earlier than Ferguson and Vincent's work. The survey was flown between May 5th and 12th, 1983, as part of a larger abundance estimate of the caribou occupying the northeast mainland of the previous jurisdiction of the Northwest Territories. During this survey, Heard et al. covered an estimated 5% of the northern Melville survey area utilizing only six (6) transects aligned in an east-west direction. Heard et al. counted 101 caribou on transect, yielding an estimate of 2,500 (SE=970; CV=0.38) caribou within the same area as that flown in March 2014.

Buckland et al. (2000) flew an identical survey as Heard et al. (1986) 12 years later between the 16th and 27th of May in 1995. They estimated 27 (SE=18;CV=0.68) caribou within the survey area. Both surveys had very wide (1.8 km) strip widths and low actual coverage (5%), flying only six transects oriented east-west. The low coverage likely contributed to the high CV's and resultant low reliability of the population estimates. Despite these issues, the reports document a drop in relative densities from 0.10 caribou/km$^2$ in 1983 to 0.001 caribou per km$^2$ in 1995. This reduction in caribou density may have shown some recovery by March 2014 when caribou densities across the survey strata were estimated to be 0.02 caribou/km$^2$. When making these comparisons, however, we must keep in mind that the March 2014 survey was flown two months earlier.

Further investigation into caribou abundance on Melville Peninsula during May and June revealed higher densities of caribou in the southern Melville Peninsula (Heard et al., 1987; Buckland et al., 2000). Prior to these surveys, Heard et al. (1981) had identified a high-density calving aggregation within the southern Melville Peninsula in June 1976. Coupled with the discussion above of relatively low densities of caribou in the area during May and June, this suggests that the caribou occupying the Melville Peninsula area generally calve within the peninsula's southern extents, explaining the higher calving and pre-calving densities found within the southern Melville area compared with the northern extents. Additionally, May is a highly mobile time of year for caribou trying to migrate from the wintering grounds to calving sites within annual concentrated calving areas (ACCA). Again, the available research in the area suggests that the caribou occupying the northern Melville Peninsula area in March do not represent the total population but rather the numbers of a fragment of a larger demographic unit that partially winters within the northern extent of the peninsula.

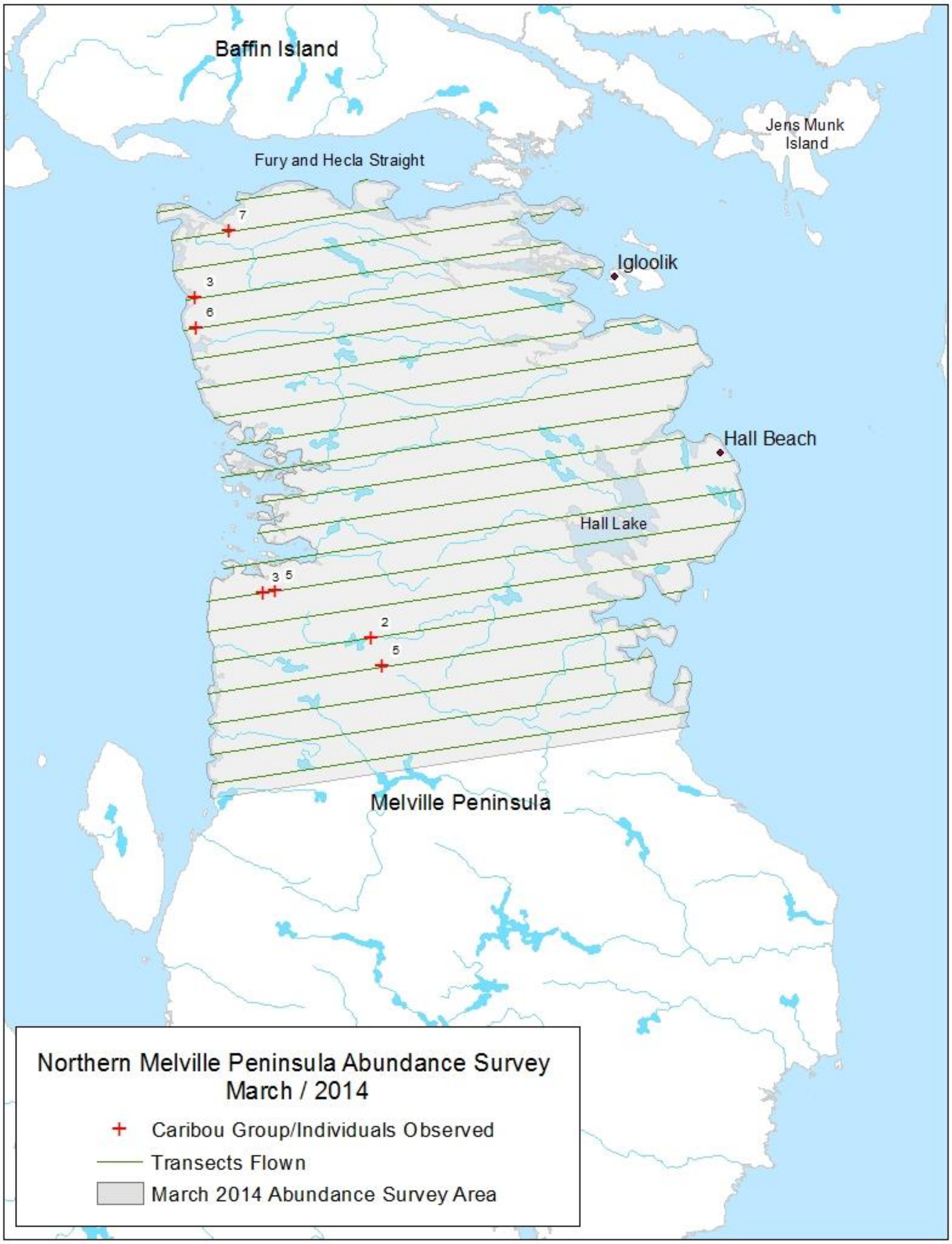



Figure 46. The March 2014 survey study area, transects, and caribou observed.

