SUBMISSION TO THE

NUNAVUT WILDLIFE MANAGEMENT BOARD

FOR

Information: **Decision: X**

Issue: Management Plan for Peary Caribou in Nunavut

Background:

Peary caribou are currently listed as an endangered species under the Species at Risk Act. Regulations under the Wildlife Act are currently outstanding and there is no management regime in place for Peary caribou in Nunavut.

The draft Management Plan for Peary Caribou in Nunavut (the plan, separate attachment) will serve as the basis for recommendations on new management units, Total Allowable Harvest (TAH), and future research and monitoring efforts.

Previous attempts to determine appropriate management units and TAH for Peary caribou were unsuccessful. This effort is less prescriptive in terms of the size and number of proposed management units and the ability of Hunters and Trappers Organizations (HTOs) to have more involvement and say in the monitoring and management of Peary caribou. In addition to recommending management units and TAH levels the plan identifies a collaborative approach to long term monitoring. The Plan uses the information presented in the Department of Environment (DoE) report "*Recent trends and abundance of Peary Caribou and Muskoxen in the Canadian Arctic Archipelago, Nunavut*," (Jenkins et al., 2011) as a baseline to monitor future trends. Through community-based ground surveys that are conducted annually, but on a spatially cyclic basis, changes in herd status can be monitored. An annual meeting to discuss results and potential management recommendations will be used to target future survey efforts and in the event of observed declines or concerns of herd status, trigger further action which may include increased ground survey frequency or aerial surveys. Recommendations that would change harvest rates or Non-Quota Limitations such as harvest seasons would be sent to the NWMB for decision.

The presentation of this submission should take approximately 45 minutes with a similar time period for questions. It is anticipated that the Board may conduct a Public Hearing at a later date to address this request for decision.

Current Status:

- The Peary Caribou Management Plan was submitted to the NWMB for decision in 2014 but the process was delayed until the September, 2017 regular board meeting.

- Several distribution and abundance surveys were conducted since the original submission of the plan but the resulting data did not differ from the data used to develop the plan and associated recommendations; therefore, no updates to the original submitted plan were necessary.

Consultations:

All communities that harvest Peary caribou were consulted on an initial draft prepared by DoE. This includes Grise Fiord, Resolute and Arctic Bay who routinely harvest, as well as occasional harvesters in the Kitikmeot, including Cambridge Bay, Gjoa Haven, Taloyoak and Kugaaruk. Consultations consisted of in-person meetings with each Hunter and Trappers Organization Board (HTO). This was followed by revisions to the draft based on input received from the HTOs.

A full list of meetings and participants is provided in Appendix 1, the consultation summary. The PowerPoint presentation used in consultations is provided in text format in Appendix 2.

In general the discussion with HTOs focused on four key areas; 1) do the proposed boundaries make sense, 2) is there support for harvest reporting and sample submission, 3) is there support to participate in community ground-based surveys, and 4) are they a species of opportunity or a targeted species and do they occur the same now as in the past?

The information obtained through these discussions was then used to revise the draft. In particular the boundaries in the Kitikmeot region were based entirely on community input.

In addition to the consultation for the plan previous workshops were held in Grise Fiord and Resolute in the fall of 2010 to share research results from the aerial surveys done to estimate Peary Caribou and Muskoxen population and distribution from 2001-2008. These workshops were very well received and generated significant discussion about management implications and Inuit knowledge about Peary caribou.

The final draft has been sent to the community HTOs for final review however only a few communities have provided comment on the final draft. Resolute did not want to proceed with a plan until results of the 2013 Bathurst Island survey were included; preliminary results have been incorporated into the plan.

The study designs and results of the post-2014 Peary Caribou population assessments were shared with the HTOs of Grise Fiord and Resolute Bay in 2015 and 2016 and were well received.

Overall the communities have expressed support for the Management Plan and its recommendations, in particular because of the ongoing collaborative process it outlines for the management of Peary caribou. There is no consensus on proposed TAH, with Grise Fiord indicating they will oppose any TAH recommendation.

Recommendations:

DOE is requesting approval from NWMB on the following:

- Approve the Draft Management Plan for Peary Caribou in Nunavut 2014-2020.
- Determine TAH for Peary caribou based on the management units and recommendations proposed in the plan.

Appendix 1
Peary Caribou Management Plan
Qikiqtaalik Region Consultation Summary
March 13-20, 2012

This round of consultations took place in March 2012 in the Qikiqtaaluk communities of Arctic Bay, Resolute, and Grise Fiord. The purpose of the consultations was to determine support for the draft management plan in general terms (as well as for a draft management plan for Peary caribou) and to obtain specific local knowledge to facilitate redrafting to include HTO input and concerns. These specifics include potential management unit boundaries, traditional and current use, and information on historic and current trends.

The sessions varied in length based on how prevalent Peary Caribou were locally and by the number of Board members that could attend. The meetings were all positive with all HTOs expressing interest in participating in development of the management plan as well as an interest in ensuring long term sustainability of Peary Caribou.

Arctic Bay HTO
March 13, 2012
GN - Chris Hotson, Peter Hale
HTO Board: Qaumayuq Oyukuluk, Adrian Arnauyumayuq, Josia Akpaliapik, Koonark Enoogoo, Paul Ejangiaq, Jack Willie Sec/Manager
Chris introduced the topic and gave a short PowerPoint presentation (attached) that introduces the management plan, the history of the initiative, the purpose of the plan, and an overview of content. This was followed by discussion and feedback.

Specific discussion took place around the following issues:

1) Do the proposed boundaries make sense?
   - Island groups make sense
   - general support from the board for boundaries
   - Discussion looked at needs for monitoring capability, so survey scale and harvest/use

2) Are Peary caribou a preferred species to harvest or a species that is taken by opportunity?
   - They are taken opportunistically and Arctic Bay hunters occasionally harvest
   - Peary Caribou are not a big issue but HTO wants to support Grise and Resolute communities

3) Are harvest levels same now as in the past?
   - It has always been only sporadic harvest, definitely not every year

4) Is there support for harvest reporting and sample submission?
    - Yes, may require some fee for sample

5) Is there interest in participating in community ground-based surveys?
    - Yes (this would allow for combined surveys with muskox) and potentially generate knowledge for other species
    -

Other issues suggested by HTO;
- Why called Peary caribou, should reflect Inuit language

Resolute HTO
March 17, 2012,
GN-Chris Hotson, Peter Hale
NTI-Glenn Williams
HTO Board: Philip Manik Sr., Paddy Aqiatusuk, Allie Salluviniq, Norman Idlout, David Kalluk, Simon Idlout, Nancy Amarualik Sec/Manager
Chris introduced the topic and gave a short PowerPoint presentation (attached) that introduces the management plan, the history of the initiative, the purpose of the plan, and an overview of content. This was followed by discussion and feedback.

Specific discussion took place around the following issues:

1) Do the proposed boundaries make sense?
    - Island groups make sense
    - general support from the board for boundaries but maybe more so for muskox than caribou
    - they do travel between islands, more so than muskox, something to consider.

2) Are caribou a preferred species to harvest or a species that is taken by opportunity?
    - Opportunistically now
    - Would like to be able to harvest more, particularly Cornwallis Island

3) Are harvest levels same now as in the past?
    - In 1970s only 3 muskox now there are too many on Prince of Wales and Somerset Island
    - Report data from 2001-2003 is misleading, want a new count
    - Proposed TAH at 3% harvest rate is too low
    -

4) Is there support for harvest reporting and sample submission?
    - Yes
    - Glenn raised a point that harvest reporting is not an imposition but a responsibility under the land claim

5) Is there interest in participating in community ground-based surveys?
    - Yes general support (in conjunction with concurrent muskox surveys)

Other issues suggested by HTO;

- Don't all die off when they drop in number, where do they go, they do move
- Totally opposed to collaring
- Need to identify calving areas
- Dust and noise from oil and seismic work negatively effects caribou

Grise Fiord HTO
March 21, 2012
GN-Chris Hotson, Peter Hale
NTI-Glenn Williams
HTO Board: Jaypetee Akeeagok, Aksajuk Ningiuk, Charlie Noah, Larry Audlaluk, Jopee kiguktak, Mark Akeeagok Sec/Manager
Chris introduced the topic and gave a short PowerPoint presentation (attached) that introduces the management plan, the history of the initiative, the purpose of the plan, and an overview of content.

This was followed by discussion and feedback.

1) Do the proposed boundaries make sense?
    - Island groups make sense

2) Are Peary Caribou a preferred species to harvest or a species that is taken by opportunity?
    - They are a targeted species but hard to reach sometimes.

3) Is there support for harvest reporting and sample submission?
    - No intention of creating HTO bylaws to gather harvest numbers
    - Glenn raised a point that sample submission and harvest reporting is not an imposition but a responsibility under the land claim

4) Is there interest in participating in community ground-based surveys?
    - Yes but the use of personal skidoos is a concern as it is difficult to purchase and repair them

Other issues suggested by HTO:

- Muskox and caribou don't mix
- Not alarmed about current decline, they cycle
- Pressure to have a document (plan) but don't want a flawed document
- Communities do not trust the science saying Peary Caribou are declining; have never existed in great numbers
- Would not support a TAH.

Peary Caribou Management Plan
Kitikmeot Region Consultation Summary
March 18-23, 2013

This round of consultations follows meetings that took place in February-March 2012 in the Qikiqtaaluk communities of Arctic Bay, Resolute, and Grise Fiord. The purpose of the consultations was to determine support for the draft management plan in general terms (as it is currently written for the Qikiqtaaluk region) and to obtain specific local knowledge to facilitate redrafting to include specifics for the Kitikmeot Region. These specifics include potential management unit boundaries, traditional and current use, and information on historic and current trends.

The sessions varied in length based on how prevalent Peary caribou (PC) were locally and by the number of Board members that could attend. The meetings were all positive with all HTO's expressing interest in participating in development of the management plan as well as an interest in ensuring long term sustainability of PC.

Cambridge Bay HTO
March 18, 2013, 16:00
Bobby Greenley, George Angohiatok, Johnny Lyall, Brenda Sitatak (Sec/Manager)
Chris Hotson, Mathieu Dumond

Mathieu introduced the topic and explained the difference between the recent Environment Canada consultations for Recovery Strategy development under SARA and the draft Nunavut Management Plan.

Chris went through a short PowerPoint presentation (attached) that introduces the management plan, the history of the initiative, the purpose of the plan, and an overview of content. This was followed by discussion and feedback.

Specific discussion took place around the following issues;

6) Is PC normally in the Cambridge Bay traditional harvesting area?
   - Yes but only at the northern edge around Hadley Bay
   - Have seen PC mix with Dolphin Union (DU) caribou in small groups and sometimes they move south for a bit with DU

7) Are PC a preferred species to harvest or a species that is taken by opportunity?
   - In 60's and 70's there were no DU caribou around so harvesters travelled north to harvest PC but not now as DU are preferred
   - Would choose to harvest DU caribou over PC when they are mixed together

8) Are harvest levels same now as in the past?

- Lower now; In the 60’s and 70’s there were no DU caribou so harvesters travelled north to harvest PC
- Now they are only taken opportunistically, usually by polar bear hunters that are travelling north to Hadley Bay area
- Harvest levels are now low, a couple of PC every year at best, sometimes none in a year

9) What are potential boundaries for management units?
   - Discussion looked at needs for monitoring capability, so survey scale and harvest/use
   - Based on discussion HTO sees utility in maintaining the Nunavut portion of Victoria Island as one management unit, also potentially Melville Island as another although no harvest occurs there

10) Is there support for harvest reporting and sample submission?
   - Yes, may require some fee for sample but it would help know harvest and perhaps provide help with genetics, other samples were discussed but it was advised that this would be an issue for stakeholder working group to determine

11) Is there interest in participating in community ground-based surveys?
   - Yes as this would allow for combined surveys for Muskox and potentially generate knowledge for other species, such as predators which are a concern

Taloyoak HTO
March 19, 2013, 19:00
Joe, David Irqiut, Lucassie Nakoolak, Sam Tulurialik, Abel Aqqaq, Anaoyok, Simon Qingnaqtuq (sec/manager)
Chris Hotson, Mathieu Dumond

Mathieu introduced the topic and explained the difference between the recent Environment Canada consultations for Recovery Strategy development under SARA and the draft Nunavut Management Plan.

Chris went through a short PowerPoint presentation (attached) that introduces the management plan, the history of the initiative, the purpose of the plan, and an overview of content. This was followed by discussion and feedback.

Specific discussion took place around the following issues;

1) Are PC normally in the Taloyoak traditional harvesting area?
   - Yes but only north of Taloyoak although local knowledge says they sometimes come further down the Boothia peninsula
   - Also Taloyoak harvesters do travel north to Prince of Wales/Somerset Islands for whale harvest and may take PC there

2) Are PC a preferred species to harvest or a species that is taken by opportunity?
    - In 60’s and 70’s PC were more common and more were taken
    - PC taste better and have more fat year round so would be preferred if they were more available

3) Are harvest levels same now as in past?
    - In 60’s and 70’s PC were more common and more were taken
    - There was a period in 80’s- 90’s when they were not seen but are starting to see again
    - A hunter would be lucky to harvest one every 5-10 years now

4) What potential boundaries for management units?
    - See the entire Boothia Peninsula a potential management unit
    - PC move north and south over the year and over time

5) Is there support for harvest reporting and sample submission?
    - Yes was the general consensus

6) Interest in participating in community ground-based surveys?
    - Yes was the general consensus

Other issues discussed;

- HTO would like to see protection or wildlife conservation areas for the whole of Boothia Peninsula as this is an important area for many species
- HTO is trying to participate in the NLUP process but struggling and needs assistance
- Board members encourage that IQ be used in helping to devise scientific surveys and studies
- PC and Muskox do not mix, increase in Muskox may explain why PC are down
- Need to study wolves/predators in conjunction with PC as they are linked
- May be good to survey wolves as well as PC/Muskox on ground surveys

Gjoa Haven HTO
March 20, 2013, 19:00
James Qitsualik, Simon Komangat, David Qiqut, Jacob, Joannie ,and Mark, Ben Kogvik (interpretor)
Chris Hotson, Mathieu Dumond

Mathieu introduced the topic and explained the difference between the recent Environment Canada consultations for Recovery Strategy development under SARA and the draft Nunavut Management Plan.

Chris went through a short PowerPoint presentation (attached) that introduces the management plan, the history of the initiative, the purpose of the plan, and an overview of content. This was followed by discussion and feedback.
Specific discussion took place around the following issues;

1) Are PC normally in the Gjoa Haven traditional harvesting area?
   - Yes, the Northwest part of King William Island is the main location for PC.
   - Have not seen many this year but did see some 2-3 years ago
   - Normally hunters go north for whales and may see PC
   - Targeted caribou harvest is to the south, so mainly barren ground are taken

2) Are PC a preferred species to harvest or a species that is taken by opportunity?
   - Would choose to harvest PC as they are fat year round but will harvest any caribou if given the chance

3) Are harvest levels same now as in past?
   - There was a low in the 60's and 70's but coming back now, they decline but also move over time
   - Harvest rates are very low 0-2 a year

4) What potential boundaries for management units?
   - King William Island and Boothia Peninsula to be one management unit, include islands to the northwest between King William and Victoria Islands
   - The rational for KWI and Boothia as a unit is that there is a movement corridor from the southwest of Boothia to the Northeast of KWI (Note: This could be of importance for maritime traffic impact assessment in particular).

5) Is there support for harvest reporting and sample submission?
   - Yes was the general consensus but need a CO in community
   - Payment for samples may be required

6) Interest in participating in community ground-based surveys?
   - Yes was the general consensus, perhaps include other species in surveys in addition to PC/MX

Other issues discussed: DU and PC may mix both spatially and in terms of breeding

- Use least invasive methods to survey
- They do not want to be excluded from future management process/actions
- Wolves, there are too many, can ground-based survey include that?
- PC and Muskox do not mix, must be taken into consideration

Kugaaruk HTO
March 21, 2013, 19:00
Barnaby Immingark, Zachary Oogark, Ema Qaggutaq (sec/manager)
Chris Hotson, Mathieu Dumond, Lee McPhail (CO)

Mathieu introduced the topic and explained the difference between the recent Environment Canada consultations for Recovery Strategy development under SARA and the draft Nunavut Management Plan.

Chris went through a short PowerPoint presentation (attached) that introduces the management plan, the history of the initiative, the purpose of the plan, and an overview of content. This was followed by discussion and feedback.

Specific discussion took place around the following issues;

1) Are PC normally in the Kugaaruk traditional harvesting area?
    - Yes but only on northern Boothia Peninsula, at the periphery of current harvest area

2) Are PC a preferred species to harvest or a species that is taken by opportunity?
    - Opportunity based harvest, very infrequent
    - PC is preferred due to taste and fat year round

3) Are harvest levels same now as in past?
    - Harvest very rare; no participating board members had ever seen a PC

4) What potential boundaries for management units?
    - Boothia Peninsula, including Simpson peninsula and Lady Peary Island which has had PC historically

5) Interest in supporting harvest monitoring?
    - Yes was the general consensus

6) Interest in participating in community ground-based surveys?
    - Yes was the general consensus

Other issues discussed: Predation and weather are important to PC and should also be considered.

Appendix 2
Community PowerPoint Presentation

The follow section is a text version of the PowerPoint used in the Kitikmeot consultations. The Qikiqtaalik version was the same only using references to the proposed management units specific to that region.

Draft Peary Caribou Management Plan

GN Department of Environment
Mathieu Dumond
Chris Hotson

Outline

- History of initiative
- Purpose of the plan
- Process
- Overview of content
- Discussion and feedback

History of the Management Plan

- Peary caribou are an outstanding issue for regulations
- Would like to have a Nunavut management plan in place prior to the Species at Risk Act recovery process
- The early draft was 10 years old and did not reflect current status
- Process was waiting for the survey report, report is now complete

Purpose of the Plan

- Establish goals for taking care of PC
- Identify the importance of working together;
- Provide current population estimates and trends;
- Define roles and responsibilities of the stakeholders;
- Define the information required to effectively manage;

Purpose continued

- Describe how to make decisions;
- Provide a framework for determining when management actions should be taken; and
- Ensure full involvement of Inuit in the future monitoring and management of Peary Caribou
- To provide NWMB with a management plan that is ready for implementation.

Process

- Consult on the initial draft with communities
- Edit draft to reflect community input and concerns
- Share revised draft with stakeholders for further clarification
- Seek support on final draft
- Submit final draft to NWMB for approval and to form basis for new regulations under the wildlife act

Overview

- Summary
- Purpose of the plan
- How it will be developed
- Goals of the plan
- Peary Caribou biology and management

Review continued

- The users
- Status
- Monitoring
- Decision making
- How to communicate
- How to update plan
- Appendices

Discussion and Feedback

- Run through each section

Organization of survey area into Island Groups;

- 1) Bathurst Island Group
- 2) Devon Island Group
- 3) Prince of Wales/Somerset Island Group
- 4) Ellesmere Island Group
- 5) Axel Heiberg Island Group
- 6) Ringnes Island Group

Kitikmeot management units?

General Recommendations

- Recommend establishing management units based on six (?) Island groups
- Establish an ongoing community-based ground survey program with appropriate support
- Establish a harvest reporting and sample collection program
- Each harvest should be reported through the submission of hunter kill reports
- Use observed changes from community monitoring program (observations of die offs, population increase or decrease) to trigger:
    1) Potential aerial surveys for severe declines,
    2) Increased frequency and coverage of community ground survey if declines are less significant,
    3) Community based changes in harvest level that would occur within a predetermined upper and lower limit.

Management Plan for Peary Caribou in Nunavut

2014 – 2020

Prepared in collaboration with

The Hunter and Trappers Organizations of Grise Fiord, Resolute Bay, Arctic Bay, Cambridge Bay, Gjoa Haven, Taloyoak, Kugaaruk, GN Department of Environment, Nunavut Tunngavik Inc., and the Nunavut Wildlife Management Board

Third Draft, January 2014

Note:

This draft is based upon the format and language used in the document "*Taking Care of Caribou -The Cape Bathurst, Bluenose West, and Bluenose East Barren Ground Caribou Herds Management Plan"* developed by the stakeholders and Terriplan Consultants and submitted to the Advisory Committee for the Cooperation on Wildlife Management. The majority of technical information is derived from the GN DoE report "*Recent trends and abundance of Peary Caribou (Rangifer tarandus pearyi) and Muskoxen (Ovibos moschatus) in the Canadian Arctic Archipelago, Nunavut"*. The information contained herein is an amalgamation of both documents and the work in both those documents represents the talent, skill and considerable efforts of those involved respectively.

TABLE OF CONTENTS

1.0 Summary

Peary caribou (*Rangifer tarandus pearyi*) are a distinct caribou subspecies that occurs almost entirely on islands within the Canadian Arctic Archipelago. These ungulates live the farthest north of all caribou in North America, and are the smallest in stature and in population size. In February 2011 Peary caribou were listed as Endangered under the *Species at Risk Act* (SARA) due to declines in abundance and expected unpredictable declines due to changes in long-term weather patterns.

Caribou are of major cultural, traditional and economic importance to Inuit, and are also a vital part of the Arctic ecosystem. Nunavummiut are concerned about the status of Peary caribou and their habitat as determined through public workshops in Grise Fiord and Resolute Bay. Peary caribou harvest in Nunavut has not been restricted through legislation; rather the Resolute Bay Hunters and Trappers Association (HTA) and the Iviq HTA of Grise Fiord have imposed temporary harvest restrictions on their members during periods of marked declines. Inuit knowledge however suggests that increasing land-use activity, such as resource exploration, poses a greater potential threat to Peary caribou and their habitat than hunting pressure.

The Department of Environment of the Government of Nunavut (GN DoE) has the ultimate responsibility for the management and conservation of Peary caribou within its jurisdiction. To address the DoE mandate for management this plan recommends management units and harvest levels to establish the basis of new regulations under the *Wildlife Act* as well as recommendations for ongoing monitoring of population trends and harvest through an inclusive approach with all co-management partners. This will include provisions for future monitoring and research, Inuit involvement in research, monitoring and decision making, and consensus based decision making in response to observed changes in population.

2.0 PURPOSE OF THE PLAN

The need for a management plan for Peary caribou is born out of several issues including Inuit harvest rights, territorial responsibility for species management, changes in land use needs, population declines, and changing climate. The long term Department of Environment study on Peary caribou "*Recent trends and abundance of Peary Caribou (Rangifer tarandus pearyi) and Muskoxen (Ovibos moschatus) in the Canadian Arctic Archipelago, Nunavut"* has produced the first modern, comprehensive assessment of the current status of Peary Caribou in Nunavut. With the completion of the DOE report, and the success of community workshops held in Grise Fiord and Resolute, the development of management plans is essential. The need for a plan is also connected to the survey results, which for some areas are becoming outdated, although the results remain valid as a baseline.

The Peary Caribou Management Plan provides a snapshot of current population estimates and trends for the species across its range and establishes overall principles and goals for the conservation of Peary caribou in Nunavut. It highlights the critical need for co management partners to work together, defines roles of stakeholders, and provides a framework to guide management of the species throughout its range to accomplish the goals identified in Section 4.0.

The GN DoE report "*Recent trends and abundance of Peary Caribou and Muskoxen in the Canadian Arctic Archipelago, Nunavut*" provides greater technical detail on the specific island groups and their status, both historical and current. The more recent GN report "Distribution and abundance of Peary caribou (*Rangifer tarandus pearyii*) and muskox (*Ovibos moschatus*) on the Bathurst Island Group, May 2013" provides additional information.

2.1 CO-MANAGEMENT

This plan was developed through cooperation and dialogue between co management partners in Nunavut including participation by:

Iviq Hunters and Trappers Association (Grise Fjord)
Resolute Bay Hunters and Trappers Association
Ikajutit Hunters and Trappers Organization (Arctic Bay)
Spence Bay Hunters and Trappers Organization (Taloyoak)
Ekaluktutiak Hunters and Trappers Organization (Cambridge Bay)
Kurairojuark Hunters and Trappers Organization (Kugaaruk)
Gjoa Haven Hunters and Trappers Organization
Nunavut Tunngavik Inc., Wildlife Department
Nunavut Department of Environment, Wildlife Management Division

3.0 HOW THE PLAN WAS DEVELOPED

The Plan was developed in collaboration with the communities that harvest Peary caribou as well as the other co management partners under the *Nunavut Land Claims Agreement* (NLCA). Two rounds of community workshops were conducted in 2010 and 2011 in Grise Fiord and Resolute Bay in addition to the ongoing exchange of information during the aerial and ground surveys.

The workshops were designed to:

- Share results of GN DoE research
- Gather local expert knowledge
- Seek consensus on management and monitoring actions

The initial draft was developed for further community and stakeholder involvement by GN DoE and consultations were conducted in March 2012 in the Qikiqtaalik Region and

March 2013 in the Kitikmeot Region. The final draft will be submitted to the NWMB for approval and will form the basis for development of Regulations under the *Wildlife Act*.

4.0 GOALS OF THE PLAN

The goals of the Management Plan are to provide guidance and direction to the co-management partners and are as follows:

- To manage Peary caribou in a co-operative manner that involves the full participation of communities and engagement of co management partners.
- To include Inuit Qaujimajatuqangit and scientific knowledge equally in the management process.
- To promote local and regional involvement in decision making.
- To protect, conserve and manage Peary caribou in a sustainable manner.
- To ensure the full and effective participation of Inuit and co management partners in ongoing monitoring and management of Peary caribou, and decision making.

4.1 INUIT QAUJIMAJATUQANGIT

Inuit Qaujimajatuqangit (IQ) is the knowledge and insight gained by Inuit through generations of living in close contact with nature. For Inuit, IQ is an inseparable part of their culture and includes rules and views that affect modern resource use.

The practical application of IQ with scientific information demonstrates the value of local consultations, and documenting and preserving IQ before it is lost. The communities, through the HTOs, will be consulted on an on-going basis to ensure that IQ is utilized in conjunction with scientific information in the management of Peary caribou.

This plan supports those values and reflects the following principles:

- Management decisions will reflect the wise and sustainable use of Peary caribou.
- Adequate habitat (quantity and quality) is fundamental to the welfare of Peary caribou.
- Management decisions will be based on the best available information - both science and IQ; and management actions will not be postponed in the absence of complete information, whether from science or IQ.
- Effective management requires participation, openness and cooperation among all users and agencies responsible for caribou and their habitat.
- We must anticipate and minimize negative impacts to caribou and their habitat.

5.0 PEARY CARIBOU BIOLOGY AND MANAGEMENT

Common name (English): Peary caribou
Common name (French): Caribou de Peary
Inuktitut name: Tuktu

Innuinaqtun name: Qinianaq or Tuktuinal (‘small caribou”)
Scientific Name: *Rangifer tarandus pearyi*

Status: SARA – Endangered
Wild Species 2010 – At Risk

5.1 PEARY CARIBOU RANGE

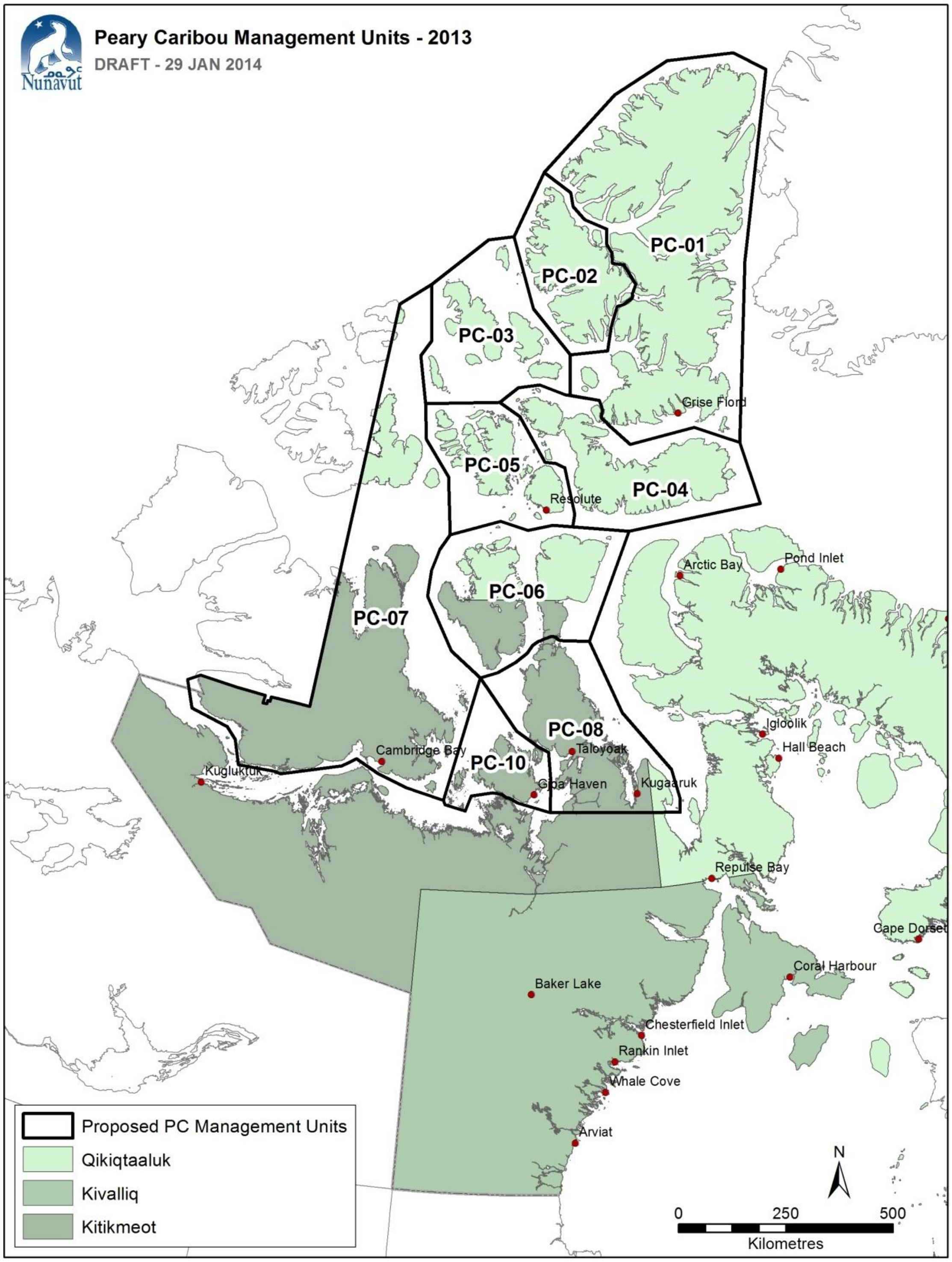
Endemic to Canada, the terrestrial range of Peary caribou is roughly 540,000 km^2 and extends across the Queen Elizabeth Islands in the north, the mid-Arctic islands and from the west of Banks Island to Somerset and the Boothia Peninsula in the southeast (Figure 1). Ice surrounds the islands for most of the year and caribou on some islands use the sea ice during seasonal migrations. The range is vast and the area is characterized by extreme weather, long periods of either continual darkness or continual light, and large expanses of ice, bare ground, and rock. The landscape is characterized by a polar desert and polar semi-desert where environmental conditions approach the physiological tolerance limits of plants.

5.2 MANAGEMENT OF PEARY CARIBOU BY ISLAND GROUPS

The GN DoE report “*Recent trends and abundance of Peary Caribou and Muskoxen in the Canadian Arctic Archipelago, Nunavut,”* is the most reliable study of Peary caribou in Nunavut to date on which to base this management plan. This report provides the baseline for scientific knowledge of Peary caribou, as well as providing the estimates of numbers of Peary Caribou and specific habitat for management purposes.

As outlined in the report, Peary caribou make seasonal movements among islands within their range, and are also known to make longer distance movements in response to severe weather. The following proposed island grouping (Figure 1) applies the best available scientific information and Inuit knowledge about Peary caribou movement and proposes geographic units that are useful for management of the species. This plan refers to each management group by the ‘Island Group’ name. For the purpose of the management plan, it is important to note that the island group management units are not to be considered as discrete populations or sub-populations as adequate genetic information is not available to define populations at this time.
The Queen Elizabeth Islands (QEI) form the majority of the island groups, with the Bathurst Island group, the Axel Heiburg Island group, the Ringnes Island Group, the Ellesmere Island Group and the Devon Island Group being wholly within the QEI.

Figure 1. Proposed Peary Caribou Management Units



Melville Island for the purposes of this management plan is placed within the Victoria Island group.

5.2.1 Ellesmere Island Group (PC-01). Ellesmere Island is the largest of the Queen Elizabeth Islands (197,577 km^2). The island is largely covered by mountain ranges and glaciers that are separated by a series of east-west passes. These features fragment the island, particularly where the north end of Vendom Fiord approaches the Prince of Wales Ice Cap, and divides the southern portion of the island from the north. Vegetation is sparse with mosses, lichens, and cold-hardy vascular plants such as sedges and cottongrass dominant at higher elevations while mosses and low-growing herbs and shrubs, such as purple saxifrage, *Dryas spp.,* arctic willow, kobresia, sedge, and arctic poppy more common at lower elevations.

5.2.2 Axel Heiberg Group (PC-02). Axel Heiberg Island (42,319 km^2) is separated from Ellesmere Island by Nansen and Eureka Sound. This island is mountainous and includes the Princess Margaret Range, which runs north to south through its center. Large ice caps cover much of the landmass and spawn many glaciers that flow primarily to the west. East of the Princess Margaret Range, vegetation progresses from an herb-shrub transition zone at higher elevations to an enriched low shrub zone along the low-lying coast. There, plant species are diverse and dense, dominated by shrubs and sedge meadows.

5.2.3 Ringnes Island Group (PC-03). This island group consists of Ellef Ringnes, Amund Ringnes, Lougheed, King Christian, Cornwall, and Meighen Islands, all situated to the west of Axel Heiberg Island and north of the Bathurst Island Complex. Lougheed Island (1,321 $km^{2)}$ has vegetation described as entirely herbaceous with rich vegetation patches. Ellef Ringnes Island (11,428 km^2) is sparsely vegetated with low plant diversity.

Amund Ringnes Island (5,299 km^2) is relatively low lying but features greater relief in the north. Vegetation is entirely herbaceous with the southern half of the island supporting more diverse vegetation, primarily herbaceous plants with some shrubs and sedges. To the south of Amund Ringnes is Cornwall Island, a small hilly landmass also dominated by herbaceous vegetation. Meighen Island (approximately 933 km^2), to the northeast of Amund Ringnes, is low-lying with sparse herbaceous vegetation and a large centrally located glacier. King Christian Island is located southwest of Ellef Ringnes, has an area of 647 km^2.

5.2.4 Devon Island Group (PC-04). Devon Island (55,534 km^2; including small proximal islands) is characterized by several mountain ranges (e.g. Cunningham Mountains, Treuter Mountains, and the Douro Range), coastal lowlands, and extensive glaciers. The Devon Ice Cap covers a large portion of eastern Devon Island. Extensive uplands stretch west of the Ice Cap across central Devon Island. Low-lying areas occur in coastal areas, primarily along the north and western coast (the Truelove lowlands), but also other smaller areas. The landscape is predominantly polar desert with sparse cover of vascular plants; however low lying areas support a greater diversity of vegetation dominated by low shrubs and sedges.

5.2.5 The Bathurst Island Group (PC-05). This group of islands includes the Bathurst Island Complex (BIC), and Cornwallis and Little Cornwallis Islands. The BIC (19,644 km^2) includes Bathurst Island and five major satellite islands (> 200 km^2; Cameron, Vanier, Alexander, Massey, and Helena), and three minor satellite islands. These islands are low-lying with few areas exceeding 300 m elevation. The terrain is sparsely vegetated however low-lying wetlands such as at Goodsir-Bracebridge Inlet have a higher cover of sedges and low-growing willows. Cornwallis and Little Cornwallis Islands (7,474 km^2 including small proximal islands) are low-lying with uplands and hills below 300 m and mostly polar desert with sparse vegetation. Portions of the western coastline and Eleanor Lake watershed (Cornwallis Island) support more diverse vegetation, including prostrate shrubs in moderately moist habitats, and sedges in the wet areas.

5.2.6 Prince of Wales/Somerset Island Group (PC-06). Prince of Wales (33,274 km^2) is a tundra-covered island that features many small inland lakes. Although the island is generally below 300 m in elevation, some uplands occur along the eastern coast and across the north. Russell Island and Prescott Island are small proximal islands north and east of Prince of Wales, respectively. Somerset Island (24,548 km^2), separated from Prince of Wales Island by Peel Sound, is hilly with extensive uplands.

5.2.7 Victoria Island Group (PC-07). This group includes Victoria Island (217,291 km^2) and Melville Island (42,149 km^2). Both of these islands have a shared border with the Northwest Territories. The eastern two thirds of Victoria Island lie in Nunavut along with roughly the eastern half of Melville Island. The majority of Victoria Island lies within the Victoria Lowlands is characterized by a discontinuous upland vegetative cover dominated by purple saxifrage, other saxifrage *spp., Dryas spp.,* arctic willow, alpine foxtail, and wood rush. Wet areas have a continuous cover of sedge, cottongrass, saxifrage *spp.*, and moss. Remaining upland areas are largely devoid of vegetation. Besides the presence of Mount Pelly and Little Pelly, elevations lie predominantly below 100 m asl. except in central Victoria Island where elevations rise up to over 200 m asl.

A small portion of Victoria Island, along the northwest boundary with NWT, is composed of the Shaler Mountains. The Shaler Mountains are characterized by a 40-60% vegetative cover mixed with exposed bedrock. Tundra vegetation includes purple saxifrage, other saxifrage *spp., Dryas spp.,* arctic willow, alpine foxtail, and wood rush. Wet areas have a continuous cover of sedge, cottongrass, saxifrage *spp*., and moss. The centre part of the mountains reaches about 760 m asl.

Melville Island is predominately within the Parry Plateau. It has a sparse and discontinuous vegetative cover of moss, along with mixed low-growing herbs and shrubs such as purple saxifrage, *Dryas spp.,* arctic willow, kobresia, sedge, and arctic poppy. The terrain of this plateau is strongly ridged. Their elevations average less than 250 m asl. Separate, flat-floored, longitudinal valleys are transected by rugged, ravine-like cross valleys. On Melville Island, a few hills reach 760 m asl, and cliff-walled fjord-like bays and straits cut deeply into the uplifted plateau.

5.2.8 Boothia Peninsula (PC-08). Boothia Peninsula (32,331km^2) is predominately covered by the Boothia Plateau uplands. Vegetation is discontinuous, and dominated by tundra species such as purple saxifrage, other saxifrage *spp., Dryas spp.,* arctic willow, alpine foxtail, and wood rush. Wet areas have a continuous cover of sedge, cottongrass, saxifrage *spp*., and moss. It averages around 760 m asl. Bedrock outcroppings are common.

The eastern side of the Boothia Peninsula along the lowland coastal fringes of Boothia and Simpson peninsulas is composed of plains. It is characterized by discontinuous upland tundra vegetation, dominated by purple saxifrage, other saxifrage *spp., Dryas spp.,* arctic willow, alpine foxtail, and wood rush. Wet areas have a continuous cover of sedge, cottongrass, saxifrage *spp.*, and moss. The region slopes gently southward, ranging from sea level to about 300 m asl.

The south-western coastal portion of the Boothia Peninsula lies within the Victoria Lowlands which is characterized by a discontinuous upland vegetative cover dominated by purple saxifrage, other saxifrage *spp., Dryas spp.,* arctic willow, alpine foxtail, and wood rush. Wet areas have a continuous cover of sedge, cottongrass, saxifrage *spp*., and moss. Elevations lie predominantly below 100 m asl.

5.2.9 King William Island Group (PC-10). King William Island (13,111 km^2) is separated from the Boothia Peninsula by the James Ross Strait to the northeast, Rae Strait to the east, Victoria Strait to the west, and Simpson Strait to the south. Satellite islands include the Irving Islands, the Todd Islets, Matty Island, the Tennent Islands, and the Clarence Islands.

This group is in the Victoria Lowlands region which is characterized by a discontinuous upland vegetative cover dominated by purple saxifrage, other saxifrage *spp., Dryas spp.,* arctic willow, alpine foxtail, and wood rush. Wet areas have a continuous cover of sedge, cottongrass, saxifrage *spp.*, and moss. Remaining upland areas are largely devoid of vegetation. Elevations lie predominantly below 100 m asl.

6.0 THE USERS

Inuit are the traditional and current users of Peary caribou. The communities of Resolute Bay and Grise Ford were established in the early 1950's by the Canadian government as part of an arctic sovereignty program. Inuit that were relocated to these communities relied on the availability of Peary caribou as a food source. This reliance continues today. Arctic Bay is also an occasional user in the Qikiqtaaluk region. In the Kitikmeot region, the communities of Cambridge Bay, Taloyaok, Gjoa Haven, and Kugaaruk are also occasional users of Peary caribou; when Peary caribou are available they are taken opportunistically by harvesters from these communities.

7.0 STATUS OF THE ISLAND GROUPS

7.1 SURVEY HISTORY

In 1961 the first comprehensive survey of Peary caribou done in a single season across the Queen Elizabeth Islands was completed. During this survey approximately 25,845 Peary caribou were estimated. The majority of caribou (approximately 94%) were located in the western Queen Elizabeth Islands (QEI) (Bathurst Island Complex, Cornwallis, Melville, Prince Patrick, Eglinton, Emerald, Borden, Mackenzie King, and Brock). Survey coverage of some island groups, particularly Ellesmere, was minimal.

The first population estimates for the western Arctic islands included a 1972 estimate of 11,000 Peary caribou on Banks Island, a 1974 estimate of 5,515 Peary caribou on the eastern islands of Prince of Wales and Somerset Islands and 561 Peary caribou on the Boothia Peninsula in 1974, and a 1980 estimate of 4512 Peary caribou on northwestern Victoria Island. Combined with the 1961 QEI estimate, these estimates of abundance reveal a historic number of 48,000 Peary caribou throughout their entire range.

The decline of Peary caribou is characterized by four major die-offs which were observed primarily in the western Queen Elizabeth Islands between 1970 and 1998. Die-off events have been associated with deep snow and icing, which can limit access to forage, increase energy requirements, and lead to extreme under-nutrition and death. Observations by local Inuit are in agreement, reporting up to 2 inches of ice in some years.

Although limited, the data suggests that periods of decline and recovery vary among island groups, and a variety of factors such as human activities, landscape changes, predation, hunting, and competition with other herbivores may also contribute to the fluctuation of caribou. Inuit in Resolute Bay and Grise Fiord have identified exploration activities (i.e. oil and gas, coal and base minerals) as an additional stressor for caribou during some winters. They suggest that during years of high snow accumulation, industrial activities can prevent caribou from moving into areas that may be vital for their survival.

7.2 STATUS OF ISLAND GROUPS

7.2.1 Ellesmere Island Group

Results from the first aerial survey in 1961 suggested that there were approximately 200 caribou on Ellesmere Island, but only a small portion of the island was studied. The most recent survey (2005 and 2006) for Ellesmere Island revealed extremely low densities of 8-9 caribou/1000 km^2 for Peary caribou, which implies approximately 1,000 animals. Unfortunately surveys of Ellesmere Island are infrequent and limited in their spatial coverage making the determination of a trend in number impossible in this group. By 2003, Inuit reported that numbers of caribou on southern Ellesmere were increasing.

7.2.2 Axel Heiberg Island Group

The 1961 estimate of about 300 caribou on the island was based on limited survey coverage. No other surveys of the island have occurred since that time until 2007. The last survey results show a higher number of caribou than the only previous description of caribou abundance for Axel Heiberg Island. Lack of data and this 50-year gap in monitoring make it impossible to discuss population status or trends for Peary caribou on Axel Heiberg Island.

The Axel Heiberg Group currently supports the largest population of Peary caribou in Nunavut, with an estimated 2,291 animals based on 2007 survey results. This population accounts for a significant portion of the total estimated Peary caribou population within the Nunavut range. This may be a consequence of the local climate, plant biomass and diversity of vegetation, the varied topography, and isolation from human disturbance.

7.2.3 Ringnes Island Group

The 2007 survey of the Ringnes Island Group estimated a total of 654 caribou. Survey results suggest that caribou abundance is lower than the historical value of 1,324 in summer 1961. Overall it is difficult to interpret trends or fluctuation within this Island Group as survey information is limited, typical seasonal movement patterns are unknown, and the only two surveys completed have occurred at different times of year. Nonetheless, the overall proportion of calves (14%) observed in 2007 is encouraging given the extreme northern latitude and the small calf crops recorded for other survey areas.

7.2.4 Devon Island Group

The few surveys conducted suggest that Devon Island supports only a low number of Peary caribou. During a full island survey completed in 1961, 150 Peary caribou were estimated. Minimum counts for western Devon Island in 2002 suggested that caribou numbers were low. In 2008, the count remained low with 17 Peary caribou. Thus, it appears that Peary caribou have existed at low numbers in the Devon Island group, although numbers are decreasing from previous estimates or counts which indicate a declining trend.

Movement patterns for caribou on Devon Island are not well understood and it is possible that there were caribou in other areas of the island at the time surveys were conducted. Inuit knowledge indicates that there have been caribou on the northeastern coast of Devon Island, on the Grinnell Peninsula, and that they can reliably be found along the western coast of the island.

7.2.5 Bathurst Island Group

The 2013 survey showed a significant increase in Peary caribou numbers, more than 1200 caribou, over the previous 2001 estimate of 187, however it is still low in relation to historical values of over 3,000 individuals (including calves) in both 1961 and 1994. Although evaluation of trends in abundance is complicated by differences in survey design and the inclusion or exclusion of calves, the overall trend of decline and current recovery is apparent.

This group has seen sharp fluctuations in 1973-74, and again in 1995-1997. The first two surveys of the Bathurst Island Complex (BIC, which consists of Bathurst, Vanier, Cameron Alexander, Massey, and Marc islands) were separated by 12 years (1961-1973) and revealed an 83% reduction in this caribou population from 3,565 to 608 (both estimates including calves). Late winter and summer surveys in 1973 and 1974 respectively identified a further reduction in caribou numbers to 228 (no calves were observed). This additional 62% decline was attributed to deep snow cover and icing, which caused widespread mortality and resulted in little or no reproductive success. Subsequent surveys from 1985 to 1994 indicated an increase and by 1994 Peary caribou were estimated at 3,100 on the BIC. Aerial surveys in 1995, 1996, and 1997 revealed a second die-off with an all-time low estimate of 78 caribou in 1997. Based on carcass counts, it was estimated that 85% of the overall decline was directly related to caribou mortality (and not movement). During the survey in 2001, the number of caribou in this group was estimated at 187.

Since that time Inuit have reported a slow increase in Peary caribou numbers. In 2010, Parks Canada conducted a reconnaissance survey on Bathurst Island and counted 300 Peary caribou in a non-systematic survey with no estimate derived. An aerial survey was conducted of the entire Bathurst Island group in May 2013 which generated a preliminary updated estimate of 1300 caribou which corresponds to Inuit observation of recovery since 2001.

For the Cornwallis Islands the only observation of live caribou in the 2001 survey was on northwest Cornwallis Island. Two caribou were seen on southern Cornwallis Island, and another single caribou on Little Cornwallis Island during the 2013 survey, but occasional tracks and local knowledge also suggest densities remain very low. Previous estimates that include both Cornwallis Island and Little Cornwallis Island are limited to the summer 1961 and 1988, when 43 and 51caribou (with calves) were estimated respectively. Earlier surveys of Little Cornwallis in 1973 and 1974, produced estimates of 8 and 12 caribou, respectively, with no calves observed. By the mid- to late 1960s, Inuit reported that it was difficult to find caribou on this island and that none were observed from 1990 to 2003. These observations are consistent with ground and aerial survey results from 2002.

7.2.6 Prince of Wales Island Group

Peary caribou in this Group declined from an estimated 5,682 caribou (one year or older) in 1974 to a minimum count of two in 1996. Current scientific knowledge indicates that there has been little recovery since 1996. During the 2004 aerial survey, no Peary caribou were observed on the Prince of Wales Island Group. These results are consistent with ground surveys of Prince of Wales Island in 2004 and Somerset Island in 2005, in which crews reported only four caribou after traveling a distance of 4,831 km. Local knowledge however, indicates that there has been some return or increase in recent years as they see more caribou on the coast of Prince of Wales Island however there is presently no monitoring in place to help determine if the herd is recovering.

7.2.7 Boothia Peninsula Group.

Boothia Peninsula has had aerial surveys from 1961 to 1995. During this time some surveys have counted both Peary and Barren ground caribou together and others have counted them separately so extrapolation of trend is difficult. Regardless, local knowledge indicates that Peary caribou numbers have always been relatively low with some fluctuation over periods of decades. Peary caribou have been seen primarily north of Taloyoak and less frequently north of Kugaaruk and at the north end of the Simpson Peninsula. Peary caribou are known to have used Lady Parry Island.

Hunters in Taloyoak harvest Peary caribou opportunistically with a couple taken every year. Historically more Peary caribou where taken in the 1960’s and 1970’s when they were more abundant. In Kugaaruk, harvest is also opportunistic with only a caribou harvested every few years. There is currently no system in place to report the Peary caribou harvested at these locations and thus monitor harvest rate.

7.2.8 Victoria Island Group.

Both Victoria Island and Melville Island have a long history of aerial surveys. Peary caribou have been more consistently observed, and at higher numbers on Melville

Island with a high of over 10,000 adults in 1961 and a low of 700 in 1972. A recent survey of Melville Island conducted by the Government of Northwest Territories (GNWT) has produced a new estimate of 2,990 adults in 2012 which suggests a recovery from the 1972 low. No harvest currently occurs in the Nunavut portion of Melville Island.

Local and scientific knowledge indicates that Victoria Island has consistently supported Peary caribou at low numbers. IQ also indicates that the distribution for Peary caribou in the Nunavut portion is largely in the north-east near Hadley Bay. The known high was 4,500 (including calves) in 1980 with a known low of 20 adults in 1993. The most recent estimate conducted by GNWT was 150 adults in 2010. Peary caribou are harvested by Inuit from Cambridge Bay opportunistically, usually in conjunction with polar bear hunters travelling to Hadley Bay. Harvest is low with only a few Peary caribou every few years although their harvest is not monitored. Caribou harvest is targeted to Dolphin and Union caribou which are typically closer to the community. Local preference even when Peary caribou are mixed with Dolphin-Union caribou is to harvest the latter.

7.2.9 King William Island Group

This group has little scientific data and most recent data indicates that this area lies outside the normal range of Peary caribou. Local knowledge indicates that Peary caribou occasionally move from Boothia Peninsula to the north coast of King William Island. Local knowledge suggests that here may also be mixing with Dolphin and Union caribou that migrate from Victoria Island.

8.0 MONITORING

The number of Peary caribou per Island Group shows fluctuation over time, with periods of abundance and periods of scarcity. Caribou are also known to move over time in response to environmental conditions. Monitoring programs collect information about changes in number, distribution, and changes in ecological factors that affect caribou numbers and health. It is important to involve both scientists and community harvesters in monitoring efforts. This plan seeks to ensure that both science and IQ are effectively collected and used for research and decision making.

The effects of individual factors, such as weather or human disturbance, can affect caribou both individually and at the Island Group level. These factors however can work in combination such that the total or cumulative effects may be greater than that which occurs from each factor on its own. These impacts may be either positive or negative.

8.1 MAIN CRITERIA FOR ASSESSING ISLAND GROUP STATUS

The main pieces of information on which management actions will be based include:

- Population size

- Recruitment
- Bull-to-cow ratio
- Body condition and health
- Harvest levels
- Number trend by management units

8.1.1 ISLAND GROUP STATUS

The main factor to assess island group status, and the key consideration when recommending the sustainable harvest level for any given island group, is the estimated number of animals in the Island Group. The current baseline survey completed by GN DoE was conducted with aerial distance sampling. Although effective and accurate for determining the number of Peary caribou in an Island Group, this method is costly. Aerial surveys will continue as required. However the implementation of a community-based monitoring program involving ground surveys can be conducted in predetermined areas, such as traditional hunting areas or areas where caribou are normally seen but absent, and provide data to help inform decision making in the interim between aerial surveys.

8.1.2 RECRUITMENT

Recruitment refers to the number of calves that survive to one-year of age. Calf/cow ratios are used as a measure of recruitment. Herd composition observed during community-based ground surveys and/or aerial surveys will be useful for determining the cow/calf ratio.

These ratios, while informative, are often difficult to interpret as they are influenced by various factors such as changes in cow mortality. Typically, recruitment rates are low before the number of animals begins to decline, whereas high recruitment rates, particularly several years in a row, may indicate an increase in herd size.

8.1.3 BULL-TO-COW RATIO

Caribou bulls can mate with many females within the same season. It is important to monitor the bull-to-cow ratio to help determine if there are enough bulls to impregnate cows. Monitoring herd structure can be done during the rut both by aerial surveys and ground based surveys, by scientists or harvesters, who can provide information on the number of bulls observed in relation to the number of cows.

8.1.4 BODY CONDITION AND HEALTH

The health and condition of individual caribou can affect productivity and survival of calves and adults. Sample kits are provided to harvesters to measure or collect: pregnancy (presence of fetus), back fat thickness, left kidney with the fat to assess contaminant levels and condition, blood samples to assess disease, body condition score, collection of lower front teeth for age determination, and location, date and sex of the animal harvested. When a sample kit is not provided, harvesters typically have a general overview of the condition of caribou. Body condition information collected by community members, harvesters and scientists provides supporting evidence of health.

8.1.5 HARVEST

Long term monitoring of harvest levels is very important for management decisions, and to help determine sustainable harvest rates. However, there is currently no obligation to report harvest of Peary caribou in the communities. Establishing a harvest monitoring program is a priority and fundamental to the overall monitoring of caribou. Harvest reporting is also a means of participation in management by the users at the individual level.

8.1.6 ISLAND GROUP TREND AND RATE OF CHANGE

The trend or the rate of increase or decrease is also a key indicator of island group status. Trend can be determined by comparing island group estimates over many years. When a population estimate is not possible, we can look at other data to help determine the trend, such as recruitment, body condition and health, harvest levels, and bull-cow ratio. Beyond the scope of scientific studies, information on the changes in abundance, movement, and distribution of caribou on an Island Group can be provided by Inuit Qaujimajatuqangit.

8.2 ADDITIONAL CRITERIA FOR ASSESSING ISLAND GROUP STATUS

In addition to information on caribou such as population size and cow/calf ratios, there is important information about habitat and land use that should be considered. This can include habitat quality and quantity, predation, and human disturbance that may limit caribou access to parts of their range. Co-management partners can support long-term research and monitoring of these factors that will allow provide greater information for decision making and more effective review into land use permitting processes.

8.2.1 PREDATORS

Predators affect caribou behaviour and mortality. Predator numbers tend to decline as caribou decline but usually there is a delay of one or two years.If other prey species are available, predator numbers may not decline at all. When caribou numbers begin to decrease, the impact of predation may become proportionately greater. Caribou users have requested increased monitoring of predator populations, measurement of predation and the impact of predation on the populations.

8.2.2 ENVIRONMENT AND HABITAT

Better understanding of cumulative effects at the ecosystem level can be obtained through long term research on habitat quality and quantity and impacts of human activities. Co management partners can continue to call for and support such long-term research and monitoring. With improved understanding there is a better opportunity to use regulatory management tools to limit disturbance on caribou.

Community workshops held in Grise Fiord and Resolute indicate that a combination of heavy snow and increased oil exploration and activity (particularly Bent Horn) in the early 1970s created a combined effect that may have impacted caribou more than either would have on their own. Caribou can move in response to changes in local environmental conditions such as increased snow or severe ice events. However at this time the increased activities on the land, including seismic activity, may have disrupted this ability to move. It was this combination of weather and human activity that caused die-offs during this period. This information highlights the importance of improving our understanding of cumulative effects and collection and use of local knowledge.

Some steps to assess habitat conditions for each island group are:

- Develop and monitor key habitat indicators of quality and quantity using remote sensing and ground surveys;
- Monitor trends in climate and weather; and
- Define seasonal and occasional movement patterns.

8.2.3 HUMAN DISTURBANCE

Disturbance of caribou from human activities such as aircraft over-flights and resource development can influence caribou behaviour and energy use, which in turn can affect condition and health. Indirect effects can also include a reduction in quality and quantity of habitat or access to quality habitat. Particularly when caribou numbers are low, human activities have the potential to alter the rate and extent of the decline or length of time it takes the population to recover.

The range of Peary caribou extends over lands that are protected from development and lands where exploration is occurring. Concern about the impacts of non-renewable resource development has increased as changing ice and weather patterns encourage a renewed surge in exploration and potential resource development.

9.0 TOOLS FOR DECISION MAKING

9.1 HOW CARIBOU POPULATIONS CYCLE OVER TIME

Inuit Qaujimajatuqangit and scientific knowledge agree that caribou populations rise and fall over time. The length of the phases varies, particularly the length of time that a population stays at a low level. Scientific evidence, the journals of missionaries and trading post managers, and IQ all suggest that caribou populations go through cycles 30-60 years long. The causes for these population cycles in caribou are not well understood, but likely result from several factors such as habitat quality and quantity, climate, and disease. In addition to population cycling, caribou can also move over time.

Although Peary caribou have existed at higher levels than today, they have never existed at numbers such as the large barren ground herds found to the south. The climate and topography of their range favours smaller groups dispersed over the landscape. These groups move with weather and food availability and are more susceptible to extreme weather events which can cause large die offs.

9.2 WHEN TO TAKE ACTION

Actions to ensure the future of Peary caribou will be determined in part by the number of Peary caribou found in each island group, and whether it is increasing or decreasing. Management decisions will also be influenced by other information from harvesters and research and monitoring programs, such as recruitment, bull-to-cow ratio, body condition and health.

In this management plan there are four levels of island group status and associated management actions. These are colour-coded green, yellow, orange, and red. The island group status provides a trigger for specific management actions.

Green:	The population level is high
Yellow:	The population level is increasing
Orange:	The population level is decreasing
Red:	The population level is low

9.3 USING MONITORING INFORMATION TO MAKE DECISIONS

Accurate and timely information is necessary for making good management decisions. Because the island groups are shared between communities and regions, it is also important that information is collected and shared by all harvesters and managers.

Island group status (e.g. green, yellow, orange or red) will be determined based on information including:

- Estimate of the overall population size of the island group
- Previous estimates to provide a trend (increasing, decreasing, or stable)
- Additional monitoring indicators such as ground based surveys to supplement the interpretation.

It is important to have up-to-date information so ensuring sufficient frequency of research and monitoring effort is very important. Certain monitoring will take place regardless of whether the island group status is green, yellow, orange or red. However, the frequency and intensity of monitoring will vary in response to island group status.

Long-term monitoring of environmental factors, including range quality and quantity, development activity and trends, and disturbances that influence caribou populations are important in understanding changes in caribou health and abundance.
Some of these indicators of population status can be difficult or expensive to measure. In these cases there may be some information available through long-term research programs or methodical collection of IQ. All of this information will be considered by the co management partners.

Working with all stakeholders an ongoing community based ground survey program will be established with the appropriate financial and technical support. This would occur, due to the spatial scale, on a rotating basis so that areas will be monitored at least every two or three years, unless observations of decline trigger more intensive efforts. The ground based surveys will be primarily in areas where regular community harvest occurs. Surveys should be followed with an annual meeting of stakeholders to review the results and recommend management changes if required.

Further changes observed from community monitoring programs (observations of die offs, starvation, population increase or decrease) can trigger:
1) Aerial surveys if declines are considered significant,
2) Increased frequency and coverage of community ground survey if declines are considered less significant but still of concern,
3) Community-based changes in harvest level that would occur within a predetermined upper and lower limit.

9.4 WHAT MANAGEMENT ACTIONS CAN WE TAKE

The NWMB has the responsibility for decision making as the primary instrument of wildlife management under the NLCA. Regional Wildlife Organizations (RWOs) have the authority to allocate harvest among their member HTOs, and in turn the HTOs can regulate their harvesters and allocate their share of a Total Allowable Harvest (TAH). Through regular annual meetings of the stakeholders, consensus on recommended actions can be reached and submitted to the NWMB for decision. Further, HTOs can make decisions to regulate local harvest through seasons, sex selectivity, area restriction, or reduction. These consensus-based recommendations can also be made to government and land use agencies following the general management actions described below.

9.4.1 HARVEST

As an Endangered species under SARA, Peary caribou are automatically protected from harvest, with the exception of Inuit harvest which would require a decision by the NWMB. Any decision of the NWMB should be informed by the consensus based recommendations of the co management partners developed through annual stakeholder meetings or as recommended in this plan. Recommendations can also take the form of harvest composition (e.g. sex selective) or seasonal restrictions or other Non-Quota Limitations (NQLs).

9.4.2 LAND USE ACTIVITIES

Increasing land use activity demands that meaningful input and review be provided into the various permitting process in Nunavut, whether it be the Nunavut Impact Review Board (NIRB), Nunavut Water Board (NWB), or the Nunavut Planning Commission (NPC) land use plan. Effort should be made to ensure capacity is available within all co management agencies to ensure effective participation. The community-based ground surveys will gather valuable information for both HTOs and DOE to effectively participate in these permitting processes. Co management partners can continue to recommend actions to help reduce the negative impacts of exploration and development on caribou. Advice can be given to avoid important caribou seasonal ranges like calving grounds, and how to mitigate disturbance from noise and access.

9.4.3 COMMUNICATION AND EDUCATION

Co management partners can work together to provide active and accessible communication programs, and recommend education programs. This can include different programs and approaches for elders, harvesters and youth to encourage traditional harvesting practices, use of alternate species and increased trade and barter of traditional foods. It can also include work with members of industry including resource developers.

9.4.4 HABITAT

Co management partners can continue to encourage and support increased research and monitoring related to seasonal range use, key habitat indicators, trends in climate and weather, and delineation of calving grounds.

9.5 MANAGEMENT ACTIONS BASED ON STATUS

The type of management action and the degree of management intervention will vary depending on the status of each island group. There are four levels of island group status which are colour-coded green, yellow, orange, and red. The island group status will trigger specific management actions or a change in the frequency of action, as described below:

Green: the population level is high
Management actions include:

- Support harvest
- Provide standard advice on mitigation of the impacts of exploration and development activities to proponents and regulators
- Provide active and accessible communication, and recommend education programs for all

Yellow: the population level is increasing
Management actions include:

- Recommend easing limits on harvest
- Provide standard advice on mitigation of industrial impacts to proponents and regulators
- Provide active and accessible communication and recommend education programs for all

Orange: the population level is decreasing
Management actions include:

- Recommend a TAH
- Recommend a majority-bulls harvest
- Recommend harvest of alternate species and encourage increased trade and barter of traditional foods
- Recommend increased community monitoring
- Provide active and accessible communication and recommend education programs for all

Red: the population level is low
Management Actions include:

- Recommend no harvest
- Work directly with proponents and regulators of exploration and development activities to advise on mitigation measures
- Recommend harvest of alternate species and meat replacement programs, and encourage increased trade and barter of traditional foods.
- Recommend increased enforcement including increased use of community monitors.
- Provide active and accessible communication and recommend education programs for all.

9.6 PROCESS TO MAKE DECISIONS

The co management partners shall meet annually to discuss results of all recent research and monitoring efforts which may include harvest reporting, caribou health monitoring, and ground or aerial surveys. The purpose of this annual meeting is to review information and reach consensus-based recommendations, if required, for submission to the NWMB. Action may also be taken at the local level by HTOs based on the information reviewed.

9.6.1 GUIDING DOCUMENTS: ACTION PLAN

This Management Plan is supported by an Action Plan which outlines the management actions to be taken and how they will be implemented. Based in large part on the island group status, the Action Plan will outline specific management actions and how they will be implemented, by whom, and within what timeframe. Funding for the management action will be discussed by the co management partners. A third document, the GN DoE report "*Recent trends and abundance of Peary Caribou (Rangifer tarandus pearyi) and Muskoxen (Ovibos moschatus) in the Canadian Arctic Archipelago, Nunavut,"* will provide the technical baseline for decision making. Inuit Qaujimajatuqangit will be provided by the participating HTOs in the Stakeholder Working Group (See Appendix B). New information will be reviewed as it becomes available ensuring decisions are based on the most up to date scientific and local knowledge.

Implementation of the Action Plan is cooperative, and ongoing community input and support will help to develop and implement management actions. Each co management partner will be responsible for approving the Action Plan for its implementation. The effectiveness of the Action Plan will be reviewed annually.

9.6.2 STAKHOLDER MEETINGS

Stakeholders will meet annually after survey work has been completed and annual data summarized to review all new information and implementation of the Action Plan. It will be presented with the best available IQ and scientific knowledge and community based monitoring information. The Action Plan will be reviewed, and possibly updated, at the same time that the stakeholders review the current status of the Island Groups. Although normally revised only following an aerial survey, an Island Group's status or Action Plan may be revised more frequently if, for example, there has been some extreme change observed through community-based ground surveys.

9.6.3 ALLOCATION OF HARVEST

If a Total Allowable Harvest (TAH) is recommended it shall be determined and allocated in accordance with processes described in the NLCA.

10.0 COMMUNICATION BETWEEN STAKEHOLDERS AND WITH USERS

Communication is the responsibility of all parties engaged in wildlife management. Knowledge must flow both ways - between local knowledge holders and management agencies. There will be varied communication and education techniques used depending on the message and the intended audience. They may include local radio programs, visits to schools, posters or presentations, public meetings, and on-the-land gatherings.

Stakeholders will meet on an annual basis to discuss survey results and island group status and to take appropriate actions when needed. Further details on the annual meeting will be provided in the Action Plan.

The information communicated to the public will include island group status; any voluntary or management limits on harvesting; what is being monitored and why; the results of the monitoring programs; why harvesting mostly bulls rather than cows may be preferable; and education of youth in traditional hunting practices.

11.0 UPDATING THE MANAGEMENT PLAN

The Plan will first be reviewed after seven years (i.e. 2020) and at ten-year intervals thereafter. Any party may request a review, at any time, through a letter to the other signatories.

12.0 SIGNATORIES TO THE PLAN

Iviq Hunters and Trappers Association
Resolute Bay Hunters and Trappers Association
Ikajutit Hunters and Trappers Organization
Spence Bay Hunters and Trappers Organization
Ekaluktutiak Hunters and Trappers Organization
Kurairojuark Hunters and Trappers Organization
Gjoa Haven Hunters and Trappers Organization
Nunavut Tunngavik Inc., Wildlife Department
Qikiqtaalik Wildlife Board
Kitikmeot Hunters and Trappers Association
Nunavut Department of Environment, Wildlife Management Division

APPENDICES

APPENDIX A
RECOMMENDATIONS AND TOTAL ALLOWABLE HARVEST BY ISLAND GROUP

General Recommendations

It is recommended to establish management units based on the proposed nine Island Groups. This includes six as presented in "*Recent trends and abundance of Peary Caribou (Rangifer tarandus pearyi) and Muskoxen (Ovibos moschatus) in the Canadian Arctic Archipelago, Nunavut"*, and three additional management units in the Kitikmeot region. This will facilitate future collection of consistent data for comparison and management decisions. However there is a need for provisions within the management plans to allow for finer scale management in response to changes in Peary caribou numbers, such as those observed through community observations or by additional survey work where warranted. In particular, the HTOs should control local harvesting within an agreed upon herd size, thus allowing for management at the community level.

Working with all stakeholders, an ongoing community-based ground survey program should be established with the appropriate financial and technical support. This would occur, due to the spatial scale, on a rotating basis so that areas will be monitored at least every two or three years, unless observations of decline trigger more intensive efforts. The ground based surveys would be primarily in areas other than where regular community harvest occurs as normal harvest areas will be monitored through harvest reporting. Surveys should be followed with an annual meeting of stakeholders to review the results and recommend management changes where required.

Observed changes from the community monitoring program (observations of die-offs, starvation, population increase or decrease) would trigger:
1) Potential aerial surveys if declines are considered significant,
2) Increased frequency and coverage of community ground survey if declines are considered less significant but still noteworthy,
3) Community based changes in harvest level that would occur within a predetermined upper and lower limit.

Predominately all island groups have declined and remain at low density with the exception of Bathurst and Melville, which are both showing signs of recovery. Caution must be exercised to prevent local extirpations. As harvest restrictions may only be to the level to address a valid conservation concern, there is currently a strong argument to maintain harvest restrictions for several island groups.

Harvest restrictions must allow communities to have input and control over how harvest will be allocated by allowing flexibility for HTO's to respond to changes in Peary caribou numbers that they observe and monitor through community-based ground surveys. These surveys may trigger more extensive ground or aerial surveys in the case of observed declines. An annual survey/meeting structure will allow for management action at the community level to occur in a timely and responsive manner.

Harvest reporting and sample collection is critical information for management. Each harvest should be reported through a hunter report. Information collected on the reports should include date, location (Latitude and Longitude), hunters name, tag number, sex, approximate age, and size of group harvested from. A Peary caribou health monitoring program should be established and sample kits provided to the hunters. The information provided will further our understanding of survival rates, diet, health, and space use. There is also a need to indentify population boundaries to better manage Peary caribou.

With the current low numbers of Peary caribou in some of the island groups it is suggested to consider male sex selective harvests to help conserve females in the effort to reduce impacts and promote potential recovery.

Specific Island group TAH recommendations

Ellesmere Island Group (PC-01)
It is recommended to maintain existing harvest levels with a TAH of 45- 50 (allowing community to adjust as required within that amount). This harvest rate may impact caribou on south Ellesmere negatively; to alleviate this effect there should be encouragement and support to increase harvest on north Ellesmere. Harvest reporting and sample submission for genetics will assist greatly in understanding the dynamics of Peary caribou genetics and movement.

Axel Heiburg Group (PC-02)
No harvest occurs here and the population is abundant, therefore no TAH is required. Should harvest start to occur here, as determined through harvest reporting, the stakeholder working group should discuss potential harvest limits. Recommend no harvest by non- Inuit.

Ringnes Islands Group (PC-03)
No harvesting occurs here, therefore no TAH is required. Should harvest start to occur here, as determined through harvest reporting, the stakeholder working group should discuss potential harvest limits. Recommend no harvest by non- Inuit.

Devon Island Group (PC-04)
With only 17 animals observed in 2008 and no abundance estimate, this group should be under a moratorium until such time as an increase is observed through community-based ground surveys. Harvest reporting and sample submission for genetics will assist greatly in understanding the dynamics of Peary caribou genetics and movement.

Bathurst Island Group (PC-05)
Managing for recovery, a conservative TAH based on the preliminary results of the 2013 estimate of 1200 caribou would be 36 caribou (a 3% harvest rate). Although scientific knowledge and local knowledge agree that there is recovery in this group caution is warranted in order to not jeopardize that recovery. Harvest reporting and sample submission for genetics will assist greatly in understanding the dynamics of Peary caribou genetics and movement.

Prince of Wales Group (PC-06)
With too few caribou to support harvesting at current numbers, this group should be under a moratorium until such time as an increase is observed through community based monitoring. Survey frequency should be increase to monitor sign of recovery. Harvest reporting and sample submission for genetics will assist greatly in understanding the dynamics of Peary caribou genetics and movement.

Victoria Island Group (PC-07)
As there is no targeted harvest in the area and only an occasional caribou is taken opportunistically, no TAH is required. Harvest reporting and sample submission for genetics will assist greatly in understanding the dynamics of Peary caribou genetics and movement. Should harvest reporting indicate an increase over the current rate of sporadic opportunistic harvest the stakeholder working group should discuss potential harvest limits. Recommend no harvest by non- Inuit.

Boothia Peninsula Group (PC-08)
As there is no targeted harvest in the area, and only an occasional caribou is taken opportunistically, no TAH is required. Harvest reporting and sample submission for genetics will assist greatly in understanding the dynamics of Peary caribou genetics and movement. Should harvest reporting indicate an increase over the current occasional harvest, the stakeholder working group should discuss potential harvest limits. Recommend no harvest by non- Inuit.

King William Island Group (PC-10)
As there is no targeted harvest in the area and only an occasional caribou is taken opportunistically, no TAH is required. Harvest reporting and sample submission for genetics will assist greatly in understanding the dynamics of Peary caribou genetics and movement. Should harvest reporting indicate an increase over the current rate of

sporadic opportunistic harvest, the stakeholder working group should discuss potential harvest limits. Recommend no harvest by non- Inuit.

APPENDIX B
Recommended stakeholder working group for annual meetings

The stakeholder working group consists of the Chairpersons (and/or their alternates) of:
Iviq Hunters and Trappers Association
Resolute Bay Hunters and Trappers Association
Ikajutit Hunters and Trappers Organization
Spence Bay Hunters and Trappers Organization
Ekaluktutiak Hunters and Trappers Organization
Kurairojuark Hunters and Trappers Organization
Gjoa Haven Hunters and Trappers Organization
Qikiktaalik Wildlife Board
Kitikmeot Hunters and Trappers Association
And staff from the:

- Nunavut Wildlife Management Board
- Nunavut Tunngavik Inc.
- GN DoE, Regional Biologists and Regional Managers

Additional experts, either scientists or qaujimanilik, will be invited as required for support.

APPENDIX C
ACTION PLAN

The following action plan supports the implementation of the management plan. It lists essential tasks that the co management partners recommend for the ongoing monitoring and management of Peary caribou. The actions support and emphasize programs and projects that will be invaluable in decision making and recommends what needs to be done to achieve the goals of the management plan.

The Action Plan assigns responsibilities for conducting programs and projects and covers the following categories:

1. Aerial survey program
2. Community-based ground survey program
3. Establishing harvest reporting and caribou health monitoring programs
4. NWMB Decision on Regulatory Changes
5. Annual Stakeholders meeting

1. Establishing an Aerial Survey Program

Background:
Aerial surveys are expensive and require significant logistic preparation. An aerial survey will be used in two fashions, as part of a cyclic program over the long-term to monitor population size and trend as well as other indices such cow/calf ratio and bull/cow ratio.

Problem Statement:
GN DoE has limited funds available for research of all species under its mandate for all of Nunavut. Regular surveys are expensive both in terms of financial and human resources. Co management partners need to agree on a monitoring cycle that is financially viable and still allow for surveys to occur in emergent situations when ground-based surveys observe significant die-offs or declines.