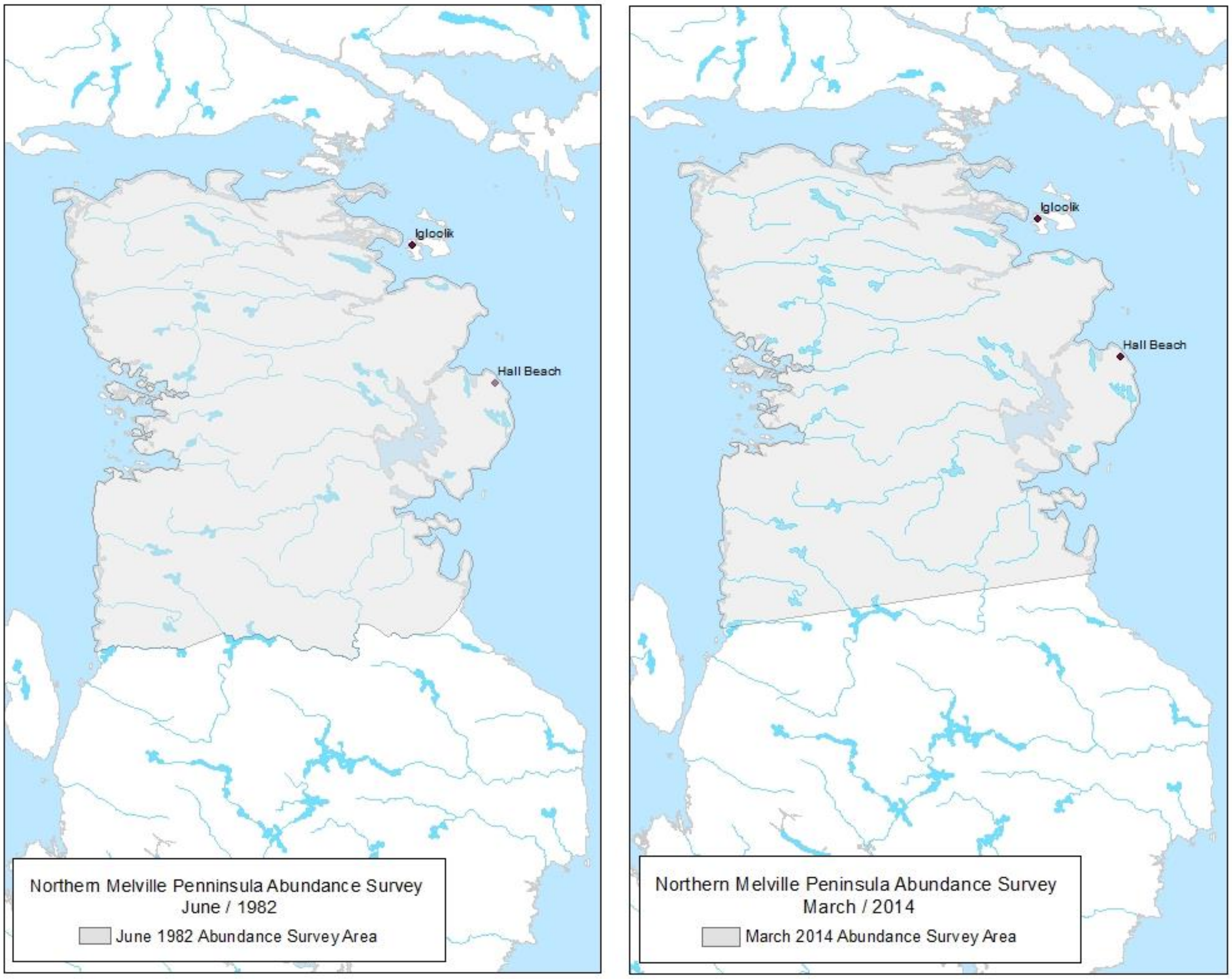



Figure 47. A comparison of the study areas utilized to assess the abundance of caribou on northern Melville Peninsula. Survey areas are very similar differing less than two (1) percent.

## 5.9 Northeast Baffin

Unfortunately, no scientific estimates of caribou abundance were ever made in the Northeast Baffin area. The 2014 survey represents the only quantitative estimate of the area, observing only 13 individuals yielding a mean estimate of 85 caribou (95% CI = 31-230; SE=45; CV= 0.53). Clearly, caribou densities within this grouping are extremely low though there are no previous quantitative estimates with which to compare. Though not quantitatively estimated, Ferguson and Gauthier (1992) had “guessed” that this population or grouping numbered in excess of 10,000 animals in 1991, which suggests a dramatic decline. However, as this information represents a best guess, the substantiation of trend remains unreliable. Based on Inuit knowledge, the Northeast grouping, was more numerous in the 1980’s and early 90’s than it was in 2014.

## 5.10 HTO Led Ground Surveys

Caribou ground surveys can be useful when trying to determine presence or absence of caribou within a specific area. We utilized information from HTO led ground surveys to help determine the presence or absence, and approximate relative densities of caribou in Strata 2 delineated areas. We were hoping to use these observations to evaluate whether caribou observed within the Strata 2 were consistent with caribou densities observed in Strata 3, and as a result, could be reclassified to be systematically surveyed by air. Following the results of the ground surveys, Qikiqtarjuaq Strata 2, Clyde River Strata 2 south, and Arctic Bay Strata 2, were reclassified as Strata 1 as no caribou and/or caribou sign were observed, maintaining their Strata 1 designation. The Clyde River Strata 2 north, with an estimated 30 caribou observed, was unsystematically surveyed during ferry flights to and from aerial survey transects or to remote refueling location. No additional caribou were observed by air, however, one set of tracks was located. We choose not to classify this strata as a Strata 3 due to the con-current harvest of an undisclosed number of ground survey observed caribou within this strata, shortly following the ground observations. Additionally, high densities of skidoo tracks were observed by air crews just outside of the ground survey strata crossing into the aerial survey strata where aircrews had observed 3 caribou approximately one week following the ground survey observations. The survey observations provided strong evidence that all or a portion of the caribou observed by ground survey crews, could have been pushed south west outside of the ground survey strata by hunters, and into the aerial Strata 3 survey area. Additionally an unreported number of the ground survey observed caribou were harvested within approximately one week following the ground survey.

It is difficult to accurately report the findings of the ground surveys because the method of data recording was in many cases unsystematic and/or limited. Only one ground survey crew (from Qikiqtarjuaq) provided a detailed written account of their progress and findings, including labelled track logs and waypoints of observations. The remainder provided only track logs and unidentified waypoints collected from GPS's used during the survey. Additional post-survey communication with surveyors via phone and email was required to deduce the minimum required information (e.g. number and location of caribou seen) from the data provided. In one case, this took nearly six months post-survey to acquire. The deficiencies in reporting also makes it difficult to acquire funding for such projects as there is little accountability for project expenditures. Future funding may be compromised where a history of non-reporting exists for project investigators. This issue highlights the need for future ground survey projects to specifically hire and train a project coordinator to ensure consistent data collection and recording in the field and report on the findings immediately post-survey. Much of the post-survey communication and reporting defaulted to HTO managers. Identifying a project coordinator early in the planning phase of the project may alleviate the added pressure that research project requirements put on already over-worked HTOs. Regardless, ground survey costs were comparable to aerial survey costs over the same delineated areas.

Further, increased harvesting may occur as a result of research activities where animals are difficult to locate and no harvest restrictions exist. Prior to both the ground and aerial surveys commencing it was requested that survey observers not disclose specific locations where caribou were observed, or hunt caribou while conducting the surveys, to prevent added harvesting pressure on an already critically low caribou population. Local harvesters may find location data from surveys lucrative as it decreases the time and cost required to locate caribou that exist at very low densities. In Clyde River, location data was released immediately upon return to the community resulting in a number of local harvesters traveling to the survey area to hunt the caribou observed. This created contention within the community, with some members of the public denouncing ground surveys because of the anticipated hunting pressure and unfair practices. In addition, one caribou was harvested during the Arctic Bay ground survey by a member of the survey team in direct violation with ground survey directives of no hunting or caribou location disclosure, relayed to all ground crews by all co-management partners. It should be noted that this issue is not limited to ground surveys and can and did also occur during aerial surveys through both word of mouth and internet channels. The potential for disclosure of sensitive data should be considered when designing survey methods where an increase in harvesting poses a risk to the population being assessed.

Low snow cover and steep or rocky terrain presented additional challenges for ground surveyors travelling on snowmobile. Ground surveyors in Qikiqtarjuaq and Clyde River reported that at times, poor travel conditions prevented surveyors from reaching areas where caribou were thought to be located. Future ground surveys should consider accessibility when delineating survey areas and focus on areas with less limitations for travel by snowmobile, such as flatter terrain and adequate snow cover. Less accessible areas are better surveyed by air.

Despite the many challenges associated with ground surveys, there are also benefits when ground surveys are applied with appropriate, realistic objectives and stringent protocols. Local harvesters may better understand the methodology used during ground surveys because it utilizes expert hunting and searching techniques inherent to Inuit culture, in comparison to aerial surveys that employ at times, complex scientific and statistical methods to derive an estimate that can be difficult for the lay person to understand. Many HTOs want to actively contribute or be involved in research, and ground surveys take advantage of a specific skill set already embedded in their organization and based on subsistence harvesting practices. These self-led projects can produce a sense of ownership and understanding of the results and methodology used if rigidly managed. For these reasons, ground surveys are a good means to foster understanding and engage community members in the research effort when appropriate to the objectives of the study. This being said, ground surveys simply cannot replace aerial surveys on Baffin Island and in most other survey situations, and should only be considered as a supplementary method for very specific requirements. Additionally, ground surveys within rugged, isolated country can exceed aerial survey costs, and present unnecessary safety risks to ground survey crews. Generally, abundance survey estimate accuracy and precision are exceedingly difficult to achieve under most ground survey conditions. Managers must consider the overall need for reliable abundance estimates in addition to the impacts incurred when revealing sensitive location information for vulnerable groupings, prior to considering the value of engauging ground survey methods.