Objectives:
1. Seek support from NWMB for Nunavut Wildlife Research Trust (NWRT) funding for a long term survey as well as seek out other funding sources, such as INAC, and Environment Canada under federal funding programs for species at risk.
2. Stakeholders will agree upon an aerial survey schedule and thresholds that will trigger aerial surveys in emergent situations.

Methods:

1. GN DoE proposal to NWMB for NWRT with inventory schedule and maximum three year term request.
2. GN DoE to make formal requests to other third parties, via letter, for additional financial support for monitoring programs

Schedule:
Upon acceptance of Management Plan – GN DoE to seek support from third parties
January 2015 – GN DoE proposal to NWMB
January 2015 – Letter from co management partners to NWMB supporting DoE proposal

Evaluation: Ongoing at annual Stakeholder meeting

Lead Role: GN DoE

Support Role: HTOs, QWB

2. Establishing a Community-Based Ground Survey Program

Ground surveys are expensive and require significant logistic preparation. Community-based ground surveys will be used as part of a cyclic program over the long term to monitor population size and trend as well as other indices such as cow/calf ratio and bull/cow ratio.

Problem Statement:
HTOs have limited capacity to conduct monitoring programs. Regular surveys are expensive both in terms of financial and human resources. Co management partners need to agree on a monitoring cycle that is financially viable and has the financial and technical support to succeed.

Objectives:

1. Seek commitment from NWMB for HTO proposals to the Community Studies Fund for support of community based ground surveys on an annual and cyclic basis. HTOs to seek out other sources such as Habitat Stewardship Program and Aboriginal Fund for Species At Risk.
2. Stakeholders will agree upon a ground survey schedule and thresholds that will trigger additional ground surveys such as observed die offs and extreme weather events.

Methods:
1. HTOs submit proposal to NWMB for Studies Fund.
2. Co management partners to provide technical, logistic and financial support.

Schedule:
Upon acceptance of Management Plan – HTOs to seek support from third parties
January 2015 – HTO proposals to NWMB
January 2015 – Letter from co management partners to NWMB supporting HTOs proposals.

Evaluation: Ongoing at annual Stakeholder meeting

Lead Role: Each HTO that wishes to participate in the ground-based survey

Support Role: QWB, NIWS, GN DoE

3. Establishing Harvest Reporting and Caribou Health Monitoring Programs

Background:
Harvest monitoring and caribou health monitoring are identified in the Plan as important factors for management decisions. Collection of harvest data and condition and health data are means of Inuit involvement at the individual level

Problem Statement:
Currently harvest monitoring is not official or well-organized. Efforts have been made at establishing a general caribou health monitoring program, but this needs to be expanded to Peary caribou.

Objectives:
1. Get commitment from stakeholders to implement a harvest reporting program.
2. Harvest reporting will include sample submission that will be utilized in the health and condition monitoring program.

Methods:
1. NIWS, NTI and GN DOE to assist QWB, KRWB in preparing Management Plan
2. NTI and GN DOE to provide letters of support

Schedule:
Upon acceptance of plan - Determine harvest and sample collection needs and design reporting form

Evaluation: Annually at stakeholder meeting

Lead Role:
QWB/ KRWB / HTOs/ GN DOE / NTI Wildlife

4. NWMB Decision on acceptance of the Plan and Regulatory Changes

Background:
The co management partners are responsible for the protection, conservation, and management of Peary caribou in a sustainable manner. However the NWMB has the mandate to make decisions under the NLCA with regards to changes in TAH and approval of management plans. GN DoE has the responsibility to develop regulations under the *Wildlife Act*. This Plan will serve as the basis for development of Regulations for the management of Peary caribou under the *Wildlife Act*.

Problem Statement:
The NWMB must approve the proposed management plan, action plan and recommended changes to the regulations. The plan is the result of consultation with the co-management partners.

Objectives:
The co management partners have developed the Management Plan and Action Plan in regard to implementing changes in the management of Peary caribou. The objective is to have the plan approved by NWMB so that the plan can be implemented and regulatory changes can be implemented.

Methods:
1. DoE will submit the draft plan to the NWMB for decision.

Schedule:
Upon completion of an acceptable draft plan submit the draft and briefing note to NWMB for first available regular meeting
January 2014 –submit briefing note and supporting documents to NWMB

Lead Role: GN DOE

5. Annual Stakeholder Meeting

Background:
The co-management partners need to ensure that all information gathered annually on Peary caribou, such as harvest and survey results, are shared fully and reviewed

collaboratively for the purposes of taking action when needed. The action plan shall undergo annual review at this meeting and be amended as required.

Problem Statement:
Scheduling and financing meetings in the remote communities of Nunavut is a challenge. Support is needed by all co management partners to ensure that the parties can meet and discuss, by whatever means available, the current information available.

Objectives:
To ensure that participants are adequately supported to effectively participate in the annual stakeholder meeting.

Methods:
1. Co management partners will seek to plan and budget the adequate resources for their respective participants to effectively participate in the annual meeting.
2. Where possible the participants may already be in joint attendance at other meetings (i.e. NWMB) and this should be capitalized upon.

Schedule:
The annual general meeting shall occur at a mutually convenient time that allows for the data collected in the previous year to be analyzed and summarized for use by the co management partners.

Evaluation: Annual stakeholder meeting

Lead Role: QWB/KRWB / GN DOE / NTI Wildlife/ HTOs

GN High Arctic Region Consultation Report

2016

This document contains consultations with regards to the Government of Nunavut, Department of Environment, Wildlife Management, Research Section –High Arctic Region Biologist

Table of Contents

1.0 Peary Caribou Federal Recovery Strategy Consultations

Kitikmeot Region: February 22-25, 2016
Qikiqtani Region: February 29 and March 1, 2016
Inuvialuit Settlement Region: March 8-10, 2016

Representatives from Environment and Climate Change Canada (ECCC) travelled to communities in February and March 2016 to present the draft *Recovery Strategy for the Peary Caribou in Canada*. Where possible, representatives from the Government of Nunavut (GN), the Government of the NWT (GNWT) and Parks Canada were present to answer questions regarding their respective jurisdictions or to provide insight on Peary caribou biology, surveys, management, harvest and information on other arctic species such as muskoxen. The Hunter and Trapper Organizations/Committees/Associations in nine communities as well as community members participated in these meetings.

Peary caribou were federally listed under the *Species at Risk Act* as Endangered in 2011. A recovery strategy must be written to set out the national plan of how to ensure the survival of Peary caribou into the future. A federal recovery strategy is due to be posted on the Species at Risk Public Registry for the 60-day public comment period by the end of March 2017. ECCC presented key sections of the draft recovery strategy and gathered feedback from each community. The following is a summary of the major concerns / topics of discussion.

See 1.9 Community's attendee lists for the list of attendees for each community.

Main Issue or Concern

1.1 Description, Important areas & movement routes, Range

Gjoa Haven, Taloyoak, Resolute Bay

Some communities spoke about the need for caribou to migrate between islands or to access large areas of landscape (to mate, give birth, feed, and escape bad weather conditions). For example, in fall when food is getting low, the caribou would be found walking along the shore trying to get across to another island. It was noted that they sometimes die trying to cross between islands if the ice is too thin or there is no ice for them to get across (Gjoa Haven).

Taloyoak

Question about the area of the range of Peary caribou? → *ECCC: The extent of occurrence of Peary caribou is estimated a*s 1.9 million km2

Paulatuk

Wanted the long "important area" area south of their community (previously identified at the Technical meeting as an Important areas) to be removed, it is not an important breeding area.
→ *Area was removed from figure 2 (see appendix 2 of this document)*

Paulatuk

Caribou on Baffin Island is also Peary caribou. Baffin should then be included in the range.
→ *GNWT: to confirm what subspecies occurs on Baffin Island*

Ulukhaktok

Identified 3 areas where Peary Caribou are seen: Wynniatt Bay, Shaler Mountains (wintering area), and Hadley Bay

1.2 Population Sizes and Trends

Sachs Harbour, Gjoa Haven, Kugaaruk
Recognized the importance and the difficulties to survey Peary caribou: hard to see in the winter time, they mix with Dolphin and Union caribou and other caribou in the southern part of their range, and surveys are very expensive.
Sachs Harbour, Ulukhaktok
Concerns about surveys being too far apart in years and not covering the whole caribou range. [Explained that surveys are very expensive, so GNWT try to survey group of islands at the same time, and prioritize areas where there are communities as they harvest caribou.]
Sachs Harbour, Kugaaruk
Showed interest in knowing how many caribou we need so that populations don't go extinct or to have a healthy population. [Explained that we don't have enough information, have part of the cycle but do not know what the safe range is. GNWT try to survey more often.]
Gjoa Haven
Community members stated that they were not very concerned about Peary caribou because Peary caribou are hardly ever seen there; they are mainly concerned about the Barren-ground caribou.

1.2.1 Have Peary Caribou been increasing or decreasing in your area over the past: 10 years / 30 years?

Sachs Harbour
Notably increasing compared to 5 years ago. Seems to be linked to the decreasing Muskox population.
Ulukhaktok
30 years period: decreased.
Paulatuk
See small herds in fall, very few herds. They are not migrating anymore. Don't seem to expand.
Cambridge Bay
Very few Peary caribou have been sighted close by. Even 30 years ago, used to go many miles north before finding Peary caribou. Had a lot of caribou around in the 80s, it has been way down in the last few years.
Gjoa Haven
We should not expect a big expansion of Peary Caribou, population level was always low.
Taloyoak
Saw them in the 80s-early 90s and used to eat them in the mid-80s early 90s but not since then, would not know if they are increasing, mainly because nobody goes there anymore. Started to see a decline in the 80s.
Kugaaruk
Never had large populations. Catch a few in the late 80s but now hardly see them.
Resolute Bay
In the last 4-5 years, seen an increase especially on Bathurst Island (Allison Inlet), but also in Grise Fiord area and on Cornwallis Island. Have seen females with two calves.

1.2.2 Are the changes in population most likely from births/deaths or from Peary caribou moving from one area to another?

No comments.

1.3 Threats to Peary Caribou

1.3.1 Climate Change

Cambridge
Bay Noticing that the summers are warmer; so flies/mosquitoes are now really bad. New types of insects can now be seen.
Sachs Harbour
Have observed new types of mushrooms, some are poisonous for the wildlife (caribou/muskox). Abundance of mushrooms has increased last summer. Have observed land erosion occurring after melting.
Sachs Harbour, Cambridge Bay
Concerns about ecological shifts: advantages for predators (hares still white when no more snow on the ground, grizzly bear's hibernation is shorter.)
Sachs Harbour
Increased temperature might have a positive impact on vegetation, but might not be food that caribou eat/prefer as shrubs are expected to increase.

1.3.2 Marine Traffic

Ulukhaktok, Cambridge Bay, Kugaaruk
More ships of different types (cargo, cruise ship, sail boat, coast guard, etc.) are going through the ocean, opening the water longer than it normally would be. [Need to have the migration routes identified and then work with other governments/jurisdictions to mitigate shipping impacts.]
Ulukhaktok
Increased marine traffic will bring more pollution/contaminant in the north.
Cambridge Bay
Working on preventing ships going through NW Passage and nearby areas. Asking for no sailing by the last week of October for the safety of hunters and caribou.
Was raised that the Elders Committee with the DoE (GN) notified the Minister of Environment that when the ice started freezing no ships should go through.

1.3.3 Parasites and Disease

Paulatuk
Concerns about caribou disease.
Sachs Harbour, Ulukhaktok
Parasites and diseases should be higher in the list, linked with interactions with muskox and migratory birds. Many concerns expressed about the big die-off of muskox recently; parasites and diseases confirmed in other caribou (Woodland and Barren-Ground).

1.3.4 Resource Extraction

Sachs Harbour, Taloyoak
Concerns about resource extraction activities, especially near or at calving grounds.
Sachs Harbour
gave an example where calving areas were identified by the community as conservation areas where the company should not go, but the company did work there anyways.
Ulukhaktok

Concerns about industries and exploration activities pushing wolves and other predators north.
Grise Fiord, Resolute Bay
Concerns that if many mining projects are approved or there is a greater interest in mining, Peary Caribou may go back to being Endangered. Concerns about noise pollution

1.4 Competition / Predation

1.4.1 Muskox

Ulukhaktok, Gjoa Haven, Taloyoak
Concerns about the increasing population of muskoxen. Muskox is moving the caribou off. Often mentioned that caribou avoid muskox, they do not get along (competition for forage, strong smell).
Taloyoak
especially concerned about a calving ground at PoW/Boothia peninsula; used to find a good population of caribou and hardly any muskox. Ancestors say the caribou move away because muskoxen eat the same thing.

1.4.2 Wolves

Paulatuk, Ulukhaktok, Sachs Harbour (public only, not the SHHTC), Cambridge Bay, Gjoa Haven, Taloyoak, Resolute Bay
Communities expressed great concerns about the high and increasing number of predators – mainly wolves – on Peary caribou. Wolves were seen in many communities as becoming a huge problem for caribou
Cambridge Bay
Wolves are more of a concern than Grizzly bears.
Cambridge Bay
Have seen wolves chasing caribou out on the ocean or hunting caribou on the sea ice with still open or partly frozen water. Communities are seeing changes to wolf pack structure. Cambridge Bay noted that wolf packs were getting bigger, and the wolves were healthy and brave. However in Sachs Harbour (where caribou numbers were noted to be increasing) wolves were observed to be thin and packs getting smaller.

1.4.3 Grizzly bears & Wolverines

Sachs Harbour, Cambridge Bay
Concerns about the high/increasing numbers of grizzly bears and the impacts on caribou.
Cambridge Bay
Seeing grizzly bears emerging earlier from their dens, sometimes as early as the first week of April, and returning to their dens for hibernation later in the season.
Cambridge Bay
Wolverine numbers are increasing

1.4.4 Human Disturbance

Ulukhaktok, Sachs Harbour, Cambridge Bay, Taloyoak, Kugaaruk
Concerns about the increasing activities/numbers of helicopters, planes, snowmobiles, drones and their impacts on caribou.
- Noise was the main concern among the communities (increasing in intensity and frequency)

- Minimum height
- Timing of flight (calving season, hunting season-for subsistence)
- Caribou accumulate less fat because often in a flee situation

Cambridge Bay

Flight guidelines are given to the industry/pilot and best management practices have to be followed, but it seems that it is not always followed. Should be reported to GNWT.

Cambridge Bay

Concerns about sensory disturbance associated with military exercises during critical life stages for Peary caribou.

Gjoa Haven

A lot of people get out on the land when it gets warmer: scientists, explorers, etc. All these activities are a major disturbance for caribou and make them move away. One community member suggested that stopping federal government researches or mining exploration for a year might help and make a difference.

Paulatuk

Someone was interested in knowing the proportional contributing impacts of different sectors: tourism, military, research… [Explained it is only the global impact in the recovery strategy but specific contribution or locations could be addressed in an Action Plan.]

Sachs Harbour

An Elder expressed concerns about the use of quads and snowmobiles by the community and the impacts on caribou (scare them)

Resolute Bay

Concerns about the increasing activities in the next few years in the new Park on Bathurst. Community should identify critical area (calving areas, migrating routes) to minimize disturbance.→ Will be addressed in a Park Management Plan with Parks Canada

1.4.5 Harvesting

Paulatuk

Not a threat for now, but in the southern range of Peary caribou, where they mix with other caribou (ex. Bluenose), it could become a threat if hunting resumes for herds currently under restrictions. Hunting pressure could increase on Peary and Dolphin and Union caribou.

Sachs Harbour

Quotas are not respected. HTC by-laws are not respected neither enforced. Overharvesting is a big concern/threat for the Sachs Harbor HTC (illegal harvesting, not reporting captures).

1.4.6 Pollution and Contaminants

Sachs Harbour, Paulatuk, Cambridge Bay, Kugaaruk, Resolute Bay

Contaminants left over on sites are seen as a threat as well as the equipment and fuel.

Paulatuk, Cambridge Bay, Resolute Bay

Identifying and cleaning up contaminated sites was identified as a high priority.

Paulatuk, Sachs Harbour, Ulukhaktok, Cambridge Bay

Many communities noted smoke and dust from forest fires in the NWT or surrounding areas, could have negative effects on wildlife including Peary caribou.

Kugaaruk

It had been specified that air pollution was mostly man-made.

1.4.7 Are there any threats that exist in your region that we have not identified? Which threats stand out to you as having the most impact on Peary caribou in your area?

No comments.

1.4.8 Do you agree with the order of the magnitude of the threats?

Ulukhaktok, Cambridge Bay, Gjoa Haven, Taloyoak, Resolute Bay
Although predation (mainly wolves) is ranked as a low threat across the entire range of Peary caribou, these communities rank predation as a high threat in their area due to increasing numbers.
Cambridge Bay, Gjoa Haven, Taloyoak and Resolute Bay
identified wolves as the main threat in their region.
Taloyoak
Muskoxen and wolves are the biggest threats. Caribou started to decline when muskoxen population increased.
Taloyoak
In summer time, starting to witness caribou trying to cross in the ocean in the open water, usually would not witness this. These caribou cannot cross the open water, they froze and die.
Cambridge Bay
A lot of Peary caribou may drown while migrating. Ulukhaktok Already seeing caribou drowning because of shipping or thin ice.

Sachs Harbour, Ulukhaktok
Parasites and diseases should be higher in the list, linked with interactions with muskox or migratory birds.

1.5 Population and Distribution Objectives

Cambridge Bay
Stressed the importance of recognizing the natural cycle of caribou, that fluctuation is natural and that die-offs occur periodically. [The natural limits (upper and lower population level or safe range) have not yet been identified because more data is needed.]

1.6 Critical Habitat and Knowledge Assessment

Paulatuk, Cambridge Bay, Grise Fiord
Community members discussed reasons for needing such large areas of critical habitat. These reasons brought up included that caribou use a wide range of habitats and have unpredictable migration routes, and thus need access to large areas of landscape.
Sachs Harbour, Paulatuk, Grise Fiord
Discussed that once critical habitat is identified in the recovery strategy and posted as final, Environmental Assessments have to consider Peary Caribou habitat in their evaluation. This means development is possible in the future but consideration will be given to the caribou in projects that will be going on in critical habitat.
Sachs Harbour
One calving ground (Community Conservation Plan) at the southern tip of Banks Island might not be all identified as critical habitat. → *GNWT: to confirm* Concerns on how critical habitat will impact their local activities like the establishment of cabins.
Sachs Harbour, Taloyoak

Need to take care/protect the habitat and the calving areas. Sachs Harbour had concerns about effectively protecting sensitive areas identified in the Community Conservation Plan, on a long-term basis.
Cambridge Bay
Had a question about having a plan to identify Critical habitat on the lower hashed out area (critical habitat not yet identified). [ECCC will work with territorial governments to determine how habitat will be identified.]

Cambridge Bay
Beneficiaries working at Alert should be contacted to get information from them on caribou distribution on the northern tip of Ellesmere Island.
Grise Fiord
Corrections to the areas of critical ice habitat in the area of Cardigan Str and Norwegian Bay were pointed out. → *These corrections have been made to the Figure 4 (see **1.10 Revised maps** of this document)*

Grise Fiord
Axel Heiberg and Ellesmere are seen as potential locations for future coalmines.

1.7 Strategic Direction for Recovery

Ulukhaktok
Would like to work with Nunavut so they can work in the same direction for the caribou.
Grise Fiord
Had been discussed that once the Recovery Strategy is final it will serve as a high-level guidance document for regional plans as the Nunavut Land Use Plan (LUP). Identified critical habitat in the Recovery Strategy could be one of the ways to set aside Protected Areas as part of the LUP, or to protect critical habitat outside of Protected Areas. As the Recovery Strategy is not yet final, community members should stressed the important of this habitat to QIA/Planning Commission.

1.7.1 Monitoring and research

Ulukhaktok, Kugaaruk
Need to know more about caribou crossing (when and where) and movements on the ice.
Resolute Bay
Need to identify areas of calving routes in summer. Some areas are used year after year.
Cambridge Bay
Monitoring of vessel traffic through the range of Peary caribou for the routes and timing of travel, and type of ships.
Sachs Harbour, Ulukhaktok
Need was expressed that more research is needed on relationships between caribou, muskox and wolf.
Sachs Harbour
HTO receives a lot of demand from university researchers. They now want to prioritize research activities on their territory.
Ulukhaktok
Need to have more studies on grizzly bear.

Sachs Harbour, Ulukhaktok
Surveys are very important. Need for new survey technology: less intrusive and less expensive (by snowmobile, drones,…). More money should be invested into communities to do ground survey with the biologists (by snowmobile with local hunters) – would also be an opportunity to work collaboratively.
Ulukhaktok
Research needed on parasites and diseases, linked with interactions with muskox or migratory birds.
Ulukhaktok
Need more studies on vegetation: eg caribou diet, grazing impact, recovery after grazing, plant growth
Resolute Bay
Showed interests in monitoring the caribou population. This type of work is called community-based monitoring programs (CBMP).

1.7.2 Habitat and species conservation and management

Paulatuk, Ulukhaktok, Cambridge Bay, Taloyoak, Kugaaruk, Resolute Bay
Since wolves have a great impact on caribou, something needs to be done about wolves. Communities suggested that the wolf or predator (wolves + grizzly bears) populations should be controlled. This is something they can control and that had been done in the past for wolves. [There is a lot of controversy about culling wolves; we need to better understand potential impacts of wolf management. GNWT might be considering it; they currently have a wolf program where skulls are collected; there is a fur bonus.]
Paulatuk, Cambridge Bay, Resolute Bay
Concerns about cleaning-up old exploitation sites. Sites identified as critical habitat and containing waste/contaminants (from past researches, extraction sites, military or Ranger exercises…) should be prioritized and cleaned-up. Cleaning up contaminated sites should be done by professionals with the proper equipment.

1.7.3 Education and awareness, stewardships and partnerships

Cambridge Bay
Promote education among the mining and marine sectors (sensitive areas and seasons). Promote education amongst harvesters.
Kugaaruk
Educate young generation (eg don't waste the meat).
Ulukhaktok
Educating young people to identify the different caribou while hunting. Transfer knowledge to the younger people so they can learn where are the important areas to hunt and the migration routes. Young people will be able to hunt for their subsistence when hunting will resume, it is their future.
Resolute Bay
Are developing a program aiming at transferring knowledge to young people on where and how to hunt caribou, but lack of money is big issue. For the Recovery Strategy, would like to see something like: ''Promote education amongst youth or young harvesters" or "Better practices for youth". Should also replace the word 'harvesters' with 'hunters'. Harvesting could also mean berry picking or to people who use things from the land for use, not just animals but plants.

1.7.4 Law and Policy

Ulukhaktok, Cambridge Bay

Some communities recommended higher restrictions for flights (minimum height, specific for calving season) or that the existing rules are enforced. The community of Ulukhaktok doesn't allow flying around calving season.

Paulatok, Kugaaruk

Some communities recommended higher restrictions for marine traffic (controlling timing of ship traffic). Migration routes on sea ice should be protected.

Taloyoak

Resource extraction or exploration activities should be prohibited at/near sensitive areas.

Sachs Harbour

Enforcement on quota should be stronger.

Ulukhaktok

Hunters should have their tag before they go out hunting, like it is currently done for polar bear.

1.7.5 Does your organization have any comment on the broad strategies and general approaches? Are there other things that should be done?

Grise Fiord

In many aspects, Inuit hunters are already practicing the recovery of the caribou. Discussion that imposing laws and quotas may actually increase hunting. Respect for what the community says about how to manage the caribou is important to the success of the recovery effort.

1.8 Other Comments

Gjoa Haven

Had a suggestion to do one-on-one interviews to gather more information in the future.

Cambridge Bay

Breeding between Peary and Barren-ground caribou has started. Peary may be migrating with Dolphin and Union to mainland.

Ulukhaktok

Importance of Elder knowledge on caribou hunting sites since community members cannot travel long distance anymore, too expensive.

Ulukhaktok, Cambridge Bay

Concerns from communities passing information over to the people at the federal level:

- Seem to pass it over often;
- Expect (would like) to receive feedback from them (e.g. noticing wolves, caribou decline);
- Governments take too much time to take actions and save a species.

Taloyoak

Need expressed that biologist should come regularly to their meetings on caribou management; to address wildlife issues, share information. Hunters should go with biologist when they are going to count caribou in the field (aerial survey). Getting funding for surveys is an issue for communities.

Paulatuk

Concerns about NWMB if they want more time to accept the recovery strategy, this will delay the process. Stressed that co-management is essential, cooperation is needed. [Explained that Nunavut, co-management partners and stakeholders were involved in the process from the start in order to address the concerns at the beginning and be refined through the process.]

Communities expressed great hope in this Recovery Strategy to help Peary caribou populations.

1.9 Community's attendee lists

1.9.1 Kitikmeot Region: February 22-25, 2016

Ekaluktutiak HTA Meeting
Location: Cambridge Bay, Nunavut
Date: February 22, 2016
Attendees: Mark Haongak – HTO Director, Peter Evalik – Secretary – Treasurer, Bobby Greenley – Chairperson, Jimmy Haniliak – Director, John Lyall – Director, Howard Greenley – Director, Dennis Kaomayok – Hunter, Devon Oniak – Hunter, Chad McCallum – Hunter, Sam Anghiatok Sr. – Elder, Jimmy Maniyoena – Elder, Roland Eminyak – Hunter, William Pawialak – Hunter, Dawn Andrews – Environment and Climate Change Canada (ECCC), Canadian Wildlife Service, Yellowknife, Amy Ganton – ECCC, Canadian Wildlife Service, Yellowknife

Community of Cambridge Bay Public Meeting
Location: Cambridge Bay, Nunavut
Date: February 22, 2016
Attendees: Jimmy Haniliak – EHTO Director, Ruby Haniliak, Jack Ekpakohk, Nigeonak – Kitikmeot Corp., James Ekpakohak, Dawn Andrews – ECCC, Canadian Wildlife Service, Yellowknife, Amy Ganton – ECCC, Canadian Wildlife Service, Yellowknife

Gjoa Haven HTA Meeting
Location: Gjoa Haven, Nunavut
Date: February 23, 2016
Attendees: Molly Halluqtaluk – HTO Manager, David Qirqqut – Hunter, Jacob Keanik – HTO, Ralph Porter SR – Elder, Paul Ikaullaq – Translator, Rebeccal Ikualluq – Search and Rescue Org., Marvin Aqittuq – HTO, Jimmy Qirqqut – Elder, Kenneth Puqiqrak – HTO, Dawn Andrews – ECCC, Canadian Wildlife Service, Yellowknife, Amy Ganton – ECCC, Canadian Wildlife Service, Yellowknife

Spence Bay HTA Meeting
Location: Taloyoak, Nunavut
Date: February 24, 2016
Attendees: Jimmy Oleekatalik – HTO Manager, Anaoyoak Alookee – Secretary Treasurer, Sam Tuluriazik – Chairperson, George Aklah– HTO Member, Bruce Takolik – HTO Member, Dawn Andrews – ECCC, Canadian Wildlife Service, Yellowknife, Amy Ganton – ECCC, Canadian Wildlife Service, Yellowknife

Community of Taloyoak Public Meeting
Location: Taloyoak, Nunavut
Date: February 24, 2016
Attendees: Simon Qingnaqtuq – Chair KRWB, Noah Aklait, Isaac Panigayak – Hunter, Eunice Panigayak – Hunter, Danniki Plookee – Hunter, Participant – name written in Inuktitut, David Totalik – Hunter, Bruce Italkell – Hunter, Lorraine Ukuqtunnuaq – Hunter, Simon Taktoo – Hunter, Ruth Ruben – Hunter, Nannu U., Andrew P – Hunter, Joseph Quqqiaq – Interpreter, Dawn Andrews – ECCC, Canadian Wildlife Service, Yellowknife, Amy Ganton – ECCC, Canadian Wildlife Service, Yellowknife

Kugaaruk HTA & Public Meeting
Location: Kugaaruk, Nunavut
Date: February 25, 2016
Attendees: Joshua Kringorn – HTO Manager, Mariano Uqqarqluk – HTO, Edward Inuituinuk, Adam Pujuardjuk, B. Oralri, Len Anaittuq – HTO, Tom Kayaitok – Interpreter, Dawn Andrews – ECCC, Canadian Wildlife Service, Yellowknife, Amy Ganton – ECCC, Canadian Wildlife Service, Yellowknife

1.9.2 Qikiqtani Region: February 29 and March 1, 2016

Grise Fiord Board Meeting
Date: February 29, 2016
Attendees: Jaypetee Akeeagok – HTO Chairman, Charlie Noah – HTO V-Chairman, Marty Kuluguqtuq – SEC/MES, Aksakjuk Niniuk – B.O.D., Jopee Kiguktak, Larry – Interpreter, Morgan Anderson – Department of Environment, GN, Igloolik, Andrew Maher – Parks Canada, Iqaluit, Julia Prokopick – ECCC, Canadian Wildlife Service, Iqaluit, Dawn Andrews – ECCC, Canadian Wildlife Service, Yellowknife

Grise Fiord Public Meeting
Date: February 29, 2016
Jaypetee Akeeagok – HTO Chairman, Annie Audlauk, Miinie K., Laisa Watsleo, Tina Qamaniq, Subie Kiguktak, Jopee Kiguktak, Jonathan Kiguktak, Amarulunnquaq A, Amon Akeeagok, Charlie Noah, Naomi Kuluguqtuq, Aksakjuk Niorjruk, Jamie Christensen, Justin Kaunak, Morgan Anderson – Department of Environment, GN, Igloolik, Andrew Maher – Parks Canada, Iqaluit, Julia Prokopick – ECCC, Canadian Wildlife Service, Iqaluit, Dawn Andrews – ECCC, Canadian Wildlife Service, Yellowknife

Resolute Bay Public Meeting
Date: March 1, 2016
Attendees: Martha Kalluk, Nathaniel Kalluk, Tabitha Mullin, Philip Manik – HTO chairman, Aleeasuk Idiout, Morgan Anderson – Department of Environment, GN, Igloolik, Andrew Maher – Parks Canada, Iqaluit, Julia Prokopick – ECCC, Canadian Wildlife Service, Iqaluit, Dawn Andrews – ECCC, Canadian Wildlife Service, Yellowknife

1.9.3 Inuvialuit Settlement Region: March 8-10, 2016

Sachs Harbour HTC Meeting
Location: Sachs Harbour, NWT
Date: March 8, 2016
Attendees: Joseph Carpenter – President, SH HTC, Wayne Gully – HTC, Norm Anikina – HTC, Richard Carpenter – HTC, Perter Sinkins – Parks Canada, Inuvik, Tracy Davison – Environment and Natural Resources, GNWT, Inuvik, Amy Ganton – ECCC, Canadian Wildlife Service, Yellowknife, Isabelle Duclos – ECCC, Canadian Wildlife Service, Yellowknife

Community of Sachs Harbour Public Meeting
Location: Sachs Harbour, NWT
Date: March 8, 2016
Attendees: Joseph Carpenter – President, SH HTC, Participant – Visitor, Kyle Wolki – SHHTC/SHCC, Bridget Wolki – Caterer / driver, Shanon Green – Parks Canada / Caterer, Norman C. – Sachs Harbour, Edith Hoogak, Warren Esav – Hunter, John Keogak – SHHTC,

Jean Harry – Translator, Perter Sinkins – Parks Canada, Inuvik, Tracy Davison – Environment and Natural Resources, GNWT, Inuvik, Amy Ganton – ECCC, Canadian Wildlife Service, Yellowknife, Isabelle Duclos – ECCC, Canadian Wildlife Service, Yellowknife

Ulukhaktok HTC & Public Meeting
Location: Ulukhaktok, NWT
Date: March 9, 2016
Attendees: Matthew Inuktalik, Willy Akoakhion, Corrie Soss Alice Omingmak – Elder, Markus Kuptana Margaret Kanayok – Elder, Laura Inuktalik, Allison Ekpahkyoak, Isaac Inuktalik – Hunter + trapper, Mason Alanak, Annie Inuktalik, Allison KlenKenberg, Kolten? Inuktalik, Macayla Alanak, Laverna Klengenberg – OHTC, Kieranne Joss,T. Kuptana, Grant Kuptana, Morris Nigiyok – Elder, Tobin, Mabel Nigiyok – Elder, Angen, MaryJane, Nigiyok Allison, Sadie Joss – OHTC, Corben, Donald Inuktalik – Member of Ulukhatok, Krista, Lily Alanak – Community member, Blaine, Margaret Notaina – Elder, Kaia, Mollie Oliktoak, Chelsey, Devon Notaina, Joe Nilgak, Madison Nigiyok, Maegan Klenkengberg, Pat Ekpakohak –Elder, Trent Kuptana, Jean Ekpakohak –Elder, Peter Koplomiak, Connie Alanak, Tyrell Kuptana, George Alanak, Nickolas Alonak, Andy Akoakhion, Niami Klengkenberg, Gibson Kudlak – OHTC, Allen Joss – Elder, Mary Akoakhion – Elder, Joshua Oliktoak, Jack Akhiatak, Gibson Kudlak, Julia Ekpakhoak, John Alikamik, Darlene Nigiyok, Collin Okheena, Lena Nigiyok – Youth Council, Wyatte Joss, Patrick Joss, Ross (Carmella Klengkenberg), Effie Katoyak – Elder, Perter Sinkins – Parks Canada, Inuvik, Tracy Davison – Environment and Natural Resources, GNWT, Inuvik, Amy Ganton – ECCC, Canadian Wildlife Service, Yellowknife, Isabelle Duclos – ECCC, Canadian Wildlife Service, Yellowknife

Paulatuk HTC & Public Meeting
Location: Paulatuk, NWT
Date: March 10, 2016
Attendees: Lawrence Ruben – HTC, Ray Ruben – HTC, Joe Illasiak – PHTC, Bill S. Ruben – PTHC, Tony Green – PHTC, Liz Kuptana – Elder, Eric Lede – Student, Sarah Green – Member, Charlene Green, Perter Sinkins – Parks Canada, Inuvik, Tracy Davison – Environment and Natural Resources, GNWT, Inuvik, Amy Ganton – ECCC, Canadian Wildlife Service, Yellowknife, Isabelle Duclos – ECCC, Canadian Wildlife Service, Yellowknife

1.10 Revised maps

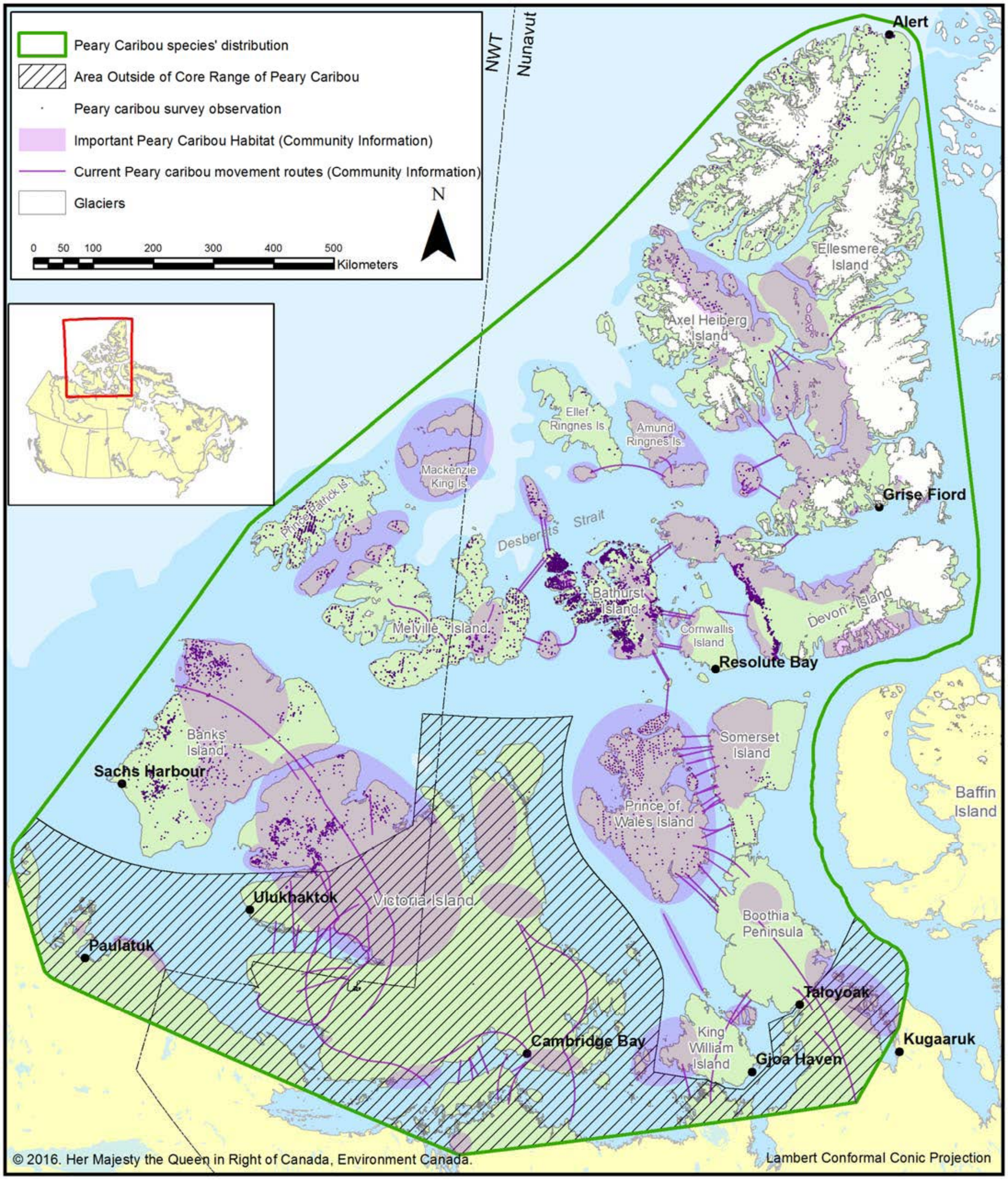


Figure 2. Peary Caribou distribution defined using a standard convex polygon methodology enclosing survey data and community information (1970-2015) modified from Johnson et al. 2016 (Johnson et al. 2016) to differentiate between core range and areas outside of core range.

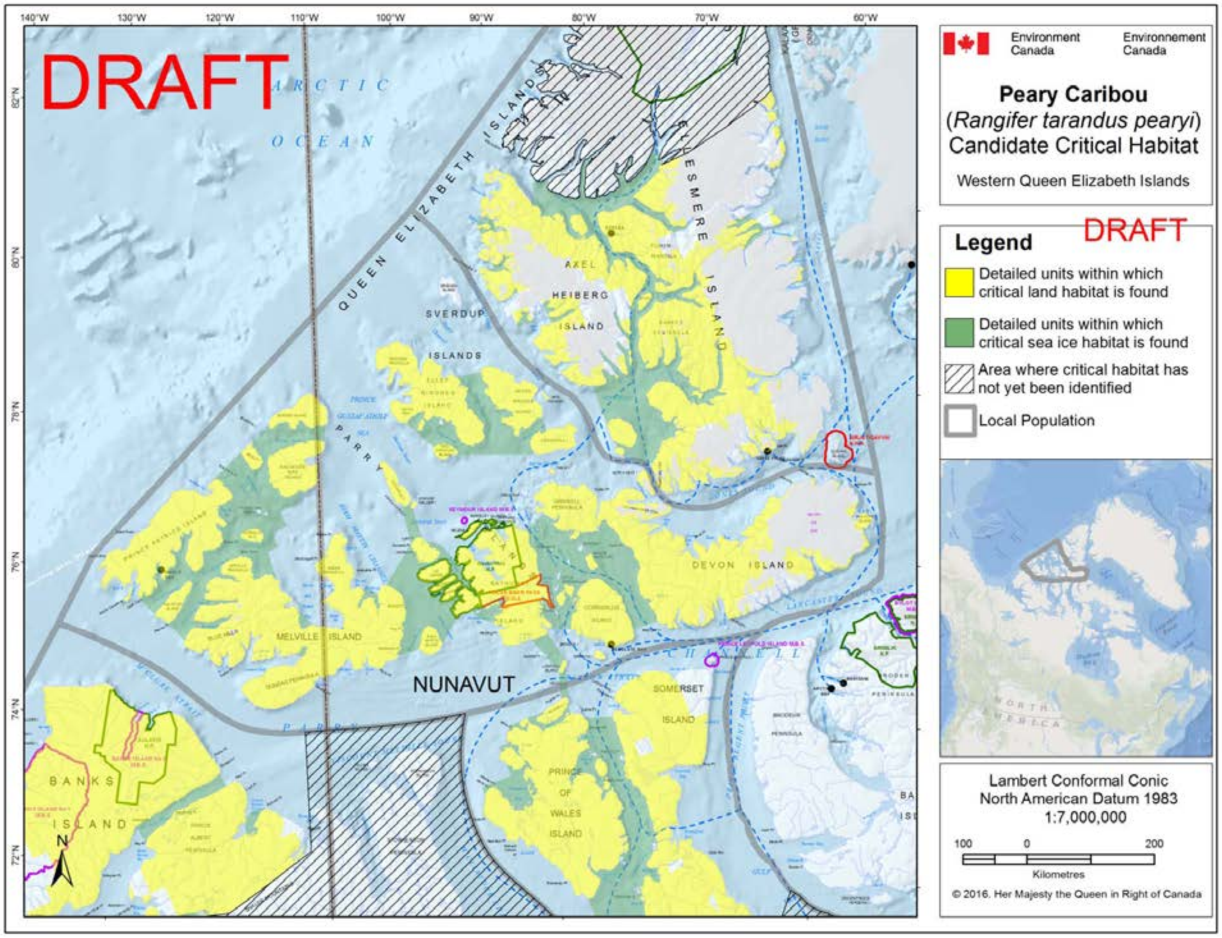


Figure 4. Detailed units that contain critical habitat for Peary Caribou in the Western Queen Elizabeth Islands local population (NT & NU).

2.0 Questions to the GN WRT Baffin Caribou Subpopulation Delineation

QWB Caribou Ranges Workshop – Jun 22 2016 ~16:00

Ben – how were the boundaries developed, and what consultation was conducted in determining them? Could have serious consequences to harvesters so requires consultation under NLCA

David – how many years would the system be imposed? Also note that the male-only harvest could have impacts on people since cows are better for clothing and hunters can select cows without calves to reduce the impact. Imposing boundaries on harvest would require consultation under the NLCA

Joannie – frustrated by the boundary, Kimmirut's recommendation would be not to have boundaries since they are allowed to harvest anywhere as beneficiaries, and the reindeer on Baffin from the 1930s have been used up or are gone and that's the only place where it seemed like a boundary would make sense

Mike – overview that populations change over time and the boundaries change over time and need to be updated, for example Pangnirtung wouldn't originally have fallen within the range delineated for south Baffin caribou but as the caribou moved this was updated. Usually this is based on IQ to update boundaries. Lines are developed for a point in time – Elders suggest that when the population is low there is less well-defined structure and more mixing, there may be one population at those times, and they are located less predictably on the landscape

Qikiqtarjuaq – these boundaries were not presented during consultations – concerned that they would not be able to harvest

Jackie – Troy and Jaylene did meet with the communities and QWB was invited but they were short-staffed and unable to attend, so she can't speak to what information was exchanged at those meetings

David – these boundaries might have been presented for research purposes but not for harvest purposes, so maybe the boundaries were consulted on in the context of research rather than for tag distribution and harvest areas

Ben – some people around the table may not know what we're discussing, and it isn't meant as a slight against researchers but there needs to be incorporation of peoples' harvesting areas and need for understanding of where and when people harvest – boundaries should be removed until that can be incorporated. Boundaries may not be valid if they were developed at a different population level and should be evaluated for current situation as well.

Abraham – thought he might be thinking of a different boundary than the one under discussion – this would be like for polar bears? Seems like an underhanded move by the government to force the NMWB into making a decision

David – current system allows communities to renegotiate tags if some are not used so that other communities could use them – can't see how that would be possible with the boundaries in place

Would there be something like for polar bears where a 30-km overlap area is incorporated around the boundary?

Mike – the lines are meant to be for caribou, not people

Lynda – People could theoretically harvest from multiple zones that reflect their hunting practices, it would be a matter of HTOs and QWB working together to assign tags in different areas to different communities, while addressing the concern that arose with the NWMB that there would be too much harvest pressure in areas where there were few caribou – i.e. south Baffin communities transferring a large number of tags to Pond Inlet and potentially exerting unsustainable harvest pressure on the north Baffin caribou

Since the hall had to be vacated and cleaned up by 17:30 and it was now 17:00 the discussion was put on hold until it could be addressed at a later date and the meeting was adjourned.

3.0 RE: Devon survey

3.1 From: rbhta [rbhta@qiniq.com]

You replied on 2/3/2016 11:27 AM.
Sent: Wednesday, February 03, 2016 10:52 AM
To: Anderson, Morgan; Mullin, Tabitha
Hi
RBHTA Directors wanted Devon Island survey if Grise Fiord HTA agree to that to.
Thanks
Nancy Amarualik
Manager
RBHTA

From: Anderson, Morgan [mailto:MAnderson@GOV.NU.CA]
Sent: February0216
8:59 AM
To: rbhta; Mullin, Tabitha
Subject: RE: Devon survey
Oh, looks like I can do Devon afterall… unless people really want Bathurst done, I can try to switch things around.

From: Anderson, Morgan
Sent: January 28, 2016 3:30 PM
To: 'rbhta'; Mullin, Tabitha
Subject: RE: Devon survey
Hi Nancy and Tabitha,
Do you have any thoughts on a Bathurst Island survey this spring? I just found out that my director wants me to fly Bathurst Island instead of Devon. So I'm touching base with you guys to see if you have any preference. I haven't heard of any big changes in the caribou or muskox on Bathurst and we just flew it 2 years ago, so I'm more interested in seeing what's going on with Devon, like if Bathurst caribou have moved over there (plus it gives an update on the northeast side for Grise). I'm still trying to get something going for Prince of Wales and Somerset this summer…
Morgan

From: rbhta [mailto:rbhta@qiniq.com]
Sent: January 25, 2016 5:03 PM
To: Anderson, Morgan
Subject: RE: Devon survey
Hi Morgan,
Directors had a meeting and read your email letter and if have the funding to do the survey at Devon and if Grise Fiord HTA agree too. Director still want Somerset Island and Prince of Wales Island to be survey too.
Nancy Amarualik
Manager
RBHTA

From: Anderson, Morgan [mailto:MAnderson@GOV.NU.CA]
Sent: January1216
10:59 AM
To: rbhta
Subject: Devon survey
Hi Nancy,
I was planning on doing a survey on central/northern Ellesmere with Grise Fiord in March, but we don't have enough fuel at Eureka to do it, so I was thinking of switching over to Devon Island, since I have funding to fly a survey until March 31. Grise has been getting a few caribou there in the last couple years and it hasn't been surveyed since 2008, so it seems like a good option. Maybe see what the Board thinks about it, or if they have any recommendations? I was thinking of splitting the survey between Grise and Resolute so both communities flew over the areas where they usually travel and harvest.And I'm still trying to make Prince of Wales/Somerset work for the summer. I'll let you know how it goes as the plans evolve… and I should be able to do a few days of pellet collection on Bathurst and Lougheed Island again this year like we've done in the past, so I'm looking forward to working with the Resolute folks on that again too.
Morgan
Morgan Anderson
Wildlife Biologist, High Arctic Region

3.1 Comments by Email from Resolute SAO on March 22, 2016

- Good Afternoon, Council didn't have any recommendation or concerns regarding the Perry Caribou and Muskox Survey that will be conducted on Devon Island.
  Angela Idlout, Senior Administrative Officer

4.0 Support from Resolute HTA for POWSI survey

Resolute Bay Hunters & Trappers Association
P.O Box 61
Resolute Bay NU X0A-0V0
P-867-252-3170
F-867-252-3800
Email- rbhta@qiniq.com
October 9,2015
To: Morgan Anderson
Wildlife Biologist
Department of Environment
Government of Nunavut
P.O Box 209
Igloolik NU X0A-0L0

RBHTA Directors are giving they support for the air survey at Somerset & Prince of Wales Island for musk ox and caribou .
Thanks
Nancy Amarualik, RBHT

5.0 Research Project Updates and Proposals, July 18 2016

Grise Fiord Hamlet Building 19:30-21:30
Meeting with Iviq Hunters and Trappers Association
In attendance: Jaypetee Akeeagok (chair), Jopee Kiguktak, Amon Akeeagok, Imooshie Nutaraqjuk, Aksakjuk Ningiuk, Etuangat Akeeagok, Charlie Noah, Monasie (secretary-manager filling in for Terry Noah), Morgan Anderson.

Jaypetee introduced Morgan and the purpose of the meeting; Morgan provided an overview of research results to date and upcoming projects for comment; Monasie provided translation throughout the meeting.

5.1 Devon Island survey

Morgan showed maps of the transects and survey strata and rationale, followed by observations of muskox and caribou groups and tracks on the island and total estimates (minimum count of 14 caribou – not an estimate – and 1963±SE343 muskoxen). Concentration areas for both caribou and muskoxen were in areas where they had previously been observed, although we did not see any caribou around Truelove – they may have been missed between transects if they are at such low densities, and the report acknowledges this. Caribou are believed to be stable at low density on the island, but muskoxen have almost quadrupled from historic estimates, so we can look at changing management for muskoxen on Devon Island. Morgan proposed that the TAH could be increased from the 15 tags currently available (a conservative harvest of 5% of the population would be about 100 tags), and maintaining tags might allow multiple communities to better coordinate harvest. Alternatively, the TAH could be removed entirely, but coordination would still be important. Morgan showed the difference she found between the voluntary reporting of the Nunavut Wildlife Harvest Study and the mandatory reporting of muskox tags. More muskoxen were reported when it was a requirement, and this is important for establishing basic needs level (if it ever needed to be determined for muskoxen) and provides a good dataset for making management changes and supporting decision-making. Morgan pointed out that prior to any official changes for the Devon Island TAH through NWMB in September, if people are interested in doing a hunt, we can put through an exemption to increase the number of tags available for it.

Comments – Jaypetee suggested that the Board further discuss options for Devon Island. His personal opinion was that opening up the harvest completely could be problematic, especially if communities that are not used to hunting muskoxen might not know the best ways to harvest them responsibly. Maintianing tags but increasing the number might be a good approach. Jaypetee and Aksakjuk both reminded everyone that the muskox might be in a 'boom' right now, but that population booms are followed by busts, and we still need to be careful. Aksakjuk pointed out that increasing muskox harvest now, while their numbers are high, could be beneficial for caribou, since Peary caribou tend to be at low numbers when muskoxen are abundant. The Board will be meeting on July 21 and will further discuss.

5.2 Upcoming surveys

Morgan provided a brief overview of plans for Prince of Wales and Somerset island caribou/muskox surveys in August and offered to provide results of the surveys to the Board, since although they do not harvest those areas directly, the population dynamics there might influence populations that they do harvest. In March/April 2017, Morgan is working on setting up an aerial survey, following the same protocols as Devon and south Ellesmere islands in 2015 and 2016, to survey central and northern Ellesmere Island. It be about 180 hours of Twin time, so getting the funding and logistics in place will determine whether/how much of the survey can be accomplished. It would be from Grise Fiord, Eureka, Tanqary Fiord, and potentially Alert.

Comments – no specific comments.

5.3 Peary caribou genetics

Morgan showed the two most recent maps of population groupings for caribou in the Arctic Archipelago. First, a more broad scale map showed division between mainland caribou, Peary caribou, and Banks Island caribou. Victoria Island and Boothia Peninsula had more mixing. Second, a finer scale map investigating just the island caribou still pulled out Banks Island as a unique group, with another group in the south-central Queen Elizabeth Islands (Bathurst Island) and another group further north (Ellesmere Island). There was more mixing between Bathurst Island/Ellesmere Island groups than with Banks Island, suggesting more movement between these island groups than with Banks Island. Another interesting point was that samples from Bathurst Island before the die-off in the 1990s and afterwards had the same haplotypes, suggesting that caribou on the island now are related to the ones prior to the die-off. This doesn't mean that they didn't move over from other nearby islands, since caribou on nearby islands like Devon also share the same genetics, but it does mean that there wasn't an influx of caribou from the Boothia Peninsula, Ellesmere Island, or Banks Island to aid in the recovery of the population. Fieldwork plans this summer are to gather more samples from Lougheed Island and Bathurst Island, and we will add Dolphin-Union caribou samples to get a better view of how caribou interact on Banks Island and Victoria Island.

Comments – Jaypetee was pleased to see that the genetics reflected what was known about movements and populations through IQ, although it is unfortunate that we have to wait for science to double-check what is already common knowledge to Inuit. Still, he is glad that this information will be better used and incorporated now with both IQ and science backing it up.

5.4 Eureka wolf work

Morgan showed maps of the home ranges and explained the minimum convex polygon ranges, which connect all the locations to provide a total area used by the wolves, and the Brownian bridge movement model home ranges, which show the intensity of use, where wolves spend 95% of their time and 50% of their time. She also showed the time series locations in Google Earth so everyone could watch the wolf movements over the seasons – especially W444's move to Axel Heiberg Island, where he is now the breeding male, and W445's movement to Dundas Harbor on Devon Island. Morgan showed a map of location clusters and pictures of several typical cluster locations – look out points, dens, and kill sites (only muskox kills have been found to date). Even clusters that were created over a couple hours were checked, to make sure caribou were not being missed. The extent to which the muskoxen have been consumed leads us to believe that there might not be any bones left from a caribou, but the rumen and hair pile would likely still be obvious. Morgan also gave a brief overview of some unusual observations from the last 2 field season, including multiple cases of more than one breeding female, and two cases this season where wolves from another pack killed pups.

Comments – Members were quite interested in W445's route along southern Ellesmere, and pointed out where she turned back at Hell Gate and likely skirted open water to cross Jones Sound on the ice. Amon suggested she may have been living off seal pups, since wolves will hunt them. She apparently passed just north of town while most people were at the fishing derby on Devon Island. Jaypetee wanted to know whether the collars that were no longer *functioning had actually dropped off the wolves. Morgan explained that of the 4 collars no longer functioning, 2 had dropped and been recovered, another had apparently dropped in a pond and could not be found, and the one on Devon Island had not been checked yet. She is trying to arrange for aircraft in the area to retrieve it, or if anyone will be boating in the area she will provide coordinates for retrieval. It's important to get the collars back to find out whether they dropped or whether the wolf died, and also to download activity data that helps interpret behaviour. Jaypetee found the cases of pup-killing quite interesting, but pointed out that in sled dogs if you wash the puppies even up to about 6 months old, sometimes the mother will kill them, so it isn't unexpected to happen with wolves, which are closely related. He pointed out that the film crew, if they got footage of the wolves killing the pups, should be careful how they interpret it if they show it, since it is part of nature. Members were also curious how the wolves were captured, so Morgan explained that her preferred method was darting from close range on the ground, since the wolves were less stressed this way, followed by helicopter net-gunning (which allows more control over how much drug is administered and less impact on injection), and finally helicopter darting, which has also been very effective. We've watched darted wolves after recovery to see if they limp or have any obvious issues at the impact site and they've been walking or running normally. As a general comment, Jaypetee was glad to have this kind of in-person communication of research results (not just for the wolf work), since it almost never happens after the Board approves projects, and they're expected to track down and accept whatever results are produced. It's good to be involved throughout the process, and the information is quite useful.*

5.5 Lancaster Sound bears

Morgan gave a very brief introduction of plans for genetic capture-mark-recapture work to update population estimates of Lancaster Sound polar bears in 2018, after Gulf of Boothia and Davis Strait populations. Since the method was the same as the Kane Basin work recently completed, it was more of an information item that the Board would consider. She also pointed out some knowledge gaps that the Board might consider assisting the Polar Bear Biologist with, including when the survey should be flown (spring/fall), good places to base operations from, and whether people would consider deploying collars or eartags to update movements and population delineations. It was introduced as questions that the Board might consider and discuss, which could be incorporated into the study design at this early stage of planning.

Comments – Jaypetee was not familiar with the satellite ear tags, and would like more information on their impact and the quality of data as compared to collars, so that the Board could consider options. Jopee explained a little about their size and configuration, as he had worked on the Kane Basin tagging. Jaypetee suggested that basing out of Grise Fiord any time October to March would allow plenty of bears to be sampled right in town. There were not many specific comments, as it was the first time the Board had been introduced to the project, so they will discuss it further.

6.0 Devon muskox at NWMB (TAH)

6.1 From: rbhta [rbhta@qiniq.com]

Sent: Thursday, August 18, 2016 10:54 AM
To: Anderson, Morgan
Subject: RE: Devon muskox at NWMB

Good morning,
Ola the board hasn't made they're decision yet, can bring it up again at the next meeting.I can also tell them we can wait tell next year to do so.

Thank you so much
Delilah manik
Acting manager

6.2 From: Iviq HTA [gfiviq_hta@qiniq.com]

Sent: Thursday, September 01, 2016 2:48 PM
To: Anderson, Morgan
Subject: RE: Devon muskox at NWMB

Hi Morgan,
The board has decided that they would like the TAH for Musk-ox on Devon Island to be raised to 100 and would require a review by all communites involved at an agreed later date. Also, they would like to be informed on how many of those 100 will be designated to North Devon Island (Grise Fiords quota).

Thanks,
Terry Noah
Manager, Iviq HTA
P: (867) 980 9063
F: (867) 980-4311

-----Original Message-----

6.3 From: Anderson, Morgan [mailto:MAnderson@GOV.NU.CA]

Sent: Wednesday, August 17, 2016 7:07 PM
To: gfiviq_hta@qiniq.com; rbhta@qiniq.com
Subject: Devon muskox at NWMB

Hi guys - just a reminder if the Boards have any resolutions or written support letters for increasing/removing TAH on Devon muskox that we'll need to get those into NWMB. Without that support and comment, it's quite likely that NWMB will just defer the Request for Decision to the next meeting, and it would be good to get it at least addressed at the September meeting...

It looks like the department would also potentially support a short-term larger or unlimited harvest as long as there was solid reporting in place, although I have no idea the logistics involved in that and I suspect it might be more realistic for next year... but if you have any comments on that, please add it to any letter or Board decision.

Thanks! Morgan

DISTRIBUTION AND ABUNDANCE OF PEARY CARIBOU (*Rangifer tarandus pearyi*) AND MUSKOXEN (*Ovibos moschatus*) ON DEVON ISLAND, MARCH 2016

MORGAN ANDERSON[1]

Version: 13 July 2016

[1]Wildlife Biologist High Arctic, Department of Environment
Wildlife Research Section, Government of Nunavut Box 209 Igloolik NU X0A 0L0

STATUS REPORT 2016-01
NUNAVUT DEPARTMENT OF ENVIRONMENT
WILDLIFE RESEARCH SECTION
IGLOOLIK, NU

ᓇᓂᖅᑲᑦ ᑕᕐ ᓂᖏᑦ ᐊᒻ ᒪᓗ ᐅᓄᕐ ᓂᖏᑦ ᕐᑯᑦ ᑎᒃ ᑐᕐ ᒥᐅᑦ ᑐᒃ ᑐᖏᑦᑕ ᑕᐃᔭ ᐅᔪᑦ (*Rangifer tarandus pearyi*)−ᒥ ᒃ ᐊᒻ ᒪᓗ ᐅᒥ ᖕ ᒪ ᐃᑦ ᑕᐃᔭ ᐅᔪᑦ (*Ovibos moschatus*)−ᒥ ᒃ ᑕᓪ ᓘᕈ ᑎᐅᑉ ᕿᑭ ᖅ ᑕᖓᓂ, ᒫ ᔾ ᔨ 2016

ᒧᐊᕆ ᓐ ᐋᓐ ᑐᕐ ᓴ ᓐ[1]

ᑎᑎᖅ ᑲ ᖅ : 13 ᔪ ᓚᐃ 2016

[1]ᓂᕐ ᔪᑎᓂᒃ ᖃᐅᔨ ᓴ ᖅ ᑎ ᕐᑯᑦ ᑎᒃ ᑐᒥ ᐅᑭ ᐅᖅ ᑕᖅ ᑐᒥ , ᐊᕙᑎᓕᕆᔨ ᒃ ᑯᑦ
ᐆᒪ ᔪ ᕐ ᓂᒃ ᖃᐅᔨ ᓴ ᖅ ᑎᒃ ᑯ ᑦ , ᓄᓇᕗᒻ ᒐ ᕙᒪ ᒃ ᑯ ᖏᑦ ᑎᑎᖅ ᑲ ᒃ ᑯᕖᐊ 209 ᐃᒡ ᓗᓕᒃ ᓄᓇᕗᑦ X0A 0L0

ᖃᓄᐃᓕᖓᓂᖏᓐ ᓂᒃ ᐅᓂᒃ ᑳ ᖅ 2016-01
ᓄᓇᕗᒻ ᒥ ᐊᕙᑎᓕᕆᔨ ᒃ ᑯᑦ
ᐆᒪ ᔪ ᕐ ᓂᒃ ᖃᐅᔨ ᓴ ᖅ ᑎᒃ ᑯᑦ
ᐃᒡ ᓗᓕᒃ , ᓄᓇᕗᑦ

Anderson, M. 2016. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) on Devon Island, March 2016. Nunavut Department of Environment, Wildlife Research Section, Status Report 2016-01, Igloolik, NU. 37 pp.

Summary

We flew a survey of Devon Island including Philpots Island (Muskox Management Zone MX-04), by Twin Otter in 58 hours between March 22 and 30, 2016, to update the population estimate for caribou and muskoxen in the study area. The previous survey, in 2008, reported a minimum count of 17 Peary caribou and population estimate of 513 muskoxen (302-864, 95%CI). The 2016 survey found the highest reported abundance estimate for muskoxen (1,963 ±343 SE), and a minimum count of 14 Peary caribou suggests that they continue to persist at low densities on the island, although the low number of observations precludes calculation of a reliable population estimate.

Muskoxen were abundant in the coastal lowlands where they have been found historically, at Baring bay, Croker Bay, Dundas Harbour, and the Truelove Lowlands. They were also abundant on the north coast of the Grinnell Peninsula, and particularly abundant on Philpots Island, where we observed 310 muskoxen. Although most previous surveys covered only part of Devon Island, they did target these lowlands and their abundance estimates or minimum counts likely represent the majority of the muskox population. This survey indicates a large increase in muskoxen on Devon Island, with more observations in all lowland areas compared to 2008, and a particular increase on Philpots Island. This population trend is mirrored on neighboring Bathurst Island to the west, surveyed in 2013, and southern Ellesmere Island to the north, surveyed in 2015.

We only saw 14 Peary caribou during the survey, concentrated on the north shore of the Grinnell Peninsula, and tracks were seen south of Baring Bay. No caribou were seen in the Truelove Lowlands, although hunters from Grise Fiord have caught caribou there over the past several years. It is likely that the low density and patchy distribution of caribou in this area meant that they were not detected on the survey flights. Previous surveys also found caribou in small numbers in specific locations, including a minimum count of 17 caribou in 2008 and 37 caribou on western Devon Island in 2002. Combined with the local knowledge of residents of Grise Fiord and Resolute Bay, it is likely that this population of Peary caribou remains stable at low densities, patchily distributed on Devon Island.

ᐋᓐᑐᕐᓴᓐ, ᒍ. 2016. ᓇᓃᖃᑦᑕᕐᓂᖕᖏ ᐊᒻᒪᓗ ᐅᓄᕐᓂᖕᖏ ᕿᑦᑎᒃᑐᕐᒥᐅᑦ ᑐᒃᑐᖕᖏᑕ ᑕᐃᔭᐅᔪᑦ (*Rangifer tarandus pearyi*)-ᒥᒃ ᐊᒻᒪᓗ ᐅᒥᖕᒪᐃᑦ ᑕᐃᔭᐅᔪᑦ (*Ovibos moschatus*)-ᒥᒃ ᑕᓪᓗᕈᑎᐅᑉ ᕿᑭᖅᑕᖕᓂ, ᒫᔾᔫ 2016. ᓄᓇᕗᒻᒥ ᐊᕙᑎᓕᕆᔾᔪᒃᑯᑦ ᐆᒪᔪᕐᓂᒃ ᖃᐅᔨᓴᖅᑎᒃᑯᑦ ᖃᓄᐃᓕᖕᖓᓂᖕᖑᓂᒃ ᐅᓂᒃᑳᖅ 2016-0, ᐃᒡᓗᓕᒃ, ᓄᓇᕗᑦ

ᓇᐃᒡ ᓕᑎᖅᓯᒪᔪᖅ

ᖃᖕᒋᑕᓚᐅᖅᐳᑦ ᓈᓴᐃᓪᓗᑕ ᑕᓪᓗᕈᑎᐅᑉ ᕿᑭᖅᑕᖕᓂ ᐃᓚᐅᓪᓗᓂ (Philpots Island) (ᐅᒥᖕᒪᓕᕆᓂᕐᒥ MX-04), ᖃᖕᒋᑕᓲᕋᑖᒃᑯᑦ 58-ᒥᓂᒥᒃ ᐊᑯᓂᐅᑎᓕᓪᓗᑕ ᒫᔾᔫ 22 ᐊᒻᒪᓗ 30, 2016 ᐊᑯᓐᓂᖕᖓᓂ, ᒫᓐᓇᒧᑦ ᓇᓗᓇᐃᕐᓗᒍ ᖃᓄᖅ ᐊᒥᓱᑎᑭᖕᒪᖖᑕ ᒥᒃᓴᐅᓴᒃᓯᒪᓕᖅᑐᑦ ᑐᒃᑐᐃᑦ ᐅᒥᖕᒪᐃᓪᓗ ᑕᐅᕙᓂ ᖃᐅᔨᓴᕐᕙᑭᔭᑦᑎᓐᓂ. ᓈᓴᐃᓂᐅ ᓚᐅᖅᓯᒪᔪᖅ, 2008-ᒥ, ᓇᓗᓇᐃᖅᓯᓚᐅᖅᓯᒪᖕᒪᑕ ᐊᒥᓲᖕᖏᖕᖏ ᓈᓴᖅᑕᐅᔪᑦ 17 ᕿᑦᑎᒃᑐᕐᒥᐅᑦ ᑐᒃᑐᖕᖏ ᐊᒻᒪᓗ ᒥᒃᓴᐅᓴᒃ ᑕᐅᔪᑦ 513-ᖑᓪᓗᑎᒃ ᐅᒥᖕᒪᐃᑦ (302-864, 95%CI). ᑖᒃᑯᐊ 2016-ᒥ ᓈᓴᖅᑕᐅᔪᑦ ᕿᑲᕙᓯ ᑏᖑᓚᐅᖅᓯᒪᕗᑦ ᐅᖃᐅᓯᐅᔪᑦ ᖃᔅᓯᐅᓂᖕᖑᓂᒃ ᓈᓴᐃᑎᓪᓗᒋᑦ ᐅᒥᖕᒪᖕᓂᒃ (1,963 ±343 SE)-ᖑᓪᓗᑎᒃ, ᐊᒥᓲᖕᖑ ᑏᖑᓪᓗᑎᒃ ᓈᓴᖅᑕᐅᔪᑦ 14 ᕿᑦᑎᒃᑐᒥ ᑐᒃᑐᖕᖏ ᓇᓗᓇᕈᓐᓅᖅᓱᓂ ᐊᒥᓲᓕᖅᓯᒪᖕᖏᑐᑦ ᑕᐃᑲᓂ ᕿᑭᖅᑕᒥ, ᑖᒃᑯᐊ ᑕᑯᔭᐅᔪᕚᓃᑦ ᐊᒥᓲᖕᖑᓂᕐ ᓴᐅᒐ ᓗᐊᖅᑎᓪᓗᒋᑦ ᑕᒪᒃᑭᖅᓯᒪᙱᒪᖕᑖᓗᓐᓅᑦ ᒥᒃᓴᐅᓴᒃᑕᐅᓯᒪᔪᑦ ᒪᓕᒃᓱᒋᑦ.

ᐅᒥᖕᒪᐃᑦ ᐊᒥᓲᓂᖅᓴᐅᓚᐅᖅᐳᑦ ᓯᒡᔭᖅᐸᓯᖕᒥ ᓇᑎᕐᓇᐅᓂᕐᓴᓂ ᑕᐅᕙᓕᓗ ᓇᓂᔭᐅᔪᓐᓇᕐᓂᕐᓴᐅᕝᕙᒃ ᑲᒥᒃ ᐅᖃᐅᓯᑐᖃᒃᑯᑦ, ᐅᑯᓇᓃᓚᔪᒃᓱᑎᒃ, (Baring bay), ᑯᓵᑯ ᖃᖕᖏᖅᓱᒃ, ᑕᓪᓗᕈᑎ, ᐊᒻᒪᓗᑦ ᑕᐅᖅ ᖃᓪᓗᓈᑦ ᑲᖕᖏᖅᓱᐊᑕ ᐊᑦᑎᖕᓂᖕᖑᓂ. ᐊᒥᓲᓂᖅᓴᐅᓚᐅᕐᒥᔪᑦ ᐅᐊᖕᓇᖕᓂ ᓯᒡᔭᖅᐸᓯᖕᒥ (Grinnell Peninsula)-ᒥ, ᐊᒻᒪᓗ ᐊᒥᓲᓂᕐᓴᐅᓪᓗᑎᒃ (Philpots Island)-ᒥ, ᓈᓴᐃᓚᐅᖅᑐᒍᑦ 310-ᓂᒃ ᐅᒥᖕᒪᖕᓂᒃ. ᒫᓐᓇ ᓇᓕᓴ ᐃᑦ ᕿᓂᕐᓃᑦ ᐃᓚᐃᓐᓇᖕᓂᐅᕝᓗᐊᖅᓱᓂ ᑕᓪᓗᕈᑎᐅᑉ ᕿᑭᖅᑕᖕᒋᑕ, ᕿᓂᕐᕚᖃᓗᐊᓚᐅᖅᐳᑦ ᐊᑦᑎᖕᓂᖕᖑᓂ ᓄᓇᐃᑦ ᐊᒥᓲᓂᖅᓴᐅᓂᖕᖏ ᒥᒃᓴᐅᓴᒃᑕᐅᔪᑦ ᓈᓴᖅᑕᐅᓪᓗᑎᒃ ᐊᒥᓲᓂᕐᓴᒡᒪᓇᐅᓯᒪᖕᒪᑕ ᑕᐅᔾᔮᓇ ᐅᒥᖕᒪᐃᑦ ᖃᔅᓯᐅᓂᖕᖏ. ᑖᓐᓇ ᓈᓴᐃᓂᐅᔪᖅ ᓇᓗᓇᐃᖅᓯᕗᖅ ᐊᒥᓯᕈᓇᐊᒃᑲᓐᓂᕐᓯᒪᓂᖕᖑᓂᒃ ᐅᒥᖕᒪᐃᑦ ᑕᓪᓗᕈᒻᒥ, ᓈᓴᖅᑕᐅᔪᕚᓃᑦ ᐊᑦᑎᖕᓂᕐᓴᓂ ᓄᓇᓂ 2008-ᒥᓂᑦ, ᐊᒻᒪᑦ ᑕᐅᖅ ᐊᒥᓯᕈᓇᐊᒃᑲᓐᓂᓇᓪᓗᑎᒃ (Philpots Island)-ᒥ. ᑖᒃᑯᐊ ᐊᒥᓲᓂᖕᖏᑕ ᐋᖅᑭᒃᑕᐅᓯᒪᓂᓇᔭᖕᖏ ᐃᓚᑭᔭᐅᑭᕗᖅ ᖃᓂᑭᔭ ᓕᒫᖕᖓ ᑐᒃᑐᓯ ᐅᕐᕚᐅᑉ ᕿᑭᖅᑕᐅᑉ ᐊᑭᓐᓇᖕᓂ, ᓈᓴᖅᑕᐅᓯᒪᔪᑦ 2013-ᒥ, ᐊᒻᒪ ᐊᐅᓯᐃᑦ ᑑᑉ ᐅᐊᖕᓇᖕᓂ ᕿᑭᖅᑖᓗᑉ ᐅᐊᖕᓇᖕᓂ ᑕᑉᐸᐅᖕᖓ ᐅᐊᖕᓇᖕᓄᑦ, ᓈᓴᖅᑕᕚᓃᑦ 2015-ᒥ.