## 5.11 Public Confidence

During the November 2014 caribou workshop, the survey was discussed at length, with HTO representatives as well as representative survey observers speaking about their impressions and experience as participants during the survey (DOE, 2015A). All Baffin Island communities with the exception of Arctic Bay (unable to attend due to weather), including Igloolik and Hall Beach, agreed with the survey results and generally agreed that the survey had met their expectations as discussed during previous consultations. The intent of the survey was to pull together the collective knowledge of local hunters, science, and the most modern survey equipment and techniques to provide a reliable population estimate of caribou on Baffin Island with which to ascribe a benchmark for future trend analysis, population, and subpopulation delineation studies.

## 5.12 Abundance Trends and Cycles

Past attempts at calculating the abundance of caribou on Baffin Island have been largely unreliable due to a lack of representation of the expanse of potential caribou habitat across Baffin Island coupled with a general lack of understanding of demographic and geographic dispersement of caribou groups. One attempt to assess caribou abundance on Baffin Island is provided by Ferguson and Gauthier (1992). Ferguson and Gauthier (1992) “guessed” that in 1991 the South Baffin caribou population, as defined by Ferguson and Gauthier (1992), was between 60,000 and 180,000 individuals, the Northeast Baffin population was greater than 10,000 individuals, and the North Baffin caribou population was between 50,000 and 150,000 animals. These abundance values do not contain sufficient quantitative rigor to be utilized for management purposes and/or trend analysis. These types of qualitative assessments can confuse the wildlife management process through the setting of unrealistic management actions to achieve equally unrealistic management goals. In this environment, managers might strive to manage a population to achieve a goal that has never, nor will ever, be attained due to limitations within the natural environment.

From the available literature, Chowns (1979) provided the most geographically extensive survey of the historically defined South Baffin caribou population while providing a reliable estimate within the survey area. The problem remains that Chowns survey area included the annual ranges of potentially two groupings, including the South East Baffin and South Central Baffin groupings as defined in this report. Additionally, Chowns survey area may have excluded a large portion of both the South East and South Central grouping November ranges, and likely represents an underestimate. To date however, Chowns estimate of 35,291 (95% CI = 29,874-40,708; SE = 2,652.8; CV = 0.17) made in November 1978, remains the highest number of caribou quantitatively estimated and reported within the South East Baffin and South Central Baffin delineated annual ranges, historically termed the South Baffin caribou population.

For the North Baffin and Northeast Baffin study areas, no reliable estimate of caribou abundance has been developed.

### 5.12.1 Population Cycles

Research on population abundance and trend was undertaken by Ferguson in the mid-1980s using Inuit Knowledge (Ferguson, 1993; Ferguson and Gauthier, 1992; Ferguson et al. 1998). During his studies, Ferguson developed a systematic interview survey of Inuit Elders and hunters designed to collect current and historical information on caribou distribution and population dynamics on Baffin Island (Ferguson and Labine, 1991). Ferguson also documented Inuit knowledge on temporal relative abundance of caribou on Baffin Island, describing periods of scarcity, stability, and abundance. Based on this knowledge in addition to other assessments of relative abundance, harvest reports and exploratory observation, a distinct pattern begins to emerge for the caribou of Baffin Island (Table 28) (Figure 48). A cyclical pattern of between 60 to 80 years between abundance highs appears to remain consistent to present. Baffin Island caribou abundance appears to have peaked in 1845, 1910 and 1985 while observed lows occurred on or about 1875, 1945 and 2014 (Table 28). Unfortunately, the information sources are not detailed enough to predict how soon following a low in abundance the population will begin to recover and to provide more harvesting opportunities to communities. Additionally, pressures facing caribou that were not present when caribou recovered from past lows including increased development, industrial activity, harvest pressure from a growing population, more advanced hunting equipment and techniques, and increased access through the construction of roads, all combine to muddy the waters when it comes to predicting recovery times. For the North Baffin grouping of caribou, the extent of disturbance and cumulative impacts from the Mary River mine will almost certainly complicate North Baffin caribou recovery, negatively affecting caribou condition near disturbance and infrastructure, as well as effecting seasonal range/habitat use.

Table 28. Reports of relative abundance of Baffin Island caribou using and combining multiple information sources. The resultant relative abundance and trend is speculative, has been interpreted from the writings of the source references, and are not based on any absolute and/or quantitative reports of abundance and/or trend.