ᑕᑯᑐᐃᓐᓇᓚᐅᕆᕗᒍᑦ 14-ᓂᒃ ᕿᑦᑎᒃᑑᑉ ᑐᒃᑐᖕᖏᓂᒃ ᓈᓴᐃᑎᓪᓗᑕ, ᑲᑎᖅᑯᓯᒪᓚᐅᖅᑐᑦ ᐅᐊᖕᓇᖕᓂ ᓯᒡᔭᖅᐸᓯᖕᒥ (Grinnell Peninsula)-ᒥ, ᑐᒥᓂᒡᓗ ᑕᑯᔪᖃᓚᐅᕆᓪᓗᓂ ᓂᓯᐊᓂ (Baring Bay). ᑐᒃᑐᓂᒃ ᑕᑯᔪᖃᓚᐅᖕᖏᑐᓐ ᖃᓪᓗᓈᑦ ᑲᖕᖏᖅᓱᐊᓂ, ᑭᓯᐊᓂᓕ ᐊᐅᓯᐃᑦ ᑐᕐᒥᐅᑦ ᐊᖑᓇᓱᒃᑎᖕᖏ ᑐᒃᑐᖃᑦᑕᖅᓯᒪᕗᑦ ᑕᐃᑲᓂ ᐊᓂᒍᖅᑐᓂ ᐊᕐᖍᒍᕙᓴᓐᓂ. ᑐᑭᓯᓇᖅᑰᔨᓕᖅᑐᖅ ᐊᒥᓲᙳᐊᕐᓂᖕᖏ ᑲᑎᙵᓵᖃᑦᑕᕐᓂᖕᖏ ᑐᒃᑐᐃᑦ ᑕᐅᕙᓂ ᓈᓴᖅᑕᔪᑦ ᐱᔾᔪᑎᖃᕋᔭᕐᒪᖕᒫᑕ ᑕᑯᔭᐅᙱᖃᑦᑕᓇᐊᒃᓴᖕᖑᓂᒃ ᖃᖕᒋᑕᓲᒃᑯᑦ ᓈᓴᐃᔪᓂᑦ. ᖃᖕᒋᕋ ᑎᐊᕈᓗᒃ ᓈᓴᐃᑎᓪᓗᒋᑦ ᓇᓂᓯᓚᐅᖅᐳᑦ ᐊᒥᓲᖕᖏᑐᓂᒃ ᑐᒃᑐᓂᒃ ᑕᐅᕙᓂ ᕿᓂᕐᕚᐅᔪᒥ, ᐃᓚᑭᔭᐅᓪᓗᑎᒃ ᓵᓴᖅᑕᐅᔪᑦ 17-ᖑᓚᐅᖅᑐᑦ ᑐᒃᑐᐃᑦ 2008-ᒥ ᐊᒻᒪᓗ 37-ᖑᓪᓗᑎᒃ ᑐᒃᑐᐃᑦ ᐊᑭᓐᓇᖕᓂ ᑕᓪᓗᕈᑦ ᕿᑭᖅᑕᖕᓂ 2002-ᒥ. ᑲᑐᔾᔪ ᖃᑎᖃᕐᓱᑎᒃ ᓄᓇᓕᖕᓂ ᖃᐅᔨᒪᔪ ᑕᐅᔪᓂᒃ ᐊᐅᓯᐃᑦ ᑐᒥ ᖃᐅᓯᐃᑦ ᑐᒥᓗ, ᓇᓗᓇᖅᑰᔨᙱᖅ ᕿᑦᑎᒃᑑᑉ ᑐᒃᑐᖕᖏ ᑕᐃᒪ ᐃᔅᓴᐃᓐᓇᖅᐳᑦ ᐊᒥᓲᓗᐊᕋᑎᒃ, ᑲᑎᙶᑦᑕᖅᐸᒃᓱᑎᒃ ᑕᓪᓗᕉᑉ ᕿᑭᖅᑕᖕᓂ.

Contents

List of Figures

List of Tables

Introduction

Peary caribou (*Rangifer tarandus pearyi*) are a small, light-coloured subspecies of caribou/reindeer inhabiting the Canadian Arctic Archipelago in the Northwest Territories and Nunavut from the Boothia Peninsula in the south to Ellesmere Island in the north. They are sympatric with muskoxen (*Ovibos moschatus*) over much of their range although diet, habitat preferences, and potentially interspecific interactions separate the two species at a finer scale (Resolute Bay Hunters and Trappers Association [HTA] and Iviq HTA, pers. comm.). Arctic wolves (*Canis lupus arctos*) occur at low densities throughout Peary caribou range, but the most significant cause of population-wide mortality appears to be irregular die-offs precipitated by severe winter weather and ground-fast ice that restricts access to forage (Miller et al 1975, Miller and Gunn 2003, Miller and Barry 2009).

Peary caribou have been surveyed infrequently and irregularly on the Canadian Arctic Archipelago since Tener's 1961 survey, which provided a best guess estimate of 150 Peary caribou on Devon Island, although persistent fog prevented the Colin Archer Peninsula from being surveyed (Tener 1963). Since Tener's survey, unsystematic surveys have been conducted irregularly, usually with a focus on muskoxen in the lowland areas where they are concentrated. In 2002, the western Devon Island was surveyed as part of a program to update population estimates for Peary caribou across their range, and a minimum count of 37 was recorded (Jenkins et al. 2011). The entire island was surveyed in 2008, with a minimum count of 17 caribou (Jenkins et al. 2011). Residents of Grise Fiord and Resolute Bay have not noticed a marked increase or decline in caribou on Devon Island (Iviq HTA, pers comm.), but with higher caribou populations to the west on the Bathurst Island Complex, residents of Resolute were interested in whether caribou have moved onto northern or western Devon Island. Grise Fiord hunters regularly travel the Truelove Lowlands and catch caribou there. Community members were interested in the abundance and distribution of caribou in that area as well as in other areas where the caribou potentially move to.

Population estimates for muskoxen on Devon Island have mostly been estimated based on their abundance in discrete lowland habitat patches. In 1961, Tener surveyed the entire island (except the Colin Archer Peninsula, due to fog) at 6% coverage, and estimated that the population was about 200 muskoxen (Tener 1963). Subsequent surveys focused on the lowland areas where muskoxen could be reliably located. The overall population of muskoxen was believed to be around 300-400 through the 1970s to 1990s (Freeman 1971, Hubert 1977, Decker in Urquhart 1982, Pattie 1990, Case 1992), reaching 513 (302-864 95%CI) by 2008 (Jenkins et al 2011). This was also the first systematic survey of the entire island, although much of Devon Island is unsuitable habitat and it is unlikely that the unsystematic surveys of lowlands missed large numbers of muskoxen. Muskoxen were located consistently in the lowlands around Baring Bay, Maxwell Bay, Dundas Harbour, Philpots Island, Truelove Inlet, Sverdrup Inlet, and the northeast shores of Grinnell Peninsula.

The Peary caribou and muskoxen of western and northern Devon Island are important to the communities of Resolute Bay and Grise Fiord. Arctic Bay hunters also access the southern shores of Devon Island, and with the decline in Baffin Island caribou, Devon Island might become more important in the harvest activities of Arctic Bay. Muskoxen have been hunted in the area since the government ban on muskox hunting was lifted in 1969. As species of presumption of need, subsistence tags are currently set aside and allocated for subsistence, commercial use, and sport hunts according to the allocation of Regional Wildlife Organization (RWO) and Hunter and Trapper Organizations/Associations (HTOs/HTAs). Caribou have been regularly hunted in the region since the communities of Resolute Bay and Grise Fiord were established in the 1950s, although parts of Devon Island have been important harvest areas for centuries. This survey was conducted to update the population estimates, demographic characteristics, and distribution of Peary caribou and muskoxen on Devon Island.

Study Area

The survey area is predominantly polar desert and semi desert, with rugged topography along the mountains and fiords of the south and east coasts, which rise from sea level to 700 m, transitioning to rolling terrain dissected by deep river valleys in the interior and on the Grinnell Peninsula. The island is dominated by the 14, 590 km^2 Devon Ice Cap, rising to 1800 m AMSL in the center, which is also the highest point on the island. Several smaller glaciers are scattered along the south coast, Grinnell Peninsula, and Colin Archer Peninsula. Cushion forb barrens or cryptogam-herb barrens dominate the island, usually at <5% cover and <100 g/m^2 biomass, with isolated patches of prostrate dwarf shrub and prostrate dwarf shrub/graminoid tundra in the coastal lowlands, where vegetation cover increases to 5-50% and biomass increases to 100-500 g/m^2 (Gould et al. 2003, Walker et al. 2005).

Mean July temperatures are 3-5°C on the west side of the study area and 5-7°C in the east (Gould et al. 2003 and references therein). In March 2016, the average daily low and high temperatures in Resolute were -32.2°C and -26.1°C; in Grise Fiord, average daily low temperatures were -32.4°C and average daily high temperatures were -25.6°C (Environment Canada weather data, available http://climate.weather.gc.ca/index_e.html). Most of the study area was snow-covered, although some valleys, particularly along the northeast coast, were largely windswept. There was 26-29 cm snow recorded on the ground at Resolute in March 2016 and 4.3 mm of precipitation, compared to 0-5 cm of snow on the ground in Grise Fiord and 5.1 mm of precipitation (Environment Canada weather data).

The March 2016 aerial survey was flown to cover the same study area as the previous 2008 survey (Jenkins et al. 2011), excluding North Kent Island and Bailie Hamilton Island. We stratified the study area to allocate more effort to good habitat where caribou or muskoxen had previously been reported with a 5-km transect spacing and areas with moderate habitat that might have wildlife were survey with a 10-km spacing. We flew transects spaced 15 km apart over barren parts of the island that were unlikely to be occupied by caribou of muskoxen, but where animals could be travelling between suitable habitat patches (Figure1).

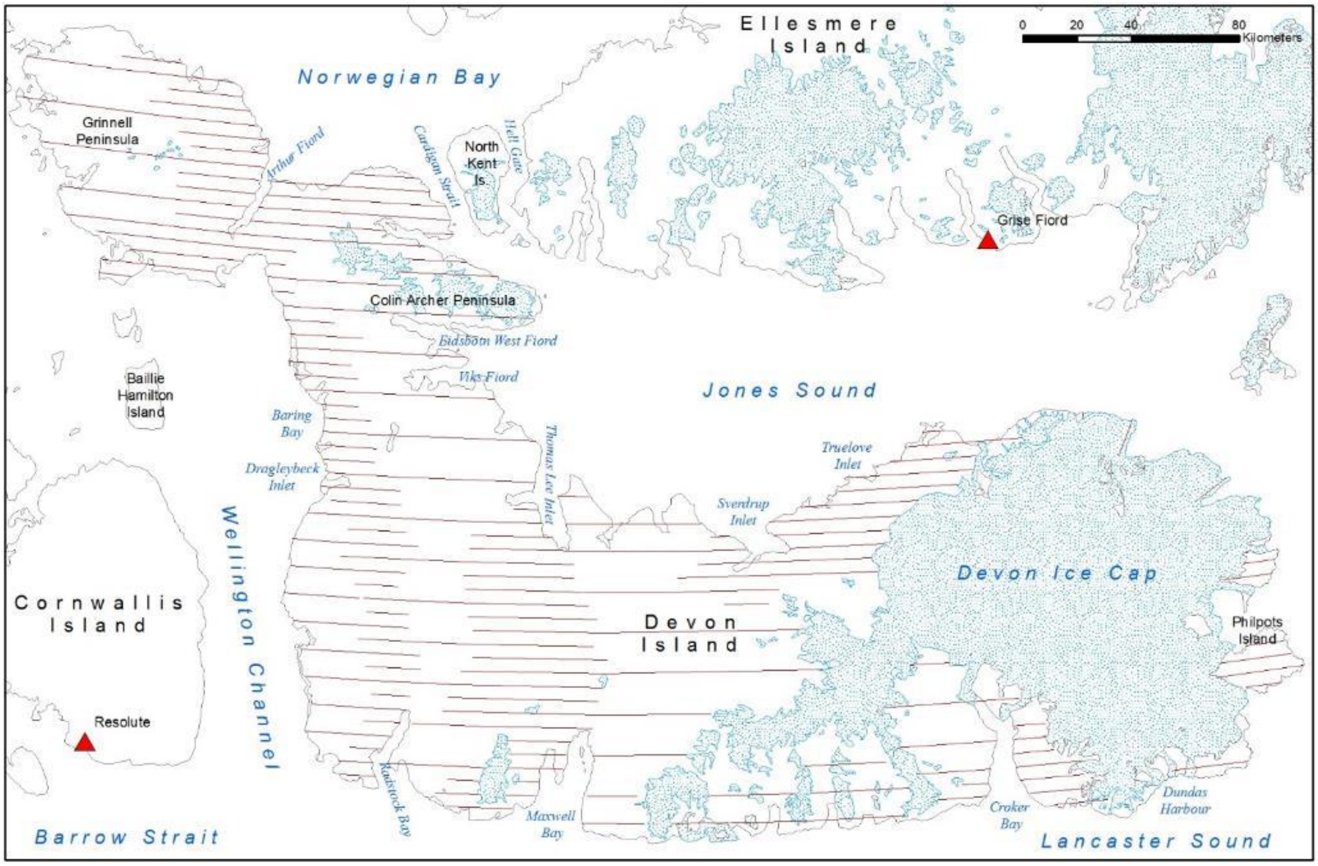


Figure 1. Major landmarks of the study area, with glaciers in stippled blue and 2016 transect lines in dark red running east-west.

Methods

Aerial Survey

Survey transects (n=166, Appendix 1) followed the transects established for the 2008 distance sampling helicopter survey, parallel to lines of latitude with 5, 10, or 15 km spacing and a 500 m strip on either side of the aircraft. Ice caps were excluded, and we did not detect any caribou, muskoxen, or their tracks on any ice caps during ferry flights. We stratified the study area to maximize survey effort in areas expected to have caribou or muskoxen, since much of Devon Island is barren gravel and till, unlikely to support wildlife. The high density (A) stratum was flown with transects spaced 5 km apart, the intermediate stratum (B) flown at 10 km spacing, and the low density stratum (C) was flown at 15 km spacing. Strata and transects are shown in Figure 2 and Table 1. Data used for delineation of the strata is provided in Appendix 2.

Table 1. Survey strata for Devon Island, March 22-30 2016.

Block ID	Stratum	Strata Area, Z (km^2)	Transect Spacing (km)	Transects Surveyed	Survey Area, z (km^2)	Sampling Fraction, f (%)
A	High Density	18438	5	117	3388	18.4%
B	Medium Density	6360	10	21	581	9.1%
C	Low Density	15076	15	28	1024	6.8%

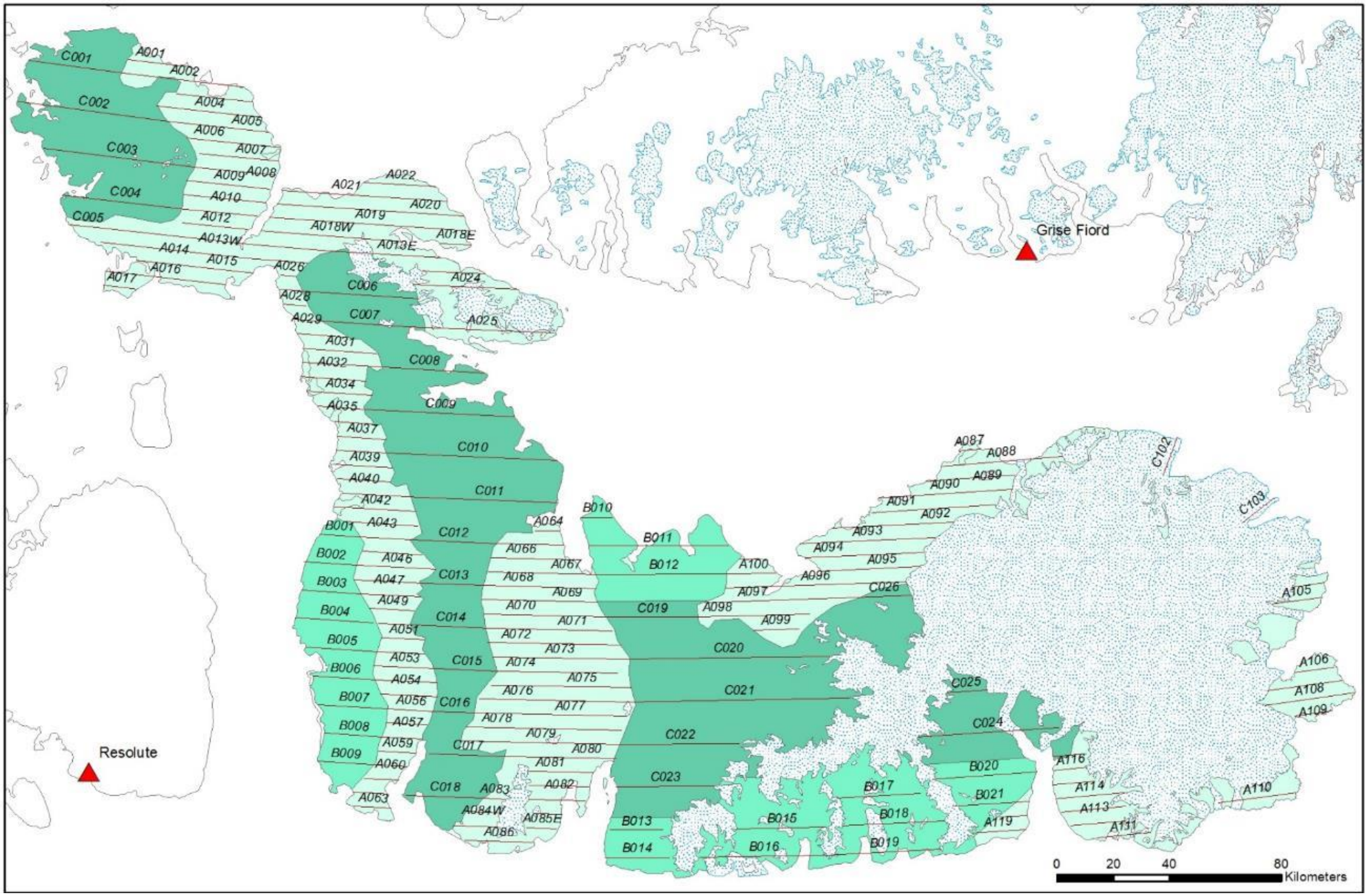


Figure 2. Transects and survey strata for Devon Island, March 22-30, 2016. A transects are the high density stratum flown with transects 5 km apart (pale green), B transects are the intermediate density stratum, flown with transects 10 km apart (bright green), and C transects are the low density stratum, flown with transects 15 km apart (dark green).

To define the transect width, we marked survey aircraft wing struts following Norton-Griffiths (1978):

$$w = W\left(\frac{h}{H}\right)$$

where W is the strip width, H is the flight height, h is the observer height when the plane is on the ground and w is calculated, measured and marked on the ground to position wing strut marks (Figure 3). For this survey we only used one mark representing 500 m marked on the wing strut. Fixed-wing strip transect sampling has been successfully used in the high arctic since 1961, and can be useful when observations are insufficient to determine the effective strip width required for distance sampling.

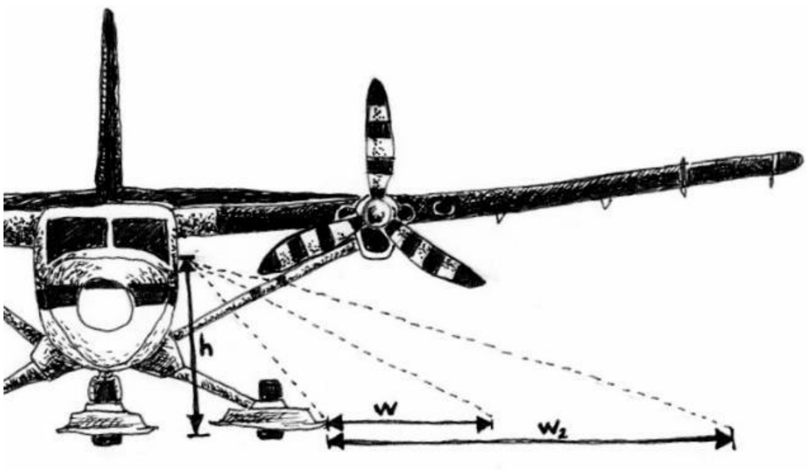


Figure 3. Derivation of wing strut marks for strip boundaries, where *w* and w_2 are calculated as described in the text, *h* is measured (2.2 m for Twin Otter on wheel-skis), and dotted lines indicate observer sightlines as modified from Norton-Griffiths (1978).

Transects were flown between 160-220 km/hr with a DeHavilland Twin Otter – higher speeds were used for uniform, snow-covered landscapes where visibility was excellent. Surveys were only conducted on good visibility days to facilitate detection of animals, tracks, and feeding craters, as well as for operational reasons to ensure crew safety. Flight height was set at 152 m (500 ft) using a radar altimeter. In rugged terrain, the flight height was adhered to as closely as possible within the constraints of crew safety and aircraft abilities.

A Twin Otter with 4-6 passengers (2 front observers, 2-4 rear observers, one of whom was also data recorder) was used to follow the double-observer methodology, which has been successful in other muskox and caribou surveys in Nunavut (see Campbell et al. 2012 for an overview of the methodology) and specifically in the High Arctic on Bathurst and Ellesmere islands (Anderson 2014, Anderson and Kingsley 2015). Front and rear observers on the same side of the plane were able to communicate and all observations by front and rear observers were combined. Estimates of group size are a potentially large source of error in calculating population estimates. However, Peary caribou and muskoxen are generally distributed in relatively small groups where observer fatigue is likely to be a more important source of error (A. Gunn, pers. comm.). We found obvious benefits of using the platform where having the added observers not only increased the accuracy of age and sex classification, but also allowed some crew members to classify with binoculars while others continued to scan for nearby groups and individuals.

All observations of wildlife and tracks were marked on a handheld Garmin Montana 650 global positioning system (GPS) unit, which also recorded the flight path every 15 seconds. Sex and age classification was limited, since the aircraft did not make multiple passes (to minimize disturbance), but adult/short yearling (calves from the previous spring, i.e. 10-11 months old) determination was often straightforward for muskoxen and aided by binoculars. Muskoxen were frequently spotted more than a kilometer off transect due to their large aggregations and dark colour in contrast to the snowy background. Depending on distance and topography, an accurate count could not always be determined for these groups. Newborn muskoxen were obvious based on size, but their small size and close association with other animals in the herd made them difficult to count in larger groups or when muskoxen were tightly grouped. GPS tracks and waypoints were downloaded through DNR-GPS and saved in Garmin GPS eXchange Format and as ESRI shapefiles. Data was entered and manipulated in Microsoft Excel and ArcMAP (ESRI, Redlands, CA).

Analysis

Flights linking consecutive transects were removed for population analysis, although survey speed and height were maintained and all observations recorded as if on survey. Similarly, sections of transect crossing sea ice and ice fields were removed, as these areas were not included in the area used for density calculations.

Although Jolly's (1969) Method II is widely used for population estimates from surveys, it is designed for a simple random design, rather than for a systematic survey of a patchy population. For comparison, population calculations following Jolly's Method II are provided in Appendix 4, along with calculations following a systematic stratified survey design (Cochran 1977). The muskoxen and caribou detected in this survey were patchily distributed and serially correlated, not randomly distributed. For systematic samples from serially correlated populations, estimates of uncertainty based on deviations from the sample mean are expected to be upwardly biased and influenced by the degree of serial correlation; high serial correlation implies that there is less random variation in the unsurveyed sections between systematically spaced transects than if serial correlation were low (Cochran 1977). Calculating uncertainty based on nearest-neighbor differences incorporates serial correlation, and the upward bias in the uncertainty is expected to be less than if it were calculated based on deviations from the sample mean. Nearest-neighbor methods have been used previously to calculate variance around survey estimates on the unweighted ratio estimate (Kingsley et al. 1981, Stirling et al. 1982, Kingsley et al. 1985, Anderson and Kingsley 2015).

The model for observations on a transect survey following Cochran (1977) is:

$$y_i = Rz_i + \varepsilon_i\sqrt{z_i}$$

Where y_i is the number of observations on transect *i* of area z_i, R is the mean density and error terms ε_i are independently and identically distributed. In this model, the variance of the error term is proportional to the area surveyed. The best estimate of the mean density $\hat{R}$ is:

$$\hat{R} = \frac{\sum_i y_i}{\sum_i z_i}$$

The error sum of squares, based on deviations from the sample mean, is given by:

$$\left(\sum_i \frac{{y_i}^2}{z_i}\right) - \frac{(\sum_i y_i)^2}{\sum_i z_i}$$

The finite-population corrected error variance of $\hat{R}$ is:

$$Var(\hat{R}) = \frac{(1-f)}{(n-1)\sum_i z_i}\left(\left(\sum_i \frac{{y_i}^2}{z_i}\right) - \frac{(\sum_i y_i)^2}{\sum_i z_i}\right)$$

Where f is the sampling fraction and n is the number of transects. The sampling fraction also provides the scaling factor for moving from a ratio (population density) to a population estimate. It is calculated as $(\sum z_i)/Z$, where Z is the study area and $\sum z_i$ is the area surveyed. The irregular study area boundaries mean that f varies from the 20% sampling fraction expected from a 1-km survey strip and 5-km transect spacing.

If we were to apply a model $y_i = Rz_i + \varepsilon_i$ instead, then the variance of the error term would be independent of z, so the variance would depend on the number of items in the sample, but not their total size. This would lead to a least squares estimate of R of $\sum zy / \sum z^2$, rather than the more intuitive density definition and model for R presented above.

To incorporate serial correlation in the variance, we used a nearest-neighbor calculation, with the error sum of squares given by:

$$\sum_{i=1}^{n-1}\left(\frac{y_i^2}{z_i} + \frac{y_{i+1}^2}{z_{i+1}} - \frac{(y_i + y_{i+1})^2}{z_i + z_{i+1}}\right)$$

i.e. the sum of squared deviations from pairwise weighted mean densities. The nearest-neighbor error variance of $\hat{R}$ is:

$$Var(\hat{R}) = \frac{(1-f)}{(n-1)\sum_i z_i}\sum_{i=1}^{n-1}\left(\frac{y_i^2}{z_i} + \frac{y_{i+1}^2}{z_{i+1}} - \frac{(y_i + y_{i+1})^2}{z_i + z_{i+1}}\right)$$

Both variance calculations were applied to the Devon Island survey data. In addition, calculations for these strata based on Jolly's (1969) Method II and Cochran's (1977) systematic survey models are provided in the appendices for comparison. For the final estimate, we used the nearest neighbor variance. All distance measurements used North Pole Azimuthal Equidistant projection and area-dependent work used North Pole Lambert Azimuthal Equal Area, with central meridian at 88°W and latitude of origin at 76°N (centered over the study area for high precision).

Population growth rates were calculated following the exponential growth function, which approximates growth when populations are not limited by resources or competition (Johnson 1996):

$$N_t = N_0 e^{rt} \qquad \text{and} \qquad \lambda = e^r$$

Where N_t is the population size at time *t* and N_0 is the initial population size (taken here as the previous survey in 2008). The instantaneous rate of change is r, which is also represented as a constant ratio of population sizes, λ. When r >0 or λ >1, the population is increasing; when r <0 or λ <1 the population is decreasing. Values of r ~0 or λ ~1 suggest a stable population.

Results

We flew surveys on March 22-30 for a total of 57.4 hours (43.2 h and 5162 km on transect). Incidental wildlife sightings are presented in Appendix 3 and daily flight summaries are presented in Appendix 4.

Visibility was excellent for all survey flights with clear skies (visual estimates of <20% cloud, except some low cloud over open water along the coasts) and high contrast. Temperatures were steady about -30°C during the survey. We saw 14 caribou and 830 muskoxen (plus 6 newborn calves) in total, including off transect sightings. This included 13 Peary caribou and 344 muskoxen on transect. Spatial data presented in Figure 4 represents waypoints taken during the survey along transects and includes on- and off-transect sightings. Except for groups observed on the transect line, waypoints have error associated with the group's distance from the plane. While observations on transect are within 500 m, some muskox groups off transect were more than 2 km away.

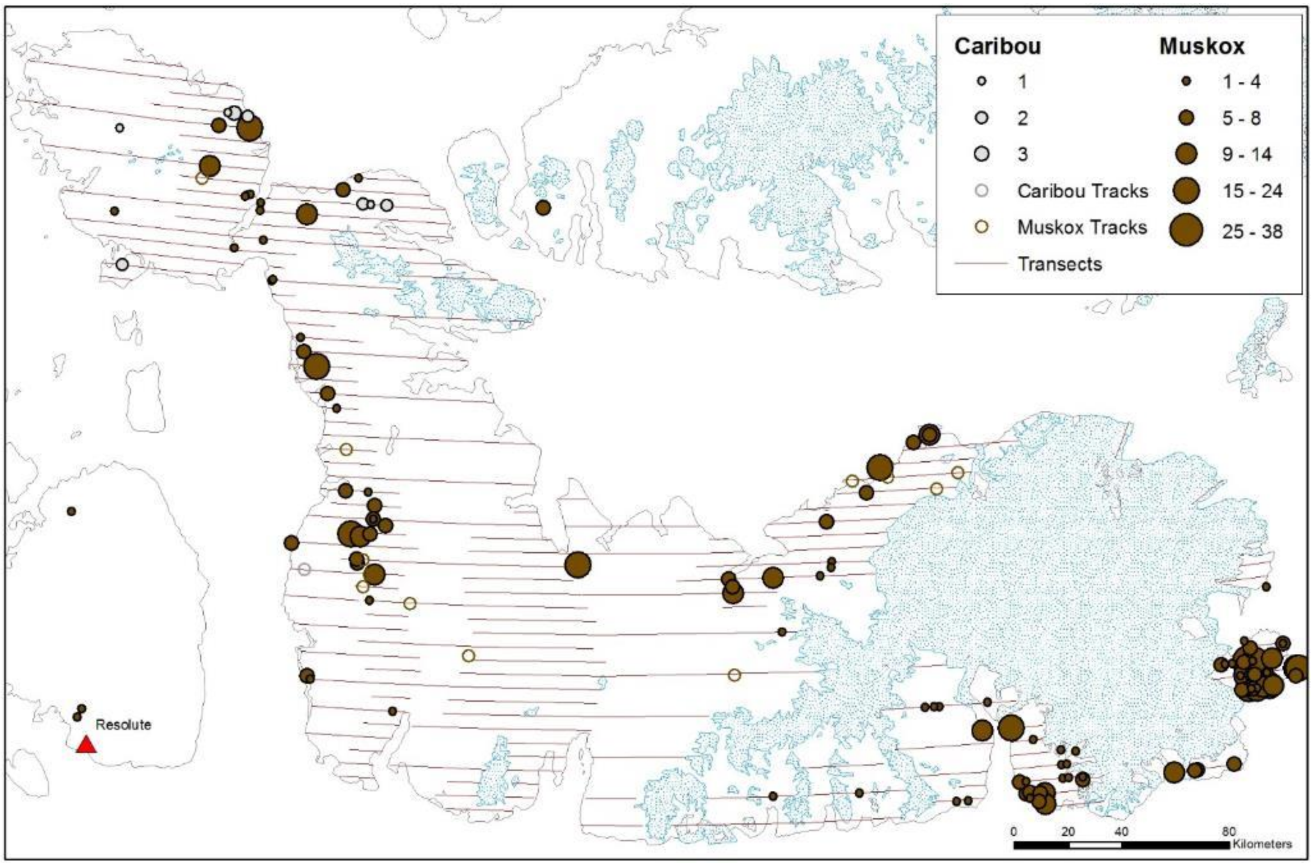


Figure 4. Observations of Peary caribou and muskoxen on Devon Island, March 2016, including observations on and off transect, and on ferry flights.

Abundance Estimates

The low number of observations in the intermediate density stratum B (9 muskoxen in 3 groups) and low density stratum C (1 group of 2 muskoxen) precluded calculation of precise population estimates for those areas, but they have been included in the overall population estimate for the island to reflect the low densities of muskoxen present in these strata. A population estimate was calculated for Peary caribou, but the few observations, which were spatially limited to the northwestern part of the study area, also prevent calculation of a precise estimate. Population estimates and variances are presented in Table 2 for muskoxen and Table 3 for caribou.

Table 2. Muskox population calculations for three strata on Devon Island with variance calculated by nearest neighbor methods and by deviations from the sample mean.

Stratum	Stratum area Z (km^2)	Surveyed area z (km^2)	Count, y	Estimate, $\hat{Y}$	Density, $\hat{R}$	Nearest Neighbor				Deviations from sample mean			
						Error Sum of Squares	Var ($\hat{Y}$)	SE	CV	Error Sum of Squares	Var ($\hat{Y}$)	SE	CV
High Density	18438.26	3387.77	2	1865	0.002	168.718	117524.7	342.8	0.184	246.355	171604.6	414.3	0.222
Medium Density	6359.77	580.54	9	69	0.016	1.101	2217.7	47.1	0.684	0.954	1922.6	43.8	0.637
Low Density	15076.34	1023.81	344	30	0.101	0.050	371.9	19.3	0.655	0.075	556.5	23.6	0.801
Total	39874.37	4992.12	355	**1963**			120114.3	346.6	0.186		174083.7	417.2	0.224

Table 3. Peary caribou population calculations for three strata on Devon Island with variance calculated by nearest neighbor methods and by deviations from the sample mean.

Stratum	Stratum area Z (km^2)	Surveyed area z (km^2)	Count, y	Estimate, $\hat{Y}$	Density, $\hat{R}$	Nearest Neighbor				Deviations from sample mean			
						Error Sum of Squares	Var ($\hat{Y}$)	SE	CV	Error Sum of Squares	Var ($\hat{Y}$)	SE	CV
High Density	18438.26	3387.77	13	69	0.004	1.314	2658.0	51.6	0.751	1.380	930.7	30.5	0.445
Medium Density	6359.77	580.54	0	0	0								
Low Density	15076.34	1023.81	0	0	0								
Total	39874.37	4992.12	13	**69**			2658.0	51.6	0.751		930.7	30.5	0.445

Population Trends

Muskoxen have increased since the last survey in 2008. Based on a population estimate of 1963±SE343 in 2016 and 513 in 2008 (302-864, 95%CI; Jenkins et al. 2011), the instantaneous growth rate r is 0.16, and lambda λ is 1.18. More sophisticated analyses incorporating uncertainty in the estimates have not been undertaken.

A population estimate for caribou was not calculated in 2008 due to the small number of observations. If the groups observed in 2008 had been observed in 2016 with a fixed-width strip transect survey instead, then 3 of the 4 groups (13 of 17 individuals) would have been on transect in the high density stratum. The 2008 population estimate would have been 69±SE47, compared to the 2016 estimate of 69±SE52. The wide confidence interval and few observations in both years make these estimates questionable. Furthermore, neither survey detected caribou in the Truelove Lowlands, where they are known to occur. The 2016 survey also did not detect caribou around Baring Bay, another area where they are known to exist. Lack of observations could be due to movement of animals out of these areas, but it is also possible that they were present but not detected.

Calf Recruitment

Although we observed 119 groups of muskoxen, many of these were too far away or individuals were grouped too closely for sex/age identification, and 59 of these groups had at least some individuals with an unknown age. It is also likely that newborn calves were missed in tightly grouped herds, since they are still small and would be inconspicuous or deliberately hidden behind the adults. Newborns were identified in herds with 5, 7, 7, 8, and 15 1+-year-old muskoxen – larger or more tightly clumped groups could easily have concealed others. The distinct size difference between yearlings and adults would also be less obvious under these circumstances. Eleven yearlings were conclusively identified in groups without any unknown age class animals, making them 4.8% of the population. This is based on a biased sample of groups, however, since the larger groups which had animals of unknown age and sex class likely had more yearlings.

Group Size

We observed 119 groups of muskoxen, with group sizes ranging from single animals to a herd of 38, with an average of 7.0 muskoxen per group (SD=6.0). Caribou were seen in smaller groups of 1 to 4.

Discussion

Population Trends

Previous surveys of Devon Island have used different survey platforms (Piper Super Cub and deHavilland Beaver, Tener 1963; ground surveys, Freeman 1971; Bell 206 helicopter, Case 1992, Jenkins et al. 2011; Twin Otter, this survey). They have also concentrated on different parts of the island, usually with the goal of estimating muskox populations and therefore focusing on the lowland areas of the north, west, and southeast coasts. The largely unsuitable habitat for caribou or muskoxen on the rest of the island minimizes the bias in estimates derived from these surveys however, especially compared to other island groups that have historically been partially surveyed. Case (1992) did note that muskoxen on the 1990 survey may have been missed inland from Baring Bay and a search of that area would have improved the survey results.

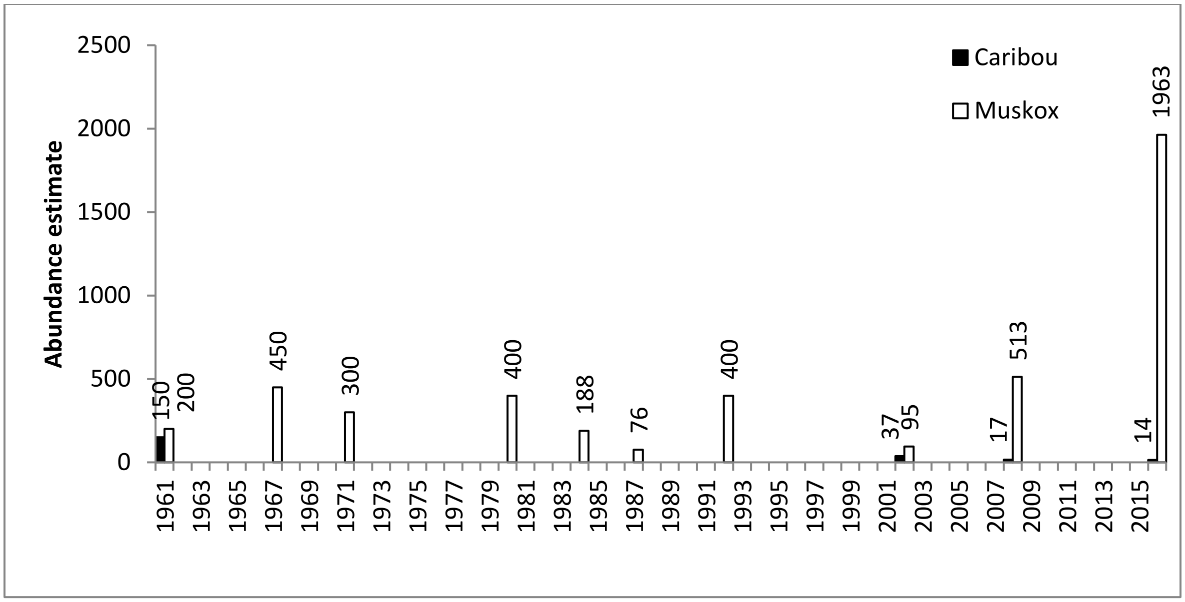


Figure 5. Population estimates for muskoxen and caribou on Devon Island. Muskox estimates prior to 1980 were extrapolations from minimum counts (Tener 1963, Freeman 1971, Hubert 1977, Decker in Urquhart 1982, Case 1992), followed by minimum counts (Pattie 1990, GN data unpublished for 2002) and then systematic surveys covering part (GN data unpublished for 2002) or all (Jenkins et al. 2011 and this survey) of Devon Island. Caribou estimates are guesses (Tener 1963) or minimum counts (Jenkins et al. 2011, this survey).

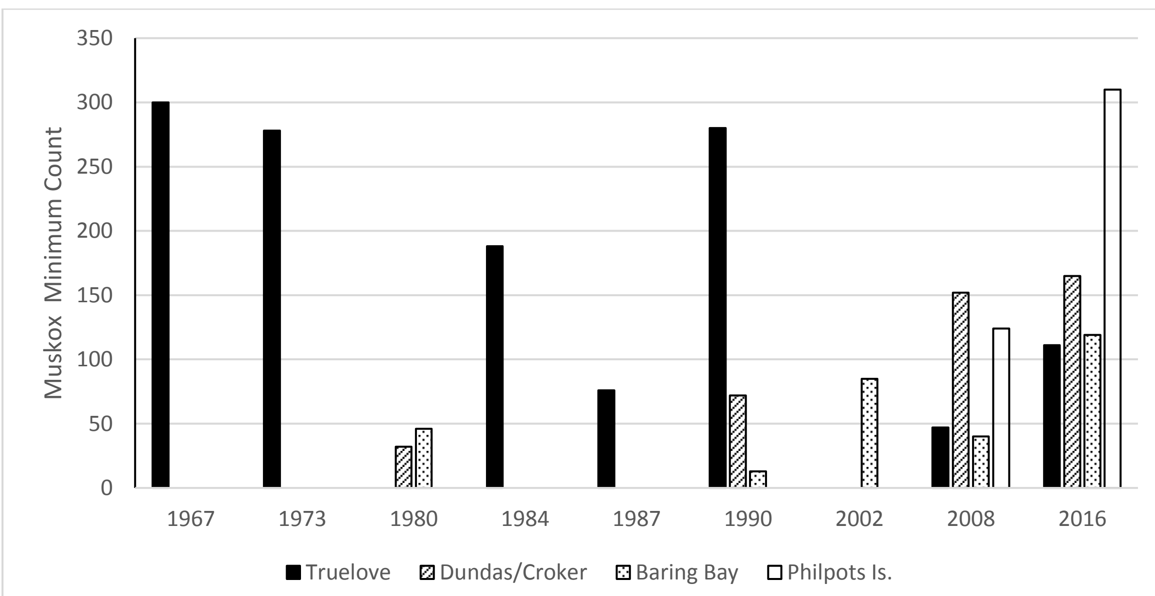


Figure 6. Minimum counts of muskoxen recorded on surveys of lowland areas where muskoxen congregate (Freeman 1971, Hubert 1977, Decker in Urquhart 1982, Pattie 1990, Case 1992, GN data unpublished for 2002 and 2008, Jenkins et al. 2011, and this survey). Not all areas were surveyed in all years.

Muskox and Caribou Distribution

Muskox concentrations have been reported consistently in the lowlands around Baring Bay, Truelove/Sverdrup Inlet, Dundas Harbour, and Philpots Island, and these continued to be places with high muskox densities. The area around Arthur Fiord on the Grinnell Peninsula also supported relatively high densities of muskoxen. Although the distribution has not changed dramatically, each of the lowland areas, and particularly Philpots Island, has experienced an increase in muskox population since the last survey in 2008. The Truelove Lowlands have historically supported larger muskox populations than the number observed during this survey, although more survey effort in these areas in the past compared to a systematic survey makes it difficult to directly compare this years' observations with historic counts. The increasing muskox population is still largely confined to discrete areas of suitable habitat, however, and the unsuitable habitat in the barren interior of the island remains largely unoccupied. Increasing populations on the Bathurst Island Complex and on southern Ellesmere Island indicate that muskox populations are increasing across the region. The increase on Devon Island may be due to recruitment within the population rather than large-scale movement of muskoxen from other neighboring island groups. High calf recruitment of 15-20% starting with a population of 531 muskoxen over the last 8 years could account for an increase to a 2016 population of 1600-2300 muskoxen, but this would be contingent on other factors like adult survival. Relatively little is known about muskox movements in the area.

Caribou distribution has apparently also remained similar to previous surveys and reports. We were unable to locate caribou in the Truelove Lowlands, despite local knowledge of their presence. This may not be surprising if the caribou persist at low densities in small isolated habitat patches. We were also unlikely to have found tracks across this part of the study area, since much of the lowlands were either windswept or had hard-packed snow, which was not conducive to track detection.

We also checked for tracks and animals along the sea ice and shorelines during short ferry flights between transects, allowing us to cover 50% of the shoreline. We did not see any caribou or muskox tracks on the sea ice that would suggest recent movement among islands, and no major movement to or from Devon Island was evident during the survey.

Calf Recruitment

The recorded proportion of muskox yearlings in the population (5%) was much lower than recorded for southern Ellesmere Island in summer 2014 (24%, Anderson and Kingsley 2015), and lower than the 10.5% calf production which Freeman (1971) estimated would be required to offset natural mortality based on observations in 1965 and 1967. Since no unusual mortality or calf crop losses have been noticed by harvesters, it is likely that the recorded proportion of yearlings represents biased sampling of small, dispersed, and often adult-dominated, muskox groups, without taking into account the proportion of yearlings in larger or tightly grouped herds. The proportion of newborn calves will be biased low due to detectability, and because the survey was at the beginning of calving season.

Lack of observations prevents any conclusions on calf recruitment for Peary caribou.

Group Sizes

Muskox groups are largest early in the spring and smaller as summer progresses (Freeman 1971, Gray 1973), with winter (including April and May) groups about 1.7 times larger than summer groups (Heard 1992). Muskoxen were encountered in herds of 2-38, with some lone adults seen as well, and averaged 7.0 muskoxen per herd. This is slightly smaller than the 10.0 muskoxen per herd encountered by Freeman (1971) and slightly smaller than herd sizes encountered in March 2015 on southern Ellesmere Island (8.9-12.1 muskoxen/group, 95%CI, Anderson and Kingsley 2015), although the degree to which muskoxen move among the two islands is not clear and group size could be different for different populations.

Ferguson (1991) suggested that caribou groups are largest in August and smaller in late winter, and Fischer and Duncan (1976) noted that groups across the Arctic islands averaged 4.0 caribou in late winter, 2.8 caribou in early summer, and 8.8 caribou in mid-summer. Peary caribou were seen singly or in small groups of 2-4, but not enough groups were observed to make any meaningful conclusions on group sizes.

Management Recommendations

Peary caribou and muskoxen on Devon Island are an important source of country food and cultural persistence for Inuit. Consistent with the Nunavut Land Claim Agreement, and the Management Plan for High Arctic Muskoxen of the Qikiqtaaluk Region, 2012-2017 (DOE 2014), these management recommendations emphasize the importance of maintaining healthy populations of caribou and muskox that support sustainable harvest.

Under the Management Plan for the High Arctic Muskoxen of the Qikiqtaaluk Region, 2013-2018 (DOE 2014), Devon Island is considered a single management unit, MX-04, with a Total Allowable Harvest (TAH) of 15. The high numbers of muskox suggest that the TAH could be increased or removed, although with 3 communities harvesting from the island, maintaining a TAH might facilitate harvest management and co-ordination by the 3 HTAs (i.e. maintaining tags to track harvest, but setting the TAH high enough to ensure any interested hunter could receive a tag). The current TAH reflects a conservative harvest rate of 4% on a population of about 400 muskoxen, which is close to the population estimates from the 1970s until 2008. The 2016 population estimate, however, is close to four times the 2008 estimate. At the same harvest rate of 4%, 79 muskox tags could be issued. At a 5% harvest rate, 98 tags could be issued. Muskoxen do move across the barren interior of the island and among habitat patches (based on unpublished GN telemetry data, and local knowledge in Grise Fiord and Resolute), but dispersing harvest among several lowlands would prevent having to wait for muskoxen to re-establish themselves in areas that might be more isolated.

It is highly recommended that a harvest reporting system be maintained even if the TAH is removed. This would allow biologists, community members, and decision makers to track harvest patterns over time and to determine whether changes to management zones or harvest restrictions have the desired effect. With muskoxen concentrated in discrete lowland habitats that can be reliably accessed for harvesting, it may be particularly useful to distribute harvest pressure among these areas or to target under-utilized areas for larger community hunts. As local knowledge and previous surveys have demonstrated, population changes can be rapid and unexpected if severe weather causes localized or widespread starvation or movement, so continuous monitoring and adaptive management is necessary even when populations are at high levels.

Harvest trends for muskoxen over the last decade suggest that Grise Fiord and Resolute Bay harvest fewer muskoxen than in the 1990s (Anderson 2016), but changing the configuration of management zones may encourage more harvesting in areas that were previously accessible but not included in a management unit. The major decline in caribou on Baffin Island, and subsequent harvest restrictions, has also reduced the availability of country food for Baffin communities, including Arctic Bay, which has harvested muskoxen on Devon Island in the past. The community of Arctic Bay has been in discussions with Grise Fiord to determine whether they would be able to harvest several muskoxen to offset the lack of Baffin caribou, and this should be further considered given the healthy populations of muskoxen on southern Ellesmere and Devon islands.

Although we saw only 14 caribou during the survey, the results of previous surveys over the same areas suggest that caribou have persisted at relatively low densities on Devon Island. There may or may not have been a decline from the 2008 survey, the few observations recorded from both surveys make it difficult to tell. Most caribou harvest activity from Resolute Bay has been focused on Bathurst Island, reducing the available recent knowledge of caribou on Devon Island, although residents of Resolute still visit Devon Island for other harvesting activities and during travel. Hunters from Grise Fiord report seeing caribou fairly regularly in the Truelove Lowlands, and a few are caught there each year. It is unlikely that harvest restrictions on Peary caribou will result in any marked increase in the population, as harvest is restricted to a small human population with limited access to the caribou range, and lack of suitable habitat on Devon Island is likely a more important factor limiting caribou population growth in the area. Monitoring sightings and harvest will continue to provide a more complete picture of where caribou are on the landscape.

ᐊᐅᓚᑕᐅᓂᕐᒧᑦ ᐊᑐᕐᑯᔭᐅᓯᒪᔪᑦ

ᕐᑯᑦ ᑎᒃ ᑑᑉ ᑐᒃ ᑐᖕᕆ ᐅᒥᖕᒪᖕᕆ ᓗᑕᓪᓗᐴᑉ ᕿᑭᖕᑕᖕᓛᓂᑦ ᑐᑦ ᓂᕿᕆᔭ ᐅᓪ ᒪᓇᖕᒪᑕ ᐃᓕᖕᑯᓯ ᑐᖅᕐ ᒥᖕᓂᓪ ᓗ ᐊᑐᕈᑎᕆᓪ ᓗᓂᑉ ᔪᒃ ᐃᓄᐃᑦ. ᑎᑎᕋᖅᑕᐅᓯᒪᔪᓂᒃ ᓄᓇᕗᒻᒥ ᓄᓇᑖᕐ ᓂᕐ ᒧᑦ ᐊᖕᕆᑲᑎᓲᒍᑎᒥ, ᐊᓪᓗ ᐊᐅᓚᑦ ᑎᓂᕐ ᒧᑦ ᐸᕐ ᓇᐅᑎᒥ ᕐᑯᑦ ᑎᒃ ᑑᑉ ᐅᒥᖕᒪᖕᕆᓄᑦ ᕿᑭᖅᑖᕈᖕᒥ, 2012-2017 (DOE 2014)–ᒥ, ᑖᒃ ᑯᐊ ᐊᐅᓚᑦ ᑎᓂᕐ ᒧᑦ ᐊᑐᕐᑯᔭᐅᓯᒪᔪᑦ ᓇᑯᓇᐃᖅᓯᖕᒪᑕ ᐱᓪ ᒪᓇᐅᓂᖕᓛᓂᒃ ᖃᓄᐃᖕᕆ ᑎᐊᖅᑎᑦ ᑎᓇᓯ ᐊᕐ ᓂᖅ ᐊᒥᓲ ᓂᖕᕆ ᓂᒃ ᑐᒃ ᑐᐃᑦ ᐅᒥᖕᒪᐃᒡ ᓗᓯᕐ ᕋᕐᑯᓇᒍ ᐊᖕᒍᓇᓯᖕᓂᐅᕙᒃ ᑐᖅ.

ᑕᐃᑲᓂ ᐊᐅᓚᑦ ᑎᓂᕐ ᒧᑦ ᐸᕐ ᓇᐅᑎᒥ ᕐᑯᑦ ᑎᒃ ᑑᑉ ᐅᒥᖕᒪᖕᕆ ᕿᑭᖅᑖᕈᖕᒥ, 2013-2018 (DOE 2014)–ᒥ, ᑖᓐᓇ ᑕᒡ ᓗᐳᑦ ᐃᓛᒃ ᑰᖅᓱᓂ ᐊᐅᓚᑕᐅᔭ ᓇᐊᖅᑲᖅᓱᓂ ᐋᖅᑭᒃ ᑕᐅᓯᒪᖕᒪᑦ, (MX-04)–ᒥ, ᑲᑎᓖᖅᓱᕆᑦ ᐱᔭ ᐅᔪᓐᓇᖅᑐᑦ (TAH)–ᒥ 15–ᖑᒡ ᓗᑎᒃ. ᐊᒥᓲᓂᖕᕆᓄᑦ ᐅᒥᖕᒪᐃᑦ ᓇᓗᓇᕈᓐᓅᖅᐳᖅ ᐅᒥᖕᒪᖕᓂᒃ ᐊᖕᒍᓇᓯᔪᓐᓇᕐᓂᕐᒧᑦ (TAH)–ᖑᔪᖅ ᐃᓚᒋᐊᖅᑕᐅᔪᓐᓇᕐᓯᔪᑦ ᐲᖅᑕᐅᑦ ᑎᐊᓪ ᒪᓇᒡ ᓗᓂᓘᓐ ᓃᑦ, ᑖᒃ ᑯᐊ ᐱᖕᒐᓲᒐ ᓗᐊᖅᓱᑎᒃ ᓄᓇᓖᑦ ᑕᑉᐹᙵ ᐊᖕᒍᓇᓯᔪᓐᓇᖅᑐᑦ ᑕᒡ ᓗᐳᓪᒥᑦ, ᐊᑐᕐ ᓗᑎᒃ ᖃᔅ ᓯᓂᒃ ᐊᖕᒍᓇᓯᔪᓐᓇᕐ ᒪᖕᓕᑕ ᑎᑎᖅᑲᑦ (TAH)–ᖑᔪᑦ ᐃᑲᔫᑕᐅᔪᓐᓇᕈᓐᓇᐃᓐ ᓇᕆᐊᖅᑲᖅᐳᑦ ᐊᖕᒍᓇᓯᒃ ᑕᐅᔪᓐᓇᖅᑐᓂᒃ ᐊᐅᓚᑦ ᑎᓂᕐ ᒧᑦ ᐊᐅᓚᑕᐅᓗᑎᓪ ᓗ ᐱᖕᒐᓄᑦ ᐊᖕᒍᓇᓯᒃ ᑐᓕᕆᔮᒃ ᑯᓐᓄᑦ (ᓲᕐ ᓗ. ᓂᕚᖖᑖᕐ ᓂᒃ ᐱᓯᒪᒃ ᓚᕐ ᓗᑎᒃ ᖃᔅ ᓯᓂᒃ ᐊᖑᔪ ᕚᓂᐅᖕᒪᖕᓖᑕ, ᑭᓯ ᐊᓂᓗ ᓈᓪ ᒪᒃ ᓯᑎᑦ ᑎᓯ ᓗᑎᒃ ᐊᖑᔭᐅᔪᓐᓇᖅᑐᑦ ᖃᔅ ᓯᐅᓂᖕᕆ ᓂᒃ ᐊᒥᓲᓂᖕᕇ ᓈᓪ ᒪᒡ ᓗᑎᒃ ᐱᔪᒪᔭᐅᔪᓐᓇᕐ ᓗᑎᒃ ᐊᖕᒍᓇᓯᒃ ᑎᓄᑦ ᓂᕚᖖᑖᑦ). ᑖᓐᓇ ᒫᓐᓇ ᐋᖅᑭᒃ ᓯᒪᔪᖅ ᐊᖑᔭᐅᔪᓐᓇᖅᑐᑦ ᖃᔅ ᓯᐅᓂᖕᕆ ᓂᒃ ᓇᓗᓇᐃᖅᓯᓯᒪᔪᖅ ᐋᖅᑭᒃ ᓯᒪᖕᒪᑦ ᓲᕐ ᓗ 4%–ᐳᓴᓐ ᖑᔪᖅ ᑖᒃ ᑯᓇᖖᒎ 400–ᓂᑦ ᐅᒥᖕᒪᖕᓂᑦ, ᑖᒃ ᑯᐊᓗ ᓈᓪ ᒪᒃ ᓯᓯᒪᑲᓴᒃ ᐳᑦ ᐊᒥᓲᓂᓇᓚᐅᖅᓯᒪᔭᖕᕆ ᓄᑦ ᓈᓴᖅᑕᐅᓯᒪᓂᒃ ᑯᑦ ᒥᒃ ᓴᐳᓴᒃ ᑕᐅᓚᐅᖅᓯᒪᔪᕙᓃᑦ 1970–ᒥᑦ 2008–ᒧᑦ. ᑖᓐᓇ 2016–ᒥ ᐊᒥᓲᓂᖕᕌ ᒥᒃ ᓴᐳᓴᒃ ᑕᐅᓯᒪᓂᓇᔭᖕᖓ ᐃᒪᐃᐸᖅ, ᖃᓪ ᓕᓯᒪᒡ ᓗᓂ ᑎᓴᒪᐃᖅᓱᑎᒡ ᓗᐊᖕᓘᒃ 2008–ᒥ ᒥᒃ ᓴᐳᓴᒃ ᑕᐅᓯᒪᓚᐅᕐ ᓂᖕᓗ. ᑕᐃᒪᓐ ᓇᑦ ᑕᐃᓐ ᓇᖅ ᐊᖑᔭᐅᔪᓐᓇᕐ ᓲᑎᒃ 4%–ᐳᓴᓐ ᓗᐊᒥᒃ, 79–ᓂᒃ ᐅᒥᖕᒪᖕᓄᑦ ᓂᕚᖕᓚᓃᒃ ᑐᓂᔭᒃ ᓴᖅᑕᖅᑲᖅᓱᓂ. 5%–ᐳᓴᓐ ᖑᒃ ᐸᑕ ᐊᖑᔭᐅᔪᓐᓇᖅᑐᑦ, 98–ᖑᓇᔭᖅᓱᑎᒃ ᓂᕚᖕᓚᑦ ᑐᓂᖅᑯᑕᐅᔫᓐᓇᖅᑐᑦ. ᐅᒥᖕᒪᐃᑦ ᓄᒃ ᑕᖅ ᐸᓪ ᓚᐊᖕᕆ ᓇᐅᔭᕐᒪᑕ ᑕᐃᑲᓂ ᕿᑭᖅᑕᒥ ᓂᕿᕆᕙᒃ ᑕᒥᖕᓂᒃ ᒪᓚᒃ ᓱᑎᒃ (ᑎᑎᕋᖅᑕᐅᓯᒪᔪᑎᒍᑦ ᓴᖅᑭᑎᑕᐅᓯᒪᖕᕆ ᓱᓂ ᓄᓇᕗᑦ ᓘᕙᒪᒃ ᑯᖕᕆ ᓂᐅᓂᒃ ᑳᓂ ᑐᖅᑯᖅᑕᐅᓯᒪᔪᓂ, ᐊᓪ ᓗ ᓄᓇᓕᖕ ᓂᑦ ᖃᐅᔨᒪᔭᐅᔪᓂᑦ ᐊᐅᓯ ᐃᑦ ᑐᒥ ᖃᐅᓯ ᐃᑦ ᑐᒥᓗ), ᑭᓯ ᐊᓂ ᐊᖑᓇᓯ ᖃᑦ ᑕᖅᐸᑕ ᓇᑎᐅᓂᖅᓴᒥ ᐊᑦ ᑎᖕ ᓂᖕᕆ ᓂ ᓄᓇᐅᑉ ᐅᑕᖅᑭᔭ ᓇᐊᖅᑲᖅᑕᕋᔭᖕᕐ ᑐᑦ ᐅᒥᖕᒪᖕᓂᒃ ᐃᓂᑦ ᑎᐊᕚᒃ ᑖᓇᐊᕐ ᓗᑎᒃ ᐃᓄᖃᖕᕿ ᔩᒥᔪᒥ.

ᑕᒪᓐᓇ ᐱᓪ ᒪᓇᐅᕗᖅ ᓂᕐ ᔪᑎᑦ ᐱᔭ ᐅᔪᑦ ᐅᖃᐅᓯᐅᕐ ᓇᖅᐸᒡ ᓗᑎᒃ ᑕᐃᓐ ᓇ ᐊᖑᔭᐅᔭᒃ ᑕᐅᔪᓐᓇᖅᑐᑦ ᖃᔅ ᓯᐅᖕᒪᖕᖁᑦ ᓇᓗᓇᐃᖅᑕᐅᓯᒪᔪᖅ (TAH)–ᖑᔪᖅ ᐲᖅᑎᑕᐅᒐ ᓗᐊᕐ ᓂᖅᐸᑦ. ᑕᐃᒪ ᐃᐸᑕ ᓂᕐ ᔪᑎᓂᒃ ᖃᐅᔨᓴᖅᑎᓄᑦ, ᓄᓇᓕᖕᒥᐅᓄᑦ, ᐊᓪ ᓗ ᐃᓯᒪᓕᐅᕆᕙᒃ ᑐᑦ ᖃᐅᔨᒪᓂᖅᓴᐅᔪᓐᓇᕋᔭᕐ ᒪᑕ ᐊᖑᑕᐅᕙᒃ ᑐᑦ ᖃᓅᖃᑦ ᑕᕐ ᒪᖕᓖᑕ ᓇᓗᖕᖏ ᐹᓕᒍᓐᓇᕋᔭᖅᐳᑦ ᐊᐅᓚᑦ ᑎᓅᑦ ᐊᖑᔭᐅᔭᓐᓃᓗ ᐊᑲᐅᓂᕐ ᓴᒧᑦ ᐊᑐᕐ ᓂᖅᑯᓐᓇᕋᔭᕐ ᒪᑕ. ᑕᒪᒃ ᑯᐊ ᐅᒥᖕᒪᐃᑦ ᑲᑎᙵᔪᔫᖑᒪᑕ ᓄᓇᐃᑦ ᐊᑦ ᑎᖕ ᓂᖕᕆ ᓂ ᓂᕿᖅᑲᔪᒃ ᓱᑎᒃ ᐱᓇᓯᒐᒃ ᓴᐅᓂᖅᓴᐅᔪᓐᓇᕐ ᒪᑕ, ᑕᐃᒪ ᐃᑲᔪᕐ ᓂᖅᑲᕐ ᓂᖅᓴᐅᔪᓐᓇᖅᐳᖅ ᐊᖑᔭᐅᓪ ᕚᕆᓗᕆᑦ ᐊᑲᐅᓇᔭᖅᑐᑦ ᐅᕝ ᕗᔫᓐ ᓃᑦ ᑲᒪᕆᔭᐅᖕᕆ ᑎᐊᓪ ᒪᓇᖕ ᓂᐅᔪᓂ ᐊᖑᔭᐅᓪ ᕚᑦ ᑎᐊᕗᐅᓇᔭᖅᑐᖅ ᐊᖏᓂᕐ ᓴᐅᔪᓄᑦ ᓄᓇᓕᖕ ᓄᑦ. ᐊᖏᓂᖅᓴᐃᑦ, ᐊᐅᓚᑕᐅᓂᕐ ᓴᐅᔪᑦ ᓄᓇᓖᑦ ᐊᖑᔭᖕ ᓂᕐ ᒧᑦ ᑐᓂᔭᐅᕗᑦ ᑐᑦ ᐊᖑᔭᓕᒃ ᓴᖕᕆ ᓂᒃ ᐃᓄᕆ ᐊᖕ ᓂᖅᓴᓃᑦ ᑐᑦ ᐃᓯᒪᕆᔭ ᐅᔭ ᓇᐊᖅᑲᖅᓴᖅ ᑰᔾ ᔪᑦ 2016-17–ᒧᑦ ᐊᖑᔭᐅᒃ ᑕᕚᓂᖕᕆ ᓇᐅᑦ ᑎᖅᓯᖅ ᑕᐅᓕᕐ ᓗᑎᒃ ᐊᑐᖕᕆ ᑲ ᓗᐊᕐ ᓗᑎᒃ (TAH)–ᖕᕆ ᓂᒃ. ᒪᓕᒡ ᓗᑎᒃ ᑖᔅ ᓯᒥᖕᖑ ᑕᐃᓐ ᓇ (TAH)–ᖑᔪᖅ 100–ᓂᒃ ᐊᖑᔭᐅᒃ ᑕᐅᔭ ᓇᐊᖅᑲᕐ ᓂᕋᐃᓯᒪ ᓗᓂ ᐃᓯᒪᕆᔭᐅᔪᓐᓇᖅᐳᖅ ᐊᕐ ᕌᒎᓂᐊᖅᑐᓄᑦ, ᑲᔪᓯ ᕗᒡ ᓕᐊᖕᕆ ᓇᐅᔭᖅᑎᒡ ᓗᒍ ᖃᔅ ᓯᐅᓕᕐ ᓂᖕᕆ ᓂᒃ ᖃᐅᔨᓴᕐᓂᐅᕗᑦᑐᖅ ᖃᖕᐅᓕᕌᖕᖑᕐ. ᓄᓇᓂᖕᒥᐅᓂᑦ ᖃᐅᔨᒪᔭᐅᔪᑐᖅ ᐊᓪ ᓗ ᒫᓐᓇᕈᓗᒃ ᖃᐅᔨᓴᕐ ᓂᒃ ᑯᑦ ᑐᕿᓯᔭᐅᔪᑦ, ᓂᕐ ᔪᑏᑦ ᐊᒥᓲᓂᖕᕆ ᒥᒃ ᓵᕙᒡ ᓕᐊᔪᓐᓇᖅᐳᖅᑦ ᕿᓚᓪ ᒥᐅᔪᒃ ᑯᑦ ᐃᓯᒪᓐᓇᖕᕆ ᑐᒃ ᑯᒡ ᓗᓐ ᓅᑦ ᓯᓚ ᐊᓯᑦ ᔭᖅᑎᒡ ᓗᒍ ᓄᓇᒥᔭᖕᖑ ᓂ ᐱᕐ ᓕᕋᖅᑐᓄᒡ ᓗ ᓄᒃ ᑕᖅᑐᓄᒡ ᓘᓐ ᓅᑦ, ᑕᐃᒪ ᐃᓪ ᒪᑦ ᖃᐅᔨᓴᖅ ᐸᒡ ᓕᐊᖅᑲᑦ ᑕᕐ ᓂᖅ ᐊᐅᓚᑦ ᑎᓂᕐ ᓗ ᐱᑕᖅᑲᓇᐊᖅᑲᖅᐳᖅ ᐊᒥᓲᒐ ᓗᐊᖅᐸᑕ ᓂᕐ ᔪᑏᑦ.

ᐊᖑᔭᖕᓂᐅᕙᒃ ᑐᖅ ᐅᒥᖕᒪᖕᓂᒃ ᑭᖑᒡ ᓕᖅᐹᓂ ᐊᕐ ᕌᒍᓂ ᕐᑯᓕᓂᒃ ᓇᓗᓇᐃᖅᓯᒪᕗᖅ ᐊᐅᓯᐃᑦ ᑐᒥ ᖃᐅᓯᐃᑦ ᑐᒥᓗ ᐅᒥᖕᒪᖅᑲᑦ ᑕᖕᕆ ᓂᕐ ᓴᐅᓕᖅᓯᒪᕗᑦ 1990–ᐅᓚᐅᖅᑐᓂᑦ (ᐋᓐ ᑐᓴᓐ 2016), ᑭᓯ ᐊᓂᓕ ᐊᓯᔾᔮᖅᑕᐅᒃ ᐸᑦ ᐊᐅᓚᑦ ᑎᓂᐊᕗᒃ ᑐᖅ ᐊᖑᔭᖕᓂᖅᓴᐅᓕᑐᐃᓐ ᓇᓇᐊᖅᑲᖅᐳᑦ ᑕᐅᕗᓂ ᑲᒪᒋᔭᐅᓯᒪᖕᒋᓐᓂᐅᔪᓂ. ᐊᖏᓗᐊᖅᑐᒥᒃ ᐊᒥᓲᓐᓃᑳᓚᖕᓂᖕᒋᑦ ᑐᒃᑐᐃᑦ ᕿᑭᖅᑖᕈᖕᒥ, ᐱᕐᑯᔭᐅᔪᓐᓃᑳᓚᖕᓂᖕᒋᓐᓄᓗ, ᒥᒃᓵᒋᐊᖅᑎᑦᑎᓯᒪᕚᓪᔪᐊᕐᒥᖕᒪᑦ ᓄᓇᒥᖕᓂᑦ ᓂᕿᕆᕗᑕᒥᖕᓄᑦ ᓄᓇᓕᖕᓂ ᕿᑭᖅᑖᕈᖕᒥ, ᐃᓚᐅᓗᓂ ᐃᒃᐱᐊᕐᔪᖕᒥ,

ᐅᒥᖕᒪᒃᐸᓚᐅᕋᓗᐊᖅᑎᓪᓗᒋᑦ ᑕᓪᓗᕈᒻᒥᑦ ᐊᓂᒍᖅᑐᒥ ᐊᕐᕌᒍᒥ. ᑖᒃᑯᐊ ᓄᓇᓖᑦ ᐃᒃᐱᐊᕐᔪᖕᒥ ᐅᖃᖃᑎᖃᖃᑦᑕᖅᓯᒪᓕᖅᑐᑦ ᐊᐅᓯᐃᑦᑐᕐᒥᐅᓂᒃ ᐊᒥᓱᓂᒃ ᐅᒥᖕᒪᒍᓐᓇᕐᒪᖔᑕ ᐃᓇᖏᕐᔪᐊᑎᒋᓗᓂᔾᔪᒃ ᕿᑭᖅᑖᓗᖕᒥ ᑐᒃᑐᖏᓐᓄᑦ, ᐊᒻᒪᓗ ᑕᒪᓐᓇ ᐃᓯᒪᒋᔭᐅᔪᓐᓇᓂᕗᖅ ᓈᒻᒪᑎᐊᕐᓂᖏᓐᓂᒃ ᐅᒥᖕᒪᐃᑦ ᐊᒥᖏᓂᖏᑦ ᓂᕆᐊᓂ ᐊᐅᓯᐃᑦᑑᑉ ᕿᑭᖅᑖᓗᐊᑕ ᐊᒻᒪᓗ ᑕᓪᓗᕈᑦ ᕿᑭᖅᑕᖏᓐᓂ.

ᑕᑯᓚᐅᕋᓗᐊᖅᐳᑕ 14−ᖏᓐ ᓇᕐᓂᒃ ᑐᒃᑐᓂᒃ ᓈᓴ ᐃᑎᓪᓗᑕ, ᖃᓄᐃᓕᖖᓂᕆᓚᐅᖅᑕᖏᓐ ᓈᓴ ᐃᓂᐅᓚᐅᖅᓯᒪᔫᑉ ᑕᐅᕗᓂᔅ ᓴᐃᓐᓇᖅ ᓇᓗᓇᐃᖅᓯᕗᑦ ᑕᐃᒃᑯᐊ ᑐᒃᑐᖏᓐ ᑕᐃᒪ ᐃᖏᓐ ᓇᕈᔪᒃᑐᑦ ᐊᒥᓲᓗᐊᖏᓐ ᓱᑎᒃ ᑕᓪᓗᕈᒻᒥ. ᐊᒥᓲᔪᓐ ᓅᖅᐹᓪᓕᖏᓐ ᑐᕓᓂᐅᑐᐃᓐ ᓇᕆᐊᓖᑦ 2008−ᒥ ᓈᓴᖅᑕᐅᓚᐅᖅᓯᒪᓂᖏᓐ ᒪᓕᒃ ᓱᕆᑦ, ᑕᐃᒃᑯᐊᒃ ᑕᒪᕐᒥᒃ ᓈᓴ ᐃᓂᐅᓚᐅᖅᓯᒪᔫᒃ ᒪᓕᒃ ᓱᕆᒃ ᐊᓯᔾᓵᕐ ᓯᒪᖕᒪᖔᑕ ᓇᓗᓇᕈᔾᔪᒃᑐᖅ. ᑐᒃ ᑐᑕᐅᖃᑦᑕᖅᓯᒪᔪᑦ ᖃᐅᓯᐃᑦᑐᕐᒥ ᑐᒃ ᑐᒥ ᐅᕐᕕᐅᑉ ᕿᑭᖅᑕᖕᓚᓂᑦ ᑐᒃ ᑐᓐ ᓂᖅᓴ ᐅᖃᑦᑕᖅᓯᒪᖕᒪᑕ, ᑕᐃᒃᑯᐊ ᒥᒃ ᓵᒋ ᐊᕈᑕᐅᕖ ᓕᖅᓯᒪᖕᒪᑕ ᑕᓪᓗᕉᑉ ᑐᒃᑐᖏᓐᓄᑦ, ᑭᓯᐊᓂ ᖃᐅᓯᐃᑦᑐᕐᒥᐅᑦ ᐊᖑᓇᓱᒃᑎᖏᓐ ᑕᓪᓗᕈᓪ ᔾᐊᖅᐸᒃ ᑑᓪᓗ ᓗᐊᑦ ᓯᓕ ᐊᓯᖏᓐᓂᒃ ᐊᖑᓇᓱᒋᐊᖅᓱᑎᒃ ᐊᖅᑯᓵ ᑐᐃᓐᓇᖅᓱᑎᑉ ᓘᓐᓈᑦ ᑕᐃᑰᓇ. ᑕᐃᒃᑯᐊ ᐊᐅ)ᐃᑦᑐᒥᑦ ᐊᖑᓇᓱᒃᑏᑦ ᐅᖃᐅᓯᖃᖃᑦᑕᖅᓯᒪᔫᓚᓗᐊᑦ ᑕᑯᖃᑦᑕᕐᓂᕐᒥᖕᓂᒃ ᑐᒃᑐᓂᒃ ᓯᓚ ᑕᐃᒪᓐᓇ ᑕᐃᑲᓂ ᖃᓪᓗᓈᑦ ᑲᖏᖅᓱᐊᓂ ᐊᑦᑎᒃ ᑑᑕᐅᓂᖏᓐᓂ ᓄᓇᖓᑕ, ᐊᒻᒪᓗ ᐊᒥᓲᖏᓐ ᑑᖖᓗᐊᓂᒃ ᑐᒃᑐᐸᒃᓱᑎᒃ ᑕᐃᑲᖖᒍ ᐊᕐᕋᒍ ᑖᓖᑦ. ᑕᐃᒃᑯᐊ ᑐᒃᑐᑕᐅᔭᓇᕐᓂᖔᑕ ᐊᒥᓲᓂᖏᓐ ᖁᑦᑎᒃᑐᕐᒥᐅᑦ ᑐᒃᑐᖔᑕ ᐊᑑᑎᖃᕐᓂᐊᖅᑐᑦ ᐊᒥᓲᓕᒃ ᑲᓇᕐᓂᕋᖅᑕᐅᑐᐊᖅᐸᑕ ᑐᒃᑐᖏᓐ, ᒫᓇ ᑐᒃᑐᑦ ᑐᓐᓇᖕᖏᑕᐅᖕᒪᑕ ᐊᒥᓲᖏᓐ ᒪᓇᒃ ᑲᓗᐊᖅᑎᓪᓗᒋᑦ ᐃᓄᖏᓐ ᑕᐹᓂ, ᐊᒻᒪᓗ ᐱᔪᒪᔾᔪᐅᔫᑲᓗᐊᓂᒃ ᓂᕐᔪᑎᖃᑦᑎᐊᖏᓐᓱᓂ ᐱᕈᖅᑐᖃᓗᐊᕋᓂᓗ ᑕᓪᓗᕈᒻᒥ ᐱᔾᔪᑕᐅᓗᐊᒃ ᑲᓐᓂᖅᑐᒃ ᓴᐅᖕᒪᑦ ᑐᒃᑐᑦ ᐊᒥᓯᕈᒃ ᑲᓐᓂᕈᓐᓇᓇᐊᒃ ᓴᖏᓐ ᑕᐅᕗᓂ. ᖃᐅᔾᓴ ᐃᓐᓇᕐᓗᒋᑦ ᑕᑯᔭᐅᔪᑦ ᐊᖑᑦ ᑕᐅᔪᕓᓃᓪᓗ ᓇᓗᓇᕈᓐ ᓅᖅᓯᒪᔾᔪᑕᐅᔪᓐᓇᕐᒪᑦ ᓇᓅᖃᑦᑕᕐᒪᖕᒋᑦ ᓄᓇᐅᑉ ᑭᑐᑯᑦᑎᖏᓐᓂ.

Acknowledgements

Thank you to everyone involved in this survey – without their hard work, this kind of project could never be completed. Thanks to the survey observers for Grise Fiord and Resolute for their sharp eyes and welcome insights: PJ Attagootak, Saroomie Manik, Oolat Iqaluk, Debbie Iqaluk, James Iqaluk, Aksakjuk Ningiuk, Jopee Kiguktak, Frankie Noah, Olaph Christianson, Simon Singoorie, and Junior Kakkee. Kenn Borek Air pilots Phil Amos and Reagan Schroeder flew us for 9 days straight with more enthusiasm than any pilot on any of my projects should ever have, and engineer Brian Warness kept an eye on KBH while we had her in Grise Fiord. Thanks to the other Borek engineers in Resolute too, who pulled long days to keep us safely surveying. As always, thanks to the Iviq HTA (Grise Fiord) and Resolute Bay HTA for their guidance and support, and HTA managers Terry Noah and Nancy Amarualik organized observers – as did PJ Attagootak on our arrival in Grise Fiord. Wildlife Officer Tabitha Mullin in Resolute also provided guidance. Mike Kristjanson, Tim McCaugherty, Glenn Parsons, Jodi MacGregor, Barry Hough, Tanya Lemieux, and the rest of the team at Polar Continental Shelf Program provided logistical support and legendary snacks.

Funding for this work was provided by the Nunavut Department of Environment Wildlife Research Section, Environment Canada’s Habitat Stewardship Fund, and NatureServe Canada. The Polar Continental Shelf Program provided logistical support (Project 301-16). The work was completed under Government of Nunavut Wildlife Research Section permit 2016-009.

Literature Cited

Anderson, M. 2014. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) on the Bathurst Island Group, May 2013. Nunavut Department of Environment, Wildlife Research Section, Status Report, Igloolik, NU. 39 pp.

Anderson, M. 2015. High arctic muskox (*Ovibos moschatus*) and Peary caribou (*Rangifer tarandus pearyi*) harvest summary 1990-2015. Nunavut Department of Environment, Wildlife Research Section, Status Report 2015-03, Igloolik, NU. 62 pp.

Anderson, M. and M. C. S. Kingsley. 2015. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) on southern Ellesmere Island, March 2015. Nunavut Department of Environment, Wildlife Research Section, Status Report, Igloolik, NU. 46 pp.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press. 432 pp.

Campbell, M., J. Boulanger, D. S. Lee, M. Dumond, and J. McPherson. 2012. Calving ground abundance estimates of the Beverly and Ahiak subpopulations of barren-ground caribou (*Rangifer tarandus groenlandicus*) – June 2011. Nunavut Department of Environment, Technical Summary, Arviat NU. 111 pp.

Case, R. 1992.Distribution and abundance of muskoxen on Devon Island, NWT, August 1990. Department of Renewable Resources, Government of the Northwest Territories, Manuscript Report 58, Yellowknife, NT. 11 pp.

Caughley, G. 1977. Sampling in aerial survey. Journal of Wildlife Management 41(4): 605-615.

Cochran, W. G. 1977. Sampling techniques. 3rd ed. Wiley, New York, NY. 428 pp.

Department of Environment (DOE), in collaboration with Nunavut Tunngavik Inc. (NTI) Wildlife, Resolute Bay Hunters and Trappers Association, Ikajutit Hunters and Trappers Organization (Arctic Bay), Iviq Hunters and Trappers Association (Grise Fiord) and the Qikiqtaaluk Wildlife Board. 2013. Management Plan for the High Arctic Muskoxen of the Qikiqtaaluk Region, 2013-2018. Nunavut Department of Environment, Iqaluit, NU. 20 pp.

Ferguson, M. A. D. 1991. Peary caribou and muskoxen on Bathurst Island, Northwest Territories, from 1961-1981. Government of Northwest Territories, Pond Inlet. File report 88. 54 pp.

Fischer, C. A. and E. A. Duncan. 1976. Ecological studies of caribou and muskoxen in the Arctic Archipelago and northern Keewatin. Renewable Resources Consulting Services. Report to Polar Gas Project. 194 pp.

Freeman, M. M. R. 1971. Population characteristics of musk-oxen in the Jones Sound region of the Northwest Territories. Journal of Wildlife Management 35(1): 103-108.

Gould, W. A., M. Raynolds, and D. A. Walker. 2003. Vegetation, plant biomass, and net primary productivity patterns in the Canadian Arctic. Journal of Geophysical Research 108 (D2): 8167, doi:10.1029/2001JD000948.

Gray, D. R. 1973. Social organization and behavior of muskoxen (*Ovibos moschatus*) on Bathurst Island, NWT. PhD Thesis. University of Alberta, Edmonton, AB. 212 pp.

Heard, D. 1992. The effects of wolf predation and snow cover on muskox group size. The American Naturalist 139(1): 190-204.

Hubert, B. A. 1977. Estimated productivity of muskox on Truelove Lowland. Pp. 467-491 in L. C. Bliss. Truelove Lowland, Devon Island, Canada: a High Arctic ecosystem. University of Alberta Press, Edmonton, AB.

Jenkins, D., M. Campbell, G. Hope, J. Goorts, and P. McLoughlin. 2011. Recent trends in abundance of Peary Caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) in the Canadian Arctic Archipelago, Nunavut. Department of Environment, Government of Nunavut, Wildlife Report No. 1, Pond Inlet, Nunavut. 184 pp.

Johnson, D. H. 1996. Population analysis. In: T. A. Bookhout, ed. Research and management techniques for wildlife and habitats. The Wildlife Society, Bethesday, MD: 419-444.

Johnson, C.A., Neave, E., Blukacz-Richards, A., Banks, S.N., and P.E. Quesnelle. 2016. Knowledge assessment (community and scientific) to inform the identification of critical habitat for Peary caribou, *Rangifer tarandus pearyi*, in the Canadian Arctic. Environment and Climate Change Canada, Science and Technology, Ottawa, Ontario, Canada.

Jolly, G. M. 1969. Sampling methods for aerial censuses of wildlife populations. East African Agricultural and Forestry Journal 34 (special issue):46-49.

Kingsley, M. C. S., and G. E. J. Smith. 1981. Analysis of data arising from systematic transect surveys. Pp 40-48 in F. L. Miller and A. Gunn, eds. Proceedings, Symposium on Census and Inventory Methods for Populations and Habitats, Banff, AB, April 1980.

Kingsley, M. C. S., I. Stirling, and W. Calvert. 1985. The distribution and abundance of seals in the Canadian high arctic, 1980-82. Canadian Journal of Fisheries and Aquatic Sciences 42 (6): 1189-1210.

Miller, F. L. and S. J. Barry. 2009. Long-term control of Peary caribou numbers by unpredictable, exceptionally severe snow or ice conditions in a non-equilibrium grazing system. Arctic 62(2): 175-189.

Miller, F.L., and A. Gunn. 2003. Catastrophic die-off of Peary caribou on the western Queen Elizabeth Islands Canadian High Arctic. Arctic 56: 381–390.

Miller, F. L., R. H. Russell and A. Gunn. 1975. The decline of caribou on the western Queen Elizabeth Islands. Polarforschung 45: 17-22.

Norton-Griffiths, M. 1978. Counting animals. In: J. J. R. Grimsdell, ed. Handbooks on techniques currently used in African wildlife ecology. No 1. AWLF, Nairobi, Kenya.

Olthof, I., R. Latifovic and D. Pouliot. 2008. Circa-2000 northern land cover of Canada. Earth Sciences Sector, Canada Centre for Remote Sensing, Natural Resources Canada.

Pattie, D. L. 1990 Muskox (*Ovibos moschatus* Zimmermann) populations on the notherneast coast of Devon Island. Northern Institute of Technology: 633-641.

Stirling, I., M. C. S. Kingsley and W. Calvert. 1982. The distribution and abundance of seals in the Beaufort Sea, 1974-1979. Canadian Wildlife Service Occasional Paper 47.

Taylor, A. D. M. 2005. Inuit Qaujimajatuqangit about population changes and ecology of Peary caribou and muskoxen on the High Arctic Islands of Nunavut. MA Thesis. Queen's University, Kingston ON. 123 pp.

Tener, J. S. 1963. Queen Elizabeth Islands game survey, 1961. Canadian Wildlife Service Occasional Paper No. 4. 50 pp.

Urquhart, D. R. 1982. Life history and current status of muskox in the NWT. Northwest Territories Department of Renewable Resources Yellowknife, NWT.

Walker, D. A., M. K. Raynolds, F. J. A. Daniëls, E. Einarsson, A. Elvebakk, W. A. Gould, A. E. Katenin, S. S. Kholod, C. J. Markon, E. S. Melnikov, N. G. Moskalenko, S. S.Talbot, B. A. Yurtsev, and the other members of the CAVM Team. 2005. The Circumpolar Arctic vegetation map. Journal of Vegetation Science 16: 267-282.

Appendix 1. Devon Island survey transects, 2016.

Table 4. Transect end points and strata on Devon Island for a fixed-wing survey, March 2016.

Transect	Stratum	Lon (West)	Lat (West)	Lon (East)	Lat (East)
A001	High	-95.4515	76.9729	-94.5496	76.9736
A002	High	-95.5004	76.9283	-93.7822	76.9278
A003	High	-94.7150	76.8833	-93.6314	76.8824
A004	High	-94.9700	76.8372	-93.5000	76.8371
A005	High	-94.7862	76.7916	-93.3761	76.7913
A006	High	-94.5015	76.7461	-93.1818	76.7466
A007	High	-94.3147	76.7014	-93.2004	76.7013
A008	High	-94.2895	76.6557	-93.2195	76.6559
A009	High	-94.4366	76.6110	-93.2781	76.6106
A010	High	-94.4592	76.5652	-93.3219	76.5653
A011	High	-94.4104	76.5201	-93.4145	76.5200
A012	High	-94.4379	76.4753	-93.5371	76.4743
A013	High	-95.5015	76.4292	-90.8734	76.4297
A014	High	-95.5037	76.3837	-92.6704	76.3843
A015	High	-95.0002	76.3382	-93.4020	76.3383
A016	High	-95.4086	76.2931	-93.7747	76.2934
A017	High	-95.3984	76.2480	-94.9366	76.2486
A018	High	-93.3600	76.4744	-90.4714	76.4742
A019	High	-93.2573	76.5203	-90.5103	76.5198
A020	High	-93.1695	76.5650	-90.5891	76.5652
A021	High	-92.2238	76.6103	-90.8334	76.6108
A022	High	-91.9925	76.6557	-90.9958	76.6558
A023	High	-91.1194	76.3840	-90.2572	76.3837
A024	High	-91.2429	76.3394	-89.8187	76.3386
A025	High	-91.0414	76.2040	-89.3047	76.2023
A026	High	-93.0451	76.3390	-92.8219	76.3387
A027	High	-93.0268	76.2946	-92.7023	76.2936
A028	High	-92.9776	76.2478	-92.6527	76.2479
A029	High	-92.7997	76.2024	-92.4764	76.2025
A030	High	-92.7452	76.1573	-92.0528	76.1574
A031	High	-92.6659	76.1118	-91.6568	76.1119
A032	High	-92.6472	76.0663	-91.8596	76.0690
A033	High	-92.6542	76.0211	-91.7933	76.0209
A034	High	-92.5567	75.9763	-91.6839	75.9766
A035	High	-92.4049	75.9306	-91.7767	75.9314
A036	High	-92.1608	75.8853	-91.6562	75.8857
A037	High	-92.1191	75.8399	-91.4810	75.8389
A038	High	-92.1076	75.7946	-91.4616	75.7956
A039	High	-92.1276	75.7492	-91.3693	75.7499
A040	High	-92.0838	75.7040	-91.3943	75.7037

Transect	Stratum	Lon (West)	Lat (West)	Lon (East)	Lat (East)
A041	High	-92.0019	75.6590	-91.0036	75.6591
A042	High	-92.0969	75.6130	-91.0329	75.6135
A043	High	-91.9416	75.5678	-91.0005	75.5677
A044	High	-91.7431	75.5229	-91.0916	75.5224
A045	High	-91.6967	75.4771	-90.9195	75.4770
A046	High	-91.7627	75.4319	-90.7419	75.4321
A047	High	-91.7767	75.3852	-90.9011	75.3865
A048	High	-91.6819	75.3410	-90.9186	75.3418
A049	High	-91.5624	75.2962	-90.9901	75.2959
A050	High	-91.5011	75.2503	-91.4406	75.2504
A051	High	-91.3900	75.2043	-90.8364	75.2054
A052	High	-91.4369	75.1599	-90.8372	75.1600
A053	High	-91.4721	75.1145	-90.6935	75.1145
A054	High	-91.4349	75.0696	-90.6713	75.0696
A055	High	-91.3613	75.0243	-90.6430	75.0249
A056	High	-91.2629	74.9785	-90.7010	74.9785
A057	High	-91.2693	74.9338	-90.7616	74.9338
A058	High	-91.3129	74.8880	-90.8166	74.8878
A059	High	-91.3528	74.8429	-90.8916	74.8427
A060	High	-91.4164	74.7973	-90.9834	74.7973
A061	High	-91.5014	74.7520	-91.0738	74.7524
A062	High	-91.6261	74.7065	-91.1911	74.7067
A063	High	-91.6055	74.6614	-91.1491	74.6611
A064	High	-89.4999	75.5675	-89.1716	75.5679
A065	High	-89.9996	75.5219	-89.1295	75.5227
A066	High	-90.0587	75.4768	-88.9798	75.4771
A067	High	-90.0836	75.4316	-88.6913	75.4319
A068	High	-90.1396	75.3866	-88.7039	75.3865
A069	High	-90.1529	75.3415	-88.6963	75.3418
A070	High	-90.1137	75.2960	-88.5720	75.2960
A071	High	-90.0533	75.2507	-88.4995	75.2504
A072	High	-90.0618	75.2053	-88.3821	75.2051
A073	High	-89.9997	75.1599	-88.3181	75.1599
A074	High	-89.9242	75.1146	-88.4192	75.1148
A075	High	-89.9997	75.0694	-88.2573	75.0698
A076	High	-90.1350	75.0240	-88.2871	75.0240
A077	High	-90.1881	74.9784	-88.3126	74.9785
A078	High	-90.2849	74.9335	-88.3626	74.9326
A079	High	-90.3433	74.8877	-88.3949	74.8878
A080	High	-89.7865	74.8426	-88.4362	74.8430
A081	High	-89.5025	74.7966	-88.7032	74.7974
A082	High	-89.5010	74.7520	-88.7710	74.7525

Transect	Stratum	Lon (West)	Lat (West)	Lon (East)	Lat (East)
A083	High	-90.0525	74.7068	-88.8018	74.7066
A084	High	-90.2588	74.6614	-89.1049	74.6617
A085	High	-90.3994	74.6157	-89.1419	74.6158
A086	High	-90.2637	74.5705	-89.4294	74.5707
A087	High	-84.0040	75.7944	-83.7115	75.7945
A088	High	-84.2406	75.7490	-82.6540	75.7493
A089	High	-84.4573	75.7043	-83.2935	75.7036
A090	High	-85.0695	75.6586	-83.3435	75.6585
A091	High	-85.1656	75.6136	-83.5736	75.6132
A092	High	-85.6929	75.5679	-84.1179	75.5682
A093	High	-86.1124	75.5229	-84.3768	75.5222
A094	High	-86.0504	75.4775	-84.5217	75.4767
A095	High	-85.8495	75.4322	-84.5947	75.4319
A096	High	-87.0686	75.3870	-84.7760	75.3866
A097	High	-87.3422	75.3412	-85.4043	75.3412
A098	High	-87.4193	75.2959	-86.0030	75.2958
A099	High	-86.7360	75.2507	-86.1493	75.2508
A100	High	-86.9984	75.4318	-86.4147	75.4318
A101	High	-86.8880	75.4776	-86.6370	75.4777
A104	High	-79.9315	75.2511	-79.5140	75.2505
A105	High	-80.2150	75.2056	-79.5756	75.2049
A106	High	-80.0445	74.9786	-79.5506	74.9782
A107	High	-80.4098	74.9334	-79.4804	74.9333
A108	High	-80.4593	74.8879	-79.3482	74.8880
A109	High	-80.1173	74.8423	-79.6645	74.8426
A110	High	-81.1654	74.5974	-80.2187	74.5974
A111	High	-82.6603	74.5250	-81.9998	74.5251
A112	High	-82.9629	74.5704	-82.2931	74.5706
A113	High	-83.0611	74.6157	-82.2674	74.6165
A114	High	-83.1139	74.6612	-82.2818	74.6615
A115	High	-83.1294	74.7063	-82.6106	74.7063
A116	High	-83.1117	74.7522	-82.6943	74.7522
A117	High	-83.1035	74.7973	-82.6953	74.7969
A118	High	-83.8110	74.6163	-83.4697	74.6147
A119	High	-84.1586	74.5706	-83.4989	74.5710
B001	Medium	-92.2611	75.5225	-91.7431	75.5229
B002	Medium	-92.4253	75.4319	-91.7627	75.4319
B003	Medium	-92.4319	75.3413	-91.6819	75.3410
B004	Medium	-92.4867	75.2507	-91.5011	75.2503
B005	Medium	-92.3308	75.1599	-91.4369	75.1599
B006	Medium	-92.2119	75.0691	-91.4349	75.0696
B007	Medium	-92.1187	74.9786	-91.2629	74.9785

Transect	Stratum	Lon (West)	Lat (West)	Lon (East)	Lat (East)
B008	Medium	-92.0224	74.8882	-91.3129	74.8880
B009	Medium	-92.0776	74.7972	-91.4164	74.7973
B010	Medium	-88.9181	75.6133	-88.4986	75.6130
B011	Medium	-88.8185	75.5222	-87.0187	75.5222
B012	Medium	-88.6913	75.4319	-86.9984	75.4318
B013	Medium	-88.5004	74.6154	-87.8639	74.6159
B014	Medium	-88.5684	74.5253	-87.7900	74.5256
B015	Medium	-86.9721	74.6158	-85.8925	74.6148
B016	Medium	-87.4396	74.5258	-85.8803	74.5241
B017	Medium	-85.7538	74.7063	-84.7336	74.7067
B018	Medium	-85.6999	74.6155	-84.4595	74.6160
B019	Medium	-85.8803	74.5241	-84.5302	74.5254
B020	Medium	-84.5960	74.7519	-83.3208	74.7524
B021	Medium	-84.3724	74.6606	-83.4318	74.6597
C001	Low	-96.8561	76.9279	-95.5004	76.9283
C002	Low	-96.9199	76.7922	-94.7862	76.7916
C003	Low	-96.4657	76.6559	-94.2895	76.6557
C004	Low	-96.1059	76.5168	-94.4104	76.5201
C005	Low	-95.9554	76.4259	-95.5015	76.4292
C006	Low	-92.7023	76.2936	-91.1545	76.2941
C007	Low	-92.4764	76.2025	-91.2682	76.2033
C008	Low	-91.8596	76.0690	-90.2112	76.0666
C009	Low	-91.7767	75.9314	-89.8083	75.9305
C010	Low	-91.4616	75.7956	-89.2222	75.7949
C011	Low	-91.0036	75.6591	-89.2157	75.6586
C012	Low	-91.0916	75.5224	-89.9996	75.5219
C013	Low	-90.9011	75.3865	-90.1396	75.3866
C014	Low	-91.0024	75.2506	-90.0533	75.2507
C015	Low	-90.6935	75.1145	-89.9242	75.1146
C016	Low	-90.7010	74.9785	-90.1881	74.9784
C017	Low	-90.7393	74.8424	-89.7865	74.8426
C018	Low	-90.9777	74.7063	-90.0525	74.7068
C019	Low	-88.5720	75.2960	-87.4193	75.2959
C020	Low	-88.3181	75.1599	-85.7670	75.1600
C021	Low	-88.2871	75.0240	-85.5456	75.0245
C022	Low	-88.3949	74.8878	-86.9173	74.8876
C023	Low	-88.4291	74.7518	-87.2422	74.7531
C024	Low	-84.7369	74.8883	-83.0024	74.8876
C025	Low	-84.3593	75.0242	-83.8459	75.0245
C026	Low	-85.4042	75.3443	-84.7132	75.3416
C102	Low	-81.3948	75.6551	-81.1461	75.7744
C103	Low	-80.4653	75.4746	-80.0000	75.5419

Appendix 2. Delineation of survey strata for Devon Island.

The following figures show the boundaries for high, intermediate, and low density strata for caribou and muskoxen. Both species were considered together, since much of the information indicated overlapping ranges and both species were targeted for the survey. In addition to the maps provided below, we used maps provided in Case (1992) of high muskox density areas and locations indicated by community members (summarized in Taylor 2005 and Johnson et al. 2016, but also indicated by elders and hunters prior to and during the survey).

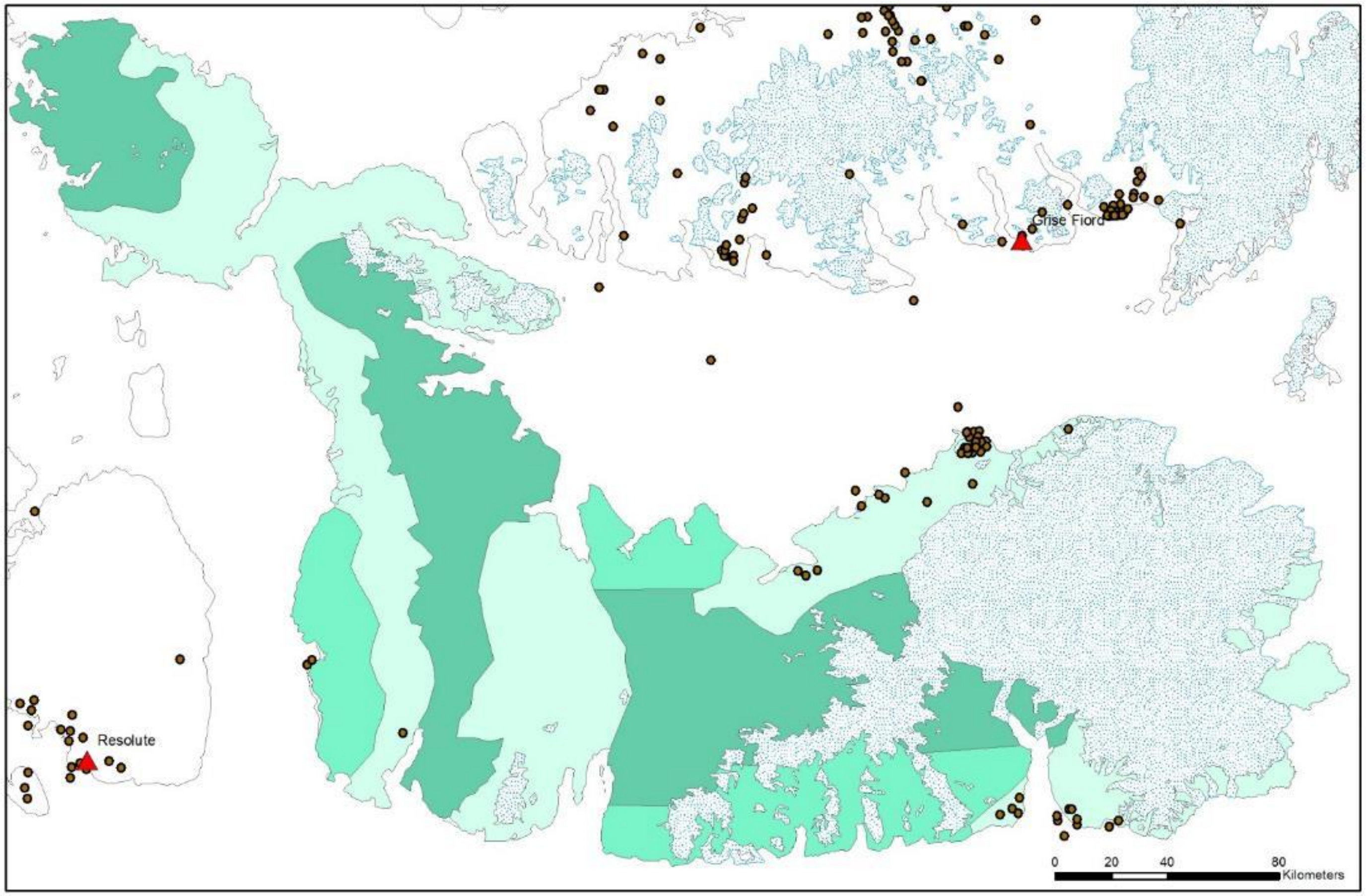


Figure 7. Locations of muskox harvest from Grise Fiord, Resolute Bay, and Arctic Bay, 1990-2015. Survey strata are indicated by shaded green – high density (pale green), intermediate density (bright green), low density (dark green).

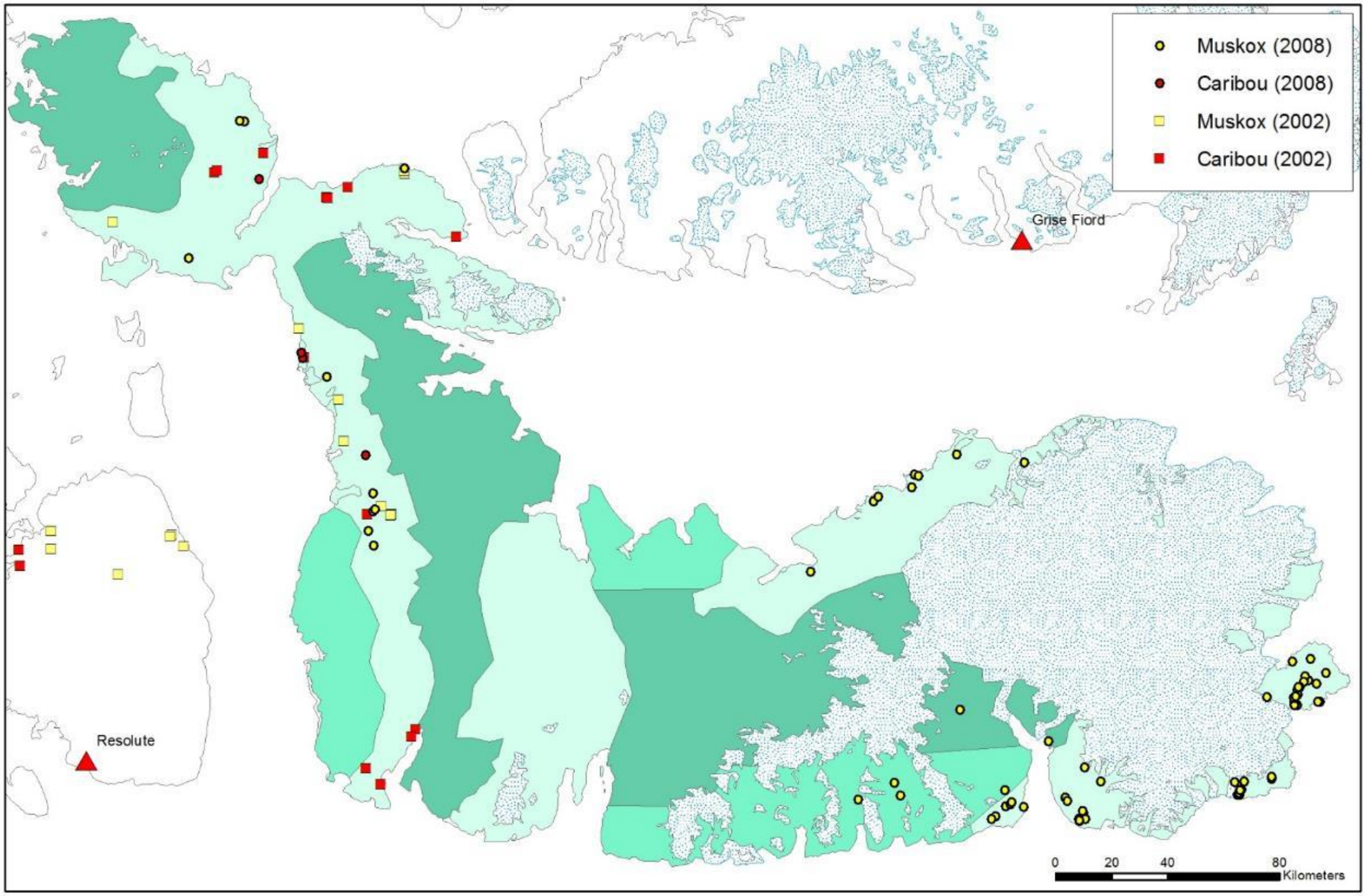


Figure 8. Locations of caribou and muskoxen seen on aerial surveys in 2002 and 2008. Survey strata are indicated by shaded green – high density (pale green), intermediate density (bright green), low density (dark green).

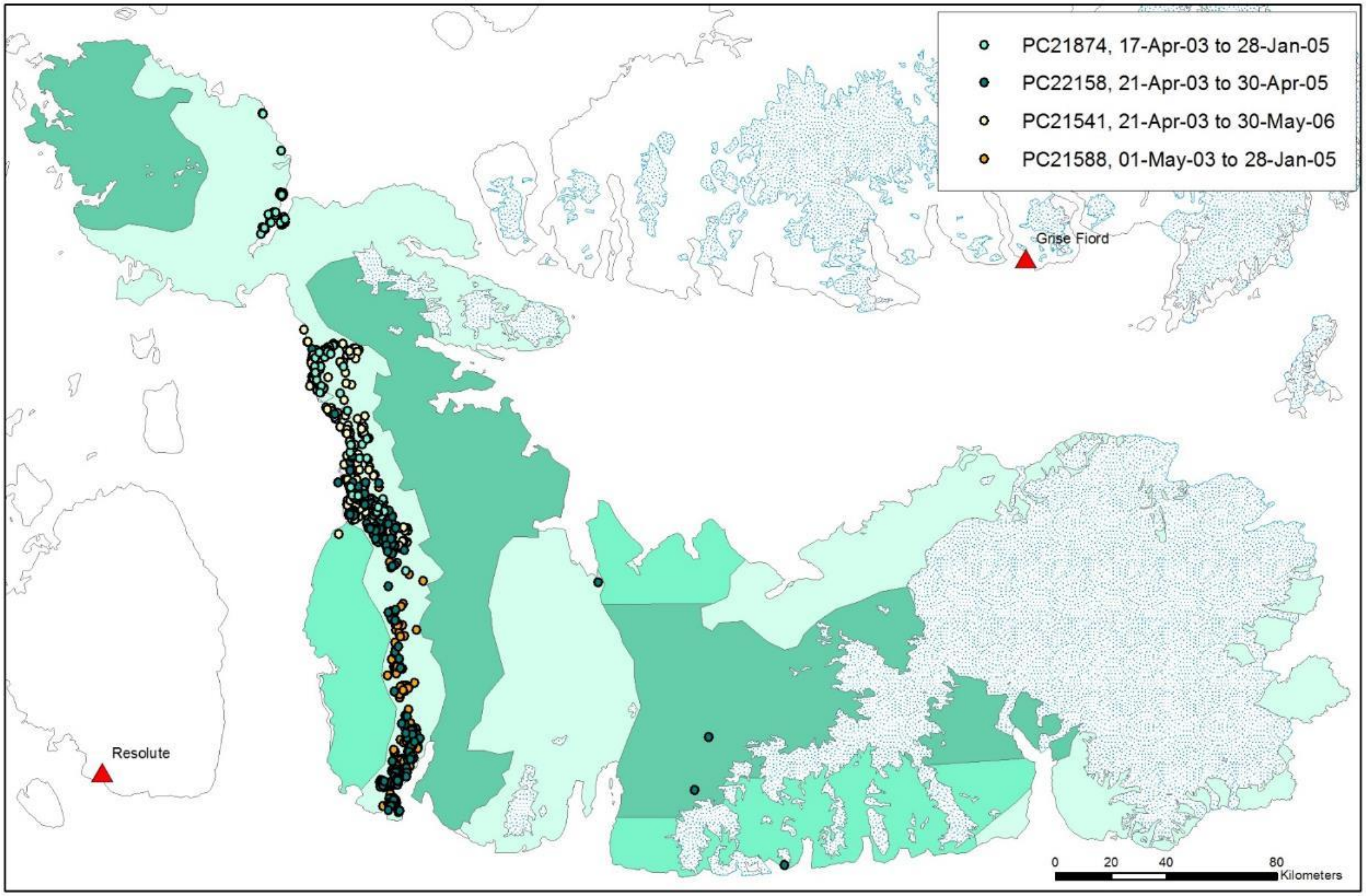


Figure 9. Telemetry locations of 4 collared female caribou, 2003-2006, on Devon Island. Survey strata are indicated by shaded green – high density (pale green), intermediate density (bright green), low density (dark green).

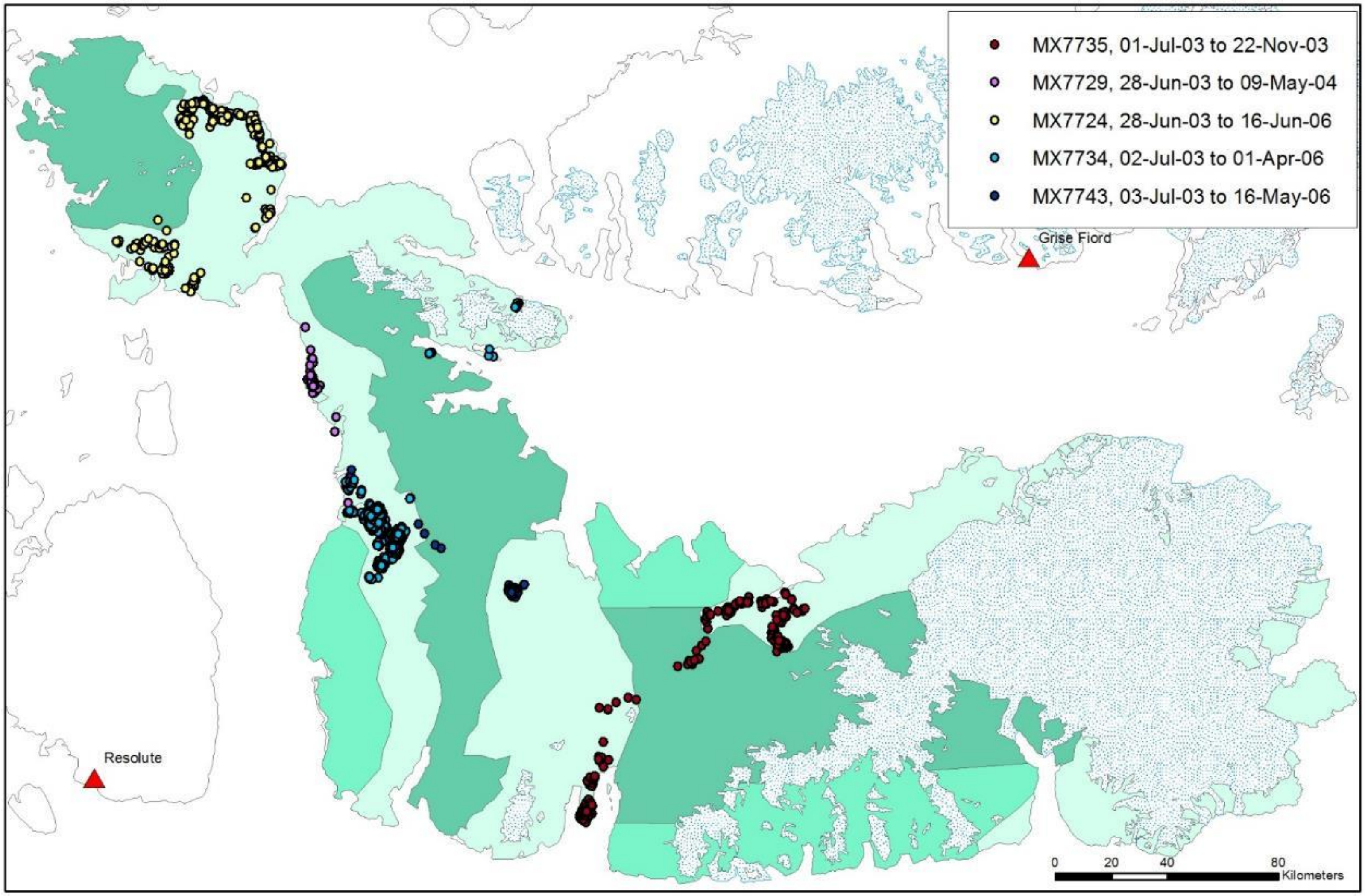


Figure 10. Telemetry locations of 5 collared female muskoxen, 2003-2006, on Devon Island. Survey strata are indicated by shaded green – high density (pale green), intermediate density (bright green), low density (dark green).

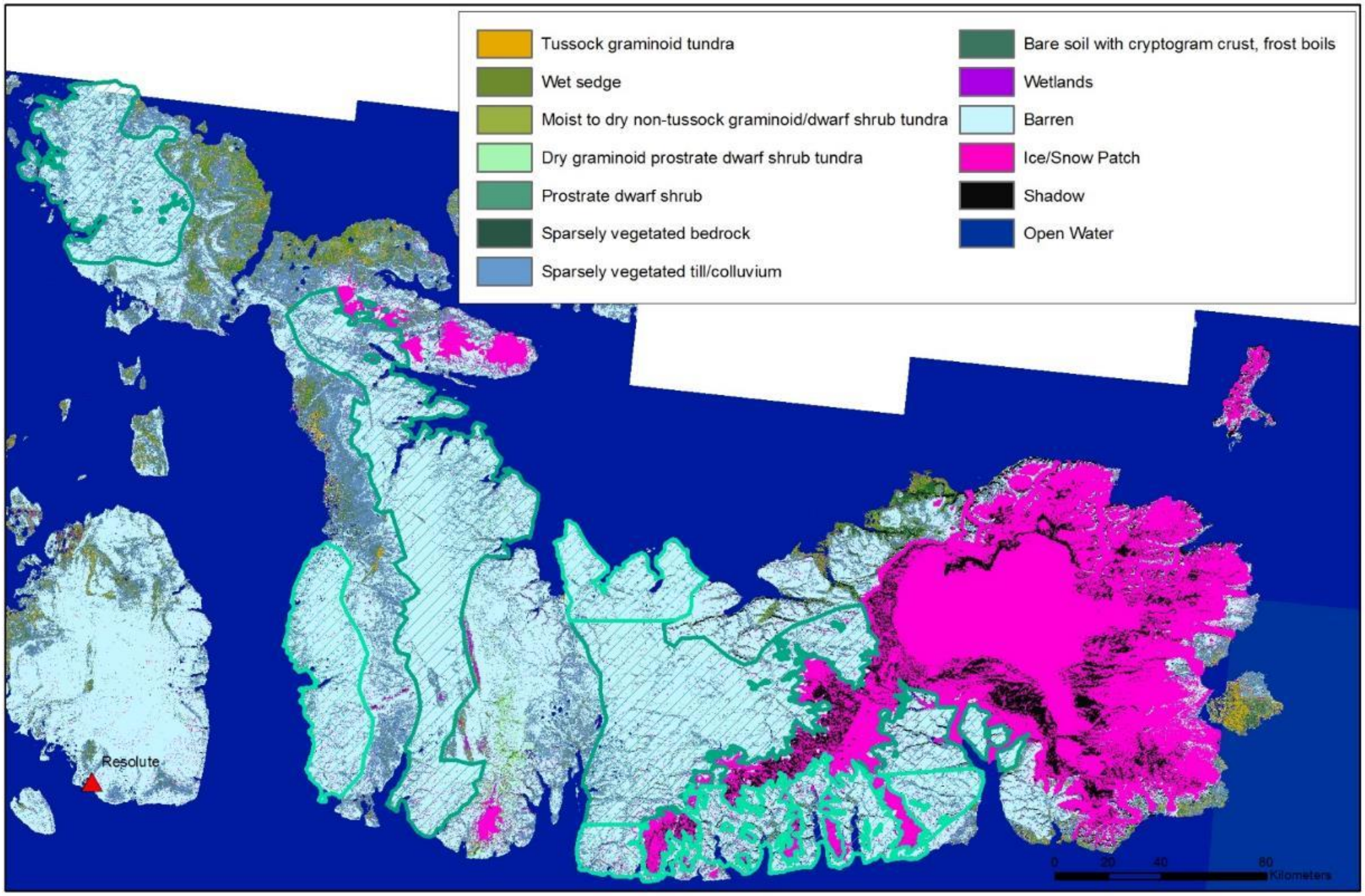


Figure 11. Land cover classification developed from Landsat imagery 1999-2002 (Olthof et al. 2008; available online through Natural Resources Canada). Survey strata are outlined and hatched by light green (intermediate density) or dark green (low density), with remaining non-icecap areas as high density strata.

Appendix 3. Alternate population calculations.

Jolly Method II Calculations

In this report, we used a systematic sampling approach to analysis, since we were estimating abundance of a patch population rather than estimating density in a habitat (which varied across the study area). Other systematic aerial surveys have frequently used Jolly's Method II, and estimates derived from both analyses were similar. Population estimates for fixed-width strip sampling using Jolly's Method 2 for uneven sample sizes (Jolly 1969; summarized in Caughley 1977) are derived as follows:

$$\hat{Y} = RZ = Z\frac{\sum_i y_i}{\sum_i z_i}$$

Where $\hat{Y}$ is the estimated number of animals in the population, R is the observed density of animals (sum of animals seen on all transects $\sum_i y_i$ divided by the total area surveyed $\sum_i z_i$), and Z is the total study area. The variance is given by:

$$Var(\hat{Y}) = \frac{N(N-n)}{n}\left(s_y^2 - 2Rs_{zy} + R^2 s_z^2\right)$$

Where N is the total number of transects required to completely cover study area Z, and n is the number of transects sampled in the survey. s_y^2 is the variance in counts, s_z^2 is the variance in areas surveyed on transects, and s_{zy} is the covariance. The estimate $\hat{Y}$ and variance $Var(\hat{Y})$ are calculated for each stratum and summed. The Coefficient of Variation (CV = σ/$\hat{Y}$) was calculated as a measure of precision.

Table 5. Abundance estimates (Jolly 1969 Method II) for muskoxen on Devon Island, March 2016. *N* is the total number of transects required to completely cover study area *Z*, *n* is the number of transects sampled in the survey covering area *z*, *y* is the observed muskoxen, *Y* is the estimated muskoxen with variance Var(*Y*). The coefficient of variation (CV) is also included.

Stratum	**Y**	**Var(Y)**	**n**	**Z (km²)**	**z (km²)**	**N**	**y**	**Density (per km²)**	**CV**
A	1815.81	39767.06	117	18438.26	3479.02	288	344	0.098	0.110
B	95.85	847.56	21	6359.77	597.17	138	9	0.015	0.400
C	27.77	undefined	28	15076.34	1085.68	288	2	0.002	
Total	1939.43		166	39874.37	5161.87	288	355		

Table 6. Abundance estimates (Jolly 1969 Method II) for Peary caribou on Devon Island, March 2016. *N* is the total number of transects required to completely cover study area *Z*, *n* is the number of transects sampled in the survey covering area *z*, *y* is the observed caribou, *Y* is the estimated caribou with variance Var(*Y*). The coefficient of variation (CV) is also included.

Stratum	**Y**	**Var(Y)**	**n**	**Z (km²)**	**z (km²)**	**N**	**y**	**Density (per km²)**	**CV**
A	70.46	1806.83	117	18438.26	3479.02	288	13	0.004	0.603
B	0		21	6359.77	597.17	138	0	0	
C	0		28	15076.34	1085.68	288	0	0	
Total	70.46		166	39874.37	5161.87	288	13		

Stratified Systematic Survey Calculations
Following Cochran (1977), the abundance estimate for a systematic survey is given by:

$$\hat{Y} = \frac{S}{w} \times \sum n_i$$

Where $\hat{Y}$ is the population estimate, *S* is the transect spacing (5 km), *w* is the transect width (1 km), and n_i is the total number of animals observed on transect *i*, the sum of which is all animals observed on *I* transects in the survey. The configuration of the study area may mean that the actual sampling fraction (proportion of the study area that is surveyed) varies, which was partly why Cochran's ratio estimator was used instead, and why the estimate varied between methods and stratification regimes. The variance is based on the sum of squared differences in counts between consecutive transects:

$$Var(\hat{Y}) = \frac{\frac{S}{w} \times \left(\frac{S}{w} - 1\right) \times I}{2 \times (I - 1)} \times \sum (n_i - n_{i-1})^2$$

Table 7. Abundance estimates for a stratified systematic survey (Cochran 1977) of muskoxen on Devon Island, March 2016. *I* is the number of transects sampled.

Stratum	**Estimated Abundance $\hat{Y}$**	**Var($\hat{Y}$)**	**I**	**Transect Spacing S (km)**	**Transect Width w (km)**	**Observed Individuals y**	**Density (per km^2)**	**CV**
A	1720	67436.38	117	5	1	344	0.098	0.151
B	90	2740.50	21	10	1	9	0.015	0.582
C	30	871.11	28	15	1	2	0.002	0.984
Total	1840	71047.99	166			355		

Table 8. Abundance estimates for a stratified systematic survey (Cochran 1977) of Peary caribou on Devon Island, March 2016. *I* is the number of transects sampled.

Stratum	**Estimated Abundance $\hat{Y}$**	**Var($\hat{Y}$)**	**I**	**Transect Spacing S (km)**	**Transect Width w (km)**	**Observed Individuals y**	**Density (per km^2)**	**CV**
A	65	67436.38	117	5	1	13	0.004	0.557
B	0	2740.50	21	10	1	0	0	
C	0	871.11	28	15	1	0	0	
Total	65	71047.99	166			13		

Appendix 4. Daily flight summaries for Devon Island survey flown by Twin Otter, March 2016.

Table 9. Summary by day of survey flights and weather conditions for March 2016 Peary caribou and muskox survey, Devon Island.

Date	Time Up	Time Down	Time Up 2	Time Down 2	Time Up 3	Time Down 3	Flying Time	Transect Time	Area	Comment
22-Mar-16	9:35	13:15	13:54	17:15			7:01	4:18	Grinnell Peninsula	Clear, calm, -31°C, light wind ~20 kph at Arthur Fiord for fuel; right engine 'hiccup' but likely just water/ice in fuel line and fixed itself
23-Mar-16	10:00	13:45					3:45	1:03	Grinnell Peninsula	Sunny clear calm -32°C except severe/moderate turbulence in hills s of Arthur Fiord; left generator not working so only one flight
24-Mar-16	9:05	13:20	14:25	17:35			7:25	4:59	Colin Archer Peninsula; west coast	Clear -32°C slight wind N/NW ice crystals
25-Mar-16	8:45	13:00	13:41	17:34			8:08	5:17	West coast	Clear -32°C with ice crystals/fog along south shore (unable to fly below 3000' so moved north); burning off in pm
26-Mar-16	9:08	13:35	14:15	18:11			8:23	5:28	West central	-29°C clear some cloud/ice crystals/foggy cover at south end but burned off in pm. Late start/one flight since autofeather not engaging.
27-Mar-16	10:07	12:41					2:34	0:51	YRB-YGF, some lines in between	-29°C clear, some low cloud west of transects
28-Mar-16	8:34	12:46	13:26	13:56	14:41	17:30	7:31	3:27	Truelove and east coast	-30°C calm clear, landed at Truelove cache and scraped teflon off the left ski, so no more offstrip until its back to YRB for repair
29-Mar-16	7:50	12:00	12:46	16:25			7:49	16:13	Dundas Harbor and south coast	-30°C clear calm, some cloud south over Lancaster Sound
30-Mar-16	9:54	13:05					3:11	1:35	YGF-YRB, some lines in between	-30°C clear calm

Pilots – Phil Amos, Reagan Schroeder; Navigator - Morgan Anderson

Observers:
Mar 22 – Morgan Anderson, Saroomie Manik, PJ Attagootak, James Iqaluk, Oolat Iqaluk
Mar 23 – Morgan Anderson, Saroomie Manik, PJ Attagootak, James Iqaluk, Oolat Iqaluk
Mar 24 – Morgan Anderson, Saroomie Manik, PJ Attagootak, James Iqaluk, Oolat Iqaluk
Mar 25 – Morgan Anderson, PJ Attagootak, Debbie Iqaluk, Oolat Iqaluk
Mar 26 – Morgan Anderson, PJ Attagootak, Debbie Iqaluk, Oolat Iqaluk
Mar 27 – Morgan Anderson, PJ Attagootak
Mar 28 – Morgan Anderson, Jopee Kiguktak, Aksakjuk Ningiuk, Frankie Noah, Simon Singoorie, Olaph Christianson
Mar 29 – Morgan Anderson, Jopee Kiguktak, Aksakjuk Ningiuk, Frankie Noah, Simon Singoorie, Junior Kakkee
Mar 30 – Morgan Anderson, PJ Attagootak

Appendix 5. Incidental wildlife observations.

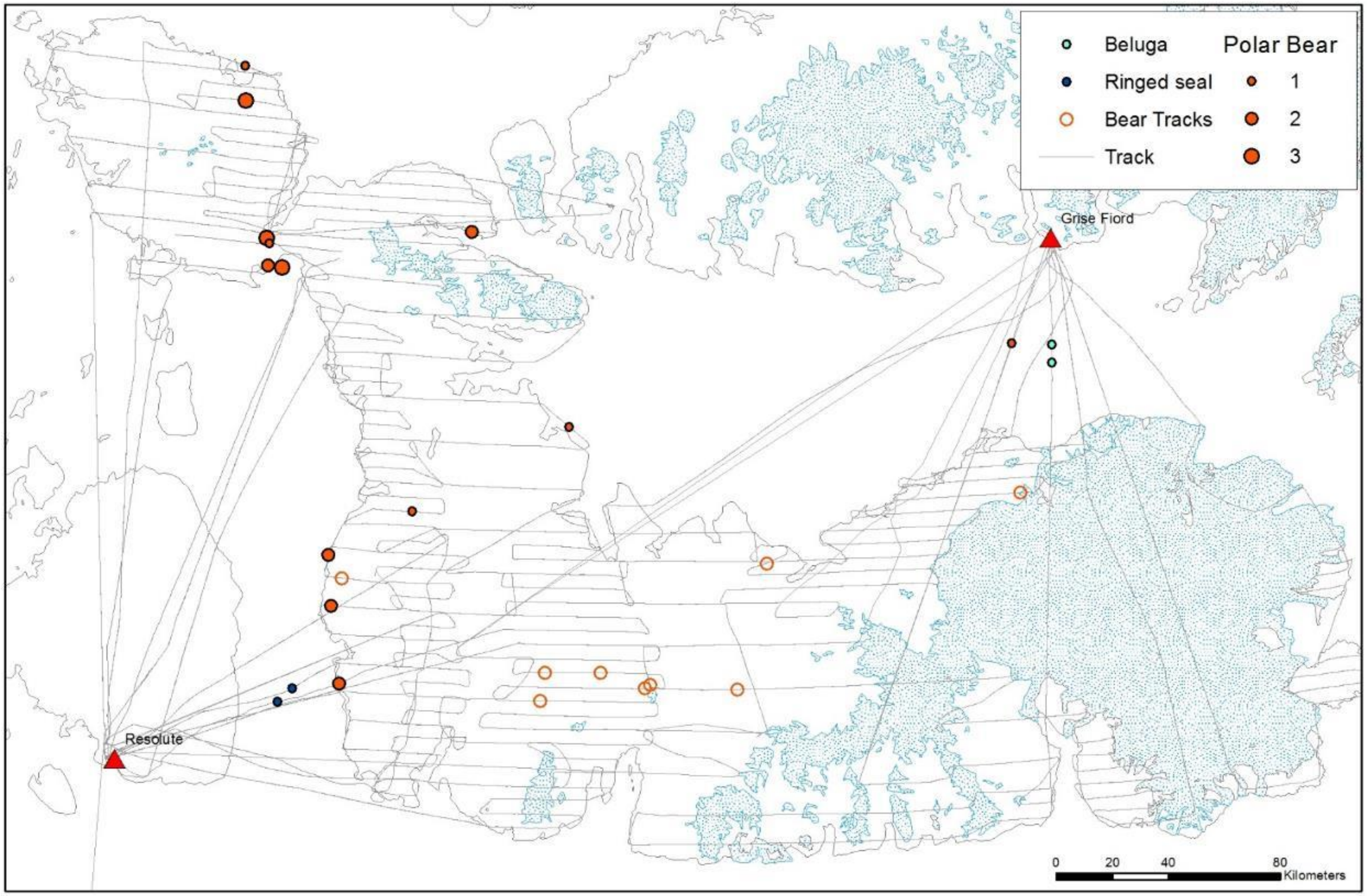


Figure 12. Incidental observations, Mar 22-30 2016, and flight lines for an aerial survey of Devon Island. Some track lines are incomplete due to loss of satellite coverage. A total of 37 polar bears were observed, as well as 5 ringed seals basking on the sea ice in Wellington Channel, and 2 groups of beluga (6 and 7 individuals) along the floe edge south of Grise Fiord. Polar bear family groups included very small cubs recently emerged from dens, and one den was seen with tracks, 40 km northwest of Maxwell Bay.

DISTRIBUTION AND ABUNDANCE OF MUSKOXEN (*Ovibos moschatus*) AND PEARY CARIBOU (*Rangifer tarandus pearyi*) ON PRINCE OF WALES, SOMERSET, AND RUSSELL ISLANDS, AUGUST 2016

MORGAN ANDERSON[1]

Version: 13 September 2016

[1]Wildlife Biologist High Arctic, Department of Environment
Wildlife Research Section, Government of Nunavut Box 209 Igloolik NU X0A 0L0

STATUS REPORT 2016-06
NUNAVUT DEPARTMENT OF ENVIRONMENT
WILDLIFE RESEARCH SECTION
IGLOOLIK, NU

Anderson, M. 2016. Distribution and abundance of muskoxen (*Ovibos moschatus*) and Peary caribou (*Rangifer tarandus pearyi*) on Prince of Wales, Somerset, and Russell islands, August 2016. Nunavut Department of Environment, Wildlife Research Section, Status Report 2016-06, Igloolik, NU. 27 pp.

Summary

We flew a survey of Prince of Wales, Somerset, Russell, Pandora, and Prescott islands (Muskox Management Zone MX-06), by Turbine Otter and Twin Otter in 82 hours between August 5 and 23, 2016, to update the population estimate for Peary caribou and muskoxen in the study area. The previous survey, in 2004, did not detect any Peary caribou, although ground surveys the following year found two groups of seven caribou on Somerset Island. The survey provided a population estimate of 3,052± SE 440 muskoxen on Prince of Wales and Somerset islands (including smaller satellite islands), with 1,569 ± SE 267 on Prince of Wales, Pandora, Prescott, and Russell islands, and 1,483 ± SE 349 muskoxen on Somerset Island. The 2016 survey results suggest a decline from the mid-1990s, but no clear decline from the 2004 estimates of 2,086 muskoxen on Prince of Wales/Russell islands (1,582-2,746, 95% CI) and 1,910 muskoxen on Somerset Island (962-3,792 95% CI; Jenkins et al. 2011). No Peary caribou were seen on the survey, but two Peary caribou were seen by hunters searching rugged terrain along the west coast of Somerset Island south of Aston Bay. The consistent lack of observations of Peary caribou suggest that the population has not recovered from the precipitous decline in the late 1980s and early 1990s.

ᐅᓂᒃᑳᖅᓯᒪᓂᖏᑦ

ᖁᓀᑰᓚᐅᕋᑦᑕ ᕿᒻᒪᓗᐃᓀᑉ, ᑰᓐᒐᓇᔩᑉ, ᐃᓐᓂᓕᖅᓯᒪᔩᑉ, ᐊᕿᑦᑐᓕᐅᑉ ᖃᖃᖅᑕᐅᑉ, ᐊᒻᒪᓗ ᖃᖃᖅᑕᕈᓘᑉ ᓇᐅᔭᓕᐅᑉ ᖁᓀᒍᑦ (ᐅᒥᖕᒪᖕᓂᒃ ᐊᐅᓚᑎᕝᕕᐅᓂᐅᔪᖅ ᐃᓂᐅᔪᖅ MX-06), ᐊᑕᐅᓯᓕᒃᑰᖅᓱᑕ 82-ᓄᑦ ᐃᑲᕐᕋᓄᑦ ᐅᑯᐊ ᐅᓪᓗᑦ ᐊᑯᓐᓂᖓᓂ ᐊᐅᒍᓯ 5 ᐊᒻᒪᓗ 23, 2016-ᒥ, ᒫᓇᓕᕆᙵᖅᑎᓐᓇᓱᐊᖅᓱᖏᑦ ᐅᓄᕐᓂᔪᑦ ᒥᒃᓴᐅᑕᐅᓯᒪᔪᑦ ᖁᑎᒃᑑᑉ ᑐᒃᑐᖏᑦ ᐊᒻᒪᓗ ᐅᒥᖕᒪᐃᑦ ᑕᐅᕗᓂ ᖃᐅᔨᓴᕐᕕᐅᔪᒥ. ᓯᕗᓂᐊᒍᑦ ᖃᐅᔨᓴᕐᓂᐅᓚᐅᖅᓯᒪᔪᖅ, 2004-ᒥ, ᖃᐅᔨᕝᕕᐅᓚᐅᖏᑦᑐᖅ ᑐᒃᑐᑕᕐᑲᕐᓂᖓᓂᒃ ᖁᑎᒃᑑᑉ ᑐᒃᑐᖏᓐᓂᒃ, ᐊᕐᕌᒍᑎᓪᓗᒍ ᑭᓯᐊᓂ ᒪᓂᕐᑲᒃᑯᑦ ᖃᐅᔨᓴᕐᓂᕐᒥ ᒪᕐᕉᓂᒃ ᑐᒃᑑᖅᑲᑎᒌᓂᒃ 7 ᐅᓪᓗᑎᒃ ᓇᓂᓯᓚᐅᖅᓯᒪᔩᓗᒍᐊᑦ ᑕᐅᕙᓂ ᑰᓗᓇᔩᑉ ᖃᖃᖅᑕᖓᓂ. ᖃᐅᔨᓴᕐᓂᕐᒥᑦ ᖃᐅᔨᔭᐅᔪᑦ ᐅᓄᕐᓂᐅᔪᑦ ᒥᒃᓴᐅᑕᐅᓯᒪᔪᑦ 3,052± ᓂᕆᐅᓪᓗ ᑲᓇᖕᓇᐅᓪᓗ ᐊᑯᓐᓂᖓᓂ 440-ᐅᓪᓗᑎᒃ ᐅᒥᖕᒪᑦ ᑕᐅᕙᓂ ᕿᒻᒪᓗᐃᓀᑉ ᐊᒻᒪᓗ ᑰᓗᓇᔩᑉ ᖃᖃᖅᑕᖓᓂ (ᐱᖃᓯᐅᑎᓪᓗᒋᑦ ᒥᑭᓐᓂᖅᓴᐅᔪᑦ ᖃᖃᖅᑕᓗᓇᐃᑦ), ᐃᒪᓐᓇᐅᑎᒋᓪᓗᑎᒃ 1,569 ± ᓂᕆᐅᓪᓗ ᑲᓇᖕᓇᐅᓪᓗ ᐊᑯᓐᓂᖓᓂ 267-ᖑᓪᓗᑎᒃ ᑕᐅᕙᓂ ᕿᒻᒪᓗᐃᓀᑉ, ᐊᕿᑦᑐᓕᐅᑉ ᖃᖃᖅᑕᐅᑉ, ᖃᖃᖅᑕᕈᓘᑉ ᓇᐅᔭᓕᐅᑉ, ᐊᒻᒪᓗ ᐃᓐᓂᓕᖅᓯᒪᔩᑉ ᖃᖃᖅᑕᖏᓐᓂ, ᐊᒻᒪᑦᑕᐅᖅ 1,483 ± ᓂᕆᐅᓪᓗ ᑲᓇᖕᓇᐅᓪᓗ ᐊᑯᓐᓂᖓᓂ 349-ᖑᓪᓗᑎᒃ ᐅᒥᒻᒪᑦ ᑕᐅᕙᓂ ᑰᓗᓇᔩᑉ ᖃᖃᖅᑕᖓᓂ. 2016-ᒥ ᖃᐅᔨᓴᕐᓂᕕᓂᕐᓂᑦ ᐱᓯᒪᔪᑦ ᓇᓗᓇᐃᖅᓯᓯᒪᖕᒪᑕ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᐊᔪᓂᒃ ᑕᐃᒪᖕᒐᑦ 1990-ᖏᓐᓂᑦ, ᑭᓯᐊᓂ ᐅᓄᕈᓐᓃᖅᐸᓪᓕᐊᓂᕋᐃᓯᒪᓇᑎᒃ ᓇᓗᓇᐃᖅᓯᒪᔪᒃᑯᑦ ᑕᐃᑲᖕᒐᙵᓂᑦ 2004-ᒥᑦ ᒥᒃᓴᐅᑕᐅᓯᒪᔪᑦ 2,086 ᐅᒥᖕᒪᐃᑦ ᑕᐅᕙᓂ ᕿᒻᒪᓗᐃᓀᑉ/ᐃᓐᓂᓕᖅᓯᒪᔩᑉᓗ ᖃᖃᖅᑕᖏᓐᓂ (1,582-2,746, 95% CI) ᐊᒻᒪ 1,910 ᐅᒥᖕᒪᐃᑦ ᑕᐅᕙᓂ ᑰᓗᓇᔩᑉ ᖃᖃᖅᑕᖓᓂ (962-3,792 95% CI; Jenkins et al. 2011). ᑕᑯᔭᖅᑲᓚᐅᙱᑦᑐᖅ ᖁᑦᑎᒃᑑᑉ ᑐᒃᑐᖏᓐᓂᒃ ᐊᖑᓇᑦᑎᓂᑦ ᕿᓂᖅᑐᓂᑦ ᒪᓂᑐᕈᔪᖕᒥ ᐅᐊᖕᓇᖅᐸᓯᐅᔪᒥ ᓯᓪᔭᖅᐸᓯᖕᒥ ᑰᓗᓇᔩᑉ ᖃᖃᑖᓂ ᓂᕆᐊᓂ Aston ᑲᖏᕐᓗᐊᓂ. ᓇᐅᑦᑎᖅᓱᖅᑕᐅᑦᑎᐊᖕᒋᓐᓂᖏᓐᓄᑦ ᖁᑎᒃᑑᑉ ᑐᒃᑐᖏᑦ ᓇᓗᓇᖏᓚᑦ ᑕᐃᒃᑯᐊ ᐅᓄᕐᓂᐅᔪᑦ ᖃᓄᐃᓕᕗᓪᓕᐊᓗᐊᖏᑦᑐᑦ ᐅᓄᕈᓐᓃᓗᐊᓚᐅᖅᓯᒪᓪᓗᑎᒃ ᑕᐅᕙᓂ 1980-ᖏᓐᓂ ᐊᒻᒪᓗ 1990 ᐱᒋᐊᕐᓂᖏᓐᓂ.

Contents

List of Figures

List of Tables

Introduction

Peary caribou (*Rangifer tarandus pearyi*) are a small, light-coloured subspecies of caribou inhabiting the Canadian Arctic Archipelago. They were listed as Endangered in Canada under the Species at Risk Act (SARA) in 2011, largely due to precipitous declines caused by severe weather events in the 1990s. Lack of scientific information and, across much of their range, lack of local knowledge about the populations, has made research and management of Peary caribou difficult. A federal Recovery Strategy is currently in draft form, based on a Knowledge Assessment drawing on Inuit Qaujimajatuqangit (IQ), local knowledge, and scientific information (Johnson et al. 2016). A territorial management plan is under review at the Nunavut Wildlife Management Board (DOE in prep). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) down-listed Peary caribou from Endangered to Threatened in November 2015, in recognition of recent population increases in important populations on Melville and Bathurst islands, and apparently stable population trends in other areas. Peary caribou are still listed under SARA as Endangered.

Historically, Prince of Wales Island, Somerset Island and the Boothia Peninsula supported a thriving population of Peary caribou at the southern edge of their range. Peary caribou migrated from winter ranges on Somerset Island and Boothia Peninsula to calve and spend the summer on Prince of Wales Island, Russell Island, and parts of Somerset Island to calve and spend the summer. Some Peary caribou also calved and spent the summer at the north end of the Boothia Peninsula. A late July survey in 1974 estimated 5,437 adults and calves on Prince of Wales Island (Fischer and Duncan 1976). In June 1975 there were 3,768, including calves (Fischer and Duncan 1976), and in July 1980 there were 3,952 (±474 SE not including calves; Gunn and Decker 1984). However, a 1995 survey counted only 5 animals (Gunn and Dragon 1998) and unsystematic helicopter searches in April 1996 found only 2 caribou on Somerset Island (Miller 1997). Miller (1997) suggested possibly as few as 100-200 caribou existed in the island complex at that time. The most recent survey, conducted by helicopter distance sampling, failed to locate any caribou on Somerset Island, although concurrent snowmobile ground surveys located 2 groups of 4 caribou, 1 set of tracks, and 1 feeding site on Somerset Island (Jenkins et al. 2011). The decline in Peary caribou on Prince of Wales and Somerset islands was predicted by Inuit familiar with the islands as a natural response to the high densities during the 1970s and early 1980s. Under favorable environmental conditions, a long, slow recovery of the populations on the islands is expected (Campbell 2006).

Peary caribou movements between Prince of Wales, Somerset, and the Boothia Peninsula occurred seasonally, and surveys of the Boothia have been infrequent, without distinguishing Peary caribou from mainland caribou. A geomagnetic survey conducted in summer/fall 2013 by Natural Resources Canada did not locate any Peary caribou on Boothia Peninsula/southern Somerset Island. Video footage of the survey is available, but the resolution is likely insufficient for using it to determine a population estimate of Peary caribou or muskoxen. Most Peary caribou from the inter-island/peninsula population would be expected to be on Prince of Wales and Somerset islands or their smaller satellite islands in August, so the Boothia Peninsula was not included in this survey. A different methodology may be required to allow Peary and barren-ground caribou to be accurately differentiated on the peninsula.

Muskoxen (*Ovibos moschatus*) are also present on the island group, and they have been increasing since the 1970s. In June 1974, Fischer and Duncan (1976) estimated 564 adult muskoxen on Prince of Wales Island, and none on Somerset or Russell islands. The islands were surveyed again in July 1975, with an estimate of 872 adult muskoxen on Prince of Wales Island

and none on Russell or Somerset Island (Fischer and Duncan 1976). In 1980, 29 muskoxen were seen on Somerset Island, none on Russell, and 1,126± SE 276 (1+ year old; Gunn and Decker 1984) on Prince of Wales. By 1995, the estimate for Prince of Wales Island (including Pandora Island) was 5,157± SE 414 (including calves), Russell Island had 102± SE 54 adult muskoxen, and Somerset Island had 1,140± SE 260 muskoxen (including calves; Gunn and Dragon 1998). The last survey, flown in 2004, estimated 1,582-2,746 (95%CI) adult muskoxen on Prince of Wales (including Pandora and Russell islands) and 962-3,792 adult muskoxen on Somerset Island (Jenkins et al. 2011). Hunters in Resolute Bay and Taloyoak report large numbers of muskoxen on the islands as well.

Study Area

Prince of Wales Island is mostly flat and low-lying, with abundant ponds and lakes in the south and western parts of the island, rising to rolling hills along the east coast and in the north, with a maximum elevation of 415 m ASL near Cape Hardy. Prescott and Vivian islands lie just east of Prince of Wales Island, separating Browne Bay from Peel Sound. Pandora Island, south of Prescott Island, is also in Peel Sound, at the mouth of Young Bay. Russell Island to the north is separated from Prince of Wales Island by the narrow Baring Channel. Somerset Island is dominated by a rolling barren plateau approximately 400 m ASL, deeply incised by river valleys. Productive lowlands around the Creswell River and Stanley Fletcher Basin transition into igneous hills along the west coast and south part of the island, where it is separated by narrow Bellot Strait from the Boothia Peninsula.

Mean July temperatures are 3-5°C in the north part of the study area, which is dominated by cushion-forb barrens on Somerset Island, and by cushion-forb barrens, cryptogam barrens, and prostrate dwarf shrub-graminoid tundra on Russell and Prince of Wales islands (Gould et al. 2003 and references therein). The southern part of the study area has mean July temperatures between 5-7°C. Southern Somerset Island is dominated by prostrate dwarf shrub-graminoid tundra and hemiprostrate dwarf shrub tundra (Gould et al. 2003). Southern Prince of Wales Island is dominated by prostrate dwarf shrub tundra, with some prostrate dwarf shrub-graminoid tundra and sedge-moss tundra (Gould et al. 2003).

The August 2016 aerial survey was flown to cover the same study area as the previous 2004 survey (Jenkins et al. 2011), by fixed-wing aircraft rather than helicopter. We used fixed-wing aircraft to address community concerns about the greater disturbance experienced by wildlife from helicopter overflights as well to improve our chances of safely completing the survey in an area prone to poor weather conditions.

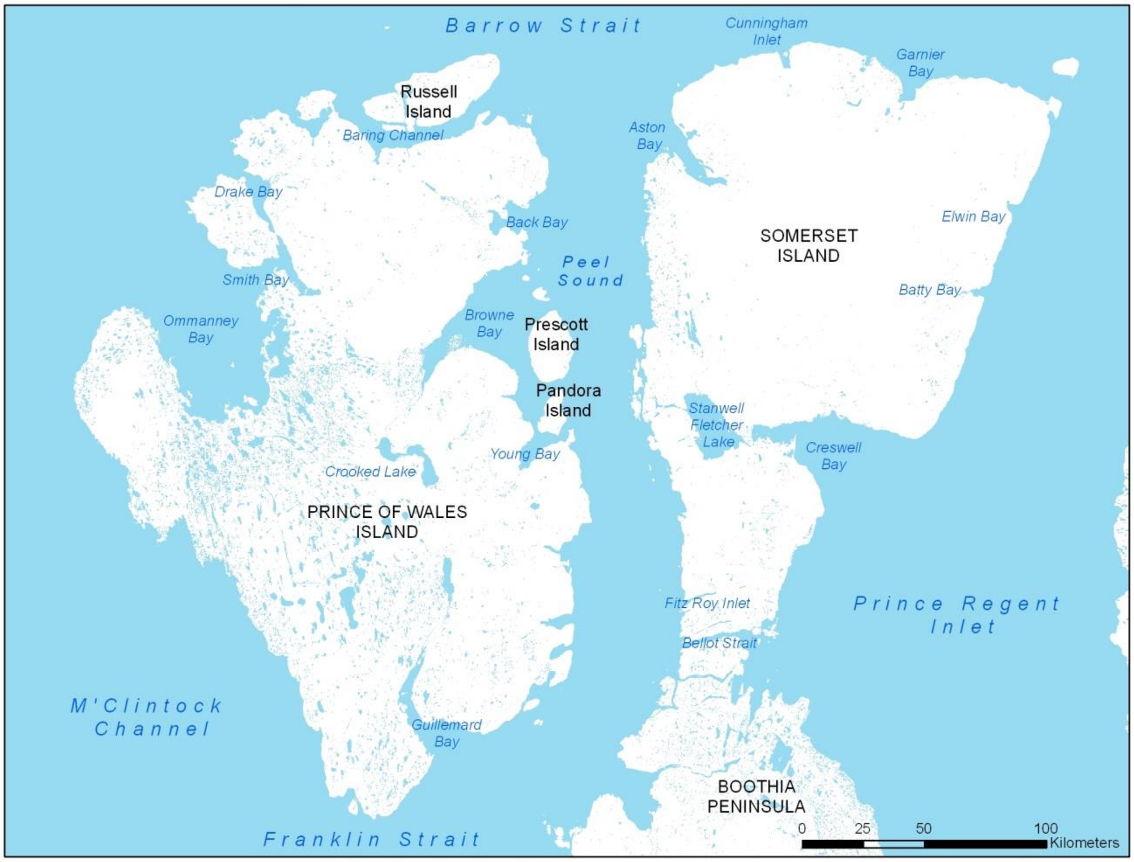


Figure 1. Major landmarks of the study area.

Methods

Aerial Survey

Survey transects (n=71, Appendix 1, Figure 2) were established to provide approximately 20% coverage in each stratum running east-west with a 800 m strip on either side of the aircraft. We stratified the study area by island only, with transects spaced 8.64 km apart on Prince of Wales Island and 10.16 km apart on Somerset Island.

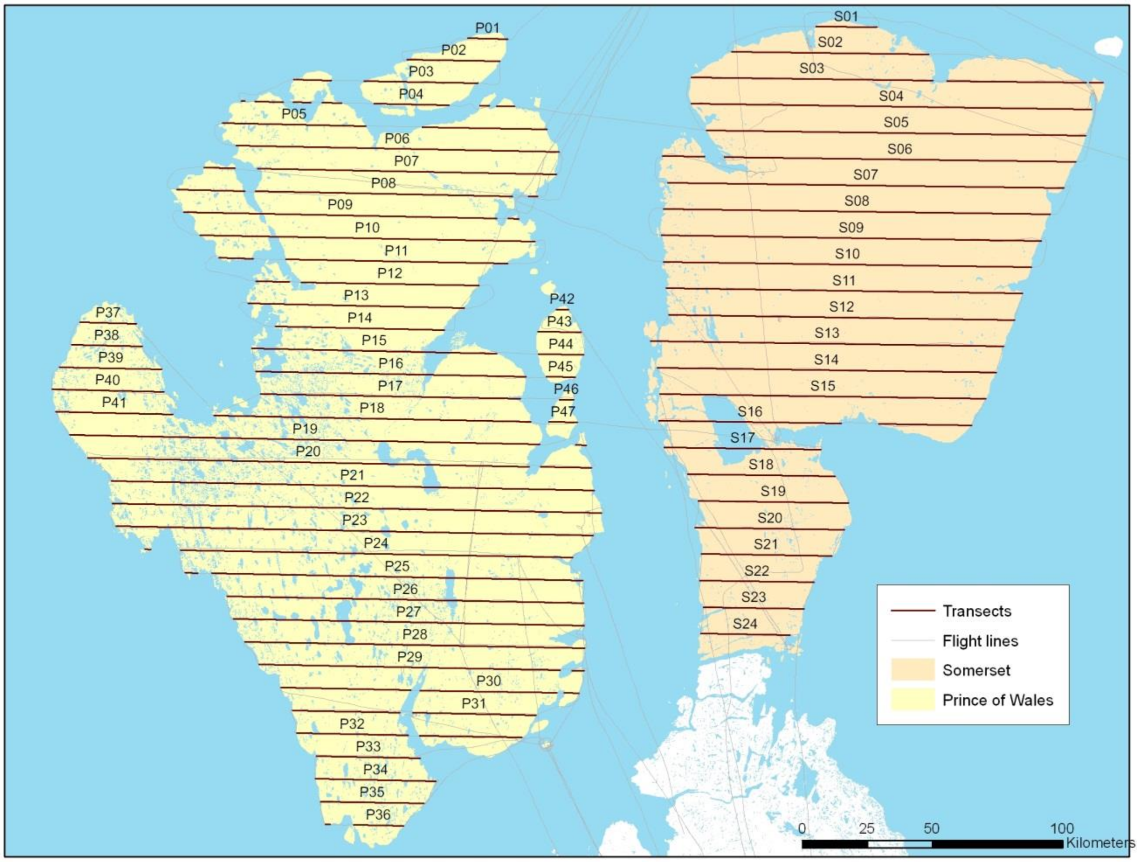


Figure 2. Transects and survey strata for Prince of Wales and Somerset islands, August 5-23, 2016. Transects on Prince of Wales are 8.64 km apart and transects on Somerset are 10.16 km apart.