| Year | Relative Abundance | Observed Trend | Information Type<br>IQ = Inuit Knowledge<br>FO = Field Observations<br>SS = Scientific Studies<br>HR = Harvest Returns<br>NI = No Information | Source |
|---|---|---|---|---|
| 1845 | High | Stable | **IQ** | *M.A.D. Ferguson et al., 1998* |
| 1850 | High | Decreasing | **NI** | *No Reference* |
| 1855 | High | Decreasing | **NI** | *No Reference* |
| 1860 | High | Decreasing | **IQ** | *M.A.D. Ferguson et al., 1998* |
| 1865 | Low | Decreasing | **NI** | *No Reference* |
| 1870 | Low | Decreasing | **NI** | *No Reference* |
| 1875 | Low | Stable | **IQ** | *M.A.D. Ferguson et al., 1998* |
| 1880 | Low | Increasing | **FO** | *Kumlien, 1879 in J.D. Soper, 1928* |
| 1885 | Low | Increasing | **NI** | *No Reference* |
| 1890 | Low | Increasing | **NI** | *No Reference* |
| 1895 | High | Increasing | **NI** | *No Reference* |
| 1900 | High | Increasing | **IQ** | *M.A.D. Ferguson et al., 1998* |
| 1905 | High | Increasing | **IQ** | *M.A.D. Ferguson et al., 1998* |
| 1910 | High | Stable | **IQ / FO** | *Hantzsch, 1913 in J.D. Soper, 1928* |
| 1915 | High | Decreasing | **IQ** | *M.A.D. Ferguson et al., 1998* |
| 1920 | High | Decreasing | **FO** | *J.D. Soper, 1928* |
| 1925 | High | Decreasing | **IQ** | *M.A.D. Ferguson et al., 1998* |
| 1930 | Low | Decreasing | **IQ / FO** | *J.D. Soper, 1928/Ferguson et al., 1998* |
| 1935 | Low | Decreasing | **IQ** | *M.A.D. Ferguson et al., 1998* |
| 1940 | Low | Decreasing | **IQ / FO / SS** | *J.G. Wright, 1944/J.P. Kelsall, 1949/M.A.D. Ferguson et al., 1998/T.H. Manning, 1941* |
| 1945 | Low | Stable | **IQ / SS / HR** | *J.P. Kelsall, 1949/J.S. Tener & V.E.F. Solman. 1960/M.A.D. Ferguson et al., 1998/T. Chowns, 1979* |
| 1950 | Low | Stable | **IQ / SS / HR** | *J.S. Tener and V.E.F. Solman. 1960.* |
| 1955 | Low | Increasing | **IQ / SS / HR** | *A.G. Loughrey, 1954/M.A.D. Ferguson et al., 1998/T. Chowns, 1979* |
| 1960 | Low | Increasing | **IQ / SS / HR** | *J.S. Tener & V.E.F. Solman. 1960/M.A.D. Ferguson et al., 1998* |
| 1965 | Low | Increasing | **SS / HR** | *A.H. Macpherson. 1963/G. Armstrong,1965* |
| 1970 | High | Increasing | **NI** | *No Reference* |
| 1975 | High | Increasing | **SS / FO** | *T. Chowns, 1979* |
| 1980 | High | Increasing | **NI** | *No Reference* |
| 1985 | High | Stable | **IQ** | *M.A.D. Ferguson et al., 1998* |
| 1990 | High | Stable | **FO** | *Hines et al., 1988* |
| 1995 | High | Decreasing | **NI** | *No Reference* |
| 2000 | High | Decreasing | **IQ / HR** | *NWMB Harvest Study,* |
| 2005 | Low | Decreasing | **NI** | *No Reference* |
| 2010 | Low | Decreasing | **SS / IQ** | *D.A. Jenkins & J. Goorts, 2011* |
| 2014 | Low | Stable | **SS / IQ** | *This Study* |