To define the transect width, we marked survey aircraft wing struts following Norton-Griffiths (1978):

$$w = W\left(\frac{h}{H}\right)$$

where W is the strip width, H is the flight height, h is the observer height when the plane is on the ground and w is calculated, measured and marked on the ground to position wing strut marks (Figure 3). For this survey we used one mark representing 500 m, in anticipation of reduced detection of caribou beyond 500 m, and another mark for 800 m, to provide a strip for more readily detecting muskoxen. Fixed-wing strip transect sampling has been successfully used in the high arctic since 1961, and can be useful when observations are insufficient to determine the effective strip width required for distance sampling. An 800-m strip has been successfully used in the area previously for muskoxen on the islands (Gunn and Decker 1985, Gunn and Dragon 1998).

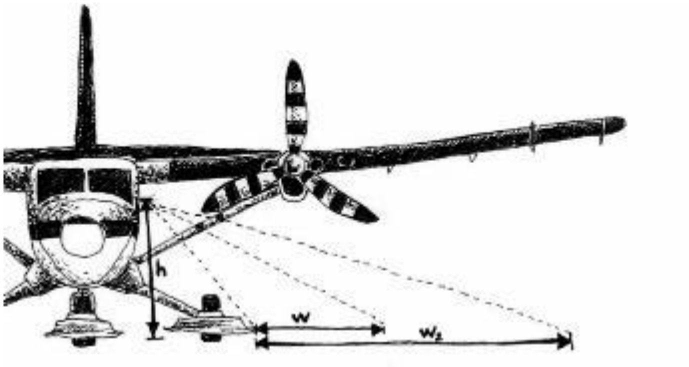


Figure 3. Derivation of wing strut marks for strip boundaries, where *w* and w_2 are calculated as described in the text, *h* is measured, and dotted lines indicate observer sightlines as modified from Norton-Griffiths (1978).

Most of the survey was flown with a DeHavilland Turbine Otter, but the air charter company was not able to stage out of Resolute, so the northern part of the survey area (transects P01-P14 and S01-S10) were flown with a DeHavilland Twin Otter with bubble windows stationed in Resolute. On both platforms we had 4-6 passengers (2 front observers, 2-4 rear observers, one of whom was also data recorder) in a co-operative double-observer set up (Campbell et al. 2012 for an overview of the methodology). Front and rear observers on the same side of the plane were able to communicate and all observations by front and rear observers were combined.

Transects were flown between 160-220 km/hr with higher speeds over flat uniform terrain where visibility was excellent. Surveys were only conducted on good visibility days to facilitate detection of animals, as well as for operational reasons to ensure crew safety. Flight height was set at 152 m (500 ft) using a radar altimeter. In rugged terrain, the flight height was adhered to as closely as possible within the constraints of crew safety and aircraft abilities.

Observations were recorded on a handheld Garmin Montana 650 global positioning system (GPS) unit, which also recorded the flight path every 15 seconds. Sex and age classification was limited, since the aircraft did not make multiple passes (to minimize disturbance), but adult/calf determination was possible for muskoxen and aided by binoculars and therefore recorded. However, the small size of calves and their close association with other animals in the herd made them difficult to count accurately when muskoxen were tightly grouped. Muskoxen were frequently spotted more than a kilometer off transect due to their large aggregations and dark colour, but depending on distance and topography, an accurate count could not always be determined for distant groups and they are not included in determination of adult-calf ratios. GPS tracks and waypoints were downloaded through DNR-GPS and saved in Garmin GPS eXchange Format and as ESRI shapefiles. Data was entered and manipulated in Microsoft Excel and ArcMAP 10.0 (ESRI, Redlands, CA).

Analysis

Flights linking consecutive transects were removed for population analysis and sections of transect crossing bays and inlets were removed, as these areas were not included in the area used for density calculations. Transect segments crossing lakes were retained and lake areas were not subtracted from the total area of the strata. Distances and lengths were calculated using a North Pole azimuthal equidistant projection centered over the study area at N73° and W96°;

areas were calculated using a North Pole Lambert azimuthal equal area projection centered on the same coordinates.

Although Jolly's (1969) Method II is widely used for population estimates from surveys, it is designed for a simple random survey design, rather than for a systematic survey of a patchy population. For comparison, population calculations following Jolly's Method II are provided in Appendix 3, along with calculations following a systematic stratified survey design (Cochran 1977). The muskoxen detected in this survey were patchily distributed and serially correlated, not randomly distributed. For systematic samples from serially correlated populations, estimates of uncertainty based on deviations from the sample mean are expected to be upwardly biased and influenced by the degree of serial correlation; high serial correlation implies that there is less random variation in the unsurveyed sections between systematically spaced transects than if serial correlation were low (Cochran 1977). Calculating uncertainty based on nearest-neighbor differences incorporates serial correlation, and the upward bias in the uncertainty is expected to be less than if it were calculated based on deviations from the sample mean. Nearest-neighbor methods have been used previously to calculate variance around survey estimates on the unweighted ratio estimate (Kingsley et al. 1981, Stirling et al. 1982, Kingsley et al. 1985, Anderson and Kingsley 2015).

The model for observations on a transect survey following Cochran (1977) is:

$$y_i = Rz_i + \varepsilon_i\sqrt{z_i}$$

Where y_i is the number of observations on transect *i* of area z_i, R is the mean density and error terms ε_i are independently and identically distributed. In this model, the variance of the error term is proportional to the area surveyed. The best estimate of the mean density $\hat{R}$ is:

$$\hat{R} = \frac{\sum_i y_i}{\sum_i z_i}$$

The error sum of squares, based on deviations from the sample mean, is given by:

$$\left(\sum_i \frac{{y_i}^2}{z_i}\right) - \frac{(\sum_i y_i)^2}{\sum_i z_i}$$

The finite-population corrected error variance of $\hat{R}$ is:

$$Var(\hat{R}) = \frac{(1-f)}{(n-1)\sum_i z_i}\left(\left(\sum_i \frac{{y_i}^2}{z_i}\right) - \frac{(\sum_i y_i)^2}{\sum_i z_i}\right)$$

Where f is the sampling fraction and n is the number of transects. The sampling fraction also provides the scaling factor for moving from a ratio (population density) to a population estimate. It is calculated as $(\sum z_i)/Z$, where Z is the study area and $\sum z_i$ is the area surveyed. The irregular study area boundaries mean that f varies from the 20% sampling fraction expected from a 1-km survey strip and 5-km transect spacing.

If we were to apply a model $y_i = Rz_i + \varepsilon_i$ instead, then the variance of the error term would be independent of z, so the variance would depend on the number of items in the sample, but not their total size. This would lead to a least squares estimate of R of $\sum zy / \sum z^2$, rather than the more intuitive density definition and model for R presented above.

To incorporate serial correlation in the variance, we used a nearest-neighbor calculation, with the error sum of squares given by:

$$\sum_{i=1}^{n-1}\left(\frac{y_i^2}{z_i}+\frac{y_{i+1}^2}{z_{i+1}}-\frac{(y_i+y_{i+1})^2}{z_i+z_{i+1}}\right)$$

i.e. the sum of squared deviations from pairwise weighted mean densities. The nearest-neighbor error variance of $\hat{R}$ is:

$$Var(\hat{R}) = \frac{(1-f)}{(n-1)\sum_i z_i}\sum_{i=1}^{n-1}\left(\frac{y_i^2}{z_i}+\frac{y_{i+1}^2}{z_{i+1}}-\frac{(y_i+y_{i+1})^2}{z_i+z_{i+1}}\right)$$

Both variance calculations were applied to the survey data. In addition, calculations for these strata based on Jolly's (1969) Method II and Cochran's (1977) systematic survey models are provided in the appendices for comparison. For the final estimate, we used the nearest neighbor variance.

Population growth rates were calculated following the exponential growth function, which approximates growth when populations are not limited by resources or competition (Johnson 1996):

$$N_t = N_0 e^{rt} \qquad \text{and} \qquad \lambda = e^r,$$

where N_t is the population size at time t and N_0 is the initial population size (taken here as the previous survey in 2008). The instantaneous rate of change is r, which is also represented as a constant ratio of population sizes, λ. When r >0 or λ >1, the population is increasing; when r <0 or λ <1 the population is decreasing. Values of r ~0 or λ ~1 suggest a stable population.

Results

We flew surveys August 5-23, 2016 for a total of 82.0 hours not including positioning time, 53.8 hours by single Otter and the remainder by Twin, with a total of 39.9 hours on transect. Incidental wildlife sightings are presented in Appendix 5 and daily flight summaries are presented in Appendix 4. Visibility was excellent for most survey flights, although some fog and low cloud on Russell Island and northwestern Somerset Island required a second pass to ensure the areas were covered. We did not see any caribou on the survey, although hunters travelling from Creswell Bay by ATV did see two caribou on the west coast of Somerset Island south of M'Clure Bay and north of Fiona Lake. They believed there were more in the river valleys in the area, but were unable to confirm due to the rough terrain. We saw 1,264 muskoxen (769 on Prince of Wales Island and 495 on Somerset Island), including off transect sightings. This included 519 muskoxen on transect (288 on Prince of Wales Island and 231 on Somerset Island). Spatial data presented in Figure 4 represents waypoints taken during the survey along transects and includes on- and off-transect sightings, and except for groups observed on the transect line, waypoints have error associated with the group's distance from the plane. While observations on transect are within 800 m, some muskox groups off transect were more than 2 km away.

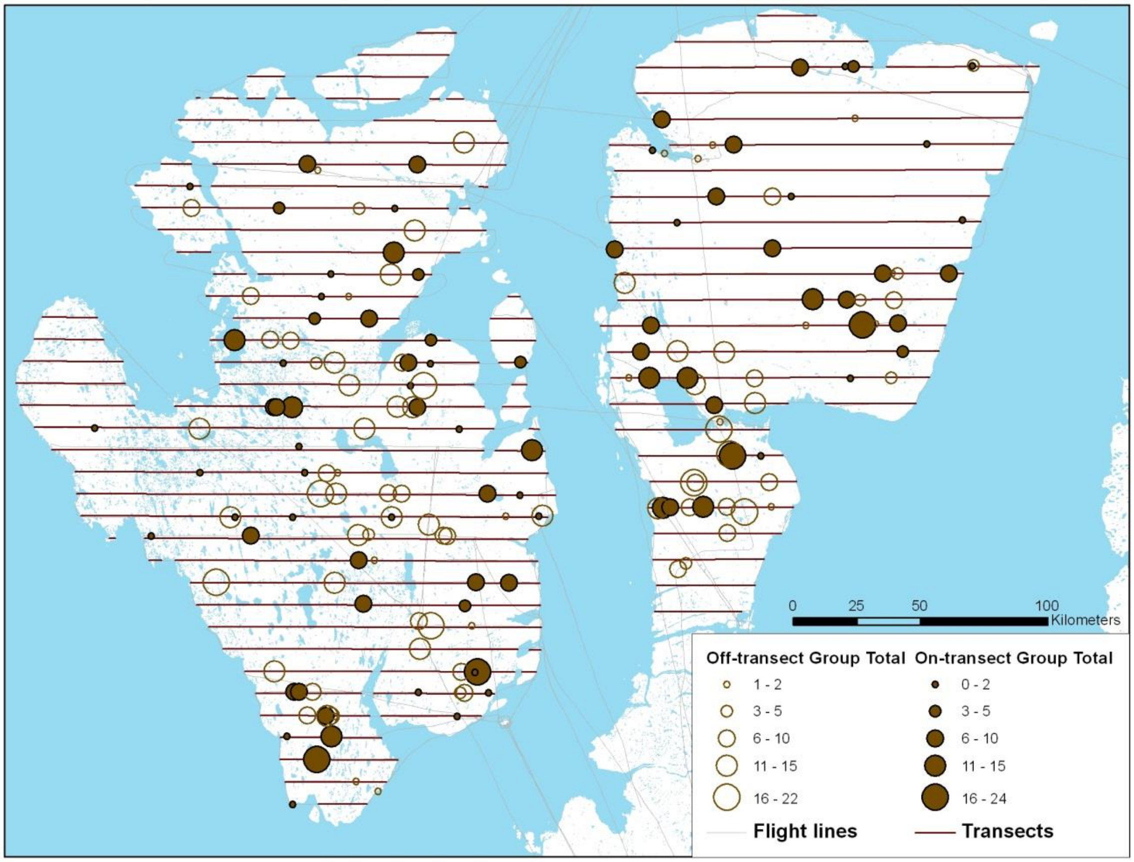


Figure 4. Observations of muskoxen on Prince of Wales and Somerset islands, August 2016, including observations on and off transect, and on ferry flights.

Abundance Estimates

Muskox population estimates and variances are presented in Table 1.

Table 1. Muskox population calculations for Prince of Wales and Somerset islands with variance calculated by nearest neighbor methods and by deviations from the sample mean.

	Prince of Wales		**Somerset**		**Total**	
Stratum area Z (km^2)	35592		25228		60820	
Surveyed area z (km^2)	6533		3929		10462	
Count, y	288		231		519	
Estimate, $\hat{Y}$	1569		1483		3052	
Density, $\hat{R}$ (muskox/km^2)	0.0441		0.0588		0.0496	
	Nearest Neighbor	*Deviations from sample mean*	*Nearest Neighbor*	*Deviations from sample mean*	*Nearest Neighbor*	*Deviations from sample mean*
Error Sum of Squares	21.125	21.527	21.424	19.725		
Var ($\hat{Y}$)	71157.6	72512.6	122096.1	112413.3	193253.7	184925.9
SE	267	269	349	335	440	430
CV	0.170	0.172	0.236	0.226	0.144	0.141

Since there were no observations of Peary caribou on the aerial survey in 2016, we were not able to calculate a population estimate. The observation of two caribou by hunters during the survey confirms that they are still present on the islands, but at such a low abundance that conventional aerial surveys are not able to detect them reliably or calculate a population estimate. A similar situation was encountered in 2004, when no caribou were seen on the aerial survey, but presence was confirmed during ground searches.

Population Trends

The variance associated with the population estimates in 2004 and 2016 makes it difficult to determine whether muskox populations are increasing, decreasing, or stable on Prince of Wales and Somerset islands. Using the population estimate for Prince of Wales Island (including Russell, Prescott, and Pandora islands) and Somerset Island in 2004 and 2016, the exponential growth rate *r* is -0.02 and the intrinsic growth rate λ is 0.98, which would suggest a slight decline. However, the 95% confidence intervals have large overlaps between 2004 and 2016 surveys: Somerset 2016 - 885-2,082 muskoxen, Somerset 2004 962-3,792 muskoxen; Prince of Wales 2016 – 1,121-2,017 muskoxen, Prince of Wales 2004 1,582-2,746 muskoxen.

Calf Recruitment

Yearlings could often be classified even in distant groups, but not consistently enough to facilitate accurate data collection. For this reason, only two age categories were used. Sixteen groups of muskoxen were too far away or grouped too closely to determine how many calves were present. However, we were able to classify the remaining 156 muskox groups as adults or calves, where adults were considered any animals over 1 year old. We classified the animals in these groups as 887 1+-year-old muskoxen and 192 calves, a calf to adult ratio of 0.214. Calves made up 17.8% of the population.

Group Size

We observed 172 groups of muskoxen, with group sizes ranging from single animals to 24 muskoxen, with an average of 7.3 muskoxen per group (SD=5.6). Considering only the 132 groups that were not single animals, the average group size was 9.3 muskoxen (SD=5.0).

Discussion

Population Trends - Caribou

Previous surveys of Prince of Wales and Somerset islands have used different survey platforms (Helio-Courier, Gunn and Decker 1984, Gunn and Dragon 1998; ground surveys, Jenkins et al. 2011; Bell 206 helicopter, Miller 1997, Jenkins et al. 2011; Turbine Otter and Twin Otter, this survey). They have also concentrated on different parts of the island, and been conducted at different times of year, which is an important consideration for a Peary caribou population that historically migrated between the islands and south to the Boothia Peninsula in winter.

Historically, Prince of Wales and Somerset islands supported a large population of Peary caribou. Although larger than Peary caribou further north on the Arctic Archipelago, they were still more closely related to Peary caribou than to the barren-ground caribou with which they shared winter range on Boothia Peninsula (McFarlane et al. 2014). Between 1928 and 1930 there was a die-off on Somerset Island, but caribou were still present and had increased by the late 1960s and reached high densities in the 1970s (IQ in Taylor 2005). In the 1950s and 1960s, hunters had to travel farther than Somerset Island to find Peary caribou, and reported finding some on Prince of Wales Island (IQ in Taylor 2005). By the 1970s, high densities of caribou were observed on Prince of Wales Island as well, and people became concerned that there were too many (IQ in Taylor 2005). In the 1980s and early 1990s, the population crashed by 98% from an estimated 6048 caribou in 1980 (Gunn and Decker 1984) to an estimated 100 caribou in 1995 (Gunn et al. 2006). When Prince of Wales and Somerset islands were flown in 1995, only 2 bulls and 3 cows were seen on Prince of Wales Island, and 2 cows on Somerset Island. In spring 1996, Miller (1997) flew extensive unsystematic helicopter searches of the islands and recorded only 2 caribou.

The decline was predicted by Inuit familiar with the caribou on these islands (IQ in Taylor 2005); however, the mechanism of the decline remains unknown. Gunn et al. (2006) examined possible reasons for the decline, and although no one factor was identified as the sole cause, the authors suggested it was likely due to a combination of low adult female survival and low calf and yearling recruitment, high annual harvest rates from Taloyoak and Resolute, and increasing predation pressure from a wolf population supported by an increasing and more sedentary muskox population. Reports of groundfast ice on Prince of Wales Island, likely in 1990 or 1991, may also have contributed to the decline (IQ in Taylor 2005, Gunn et al. 2006) and similar events have contributed to Peary caribou declines elsewhere in the Arctic Archipelago (Miller et al. 1975, Miller and Gunn 2003, Miller and Barry 2009). Mass movement of caribou off the islands is not believed to explain the decline (Gunn et al. 2006). Based on the known migration patterns, Boothia Peninsula would be the most likely place for island caribou to move, but although caribou on the Boothia Peninsula did increase over the time period of the Prince of Wales/Somerset decline, it was not enough to account for the decline (Gunn et al. 2006, Miller et al. 2007). Although caribou on Prince of Wales and Somerset islands cross north to Bathurst and Cornwallis islands and potentially west to Victoria Island or King William Island, no large influx of caribou on any of those islands was noted by harvesters or recorded during surveys at the time of the decline on Prince of Wales and Somerset islands (Gunn et al. 2006).

Regardless of the reasons for the original decline, caribou populations on Prince of Wales and Somerset islands have not recovered since the early 1990s, although some caribou are still present on the islands. The two caribou observed by local hunters were in an area where caribou had been previously encountered, and identified as important winter range by Russell and Edmonds (1977). There was no sea ice present around the islands group during August, including in Peel Sound, so we did not miss animals crossing between the islands over ice.

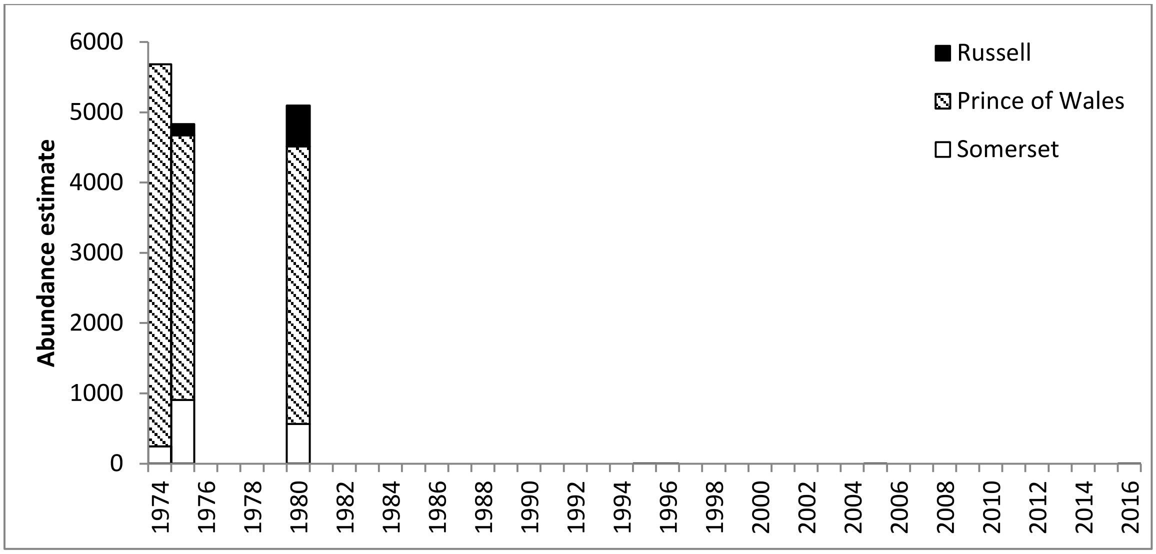


Figure 5. Population trends for Peary caribou on Prince of Wales, Somerset, and Russell islands, showing a catastrophic decline between 1980 and 1995. Surveys were conducted in June-July1974 and 1975 (Fischer and Duncan 1976), July 1980 (Gunn and Decker 1984), July-August 1995 (Gunn and Dragon 1998), April-May 1996 (Miller 1997), April 2004 and 2005 (Jenkins et al. 2011), and August 2016. Error bars are not shown and are not available for all estimates.

Although the 1985 estimate of Peary (or Peary-like) caribou on the Boothia Peninsula could account for some of the 'missing' Prince of Wales and Somerset island caribou, it is not clear how many Peary caribou persist on northern Boothia Peninsula. A survey in 2006 identified only one caribou that observers were confident was a Peary caribou, although the survey was not designed to differentiate between the two subspecies (Dumond 2006). No caribou were seen during aeromagnetic survey flights on northern Boothia Peninsula between Sept 7-Oct 4, 2013 (survey altitude was 150 m; W. Miles, Airborne Geophysics Section, Geological Survey of Canada, pers. comm.).If harvest levels in the 1980s and 1990s were maintained or increased, and if Peary caribou were selectively harvested, it is possible that the population on Boothia Peninsula was drawn down simultaneously with the Prince of Wales and Somerset islands caribou, even if some of them were resident on the Boothia Peninsula (Gunn and Ashevak 1990, Gunn and Dragon 1998, Gunn et al. 2006, Miller et al. 2007). Hunters in Taloyoak occasionally report catching smaller, fatter caribou with short faces and legs, but these characteristics are often mixed with classic barren-ground caribou traits.

Population Trends - Muskoxen

In 1975, Hubert (1975) estimated 2,381 muskoxen on Prince of Wales Island; Fischer and Duncan (1976) estimated 907 muskoxen for the same time frame, although their survey coverage was lower. Gunn and Decker (1984) estimated 1,126 ± SE 276 muskoxen on Prince of Wales Island in 1980, but they suggest that the actual number was likely closer to 850, given their knowledge of the available habitat. By 1995, the muskox population had increased dramatically to

5,259 ± SE 414 muskoxen (Gunn and Dragon 1998), but dropped to 2,086 by 2004 (1,582-2,746, 95% CI, Jenkins et al. 2011). Our estimate of 1,569 ± SE 267, without information on abundance or trends between surveys, could indicate that the population could be increasing after a period of low abundance, stable at slightly lower abundance, or continuing to decline. Continued monitoring is necessary to determine trend.

Two piles of skulls near the Union River suggested that muskoxen had previously been abundant and harvested on Somerset Island (Russell and Edmonds 1977). However, only 12 muskoxen were seen on Somerset Island in 1974. They expanded on Somerset Island to a population of 1,140 ± SE 260 in 1995 (Gunn and Dragon 1998), increased to 1,910 muskoxen in 2004 (962-3,792 95% CI, Jenkins et al. 2011), and appear to have declined slightly to 1,483 ± SE 335 muskoxen in 2016.

Although the population estimate for muskoxen on Prince of Wales and Somerset islands is lower than in 2004, there is uncertainty in whether this is a true declining trend. Considering the lack of monitoring in between the surveys, the overlap in confidence intervals, and the proportion of calves, in the muskox population on Somerset and Prince of Wales islands could be stable population or showing early signs of increase from an even lower population level.

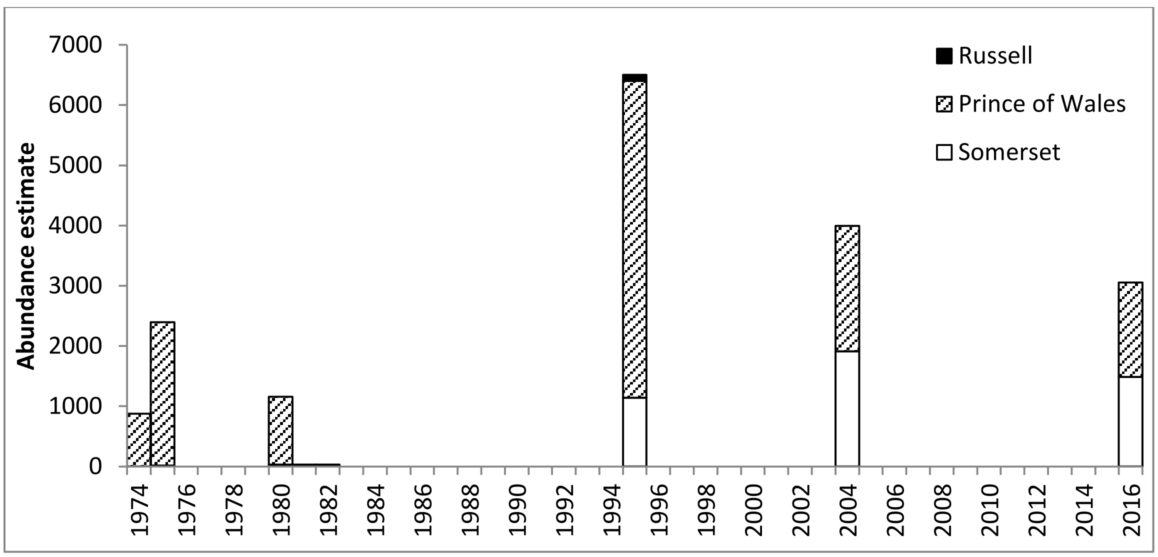


Figure 6. Population trends for muskoxen on Prince of Wales, Somerset, and Russell islands, showing an increase from the 1970s and a gradual decline since the mid-1990s.Surveys were conducted in June-July1974 and 1975 (Fischer and Duncan 1976), July 1980 (Gunn and Decker 1984), July-August 1995 (Gunn and Dragon 1998), April-May 1996 (Miller 1997), April 2004 and 2005 (Jenkins et al. 2011), and August 2016 (this report). Error bars are not shown and are not available for all estimates.

Muskox Distribution

On Prince of Wales Island, the areas around Back Bay, Browne Bay, and between Fisher and Crooked lakes were identified as muskox winter and summer range by Russell and Edmonds (1977) based on their observations in the mid-1970s, although only the eastern half of the island was surveyed. During more comprehensive surveys in 1980, muskoxen were still only seen on the eastern third of Prince of Wales Island (Gunn and Decker 1984). By 1995, they were found across Prince of Wales and Russell islands, but the eastern third of Prince of Wales Island was still the area with the highest density (Gunn and Dragon 1998). We saw muskoxen across the island, although not on the smaller satellite islands of Russell or Pandora, and they were almost absent from the western peninsula in the vicinity of the Rawlinson Hills. The distribution of muskoxen on Prince of Wales Island was similar to the distribution seen in 2004, although one muskox group was seen on Pandora Island and two groups were seen on Russell Island (Jenkins et al. 2011).

Muskox concentrations on Somerset Island recorded on this survey were in areas where they were also detected in 2004, with more sightings farther north on Somerset Island. The northeast part of the island is largely a barren plateau with little vegetation where few muskoxen were seen. Most sightings, and the largest groups, were encountered northwest from Creswell Bay to Fiona Lake and south of Creswell Bay where vegetation was more abundant.

Calf Recruitment

The recorded proportion of muskox calves in the population (17.8%) was slightly lower than that recorded for southern Ellesmere Island in summer 2014 (24%, Anderson and Kingsley 2015), but higher than the 10.5% calf production which Freeman (1971) estimated would be required to offset natural mortality based on observations in 1965 and 1967 on Devon Island. The proportion of calves is higher than the 2004 survey, but since that survey was conducted during calving season in April, the 2% calves recorded likely accounted for only part of the calf crop in 2004. No unusual mortality or calf crop losses have been noticed by harvesters. The proportion of calves may be biased low due to detectability, but the open terrain allowed us to classify most groups before muskoxen herded together and blocked calves from sight.

Group Sizes

Muskox groups are largest early in the spring and smaller as summer progresses (Freeman 1971, Gray 1973), with winter groups about 1.7 times larger than summer groups (Heard 1992). Muskoxen were encountered in herds of 2-24, with some lone adults seen as well, and averaged 7.3 muskoxen per herd, or 9.3 muskoxen per herd is single animals are discounted. This is slightly smaller than the 10.0 muskoxen per herd encountered by Freeman (1971) in the Jones Sound region and slightly smaller than herd sizes encountered in March 2015 on southern Ellesmere Island (8.9-12.1 muskoxen/group, 95% CI, Anderson and Kingsley 2015). The mechanisms behind group size variation are not well understood, and may vary by population as well as time of year.

Management Recommendations

Peary caribou and muskoxen are an important source of country food and cultural identity for Inuit. Consistent with the Nunavut Land Claims Agreement, the Management Plan for High Arctic Muskoxen of the Qikiqtaaluk Region, 2013-2018 (DOE 2014), the draft Management Plan for Peary Caribou in Nunavut (DOE in prep), and the draft Recovery Strategy for Peary Caribou in Canada (ECCC in prep), these management recommendations emphasize the importance of maintaining healthy populations of caribou and muskox that support sustainable harvest.

Under the Management Plan for the High Arctic Muskoxen of the Qikiqtaaluk Region, 2013-2018 (DOE 2014), Prince of Wales, Somerset, and Russell islands are considered a single management unit, MX-06, which was previously assigned a Total Allowable Harvest (TAH) of 20, allocated to Resolute. In September 2015, based on stable high densities of muskoxen in MX-06, the TAH was removed, and anyone can now harvest a muskox from MX-06. Considering the continued high densities of muskoxen, even with a slightly declining trend, implementing a TAH is not required for the continued sustainable use of muskoxen in MX-06, which are generally harvested at low levels (Anderson 2015). Harvest practices that maintain group cohesion and predator defense could still be considered, for example, limited the number of animals harvested from small groups.

It is highly recommended that a harvest reporting system be maintained even if the TAH is removed. This would allow biologists, community members, and decision-makers to track harvest patterns over time and to determine whether changes to management zones or harvest restrictions have the desired effect. As local knowledge and previous surveys have demonstrated, population changes can be rapid and unexpected if severe weather causes localized or widespread starvation or movement; so continuous monitoring and adaptive management is necessary even when populations are at high levels.

Harvest trends for muskoxen over the last decade suggest that hunters from Resolute Bay harvest fewer muskoxen than in the 1990s (Anderson 2016), but changes to the configuration of management zones in September 2015 appear to be encouraging more harvest in areas that were previously accessible but not included in a management unit, primarily Cornwallis Island near Resolute Bay. The major decline in caribou on Baffin Island and subsequent harvest restrictions have reduced the availability of country food for Baffin communities, including Arctic Bay, which has harvested muskoxen on Somerset in the past using tags transferred from Resolute Bay. The areas of Somerset Island most accessible from Arctic Bay had low muskox densities, as the habitat is largely unsuitable for muskoxen.

Since only two caribou were seen during the survey (and not even on the survey itself), it is clear that the population has not yet recovered. This was not surprising, since harvesters had not reported drastic changes in caribou abundance. Peary caribou are known to cross between Bathurst and Cornwallis islands to Somerset and Prince of Wales islands (IQ in Johnson et al. 2016). Not harvesting Peary caribou on Somerset and Prince of Wales islands might allow the new immigrants to establish themselves and the population to increase again. However, harvest is likely not the limiting factor for Peary caribou on Prince of Wales and Somerset islands at present, since they are rarely seen and harvest pressure is directed elsewhere. Harvesting more muskoxen in areas where caribou were historically found might provide the caribou with more suitable places to expand, since Inuit Qaujimajatuqangit recognizes that Peary caribou and muskoxen tend not to overlap.

Acknowledgements

Thank you to everyone involved in this survey, which seemed to switch to new contingency plans at least once a day. Thanks to the survey observers from Taloyoak and Resolute: Debbie Iqaluk, James Iqaluk, Thomas Kalluk, Belinda Oqallak, Eric Saittuq, Robert Quqqiaq, and Bill Ekalik, as well as Government of Nunavut summer student Etuangat Akeeagok and Polar Shelf summer student Keesha Allurut, who was also drafted into logistics when we unexpectedly overnighted in Arctic Bay. Thanks to Wayne Pollard for lending 4 undergraduate observers last-minute from the McGill University Arctic Field School (Eva Wu, Hana Moidu, Olivia Gau, and Lauren Thompson). Ookpik Air pilots Mike Bergmann and Alan Gilbertson flew the Turbine Otter part of the survey, and Kenn Borek Air pilots Troy Mckerrall and Alex Pelletier in the Twin Otter provided the much-anticipated countdown to the end of the last transect. Their assistance in classifying muskox before they grouped together was extremely helpful. Thanks to the Taloyoak HTO and Resolute Bay HTA for their guidance and support. Delilah Manik and Jimmy organized observers. Mike

Kristjanson, Tim McCaugherty, Glenn Parsons, Jodi MacGregor, Tanya Lemieux, and the rest of the team at Polar Continental Shelf Program provided logistical support for a survey that seemed to encounter some new exciting problem every day. Sometimes twice a day. Lisa-Marie Leclerc provided comments on an earlier draft of the report and communicated with Kitikmeot communities prior to the survey.

Funding for this work was provided by the Nunavut Department of Environment Wildlife Research Section, Environment and Climate Change Canada's Habitat Stewardship Fund (Project GCXE17C330), and the Nunavut Wildlife Research Trust (Project 2-16-09). The Polar Continental Shelf Program provided logistical support (Project 302-16). The work was completed under Government of Nunavut Wildlife Research Section permit 2016-055.

Literature Cited

Anderson, M. 2015. High arctic muskox (*Ovibos moschatus*) and Peary caribou (*Rangifer tarandus pearyi*) harvest summary 1990-2015. Nunavut Department of Environment, Wildlife Research Section, Status Report 2015-03, Igloolik, NU. 62 pp.

Anderson, M. and M. C. S. Kingsley. 2015. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) on southern Ellesmere Island, March 2015. Nunavut Department of Environment, Wildlife Research Section, Status Report, Igloolik, NU. 46 pp.

Campbell, M. 2006. Estimating Peary caribou (*Rangifer tarandus pearyi*) and muskox (*Ovibos moschatus*) numbers, composition and distribution on the High Arctic islands of Nunavut. Nunavut Department of Environment, Status Report 19, Arviat NU. 12 pp.

Campbell, M., J. Boulanger, D. S. Lee, M. Dumond, and J. McPherson. 2012. Calving ground abundance estimates of the Beverly and Ahiak subpopulations of barren-ground caribou (*Rangifer tarandus groenlandicus*) – June 2011. Nunavut Department of Environment, Technical Summary, Arviat NU. 111 pp.

Caughley, G. 1977. Sampling in aerial survey. Journal of Wildlife Management 41(4): 605-615.

Cochran, W. G. 1977. Sampling techniques. 3rd ed. Wiley, New York, NY. 428 pp.

Department of Environment (DOE), in collaboration with Nunavut Tunngavik Inc. (NTI) Wildlife, Resolute Bay Hunters and Trappers Association, Ikajutit Hunters and Trappers Organization (Arctic Bay), Iviq Hunters and Trappers Association (Grise Fiord) and the Qikiqtaaluk Wildlife Board. 2013. Management Plan for the High Arctic Muskoxen of the Qikiqtaaluk Region, 2013-2018. Nunavut Department of Environment, Iqaluit, NU. 20 pp.

Department of Environment (DOE), in collaboration with communities of Grise Fiord, Resolute Bay, Qikiqtaalik Wildlife Board, Nunavut Tunngavik Inc., and the Nunavut Wildlife Management Board. In prep. Draft management plan for Peary Caribou in Nunavut, 2014-2020. Nunavut Department of Environment, Iqaluit, NU. 36 pp.

Dumond, M. 2006. Muskoxen abundance and distribution, and caribou distribution and calving areas on Boothia Peninsula, Nunavut. Status Report 20. Nunavut Department of Environment, Kugluktuk, NU. 6 pp.

Fischer, C. A., and E. A. Duncan. 1976. Ecological studies of caribou and muskoxen in the Arctic Archipelago and northern Keewatin. Renewable Resources Consulting Services Ltd. 194 pp.

Freeman, M. M. R. 1971. Population characteristics of musk-oxen in the Jones Sound region of the Northwest Territories. Journal of Wildlife Management 35(1): 103-108.

Gould, W. A., M. Raynolds, and D. A. Walker. 2003. Vegetation, plant biomass, and net primary productivity patterns in the Canadian Arctic. Journal of Geophysical Research 108 (D2): 8167, doi:10.1029/2001JD000948.

Gunn, A., and R. Decker. 1984. Numbers and distributions of Peary caribou and muskoxen in July 1980 on Prince of Wales, Russell, and Somerset Islands, N.W.T. File Report 38. Northwest Territories Department of Renewable Resources, Yellowknife, NT. 56 pp.

Gunn, A. and J. Dragon. 1998. Status of caribou and muskox populations within the Prince of Wales Island – Somerset Island – Boothia Peninsula Complex, NWT, July-August 1995. File Report 122. Northwest Territories Department of Resources, Wildlife and Economic Development, Yellowknife, NT. 45 pp.

Heard, D. 1992. The effects of wolf predation and snow cover on muskox group size. The American Naturalist 139(1): 190-204.

Jenkins, D., M. Campbell, G. Hope, J. Goorts, and P. McLoughlin. 2011. Recent trends in abundance of Peary Caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) in the Canadian Arctic Archipelago, Nunavut. Department of Environment, Government of Nunavut, Wildlife Report No. 1, Pond Inlet, Nunavut. 184 pp.

Johnson, D. H. 1996. Population analysis. In: T. A. Bookhout, ed. Research and management techniques for wildlife and habitats. The Wildlife Society, Bethesday, MD: 419-444.

Johnson, C.A., Neave, E., Blukacz-Richards, A., Banks, S.N., and P.E. Quesnelle. 2016. Knowledge assessment (community and scientific) to inform the identification of critical habitat for Peary caribou, *Rangifer tarandus pearyi*, in the Canadian Arctic. Environment and Climate Change Canada, Science and Technology, Ottawa, Ontario, Canada.

Jolly, G. M. 1969. Sampling methods for aerial censuses of wildlife populations. East African Agricultural and Forestry Journal 34 (special issue):46-49.

Kingsley, M. C. S., and G. E. J. Smith. 1981. Analysis of data arising from systematic transect surveys. Pp 40-48 in F. L. Miller and A. Gunn, eds. Proceedings, Symposium on Census and Inventory Methods for Populations and Habitats, Banff, AB, April 1980.

Kingsley, M. C. S., I. Stirling, and W. Calvert. 1985. The distribution and abundance of seals in the Canadian high arctic, 1980-82. Canadian Journal of Fisheries and Aquatic Sciences 42 (6): 1189-1210.

McFarlane, K., F. L. Miller, S. J. Barry, and G. A. Wilson. 2014. An enigmatic group of arctic island caribou and the potential implications for conservation of biodiversity. Rangifer 34(1): 73-94.

Miller, F. L. 1997. Late winter absence of caribou on Prince of Wales, Somerset, and Russell islands, Northwest Territories, April-May 1996. Technical Report Series 291. Canadian Wildlife Service, Prairie and Northern Region, Edmonton, AB. 35 pp.

Miller, F. L. and S. J. Barry. 2009. Long-term control of Peary caribou numbers by unpredictable, exceptionally severe snow or ice conditions in a non-equilibrium grazing system. Arctic 62(2): 175-189.

Miller, F.L., and A. Gunn. 2003. Catastrophic die-off of Peary caribou on the western Queen Elizabeth Islands Canadian High Arctic. Arctic 56: 381–390.

Miller, F. L., R. H. Russell and A. Gunn. 1975. The decline of caribou on the western Queen Elizabeth Islands. Polarforschung 45: 17-22.

Norton-Griffiths, M. 1978. Counting animals. In: J. J. R. Grimsdell, ed. Handbooks on techniques currently used in African wildlife ecology. No 1. AWLF, Nairobi, Kenya.

Stirling, I., M. C. S. Kingsley and W. Calvert. 1982. The distribution and abundance of seals in the Beaufort Sea, 1974-1979. Canadian Wildlife Service Occasional Paper 47.

Taylor, A. D. M. 2005. Inuit Qaujimajatuqangit about population changes and ecology of Peary caribou and muskoxen on the High Arctic Islands of Nunavut. MA Thesis. Queen's University, Kingston ON. 123 pp.

Appendix 1. Prince of Wales and Somerset islands survey transects, 2016.

Table 2. Transect end points and strata on Prince of Wales, Somerset, and Russell islands for a fixed-wing survey, August 2016.

Transect	Stratum	Lon (West)	Lat (West)	Lon (East)	Lat (East)
1	Somerset	-93.7291	74.15611	-92.968	74.14743
2	Somerset	-94.798	74.07323	-92.3281	74.04721
3	Somerset	-95.3025	73.98443	-90.1791	73.9117
4	Somerset	-95.2975	73.89351	-90.3435	73.82454
5	Somerset	-95.1054	73.8019	-90.4406	73.73563
6	Somerset	-95.6479	73.71242	-90.5865	73.64785
7	Somerset	-95.5839	73.62132	-90.7573	73.56056
8	Somerset	-95.6292	73.53037	-90.9468	73.47359
9	Somerset	-95.6506	73.43935	-91.074	73.38509
10	Somerset	-95.6203	73.34822	-91.215	73.29681
11	Somerset	-95.5854	73.25704	-91.3403	73.20812
12	Somerset	-95.5549	73.16583	-91.4522	73.11907
13	Somerset	-95.7674	73.07499	-91.5983	73.03066
14	Somerset	-95.6841	72.98368	-91.7045	72.94136
15	Somerset	-95.6475	72.8924	-91.8391	72.85255
16	Somerset	-95.6578	72.80116	-92.0198	72.76452
17	Somerset	-95.5907	72.70975	-93.7768	72.69858
18	Somerset	-95.3206	72.61775	-93.6243	72.60556
19	Somerset	-95.1974	72.52597	-93.4769	72.51245
20	Somerset	-95.229	72.43472	-93.5282	72.42162
21	Somerset	-95.1572	72.34304	-93.6823	72.33191
22	Somerset	-95.1741	72.25168	-93.8884	72.24262
23	Somerset	-95.1367	72.16008	-94.007	72.1523
24	Somerset	-95.1631	72.06871	-94.1674	72.06227
1	Prince of Wales	-98.1143	74.09704	-97.6124	74.10107
2	Prince of Wales	-98.8542	74.01181	-97.698	74.02321
3	Prince of Wales	-100.247	73.9129	-97.9585	73.94386
4	Prince of Wales	-100.873	73.82293	-97.4929	73.87006
5	Prince of Wales	-101.076	73.74093	-97.0791	73.79508
6	Prince of Wales	-100.881	73.66766	-96.9246	73.71843
7	Prince of Wales	-101.244	73.5819	-96.9479	73.64099
8	Prince of Wales	-101.543	73.49703	-97.1679	73.56258
9	Prince of Wales	-101.434	73.42201	-97.386	73.48394
10	Prince of Wales	-101.211	73.34968	-97.1765	73.40772
11	Prince of Wales	-100.956	73.27784	-97.495	73.32836
12	Prince of Wales	-100.487	73.21024	-97.8302	73.24836
13	Prince of Wales	-100.557	73.13111	-97.9881	73.16948
14	Prince of Wales	-100.212	73.06036	-98.2089	73.08983

Transect	Stratum	Lon (West)	Lat (West)	Lon (East)	Lat (East)
15	Prince of Wales	-100.467	72.97756	-97.5817	73.01773
16	Prince of Wales	-100.39	72.9014	-97.2279	72.94247
17	Prince of Wales	-100.314	72.82519	-97.2842	72.86458
18	Prince of Wales	-100.832	72.73635	-97.1535	72.78773
19	Prince of Wales	-102.459	72.6153	-97.039	72.71071
20	Prince of Wales	-102.228	72.5442	-96.4311	72.63518
21	Prince of Wales	-101.929	72.4748	-96.3925	72.55762
22	Prince of Wales	-101.885	72.39804	-96.3039	72.48012
23	Prince of Wales	-101.813	72.32202	-96.3931	72.4023
24	Prince of Wales	-101.06	72.26366	-96.6206	72.32406
25	Prince of Wales	-100.982	72.18758	-96.5033	72.24666
26	Prince of Wales	-100.488	72.12092	-96.4805	72.16899
27	Prince of Wales	-100.396	72.04497	-96.4724	72.09126
28	Prince of Wales	-100.242	71.97024	-96.4566	72.01353
29	Prince of Wales	-100.064	71.8959	-96.4618	71.93574
30	Prince of Wales	-99.8025	71.82299	-96.5125	71.85781
31	Prince of Wales	-99.6589	71.74767	-96.9794	71.77828
32	Prince of Wales	-99.5932	71.67088	-97.1242	71.69969
33	Prince of Wales	-99.3587	71.59695	-98.2275	71.61265
34	Prince of Wales	-99.3477	71.51916	-98.0401	71.53673
35	Prince of Wales	-99.2754	71.44236	-98.1608	71.45753
36	Prince of Wales	-99.2058	71.36549	-98.3678	71.37723
37	Prince of Wales	-102.508	73.00371	-101.847	73.02254
38	Prince of Wales	-102.575	72.92373	-101.747	72.94737
39	Prince of Wales	-102.677	72.84262	-101.49	72.87619
40	Prince of Wales	-102.733	72.76286	-101.439	72.79963
41	Prince of Wales	-102.654	72.68731	-101.307	72.72508
42	Prince of Wales	-96.8937	73.17667	-96.7511	73.1772
43	Prince of Wales	-97.1005	73.09822	-96.5907	73.1002
44	Prince of Wales	-97.0877	73.02076	-96.5537	73.02278
45	Prince of Wales	-96.9878	72.9437	-96.646	72.94499
46	Prince of Wales	-96.8262	72.86682	-96.6557	72.8674
47	Prince of Wales	-96.9366	72.78878	-96.6058	72.78997

Appendix 2. Alternate population calculations.

Jolly Method II Calculations
In this report, we used a systematic sampling approach to analysis, since we were estimating abundance of a patch population rather than estimating density in a habitat (which varied across the study area). Other systematic aerial surveys have frequently used Jolly's Method II, and estimates derived from both analyses were similar. Population estimates for fixed-width strip sampling using Jolly's Method 2 for uneven sample sizes (Jolly 1969; summarized in Caughley 1977) are derived as follows:

$$\hat{Y} = RZ = Z\frac{\sum_i y_i}{\sum_i z_i}$$

Where $\hat{Y}$ is the estimated number of animals in the population, R is the observed density of animals (sum of animals seen on all transects $\sum_i y_i$ divided by the total area surveyed $\sum_i z_i$), and Z is the total study area. The variance is given by:

$$Var(\hat{Y}) = \frac{N(N-n)}{n}\left(s_y^2 - 2Rs_{zy} + R^2 s_z^2\right)$$

Where N is the total number of transects required to completely cover study area Z, and n is the number of transects sampled in the survey. s_y^2 is the variance in counts, s_z^2 is the variance in areas surveyed on transects, and s_{zy} is the covariance. The estimate $\hat{Y}$ and variance $Var(\hat{Y})$ are calculated for each stratum and summed. The Coefficient of Variation (CV = σ/$\hat{Y}$) was calculated as a measure of precision.

Table 3. Abundance estimates (Jolly 1969 Method II) for muskoxen on Devon Island, March 2016. *N* is the total number of transects required to completely cover study area *Z*, *n* is the number of transects sampled in the survey covering area *z*, *y* is the observed muskoxen, *Y* is the estimated muskoxen with variance Var(*Y*). The coefficient of variation (CV) is also included.

Stratum	**Y**	**Var(Y)**	**n**	**Z (km^2)**	**z (km^2)**	**N**	**y**	**Density (per km^2)**	**CV**
Prince of Wales	1569	58619.73	47	35591.87	6532.82	198	288	0.044	0.154
Somerset	1483	113988.75	24	25227.87	3928.63	154	231	0.059	0.228
Total	3052	172608.48	71	60819.74	10461.45	352	519	0.050	0.136

Stratified Systematic Survey Calculations
Following Cochran (1977), the abundance estimate for a systematic survey is given by:

$$\hat{Y} = \frac{S}{w} \times \sum n_i$$

Where $\hat{Y}$ is the population estimate, *S* is the transect spacing (5 km), *w* is the transect width (1 km), and n_i is the total number of animals observed on transect *i*, the sum of which is all animals observed on *I* transects in the survey. The configuration of the study area may mean that the actual sampling fraction (proportion of the study area that is surveyed) varies, which was partly why Cochran's ratio estimator was used instead, and why the estimate varied between methods and stratification regimes. The variance is based on the sum of squared differences in counts between consecutive transects:

$$Var(\hat{Y}) = \frac{\frac{S}{w} \times \left(\frac{S}{w} - 1\right) \times I}{2 \times (I - 1)} \times \sum (n_i - n_{i-1})^2$$

Table 4. Abundance estimates for a stratified systematic survey (Cochran 1977) of muskoxen on Prince of Wales and Somerset islands, August 2016. *I* is the number of transects sampled.

Stratum	**Estimated Abundance $\hat{Y}$**	**Var($\hat{Y}$)**	**I**	**Transect Spacing S (km)**	**Transect Width w (km)**	**Observed Individuals y**	**Density (per km^2)**	**CV**
Prince of Wales	1555	77320.72	47	8.64	1.6	288	0.044	0.179
Somerset	1467	91885.27	24	10.16	1.6	231	0.059	0.207
Total	3022	169205.99	71			519	0.050	0.136

Appendix 3. Daily flight summaries for Prince of Wales and Somerset islands survey, August 2016.

Table 5. Summary by day of survey flights and weather conditions for March 2015 Peary caribou and muskox survey, southern Ellesmere Island.

Date	Time Up	Time Down	Time Up 2	Time Down 2	Time Up 3	Time Down 3	Time Up 4	Time Down 4	Flying Time	Transect Time	Comment
05-Aug-16	6:30	9:00	10:27	11:46	12:18	16:24	16:56	18:05	9:04	3:13	500' ceilings scattered fog and mist, mostly on west coast of Prince of Wales, up to 20kt wind
08-Aug-16	7:58	10:30	10:56	15:05	15:56	20:30			11:15	7:21	CAVU 10 kt wind from SE at Taloyoak
09-Aug-16	7:00	9:30	11:44	15:26	16:00	19:29	19:46	21:00	10:55	4:17	CAVU, some cirrus to north and fog starting on west coast Prince of Wales
10-Aug-16	15:17	17:55							2:38	0:00	CAVU
11-Aug-16	8:08	12:49	13:33	17:23	18:09	20:12			10:34	5:58	CAVU some fog on east side of Boothia Peninsula and some higher clouds at 8000' over Prince of Wales, some fog on west side
12-Aug-16	10:48	14:10	14:35	16:04	16:30	18:00	19:00	22:00	9:21	2:37	Fog on west coast of Somerset and Boothia but clear with some clouds at 800' north of Creswell Bay
15-Aug-16	15:40	21:05							5:25	3:41	
16-Aug-16	8:32	13:13	13:39	16:38	18:30	20:31			9:41	5:56	OVC with fog in the west, weather down in Resolute and forced to Arctic Bay for night
17-Aug-16	11:08	13:00							1:52	0:00	Fog and low ceilings coming in for Arctic Bay, up and down for Resolute but made it back
22-Aug-16	14:42	19:15							4:33	3:15	OVC 1500' down to 800' on hill at east side of island, 20-30 kt wind from N
23-Aug-16	9:02	11:14	11:14	13:02	13:34	15:00			5:26	3:37	OVC down to 800' with low cloud and fog on parts of Russell, broken over Somerset, wind light from south (not down at 11:14 just off and moving to Somerset)

Pilots – Mike Bergmann (Aug 5-9), Alan Gilbertson (Aug 11-12), Troy Mckerrall and Alex Pelletier (Aug 15-23); Navigator - Morgan Anderson

Observers:
Aug 5 – Morgan Anderson, Etuangat Akeeagok, Bill Ekelik, Eric Saittuq
Aug 8 – Morgan Anderson, Etuangat Akeeagok, Bill Ekelik, Eric Saittuq
Aug 9 – Morgan Anderson, Etuangat Akeeagok, Bill Ekelik, Eric Saittuq
Aug 11 – Morgan Anderson, Etuangat Akeeagok, Bill Ekelik
Aug 12 – Morgan Anderson, Etuangat Akeeagok, Bill Ekelik, Robert Quqqiaq
Aug 15 – Morgan Anderson, Etuangat Akeeagok, Debbie Iqaluk, Keesha Allurut, James Iqaluk
Aug 16 – Morgan Anderson, Etuangat Akeeagok, Debbie Iqaluk, Keesha Allurut, Thomas Kalluk
Aug 22 – Morgan Anderson, Thomas Kalluk, Belinda Oqallak
Aug 23 – Morgan Anderson, Belinda Oqallak, Eva Wu, Hana Moidu, Lauren Thompson, Olivia Gau

Appendix 4. Incidental wildlife observations.

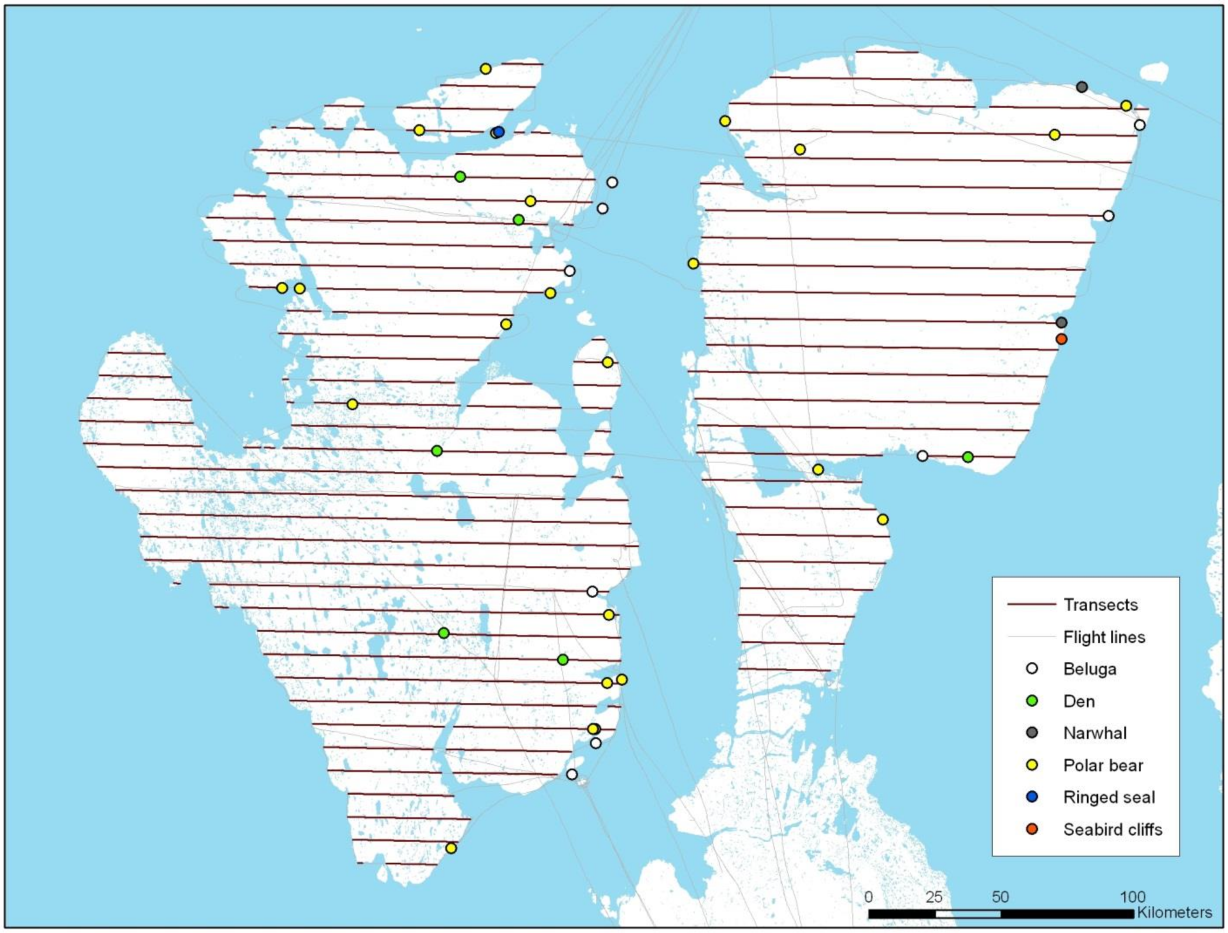


Figure 7. Incidental observations, Aug 5-23 2016, and flight lines for an aerial survey of Prince of Wales and Somerset islands. Some track lines are incomplete due to loss of satellite coverage. A total of 34 polar bears were observed, including 5 family groups. Some beluga pods were more than 60 individuals with many calves, and several of these pods were sometimes congregated in and around bays. Snowy owls were abundant on southern Prince of Wales Island but we did not mark them; snow geese were abundant on Prince of Wales Island but we did not mark them either. Dens appeared to be fox dens but could not be confirmed and some may have been used by wolves.

DISTRIBUTION AND ABUNDANCE OF PEARY CARIBOU (*Rangifer tarandus pearyi*) ON LOUGHEED ISLAND, JULY 2016

MORGAN ANDERSON[1]

Version: 13 August 2016

[1]Wildlife Biologist High Arctic, Department of Environment
Wildlife Research Section, Government of Nunavut Box 209 Igloolik NU X0A 0L0

STATUS REPORT 2016-02
NUNAVUT DEPARTMENT OF ENVIRONMENT
WILDLIFE RESEARCH SECTION
IGLOOLIK, NU

ᓯ ᐊᓪ ᒪᑦ ᓯ ᒪ ᓂᖏᓐ ᐊᒥ ᓲ ᓂᖏ ᓗ ᐱᐅᓇ ᑐᒃ ᑐᐃᑦ (PEARY CARIBOU) (*Rangifer tarandus pearyi*)
LOUGHEED ISLAND (ᕿᑭ ᖅ ᑕᒥ), ᔪ ᓚᐃ 2016

ᒧ ᐊᕐ ᒐ ᓐ ᐋᓐ ᑐᓴ ᓐ [1]

ᐱᓯ ᒪ ᔪ ᖅ : 13 ᐊᐅᒡ ᒍᓯ 2016

[1]ᐆᒪ ᔪ ᓕᕆᔨ ᖁᑦ ᓯ ᑦ ᑐᒧ ᑦ , ᒥ ᓂᔅ ᑕᐅᕙ ᖕᒍ ᓂᒃ ᐊᕙᑎᓕᕆᔨ ᒃ ᑯ ᑦ
ᐆᒪ ᔪ ᕐ ᓂᒃ ᖃᐅᔨ ᓴ ᕐ ᓂᓕᕆᔩ ᑦ , ᒐ ᕙᒪ ᒃ ᑯ ᖏᓐ ᓂ ᓄᓇᕗᑦ ᑎᑎᖅᑲ ᒃ ᑯ ᕕᐊ 209 ᐃᒡ ᓗᓕᒃ , ᓄᓇᕗᑦ X0A 0L0

ᖃᓄᐃᓕᖓᓂᐅᔪ ᓄᑦ ᐅᓂᒃ ᑳ ᑦ 2016-02
ᓄᓇᕘᒻ ᒥ ᒥ ᓂᔅ ᑕᐅᕙ ᖕᒋᑦ ᐊᕙᑎᓕᕆᓂᕐ ᒧᑦ
ᐆᒪ ᔪ ᕐ ᓂᒃ ᖃᐅᔨ ᓴ ᖅ ᑏᑦ
ᐃᒡ ᓗᓕᒃ , ᓄᓇᕗᑦ

Anderson, M. 2016. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyi*) on Lougheed Island, July 2016. Nunavut Department of Environment, Wildlife Research Section, Status Report 2016-02, Igloolik, NU.

ᐋᓐᑐᓴᓐ, ᒫ. 2016. ᓯᐊᓪᒪᖅᓯᒪᓂᖕᒋᑦ ᐊᒥᓃᓂᖕᒋᓐ ᓗ ᑐᒃᑐᐃᑦ ᐱᐅᓚ ᑐᒃᑐᐃᑦ (Peary caribou) (*Rangifer tarandus pearyi*) Lougheed ᕿᑭᖅᑕᓂᒃ, ᔫᓚᐃ 2016. ᓄᓇᕗᑦ ᒥᒥᓂᔅ ᑕᐅᕝᕙᐊᕗᑎᓕᕆᓂᖅ ᒧᑦ, ᐆᒪᔪᓕᕆᓂᖅ ᒧᑦ ᖃᐅᔨᓴᖅᑎᑦ, ᖃᓄᐃᓕᖓᓂᖅ ᒧᑦ ᐅᓂᒃᑳᑦ 2016-02, ᐃᒡᓗᓕᒃ, ᓄᓇᕗᑦ.

Summary

We flew a survey of Lougheed Island on July 28, 2016, as reconnaissance to find caribou groups for collection of fecal pellets. We encountered enough caribou groups to allow us to calculate a population estimate for the island, which had been last surveyed in 2007. We observed 61 caribou, 26 of which were on transect, during the flight. The estimate of 140±SE33 Peary caribou indicates a decline from the 2007 survey, which estimated 205-672 caribou on the island (95% CI, Jenkins et al. 2011). We did not see any muskoxen on Lougheed Island, but we did see 2 wolves last summer and wolf tracks this summer. Lougheed Island too remote to be regularly accessed for harvesting.

ᓇᐃᓐᓕᑎᖅᓯᒪᔪᑦ

ᖃᐅᔨᓴᕐᓂᖃᔪᔪ iii ᖁᓚᐅᑦᓯᑕ Lougheed ᕿᑭᖅᑕᒥᒃ ᔪᓚᐃ 28, 2016, ᑲᑎᖅᓯᐃᒍᒪᓪᓗᑎᒃ ᑲᑎᒪᐅᖅᑐᓂᒃ ᑐᒃᑯᓂᒃ ᓄᐊᑦᓯᒍᒪᓪᓗᑎᒃ ᐊᓇᖕᖏᓂᒃ. ᑕᑯᔪᔪᒍᑦ ᓈᒻᒪᑦᑐᓂᒃ ᑐᒃᑐᓂᒃ ᑲᑎᒪᐅᖅᑐᓂᒃ ᐱᕙᖅᑭᑎᒋᓪᓗᒍ ᓈᓴᐃᒍᓐᓇᕐᓂᕐᒥᒃ ᐊᒥᓃᓂᖕᒋᑦ ᑕᓇᓚᐅᑦᓵᖅᑕᐅᖕᖏᓐᓂᒃ ᕿᑭᖅᑕᒥ, ᑭᖑᓪᓕᖅᐹᒥ ᖃᐅᔨᓴᖅᑕᒥ ᓂᐅᑦᓯᓂ 2007−ᒥ. ᑕᑯᔪᔪᒍᑦ 61−ᓂᒃ ᑐᒃᑐᓂᒃ, 26−ᖑᑦ ᓯᑎᒃ ᓅᐸᓪᓕᐊᔪᑦ, ᖃᖕᑕᓂᑦ ᑎᓐᓂ. ᒥᑦᓴᐅᓯᔭᐅᓂᖕᓂᑦ 140±SE33 ᐱᐅᓚ ᑐᒃᑐᐃᑦ ᓇᓗᓇᐃᖅᓯᒍᑕᐅᔪᖅ ᐃᓄᐃᓴᓕᕚᓪᓕᓚᐊᖕᓂᑦ 2007−ᒥ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᓯᒪᑎᓪᓗᒋᑦ, ᑕᐃᑦᓯᒪᓂᓕ ᓇᓚᐅᑦᓵᖅᑕᐅᓯᒪᔪᔪᑦ 205-672 ᑐᒃᑐᐃᑦ ᕿᑭᖅᑕᒥ (95% CI, Jenkins et al. 2011). ᑕᑯᔪᓐᖏᑦᑐᒍᑦ ᐅᒥᒻᒪᓐᓂᒃ Lougheed ᕿᑭᖅᑕᖕᒐᓂ, ᑭᓯᐊᓂ ᑕᑯᔪᒐᓗᐊᖅᑐᒍᑦ ᒪᕐᕈᓐᓂᒃ ᐊᒪᕈᓐᓂᒃ ᐊᕐᖁᓂ ᐊᐅᔭᒃᑯᑦ ᐊᒪᕈᕐᓄᓪᓗ ᑐᒥᓂᒃ ᑕᕝᕙᓂ ᐊᕐᖁᒍᕐᒥ. Lougheed ᕿᑭᖅᑕᖕᒐ ᐅᖓᓯᒃᓗᐊᕐᒪᑦ ᐊᖑᓇᓯᕝᕕᐅᓕᐅᒥᔮᕐᓗᓂ.

Contents

List of Figures

List of Tables

Introduction

Peary caribou (*Rangifer tarandus pearyi*) are a small, light-coloured subspecies of caribou/reindeer inhabiting the Canadian Arctic Archipelago in the Northwest Territories and Nunavut from the Boothia Peninsula in the south to Ellesmere Island in the north. They are sympatric with muskoxen (*Ovibos moschatus*) over much of their range although diet, habitat preferences, and potentially interspecific interactions separate the two species at a finer scale (Resolute Bay Hunters and Trappers Association [HTA] and Iviq HTA, pers. comm.). Arctic wolves (*Canis lupus arctos*) occur at low densities throughout Peary caribou range, but the most significant cause of population-wide mortality appears to be irregular die-offs precipitated by severe winter weather and ground-fast ice that restricts access to forage (Miller et al 1975, Miller and Gunn 2003, Miller and Barry 2009).

Peary caribou have been surveyed infrequently and irregularly on the Canadian Arctic Archipelago since Tener's 1961 survey, which counted 232 caribou and calculated 4.2 caribou per square mile on Lougheed Island. This density was surprising for such a small, isolated island, but similar to western Mackenzie King Island, which was surveyed the same year (Tener 1963). Subsequent surveys indicated far lower densities of caribou, however - the most recent survey estimated 205-672 caribou on the island (95% CI, Jenkins et al. 2011).

Although there is no harvest currently reported of Peary caribou on Lougheed Island, there is some connectivity between the Findlay Group and the Bathurst Island Group, which is largely relied up on by Resolute for caribou harvesting, since the caribou population on Somerset and Prince of Wales islands has not yet recovered. Changes in distribution and abundance between Lougheed and Bathurst islands could indicate movements among the islands or a change in population across all islands.

ᓇᓗᓇᐃᔭ ᐃᓂᖅ

ᐱᐅᕆ ᑐᒃᑐᐃᑦ (Peary caribou) (*Rangifer tarandus pearyi*) ᒥᑭᔪᐃᑦ, ᑕᐅᑦᑐᙱᑦ ᖃᑯᖓᙵᓯᑎᒃ ᑐᒃᑐᓃᖓ ᙵᖅᑐᑦ/ᑑᒃ ᑑᔭᕐᓂᒃ ᓇᔪᒐᖄᖅᑐᓂᒃ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᒥ ᕿᑭᖅᑕᖖᓂᒃ ᓄᓇᑦᓯᐊᕐᒥ ᓄᓇᕗᒻᒥᓗ ᐊᓚᕐ ᓈᕐᔪᒻᒥ ᓂᒋᐊᓂ ᐊᐅᔪᐃᑦᑑᑉ ᕿᑭᖅᑕᙳᓐᑦ ᐅᐊᓐᓇᒥ. ᓄᓇᖅᑲᑎᓖᑦ ᐅᒥᒻᒪᓂᒃ (*Ovibos moschatus*) ᐃᓘᓐ ᓇᒐ ᓚᙵᓂ ᓇᔪᒐᕐᒥᓂ ᓂᕆᔭᙱᑦ, ᓇᔪᒐᕆᒍᒪᔭᙱᑦ, ᐊᒻᒪᓗ ᑲᓲᒪᖃᑎᖃᕐ ᓂᙱᑦ ᐃᒥᒃ ᑰᙻ ᓗᐊᖅᓯᑎᒃ ᑖᒃ ᑯᐊ ᐆᒪᔩᒃ (ᖃᐅᓯᐃᑦᑐᕐᒥ ᐊᖑᓇᓯᑦᑏᑦ ᑲᑎᒪᔨᙱᑦ (HTA) ᐊᒻᒪᓗ ᐊᐃᕖᖅ HTA, pers.comm.). ᐅᑭᐅᖅᑕᖅᑐᒥ ᐊᒪᕈᐃᑦ (*Canis lupus arctos*) ᐱᑕᖃᖅᐸᑦᑐᑦ ᐊᒥᓲᓈᖅᓯᒪᓕᑎᒃ ᐱᐅᕆ ᑐᒃᑐᑕᓕᓐ ᓂ, ᑭᓯᐊᓂ ᐊᓚᒡ ᓕᐃᓂᖅᐸᐅᔫᖅᑐᖅ ᐊᒥᓱᓄᑦ ᑐᒃᑐᓄᑦ ᑐᖅᑯᕋᓕᐅᒥᔶᕈᑕᐅᔪᖅ ᐊᐅᓚᔾᔭᑦᑕᐅᕙᑦᑐᖅ ᐅᑭᐅᒃ ᑯᑦ ᓯᓚᕐ ᓗᓂᖅ ᒍᑦ ᐊᒻᒪᓗ ᓄᓇᐅᑉ ᖁᐊᖅᐸᓪ ᓕᐊᓂᙵᓄᑦ ᓂᓚᕈᖅᓯᓂ ᓂᖀᑦ ᓴᙱ ᓄᑦ ᖁᐊᕈ ᑕᐅᓕᖅᓯᓂ (Miller et al 1975, Miller and Gunn 2003, Miller and Barry 2009).

ᐱᐅᕆ ᑐᒃᑐᐃᑦ ᖃᐅᔨᓴᖅᐅᖃᑦ ᑕᖅᓯᒪᔪᖅ ᐅᕙᑦᓯ ᐊᐆᓕᕋᐃᒻᒪᑦ ᓈᓴᖅᑕᐅᓕᒥᔮ ᑐᐃᓐ ᓇᖅᓯᑎᒃ ᑲᓇᑕᒥ ᐅᑭᐅᖅᑕᖅᑐᒥ ᕿᑭᖅᑕᙳ ᓂ ᑕᐃᒪᓐ ᙵᓂᑦ 1961 ᑕᓄᕐ ᖃᐅᔨᓴᕐ ᓂᐅᓯᒪᔪᒥ, ᓈᓴᐃᑦᓯᑎᒃ 232–ᓂᒃ ᑐᒃᑐᓂᒃ ᓇᓴᐃᓕᖅᓯᑎᒃ 4.2 ᑐᒃᑐᓂᒃ ᐊᑐᓂᑦ ᑭᐸᕙᕆᑦᑐᒥ ᒪᐃᓕᒥ Lougheed ᕿᑭᖅᑕᒥ. ᑕᐃᒫᒃ ᐊᒥᓲᓂᖃᕆᐊᙱᑦ ᑲᒪᓂᐊᕆᔭ ᐅᓯᒪᔪᑦ ᕿᑭᖅᑖ ᓚᑐᐊᓗᒻᒥ ᐅᙴᑦᑐᒦᑦᑐᒥ, ᑭᓯᐊᓂ ᐊᔾ ᔾᒐᓚᒋᓪ ᓗᓂᐅᒃ ᐱᙳᓇᒥ ᒪᒃ ᑲᓐᔾ ᑭᖕ ᕿᑭᖅᑕᒥ, ᖃᐅᔾᓴᖅᑕᐅᓯᒪᑦᓯᓂᑦᑕᐅᖅ ᑕᐃᑲᓂᑦ ᓴᐃᓇᖅ ᐊᕐ ᕌᒍᒥ (Tener 1963). ᑭᖑᓪᖓᑦ ᖃᐅᔨᓴᕐᓂᐅᓯᒪᔪᑦ ᓇᓗᓇᐃᖅᓯᓯᒪᔪᑦ ᐃᓄᐃᓴᓐᓂᖅᓴᑉᓗᓐᓂᒃ ᑐᒃᑐᓂᒃ, ᑭᓯᐊᓂᓕ – ᒫᓐᓇᖅᑲᕐᒥᐅᓂᖅᐹᖅ ᖃᐅᔨᕐᓴᓂᐅᓯᒪᔪᖅ ᓇᓚᐅᑦᓵᖅᓯᒪᔪᑦ 205-672 ᑐᒃᑯᓂᒃ ᕿᑭᖅᑕᒥ (95% CI, Jenkins et al. 2011).