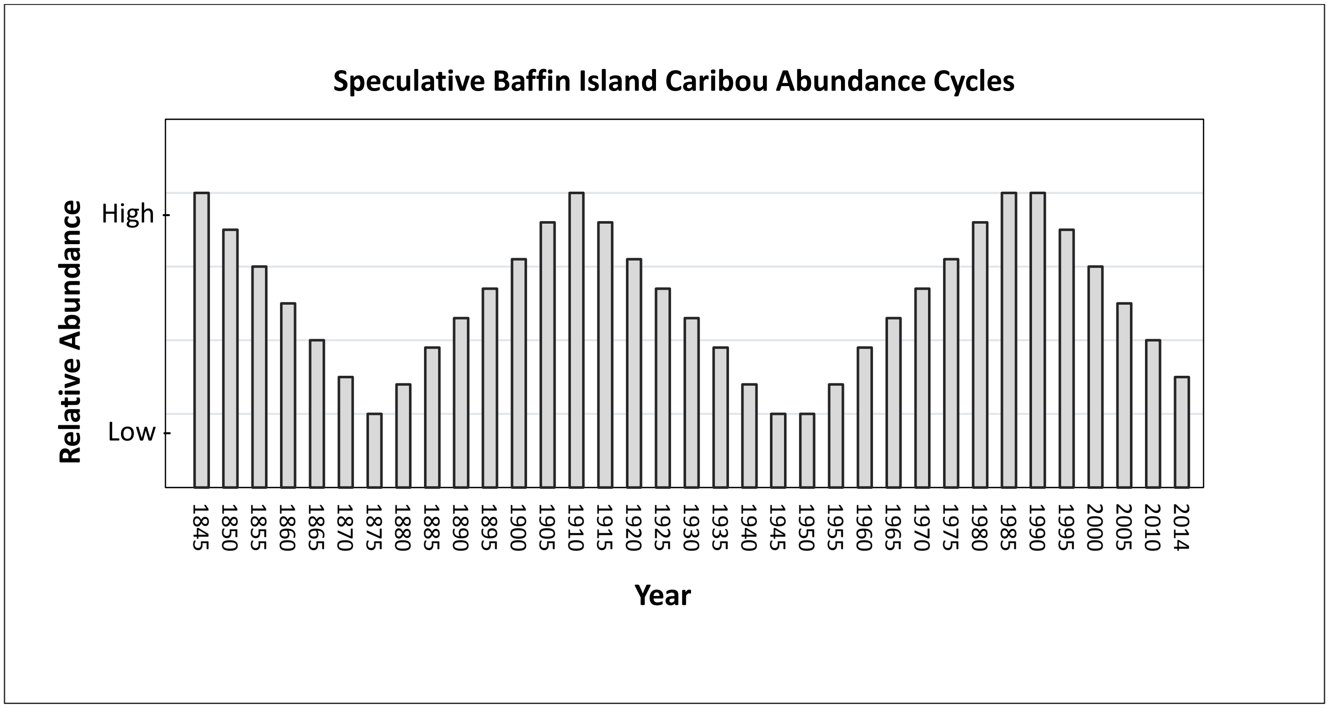



Figure 48. Tracking the population cycles of Baffin Island caribou utilizing multiple data sources including Inuit Knowledge, scientific studies, field observations and harvest records (for information type and source see Table 18). The resultant relative abundance and trend is speculative, has been interpreted from the writings of the source references, and are not based on any absolute and/or quantitative reports of abundance and/or trend, with the exception of the 2014 results.

## 5.13 Abundance Survey and Analysis Summary

All ungulate surveys face challenges and the Baffin Island Feb/March 2014 survey was particularly challenging due to the geographic scale of the project. To address the scale and associated temporal limitations, we used four survey aircraft to ensure the survey could be completed within available flyable weather windows while minimizing any delays between daily transect observations. Additionally, we utilized a six observer system which maintained 4 dedicated observers (double observer pair method) to increase sightability and reduce the number of caribou missed. We also ran the survey during the late winter period when movement is at a minimum and the snow background enhances sightability.

The 2014 survey effort utilized the lessons learned in 2012 to minimize the problems faced during the earlier survey and exclude the possibility of caribou distributional shifts between survey areas and groupings. Additionally the north Melville Peninsula area was surveyed to examine the potential for movement of caribou to or from Melville Peninsula from the North Baffin grouping annual range. We believe the 2014 South Baffin Island survey estimate of 4,337 caribou (95% CI=3,169-5,935;SE=691;CV=0.16) represents the first reliable estimate.

During the 2014 survey, coverage was increased in areas pre-stratified as being potential caribou habitat using IQ collected from all Baffin Island communities (including Igloolik and Hall Beach), as well as past telemetry and survey information. The entire survey effort began February 26$^{th}$ and concluded March 21$^{st}$, lasting a total of 23 days. Aircraft were grounded due to bad weather only 3 days out of the 23 days, of which only 2 days were consecutive. The use of more stable survey platforms staffed by four dedicated observers (of which a minimum of two were experienced) and additional two experienced observers/ data recorders improved our ability to observe caribou across varying terrain features. We also collected six (6) co-variates to assess and account for changes in sightability. We believe these improvements in the survey methods improved caribou sightibility as well as reduce the number of caribou missed due to temporal gaps in the aerial field collection.

In 1981, Heard grappled with the inaccuracy and imprecision of previous visual calving ground surveys noting, amongst other issues, four major survey design flaws. We worked to address these flaws during the development phase of the survey. These potential flaws include but are not limited to:

***1*** Animals found in groups too large to count accurately.
***2*** Lack of consistent and robust statistical analysis of results.
***3*** Observer bias and caribou sightability.
***4*** Error resulting from fixed wing inconsistent flying characteristics and blind spots.

Because of the low densities encountered across Baffin Island coupled with the incorporation of the double observer pair method, the 2014 February/March survey mitigated some of the bias, reducing the third by rotating and comparing observers across front, back and left and right seats (Koneff *et al,* 2008). Additionally we used double observer pair/ distance sampling methods to estimate and account for sightability (Buckland et al., 2010). Errors resulting from inconsistent flying characteristics will always be a consideration in the interpretation of survey results; however, the addition of a radar altimeter dramatically reduces errors based on inconsistent altitude. We also utilized left truncation of distance data at 100 meters to reduce issues with blind spots under the aircraft. In addition, the Cessna Grand Caravan is a large, stable aircraft, reducing pitch and roll flaws in gusty conditions. Additional efforts to increase overall accuracy and precision incorporated into the February/March 2014 survey effort included:

***A*** The use of four aircraft to reduce survey time and to take full advantage of weather windows allowing us to address the potential for caribou distributional shifts across the survey area.

***D*** Visual survey observers were trained prior to the actual survey and at least two (2) experienced observers were utilized within each aircraft, one on each of the left and right side rotating occasionally in front and rear positions. The data from the four (two per side) observers and the distance data were used to estimate the proportion of caribou not observed therefore minimizing any bias due to observer bias and sightibility (point 3 above).

***E*** Additional trained observers were available within the survey aircraft to alleviate error due to primary observer fatigue.

***F*** There were only two weather days during which no survey aircraft were deployed.

***G*** The survey through all delineated strata was continuous with no planned temporal breaks or geographic breaks. The survey proceeded from the south east proceeding up-island to Baffin Islands north western extents, followed by a north to south progression across Melville Peninsula.

***H*** Extensive weather research was undertaken to determine likely weather windows across the survey area. Timing of the survey and type and number of aircraft could then be accurately assessed and acquired to fit the weather windows and their geographic extents.

Despite attempts to reduce overall type one and type two errors, there remain items for improvement to consider for future surveys. Future surveys should systematically rotate their front and rear observers to help determine sightibility variances between observers. The use of the pre-stratified double observer pair visual survey technique allowed us to focus more resources within abundance strata, which we believe, increased the accuracy of the survey result; however, future surveys should consider employing only experienced aerial observers to ensure maximum sightibility of the caribou dispersed across the survey strip.