ᒫᓐᓇᕐ ᓂᑕᕐ ᓂᒃ ᑐᒃᑐᑕᒥ ᓂᐅᔪᓂᒃ ᐅᖃᖅᓯᒪᔪᖃᙱᒃ ᑲᓗᐊᖅᑎᓪᓗᒍ ᐱᐅᕆ ᑐᒃᑐᓂᒃ Lougheed ᕿᑭᖅᑕᙳᓂ, ᑲᓰᒪᓂᖅᑕᖅᑐᖅ ᐊᑯᕐ ᙵᓂ Findlay Group ᑲᑎᒪᐅᖅᑐᑦ ᐊᒻᒪᓗ ᕿᙳᐅᒻᒥ ᑲᑎᒪᐅᖅᑐᖅ, ᓯᙲᖅᑑᑕᐅᒐᔪᑦᓯᑎᒃ ᖃᐅᓯᐃᑦᑐᕐᒥᒃ ᑐᒃᑐᓕᐊᖅᓯᑎᒃ, ᑐᒃᑐᐃᑦ ᐊᒥᓲᓂᙱᑦ ᐅᑎᖅᓯᒪᓐᖏᒪ ᒪᑕ ᖃᐅᓯᐃᑦᑑᑉ ᕿᑭᖅᑕᙳᓂ ᐊᒻᒪᓗ Wales Islands ᕿᑭᖅᑕᓂ. ᐊᓯᔾᔨᖅᓯᒪᓂᙱᑦ ᓯᐊᒻᒪᖅᓯᒪᓂᙱᑦ ᑕ ᐊᒥᓲᓂᙱᑦ ᑕᓗ ᐊᑯᕐ ᙵᓂ Lougheed ᐊᒻᒪᓗ ᕿᙳᐅᒻᒥ ᕿᑭᖅᑕᐃᑦ

ᓇᓗᓇᐃᖅᓯᒍᑕᐅᒍᓐᓇᖅᑐᑦ ᓄᑦ ᑕᑎᐊᖏᑦ ᐊᑯᖕᖓᓂ ᕿᑭᖅᑕᐃᑦ ᐅᕝᕙᓗ ᐊᓯᔾᔨᐸᓪᓚᐊᔪᑦ ᐊᒥᓲᓂᖏᑦ ᐃᓘᓐᓇᖏᓂ ᕿᑭᖅᑕᐃᑦ.

Study Area

The survey area is predominantly polar desert and semi desert, with rolling topography, highest on the north of the island at 150 m, and a flat coastal plain in the south. Cushion forb barrens dominate the island, with some areas of graminoid-forb tundra, usually at <5% cover and <100 g/m^2 biomass, with isolated patches of 5-50% vegetation cover and biomass increases to 100-500 g/m^2 (Gould et al. 2003, Walker et al. 2005). Mean July temperatures are <3°C (Gould et al. 2003 and references therein).

Methods

Aerial Survey

To define the transect width, we marked survey aircraft wing struts following Norton-Griffiths (1978):

$$w = W\left(\frac{h}{H}\right)$$

where W is the strip width, H is the flight height, h is the observer height when the plane is on the ground and w is calculated, measured and marked on the ground to position wing strut marks. For this survey we only used one mark representing 500 m marked on the wing strut.

Four transects parallel to the long axis of the island were flown at 90 kts with a DeHavilland Twin Otter (Table 1). Weather was clear and sunny although fog banks were present offshore. Flight height was set at 152 m (500 ft) using a radar altimeter. We had one dedicated observer on each side, as well as a navigator/recorder. All observations were marked on a handheld Garmin Montana 650 global positioning system (GPS) unit, which also recorded the flight path every 15 seconds. Sex and age classification was limited, since the aircraft did not make multiple passes (to minimize disturbance), but adult/calf determination was straightforward for groups on transect. GPS tracks and waypoints were downloaded through DNR-GPS and saved in Garmin GPS eXchange Format and as ESRI shapefiles. Data was entered and manipulated in Microsoft Excel and ArcMAP (ESRI, Redlands, CA).

Table 1. Transects on Lougheed Island for a fixed-wing survey, July 28, 2016.

Transect	Length (km)	Lon (North)	Lat (North)	Lon (South)	Lat (South)
1	58.22	-105.5344	77.7193	-104.3511	77.1957
2	76.80	-105.8722	77.7620	-104.4662	77.1456
3	76.59	-106.0556	77.7399	-104.6470	77.1261
4	40.52	-105.6982	77.4915	-104.9597	77.1668

Analysis

Flights linking consecutive transects were removed for population analysis, although survey speed and height were maintained and all observations recorded as if on survey. Similarly, sections of transect crossing water were removed.

Although Jolly's (1969) Method II is widely used for population estimates from surveys, it is designed for a simple random design, rather than for a systematic survey of a patchy population. For comparison, population calculations following Jolly's Method II are provided in Appendix 4, along with calculations following a systematic stratified survey design (Cochran 1977). The muskoxen and caribou detected in this survey were patchily distributed and serially correlated, not randomly distributed. For systematic samples from serially correlated populations, estimates of uncertainty based on deviations from the sample mean are expected to be upwardly biased and influenced by the degree of serial correlation; high serial correlation implies that there is less random variation in the unsurveyed sections between systematically spaced transects than if serial correlation were low (Cochran 1977). Calculating uncertainty based on nearest-neighbor differences incorporates serial correlation, and the upward bias in the uncertainty is expected to be less than if it were calculated based on deviations from the sample mean. Nearest-neighbor methods have been used previously to calculate variance around survey estimates on the unweighted ratio estimate (Kingsley et al. 1981, Stirling et al. 1982, Kingsley et al. 1985, Anderson and Kingsley 2015).

The model for observations on a transect survey following Cochran (1977) is:

$$y_i = Rz_i + \varepsilon_i\sqrt{z_i}$$

Where y_i is the number of observations on transect *i* of area z_i, R is the mean density and error terms ε_i are independently and identically distributed. In this model, the variance of the error term is proportional to the area surveyed. The best estimate of the mean density $\hat{R}$ is:

$$\hat{R} = \frac{\sum_i y_i}{\sum_i z_i}$$

The error sum of squares, based on deviations from the sample mean, is given by:

$$\left(\sum_i \frac{{y_i}^2}{z_i}\right) - \frac{(\sum_i y_i)^2}{\sum_i z_i}$$

The finite-population corrected error variance of $\hat{R}$ is:

$$Var(\hat{R}) = \frac{(1-f)}{(n-1)\sum_i z_i}\left(\left(\sum_i \frac{{y_i}^2}{z_i}\right) - \frac{(\sum_i y_i)^2}{\sum_i z_i}\right)$$

Where f is the sampling fraction and n is the number of transects. The sampling fraction also provides the scaling factor for moving from a ratio (population density) to a population estimate. It is calculated as $(\sum z_i)/Z$, where Z is the study area and $\sum z_i$ is the area surveyed. The irregular study area boundaries mean that f varies from the 20% sampling fraction expected from a 1-km survey strip and 5-km transect spacing.

If we were to apply a model $y_i = Rz_i + \varepsilon_i$ instead, then the variance of the error term would be independent of z, so the variance would depend on the number of items in the sample, but not their total size. This would lead to a least squares estimate of R of $\sum zy\,/\sum z^2$, rather than the more intuitive density definition and model for R presented above.

To incorporate serial correlation in the variance, we used a nearest-neighbor calculation, with the error sum of squares given by:

$$\sum_{i=1}^{n-1}\left(\frac{y_i^2}{z_i}+\frac{y_{i+1}^2}{z_{i+1}}-\frac{(y_i+y_{i+1})^2}{z_i+z_{i+1}}\right)$$

i.e. the sum of squared deviations from pairwise weighted mean densities. The nearest-neighbor error variance of $\hat{R}$ is:

$$Var(\hat{R}) = \frac{(1-f)}{(n-1)\sum_i z_i}\sum_{i=1}^{n-1}\left(\frac{y_i^2}{z_i}+\frac{y_{i+1}^2}{z_{i+1}}-\frac{(y_i+y_{i+1})^2}{z_i+z_{i+1}}\right)$$

Both variance calculations were applied to the Devon Island survey data. In addition, calculations for these strata based on Jolly's (1969) Method II and Cochran's (1977) systematic survey models are provided in the appendices for comparison. For the final estimate, we used the nearest neighbor variance. All distance measurements used North Pole Azimuthal Equidistant projection and area-dependent work used North Pole Lambert Azimuthal Equal Area, with central meridian at 88°W and latitude of origin at 76°N (centered over the study area for high precision).

Population growth rates were calculated following the exponential growth function, which approximates growth when populations are not limited by resources or competition (Johnson 1996):

$$N_t = N_0 e^{rt} \qquad \text{and} \qquad \lambda = e^r$$

Where N_t is the population size at time t and N_0 is the initial population size (taken here as the previous survey in 2008). The instantaneous rate of change is r, which is also represented as a constant ratio of population sizes, λ. When r >0 or λ >1, the population is increasing; when r <0 or λ <1 the population is decreasing. Values of r ~0 or λ ~1 suggest a stable population.

Results

We flew the survey on July 28, 2016 with 252 km on transect, equating to 18.5% coverage of Lougheed Island. The primary intent of the survey was to locate caribou groups for ground sampling efforts July 28-31, so Edmund Walker, Grosvenor, and Patterson islands were not covered. We saw 61 caribou (26 on transect) and no muskoxen. Although we saw no wolves during the survey, fresh tracks at the airstrip confirmed that they are still present on the island (2 wolves were seen on the south end of the island in July 2015). Spatial data presented in Figure 4 represents waypoints taken during the survey along transects and includes on- and off-transect sightings. Except for groups observed on the transect line, waypoints have error associated with the group's distance from the plane.

ᖃᐅᔨᔭᐅᔪᑦ

ᖃᖓᑕᔪᔪᒍᑦ ᖃᐅᔨᓴᕐᓂᖃᖅᓯᑕ ᔪᓚᐃ 28, 2016 252 km−ᓂᒃ ᑲᓯᕐᕕᖃᖅᓯᑎᒃ, ᐊᔾᔨᒋᓪᓗᓂᐅᒃ 18.5%−ᖓ ᐊᑕᖏᖅᓯᓂ Lougheed ᕿᑭᖅᑕᐅᑉ. ᑐᕌᒐᓪᓗᐊᑕᐅᓯᒪᔪᖅ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᓇᐃᐱᑦᓯᒍᒪᓪᓗᑎᒃ ᑐᒃᑐᓂᒃ ᑲᑎᒪᐅᖅᑐᓂᒃ ᓄᓇᒥ ᖃᐅᔨᓴᖅᑕᐅᓂᖃᕋᓯ ᐊᓚᖑᑎᓪᓗᒋᑦ ᑐᒃᑐᐃᑦ ᓄᓇᒥ ᖃᐅᔨᓴᖅᑕᐅᓂᖃᕋᓯ ᐊᕈᒪᑦᓯᑎᒃ ᔪᓚᐃ 28-31, ᑕᐃᒪ ᐃᒻᒪᑦ ᕿᑭᖅᑕᐃᑦ Edmund Walker, Grosvenor, ᐊᒻᒪᓗ Patterson ᓈᓴ ᐃᕖᐅᓯᒪᙱᑐᑦ. ᑕᑯᔪᔪᒍᑦ 61−ᓂᒃ ᑐᒃᑐᓂᒃ (26 ᑲᓯᖅᓯᒪᔪᓂ) ᐅᒥᒻᒪᑦ ᑕᖃᕋᓂᓗ. ᑕᑯᓚᐅᓐᖏᑲᓗᐊᖅᑐᒍᑦ ᐊᒪᕈᕐᓂᒃ ᖃᐅᔨᓴᕐᓂᑎᓐᓂ, ᑐᒥᓂᒃ ᓅᑖᓂᒃ ᓇᓗᓇᐃᖅᑕᐅᔪ ᖃᔪᔪᖅ ᒥᕝᕖᒻᒥ ᓯᓕ ᐱᑕᖃᓚᐊᖏᓐ ᕿᑭᖅᑕᒥ (ᒪᕐᕉᒃ ᐊᒪᕉᒃ ᑕᑯᔭᐅᔫᒃ ᓂᒋᖅᐸᓯᓂᐊ ᕿᑭᖅᑕᐅᑉ ᔪᓚᐃ 2015−ᒥ). ᑲᑎᖅᓯᖅᑕᐅᓯᒪᔪᑦ ᑕᑯᑦᓴᐅᑎᑕᐅᔪᑦ ᑎᑎᖅᑑᔭᖅᓯᒪᔪᒥ 4−ᒥ ᑕᑯᑦᓴᐅᑎᑦᓯᔪᑦ ᑲᓯᕐᕖᐅᔪᓂᒃ ᖃᐅᔨᓴᕐᑕᕐᓂᐅᔪᓂ ᐱᖃᓯᐅᔾᔨᑦᓯᑎᒃ

ᑕᑯᑦᓴᓂᒃ ᑲᓱᖅᓯᒪᕗᓂᖓ ᑕᑯᔭᐅᔪᓂᒃ. ᐋᒻ ᒐᐅᒐ ᓗᐊᖅ ᑐᒃ ᑐᐃᑦ ᑲᑎᒪᐅᖅᑐᑦ ᑲᓱᕐ ᓂᐅᓯᒪᔪᒥ, ᐊᖅᑯᑎᒦᑦᑐᑦ ᑖᒻ ᒪᖅᓯᒪᓂᖃᖅᑐᑦ ᐊᑦᑐᐊᔪᓄᑦ ᑲᑎᒪᐅᖅᑐᑦ ᐅᖓᔾᓂᖏᓄᑦ ᖃᖓᑕᔫᕐᒥᒃ.

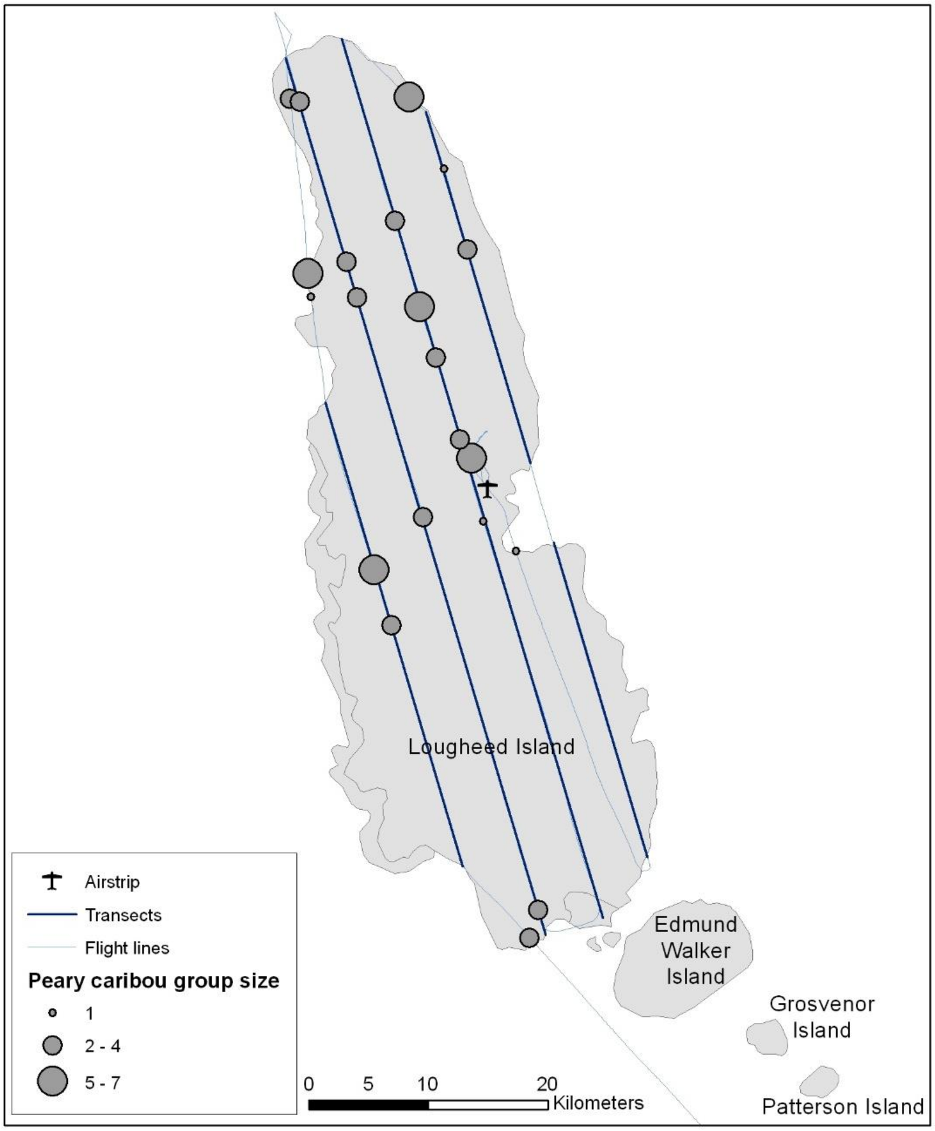


Figure 1. Observations of Peary caribou on Lougheed Island, July 2016, including observations on and off transect, and on ferry flights. ᑎᑎᖅᑑᔭᖅᓯᒪᔪᖅ 2. ᑕᑯᔭᐅᔪᑦ ᐱᐅᓇᑐᒃ ᑐᐃᑦ Lougheed ᕿᑭᖅᑕᖕᒐᓂ, ᔪᓚᐃ 2016-ᒥ, ᐱᖃᓯ ᐅᑎᑦᓱᑎᒃ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᑲᓱᕐ ᕕᒻᒥ ᓯᓚᑖᓂᓗ. ᐊᒻᒪᓗ ᐅᒥᐊᕐ ᔪᐊᒻᒪᖕᒃ ᑰᖅᑐᓂ.

A population estimate was calculated for Peary caribou, but the few observations limit the precision of the estimate. Population estimates and variances are presented in Table 2.

ᐊᒥᓲᓂᖏᑦ ᓇᓚᐅᑦᓵᖅᑕᐅᓯᒪᔪᑦ ᐱᐅᓇ ᑐᒃ ᑐᓄᑦ, ᑭᓯᐊᓂ ᐊᒥᓲᙱᑦᑐᓂᒃ ᑕᑯᑦᓯᑎᒃ, ᐊᐳᖅᓯᒪᒍᑕᐅᒻ ᒪᑦ ᓈᓴᐃᑦᓯᐊᕐ ᓂᐅᓯᒪᒐᕚᖅᑐᒥᒃ. ᐊᒥᓲᓂᖏᓂᒃ ᓇᓚᐅᑦᓵᖅᑐᑦ ᐊᔾ ᔫᑮᖕᖏᓂᐅᔪᓪᓗ ᐊᑐᐃᓐ ᓇᐅᑎᑕᐅᔪᑦ ᑎᑎᖅᑑᔭᖅᓯᒪᔪᖅ 2-ᒥ.

Table 2. Peary caribou population calculations Lougheed Island with variance calculated by nearest neighbor methods and by deviations from the sample mean.

	Stratum area Z (km²)	Surveyed area z (km²)	Count, y	Estimate, $\hat{Y}$	Density, $\hat{R}$ (per km²)	Error Sum of Squares	Var ($\hat{Y}$)	SE	CV
Nearest-Neighbor Difference	1359.6	252.1	26	**140**	0.103	0.713	1064.78	32.63	0.232
Sample Mean Difference	1359.6	252.1	26	**140**	0.103	0.449	670.57	25.90	0.185

ᑎᑎᖅᑑᔭᖅᓯᒪᔪᖅ 2. ᐱᐅᕆ ᑐᒃ ᑐᐃᑦ ᐊᒥᓱᓂᖕᓂ ᓂᒃ ᓈᓴ ᐃᓂᐅᓯᒪᔪᑦ Lougheed ᕿᑭᖅᑕᖓᓂ ᐊᔾᔾᒌᓐᖏᓂᐅᔪᑦ ᓈᓴᖅᑕᐅᓯᒪᑦᓯᑎᒃ ᓴᓐ ᓂᓕᕆᓂᖅᐸᖕᓂᒃ ᐊᑐᖅᓯᑎᒃ ᐊᑐᖅᑕᐅᓕᖅᓯᑎᒃ ᓈᓴ ᐅᑏᑦ ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᒦᖕᖒᖅᑐᑦ.

	ᕿᓪᓕᕆᓪᓕᖅᓯᒪᔪᑦ ᐊᖏᓂᖏᑦ Z (km²)	ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᖅ z (km²)	ᓈᓴᖅᑕᐃᑦ, y	ᓇᓚᐅᑦᓵᖅᑕᐃᑦ, $\hat{Y}$	ᐊᒥᓱᓂᖏᑦ, $\hat{R}$ (ᐊᑐᓂᑦ km²)	ᑖᒪᖅᑕᐅᑐᐃᓐ ᓇᑎ ᐊᓖᑦ ᖃᑦᓯᐅᓂᖏᑦ ᑭᑉᐹᓇᑦ ᑐᓂ	ᐊᔾᔾᒌᖕᖏᓂᖅ ($\hat{Y}$)	SE	CV
ᓴᓂᑦ ᓕᕆᔭ ᐅᓂᖅ ᐸᓃᖕᖓᔪᑦ ᐊᔾᔾᒌᖕᖏᓃᑦ	1359.6	252.1	26	**140**	0.103	0.713	1064.78	32.63	0.232
ᖃᐅᔨᓴᖅᑕᐅᓂᖕᖓᑕ ᐊᔾᔾᒌᖕᖏᓂᖕᖓ	1359.6	252.1	26	**140**	0.103	0.449	670.57	25.90	0.185

Caribou have declined since the last survey in 2007. Based on a population estimate of 140±SE33 in 2016 and 372 in 2007 (205-672, 95%CI; Jenkins et al. 2011), the instantaneous growth rate r is -0.11, and lambda λ is 0.90. More sophisticated analyses incorporating uncertainty in the estimates have not been undertaken.

ᑐᒃᑐᐃᑦ ᐃᓄᐃᓴᓪᓕᕚᓪᓕᖅᓯᒪᔪᑦ ᕿᖑᓪᓕᖅᐹᒥ ᖃᐅᔨᓴᖅᑕᐅᔫᒪᑕᓂᑦ 2007–ᒥ. ᑐᓐᖓᕙᐅᑦᓯᑎᒃ ᐊᒥᓲᓂᖕᖏᑦᑕ ᖃᐅᔨᓴᖅᑕᐅᓂᕆᔭᖕᖏᑦ 140±SE33 2016–ᒥ ᐊᒻᒪᓗ 372 2007–ᒥ (205-672, 95%CI; Jenkins et al. 2011), ᑕᕝᕙᓴᐃᓐᓇᖅ ᐱᕈᖅᐸᓪᓕᐊᓂᖕᖏᑦ r is -0.11, ᐊᒻᒪᓗ lambda λ is 0.90. ᐃᓗᓕᖅᑐᓂᖅᓴᐃᑦ ᖃᐅᔨᓴᕐᓂᐅᔪᑦ ᐃᓚᒍᑦᓯᐅᔾᔨᔪᑦ ᓇᓗᓇᖅᑐᓂᒃ ᒥᑦᓴᐅᓯᔭᐅᔪᓂᒃ ᓇᓚᐅᑦᓵᖅᑕᐅᓯᒪᓐᖏᑦᑐᑦ.

Discussion

Previous surveys of Lougheed Island have used different survey platforms (Piper Super Cub and deHavilland Beaver, Tener 1963; Helio-courier, Gunn and Dragon 2002; Bell 206 helicopter, Jenkins et al. 2011; Twin Otter, this survey) with different coverage and at different times of the year (spring, Miller et al. 1977, Jenkins et al. 2011; summer, Tener 1961, Miller et al. 1977, Miller 1987, Gunn and Dragon 2002, this survey). In 1974 and 1985, only a few caribou were seen on the island. In 1997, the presence of 28±29 caribou carcasses suggested that a die-off had occurred on the island – weather-related die-offs had occurred in 1997 and for 3 years prior on the Bathurst Island Complex as well (Gunn and Dragon 2002).

Widespread weather-related die-offs recorded elsewhere in the Arctic Archipelago in the 1970s may have been responsible for the lack of caribou observed on the island in 1973 and 1974, either due to die-offs or movement off the island. Population densities equivalent to the 1961 survey have not been observed on Lougheed Island in the last 50 years of sporadic survey work. Lougheed Island caribou were impacted by the mid-1990s die-offs related to severe winter weather at least in 1996-97, an estimated 28±SE19 caribou carcasses on the island (Gunn and Dragon 2002). The 2007 survey recorded an increase in caribou numbers on Lougheed Island following die-offs in the 1990s, but the population appears to be lower now than 9 years ago. Higher caribou populations on both Melville Island and Bathurst Island could account for some of the 'missing' caribou. In October 1995, one satellite-collared female caribou crossed to Lougheed

Island, at least 110 km across the sea ice from Bathurst Island (Poole et al. 2015). She then continued 110 km across the ice to Borden Island, where she died in December 1995 (Poole et al. 2015).

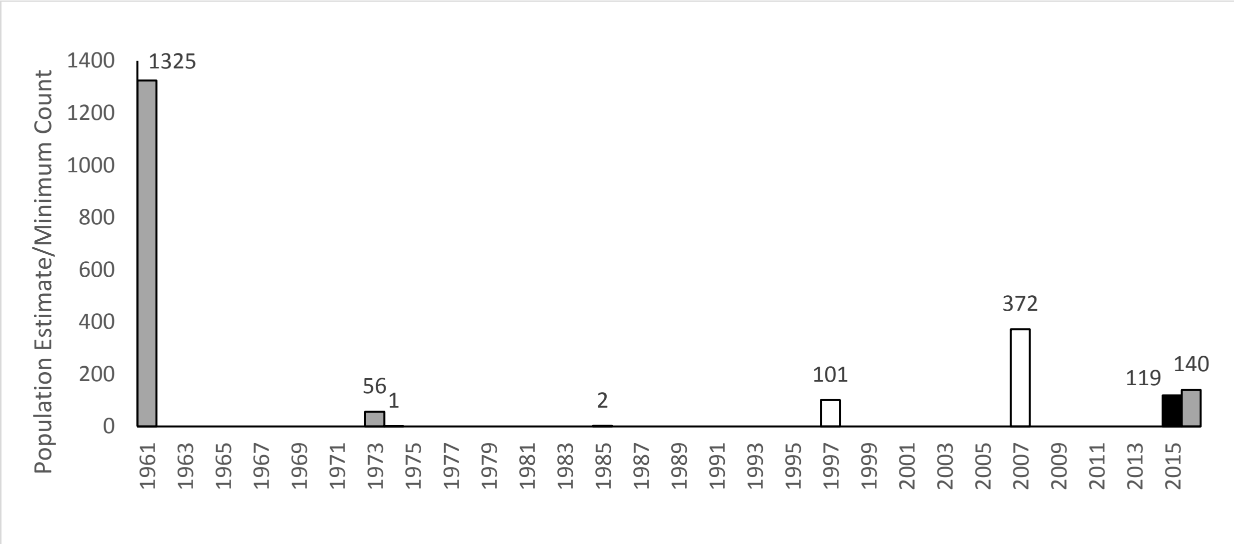


Figure 3. Population estimates for Peary caribou on Lougheed Island. Grey bars indicate estimates including calves (Tener 1963, Miller et al. 1977, this report), black bars are minimum counts (Miller et al. 1977, Miller 1987, this report for 2015), and white bars are population estimates of 1+-year-old caribou (Gunn and Dragon 2002, Jenkins et al. 2011).

Although not conducted as a survey, we did fly over Lougheed Island in 2015 to determine whether we could collect pellet samples using a Twin Otter drop-off and pick-up, or whether a helicopter would be required. We counted at least 119 Peary caribou during the flight, including some groups of 15-20 individuals (in which case the lower value was added for the minimum count of 119; Figure 4). Flight height was 90-150 m above ground and conditions were clear and sunny, with one observer each side of the plane and a navigator/recorder. No marks were made on the wing struts to define a survey strip.

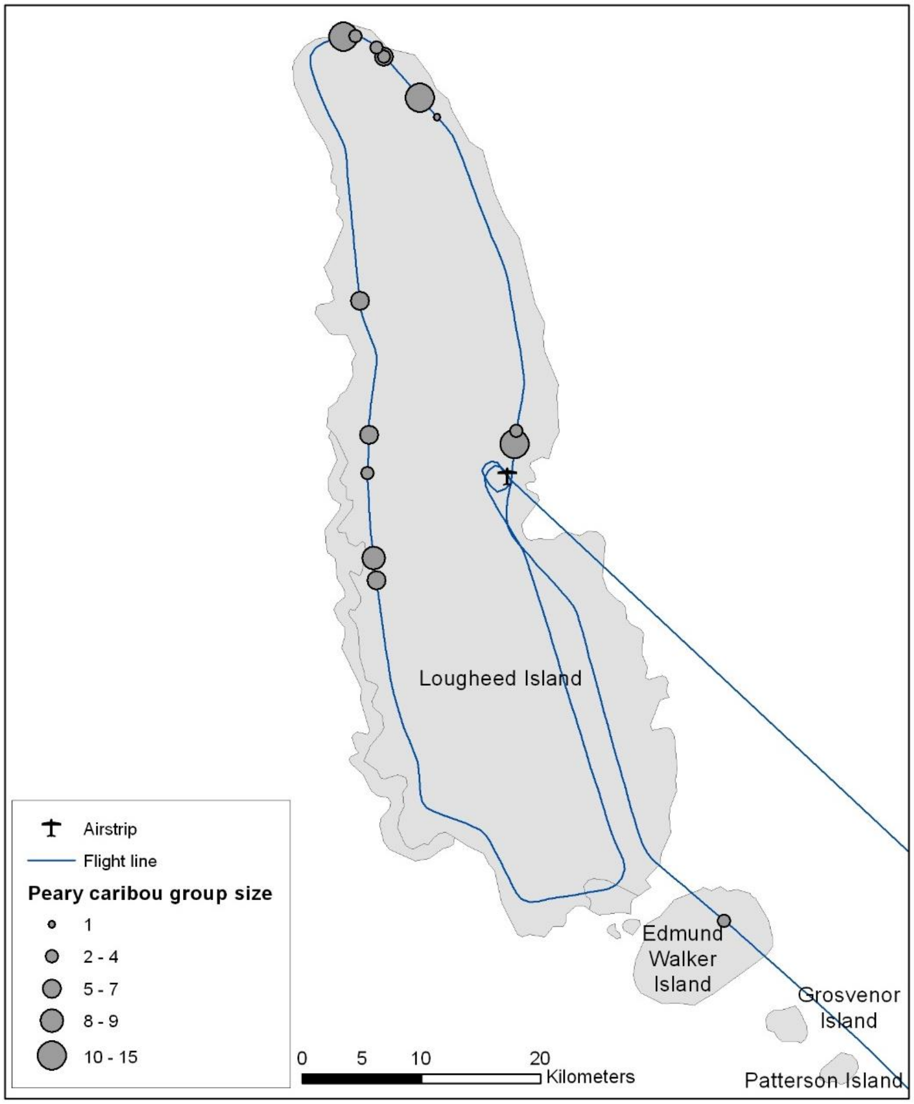


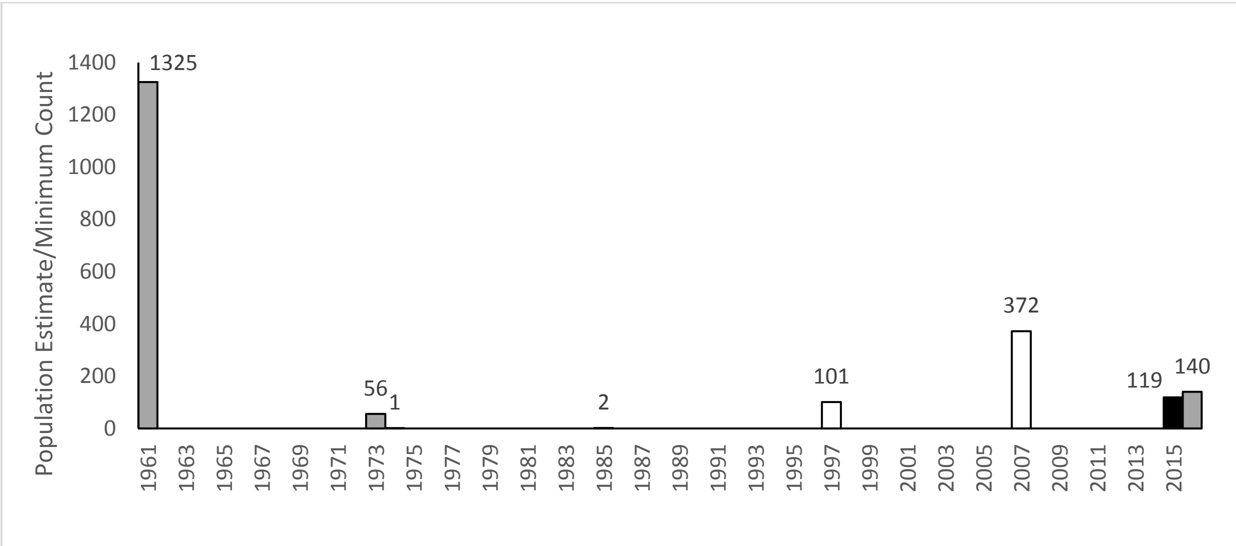
Figure 4. Locations of Peary caribou groups seen on a July 23, 2015 Twin Otter flight over Lougheed Island.

ᐅᖃᖃᑎᒌᓐᓂᖅ

ᓯᕗᕐᖑᓂ ᖃᐅᔨᓴᕐᓂᐅᓯᒪᔪᑦ Lougheed ᕿᑭᖅᑕᖓᓂ ᐊᑐᖅᓯᒪᔪᑦ ᐊᕐᔨᕆᓐᖏᑐᓂᒃ ᖃᐅᔨᓴᕐᓂᕐᒧᑦ ᑐᓐᖓᐅᔪᓂᒃ (Piper Super Cub ᐊᒻᒪᓗ deHavilland Beaver, Tener 1963; Helio-courier, Gunn ᐊᒻᒪᓗ Dragon 2002; Bell 206 ᖁᓛᒨᓕᒃ, Jenkins et al. 2011; ᒪᕐᕈᓕᒃ ᑕᕝᕙᓂ ᖃᐅᔨᓴᕐᓂᕐᒥ) ᐊᕐᔨᕆᓐᖑᓂᒃ ᖃᐅᔨᓴᖅᓯᑎᒃ ᑕᕝᕙᓂᑦᓴ ᐃᓐᓇᐅᓐᖏᑐᖅ ᐊᕐᕋᒨᑉ ᐃᓗᐊᓂ (ᐅᐱᕐᖑᐆ ᑯᑦ, Miller et al. 1977, Jenkins et al. 2011; ᐊᐅᔭᒃ ᑯᑦ, Tener 1961, Miller et al. 1977, Miller 1987, Gunn ᐊᒻᒪᓗ Dragon 2002, ᐅᕙᓂ ᖃᐅᔨᓴᕐᓂᕐᒥ). 1974 ᐊᒻᒪᓗ 1985, ᐃᓄᐃᓴᑦᑐᐹᓗᐃᑦ ᑐᒃᑐᐃᑦ ᑕᑯᔭᐅᓯᒪᔪᑦ. 1997−ᖑᑎᓪᓗᒍ, ᑕᕝᕚᐅᔪᑦ 28±29 ᑐᒃᑐᒥᓈᑦ ᓇᓗᓇᐃᖅᓯᒍᑕᐅᓯᒪᔪᑦ ᑐᖁᕋᖅᓯᒪᔪᖃᓇᐊᖓ ᕿᑭᖅᑕᒥ − ᓯᓚᒥᒃ ᐱᔪᑎᖃᖅᓯᑎᒃ ᑐᖁᕋᖅᓯᒪᔪᑦ 1997−ᒥ ᐊᒻᒪᓗ ᐊᕐᕋᒍᐃᑦ ᐱᖓᓱᑦ ᓯᕗᕐᖑᓂ ᕿᖓᐅᑦ ᕿᑭᖅᑕᖑᓂ ᐊᒻᒪᓗ gunn ᐊᒻᒪᓗ Dragon 2002).

ᓯᐊᒻᒪᑦᓯᒪᔪᑦ ᓯᓚᒥᒃ ᐱᔪᑎᖃᖅᓯᑎᒃ ᑐᖁᕋᖅᓯᒪᔪᑦ ᑎᑎᕋᖅᑕᐅᓯᒪᔪᑦ ᐊᓯᖏᓂ ᐅᑭᐅᖅᑕᑐᒥ ᕿᑭᖅᑕᓂ 1970−ᖏᓂ ᐱᔾᒧᑕᐅᓯᒪᑐᐃᓐ ᓇᑎᐊᓕᒃ ᑐᒃ ᑐᖃᑦᓯᐊᖏᓂᖕᒪᑦ ᕿᑭᖅᑕᒥ 1973 ᐊᒻᒪᓗ 1974, ᑐᖁᕋᕐᓂᖅ ᐱᔪᑕᐅᓪᓗᓂ ᐅᕝᕙᓘᓐᓈᑦ ᓅᓯᒪᓕᑐᐃᓐ ᓇᑎᐋᓖᑦ ᕿᑭᖅᑕᒥ. ᐊᒥᓲᓂᖏᑦ ᐊᕐᔨᐸᓗᖏᑦ 1961−ᒥ ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᑦ ᑕᑯᔭᐅᓯᒪᓐᖏᑦᑐᑦ Lougheed ᕿᑭᖅᑕᖓᓂ ᐊᕐᕋᒍᓂ 50−ᓂ ᐊᓂᒍᖅᑐᓂ ᖃᐅᔨᓴᕐᓂᐅᓕᐅᒥᔫᖅᓯᒪᔪᓂ. Lougheed ᕿᑭᖅᑕᒥ ᑐᒃᑐᐃᑦ ᐊᑦᑐᖅᑕᐅᓯᒪᔪᑦ ᕿᑎᖓᓂ 1990 ᐊᕐᕌᒍᖏᑕ ᑐᖁᕋᖅᓯᒪᔪᑦ ᐊᑦᑐᐊᔪᑦ ᐅᑭᐅᒃᑯᑦ ᓯᓚᕐᓂᓗᕐᓂᕐᔪᐊᕐᓄᑦ ᑕᐃᑲᓂ 1996-97, ᓇᓚᐅᑦᔩᖅᑕᐅᓯᒪᔪᑦ 28±SE19 ᑐᒃᑐᒥᓈᑦ ᕿᑭᖅᑕᒥ (Gunn and Dragon 2002). 2007−ᒥ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᑎᑎᕋᖅᑕᐅᓯᒪᔪᑦ ᐊᒥᓲᓐᖑᐹᓪ ᓕᕈᑕᐅᔪᔪ 13 ᑐᒃᑐᓄᑦ Lougheed ᕿᑭᖅᑕᖓᓂ ᑭᖑᕐ ᖔᑦ ᑐᖁᕋᓚᐅᖅᑎᓪᓗᒋᑦ 1990−ᖏᓂ, ᑭᓯᐊᓂ ᐊᒥᓲᓂᖏᑦ

ᐃᓄᐃᓴᓐᓂᖅᓴᕐ ᔩᔮᓕᖅᑐᖅ ᐊᕐ ᕌᒍᐃᑦ 9 ᐊᓂᒍᖅᓯᒪᓕᖅᑎᓪᓗᒋᑦ. ᐊᒥᓲᓂᖅᓴᕈᖅᓯᒪᔪᑦ ᑐᒃ ᑐᐃᑦ Melville ᕿᑭᖅᑕᓪᓂ ᐊᒻᒪᓗ ᕿᓐᑖᒻᒥ ᑭᐅᔾ ᔪᑕᐅᒍᓐ ᓇᑐᐃᓐ ᓇᕆᐊᓖᑦ 'ᑭᓐ ᖑᖅᑕᐅᓯᒪᔪᓄᑦ" ᑐᒃ ᑐᓄᑦ. ᐅᑦᑑᕐᕙ 1995-ᖑᑎᓪᓗᒍ, ᖃᓪᓚᖅᑎᑕᐅᓯᒪᔪ ᒨᓪᔪᓂᒃ ᖁᓪᓚᕈᑎᓖᑦ ᐊᕐ ᓇᖅ ᑐᒃ ᑐᐃᑦ ᐃᑳᖅᓯᒪᔪᑦ Lougheed ᕿᑭᖅᑕᓪᓚᓄᑦ, 110 ᑭᓗᒦ ᑕᓂᒃ ᐃᑳᖅᓱᓂ ᑕᕆᐅᒃ ᑯᑦ ᓯᑯᒃ ᑯᑦ ᐊᑯᕐ ᖕᖑᓂ ᕿᓐᑖᑦ ᕿᑭᖅᑕᓪᓚᑦ (Poole et al. 2015). ᑲᔪᓯᒋᐊᒃ ᑲᓐᓂᖅᓱᓂ 110 ᑭᓗᒦ ᑕᓂᒃ ᐃᑳᖅᓱᓂ Borden ᕿᑭᖅᑕᓪᓚᓄᑦ, ᐃᓅᒍᓐ ᓃᖅᓱᓂ ᑕᐃᑲᓂ ᑏᓴᕐᕙ 1995 (Poole et al. 2015).



ᑎᑎᖅᑑᔭᖅᓯᒪᔪᖅ 5. ᐊᒥᓲᓂᖕᓂᒃ ᓇᓚᐅᑦᓵᕐᓂᖅ ᐱᐅᖏ ᑐᒃ ᑐᓂᒃ Lougheed ᕿᑭᖅᑕᓪᓂ. ᐃᓱᖅᑐᑦ ᐃᑳᖕᖓᑦ ᓇᓗᓇᐃᖅᓯᔪᖅ ᓇᓚᐅᑦᓵᖅᑕᐅᔪᑦ ᐱᖃᓯᐅᑎᑦᓱᑎᒃ ᓄᕐ ᕋᐃᑦ (Tener 1963, Miller et al. 1977, ᐅᑯᐊ ᐅᓂᒃ ᑳᑦ), ᕿᕐ ᓂᖅᑐᑦ ᐃᑳᖕᖓᑦ ᐊᑦᓯᓂᖅᐹᑦ ᓈᓴᐃᓂᐅᔪᑦ (Miller et al. 1977, Miller 1987, ᐅᑯᐊ ᐅᓂᒃ ᑳᑦ 2015−ᒧᑦ), ᖃᑯᖅᑕᐃᓕᓗ ᐃᑳᖕᖓᑦ ᐊᒥᓲᓂᖕᓂᒃ ᓇᓚᐅᑦᓵᖅᑐᑦ 1+- ᐊᕐ ᕌᒍᓕᓐ ᓂᒃ ᑐᒃ ᑐᓂᒃ . (Gunn and Dragon 2002, Jenkins et al. 2011).

Management Recommendations

Harvest is low and accessibility of Lougheed Island is difficult. There is currently no TAH on Peary caribou, and no changes to harvest management are recommended based on this survey. Monitoring changes in both the Bathurst Island Group and Lougheed Island caribou populations as if they are one population unit may provide better information in future to determine whether caribou are moving among the islands or primarily increasing and decreasing based on survival and recruitment on the Bathurst Island group and Findlay Group separately. The continued lack of muskoxen on the island also makes Lougheed an ideal area to examine caribou behavior and population dynamics independent of the influence of muskoxen.

ᐊᐅᓚᑦᓯᓂᕐ ᒧᑦ ᐃᓱᒪᓕᐅᕈᑕᐅᔪᑦ

ᐊᖑᓇᓱᓐᓂᖅ ᐊᑦᓯᑦᑐᑉᐹᓗᒃ Lougheed ᕿᑭᖅᑕᓕᐊᕐᓂᖅ ᐱᔭᕆᐊᑭᓐᖏᒪᑦ. ᒫᓐᓇ ᑲᑎᑦᓯᑎᒃ ᐊᖑᓇᓱᑦᑕᐅᔪᑦᓴᓂᒃ ᐱᑕᖃᓐᖏᑦᑐᖅ ᐱᐅᖏ ᑐᒃ ᑐᓄᑦ, ᐊᓯᔾᔨᖅᑕᐅᓯᒪᒐᑎᓪᓗ ᐊᖑᓇᓱᓐᓂᕐ ᒧᑦ ᐊᐅᓚᑦᓯᓂᖅ ᐃᓱᒪᓕᐅᕈᑕᐅᓯᒪᔪᖅ ᑐᓐᖓᕕᐅᑦᓱᓂ ᐅᓇ ᖃᐅᔨᓴᕐᓂᐅᔪᖅ. ᖃᐅᔨᓴᕐᓂᖅ ᑕᒪᒃ ᑮᓐᓂ ᕿᓐᑖᒻᒥ ᑲᑎᒪᐅᖅᑐᓂᒃ ᐊᒻᒪᓗ Lougheed ᕿᑭᖅᑕᒥ ᑲᑎᒪᐅᖅᑐᓂᒃ ᓲᕐᓗ ᐊᑕᐅᓯᕐ ᑎᑐᑦ ᑐᓴᐅᒪᑦᓯᐊᑲᓐᓂᕈᑕᐅᓂᖅᓴᐅᕚᓚᐃᔪᖅ ᓯᕗᓂᖅᑎᓐᓂ ᓇᓗᓇᐃᖅᓯᒍᑕᐅᓗᑎᒃ ᑐᒃ ᑐᐃᑦ ᓄᑦᑕᕐᒪᖓᑦ ᐊᑯᕐ ᖕᖑᓂ ᕿᑭᖅᑕᐃᑦ ᐅᕐᕙᓗ ᐊᒥᓲᓐᖑᐸᓕᐊᒻᒪᖓᑦ ᐃᓄᐃᓴᑦᓕᕚᓕᐊᒻᒪᖓᑦᑐᓐᓃᑦ ᑐᓐᖓᕕᐅᑦᓱᓂ ᐊᓐ ᓇᒍᓐ ᓇ14ᓂᖑᕐ ᓄᑦᑕᕐ ᓂᖕᓂᓗ ᕿᓐᑖᑦ ᕿᑭᖅᑕᓪᓂ ᑲᑎᒪᐅᖅᑐᓂ ᐊᒻᒪᓗ Findlay Group ᐃᒻᒥᒃ ᑯᑦ. ᐅᒥᒻᒪᖃᑦᓯᐊᕐᖕᓂᖅᑕᐅᖅ Lougheed ᕿᑭᖅᑕᓪᓂ ᖃᐅᔨᓴᕐ ᕕᓴᑦᓯᐊᖑᔪᑦ ᑐᒃ ᑐᐃᑦ ᐱᐅᓯᖕᖏᓂᒃ ᐊᒥᓲᓂᖕᖏᓂᓪᓗ ᐃᒻᒥᒃ ᑰᖕᖓᓂᒃ ᐅᒥᒻᒪᐃᑦ.

Acknowledgements

Thank you to survey observers Etuangat Akeeagok and James Iqaluk, Kenn Borek Air pilots Terry Welsh and Tanner Seely, the Resolute Bay HTA for their guidance and support, and the team at Polar Continental

Shelf Program for logistical support. Funding for this work was provided by the Nunavut Department of Environment Wildlife Research Section. The Polar Continental Shelf Program provided logistical support (Project 308-16). The work was completed under Government of Nunavut Wildlife Research Section permit 2016-010.

Literature Cited

Anderson, M. and M. C. S. Kingsley. 2015. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) on southern Ellesmere Island, March 2015. Nunavut Department of Environment, Wildlife Research Section, Status Report, Igloolik, NU. 46 pp.

Caughley, G. 1977. Sampling in aerial survey. Journal of Wildlife Management 41(4): 605-615.

Cochran, W. G. 1977. Sampling techniques. 3rd ed. Wiley, New York, NY. 428 pp.

Gould, W. A., M. Raynolds, and D. A. Walker. 2003. Vegetation, plant biomass, and net primary productivity patterns in the Canadian Arctic. Journal of Geophysical Research 108 (D2): 8167, doi:10.1029/2001JD000948.

Jenkins, D., M. Campbell, G. Hope, J. Goorts, and P. McLoughlin. 2011. Recent trends in abundance of Peary Caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) in the Canadian Arctic Archipelago, Nunavut. Department of Environment, Government of Nunavut, Wildlife Report No. 1, Pond Inlet, Nunavut. 184 pp.

Jolly, G. M. 1969. Sampling methods for aerial censuses of wildlife populations. East African Agricultural and Forestry Journal 34 (special issue):46-49.

Kingsley, M. C. S., and G. E. J. Smith. 1981. Analysis of data arising from systematic transect surveys. Pp 40-48 in F. L. Miller and A. Gunn, eds. Proceedings, Symposium on Census and Inventory Methods for Populations and Habitats, Banff, AB, April 1980.

Kingsley, M. C. S., I. Stirling, and W. Calvert. 1985. The distribution and abundance of seals in the Canadian high arctic, 1980-82. Canadian Journal of Fisheries and Aquatic Sciences 42 (6): 1189-1210.

Miller, F. L., R. H. Russell, and A. Gunn. 1977. Distributions, movements and numbers of Peary caribou and muskoxen on western Queen Elizabeth Islands, Northwest Territories, 1972-74. Canadian Wildlife Service Report Series No. 40, Edmonton, Alberta. 55 pp.

Miller, F. L. 1987. Peary caribou and muskoxen on Bathurst, Alexander, Marc, Massey, Vanier, Cameron, Helena, Lougheed, and Edmund Walker islands, Northwest Territories, July 1985. Technical Report Series No. 20, Canadian Wildlife Service, Western and Northern Region, Alberta. 45 pp.

Miller, F. L. and S. J. Barry. 2009. Long-term control of Peary caribou numbers by unpredictable, exceptionally severe snow or ice conditions in a non-equilibrium grazing system. Arctic 62(2): 175-189.

Miller, F.L., and A. Gunn. 2003. Catastrophic die-off of Peary caribou on the western Queen Elizabeth Islands Canadian High Arctic. Arctic 56: 381–390.

Miller, F. L., R. H. Russell and A. Gunn. 1975. The decline of caribou on the western Queen Elizabeth Islands. Polarforschung 45: 17-22.

Norton-Griffiths, M. 1978. Counting animals. In: J. J. R. Grimsdell, ed. Handbooks on techniques currently used in African wildlife ecology. No 1. AWLF, Nairobi, Kenya.

Poole, K. G., A. Gunn, J. Wierzchowski, and M. Anderson. 2015. Peary caribou distribution within the Bathurst Island Complex relative to the boundary proposed for Qausuittuq National Park, Nunavut. Rangifer 35 Special Issue 23: 81-98.

Stirling, I., M. C. S. Kingsley and W. Calvert. 1982. The distribution and abundance of seals in the Beaufort Sea, 1974-1979. Canadian Wildlife Service Occasional Paper 47.

Tener, J. S. 1963. Queen Elizabeth Islands game survey, 1961. Canadian Wildlife Service Occasional Paper No. 4. 50 pp.

Walker, D. A., M. K. Raynolds, F. J. A. Daniëls, E. Einarsson, A. Elvebakk, W. A. Gould, A. E. Katenin, S. S. Kholod, C. J. Markon, E. S. Melnikov, N. G. Moskalenko, S. S.Talbot, B. A. Yurtsev, and the other members of the CAVM Team. 2005. The Circumpolar Arctic vegetation map. Journal of Vegetation Science 16: 267-282.

Appendix 1. Alternate population calculations.

Jolly Method II Calculations

In this report, we used a systematic sampling approach to analysis, since we were estimating abundance of a patchy population rather than estimating density in a habitat (which varied across the study area). Other systematic aerial surveys have frequently used Jolly's Method II, and estimates derived from both analyses were similar. Population estimates for fixed-width strip sampling using Jolly's Method 2 for uneven sample sizes (Jolly 1969; summarized in Caughley 1977) are derived as follows:

$$\hat{Y} = RZ = Z\frac{\sum_i y_i}{\sum_i z_i}$$

Where $\hat{Y}$ is the estimated number of animals in the population, R is the observed density of animals (sum of animals seen on all transects $\sum_i y_i$ divided by the total area surveyed $\sum_i z_i$), and Z is the total study area. The variance is given by:

$$Var(\hat{Y}) = \frac{N(N-n)}{n}\left(s_y^2 - 2Rs_{zy} + R^2 s_z^2\right)$$

Where N is the total number of transects required to completely cover study area Z, and n is the number of transects sampled in the survey. s_y^2 is the variance in counts, s_z^2 is the variance in areas surveyed on transects, and s_{zy} is the covariance. The estimate $\hat{Y}$ and variance $Var(\hat{Y})$ are calculated for each stratum and summed. The Coefficient of Variation (CV = σ/$\hat{Y}$) was calculated as a measure of precision.

Table 3. Abundance estimates (Jolly 1969 Method II) for caribou on Lougheed Island, July 2016. *N* is the total number of transects required to completely cover study area *Z*, *n* is the number of transects sampled in the survey covering area *z*, *y* is the observed muskoxen, *Y* is the estimated muskoxen with variance Var(*Y*). The coefficient of variation (CV) is also included.

Y	**Var(Y)**	**n**	**Z (km^2)**	**z (km^2)**	**N**	**y**	**Density (per km^2)**	**CV**
140	1511.91	4	1359.58	252.13	24	26	0.1031	0.28

DISTRIBUTION AND ABUNDANCE OF PEARY CARIBOU (*Rangifer tarandus pearyii*) AND MUSKOXEN (*Ovibos moschatus*) ON SOUTHERN ELLESMERE ISLAND, MARCH 2015

MORGAN ANDERSON[1]

And

MICHAEL C. S. KINGSLEY[2]

7 August 2015

[1]Wildlife Biologist High Arctic, Department of Environment
Wildlife Research Section, Government of Nunavut Box 209 Igloolik NU X0A 0L0
[2]Box 3, 3300-357 São Martinho da Cortiça, Portugal
mcskingsley@gmail.com

STATUS REPORT 2015-01
NUNAVUT DEPARTMENT OF ENVIRONMENT
WILDLIFE RESEARCH SECTION
IGLOOLIK, NU

ᐊᕕᒃ ᑐᖅᓯᒪᓂᖏᑦ ᖃᓄᕐ ᓗ ᐅᓄᖅᑎᒋᓂᖏᑦ ᑐᒃ ᑐᐃᑦ
ᐅᒥᖕᒪᐃᓪ ᓗ ᐅᒥᖕᒪᑦ ᓄᓈᑕ ᓂᒋᐊᓂ, ᒫᔾ ᔾ 2015

ᒍᐊᒐᓐ ᐋᓐ ᑐᓴᓐ[1]

ᐊᒻ ᒪᓗ

ᒪᐃᑯᓪ C. S. ᑭᖕᔅ ᓖ[2]

7 ᐋᒡᑭᓯ 2015

[1]ᐆᒪᔪᓂᒃ ᖃᐅᔨᓴᖅᑎ ᖁᑦ ᑎᒃ ᑐᖅ ᐅᑭᐅᖅᑕᖅᑐᒥ, ᐊᕙᑎᓕᕆᔨᒃᑯᑦ
ᐆᒪᔪᓂᒃ ᖃᐅᔨᓴᖅᑏᑦ, ᓄᓇᕗᑦ ᒐᕙᒪᖓBox 209 Igloolik NU X0A 0L0
[2]Box 3, 3300-357 São Martinho da Cortiça, Portugal
mcskingsley@gmail.com

ᖃᓄᐃᓕᖓᓂᖓᓂ ᐅᓂᒃ ᑳᖅ 2015-01
ᓄᓇᕗᒻ ᒥ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ
ᐆᒪᔪᓂᒃ ᖃᐅᔨᓴᖅᑏᑦ
ᐃᒡ ᓗᓕᒃ, ᓄᓇᕗᑦ

Anderson, M. and M. C. S. Kingsley. 2015. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyii*) and muskoxen (*Ovibos moschatus*) on southern Ellesmere Island, March 2015. Nunavut Department of Environment, Wildlife Research Section, Status Report, Igloolik, NU. 49 pp.

Summary

We flew a survey of southern Ellesmere, Graham, and Buckingham islands by Twin Otter in 50 hours between March 19 and 26, 2015, to update the population estimate for caribou and muskoxen in the study area. Previous survey attempts in April and August 2014 were cancelled due to weather. Severe winter weather in the early 2000s, resulted in poor condition and low muskox numbers during the previous survey in 2005, although the area supported relatively high densities of muskoxen in the past. This survey found that muskoxen had recovered from the previous population crash and caribou continued to persist at low densities, as seen in previous surveys.

Muskoxen were abundant north of the Sydkap Ice Cap along Baumann Fiord, north of Goose Fiord, west and north of Muskox Fiord, and on the coastal plains and river valleys east of Vendom Fiord, although they were also seen on Bjorne Peninsula and the south coast from Harbor Fiord to Jakeman Glacier. Short yearlings (10-month old) made up 22% of the population in March 2015. We observed 1146 muskoxen, and calculated a population estimate of 3200 ± SE 602. Although this is the highest estimate recorded for surveys of the area, most previous surveys covered only part of the area, included other areas, or provided only minimum counts. However, the muskox population does appear to have recovered from the low of 312-670 (95% CI) recorded in 2005.

We only saw 38 Peary caribou during the March survey. They were concentrated on the north tip of Bjorne Peninsula and Graham Island, although not as many as had been seen there in 2005. We saw another group east of Vendom Fiord and a group between Bird Fiord and Sor Fiord. That area is also where we saw 2 groups totaling 8 caribou in the August 2014 survey attempt (neither of the 2014 survey attempts covered most of the areas where caribou were expected to be, and none were seen in April 2014). The low number of observations and large variance, making it difficult to tell whether the population has declined from 2005, when 109-442 caribou (95% CI) were estimated to inhabit the same study area. We estimated 183 ± SE 128 caribou, so the population is likely stable at low density on southern Ellesmere Island.

ᐋᓐ ᑐᓴᓐ, ᐊᒻᒪ ᑭᖕᔅ ᓖ. 2015. ᐊᕕᒃ ᑐᖅᓯᒪᓂᖕᒥ ᖃᓄᕐ ᓗ ᐅᓄᖅᑎᒋᓂᖕᒥ ᑐᒃ ᑐᐃᑦ ᐅᒥᖕᒪᐃᓪ ᓗ ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᓂᒋᐊᓂ, ᒫᔾᔮ 2015. ᓄᓇᕗᒻᒥ ᐊᕙᑎᓕᕆᔾᔪᒃᑯᑦ, ᐆᒪᔪᓂᒃ ᖃᐅᔨᓴᖅᐱᑦ, ᖃᓄᐃᓕᖕᓂᖕᓂ ᐅᓂᒃ ᑳᖅ, ᐃᒡ ᓘᓕᒃ, ᓄᓇᕗᑦ. 49 pp.

ᓇᐃᓈᖅᓯᒪᓂᖓ

ᖃᖕᒐᑖᓕ ᓘᑕ ᖃᐅᔨᓴᓚᐅᖅᑐᒍᑦ ᐅᒥᖕᒪᑦ ᓄᓈᓐᓂ, ᒍᓐᕼᐊᒻ, ᐸᑭᖕᕼᐋᒻ ᓗ ᕿᑭᖅᑕᖕᖏᓂᒃ ᒪᕐᕈᓕᒃ ᑯᑦ 50 ᐃᑲᕐ ᕋᓄᑦ ᒫᔾᔮ 19-ᒥᑦ 26-ᒧᑦ, 2015, ᓄᑖᙱᓕᐊᕈᒪᓪᓗᒍᑦ ᖃᓄᖅ ᐅᓄᖅᑎᒋᓂᖕᒋᓂᒃ ᓇᓚᐅᑦ ᑖᕐ ᓂᖅ ᑐᒃ ᑐᒧᑦ ᐅᒥᖕᒪᖕ ᓄᓪ ᓗ ᖃᐅᔨᓴᕐ ᕕᐅᔪᒧᑦ. ᖃᐅᔨᓴᕋᓱ ᐊᓚᐅᖅᑑᒐ ᓗᐊᑦ ᐊᐃᕐ ᓇᓕ ᐊᒻ ᒪ ᓗ ᐋᒎᓯ 2014-ᒥᑦ ᑭᓯᐊᓂ ᓄᖅᑲᖅᑎᑕᐅᓚᐅᖅᑐᑦ ᓯᓚ ᐱᔾ ᔪᑎᒋᓪᓗᒍᑦ. ᐅᑭᐅᖅ ᓯᓚᕈᔫᑲᑕᒃ ᑎᓪᓗᒍᑦ 2000-ᖑᓕᓂᖅᓱᓂ, ᖃᐅᔨᓴᕈᑕᐅᑦ ᑎᐊᓚᐅᙱᓚᖅ ᐅᒥᖕᒪᐃᓪ ᓗ ᐅᓄᙵᕆᑦ ᖃᐅᔨᓴᕐ ᓂᐅᓚᐅᖅᑐᒥᑦ 2005-ᖑᑎᓪᓗᒍᑦ, ᐊᒥᓲ ᕙᓚᐅᕋᓗᐊᖅᕆᑦ ᐅᒥᖕᒪᐃᑦ ᑕᐃᑲᓂ. ᖃᐅᔨᓴᖅᑎᓪᓗᒋᑦ ᖃᐅᔨᓚᐅᖅᑐᑦ ᐅᒥᖕᒪᐃᑦ ᐅᓄᖅᓯᒃ ᑲᓐ ᓂᕐ ᓂᖕᒋᓂᒃ ᐅᓄᕈᓐ ᓃᕐ ᓂᐅᓚᐅᖅᑐᒥᑦ ᑐᒃ ᑐᐃᓪᓗ ᐅᓄᖅᓯᓗᐊᙲᓇᖅᑯᑎᒃ, ᑕᐃᒫᒃ ᖃᐅᔨᔭᐅᓯᒪᔪᖅ ᖃᐅᔨᓴᖅᑕᐅᖃᑦ ᑕᕐ ᓂᑯᓂ.

ᐅᒥᖕᒪᑦ ᐊᒥᓲᓚᐅᖅᑐᑦ ᓯᕐᒥᕈᓗᒃ ᓱᕋᒃ ᑎᕐ ᓂᐅᑉ ᐅᐊᖕᓇᖕᓂ ᐸᐅᒥᓐ ᑲᖕᖏᓗᐊᓂ, ᑲᖖᑰᑉ ᐅᐊᖕᓇᖕᓂ, ᐅᒥᖕᒪᐅᑉ ᑲᖕᖏᓗᐊᑕ ᐱᖕᖑᖕᓇᖕᓂ ᐅᐊᖕᓇᖕᓂᓗ, ᖃᖕᖏᓗᐊᔫᓪ ᓗ ᐱᖕᖓᑦᑕ ᓯᒡᔭᖕᓂ ᑰᖕᓂᓗ, ᑕᑯᔭ ᐅᓚᐅᓇᓪ ᓗᑎᒡ ᓗ ᑰᓗᓇᕌᑉ ᐃᓚᖕᓂ ᕼᐅᐹ ᑲᖕᖏᔫᓪ ᓗ ᓂᒋᐊᑕ ᓯᒡᔭᖅᐸᓯᐊᓂᑦ ᓯᕐᒥᐊᓗᖕᒧᑦ. ᓄᕐ ᕋᐃᑦ (ᖁᓕᓂᒃ ᑕᖅᑭᓖᑦ) 22%-ᖑᓚᐅᖅᐳᑦ ᐅᓄᖅᑎᒋᓂᖕᒥ ᒫᔾᔮ 2015-ᒥᑦ. ᑕᑯᓚᐅᖅᑐᒍᑦ 1146 ᐅᒥᖕᒪᖕᓂᑦ, ᐅᓄᖅᑎᒋᓂᖕᒋᓂᓪ ᓗ ᓇᓚᐅᑦ ᑖᖅᓱᑕ 3200 ± SE 602. ᑖᓐ ᓇ ᐅᓄᕐ ᓂᖅᐹᖑᒐ ᓗᐊᖅᑎᓗᓂ ᓇᓚᐅᑦ ᑖᖅᑕᐅᓯᒪᔪᒥᑦ ᖃᐅᔨᓴᕐ ᕕᐅᖅᑕᖅᓯᒪᔪᒥᑦ, ᖃᐅᔨᓴᖅᑕᐅᓯᒪᔪᓕᒫᑲᓴᑦ ᑕᒪᑐᒪ ᓄᓇᐅᑉ ᐃᓚᐃᓐ ᓇᖕᓂᐅᕝᖅ, ᐱᖃᓯᐅᑎᓗᓂ ᐊᓯᖕᒥ ᓄᓇᐃᑦ, ᐅᓄᙳᓂᓪ ᓘᓐ ᓃᑦ ᓈᓴᐃᓯᒪᑐᐃᓐ ᓇᖅᓱᑎᒃ. ᑭᓯᐊᓂᓕ, ᐅᒥᖕᒪᑦ ᐅᓄᖅᑎᒋᓂᖕᒥ ᐅᓄᖅᓯᒋᐊᖅᐹᓕᖅᓯᒪᔪᑦ ᐊᒥᓲᙳᑎᔪᒥᑦ 312-670 (95% CI) ᓇᐃᓴᖅᑕᐅᓂᑯᑦ 2005-ᒥᑦ.

38-ᖏᓐ ᓇᕐ ᓂᒃ ᑐᒃ ᑐᓯᓚᐅᖅᑐᒍᑦ ᒫᔾᔮᒥ ᖃᐅᔨᓴᖅᑎᓪᓗᑕ. ᑰᓪᓗᓇᖒᑉ ᐃᒪᖕᒐ ᐅᐊᖕᓇᖕᓂ ᐊᒻᒪ ᒍᓐᕼᐊᒻ ᕿᑭᖅᑕᖕᓂ, ᑕᐃᒪᒃ ᓯᓕ ᐅᓄᖅᑎᒋᓚᐅᙱᑲᓗᐊᖅᓱᑎᒃ 2005-ᒥᑦ. ᑐᒃ ᑐᓂᑦ ᑕᑯᓚᐅᕐ ᒥᔪᑦ ᑲᖕᖏᓱᐊᓗᖕᒥ ᑕᑯᒃ ᑳᓂᓇᓕ ᓘᑕ ᑎᖕᒥᐊᑦ ᑲᖕᖏᓱᐊᓂ ᐊᒻᒪ ᓯᐊ ᑲᖕᖏᓱᐊᓂ. ᑕᐃᑲᓂᔅ ᓴᐃᓐ ᓇᖅ ᑕᑯᓚᐅᕐ ᒥᔪᑦ ᒪᕐ ᕉᓕᖕᖓᓂᑦ ᑲᑎᕝ ᓱᒋᑦ 8 ᑐᒃ ᑐᐃᑦ ᐋᒎᓯ 2014-ᒥᑦ ᖃᐅᔨᓴᕕᐅᓇᓱᐊᓚᐅᖅᑐᒥᑦ (2014-ᒥᑦ ᖃᐅᔨᓴᕈᑕᐅᓇᓱᐊᓚᐅᖅᑐᑦ ᑕᒪ ᐅᓈᓗᐊᓚᐅᙲᑦ ᓄᓇᒃ ᑯᑦ ᑐᒃ ᑐᓄᑦ ᐃᓂᒋᓪ ᓗᐊᕋᓱᒋᔭᐅᔪ ᓄᑦ, ᑕᑯᓚᐅᕋᑎᒃ ᓗ ᐊᐃᕐ ᓇᓕ 2014-ᒥᑦ). ᐊᒥᓲᙱᓂᖕᒥ ᑕᑯᔭᐅᔪᑦ ᖃᓄᐃᑦ ᑐᑯ ᓘᔭ ᐅᓂᖕᒋᓂᓪ ᓗ, ᓇᓗᓇᕈᑕᐅᓚᐅᖅᐳᖅ ᐅᓄᕈᓐ ᓅᓇᐊᕐ ᒪᖕᒌ 2005-ᒥᑦ, 109-442 ᑐᒃ ᑐᐃᑦ (95% CI) ᓇᓚᐅᑦ ᑖᖅᑕᐅᓚᐅᖅᑎᓪ ᓗᒋᑦ ᑕᐃᑲᓂᔅ ᓴᐃᓐ ᓇᖅ ᖃᐅᔨᓴᕐ ᕕᐅᔪᒥᑦ. ᓇᓚᐅᑦ ᑖᓚᐅᖅᑐᒍᑦ 183 ± SE 128 ᑐᒃ ᑐᖅᑲᕋᓱᖏᓐ ᓈᓪ ᓗᑕ, ᐅᓄᕈᓐ ᓅᖅᐸᓪ ᓕᐊᓗᐊᕋᓗᙱᑐᒃ ᓴᐅᔪᑦ ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᓂᒋᐊᓂ.

Contents

List of Figures

List of Tables

Introduction

Peary caribou (*Rangifer tarandus pearyi*) are a small, light-coloured subspecies of caribou/reindeer inhabiting the Canadian Arctic Archipelago in the Northwest Territories and Nunavut from the Boothia Peninsula in the south to Ellesmere Island in the north. They are sympatric with muskoxen (*Ovibos moschatus*) over much of their range although diet, habitat preferences, and potentially interspecific interactions separate the two species at a finer scale (Resolute Bay Hunters and Trappers Association [HTA] and Iviq HTA, pers. comm.). Arctic wolves (*Canis lupus*) occur at low densities throughout Peary caribou range, but the most significant cause of population-wide mortality appears to be irregular die-offs precipitated by severe winter weather and ground-fast ice that restricts access to forage (Miller et al 1975, Miller and Gunn 2003, Miller and Barry 2009).

Peary caribou have been surveyed infrequently and irregularly on Ellesmere Island since Tener's 1961 survey extrapolated 200 animals for the island (Tener 1963). Weather issues prevented a full systematic survey of the island however, and the reliability of this estimate is questionable. Riewe (1976) flew unsystematic surveys primarily north of the Sydkap Ice Cap, along Baumann and Vendom Fiords and on the Svendsen, Raanes, and Bjorne peninsulas in 1973, with minimum counts of 150 caribou. In 1989, surveys on southern Ellesmere estimated 89 ± SE 31 caribou, including the Svendsen Peninsula (Case and Ellsworth 1991). In 2005, the GN systematically surveyed southern Ellesmere and Graham islands, with an estimate of 219 caribou (95% CI=109-244). Central and northern Ellesmere Island were surveyed in 2006, with an estimate of 802 caribou (95%CI=531-1207). Residents of Grise Fiord have not noticed a marked increase or decline in caribou where they hunt, primarily on Graham Island, the Bjorne Peninsula, the head of Muskox Fiord, and Baumann Fiord from Okse Bay to Stenkul Fiord. They have noticed some changing distribution patterns, with caribou caught in 2014 and 2015 on northeast Devon Island (Iviq HTA and Wildlife Officer J. Neely, pers. comm.).

Muskoxen are generally surveyed at the same time as caribou. Ellesmere Island was estimated by Tener (1963) to have more muskoxen, about 4000, than the rest of the Queen Elizabeth Islands combined. Southern Ellesmere Island, being largely comprised of ice fields, mountains and fiords, has historically had a much smaller muskox population than the Fosheim Peninsula and Lake Hazen areas further north (Tener 1963, Jenkins et al. 2011). The coastal lowlands along Baumann Fiord support some of the highest densities of muskoxen south of the Svendsen Peninsula (Iviq HTA pers. comm., Case and Ellsworth 1991, Inuit Qaujimajatuqangit [IQ] in Taylor 2005). In ground surveys of the Jones Sound region in 1966-67, Freeman (1971) counted 470 muskoxen on southern Ellesmere Island. In July 1973, Riewe (1973) estimated 1060 muskoxen north of the Sydkap Ice Cap, and on the Bjorne Peninsula, Raanes Peninsula, Svendsen Peninsula, Graham Island, and Buckingham Island. Of these, 260 muskoxen were estimated on Bjorne Peninsula alone (Riewe 1973). Case and Ellsworth (1991) estimated 2020 ± SE 285 muskoxen (including calves) on southern Ellesmere Island, including the Svendsen Peninsula, in July 1989. In May 2005, the population was estimated at only 456 (95%CI 312-670) 1+ year-old muskoxen south of Baumann and Vendom Fiords, including Graham and Buckingham islands, and many muskoxen seen on the survey were in poor condition (Campbell and Hope 2006, Jenkins et al. 2011). Residents of Grise Fiord recall freezing rain and ground-fast ice in fall/winter 2005, causing many muskox to starve (Iviq HTA, pers. comm.).

The Peary caribou and muskoxen of northern Devon Island, southern Ellesmere Island, and Graham Island are vitally important to the community of Grise Fiord. Muskoxen have been hunted in the area since the government ban on muskox hunting was lifted in 1969, and tags are currently set aside for domestic/commercial use and sport hunts. Caribou have been regularly hunted in the region since Grise Fiord was established in 1953, with most harvest since 1964 focusing on the Bjorne Peninsula, south shore of Baumann Fiord, and Graham Island (Riewe 1973, IQ in Taylor 2005, Iviq HTA pers. comm.). Petroleum exploration in the 1970s is believed to have caused caribou to shift their ranges and movements, and there is concern that future industrial activity could be detrimental to the herds as well (Iviq HTA, pers. comm.) This survey was conducted to update the population estimates, demographic characteristics, and distribution of Peary caribou and muskoxen on southern Ellesmere Island and Graham Island.