### 5.13.1 Future Considerations

The following factors should be considered when assessing the 2014 results as well as for planning/analyzing future survey results:

- The key assumption with distance sampling is that sightibility on the transect line is equal to 1. If this assumption is not met then estimates will be negatively biased. If this assumption is met, but sightibility is lower due to factors such as single (rather than double) observer pair, weather, or snow conditions, then estimates may still be unbiased given that sightibility is estimated and accounted for by fitting of detection functions. Therefore, the key question for the 2012 survey in terms of estimating robustness is whether sightibility equaled one on the survey line.

- For the 2014 survey, the estimate for Baffin Island with double observer pair/ distance methods, which estimate sightability on the transect line, was 4,872 whereas it was 4,590 (about 6% lower) with distance sampling only (that assumes sightability=1 on the transect line). It is hard to know if this same ratio would apply to helicopter based surveys or to the survey conditions in 2012 that may have been more challenging due to snow and cloud cover.

- The 2012 survey employed a forward observer (pilot or recorder) and two single side observers whereas the 2014 survey added an additional observers per side (for the double observer pair method). This increased sightability on the transect line especially if survey conditions were marginal due to cloud and patchy snow cover (Campbell et al. 2012, Boulanger et al. 2014).

- One additional assumption of distance sampling is that all observations occur while the helicopter is on the transect survey line as opposed to ferrying to waypoint groups. If observations were added for caribou that were observed during ferrying (off the transect line), then the resulting detection function will overestimate sightability leading to a negatively biased estimate.

- Distance sampling also assumes that adjacent caribou do not move due to the helicopter flying off transect to mark groups. This assumption could be violated if caribou move in response to the helicopter before marking their waypoint. If movement is away from the line then estimates will be biased low (Buckland et al. 1993). Binning with fixed-wing survey platforms avoids this bias.

- Snow and cloud cover were not recorded as covariates during the 2012 survey. However, both snow and cloud cover have been found to influence sightability in the 2014 analysis, as well as stand-alone double observer analyses on other caribou surveys (Campbell et al. 2012, Boulanger et al. 2014). It is possible that snow cover, especially “salt and pepper” snow conditions, could reduce sightability on the transect line which would negatively bias estimates. As the 2012 survey effort continued well into May and the beginning of the melt, incidence of salt and pepper snow patchiness conditions were common within some portions of the May survey extents, likely exacerbating this sightability problem.

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# 7.0 Acknowledgements

The success of any large-scale wildlife survey initiative is completely dependent on the quality of the team assembled to complete the task. Our team was of the highest quality. In total, 70 individuals from communities across the north were involved (**Table 27**). Of the 70 participants, 36 were Nunavut beneficiaries from the communities of Arctic Bay, Pond Inlet, Clyde River, Qikiqtarjuak, Pangniryung, Cape Dorset, Iqaluit, Kimmirut, Igloolik, Hall Beach, Arviat, and Rankin Inlet. In all, harvesters and community members from across the Baffin Region made up 47% of the survey team. In addition, our thanks also go out to all the organizations that acknowledged the value of this survey effort through their generous financial and in-kind contributions (**Table 27**).

Simple thanks cannot adequately express our immense appreciation to all those involved in this survey from the observers to the charter companies and hotel staff that safely carried and accommodated our team. We would like to extend a special thanks to Air Tindi (Discovery Air) and their highly skilled pilots Ted Duinker, Jason Pineau and Andrew Dennison who in many ways carried this project through to its successful completion.

Table 29. The participants, funding agencies and co-management partners involved in the Baffin Island February/March 2014 caribou abundance survey.

# 2014 Baffin Island Caribou Survey Participants List

**Project Logistics and Planning:**
Mitch Campbell & Jaylene Goorts – Nunavut Department of Environment

**Project Field Leaders:**
Mitch Campbell, Jaylene Goorts (Nunavut Department of Environment) & David Lee (Nunavut Tunngavik Inc.).

**Senior Managerial Support:**
Drikus Gissing (Director of Wildlife, GN, DOE, Iqaluit), Lynda Orman (Manager of Wildlife Research, GN, DOE, Igloolik), and Jimmy Noble Jr. (Assistant Director of Operations, GN, DOE, Iqaluit)

### Aircraft Crew Leaders/Experienced Observers/Navigators:

1. David Lee – Nunavut Tunngavik Inc., Rankin Inlet, NU (Fixed Wing)
2. Jaylene Goorts – Department of Environment, Pond Inlet, NU (Rotary Wing)
3. Mitch Campbell – Department of Environment, Arviat, NU (Fixed Wing)
4. Morgan Anderson – Department of Environment, Igloolik, NU (Fixed Wing)

### Department of Environment Observers/Data Recorders:

1. Aaron Skoblenick (DOE Wildlife Officer, Cape Dorset, NU)
2. Caleb MacDonald (DOE Legislation and Management technician, Igloolik, NU)
3. Chris Wex (DOE Wildlife Officer, Pangnirtung, NU)

### Experienced Observers:

1. Andrew Muckpa (HTO Rep., Arctic Bay, NU)
2. Chris Wex (DOE Wildlife Officer, Pangnirtung, NU)
3. Jacob Jaypoody (HTO Rep., Clyde River, NU)
4. Jaypootie Akpalialuk (HTO Rep., Pangnirtung, NU)
5. Jaypootie Moesesie (HTO Rep., Qikiqtarjuak, NU)
6. Jobie Atagootak (HTO Rep., Pond Inlet, NU)
7. Kelly Owlijoot (DOE Wildlife Technician, Arviat, NU)
8. Leo Ikakhik (DOE Casual, Arviat, NU)
9. Levi Kaunak (HTO Rep., Hall Beach, NU)
10. Oqituk Ashoona (HTO Rep. Cape Dorset, NU)
11. Robert Karetak (NTI Rep., Arviat, NU)
12. Soloman Mikki (HTO Rep., Igloolik, NU)
13. Tim Soucie (HTO Rep., Pond Inlet, NU)

## Community Based Observers:

1. Albert Issigaitok (DOE Casual, Igloolik, NU)
2. Candice Sudlovenick (HTO Rep., Iqaluit, NU)
3. Carson Sangoya (HTO Rep., Pond Inlet, NU)
4. David Kuniliusie (HTO Rep., Pangnirtung, NU)
5. Isa Taqtu (HTO Rep., Arctic Bay, NU)
6. Isaac Akpaleapik (HTO Rep., Pond Inlet, NU)
7. Jeetaloo Kakkee (HTO Rep., Iqaluit, NU)
8. Jimmy Inookee (HTO Rep., Iqaluit, NU)
9. Joshua Alorut (HTO Rep., Hall Beach, NU)
10. Kolola Pitsiulak (HTO Rep., Kimmirut, NU)
11. Manasie Naullaq (HTO Rep., Hall Beach, NU)
12. Methusalah Kunuk (HTO Rep., Iqaluit, NU)
13. Mosesee Akpalialuk (HTO Rep., Pangnirtung, NU)
14. Natalino Piugattuk (HTO Rep., Igloolik, NU)
15. Paul Ejangiaq (HTO Rep., Arctic Bay, NU)
16. Paul Haulli (HTO Rep., Hall Beach, NU)
17. Pitsiula Michael (HTO Rep., Kimmirut, NU)
18. Qaumayuq Oyukuluk (HTO Rep., Arctic Bay, NU)
19. Simiga Suvega (HTO Rep. Cape Dorset, NU)

## Air Charter Support (Fixed and Rotary Wing):

1. Alain Desjardins (Rotary Wing Pilot, Expedition Helicopters, Ontario)
2. Andrew Dennison (Fixed Wing Pilot, Discovery Air, Yellowknife, NWT)
3. Bob Schnurr (Charters, Discovery Air, Yellowknife, NWT)
4. Borris Kotelewetz (Fuel Caching, Ookpik Aviation Inc., Baker Lake, NU)
5. Collin Crosby (Fixed Wing Engineer, Discovery Air, Yellowknife, NWT)
6. Douglas Singaqti (Fuel Caching Assistant, Ookpik Aviation Inc., Baker Lake, NU)
7. James Babcock (Fixed Wing Engineer, Discovery Air, Yellowknife, NWT)
8. Jason Pineau (Fixed Wing Pilot, Discovery Air, Yellowknife, NWT)
9. Mark Manikel (Rotary Wing Engineer, Expedition Helicopters, Ontario)
10. Mike Bergmann (Fixed Wing Fuel Caching Pilot, Ookpik Aviation, Baker Lake, NU)
11. Ted Duinker (Fixed Wing Pilot, Discovery Air, Yellowknife, NWT)

## Logistic Support:

1. Brenda Panipakoocho (DOE North Baffin Operations Manager, Pond Inlet, NU)
2. Brian Madore (InnesNorth, Hall Beach, NU)
3. Bruce-Jerry Hainnu (DOE Wildlife Officer, Clyde River, NU)
4. George Koonoo (DOE Wildlife Officer, Pond Inlet, NU)
5. Jackie Price (Coordinator, Research and Planning, QWB, Iqaluit, NU)
6. Jason Shaw (Geomatics Specialist, CASLYS Consulting, Victoria, BC)
7. John Boulanger (Ecological Statistician, Integrated Ecological Research, Nelson, BC)

8. John Paton (Traffic Manager, CGS, GN)
9. Kristina Alariaq (Dorset Suites, Cape Dorset, NU)
10. Louis Robillard (InnsNorth, Pangnirtung, NU)
11. Mark Mcculloch (Senior Manager, CGS, GN)
12. Mathew Akikulu (DOE Wildlife Officer, Arctic Bay, NU)
13. Nenette Demavivas (Manager of Accounting, DOE, GN)
14. Nikki Nweze (Director of Finance, DOE, GN)
15. Rex Balbuena (Financial and Travel Analyst, DOE, GN)
16. Rita Webb (InnsNorth, Pond Inlet, NU)
17. Robert Arsenault (DOE Wildlife Officer, Igloolik, NU)
18. Todd Tilley (Senior Procurement Officer, CGS, GN)
19. Wei Zeng (Manager of Finance, DOE, GN)

# Organisations

## Financial Contributors:

1. Government of Nunavut
2. Nunavut Wildlife Management Board
3. Aboriginal Affairs and Northern Development Canada (AANDC)

## In-Kind Contributors:

1. Aiviq HTO
2. Amaruq HTO
3. Hall Beach HTO
4. Igloolik HTO
5. Ikajutit HTO
6. Mayukalik HTO
7. Mittimatalik HTO
8. Nangmautuq HTO
9. Nattivak HTO
10. Nunavut Tunngavik Inc.
11. Peregrine Diamonds
12. Pangnirtung HTO
13. Qikiqtaaluk Wildlife Board

# 8.0 APPENDIX