ᐱᒋᐊᕈᑎᖓ

ᑐᒃᑐᐃᑦ ᒥᑭᔫᕝᑦ, ᑕᕝᓴᑭᓐᓂᖅᓴᐅᓪᓗᑎᒃ ᑐᒃᑐᒋᔭᐅᔪᓂᑦ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖓᓂ ᓄᓇᑦᓯᐊᕐᒥ ᓄᓇᕘᒥᒧ ᐊᓚᕐ ᓈᕐ ᔪᖕᒥᑦ ᓂᒋᐊᓂᑦ ᐅᒥᖕᒪᑦ ᓄᓈᓐᓂ ᐊᐅᖕᓇᖕᓂᑦ. ᓄᓇᖃᑎᖃᖃᑦ ᑕᕝᑐᑦ ᐅᒥᖕᒪᖕᓂᑦ ᐃᓂᒋᔭᒥᓂᑦ ᑭᓯᐊᓂᓕ ᓂᕆᑉ ᑕᖕᖏ, ᐃᓂᒋᔨᒪᔭᖕᖏ, ᓂᕐ ᔨᑎᐅᖃᑎᖃᕐ ᓂᕐ ᒧ ᐊᕚᒃ ᓯᓯᒪᔨᑦ ᑕᒪᒃ ᑯᓂᖓ ᒥᑭᓐᓂᖅᓴᒃ ᑯᑦ (ᖃᐅᓯ ᐃᑦ ᑑᑉ ᐊᖑᓇᓯ ᐊᒃ ᑐᓕᕆᔩᒃ ᑯᖏ [ᐊᖑᓯᒃ ᑐᓕᕆᔩᑦ ᐊᒻᒪᓗ ᐊᐃᕚᒃ ᐊᖑᓇᓯᒃ ᑐᓕᕆᔩᒃ ᑯᑦ, pers. comm.). ᐊᒪᕝᑯᑦ ᐱᑕᖃᖃᑦ ᑕᕝᐳᑦ ᐊᒥᓲᖖᒍᑎᒃ ᑐᒃᑐᑦ ᐃᓂᒋᔭᖕᖑᓂ, ᑭᓯᐊᓂ ᐅᓄᕈᓐ ᓅᕝᐸᓪ ᓕᕈᑕᐅᓂᐊᕝᐹᖑᔨᕝ ᓯᓚᕈᔨᒃ ᐅᑭᐅᒃ ᑯᑦ ᓄᓇᒧ ᖁᖁᑎᖃᑦ ᑕᕐ ᓂᖕᒪᓐ ᓂᕆᔭᒃ ᓴᖕᖏ ᐃᓄᓕᕝ ᓱᓂᐅᒃ (ᒥᒧ ᐃᑦ ᐅᐃᓪ 1975, ᒥᒧ ᐊᓪ ᒪ ᒐᓐ 2003, ᒥᒧ ᐊᓪ ᒪ ᐱᐅᕆ 2009).

ᑐᒃᑐᐃᑦ ᖃᐅᔨᓴᕝᑕᐅᒐᔨᓗᐊᖅᑲᑦ ᐅᒥᖕᒪᑦ ᓄᓈᓐᓂ ᑕᐃᒪᖕᖒᑎᓄ 1961-ᒥᑦ ᖃᐅᔨᓴᓚᐅᕋᒥᑦ 200 ᓂᕐ ᔨᑎᓂᒃ ᕿᑭᕝᑕᒥ (ᑎᓄ 1963). ᓯᓚ ᐱᓪᓗᒍᑦ ᓈᒪᔨᒥ ᖃᐅᔨᓴᕈᓐ ᓇᓚᐅᖕᖁᑦ ᕿᑭᕝᑕᒥ ᑭᓯᐊᓂᓕ, ᑕᑎᕆᔭᒃ ᓴᐅᓂᖓ ᑕᒪᑐᒪ ᓇᓚᐅᑦ ᑖᕝᑕᐅᔫᑉ ᐊᐱᕝᑯᑎᕆᔭᒃ ᓴᐅᕝᕝ. ᕆᐅ (1976) ᖃᖕᓚᓪ ᓗᓂ ᖃᐅᔨᒐᓛᖃᑦ ᑕᓚᐅᕝᑐᕝ ᓯᕐ ᒥᕈᒃ ᓱᕋᒃ ᑎᕐ ᓂᐅᑉ ᐅᐊᖕ ᓇᖕᓂ, ᐸᐅᒥᓐ ᐊᓪ ᒪ ᑲᖕᖏᕝᓱᐊᒍᖕᒥᓪ ᒧ ᐊᓪ ᒪ ᕐ ᕚᓐ ᓴᓐ, ᕌᓐᕐ, ᑰᒐ ᓇᔩᑉ ᐃᓚᖕᓂᓪ ᒧ 1973-ᒥᑦ, ᐅᓄᖕᖢᖕᓂ ᓈᓴᐅᕝ ᓱᓂ 150 ᑐᒃᑐᓂᑦ. 1989-ᒥᑦ, ᖃᐅᔨᓴᕝᑎᓪ ᒍᕆᑦ ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᓂᕆᐊᓂ ᓇᓚᐅᑦ ᑖᓚᐅᕝᑐᑦ 89 ± SE 31 ᑐᒃᑐᖃᕋᓱᒋᓐ ᓈᓪ ᓗᑎᒃ, ᐱᖃᓱ ᐅᑎᓪ ᓗᓂᕐ ᕚᓐ ᓴᓐ (ᑲᐃᔅ ᐊᓪ ᒪ ᐃᐅᓪᔅ ᕝᑦ 1991). 2005-ᒥᑦ, ᓄᓇᕝᑦ ᒐᕙᒪᖕᒐᐊᑕᖕᕇ ᓗᑎᒃ ᖃᐅᔨᓴᓚᐅᕝᑐᑦ ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᓂᕆᐊᓂ ᒍᕼᕼᐊᓪ ᕿᑭᕝᑕᖕᖎ ᓂᓪ ᒧ, ᓇᓚᐅᑦ ᑖᕝᓱᑎᒃ 219-ᓂᒃ ᑐᒃᑐᖃᕋᓱᒋᓐ ᓈᓪ ᓗᑎᒃ (95% CI=109-244). ᕿᑎᕝᐸᓯ ᐊ ᐅᐊᖕ ᓇᖖᓄ ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᖃᐅᔨᓴᕝᑕᐅᓚᐅᕝᑐᑦ 2006-ᒥᑦ, ᓇᓚᐅᑦ ᑖᕝᓱᑎᒃ 802ᓂᒃ ᑐᒃᑐᖃᕋᓱᒋᓐ ᓈᓪ ᓗᑎᒃ (95%CI=531-1207). ᐊᐅᓯ ᐃᑦ ᑐᕐ ᒥᐅᑦ ᐅᔾ ᔨᕈᓯᖕᖏᑐᕝ ᐅᓄᕝᓯᒋᐊᕐ ᒪᖖᒌ ᐅᓄᕈᓐ ᓅᕆᐊᕐ ᒪᖖᒌᑕᑑᓐ ᓅᑦ ᑐᒃᑐᐃᑦ ᑐᓐ ᓇᓯᑉ ᕙᒋᕝ ᑕᖕᖎ ᓂ, ᐱᓗᐊᖖᖕᐊᕝᑐᒥᑦ ᒍᕼᕼᐊᓪ ᕿᑭᕝᑖᓂ, ᑰᓗ ᓇᔩᑉ ᐃᓚᖕᓂ, ᐅᒥᖕᒪᐅᑉ ᑲᖕᖏᕝᓱᐊᑕ ᐃᓯ ᕆᐊᕐ ᕙᐊᓂ, ᐸᐅᒥᓐ ᑲᖕᖏᕝᓱᐊᓂᓪ ᒧ ᐆᒃᔅ ᒥᑦ ᔅ ᑎᓐ ᑯᓪ ᑲᖕᖏᕝᓱᖕ ᒧᑦ. ᐅᔾ ᔨᕈᓯᒃ ᓯᒪᓕᕝᑐᑦ ᐊᕚᒃ ᑐᕝᓯᒪᓂᖕᖏ ᐊᓯᔾ ᔨᕝᐸᓪ ᓕᐊᓂᖕᖎ ᓂᒃ, ᑐᒃᑐᑕᐅᓯᒪᔨᑦ 2014 ᐊᓪ ᒪ 2015-ᒥᑦ ᑕᓪ ᓗᕈᑦ ᑲᓇᖕ ᓈᓂ (ᐊᐃᕚᕝ ᐊᖑᓇᓯᒃ ᑐᓕᕆᔩᒃ ᑯᑦ ᐊᓪ ᒪᓗ ᐆᒪᔨᓕᕆᔩᒃ ᑯᑦ J. ᓅᓕ, pers. comm.).

ᐅᒥᖕᒪᐃᑦ ᖃᐅᔨᓴᕝᑕᐅᒐᔨᒃ ᐳᑦ ᐊᑕᐅᑦ ᑎᒃ ᑰᖃᑎᖃᕝᓱᑎᒃ ᑐᒃᑐᓂᑦ. ᐅᒥᖕᒪᑦ ᓄᓈ ᓇᓚᐅᑦ ᑖᕝᑕᐅᓚᕝᑐᕝ ᑎᓅᑉ (1963) ᐅᒥᖕᒪᖃᕐ ᓂᕝᓴᐅᓂᕋᕝᓱᓂᐅᒃ, 4000-ᓗᐊᑦ, ᐅᓄᕐ ᓂᕝᓴᑦ ᑲᑎᓪᓛᕝᓱᕆᑦ ᑯᐃᓐ ᐃᓪᓴ ᐱᐅᑉ ᕿᑭᕝᑕᖕᖒᑦ ᑐᑦ. ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᓂᕆᐊᓂ, ᐱᕐᑯᖃᐅᕝᓱᓂ, ᖃᕝᑲ ᖃᐅᕝᓱᓂ ᑲᖕᖏᕝᓱᖃᐅᕝᓱᓂᓗ, ᑭᖑᓂᖕᖕᓂᑦ ᐅᒥᖕᒪᑦ ᐅᓄᕈᓐ ᓂᕝᓴᐅᕙᓚᐅᕝᑐᑦ ᕝᓴ ᐃᓪ ᒥᑦ ᕼᐋᓯᓐ ᑕᓯ ᖑᕝ ᑕ ᐅᐊᖕ ᓇᖕᓂ (ᑎᓄ 1963, ᔾᓐ ᑭᓐᔅ ᐃᑦ ᐃᐅᓪ. 2011). ᓯᑉ ᔭᕝᐸᓯ ᖓ ᐸᐅᒥᑦ ᑲᖕᖏᕝᓱᐊᓂ ᐅᒥᖕᒪᖏ ᐅᓄᕐ ᓂᕝᐹᖑᖃᑕᐅᕝᑦ ᕐ ᕚᓐ ᓴᓐ ᓂᕆᐊᓂ (ᐊᐃᕚᕝ ᐊᖑᓇᓯᒃ ᑐᓕᕆᔩᒃ ᑯᑦ pers. comm., ᑲᐃᔅ ᐊᓪ ᒪ ᐃᐅᓪᔅ ᕝᑦ 1991, ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖏ [IQ] ᑕᐃᓗᒥᑦ 2005). ᓄᓇᒃ ᑯᑦ ᖃᐅᔨᓴᕝᑎᓪ ᒍᕆᑦ ᔩᓐᔅ ᓴᐅᓐ ᒥᑦ 1966-67-ᒥᑦ, ᕝᓅᒪᓐ (1971) ᓈᓴᐃᓚᐅᕝᑐᕝ 470 ᐅᒥᖕᒪᖕᓂᑦ ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᓂᕆᐊᓂ. ᔨᓚᐃ 1973-ᒥᑦ, ᕆᐅ (1973) ᓇᓚᐅᑦ ᑖᓚᐅᕝᑐᕝ 1060-ᓂᒃ ᐅᒥᖕᒪᖃᕋᓱᒋᓐ ᓈᓪ ᓗᓂ ᓯᕐ ᒥᕈᒃ ᓱᕋᒃ ᑎᕐ ᓂᐅᑉ ᐅᐊᖕ ᓇᖕᓂ, ᑰᓗ ᓇᔩᓪ ᒧ ᐃᓚᖕᓂ, ᕌᓐᕐ, ᕐ ᕚᓐ ᓴᓐ, ᒍᕼᕼᐊᓪ ᕿᑭᕝᑕ, ᐊᓪ ᒪ ᐸᑭᖕᕼᐊᓪ ᕿᑭᕝᑕᖕᓂ. ᑕᒪᒃ ᑯᓂᖓ 260-ᓂᒃ ᐅᒥᖕᒪᖃᕋᓱᒋᓐ ᓈᓚᐅᕝᑐᑦ ᑰᓗ ᓇᔩᑉ ᐃᓚᖕᓂᑐᐊᕝ (ᕆᐅ 1973). ᑲᐃᔅ ᐊᓪ ᒪ ᐃᐅᓪᔅ ᕝᑦ (1991) ᓇᓚᐅᑦ ᑖᓚᐅᕝᑐᑦ 2020 ± SE 285 ᐅᒥᖕᒪᖃᕋᓱᒋᓐ ᓈᓪ ᓗᑎᒃ (ᐱᖃᓱ ᐅᑎᓪ ᓗᑎᒃ ᓄᕐ ᕋᑦ) ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᓂᕆᐊᓂ, ᐱᖃᓱ ᐅᑎᓪ ᓗᓂᕐ ᕚᓐ ᓴᓐ, ᔨᓚᐃ 1989-ᒥᑦ. ᒪᐃ 2005-ᒥᑦ, ᐅᓄᕝᑎᒋᓂᖕᖏ 456-ᑐᐃᓐ ᓇᐅᓇᓯᒋᔭᐅᓚᐅᕝᑐᑦ (95%CI 312-670) 1+ ᓄᑲᑐᒐᐃᑦ ᐸᐅᒥᓐ ᓂᕆᐊᓂ ᑲᖕᖏᕝᓱᐊᓗᖕᒥᓪ ᒧ, ᐱᖃᓱ ᐅᑎᓪ ᓗᑎᒃ ᒍᕆᕼᐊᓪ ᐸᑭᖕᕼᐊᓪ ᒧ ᕿᑭᕝᑕᖕᖏ, ᐊᒥᓱᓪ ᒧ ᐅᒥᖕᒪᑦ ᑕᑯᔭᐅᔪᑦ ᖃᐅᔨᓴᕝᑎᓪ ᒍᕆᑦ ᑕᑯᒥ ᓇᓚᐅᖕᖁᕝᓱᑎᒃ (ᑳᑉ ᐳᓪ ᐊᓪ ᒪ ᕼᐆᑉ 2006, ᔾᓐ ᑭᓐᔅ ᐃᑦ ᐃᐅᓪ. 2011). ᐊᐅᓯ ᐃᑦ ᑐᕐ ᒥᐅᑦ ᐅᔾ ᔨᕈᓯᒃ ᑐᑦ ᒪᕐᑯᖃᑦ ᑕᓚᐅᕐ ᓂᖕᖏᑦ ᓄᓇᒧ ᕿᕿᑎᓚᐅᕐ ᓂᖕᖏᑦ ᐅᑭᐊᒃ ᕌᕝ/ᐅᑭᐅᕝ 2005-ᒥᑦ, ᐊᒥᓱᑦ ᐅᒥᖕᒪᑦ ᐱᕐ ᓕᓕᕝᓱᑎᒃ (ᐊᐃᕚᕝ ᐊᖑᓇᓯᒃ ᑐᓕᕆᔩᒃ ᑯᑦ, pers. comm.).

ᑐᒃ ᑐᐃᑦ ᐅᒥᖕᒪᐃᑦ ᓗᑕᑦ ᓘᕈᑦ ᐅᐊᖕ ᓇᖕᓂ, ᐅᒥᖕᒪᑦ ᓄᓈᑦ ᑕᓂᒋ ᐊᓂ, ᐊᒻᒪ ᒍᕇᔅᐊᒻ ᕿᑭᖅᑕᖕᓂ ᐱᒻᒪᕆᐅᕗᑦ ᐊᐅᓯᐃᑦᑐᕐ ᒥᐅᓄᑦ. ᐅᒥᖕᒪᖁᓯᖃᑦ ᑕᖅᑐᑦ ᑕᐃᑲᓂ ᑕᐃᒪᖕᖑ ᖁᕙᒪᐅᑉ ᓄᖅᑲᖅᑎᑦ ᑎᓯᒪᔪᓐ ᓅᕋᒥᑦ ᐅᒥᖕᒪᖁᓯᒍᓐ ᓇᕐ ᓂᕐ ᒥᑦ 1969-ᒥᑦ, ᓂᕚᖕᖏᒃ ᑯᑕᓅᖅ ᓱᑎᒡ ᓗ ᓄᓇᓕᖕ ᓂᕐ ᒥᐅᑦ/ᐲ ᓇᐅᔾ ᔭᒃ ᓴᓇᓯ ᐊᖅᑐᑦ ᐊᖑᓇᓯᑎ ᐊᖅᐸᒃ ᑐᓄᓪ ᓗ. ᑐᒃ ᑐᓐ ᓇᓯ ᖃᑦ ᑕᐃᓐ ᓇᖅᐳᑦ ᑕᐃᒪᖕᖑ ᐊᐅᓯ ᐃᑦᑐᖅ ᓄᓇᓕᖕᖑᖅ ᑎᑕᐅᖁᒥ 1953-ᒥᑦ, ᑐᒃ ᑐᓯ ᒪᓂᖅ ᐹᖑᓪ ᓗᑎᒃ 1964-ᒥᑦ ᑰᖁ ᓇᔩᑉ ᐃᓚᖕᓂ, ᐸᐅᒥ ᑲᖕᖏᖅ ᓱᖕᓂ ᓂᒋ ᐊᑕ ᓯᒡ ᔭᖕᓂ, ᒍᕇᔅᐊᒻ ᕿᑭᖅᑕᖕᓂᒡ ᓗ (ᑎᐅ 1973, ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖕᖏ ᑕᐃᓗᒥᑦ 2005, ᐊᐃᕙᖅ ᐊᖑᓇᓯᒃ ᑐᓕᑎᔩᒃ ᑯᑦ pers. comm.). ᐅᖅᓯ ᐊᓗᖕ ᓂ ᕿᓂᖅᑐᖃᖅᑎᓪ ᓗᒍᑦ 1970-ᖏᓐ ᓂᑦ ᑐᒃ ᑐᓄᑦ ᐊᓯᔾ ᓵᔾ ᔪᑕᐅᓇᓯᑎᔭ ᐅᕝᕙᖅ ᓇᓃᓐ ᓂᖏᓐ ᓂᒃ ᐃᖏᖕ ᕋᓂᖏᓐ ᓂᓪ ᓗ, ᐃᓯᒫ ᓘᑕᐅᓪ ᓗᓂᓗ ᓯᕗᓂᒃ ᓴᑦ ᑎᓐ ᓂ ᖃᓄᐃᓕᐅᕈᑕᐅᔪᑦ ᐱᐅᔪᓐ ᓃᕈᑕᐅᕙᓪ ᓕᐊᓂᐊᕐ ᓂᖕᓂ ᑐᒃ ᑐᓄᑦ (ᐊᐃᕙᖅ ᐊᖑᓇᓯᒃ ᑐᓕᑎᔩᒃ ᑯᑦ, pers. comm.) ᖃᐅᔨᓴᓚᐅᖅᑐᑦ ᓄᑖᖕᖒᐊᖅᓯᔪᒪᓪ ᓗᑎᒃ ᖃᓄᖅ ᐅᓄᖅᑎᒋ ᓇᓯᑎᔭᐅᖕᒪᖔᑦ, ᓄᓇᒦᑉ ᕕᒋᔭᖕᖏ ᖃᓄᐃᓕᖕᖒᖕᒪᖔᑦ, ᐊᕕᒃ ᑐᖅᓯᒪᓂᖏᓐ ᓗ ᑐᒃ ᑐᐃᑦ ᐅᒥᖕᒪᐃᑦ ᓗ ᐅᒥᖕᒪᑦ ᓄᓈᑦ ᑕᓂᒋ ᐊᓂ ᒍᕇᔅᐊᒻ ᕿᑭᖅᑕᖕᓂᒡ ᓗ.

Study Area

The March 2015 aerial survey was flown to cover the same study area as the previous 2005 survey (Jenkins et al. 2011), which included Ellesmere Island south of Vendom Fiord, excluding the Svendsen Peninsula, and also including Graham and Buckingham islands. The area south of Jakeman Glacier to King Edward Point was originally included in the survey area but could not be flown due to weather. North Kent Island was circled in a reconnaissance flight but not surveyed systematically. Neither area was included in the 2005 survey.

The survey area is predominantly polar desert and semi desert, with more rugged topography along the mountains and fiords of the south coast which rise from sea level to 1000 m, transitioning to rolling terrain in the north along Baumann Fiord and the Bjorne Peninsula. Mountains dominate the eastern edge of the study area along the ice sheets, which, along with the Sydkap Ice Cap at almost 1500 m AMSL, are the highest points in the study area. Cryptogam herb barrens, cushion forb barrens, unvegetated bedrock and talus, and icefields dominate south of the Sydkap Ice Cap, mostly with <5% vegetation cover and less than 100 g/m^2 vegetation biomass (Gould et al. 2003, Walker et al. 2005). Further north, along Baumann Fiord and Bjorne Peninsula, vegetation cover increases to 5-50% and biomass increases to 100-500 g/m^2 (Gould et al. 2003). Prostrate dwarf shrub and herb tundra dominates, extending north and west of the study area on Svendsen Peninsula (Walker et al. 2005). The north end of Bjorne Peninsula also includes sedge and grass wetlands and large areas of graminoid, dwarf prostrate shrub, and forb tundra (Walker et al. 2005), with 50-80% vegetation cover (Gould et al. 2003). Exposed carbonate and non-carbonate bedrock is common along the edges of ice sheets at the eastern edge of the study area. Graham and Buckingham islands are typified by flat to rolling terrain below 150 m AMSL and relatively lush graminoid, forb, and cryptogam tundra, with areas of sedge and grass wetland, particularly on southwest Buckingham Island (Walker et al. 2005). Prostrate dwarf shrub-lichen tundra, which is not found elsewhere is the study area, is found on Graham and Buckingham islands (Gould et al. 2003). Vegetation cover is 5-50% on the islands, with primary productivity 100-500 g/m^2 (Gould et al. 2003).

Mean July temperatures are 3-5°C on the west side of the study area and 5-7°C in the east (Gould et al. 2003 and references therein). In March 2015, the average daily low temperature was -33.4°C and the average daily high temperature was -25.4°C (Environment Canada weather data for Grise Fiord, available http://climate.weather.gc.ca/index_e.html). There was very little snow throughout the study area, with 0-5 cm snow recorded on the ground at Grise Fiord in March, and 22.9 mm of precipitation (Environment Canada weather data).

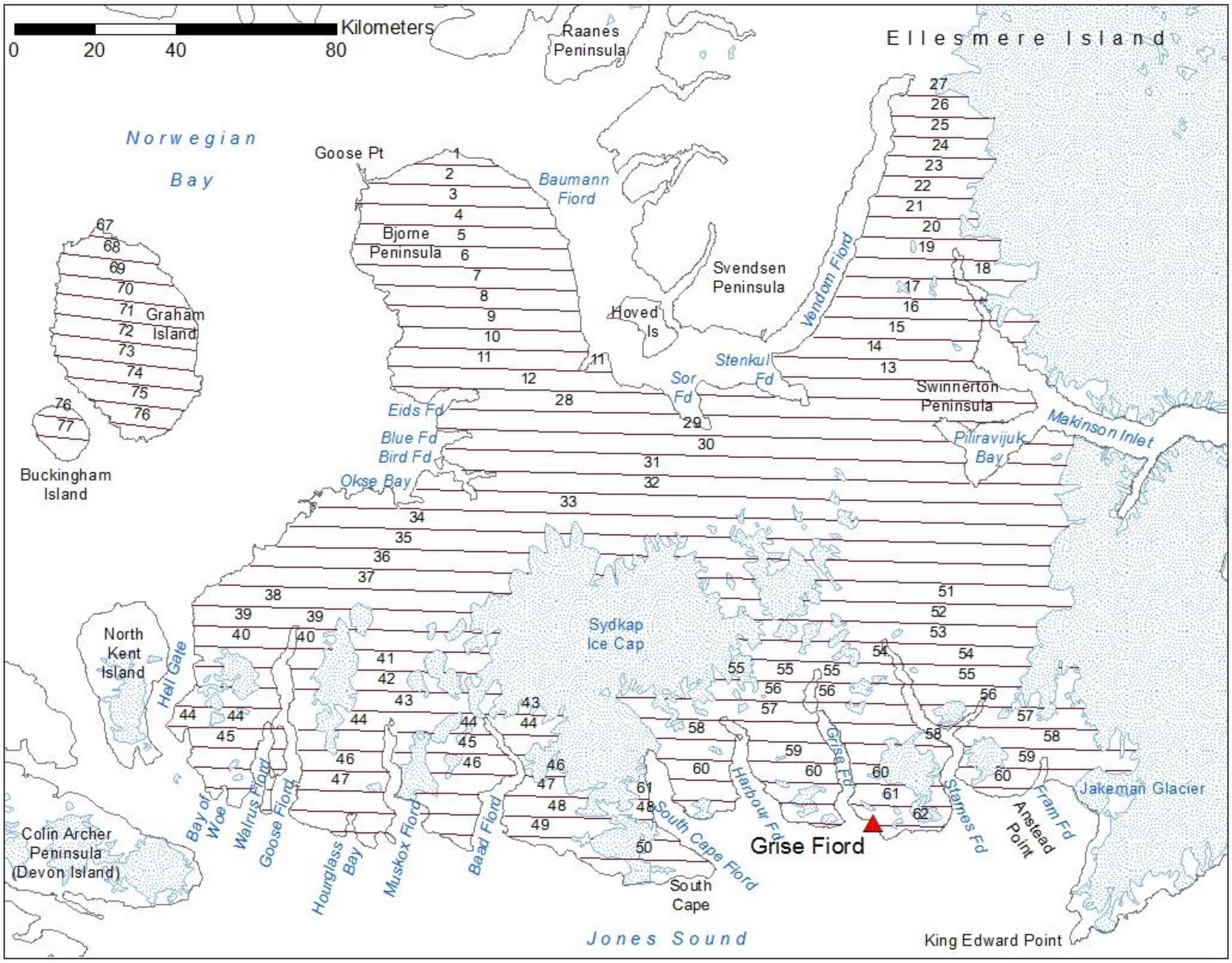


Figure 1. Transects over the study area, excluding ice caps (stippled blue), in dark red with numbers noted above the transects, running east-west, 5 km apart.

Methods

Aerial Survey

Although originally planned for April 2014, we were unable to complete the survey due to fog and wind. The survey was rescheduled in August, when caribou would be visible against the snow-free ground, but again weather prevented survey completion. Summaries of the April and August 2014 survey methodology and results are given in Appendix 1 and 2 but were not used in the analyses presented here. The survey was successfully flown March 19-26, 2015.

Survey transects (n=77, Appendix 3) followed the transects established for the 2005 distance sampling helicopter survey parallel to lines of latitude, with 5 km spacing and a 500 m strip on either side of the aircraft. Ice caps were excluded, and we did not detect any caribou, muskoxen, or their tracks on any ice caps during ferry flights. The area of southeastern Ellesmere Island from Jakeman Glacier to King Edward Point was originally included in the survey area, but persistent wind and fog in the area prevented flying the 4 short transects there. The area was not included in the 2005 survey. We flew reconnaissance around

North Kent Island since hunters had found caribou at the north end in previous years, but it was not systematically surveyed (nor was it surveyed in 2005), and we saw no caribou, muskoxen, or tracks. No caribou or muskoxen were present on North Kent Island when it was last surveyed in 2008.

To define the transect width for observers, we marked survey aircraft wing struts following Norton-Griffiths (1978):

$$w = W\left(\frac{h}{H}\right)$$

where W is the strip width, H is the flight height, h is the observer height when the plane is on the ground and w is measured and marked on the ground to position wing strut marks (Figure 2).Multiple distance bins can be incorporated and marked on the wing strut, but for this survey we only used 1 mark representing 500 m. Fixed-wing strip transect sampling has been successfully used in the high arctic since 1961.

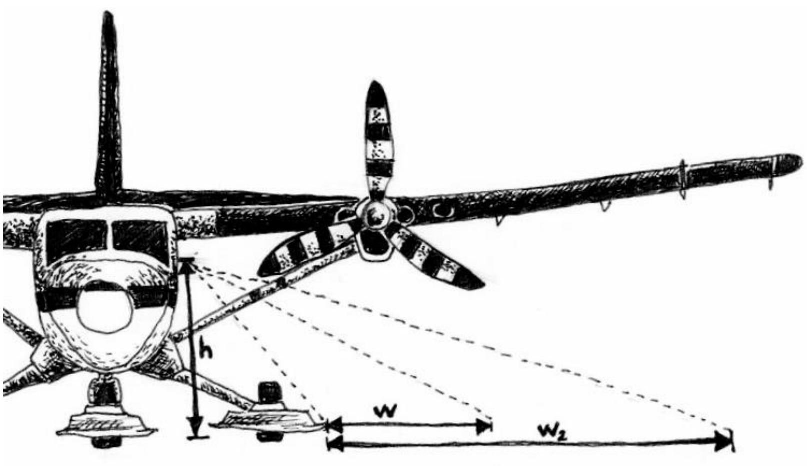


Figure 2. Derivation of wing strut marks for strip boundaries, where w and w_2 are calculated as described in the text, h is measured (2.2 m for Twin Otter on wheel-skis), and dotted lines indicate observer sightlines as modified from Norton-Griffiths (1978).

We did not stratify the study area because of changes to wildlife distributions and densities (confirmed by the April 2014 survey attempt) since the last survey 10 years ago and given the different habitat preferences for caribou and muskox,. We did, however, examine population estimates according to Case and Ellsworth's (1991) stratification for direct comparison of their July 1989 survey results (since no muskoxen were seen on transect on Graham/Buckingham islands, this part of the study area did not have to be added to the stratification).

Transects were flown at 150 km/hr (81 kts) with a DeHavilland Twin Otter. Surveys were only conducted on days with good visibility and high contrast to facilitate detection of animals, tracks, and feeding craters, as well as for operational reasons to ensure crew safety. Flight height was set at 500' (152 m), using a radar altimeter. In rugged terrain, the flight height was adhered to as closely as possible within the constraints of crew safety and aircraft abilities.

A Twin Otter with 4 passengers (2 front observers, 2 rear observers, one of whom was also data recorder) was used to follow a double-observer platform when possible (4 dedicated observers were not always available), which has been successful in the Kivalliq Region of Nunavut (see Campbell et al. 2012 for an overview of the methodology) and on Bathurst Island (Anderson 2014). In both the Bathurst Island survey and the South Ellesmere survey, front and rear observers were able to communicate and all observations by front and rear observers were lumped. Estimates of group size are a potentially large source of error in calculating population estimates, however Peary caribou are generally distributed in small groups where observer fatigue is likely to be a more important source of error (A. Gunn, pers. comm.). We found obvious benefits of using the platform where having the added observers not only increased the accuracy of age and sex classification, but also allowed for some crew members to classify with binoculars while others continued to scan for nearby groups and individuals.

All observations of wildlife and tracks were marked on a handheld Garmin GPSMAP 62STC global positioning system (GPS) unit, which also recorded the flight path every 30 seconds. Sex and age classification was limited, since the aircraft did not make multiple passes (to minimize disturbance), but adult/short yearling (calves from the previous spring, i.e. 10-11 months old) determination was often straightforward for muskox and aided by binoculars. Muskoxen were frequently spotted more than a kilometer off transect due to their large aggregations and dark colour in contrast to the snowy background. Depending on distance and topography, an accurate count could not always be determined for these groups. Newborn muskoxen were not present during the survey. GPS tracks and waypoints were downloaded through DNR Garmin and saved in Garmin GPS eXchange Format and as ESRI shapefiles. Data was entered and manipulated in Microsoft Excel and ArcMAP (ESRI, Redlands, CA).

Analysis

Flights linking consecutive transects were removed for population analysis, although survey speed and height were maintained and all observations recorded as if on survey. Similarly, sections of transect crossing inlets and ice fields were removed, as these areas were not included in the area used for density calculations. The study area was also stratified following Case and Ellsworth (1991) for direct comparison with their survey results (Figure 3). We considered stratifications by elevation and by treating the Bjorne Peninsula separately as well, to aid in future survey planning. Strata are summarized in Table 1.

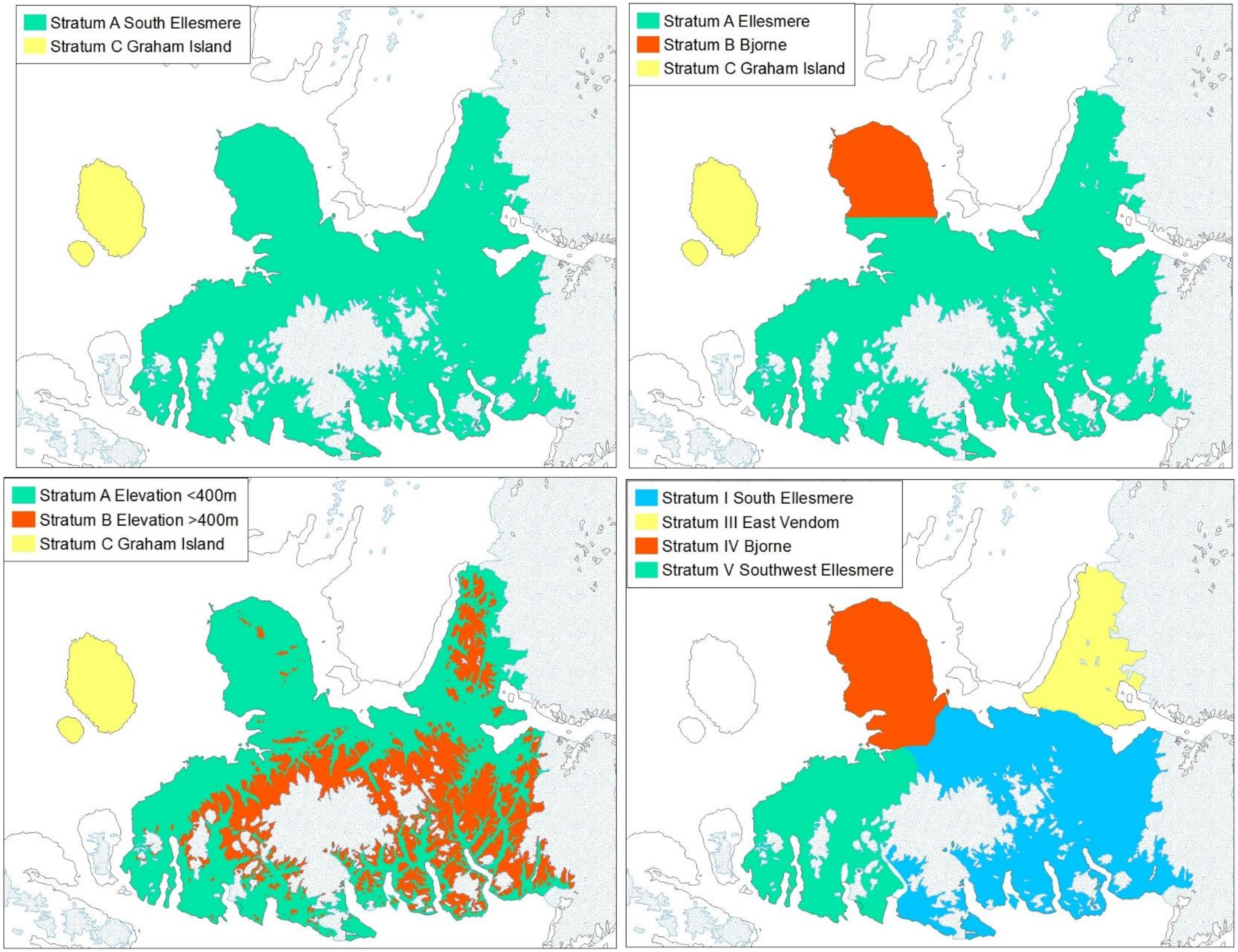


Figure 3. Several stratification regimes for the study area based on geography, elevation, and Case and Ellsworth's (1991) strata.

Table 1. Survey strata for southern Ellesmere Island, March 2015. Although 73 transects were flown, transects flown on the same latitude were combined as lines for further analysis (outlined in Appendix 3).

Stratification	**Block ID**	**Location**	**Strata Area, Z (km^2)**	**Transect Spacing (km)**	**Transects Surveyed**	**Lines Surveyed**	**Survey Area, z (km^2)**	**Sampling Fraction, f (%)**
All	A	South Ellesmere	21260	5	62	39	4896.0	0.199
	C[1]	Graham, Buckingham	1531	5	11	11	296.5	0.201
Elevation	A	South Ellesmere Low Elevation (<400 m)	13921	5	62	39	3322.5	0.195
	B[2]	South Ellesmere High Elevation (>400 m)	7339	5	54	38	1573.6	0.199
	C[1]	Graham, Buckingham	1531	5	11	11	296.5	0.198
Bjorne	A	South Ellesmere	18988	5	52	39	4439.1	0.201
	B	Bjorne Peninsula	2272	5	10	10	456.9	0.199
	C[1]	Graham, Buckingham	1531	5	11	11	296.5	0.265
Case and Ellsworth	I	South Ellesmere	10029	5	31	31	2657.9	0.201
	III	East Vendom	2865	5	17	17	576.0	0.202
	IV	Bjorne	3397	5	16	16	685.2	0.197
	V	Southwest Ellesmere	4969	5	18	18	977.0	0.230
	C[1]	Graham, Buckingham	1531	5	11	11	296.5	0.201

[1]For caribou estimates, Graham/Buckingham islands were both included and excluded, but no muskoxen were seen on transect there.
[2]No caribou were seen in the high elevation stratum.

Although Jolly's (1969) Method II is widely used for population estimates from surveys, it is designed for a simple random design, rather than for a systematic survey of a patchy population. For comparison, population calculations following Jolly's Method II are provided in Appendix 4, along with calculations following a systematic stratified survey design (Cochran 1977). The muskoxen and caribou detected in this survey were patchily distributed and serially correlated, not randomly distributed, and no stratification was applied based on population densities. For systematic samples from serially correlated populations, estimates of uncertainty based on deviations from the sample mean are expected to be upwardly biased and influenced by the degree of serial correlation; high serial correlation implies that there is less random variation in the unsurveyed sections between systematically spaced transects than if serial correlation were low (Cochran 1977). Calculating uncertainty based on nearest-neighbor differences incorporates serial correlation, and the upward bias in the uncertainty is expected to be less than if it were calculated based on deviations from the sample mean. Nearest-neighbor methods have been used previously to calculate variance around survey estimates on the unweighted ratio estimate (Kingsley et al. 1981, Stirling et al. 1982, Kingsley et al. 1985).

The model for observations on a transect survey following Cochran (1977) is:

$$y_i = Rz_i + \varepsilon_i\sqrt{z_i}$$

Where y_i is the number of observations on transect *i* of area z_i, R is the mean density and error terms ε_i are independently and identically distributed. In this model, the variance of the error term is proportional to the area surveyed. The best estimate of the mean density $\hat{R}$ is:

$$\hat{R} = \frac{\sum_i y_i}{\sum_i z_i}$$

The error sum of squares, based on deviations from the sample mean, is given by:

$$\left(\sum_i \frac{{y_i}^2}{z_i}\right) - \frac{(\sum_i y_i)^2}{\sum_i z_i}$$

The finite-population corrected error variance of $\hat{R}$ is:

$$Var(\hat{R}) = \frac{(1-f)}{(n-1)\sum_i z_i}\left(\left(\sum_i \frac{{y_i}^2}{z_i}\right) - \frac{(\sum_i y_i)^2}{\sum_i z_i}\right)$$

Where f is the sampling fraction and n is the number of transects (transects on the same latitude were combined for a total of 39 transects on Ellesmere Island and 10 transects on Graham and Buckingham islands). The sampling fraction also provides the scaling factor for moving from a ratio (population density) to a population estimate. It is calculated as $(\sum z_i)/Z$, where Z is the study area. The irregular study area boundaries mean that f varies from the 20% sampling fraction indicated by the 1-km survey strip and 5-km transect spacing (see Appendix 4 for comparative calculations with a stratified sampling regime based on transect width and spacing).

If we were to apply a model $y_i = Rz_i + \varepsilon_i$ instead, then the variance of the error term would be independent of z, so the variance would depend on the number of items in the sample, but not their total size. This would lead to a least squares estimate of R of $\sum zy / \sum z^2$, rather than the more intuitive density definition and model for R presented above.

To incorporate serial correlation in the variance, we used a nearest-neighbor calculation, with the error sum of squares given by:

$$\sum_{i=1}^{n-1}\left(\frac{y_i^2}{z_i}+\frac{y_{i+1}^2}{z_{i+1}}-\frac{(y_i+y_{i+1})^2}{z_i+z_{i+1}}\right)$$

i.e. the sum of squared deviations from pairwise weighted mean densities. The nearest-neighbor error variance of $\hat{R}$ is:

$$Var(\hat{R}) = \frac{(1-f)}{(n-1)\sum_i z_i}\sum_{i=1}^{n-1}\left(\frac{y_i^2}{z_i}+\frac{y_{i+1}^2}{z_{i+1}}-\frac{(y_i+y_{i+1})^2}{z_i+z_{i+1}}\right)$$

Both variance calculations were applied to several stratification regimes for the southern Ellesmere Island survey data. In addition, calculations for these strata based on Jolly's (1969) Method II and Cochran's (1977) systematic survey models are provided in the appendices for comparison. For the final estimate, we used the unstratified (Ellesmere plus Graham and Buckingham islands) estimate and the nearest neighbor variance. All distance measurements used North Pole Azimuthal Equidistant projection and area-dependent work used North Pole Lambert Azimuthal Equal Area, with central meridian at 85°W and latitude of origin at 76°N (centered over the study area for high precision).

Population growth rates were calculated following the exponential growth function, which approximates growth when populations are not limited by resources or competition (Johnson 1996):

$$N_t = N_0 e^{rt} \qquad \text{and} \qquad \lambda = e^r$$

Where N_t is the population size at time t and N_0 is the initial population size (taken here as the previous survey in 2005). The instantaneous rate of change is r, which is also represented as a constant ratio of population sizes, λ. When r >0 or λ >1, the population is increasing; when r <0 or λ <1 the population is decreasing. Values of r ~0 or λ ~1 suggest a stable population.

Results

We flew surveys on March 19, 20, 21, 23, 24, 25, and 26, 2015 for a total of 49.5 hours (35.6 h and 4521 km on transect). Daily flight summaries are presented in Appendix 5 and incidental wildlife sightings are presented in Appendix 6. Visibility was excellent for all survey flights with clear skies (visual estimates of <10% cloud) and high contrast. Some patches of low cloud and blowing snow were encountered near Piliravijuk Bay, but visibility on transect was not impaired. Temperatures ranged from -33°C to -14°C during the survey. We saw 38 caribou and 1146 muskoxen in total, including 36 caribou on transect and 636 muskoxen on transect. Spatial data presented here represents waypoints, so except for groups observed on the transect line, waypoints have error associated with the group's distance from the plane. While observations on transect are within 500 m, some muskox groups off transect were more than 2 km away.

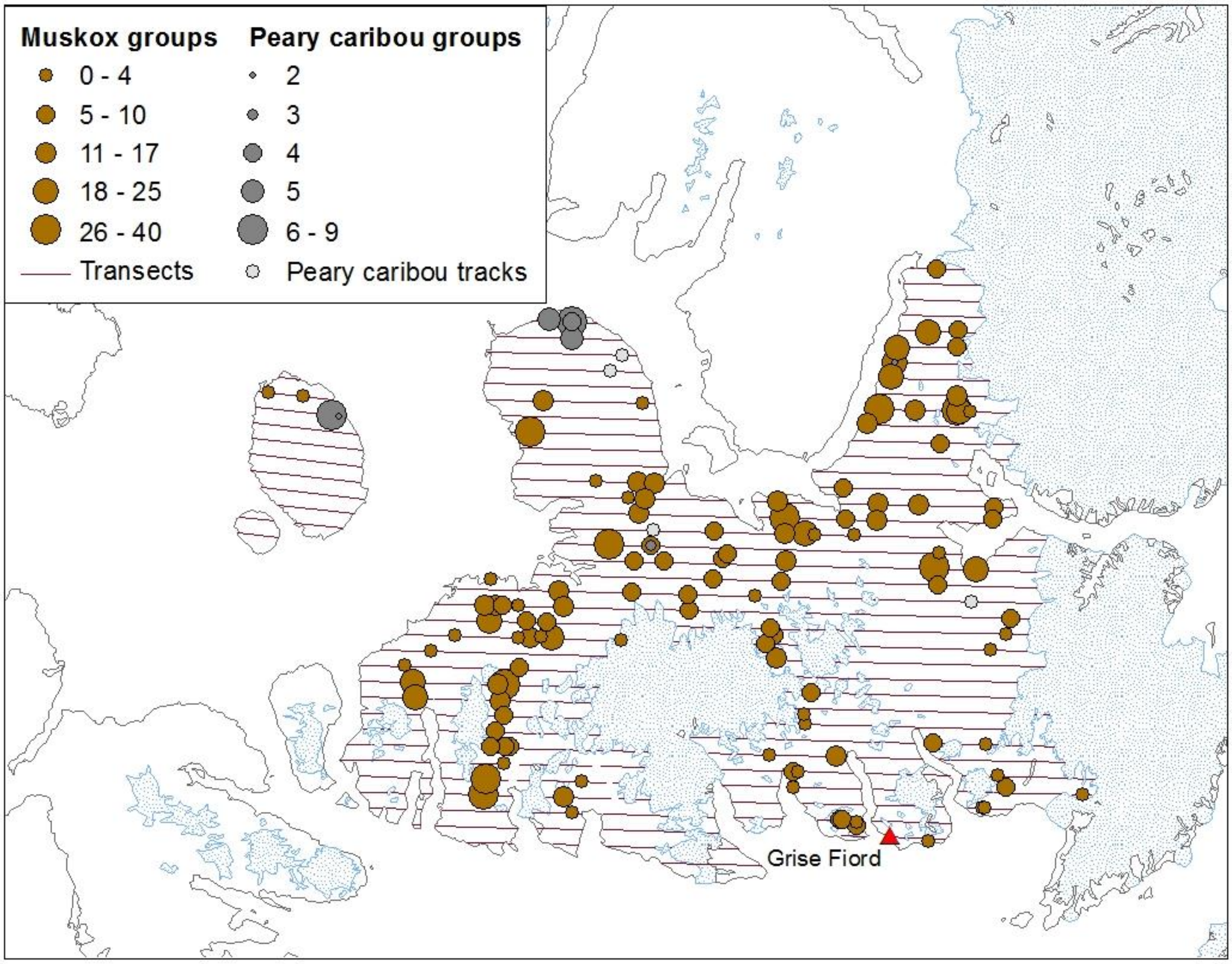


Figure 4. Observations of Peary caribou and muskoxen on southern Ellesmere, Graham, and Buckingham islands.

Abundance Estimates

Abundance estimates for muskoxen are given in Table 7 and population estimates for caribou are given in Table 8. The overall population estimates were 3200 ± SE 602 (CV=19%) and 183 ± SE 128 Peary caribou (CV=70%). The few observations used to calculate the caribou population estimate should be considered in interpreting the results.

Table 2. Calculations following Cochran (1977) for a systematic survey and ratio estimator for muskoxen on southern Ellesmere Island. Variance was calculated based on sample mean and based on nearest-neighbor to account for serial correlation in the data.

Stratum	Stratum area Z (km^2)	Surveyed area z (km^2)	Count, y	Estimate, $\hat{Y}$	Density, $\hat{R}$	Nearest Neighbor				Deviations from sample mean			
						Error Sum of Squares	Var ($\hat{Y}$)	SE	CV	Error Sum of Squares	Var ($\hat{Y}$)	SE	CV
All	21260	4225	636	**3200**	0.151	164.804	362230	602	0.188	194.057	426528	653	0.204
Low Elev	13921	2792	571	2847	0.205	180.633	257061	507	0.178	202.559	288263	537	0.189
High Elev	7339	1433	65	333	0.045	14.438	11488	107	0.322	15.726	12513	112	0.336
Total	21260	4225	636	**3180**	0.150		268549	518	0.163		300776	548	0.172
Main	18988	3768	623	3140	0.165	247.205	486171	697	0.222	340.405	669465	818	0.291
Bjorne	2272	457	13	65	0.028	3.069	3076	55	0.858	2.768	2775	53	0.815
Total	21260	4225	636	**3204**	0.151		489248	699	0.218		672240	820	0.256
I Southeast	10029	2658	222	838	0.084	48.545	43637	209	0.249	91.216	81994	286	0.342
III Vendom	2865	576	212	1054	0.368	209.096	140033	374	0.355	255.597	171175	414	0.392
IV Bjorne	3397	685	30	149	0.044	8.269	6949	83	0.560	7.128	5990	77	0.520
V Southwest	4969	977	172	875	0.176	36.869	41588	204	0.233	34.958	39433	199	0.227
Total	21260	4896	636	**2916**	0.137		232207	482	0.165		298592	546	0.187

Table 3. Calculations following Cochran (1977) for a systematic survey and ratio estimator for Peary caribou on southern Ellesmere Island. Variance was calculated based on sample mean and based on nearest-neighbor to account for serial correlation in the data.

Stratum	Stratum area Z (km^2)	Surveyed area z (km^2)	Count, y	Estimate, $\hat{Y}$	Density, $\hat{R}$	Nearest Neighbor				Deviations from sample mean			
						Error Sum of Squares	Var ($\hat{Y}$)	SE	CV	Error Sum of Squares	Var ($\hat{Y}$)	SE	CV
All	21260	4225	26	131	0.006	5.606	14405	120	0.618	7.247	18622	136	0.702
Graham	1531	296	10	52	0.034	3.513	2036	45	0.874	3.172	1838	43	0.830
Total	22791	4521	36	**183**	0.008		16441	128	0.702		20460	143	0.784
Low Elev	13921	2792	26	130	0.009	9.150	16458	128	1.103	9.193	16537	129	1.106
Graham	1531	296	10	52	0.034	3.513	2035	45	0.874	3.172	1838	43	0.830
Total	15452	3088	36	**181**	0.012		18493	136	0.750		18375	136	0.747
Main	18988	3768	3	15	0.001	0.072	168	13	0.793	0.067	156	12	0.845
Bjorne	2272	457	23	114	0.050	7.699	7717	88	0.768	14.800	14836	122	1.065
Graham	1531	296	10	52	0.034	3.513	2036	45	0.874	3.172	1838	42	0.830
Total	22791	4521	36	**181**	0.008		9921	100	0.550		16830	129	0.716
IV Bjorne	3397	685	26	129	0.038	8.027	6745	82	0.637	15.240	12806	113	0.878
Graham	1531	296	10	52	0.034	3.513	2036	45	0.874	3.172	1838	42	0.830
Total	4928	981	36	**181**	0.037		8781	94	0.519		14644	121	0.670

Population Trends

Muskoxen have clearly increased since the last survey in 2005. Based on a population estimate of 3200 in 2015 and 456 in 2005 (Jenkins et al, 2011), the instantaneous growth rate r would be 0.202, or a lambda of 1.224. The few caribou sightings and large variance in the 2015 estimate of 183 caribou make determination of a trend since the 2005 estimate of 219 difficult, and the growth rate *r* of -0.018 or lambda of 0.982 should be interpreted with that in mind. More sophisticated analyses incorporating uncertainty in the estimates have not been undertaken, but the large uncertainty in both estimates would likely still make trend determination tenuous.

Calf Recruitment

In April 2014, 33 muskox groups were classified, with 42 short yearlings to 311 adults, or 15.6% short yearlings. In August, the spring 2014 calves were easily identified in 20 groups of 23 calves and 88 adults, making the new calves 23.9% of the population. In March 2015, we classified 101 groups, with 64 short yearlings and 289 adults. Short yearlings made up 22.1% of the population in March, suggesting high overwinter survival if the August calf counts are reflective of the entire study area.

Only 4 caribou groups were classified, totaling 1 short yearling to 8 adults. The low sample size prevents drawing any conclusions on calf recruitment.

Group Size

Muskox group size was about the same in March 2015, averaging 8.9-12.1 muskoxen (95% CI, n=106, median=8; Figure 5), as in April 2014, averaging 6.8-12.0 muskoxen (95% CI, n=33, median=6). The spring groups were larger than the August 2014 groups, which averaged 2.6-6.2 muskoxen (95% CI, n=20, median=3).

Caribou groups were much smaller, 2.6-6.9 caribou (95% CI, n=8; Figure 6). No caribou were seen in April 2014, and only 2 groups, of 1 caribou and 8 caribou, were seen in August 2014.

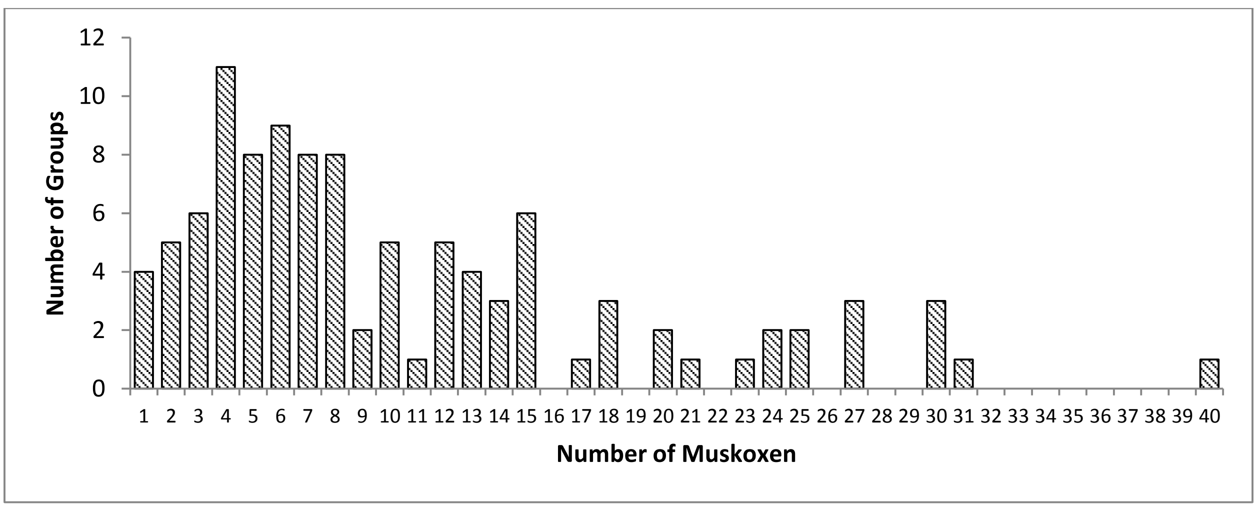


Figure 5. Histogram of group size for 106 muskox group size encountered March 19-26, 2015 on southern Ellesmere Island.

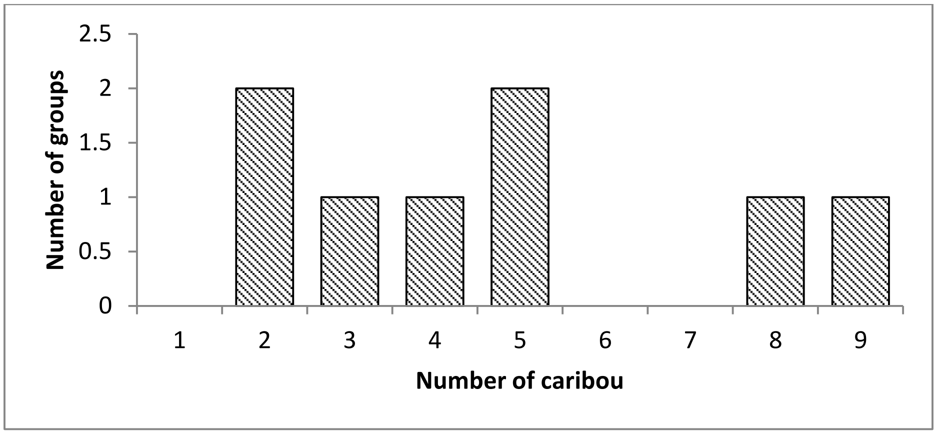


Figure 6. Histogram of group size for 8 Peary caribou groups encountered March 19-26, 2015 on southern Ellesmere Island.

Discussion

Population Trends

Previous surveys of southern Ellesmere Island have used different survey platforms (Piper Super Cub, Tener 1963; Bell 206, Case and Ellsworth 1991, Jenkins et al. 2011 and April 2014 survey attempt; Twin Otter, Riewe 1973, this survey; ground surveys, Freeman 1971), different methodologies (distance sampling, Jenkins et al. 2011 and April 2014 survey attempt; strip transect, this survey, Tener 1963, Case and Ellsworth 1991; unstratified random block sampling, Case and Ellsworth 1991; unsystematic, Freeman 1971, Riewe 1973), and different survey areas. Population estimates and minimum counts are presented in Figure 7, although perhaps the most useful interpretation of the figure is the substantial data gaps it presents. Drawing conclusions on population trends using the disparate data available is difficult.

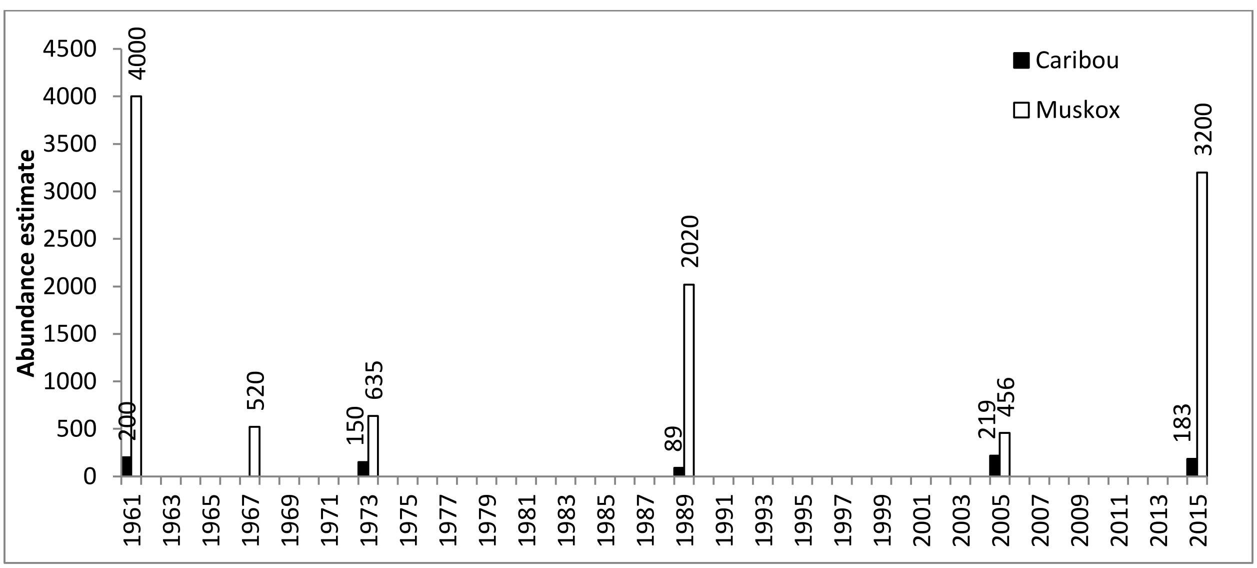


Figure 7. Summary of population estimates for muskoxen and Peary caribou on southern Ellesmere Island and Graham Island. The 1961 estimate is a guess for all of Ellesmere Island (Tener 1963), the 1989 estimate does not include Graham Island (Case and Ellsworth 1991), and 1967 and 1973 are based on minimum counts from unsystematic surveys (Freeman 1971, Riewe 1973). The 2005

and 2015 surveys covered the same study area as in 1989, but included Graham Island and excluded Hoved Island (Jenkins et al. 2011, this report).

In 1961, Tener (1963) observed 1165 muskoxen on Ellesmere Island, except parts of the south and east coasts and northwestern coasts that were inaccessible due to weather. He estimated about 4000 muskoxen on the island, and suggested about a quarter of the population was likely on the Fosheim Peninsula and Lake Hazen-Alert plateau, north of the southern Ellesmere study area (Tener 1963). Concentration areas on southern Ellesmere Island were identified at the head of Baumann Fiord and east of Vendom Fiord. Although he did not survey Vendom Fiord, Freeman (1971) counted 470 muskoxen on southern Ellesmere Island and 50 muskoxen on Graham Island during ground surveys in 1966 and 1967. In early May 1973, Riewe flew the Bjorne Penisula and saw 148 muskoxen, and an additional 60 between Sor and Stenkul Fiords – however, the transect spacing was 8 km and the flight height was 760 m AGL, too high to get more than a reconnaissance survey for muskox and too high to detect caribou at all (Riewe 1973). Later in May, they flew east of Vendom Fiord at 500 m AGL, and the July 1973 surveys were redesigned to be lower (152 m) and slower (176 kph) with more observers to more accurately survey wildlife. Overall, Riewe estimated 625 muskoxen on southern Ellesmere and another 10 on Graham Island (Riewe 1973). Case and Ellsworth (1991) estimated 2020 ± SE 285 muskoxen in July 1989 over approximately the same study area we flew in 2015 (minus Graham Island and including Hoved Island). They estimated a 56% increase in the muskox population from 1973 (Case and Ellsworth 1991). Approximating Case and Ellsworth's (1991) stratification for the 2015 survey, we calculated an average muskox density of 0.137 muskox/km^2, somewhat higher than the 1989 density estimate of 0.081 muskox/km^2 (Case and Ellsworth 1991).

In 2005, southern Ellesmere Island from Vendom Fiord south, the same area in this survey, was flown with an adaptive sampling technique, with east-west transects spaced 5 km apart, tightened to 2.5 km where caribou or caribou sign was detected (Jenkins et al. 2011). A ground survey was also conducted from Grise Fiord, primarily on the Bjorne Peninsula and north of the Sydkap Ice Cap – most other areas are not accessible by snowmobile. Ground crews observed 23 groups of 56 muskoxen and 6 dead muskoxen over 1662 km of survey (Jenkins et al. 2011). The aerial survey, May 4-30 2005, recorded 99 groups of muskoxen, totaling 277 1+ year-old animals and 2 newborns, on transect, and an additional 19 groups and 43 muskoxen off transect (Jenkins et al 2011, Government of Nunavut data unpubl.). In addition to the very low proportion of calves in the population (2%), observers reported 40 muskox carcasses during the survey and 2 adult muskoxen near death (Campbell and Hope 2006, Jenkins et al. 2011). Residents of Grise Fiord suggested freezing rain in winter 2002 (Taylor 2005), which may have reduced muskox condition, survival, and reproduction, and also recall ground-fast ice in winter 2005 (Iviq HTA, pers. comm.). The muskox population appears to have recovered from these climatic events, with rapid growth over the last 10 years.

It appears as though caribou have not been abundant on southern Ellesmere Island in recent times, which corroborates local knowledge of caribou distribution and abundance. The first survey of Ellesmere Island, in 1961, recorded 74 caribou (10.8% calves) and suggested 200 caribou present on the entire island (Tener 1963). Tener (1963) noted the low coverage and 'best guess' nature of this estimate, however. Of the observed caribou, most were seen north of the 2015 study area, and only 11 were seen at the head of Baumann Fiord (Tener 1963). The south coast from Grise Fiord to Simmons Peninsula was not surveyed due to weather (Tener 1963). In unsystematic surveys in May and July 1973, Riewe estimated 80 caribou on Bjorne Peninsula, along Sor and Stenkul Fiords, and along Vendom Fiord, and another 15 on Graham and Buckingham islands (Riewe

1973). Case and Ellsworth (1991) estimated 89 ± SE 31 caribou on southern Ellesmere Island, or an average density of 0.0036 caribou/km^2. If we include the entire 1989 study area, the caribou density would be slightly higher in 2015, at 0.006 caribou/km^2. The error around the estimate of 183 caribou for the 2015 survey is too broad to determine definitively whether the caribou population has increased, decreased, or remained stable since the 2005 survey, which estimated 109-442 caribou (95% CI). However, the pattern over several decades seems to suggest a persistent low density, so it is likely that the population is fairly stable at present.

Changes in Distribution

Muskox concentrations have been recorded along Baumann Fiord, Sor and Stenkul Fiords, the flat plain along Vendom Fiord, north of Muskox Fiord and along Norwegian Bay, and at Fram Fiord (Iviq HTA, pers. comm., Tener 1963, Riewe 1973, Case and Ellsworth 1991, Jenkins et al. 2011). Muskoxen were seen in all these areas during the 2015 survey, as well as the two survey attempts in April and August 2014, if the areas were flown.

Riewe (1973) noted some caribou on Graham Island, between Sor and Stenkul fiords, and on the Bjorne Peninsula. Case and Ellsworth (1991) described caribou observations as scattered across the study area, but in 2005 there were some clear concentration areas on Graham and Buckingham islands, northern Bjorne Peninsula, and southeast of Okse Bay. In 2014 and 2015, we saw caribou in the same areas, as well as a group on northern Vendom Fiord. We did not detect any caribou along the south coast, although they were formerly found in the area of Craig Harbor, Fram Fiord, and King Edward Point in the 1950s and 1960s, and occasionally seen there into the 1990s (IQ in Taylor 2005). We only saw one set of tracks south of Piliravijuk Bay, although caribou have been found there previously (IQ in Taylor 2005, Iviq HTA pers. comm.). Grise Fiord residents were also surprised that we did not see caribou at the head of Goose Fiord or Muskox Fiord, since they can usually be found there.

The most notable change in distribution compared to the 2005 survey is the relative lack of caribou and muskoxen on Graham and Buckingham Islands. During the 2005 survey, 50 caribou in 18 groups and 12 muskoxen in 3 groups were seen on Graham and Buckingham Islands. In 2015, we saw 10 caribou in 2 groups and 3 muskoxen in 2 groups. Part of this discrepancy is explained by the adaptive sampling protocol used in 2005; transects were flown 2.5 km apart in 2005 and 5 km apart in 2015. At the time of the 2015 survey, lack of snow had prevented hunters from Grise Fiord from accessing Graham Island, with the exception of one trip to retrieve a broken snowmobile during the survey, so additional information from hunters was not available for Graham Island. Caribou are known to move between islands in regular seasonal movements and when conditions force them (Miller 2002, Miller et al. 2005, IQ in Taylor 2005), and they do move between Graham Island and Bjorne Peninsula (IQ in Taylor 2005, Iviq HTA pers. comm.).

Calf Recruitment

The proportion of muskox calves in summer 2014 (24%) was higher than previous summer reports for the area. In 1961 Tener estimated 8% calves for the Bjorne Peninsula, not including solitary muskoxen (Tener 1963). Freeman (1971) suggested 12.5% calves for southern Ellesmere, Graham, and northern Devon islands based on 1965 and 1967 aerial surveys. Freeman (1970) developed a preliminary population model that suggested 10.5% calf production would be required to balance natural mortality for the region. Hubert (1972) surveyed northeast Devon Island in May 1972 and reported 16% calves. Riewe (1973) noted calf crops of 16% in July 1973 on the Bjorne Peninsula and surrounding area. In July 1989, Case and Ellsworth (1991) reported 17.3% calves, but only 7.3% yearlings. Only 2 newborn calves were seen on the 2005 survey (Campbell et al.

2006, Jenkins et al. 2011). The adult:calf ratios for August 2014 (24% calves) and March 2015 (22% calves) suggest high recruitment and good overwinter survival, and 16% short yearlings in April 2014 suggests good recruitment of the previous calf crop, in line with previously recorded recruitment rates for the area.

Lack of observations prevents any conclusions on calf recruitment for Peary caribou. In 1961, Tener (1963) observed 10.8% calves in the area. In July 1973, Riewe (1973) reported 5.5% calves. In July 1989, Case and Ellsworth (1991) reported 22.2% calves of 45 caribou observed, but no yearlings were present. The low yearling crop observed for muskoxen during the same survey suggests there may have been a severe winter that limited calf production and recruitment for both species in 1988. Observations by Grise Fiord hunters of caribou moving from Goose Point to Sherwood Head on Axel Heiberg and 2 dead muskoxen and 1 dead caribou on sea ice west of Bjorne Peninsula (IQ in Taylor 2005), also suggest there may have been an extreme weather event around this time. In 2005, there were no short yearlings seen and only 7% of the classified caribou were yearlings, following unusually snowy winters with icing events (Iviq HTA, pers. comm., Jenkins et al. 2011). Restricted forage access is expected to decrease calf production, since Peary caribou show a direct relationship between late winter fat and fertility (Thomas 1982). At least identifying one short yearling in the few groups we observed in 2015 is an improvement over 2005.

Group Sizes

Although there were fewer muskox groups encountered in August, the pattern of smaller group sizes reflects group sizes recorded by other researchers for summer. Muskox groups are largest early in the spring and smaller as summer progresses (Freeman 1971, Gray 1973), with winter (including April and May) groups about 1.7 times larger than summer groups (Heard 1992). Although Heard (1992) noted that group size is not generally related to muskox density, the group size in May 2005, 2.7 muskoxen on average (2.4-3.0 95% CI), was much smaller than the group sizes encountered in April 2014, August 2014, or March 2015. It is possible that the severe starvation conditions had fragmented groups and normal group structure was not observed during the 2005 survey. Group sizes encountered in March 2015 (8.9-12.1 muskoxen/group, 95%CI) were similar to the 10.0 muskoxen/group reported in 1966-1967 (Freeman 1971).

Ferguson (1991) suggested that caribou groups are largest in August and smaller in late winter. Fischer and Duncan (1976) noted that groups across the Arctic islands averaged 4.0 caribou in late winter, 2.8 caribou in early summer, and 8.8 caribou in mid-summer. The lack of observations during any of the 3 survey attempts means we are unable to evaluate any seasonal effect of group size for Peary caribou, but our average group size of 2.6-6.9 caribou (95% CI) is similar to the late winter group sizes encountered by Fischer and Duncan (1976).

The survey conducted by Case and Ellsworth (1991) in July 1989 was in response to observations by Grise Fiord residents of declining caribou populations and increasing muskox populations. It is interesting to note that after a crash in muskox populations in the early 2000s, a similar dynamic may be manifesting on southern Ellesmere again, with relatively few caribou and a muskox population that has increased rapidly over the last decade. The inverse relationship between caribou and muskox abundance has been noted by many communities where Peary caribou and muskoxen are sympatric, but the mechanism explaining this pattern remains unknown (Iviq HTA and Resolute Bay HTA, pers. comm., IQ in Taylor 2005). Furthermore, there appear to be some areas or conditions that permit both species to remain at high densities, as appears to currently be the case on Bathurst and Melville islands (Davison and Williams 2012, Anderson 2014).

Management Recommendations

Peary caribou and muskoxen on southern Ellesmere and Graham islands are an important source of country food and cultural persistence for the Inuit of Grise Fiord. Consistent with the Nunavut Land Claim Agreement, and the Management Plan for High Arctic Muskoxen of the Qikiqtaaluk Region, 2012-2017 (DOE 2014), these management recommendations emphasize the importance of maintaining healthy populations of caribou and muskox that support sustainable harvest. The current abundance and good calf recruitment suggests that the muskox population is healthy, and although relatively few caribou were seen, this appears to be fairly normal for the area.

Under the Management Plan (DOE 2014), Ellesmere Island is considered a single management unit, MX-01, with no quota. It is highly recommended that a harvest reporting system be maintained even without a quota in place. This allows biologists, community members, and decision makers to track harvest patterns and changes in wildlife populations over time and to determine whether changes to management zones or harvest restrictions have the desired effect.

Harvest trends for muskoxen over the last decade suggest that Grise Fiord harvests fewer muskoxen than in the 1990s, averaging fewer than 10 tags per year from 2005-2014 (Government of Nunavut Harvest Database, unpubl. data). An unusually high harvest in 2012-13 due to several problem muskoxen in town resulted in the use of 13 tags in what is now MX-01 - less than 0.5% harvest if the population was similar in 2013 to the current 2015 population and if only southern Ellesmere Island and Graham Island are considered (which does not take into account the high muskox populations elsewhere in MX-01, notably the Fosheim Peninsula and Lake Hazen). Hunters can also access the Svendsen and Raanes peninsulas, north of the study area, which are also included in MX-01, and were not surveyed in 2015. As local knowledge and previous surveys have demonstrated, population changes can be rapid and unexpected if severe weather causes localized or widespread starvation or movement, so continuous monitoring and adaptive management is necessary.

Although we saw only 38 caribou during the survey, the results of previous surveys over the same areas suggest that caribou have persisted at relatively low densities on southern Ellesmere Island for at least as long as they have been regularly hunted from Grise Fiord. There may or may not have been a decline from the 2005 survey, the variation around the estimates is too wide to tell. It is unlikely that harvest restrictions on Peary caribou will result in any marked increase in the population, as harvest is restricted to a small human population with limited access to the caribou range. Increased monitoring of sightings and reporting caribou harvest would provide a more complete picture of where caribou are on the landscape, and could inform population metrics like calf recruitment.

This survey also contributes additional data to the pattern observed by community members, of the inverse relationship between muskox and caribou densities. Although there is general consensus that when some muskox populations are high, sympatric caribou populations are low, the mechanism remains a subject of some debate – the strong smell of the muskoxen is repulsive to caribou, or the muskoxen trample foraging areas and compact the snow, or wolves that hunt the muskoxen have a disproportionate effect on the caribou, or some other factors. Additional research by biologists and IQ holders into this mechanism would be beneficial for informing caribou and muskox management in the High Arctic.

ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᐊᑐᓕᖁᔭᐅᔪᑦ

ᑐᒃᑐᐃᑦ ᐅᒥᖕᒪᐃᓪᓗ ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᓂᒋᐊᓂ ᒍᓈHᐊᓪ ᕿᑭᖅᑕᖕᖏᓂ ᐱᓪᒪᕆᐅᕙᑦ ᓂᕿᒃ ᓴᓇᔭᐅᕝ ᓱᑎᒃ ᐃᓕᖅᑯᓯᕐᒧᓪᓗ ᐸᐸᑦᑎᔾᔪᑕᐅᓪᓗᓂ ᐃᓄᖕᓄ ᐊᐅᓯᐃᑦᑐᒥ. ᒪᓕᒃᓱᒍᑦ ᓄᓇᕗᒻᒥ ᓄᓇᑖᕐᓂᕐᒧᑦ ᐊᖕᖑᑎ, ᐊᐅᓚᑦᑎᓂᕐᒧᓪᓗ ᐸᕐᓇᐅᑎ ᐅᑭᐅᖅᑖᖅᑑᑉ ᐅᒥᖕᒪᖏᓄ ᕿᑭᖅᑖᓗᖕᒥ, 2012-2017 (ᐊᕙᑎᓕᕆᔨᒃᑯᑦ 2014), ᑕᒪᒃᑯᐊ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᐊᑐᓕᖁᔭᐅᔪᑦ ᓴᖅᑭᔫᖅᑎᑦᑎᕙᑦ ᐱᓪᒪᕆᐅᓂᖕᒥᒃ ᐊᒥᓲᑎᑦ ᑏᓐᓇᕋᓯᐊᕐᓂᖅ ᑐᒃᑐᓂᑦ ᐅᒥᖕᒪᖕᓂᓪᓗ ᐊᖑᓇᓯᒃ ᑕᐅᖅᑐᑦ ᑕᐃᓐᓇᒍᓐᓇᖅᑯᓕᓗᒋᑦ. ᒫᓐᓇᐅᔭᖅ ᐊᒥᓲᑎᒋᓂᖕᖏᓐ ᓄᕐᕋᖃᐅᑦᑎᐊᕐᓂᖕᖏᓗ ᓇᓗᓇᐃᖅᐳᖅ ᐅᒥᖕᒪᑦ ᐅᓄᖅᑎᒋᓂᖕᖏᓐ ᖃᓄᐃᙵᑎᐊᕐᓂᖕᖓ, ᑭᓯᐊᓂᑦ ᑕᐅᖅ ᐊᒥᓲᙵᑐᓂᒃ ᑐᒃᑐᓂᑦ ᑕᑯᓚᐅᕋᓗᐊᖅᑎᓕᓗᒋᑦ, ᑕᒪᓐᓇ ᖃᐅᔨᓴᕐᕕᐅᔭᖅ ᑕᐃᒪ ᐃᓚᔭᒃᑐᖅ.

ᐊᐅᓚᑦᑎᓂᕐᒥᑦ ᐸᕐᓇᐅᑎᑎᒍᑦ (ᐊᕙᑎᓕᕆᔨᒃᑯᑦ 2014), ᐅᒥᖕᒪᑦ ᓄᓈ ᑕᐅᑐᒃ ᑕᐅᕗᖅ ᐊᑕᐅᓯᖅᑐᑦ ᐊᐅᓚᑕᐅᔭ ᓇᐊᓕᒃᑐᑦ, MX-01, ᓂᕕᙵᑯᑕᒃ ᑰᖕᖏᑐᖅ. ᐊᑐᖅᑯᔨᓪᒪᓇᒃ ᐳᑦ ᐊᖑᓇᓯᒃ ᑕᐅᕙᒃᑐᓄᑦ ᐅᓂᒃ ᑳᕈᑎᒥᒃ ᓂᕕᙵᑯᑕᒃ ᑰᖕᖏᑲᓗᐊᖅᑎᓕᓗᒋᑦ. ᑕᐃᒪ ᐃᑎᓕᓗᒍᑦ ᓂᖅ ᔪᑎᓂᒃ ᖃᐅᔨᓴᖅᑏᑦ, ᓄᓇᓕᖕᓂᖅᒥᐅᑦ, ᐃᓯᒪᓕᐅᑎᓵᓕᓗ ᓇᐅᑦᑎᖅᓯᕈᓇᖅᓂᐊᖅᑐᑦ ᐊᖑᓇᓯᓪᕕᐅᕙᒃᑐᓂᑦ ᐊᓯᔾᔨᖅᐸᓕᓕᐊᔭᓂᓪᓗ ᐊᒥᓲᑎᒋᖕᖏᓂ ᖃᑯᒎᖅᐸᓕᓕᐊᑎᓕᓗᒍᑦ ᓇᓗᓇᐃᖅᓗᑎᓪᓗ ᐊᓯᔾᔨᖅᑐᑦ ᐊᐅᓚᑦᑎᔾᔭᑕᐅᔭᓄᑦ ᐊᖑᓇᓯᒃ ᑕᐅᕙᒃᑐᓂᓕ ᓘᓐᓃᑦ ᑭᓪᓕᖃᓕᖅᑎᑦᑎᓂᕐᒧᑦ ᐊᑑᑎᓂᖃᖅᒪᖔᑦ.

ᐊᖑᓇᓯᖕᓂᐅᕙᒃᑐᑦ ᐅᒥᖕᒪᖕᓂᑦ ᐊᕐᕌᒍᑦ ᖁᓕᐅᔮᖅᑐᓄᑦ ᓇᓗᓇᐃᖅᐳᖅ ᐊᐅᓯᐃᑦᑐᕐᒥᐅᑦ ᐅᒥᖕᒪᒃ ᐸᖕᖏᓂᐊᖅᓴᓕᕐᓂᖕᖏᓂᒃ ᑕᐃᒪᖕᖓ 1990-ᖏᓂᑦ, ᖁᓕᑦ ᑐᖕᖐᓂ ᓂᕕᙵᑯᑕᓂᒃ ᐊᑐᖅᑐᖅᑲᖅᐸᒃᓱᓂ 2005-ᒥᑦ 2014-ᒧᑦ (ᓄᓇᕗᑦ ᒐᕙᒪᒃᑯᑦ ᐊᖑᓇᓯᒃ ᑕᐅᕙᒃᑐᓄᑦ ᑎᑎᖅᑲᖁᑎᖕᖏ, ᓴᖅᑭᑕᐅᓯᒪᖕᖏᑐᑦ ᑎᑎᖅᑲᑦ). ᐅᓄᖅᔩᒥᓪᓗᑎᒃ ᐊᖑᓇᓯᒃ ᑕᐅᔪᑦ 2012-13-ᒥᑦ ᐱᓪᓗᒋᑦ ᐊᒥᓯᑦ ᐊᑲᐅᙵᐅᕈᐄᑦ ᐅᒥᖕᒪᑦ ᓄᓇᓕᖕᓄᐊᖅᑕᖅᓂᖕᖏᓄᑦ ᐊᑐᕈᑕᐅᓕᓚᐅᖅᐳᖅ 13-ᓂᒃ ᓂᕕᙵᑯᑕᓂᑦ ᑕᐃᔭᐅᓕᖅᑐᒥᑦ MX-01 - 0.5% ᑐᖕᖐᓂ ᐊᖑᔭᐅᓇᔭᖅᑐᑦ ᐅᓄᖅᑎᒋᓂᖕᖏ ᐊᔾᔨᖅᑲᓚᐅᕈᑎᒃ 2013-ᒥᑦ ᒫᓐᓇᐅᔪᖅ 2015-ᒥᑦ ᐅᓄᖅᑎᒋᓂᖕᖏ ᐊᓪᒪᓗ ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᓂᒋᐊᓂᖅᒥᐅᑦ ᒍᓈHᐊᓪᓗ ᕿᑭᖅᑕᖕᖓ ᐃᓯᒪᒋᔭᐅᒍᑎᒃ (ᐃᓚᓕᐅᔾᔨᓯᒪᖕᖏᑐᖅ ᐅᒥᖕᒪᑲᓪᓚᖕᓂᑦ MX-01-ᒥᕈᔭᒃ, ᐱᓗᐊᙳᐊᖅᑐᒥᑦ ᕘᓴ ᐃᓪᒥ H ᐋᓯᓐᓗ ᑕᓯᐊᓂ). ᐊᖑᓇᓯᒃ ᐲᑦ ᔅᕕᓐᓴᓐᑰᕈᓐᓇᖅᒥᔪᑦ ᖀᓐᔅ ᑯᓪᓗ, ᖃᐅᔨᓴᖅᕕᐅᔫᑉ ᐅᐊᖕᓇᖕᖓ, ᐱᖅᑯᓯᐅᔾᔭᐅᓯᒪᔪᑦ MX-01-ᒥᑦ, ᖃᐅᔨᓴᖅᑕᐅᓚᐅᕋᑎᒃᓗ 2015-ᒥᑦ. ᓄᓇᓕᖕᓂ ᖃᐅᔨᒪᔭᐅᔪᑦ ᐊᓪᒪ ᑭᖑᓂᑎᓐᓂ ᖃᐅᔨᓴᖅᑕᐅᓂᑯᑦ ᑕᒃᑯᒃ ᓴᐅᑎᑦᑎᓯᒪᕙᑦ, ᐅᓄᖅᑎᒋᓂᖕᖏ ᐊᓯᔾᔨᖅᑳᓚᒍᓐᓇᖅᑐᑦ ᓂᓕᐅᓇᖕᖏᑐᒃᑯᓪᓗ ᓯᓚᕈᔭᒃ ᖃᓂᒋᔭᖕᖓ ᓇᓂᑯᓘᔭᖅ ᓘᓐᓃᑦ ᐱᖅᓕᓕᕈᑕᐅᔪᓐᓇᖅᑐᖅ ᓘᔾᔭᑕᐅᔪᓐᓇᖅᑐᖅ ᓘᓐᓃᑦ, ᑕᐃᒪ ᐃᓪᒪᑦ ᓇᐅᑦᑎᖅᓯᐃᓐᓇᖅᓂᖅ ᐊᓯᔾᔩᖃᑎᑦᑕᖅᓂᖅᓗ ᐊᐅᓚᑦᑎᔾᔨᓂᒃ ᐱᓪᒪᕆᐅᕙᑦ.

38-ᖏ ᓇᖅᓂᑦ ᑕᑯᓚᐅᕋᓗᐊᖅᑎᓕᓗᑕ ᑐᒃᑐᓂᒃ ᖃᐅᔨᓴᖅᑎᓕᓗᑕ, ᖃᐅᔨᓴᔪᐅᓯᒪᔪᑦ ᑭᖑᓂᑦᑎᓐᓂᒃ ᖃᐅᔨᓴᕈᑕᐅᓯᒪᔪᓂᒃ ᑕᐃᑲᓂᔅ ᓴᐃᓐᓇᖅ ᓇᓗᓇᐃᖅᐳᖅ ᑐᒃᑐᐃᑦ ᐊᒥᓲᖅᑕᖕᖏᓂᖕᖏᓂᒃ ᐅᒥᖕᒪᑦ ᓄᓈᑦᑕ ᓂᒋᐊᓂ ᑕᐃᒪᖕᖓᐊᖑᓇᓯᒃ ᑕᐅᖅᑐᖅ ᑕᖅᒪᑕ ᐊᐅᓯᐃᑦᑐᖅᒥ. ᐅᓄᕈᓐᓃᐸᓕᑐᐃᓐᓇᑎᐊᖅᑲᓚᐅᖅᑐᑦ 2005-ᒥᑦ ᖃᐅᔨᓴᖅᓂᐅᔪᒥᑦ, ᐊᔾᔨᖕᖏᓐᓂᖕᖏ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᒥᑦ ᐊᔾᔨᖕᖑᐊᖅᐳᑦ ᓇᓗᓇᐃᑎᐊᒃ ᓴᓴᖅ. ᐊᖑᓇᓯᖕᓂᖅᒧᑦ ᑭᓪᓕᖅᑎᑦᑎᓂᖅ ᑐᒃᑐᓂᑦ ᐅᓄᖅᓯᐆᓕᖅᑎᑦᑎᓇᔭᖅ ᑰᖕᖏᑲᓗᐊᖅᓱᓂ, ᐊᖑᓇᓯᖕᓂᖅ ᑭᓪᓕᖅᑎᑕᐅᖅᑲᓂᒃ ᑲᒥᑦ ᐃᓄᑭᓂᐅᔪᒧᑦ ᐱᕕᑭᕐᓱᑎᒃ ᑐᒃᑐᓕᖕᓄ. ᓇᐅᑦᑎᖅᓯᕐᔩᒥᓕᕐᓂᖅ ᑕᑯᔭᐅᕙᒃᑐᑦ ᐅᓂᒃᑲᐅᓯᖃᖃᑦᑕᕐᓂᕐᓗ ᑐᒃᑐᑕᐅᕙᒃᑐᑦ ᓇᓗᓇᐃᕈᑕᐅᔾᔩᒥᓇᔭᖅᐳᖅ ᑐᒃᑐᑦ ᓇᓃᓪᒪᖔᑦ ᓄᓇᒥᑦ, ᑐᑭᓯᓇᕈᑕᐅᔪᓐᓇᓕᓗᓂ ᓰᕐᓗ ᖃᓄᖅ ᓄᖅᕋᖅᑎᑭᖕᒪᖔᑦ.

ᑖᓇ ᖃᐅᔨᓴᕐᓂᖅ ᐃᓚᓕᐅᔾᔨᐅᑎᑦᑎᑭᕙᖅ ᑎᑎᖅᑲᓂᒃ ᖃᓄᐃᑉᐸᓕᐊᓂᓱᐅᕙᒃᑐᓂᒃ ᑕᐅᑐᒃ ᑕᐅᕙᒃᑐᑦ ᓄᓇᓕᖕᓂᖅᒥᐅᓂ, ᖃᓄᐃᖅᑲᑎᕐᒃᐸᖕᒪᖔᑦ ᐅᒥᖕᒪᑦ ᑐᒃᑐᐃᓕᓗ. ᑐᑭᓯᓇᖅᓂᖕᖓ ᐊᖏᕈᑕᐅᓯᒪᒐᓗᐊᖅᓱᓂ ᐅᒥᖕᒪᒃ ᑕᐅᖅᑲᐅᖏᖕᖏᓐ, ᑐᒃᑐᐃᑦ ᐊᒥᓲᕙᖕᖏᓐᖏᓂ, ᐊᐅᓚᓂᓱᖕᖓ ᓯᓕ ᐅᖅᑲᐅᓯᐅᖅᑲᑦᑕᖅᐳᖅ – ᐅᒥᖕᒪᒃ ᓯᓐᓂᑐᐊᖅᓂᖅ ᒪᒪᓇᔭᐅᖕᖔᖅ ᑐᒃᑐᓂᑦ, ᐅᒥᖕᒪᐃᑦ ᑐᖕᒪᖅᑕᖕᖏ ᓂᕿᖃᖅᕕᐅᕙᒃᑐᓂᑦ ᑎᓯᒃᓴᐅᑕᐅᓂᖕᖑᐊᓪᒥ, ᐊᒪᖅᑯ ᓘᓐᓃᑦ ᐅᒥᖕᒪᒐᓯᒃᐸᒃᑐᑦ ᐊᔾᔨᖕᖏᖕᖏᑐᓂᒃ ᐊᒃᑑᑎᕙᑦ ᑐᒃᑐᓄᑦ, ᐊᓯᖏ ᓘᓐᓃᑦ ᖃᓄᐃᔾᔪᑕᐅᔪᑦ. ᖃᐅᔨᓴᕈᑕᐅᒃᑲᓐᓂᖅᑐᑦ ᐆᒪᔪᓂᒃ

ᖃᐅᔨᓴᖅᑎᓂᑦ ᐊᒻᒪ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖏᓐᓂ ᐱᖃᖅᑎᐅᖃᑕᐅᔪᓂᑦ ᑕᒪᑐᒧᖓ ᐊᐅᓚᓂᕆᔭᖕᒪ ᐊᑑᑎᓇᔭᖅᑐᖅ ᑐᑭᓯᑎᐊᕈᑕᐅᓗᑎᒃ ᑐᒃ ᑐᓂᑦ ᐅᒥᖕᒪᖕᓂᓪᓗ ᐊᐅᓚᑦᑎᔾ ᔪᑎᒃ ᓴᓂᑦ ᖁᑦᑎᒃ ᑐᖅ ᐅᑭᐅᖅᑕᖅᑐᒥᑦ.

Acknowledgements

Thank you to everyone involved in attempting this survey three times in one fiscal year, probably an ill-fated record of some sort. Thanks to the survey observers, without whom we could not have run the survey: Eepa Ootoovak, Adrian Kakkee, Josh Kilabuk, Mark Akeeagok, Jaypetee Akeeagok, Etuangat Akeeagok, Frankie Noah, Olaf Killiktee, Simon Singoorie, Imooshie Nutaraqjuk, Aksakjuk Ningiuk, Jopee Kiguktak, Frank Holland, and Jon Neely. Engineers Garland Pope, Tim Hall, and Scott Darroch were also drafted into spotting wildlife beyond their maintenance duties. Universal Helicopter pilot Darryl Hefler and Kenn Borek Air pilots Terry Welsh, Sebastien Trudel, Rob Bergeron, and John Sidwell also helped spot wildlife while flying transects. Thanks to the Iviq Hunters and Trappers Association and Hamlet of Grise Fiord for their guidance, support, and for organizing observers, particularly Mark Akeeagok, Jaypetee Akeeagok, Larry Idlout, Marty Kuluguqtuq, Imooshie Nutaraqjuk, Aksajuk Ningiuk, Liza Ningiuk, and Amun Akeeagok. Wildlife Officer Jon Neely also provided guidance, logistical support. Mike Kristjanson, Tim McCaugherty, Glenn Parsons, Jodi MacGregor, and the rest of the team at Polar Continental Shelf Program provided logistical support for all 3 survey attempts. Melanie Wilson, David Lee, and Lisa-Marie Leclerc provided comments on the report.

Funding for this work was provided by the Nunavut Department of Environment Wildlife Research Section and the Nunavut Wildlife Research Trust (Project 2-14-02). The Polar Continental Shelf Program provided in-kind logistical support (Project 314-14 and 321-15). The work was completed under Government of Nunavut Wildlife Research Section permit 2014-014.

Literature Cited

Anderson, M. 2014. Distribution and abundance of Peary caribou (*Rangifer tarandus pearyii*) and muskoxen (*Ovibos moschatus*) on the Bathurst Island Group, May 2013. Nunavut Department of Environment, Wildlife Research Section, Status Report, Igloolik, NU. 39 pp.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press. 432 pp.

Campbell, M., J. Boulanger, D. S. Lee, M. Dumond, and J. McPherson. 2012. Calving ground abundance estimates of the Beverly and Ahiak subpopulations of barren-ground caribou (*Rangifer tarandus groenlandicus*) – June 2011. Nunavut Department of Environment, Technical Summary, Arviat NU. 111 pp.

Case, R. and T. Ellsworth 1991 Distribution and abundance of muskoxen and Peary caribou on southern Ellesmere Island, NWT, July 1989. Department of Renewable Resources, Government of the Northwest Territories, Manuscript Report 41, Yellowknife, NT. 23 pp.

Caughley, G. 1977. Sampling in aerial survey. Journal of Wildlife Management 41(4): 605-615.

Cochran, W. G. 1977. Sampling techniques. 3rd ed. Wiley, New York, NY. 428 pp.

Department of Environment (DOE), in collaboration with Nunavut Tunngavik Inc. (NTI) Wildlife, Resolute Bay Hunters and Trappers Association, Ikajutit Hunters and Trappers Organization (Arctic Bay), Iviq Hunters and Trappers Association (Grise Fiord) and the Qikiqtaaluk Wildlife Board. 2013. Management Plan for the High Arctic Muskoxen of the Qikiqtaaluk Region, 2012-2017. Nunavut Department of Environment, Iqaluit, NU. 20 pp.

Ferguson, M. A. D. 1991. Peary caribou and muskoxen on Bathurst Island, Northwest Territories, from 1961-1981. Government of Northwest Territories, Pond Inlet. File report 88. 54 pp.

Fischer, C. A. and E. A. Duncan. 1976. Ecological studies of caribou and muskoxen in the Arctic Archipelago and northern Keewatin. Renewable Resources Consulting Services. Report to Polar Gas Project. 194 pp.

Freeman, M. M. R. 1970. Productivity studies of high arctic muskoxen. Arctic Circular 20:58-65.

Freeman, M. M. R. 1971. Population characteristics of musk-oxen in the Jones Sound region of the Northwest Territories. Journal of Wildlife Management 35(1): 103-108.

Gould, W. A., M. Raynolds, and D. A. Walker. 2003. Vegetation, plant biomass, and net primary productivity patterns in the Canadian Arctic. Journal of Geophysical Research 108 (D2): 8167, doi:10.1029/2001JD000948.

Gray, D. R. 1973. Social organization and behavior of muskoxen (*Ovibos moschatus*) on Bathurst Island, NWT. PhD Thesis. University of Alberta, Edmonton, AB. 212 pp.

Heard, D. 1992. The effects of wolf predation and snow cover on muskox group size. The American Naturalist 139(1): 190-204.

Hubert, B. 1972. Productivity of muskox. In: Bliss, L. C., ed. Devon Island International Biological Programme Project, High Arctic Ecosystem. Project Report 1970 and 1971, Edmonton, AB. Pp 272-280.

Jenkins, D., M. Campbell, G. Hope, J. Goorts, and P. McLoughlin. 2011. Recent trends in abundance of Peary Caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) in the Canadian Arctic Archipelago, Nunavut. Department of Environment, Government of Nunavut, Wildlife Report No. 1, Pond Inlet, Nunavut. 184 pp.

Johnson, D. H. 1996. Population analysis. In: T. A. Bookhout, ed. Research and management techniques for wildlife and habitats. The Wildlife Society, Bethesday, MD: 419-444.

Jolly, G. M. 1969. Sampling methods for aerial censuses of wildlife populations. East African Agricultural and Forestry Journal 34 (special issue):46-49.

Kingsley, M. C. S., and G. E. J. Smith. 1981. Analysis of data arising from systematic transect surveys. Pp 40-48 in F. L. Miller and A. Gunn, eds. Proceedings, Symposium on Census and Inventory Methods for Populations and Habitats, Banff, AB, April 1980.

Kingsley, M. C. S., I. Stirling, and W. Calvert. 1985. The distribution and abundance of seals in the Canadian high arctic, 1980-82. Canadian Journal of Fisheries and Aquatic Sciences 42 (6): 1189-1210.

Miller, F. L. 2002. Multi-island seasonal home range use by two Peary caribou, Canadian High Arctic, 1993-94. Arctic 55:133-142.

Miller, F. L. and S. J. Barry. 2009. Long-term control of Peary caribou numbers by unpredictable, exceptionally severe snow or ice conditions in a non-equilibrium grazing system. Arctic 62(2): 175-189.

Miller, F. L, S. J. Barry, and W. A. Calvert. 2005. Sea-ice crossings by caribou in the south-central Canadian Arctic Archipelago and their ecological importance. Rangifer Special Issue 16:77-88.

Miller, F.L., and A. Gunn. 2003. Catastrophic die-off of Peary caribou on the western Queen Elizabeth Islands Canadian High Arctic. Arctic 56: 381–390.

Miller, F. L., R. H. Russell and A. Gunn. 1975. The decline of caribou on the western Queen Elizabeth Islands. Polarforschung 45: 17-22.

Norton-Griffiths, M. 1978. Counting animals. In: J. J. R. Grimsdell, ed. Handbooks on techniques currently used in African wildlife ecology. No 1. AWLF, Nairobi, Kenya.

Riewe, R. R. 1976. Final report on a survey of ungulate populations on the Bjorne Peninsula, Ellesmere Island: determination of numbers and distribution and assessment of the effects of seismic activities on the behaviour of these populations. Report fulfilling contract YK-73/74-020, University of Manitoba, Winnipeg, MB. 58 pp.

Stirling, I., M. C. S. Kingsley and W. Calvert. 1982. The distribution and abundance of seals in the Beaufort Sea, 1974-1979. Canadian Wildlife Service Occasional Paper 47.

Taylor, A. D. M. 2005. Inuit Qaujimajatuqangit about population changes and ecology of Peary caribou and muskoxen on the High Arctic Islands of Nunavut. MA Thesis. Queen's University, Kingston ON. 123 pp.

Tener, J. S. 1963. Queen Elizabeth Islands game survey, 1961. Canadian Wildlife Service Occasional Paper No. 4. 50 pp.

Thomas, D. C. and P. Everson. 1982. Geographic variation in caribou on the Canadian arctic islands. Canadian Journal of Zoology 60(10): 2442-2454.

Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques, and K. P. Burnham. 2009. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology doi: 10.1111/j.1365-2664.2009.01737.x

Walker, D. A., M. K. Raynolds, F. J. A. Daniëls, E. Einarsson, A. Elvebakk, W. A. Gould, A. E. Katenin, S. S. Kholod, C. J. Markon, E. S. Melnikov, N. G. Moskalenko, S. S.Talbot, B. A. Yurtsev, and the other members of the CAVM Team. 2005. The Circumpolar Arctic vegetation map. Journal of Vegetation Science 16: 267-282.

Appendix 1. Summary of partial survey conducted by helicopter in April 2014.

Methods – April Helicopter Survey

Survey transects approximately followed transects established for the 2005 distance sampling helicopter survey parallel to lines of latitude at 5-km spacing. The April survey was designed to follow the same methodology as the 2005 survey (helicopter distance-sampling, Buckland et al. 2001, Jenkins et al. 2011). Transects were flown at 150 km/hr (81 kts) with a Bell 206 helicopter. Surveys were only conducted on days with good visibility and high contrast to facilitate detection of animals, tracks, and feeding craters, as well as for operational reasons to ensure crew safety. Flight height was set at 400' (122 m). The April survey was flown with one pilot, 1 front observer/navigator, and 2 rear observers.

All observations of wildlife and fresh tracks were marked on a handheld Garmin Montana 650 GPS unit, which also recorded the flight path with positions taken every 30 seconds. During the helicopter survey, we circled groups and marked their exact locations, but the Twin Otter did not approach groups. Sex and age classification was limited to adult/short yearling/newborn calf. Only one newborn muskox was seen in April, on April 24. In April, because the survey was prior to caribou calving, smaller body size and shorter faces on caribou were the primary distinguishing features of young of the year (10-month-old calves/short yearlings). In August, calves were obvious by small body size and we did not attempt to distinguish yearlings. GPS tracks and waypoints were downloaded through DNR Garmin and saved in Garmin GPS eXchange Format, Google Keyhole Markup Language, and as ESRI shapefiles. Data was entered and manipulated in Microsoft Excel spreadsheets.

Small ferry flights (flights linking consecutive transects) were removed for population analysis, although survey speed and height were maintained and all observations recorded as if on survey. Similarly, sections of transect crossing inlets and between islands were removed since density calculations are based on land area only.

Since the survey was not completed, nor did it cover a reasonable unit for which a population estimate could be calculated, no population estimate was derived. The survey was structured to have data analyzed in Distance 6.0 (Thomas et al. 2009, available from http://distancesampling.org/), with distance to transects calculated for each observation using the Euclidean Distance function in ArcMap 10 (ESRI, Redlands, CA). Conventional distance sampling for line transect data would have been used, with detection function curves, following Buckland et al. (2001). The detection function $\hat{g}(x)$ is the probability of detecting a cluster of animals given its perpendicular distance from the transect line, and $\hat{P}_\alpha$ is the probability that a cluster is detected:

$$\hat{P}_\alpha = \frac{\int_0^w \hat{g}(x)dx}{w}$$

The effective strip width (ESW) is the distance at which as many clusters are detected beyond it as are missed within it (Buckland et al. 2001). The ESW can be substituted for $w\hat{P}_\alpha$ to calculate density, where *n* is the number of clusters observed and *L* is the transect length:

$$\hat{D} = \frac{n}{(2wL\hat{P}_\alpha)}$$

Since each cluster represents one or several animals, $\widehat{D}$ is multiplied by the average cluster size to obtain the density, *D*. The cluster size likely influenced detection function as well – where size bias was present, it can be incorporated into the regression; where size bias was not present, the average cluster size can be used.

Results – April Helicopter Survey

We attempted the survey from April 1-25, but the helicopter was delayed in Pond Inlet until April 9. We flew transects by helicopter on April 12, 13, 16, 20, and 24, 2014 for a total of 3,340 km (1,899 km on transect). Visibility was excellent for all survey flights with clear skies (visual estimates of <10% cloud) and high contrast. We observed 311 muskoxen in 33 groups (Figure 8), including 42 short yearlings (11 months old), making up 15.6% of the population. The only newborn calf was observed on April 24, 2014. Of the 33 groups seen, group size averaged 9.4 including short yearlings (6.8-12.0 95% CI), or 8.2 adults (5.8-10.5 95% CI) (Figure 9).

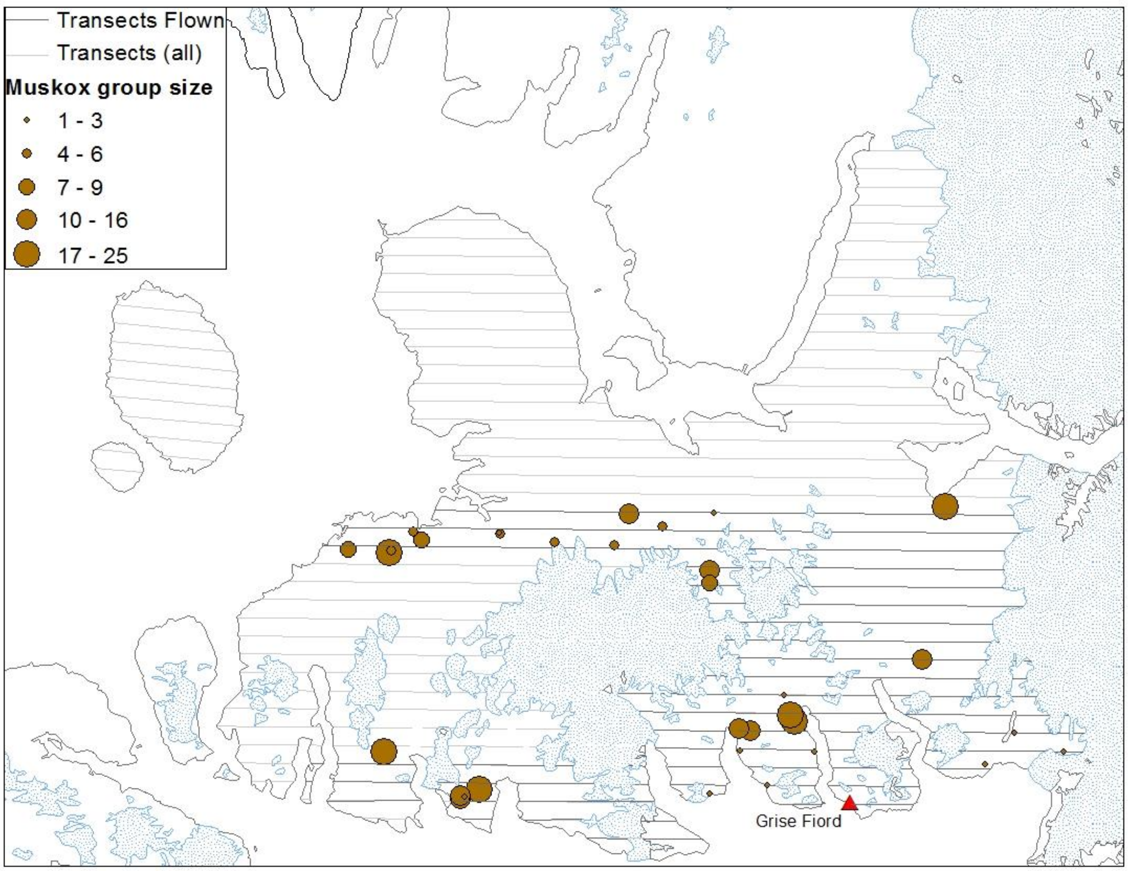


Figure 8. Observations of muskox April 12-24, 2014, totaling 311 muskoxen in 33 groups, on helicopter distance-sampling survey of southern Ellesmere Island. No caribou were observed.

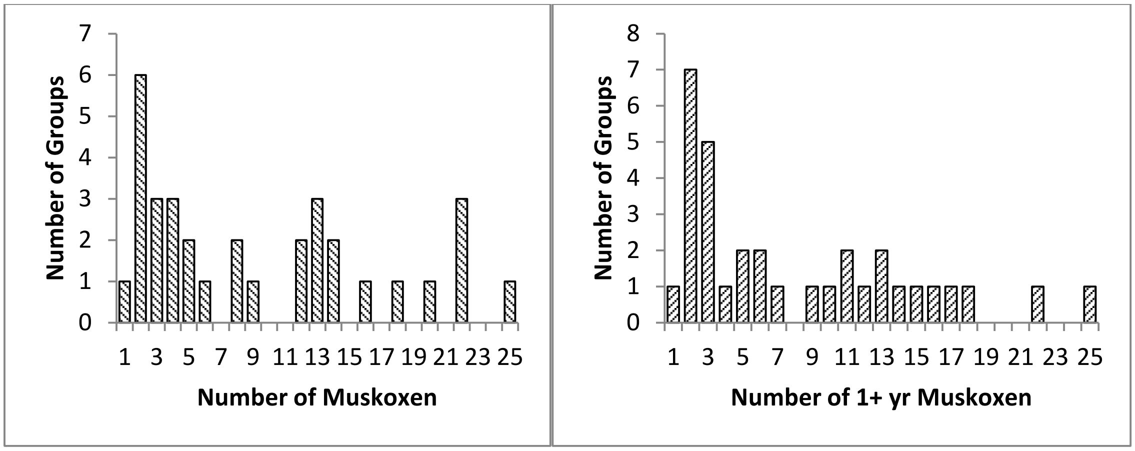


Figure 9. Histograms showing group size including short yearlings and including 1+ year-old animals only for 33 muskoxen groups observed on southern Ellesmere Island in April 2014.

Daily Flight Summaries

12 APRIL 2014

Grise Fiord, South Ellesmere
Transects 48, 49, 50, 57 (part), 58, 59, 60, 61
Track file: 12Apr2014.shp/kml/gpx
Waypoint file: SEllemsere_12Apr2014.shp/kml/gpx

Aircraft: Bell 206LR F-PHO
Pilot: Darryl Hefler
Navigator/Recorder: Morgan Anderson
Observers: Adrian Kakkee, Eepa Ootoovak

Weather mostly calm and clear with light breeze (strong at ground level off the ice cap). Saw 1 polar bear, 75 muskox – several large groups. 1 set of wolf tracks up a valley. Fog west towards Hell Gate and wind off ice caps in the east.

Flight times: 09:20-11:42; 12:00-14:28; 15:15-16:36. Refuel in Grise Fiord.

13 APRIL 2014

Sydkap Ice Cap, South Ellesmere
Transects 51, 52, 53, 54, 55, 56, 57 (part); 35, 36, 51 between ice caps
Track file: 13Apr2014.shp/kml/gpx
Waypoint file: SEllemsere_13Apr2014.shp/kml/gpx

Aircraft: Bell 206LR F-PHO
Pilot: Darryl Hefler
Navigator/Recorder: Morgan Anderson
Observers: Adrian Kakkee, Eepa Ootoovak

Weather mostly calm and clear with ice crystals over the fiords. Polar bear track in valley up onto ridge, 1 set of caribou tracks seen. 35 muskox seen.

Flight times: 13:27-16:02; 16:18-18:39. Refuel at Sydkap cache.

16 APRIL 2014
Sydkap Ice Cap, South Ellesmere
Transects East part of 51, 36, 35, 34
Track file: 16Apr2014.shp/kml/gpx
Waypoint file: SEllemsere_16Apr2014.shp/kml/gpx

Aircraft: Bell 206LR F-PHO
Pilot: Darryl Hefler
Navigator/Recorder: Morgan Anderson
Observers: Josh Kilabuk, Jaypetee Akeeagok

Morning cloudy clearing in afternoon, still hazy to north and west. Turned back early due to wind. Saw no wildlife.

Flight times: 15:04-16:34; 16:55-18:16. Refuel at Sydkap cache.

20 APRIL 2014
North of Sydkap Ice Cap, South Ellesmere
Transects 34, 33, part 32
Track file: 20Apr2014.shp/kml/gpx
Waypoint file: SEllemsere_20Apr2014.shp/kml/gpx

Aircraft: Bell 206LR F-PHO
Pilot: Darryl Hefler
Navigator/Recorder: Morgan Anderson
Observers: Morgan Anderson, Garland Pope

Weather clear and calm, -15°C. Saw 82 muskox.
Flight times: 15:55-18:20; 18:35-19:31; 19:47-20:11. Refuel at Sydkap cache.

24 APRIL 2014
Okse Bay, South Ellesmere
Transects 32, 46, 47
Track file: 24Apr2014.shp/kml/gpx
Waypoint file: SEllemsere_24Apr2014.shp/kml/gpx

Aircraft: Bell 206LR F-PHO
Pilot: Darryl Hefler
Navigator/Recorder: Morgan Anderson
Observers: Josh Kilabuk, Jaypetee Akeeagok, Mark Akeeagok

Wind 2 kts, -13°C, clear. Fuel pump issues at Okse Bay cache so returned to refuel in Grise Fiord. Engineer couldn't find anything wrong with fuel pump when checking drums at the airport – must have been vapor lock. Swapped observers and did a short trip along Jones Sound before wind picked up (some muskox groups seen previously from other survey lines).

Flight times: 11:10-12:28; 12:52-13:58; 14:50-16:51 Opened 1 drum at Okse cache but unable to pump it.

Appendix 2. Summary of partial survey conducted August 2014.

Methods – August Fixed-wing Survey

Survey methodology for the August fixed-wing survey was the same as that described for the March 2015 fixed-wing survey. However, we stratified the survey area to fly every second transect in the area north of Grise Fiord and east of the Sydkap Ice Cap (10-km transect spacing) since no caribou and few muskoxen had been observed there in April. We may have reflown that area if there was a marked seasonal distribution of muskoxen - unfortunately the limited seasons in which residents of Grise Fiord can access many of their hunting areas also meant local knowledge was not always available.

Results – August Fixed-wing Survey

We attempted to fly the survey area August 2-9, but were delayed due to weather and flew August 11-21. However, fog and wind continued to be an issue, and besides a brief flight on August 13 (593 km, 73 km on transect), we only flew 1 full day, August 15 (1865 km, 1259 km on transect). We saw 88 muskoxen in 20 groups, including 23 calves – 23.9% of the population (Figure 10). Group size was also significantly smaller than in April (t-test for unequal variances based on adult muskoxen only, p=0.001, df=48), with an average of the 20 groups observed being 4.4 muskoxen (2.6-6.2 95% CI) or 3.6 adult muskoxen (2.2-4.9 95% CI) (Figure 11).

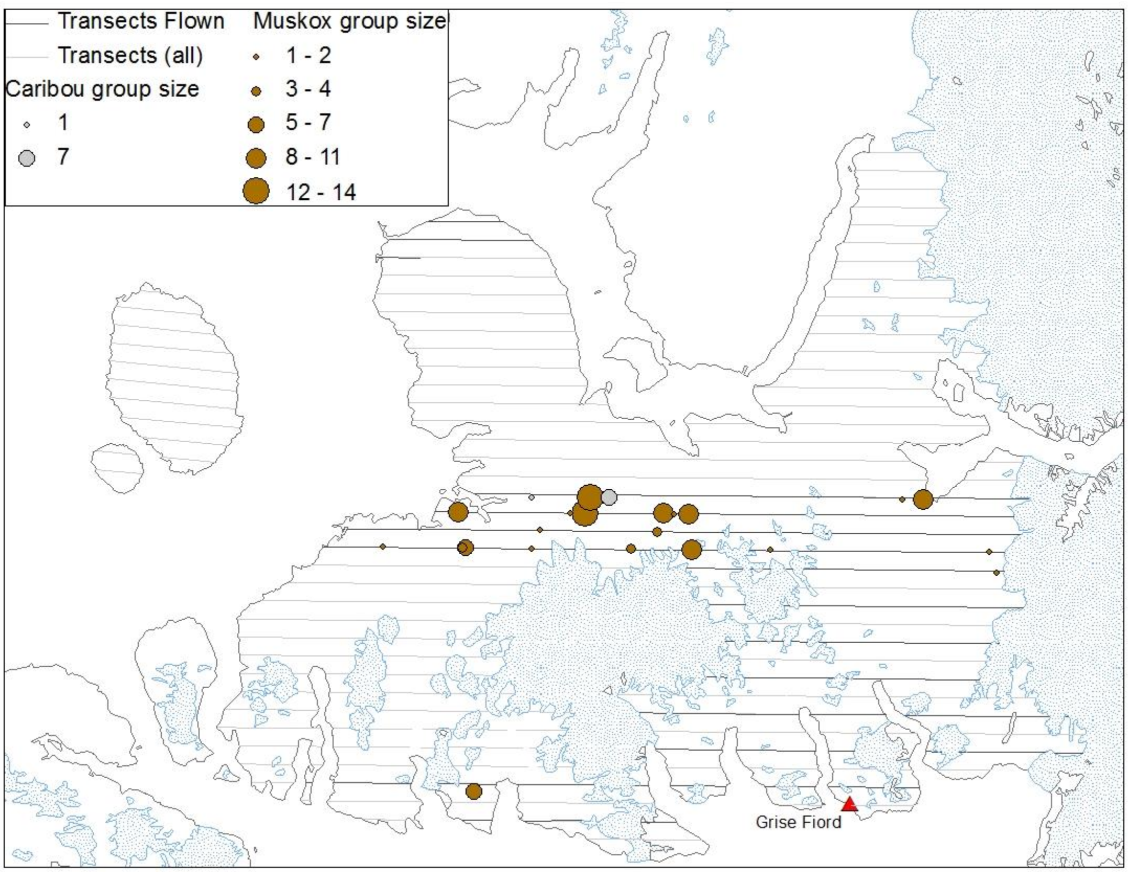


Figure 10. Observations of muskox August 15, 2014, totaling 88 muskoxen in 20 groups and 8 caribou in 2 groups, on Twin Otter fixed-width strip survey of southern Ellesmere Island.

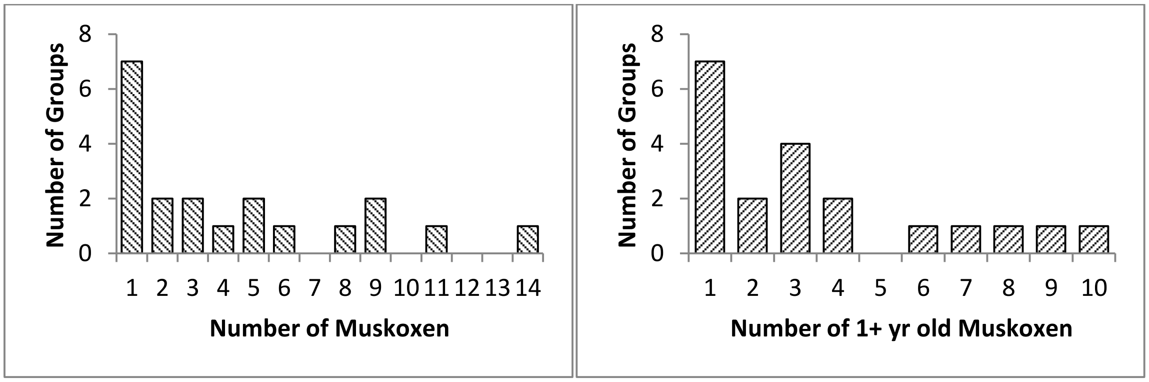


Figure 11. Histograms showing group size including short yearlings and including 1+ year-old animals only for 20 muskoxen groups observed on southern Ellesmere Island in August 2014.

Daily Flight Summaries

13 AUGUST 2014

Graham Island, Bjorne Peninsula
Transects 1, 2, 3
Track file: track_13aug14.shp/kml/gpx
Waypoint file: wpts_13aug14.shp/kml/gpx

Aircraft: Twin Otter F-KBG
Pilots: Terry Welch, Sebastien Trudel
Navigator/Recorder: Morgan Anderson
Observers: Etuangat Akeeagok, Eepa Ootoovak

Overcast at Grise Fiord with light wind from south. Ceiling dropping as day went on from 500’ at Okse Bay down to 200’ at Bjorne Peninsula until we were flying at 20’ and had to turn back. 1 polar bear on Graham Island and a herd of 263 arctic hares on Bjorne Peninsula.
Flight times: 13:25-16:00.

15 AUGUST 2014

Grise Fiord, South Ellesmere
Transects 49, 47, 61, 59, 57, 55, 53, 51, 35, 34, 33, 32, 31
Track file: track_15aug14.shp/kml/gpx
Waypoint file: wpts_15aug14.shp/kml/gpx

Aircraft: Twin Otter F-KBG
Pilots: Terry Welch, Sebastien Trudel
Navigator/Recorder: Morgan Anderson
Observers: Etuangat Akeeagok, Tim Hall

Sunny and clear with some cloud in the east moving in, ceiling about 4000’. Saw 88 muskoxen, 8 caribou.
Flight times: 09:07-13:25; 14:00-19:50; 20:30-21:00. Refuel and pack out drums from Makinson Inlet cache.

Appendix 3. South Ellesmere Island survey transects, 2014-2015.

Table 4. Transect end points and general locations on southern Ellesmere Island, Graham Island, Buckingham Island, and North Kent Island for a Peary caribou and muskox survey in April 2014, August 2014, and March 2015.

Transect	Location	Longitude West End	Latitude West End	Longitude East End	Latitude East End	Flown Apr?	Flown Aug?	Flown Mar?
1	Bjorne Peninsula	-87.63447	77.86272	-86.73525	77.86813		Y	Y
2	Bjorne Peninsula	-88.10144	77.81358	-86.38718	77.82430		Y	Y
3	Bjorne Peninsula	-88.21828	77.76728	-86.17769	77.77975		Y	Y
4	Bjorne Peninsula	-88.15352	77.72272	-86.09019	77.73481			Y
5	Bjorne Peninsula	-88.20685	77.67702	-85.97389	77.68989			Y
6	Bjorne Peninsula	-88.16799	77.63222	-85.91615	77.64484			Y
7	Bjorne Peninsula	-87.95133	77.58906	-85.87106	77.59977			Y
8	Bjorne Peninsula	-87.81693	77.54505	-85.83368	77.55468			Y
9	Bjorne Peninsula	-87.67639	77.50104	-85.80916	77.50957			Y
10	Bjorne Peninsula	-87.71097	77.45559	-85.72368	77.46451			Y
11	Bjorne Peninsula	-87.76401	77.40998	-85.47639	77.41946			Y
12	Sor Fiord	-87.70839	77.36527	-81.15694	77.33925			Y
13	Vendom Fiord	-83.73859	77.41373	-81.58975	77.39114			Y
14	Vendom Fiord	-83.82041	77.45940	-81.78288	77.43910			Y
15	Vendom Fiord	-83.42168	77.50181	-81.23609	77.47629			Y
16	Vendom Fiord	-83.30973	77.54610	-81.08733	77.51917			Y
17	Vendom Fiord	-83.18055	77.59020	-81.61272	77.57242			Y
18	Vendom Fiord	-83.08156	77.63453	-81.19908	77.61148			Y
19	Vendom Fiord	-82.97330	77.67873	-81.49649	77.66122			Y
20	Vendom Fiord	-82.89174	77.72315	-81.44469	77.70571			Y
21	Vendom Fiord	-82.82779	77.76773	-81.67575	77.75424			Y
22	Vendom Fiord	-82.75438	77.81220	-81.72205	77.80010			Y
23	Vendom Fiord	-82.64875	77.85633	-81.60740	77.84376			Y
24	Vendom Fiord	-82.61015	77.90112	-81.46311	77.88695			Y
25	Vendom Fiord	-82.54402	77.94563	-81.54255	77.93333			Y
26	Vendom Fiord	-82.55925	77.99098	-81.47106	77.97755			Y
27	Vendom Fiord	-82.41491	78.03464	-81.72545	78.02630			Y
28	Sor Fiord	-87.10957	77.32436	-81.45119	77.29861			Y
29	Sor Fiord	-87.22732	77.27847	-80.80488	77.24276			Y
30	Okse Bay	-87.14461	77.23384	-80.88482	77.19888			Y
31	Okse Bay	-86.95900	77.18976	-80.91725	77.15417		Y	Y
32	Okse Bay	-87.41053	77.14174	-80.95440	77.10954	Y	Y	Y
33	Okse Bay	-88.41144	77.08742	-80.88911	77.06313	Y	Y	Y
34	Okse Bay	-88.64246	77.03956	-81.07619	77.02108	Y	Y	Y
35	Okse Bay	-88.76076	76.99291	-81.09787	76.97618	Y	Y	Y

Transect	Location	Longitude West End	Latitude West End	Longitude East End	Latitude East End	Flown Apr?	Flown Aug?	Flown Mar?
36	Okse Bay	-88.99815	76.94463	-81.12122	76.93131	Y		Y
37	Okse Bay	-89.28209	76.89543	-86.41150	76.92134			Y
38	Hell Gate	-89.52179	76.84659	-86.78557	76.87461			Y
39	Hell Gate	-89.50189	76.80165	-86.50905	76.83068			Y
40	Hell Gate	-89.46363	76.75700	-86.60392	76.78515			Y
41	Hell Gate	-89.44504	76.71205	-86.70739	76.73954			Y
42	Hell Gate	-89.41607	76.66726	-86.46522	76.69541			Y
43	Hell Gate	-89.58928	76.61929	-85.86393	76.65183			Y
44	Hell Gate	-89.65093	76.57305	-85.89644	76.60664			Y
45	Hell Gate	-89.39647	76.53185	-86.22186	76.56078			Y
46	Hell Gate	-89.37060	76.48701	-85.82347	76.51646	Y		Y
47	Hell Gate	-89.23670	76.44380	-85.59824	76.47151	Y		Y
48	South Cape	-88.69421	76.40607	-84.97882	76.42585	Y		Y
49	South Cape	-88.03612	76.36841	-84.72207	76.38004	Y	Y	Y
50	South Cape	-85.66961	76.33605	-84.45351	76.33392	Y		Y
51	Sydkap Ice Cap East	-84.35379	76.92041	-80.91082	76.88241	Y	Y	Y
52	Sydkap Ice Cap East	-84.03205	76.87364	-81.25458	76.84301	Y		Y
53	Sydkap Ice Cap East	-84.16772	76.82922	-81.29792	76.79847	Y	Y	Y
54	Sydkap Ice Cap East	-84.05603	76.76347	-81.33347	76.75379	Y		Y
55	Sydkap Ice Cap East	-84.40423	76.74004	-81.44148	76.71028	Y	Y	Y
56	Sydkap Ice Cap East	-85.35577	76.69719	-80.83927	76.65471	Y		Y
57	Sydkap Ice Cap East	-85.12552	76.65182	-80.71679	76.60719	Y	Y	Y
58	Sydkap Ice Cap East	-84.96454	76.60639	-80.36300	76.55497	Y		Y
59	Grise Fiord	-84.94742	76.56121	-80.38464	76.51010	Y	Y	Y
60	Grise Fiord	-84.82892	76.51578	-81.38498	76.48313	Y		Y
61	Grise Fiord	-84.79307	76.47054	-82.14173	76.44914	Y	Y	Y
62	Grise Fiord	-83.64674	76.41956	-82.21794	76.40494	Y		Y
63	King Edward Point	-80.32850	76.28240	-80.08014	76.27710			
64	King Edward Point	-80.70348	76.24464	-80.10151	76.23224			
65	King Edward Point	-81.08990	76.20656	-80.44681	76.19423			
66	King Edward Point	-81.06136	76.16078	-80.90309	76.15787			

Transect	Location	Longitude West End	Latitude West End	Longitude East End	Latitude East End	Flown Apr?	Flown Aug?	Flown Mar?
67	Graham Island	-90.94404	77.63906	-90.65056	77.63938			Y
68	Graham Island	-91.20496	77.59320	-90.19494	77.59394			Y
69	Graham Island	-91.20271	77.54789	-90.01941	77.54837			Y
70	Graham Island	-91.21067	77.50254	-89.81838	77.50261			Y
71	Graham Island	-91.20102	77.45724	-89.72927	77.45705			Y
72	Graham Island	-91.18842	77.41196	-89.72520	77.41172			Y
73	Graham Island	-91.15933	77.36670	-89.72157	77.36638			Y
74	Graham Island	-90.99896	77.32173	-89.65881	77.32087			Y
75	Graham Island	-90.75374	77.27676	-89.76529	77.27587			Y
76	Graham Island	-91.23614	77.23054	-89.89893	77.23087			Y
77	Buckingham Island	-91.22981	77.18523	-90.70254	77.18616			Y
78	North Kent Island	-90.51898	76.78474	-89.82273	76.79647			
79	North Kent Island	-90.59282	76.73708	-89.72872	76.75239			
80	North Kent Island	-90.52884	76.69304	-89.71216	76.70780			
81	North Kent Island	-90.44490	76.64939	-90.14237	76.65386			
82	North Kent Island	-90.24349	76.56265	-89.84342	76.57127			
83	North Kent Island	-90.18308	76.51749	-89.74876	76.52355			

Table 5. Transects matched up by latitude from north to south to make lines for analysis.

Transect(s)	Length (below 400 m), km	Length (above 400m), km	Total Length, km
27	16.41		16.41
26	16.85	7.84	24.69
25	17.57	5.84	23.41
24	20.11	6.81	26.92
23-01	34.91	10.73	45.64
22-02	55.20	9.61	64.81
21-03	55.83	18.21	74.04
20-04	68.60	14.85	83.44
19-05	76.34	12.16	88.49
18-06	78.34	19.66	98.00
17-07	69.88	17.75	87.64
16-08	81.20	18.62	99.82
15-09	84.52	6.19	90.70
14-10	90.48	7.22	97.70
13-11	106.85	0.04	106.89
12	140.97	2.80	143.77
28	127.76	2.75	130.51
29	130.09	9.40	139.49
30	107.16	37.68	144.84
31	92.73	52.71	145.45
32	77.24	78.52	155.76
33	79.65	99.91	179.57
34	68.04	102.41	170.45
35	58.64	97.44	156.08
36	52.77	86.78	139.55
37-51	50.80	96.00	146.80
38-52	55.98	76.14	132.12
39-53	54.89	72.83	127.73
40-54	64.19	69.54	133.73
41-55	49.61	55.67	105.27
42-56	53.12	75.92	129.04
43-57	90.89	78.03	168.92
44-58	106.59	65.52	172.12
45-59	104.67	43.03	147.70
46-60	98.19	30.73	128.92
47-61	95.77	26.04	121.82
48-62	86.83	11.98	98.81
49	41.85	4.00	45.85
50	30.00	2.08	32.08

Appendix 4. Alternate population calculations.

Jolly Method II Calculations

In this report, we used a systematic sampling approach to analysis, since we were estimating abundance of a patch population rather than estimating density in a habitat (which varied across the study area). Other systematic aerial surveys have frequently used Jolly's Method II, and estimates derived from both analyses were similar. Population estimates for fixed-width strip sampling using Jolly's Method 2 for uneven sample sizes (Jolly 1969; summarized in Caughley 1977) are derived as follows:

$$\hat{Y} = RZ = Z\frac{\sum_i y_i}{\sum_i z_i}$$

Where $\hat{Y}$ is the estimated number of animals in the population, R is the observed density of animals (sum of animals seen on all transects $\sum_i y_i$ divided by the total area surveyed $\sum_i z_i$), and Z is the total study area. The variance is given by:

$$Var(\hat{Y}) = \frac{N(N-n)}{n}\left(s_y^2 - 2Rs_{zy} + R^2 s_z^2\right)$$

Where N is the total number of transects required to completely cover study area Z, and n is the number of transects sampled in the survey. s_y^2 is the variance in counts, s_z^2 is the variance in areas surveyed on transects, and s_{zy} is the covariance. The estimate $\hat{Y}$ and variance $Var(\hat{Y})$ are calculated for each stratum and summed. The Coefficient of Variation (CV = σ/$\hat{Y}$) was calculated as a measure of precision.

To determine possible stratification regimes for future surveys on southern Ellesmere, we broke the study area into several strata (Table 6) and used Jolly's Method II to calculate population estimates (Table 7, Table 8).

Table 6. Survey strata for southern Ellesmere Island, March 2015.

Stratification	Block ID	Location	Strata Area (km^2)	Base-line[1] (km)	Transect Spacing (km)	Transects Surveyed	Survey Area (km^2)	Percent Covered
Islands	A	South Ellesmere	21260	257	5	62	4896.0	19.9
	C	Graham, Buckingham	1531	59	5	11	296.5	19.3
Elevation	A	South Ellesmere Low (<400 m)	13921	257	5	62	3322.5	20.1
	B	South Ellesmere High (>400 m)	7339	217	5	54	1573.6	19.5
	C	Graham, Buckingham	1531	59	5	11	296.5	19.3
Bjorne	A	South Ellesmere	18988	257	5	52	4439.1	19.8
	B	Bjorne Peninsula	2272	51	5	10	456.9	20.1
	C	Graham, Buckingham	1531	59	5	11	296.5	19.3
Case and Ellsworth	I	South Ellesmere	10029	124	5	31	2657.9	26.5
	III	East Vendom	2865	88	5	17	576.0	20.1
	IV	Bjorne	3397	82	5	16	685.2	20.2
	V	Southwest Ellesmere	4969	94	5	18	977.0	19.7
	C[2]	Graham, Buckingham	1531	59	5	11	296.5	19.3

[1] Baseline was the number of possible transects at 1-km wide and parallel to lines of longitude, to cover the entire strata.

[2] For caribou estimates, Graham/Buckingham islands were both included and excluded, but no muskoxen were seen on transect there.

Table 7. Abundance estimates (Jolly 1969 Method II) for muskoxen on southern Ellesmere Island, March 2015, based on several stratification regimes. N is the total number of transects required to completely cover study area Z, n is the number of transects sampled in the survey covering area z, y is the observed caribou/muskoxen, Y is the estimated caribou/muskoxen with variance Var(Y). The coefficient of variation (CV) is also included.

	Stratum	**Y**	**Var(Y)**	**n**	**Z (km²)**	**z (km²)**	**N**	**y**	**Density (per km²)**
Islands CV=0.255	A	2604	441085	62	21260	5192.5	257	636	0.122
	C	0	0	11	1531	296.5	59	0	0
	Total	2604	441085	73	22791		316	636	0.122
Elevation CV=0.171	A	2392	219697	62	13921	3322.5	257	571	0.172
	B	303	8174	54	7339	1573.5	217	65	0.041
	C	0	0	11	1531	296.5	59	0	0
	Total	2696	227871	127	22791	5192.5	533	636	0.122
Bjorne CV=0.337	A	2665	594526	52	18988	4439.1	257	623	0.140
	B	19	3498	10	22712	1573.5	51	13	0.008
	C	0	0	11	1531	296.5	59	0	0
	Total	2684	598025	73	22791	6309.1	367	636	0.101
Case and Ellsworth CV=0.229	I	838	99075	31	10029	2657.9	124	222	0.084
	III	1055	241963	17	2865	576.0	88	212	0.368
	IV	149	8523	16	3397	685.2	82	30	0.044
	V	875	51843	18	4969	977.0	94	172	0.176
	Total	2916	401403	82	21260	4896.0	388	636	0.130

Table 8. Peary caribou population estimates for caribou on southern Ellesmere Island, March 2015, based on several stratification regimes. N is the total number of transects required to completely cover study area Z, n is the number of transects sampled in the survey covering area z, y is the observed caribou/muskoxen, Y is the estimated caribou/muskoxen with variance Var(Y). The coefficient of variation (CV) is also provided.

	Stratum	**Y**	**Var(Y)**	**n**	**Z (km^2)**	**z (km^2)**	**N**	**y**	**Density (per km^2)**
Islands CV=0.536	A	113	4822	62	21260	4896.0	257	26	0.005
	C	52	2343	11	1531	296.5	59	10	0.034
	Total	165	7164	73	22791	5192.5	316	36	0.007
Elevation CV=0.505	A	109	4681	62	13921	3322.5	257	26	0.008
	B	0	0	54	7339	1573.5	217	0	0
	C	57	2327	11	1531	296.5	59	10	0.037
	Total	166	7009	127	22791	5192.5	533	36	0.007
Bjorne CV=0.659	A	13	173	52	18988	4439.1	257	23	0.001
	B	33	7170	10	22712	1573.5	51	3	0.015
	C	57	0	11	1531	296.5	59	10	0.037
	Total	103	7343	73	22791	6309.1	367	36	0.006
Case and Ellsworth CV=0.786	I	0	0	31	10029	2657.9	124	0	0
	III	0	0	17	2865	576.0	88	0	0
	IV	129	7883	16	3397	685.2	82	26	0.038
	V	0	0	18	4969	977.0	94	0	0
	Total	129	7883	82	21260	4896.0	388	26	0.005
Case and Ellsworth (+Graham) CV=0.640	I	0	0	31	10029	2657.9	124	0	0
	III	0	0	17	2865	576.0	88	0	0
	IV	129	7883	16	3397	685.2	82	26	0.038
	V	0	0	18	4969	977.0	94	0	0
	C	52	2343	11	1531	296.5	59	10	0.034
	Total	181	10225	93	22791	5192.5	447	36	0.007

Stratified Systematic Survey Calculations

Following Cochran (1977), the abundance estimate for a systematic survey is given by:

$$\hat{Y} = \frac{S}{w} \times \sum n_i$$

Where $\hat{Y}$ is the population estimate, *S* is the transect spacing (5 km), *w* is the transect width (1 km), and n_i is the total number of animals observed on transect *i*, the sum of which is all animals observed on *I* transects in the survey. The configuration of the study area may mean that the actual sampling fraction (proportion of the study area that is surveyed) varies, which was partly why Cochran's ratio estimator was used instead, and why the estimate varied from 3180 muskoxen and 180 caribou between methods and stratification regimes. The variance is based on the sum of squared differences in counts between consecutive transects:

$$Var(\hat{Y}) = \frac{\frac{S}{w} \times \left(\frac{S}{w} - 1\right) \times I}{2 \times (I - 1)} \times \sum (n_i - n_{i-1})^2$$

Table 9. Abundance estimates for a stratified systematic survey (Cochran 1977) of muskoxen on southern Ellesmere Island, March 2015. *I* is the number of transects sampled.

	Strata	Estimated Abundance Y	Var(Y)	I	Transect Spacing S (km)	Transect Width w (km)	Observed Individuals y	Density (per km²)
All CV=0.223		3180	331785	73	5	1	636	0.150
Elevation CV=0.172	A	2855	282070	62	5	1	571	0.205
	B	325	17321	54	5	1	65	0.044
	Total	3180	299390	136			636	0.150
Bjorne CV=0.181	A	3115	327264	52	5	1	623	0.164
	B	65	3756	10	5	1	13	0.029
	Total	3180	331019	62			636	0.150
Case and Ellsworth CV=0.184	I	1110	83886	31	5	1	222	0.111
	III	1060	199166	17	5	1	212	0.370
	IV	150	9771	16	5	1	30	0.044
	V	860	50781	18	5	1	172	0.173
	Total	3180	343603	82			636	0.150

Table 10. Abundance estimates for a stratified systematic survey (Cochran 1977) for Peary caribou on southern Ellesmere Island, March 2015. *I* is the number of transects sampled.

	Strata	Estimated Abundance Y	Var(Y)	I	Transect Spacing S (km)	Transect Width w (km)	Observed Individuals y	Density (per km²)
All CV=0.359		180	4177	73	5	1	36	0.008
Elevation CV=0.367	A	130	2155	62	5	1	26	0.009
	B	0	0	54	5	1	0	0
	C	50	2200	11	5	1	10	0.033
	Total	180	4355				36	0.008
Bjorne CV=0.374	A	15	184	52	5	1	3	0.001
	B	115	2156	10	5	1	23	0.051
	C	50	2200	11	5	1	10	0.033
	Total	180	4539	73			36	0.008
Case and Ellsworth CV=0.366	I	0	0	31	5	1	0	0
	III	0	0	17	5	1	0	0
	IV	130	2261	16	5	1	26	0.038
	V	0	0	18	5	1	0	0
	Total	130	2261	82			26	0.006
Case and Ellsworth (+Graham) CV=0.371	I	0	0	31	5	1	0	0
	III	0	0	17	5	1	0	0
	IV	130	2261	16	5	1	26	0.038
	V	0	0	18	5	1	0	0
	C	50	2200	11	5	1	10	0.033
	Total	180	4461	93			36	0.008

Appendix 5. Daily flight summaries for south Ellesmere survey flown by Twin Otter, March 2015.

Table 11. Summary by day of survey flights and weather conditions for March 2015 Peary caribou and muskox survey, southern Ellesmere Island.

Date	Time Up	Time Down	Time Up 2	Time Down 2	Flying Time	Transect Time	Area	Comment
18-Mar-15	12:30	14:20			1.83	0	Bjorne Peninsula	-27°C, clear, some wind to east around Vendom Fd, otherwise calm
19-Mar-15	9:20	14:35	15:10	19:34	9.65	6.13	Graham and Buckingham Islands	-20°C, clear, almost no wind
20-Mar-15	12:10	16:30			4.33	3.78	Hell Gate and Grise Fiord	-28°C, some wind by Hell Gate and east, 15 kph +catabatics at ice sheets
21-Mar-15	11:30	15:40			4.17	3.63	Hell Gate to Skaare Fiord	-28°C, clouds around Hell Gate, wind about 15 kph
22-Mar-15					0	0	Grounded	Low cloud prevented flying
23-Mar-15	9:50	15:32	16:12	20:00	9.5	8.28	West of Sydkap Ice Cap and north of Grise Fiord	-25°C, 50% cloud around Grise Fiord to 100% cloud in east and fog over Hell Gate, fairly calm with more wind from east later in the day at east/west ends of study area
24-Mar-15	9:40	15:05	15:40	20:30	10.25	8.15	Sydkap ice cap north to Sor Fiord	-29°C, clear, some wind on east side of study area
25-Mar-15	9:18	13:15			3.95	2.58	Vendom Fiord	-28°C, sunny clear with scattered low cloud/fog around Makinson Inlet and along east coast (also wind/mechanical turbulence)
26-Mar-15	9:38	13:00	15:08	17:38	5.87	3.05	Sor Fiord to Makinson Inlet; Hell Gate	-30°C, clear with scattered cloud wind up to 15 kph but mostly calm, some fog around Hell Gate

Pilots - Rob Bergeron, John Sidwell; Navigator - Morgan Anderson

Observers:
Mar 19 – Morgan Anderson, Eepa Ootoovak, Scott Darroch
Mar 20 – Morgan Anderson, Aksakjuk Ningiuk
Mar 21 – Morgan Anderson, Olaf Killiktee, Imooshie Nutuqajuk, Mark Akeeagok
Mar 23 – Morgan Anderson, Simon Singoorie, Olaf Killiktee, Frankie Noah
Mar 24 – Morgan Anderson, Aksakjuk Ningiuk, Eepa Ootoovak, Simon Singoorie, Olaf Killiktee
Mar 25 – Morgan Anderson, Frankie Noah, Jon Neely, Frank Holland
Mar 26 – Morgan Anderson, Jopee Kiguktak, Scott Darroch

Appendix 6. Incidental wildlife observations.

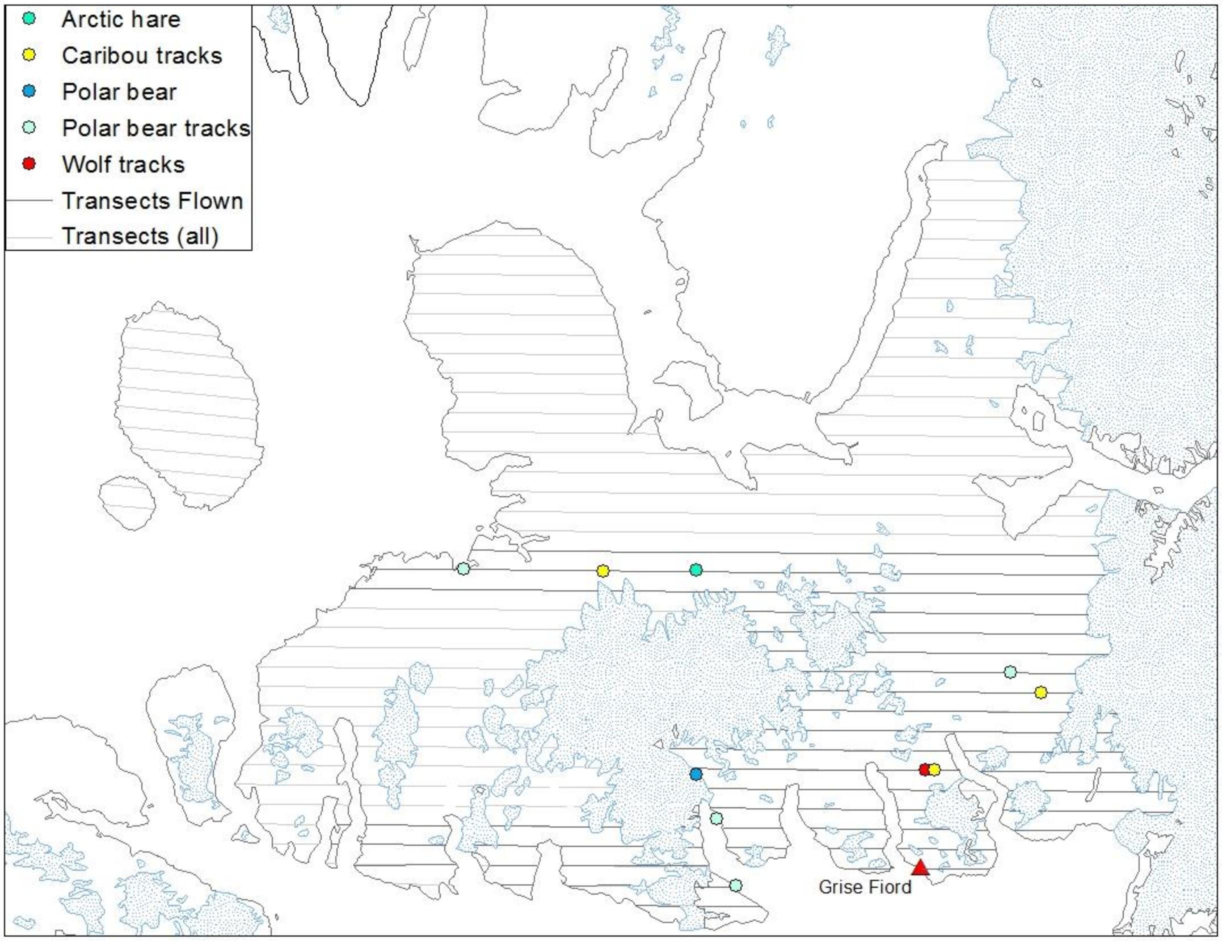


Figure 12. Incidental observations April 12-24, 2014 during a caribou/muskox survey of southern Ellesmere Island by Twin Otter.

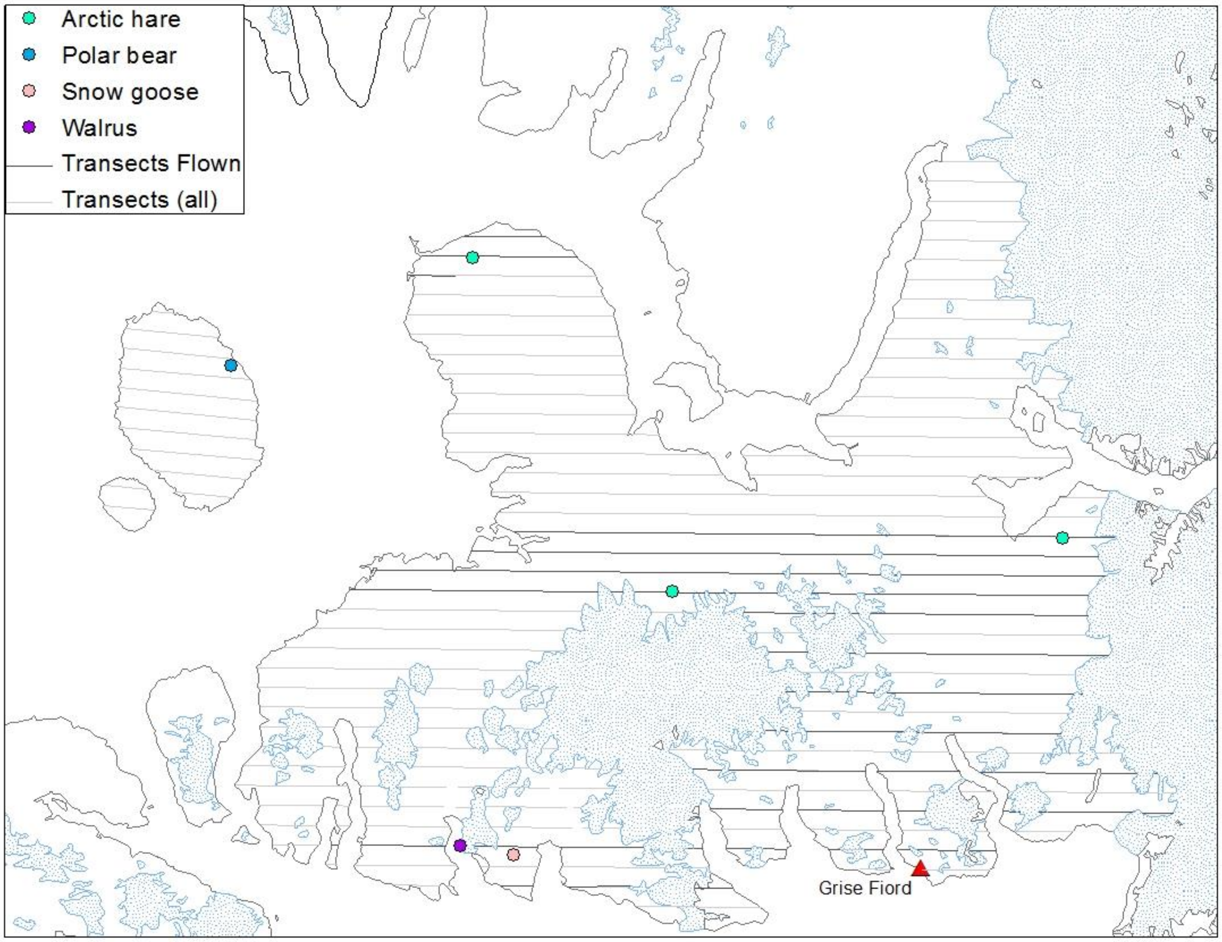


Figure 13. Incidental observations August 13 and 15, 2014 during a caribou/muskox survey of southern Ellesmere Island by Twin Otter.

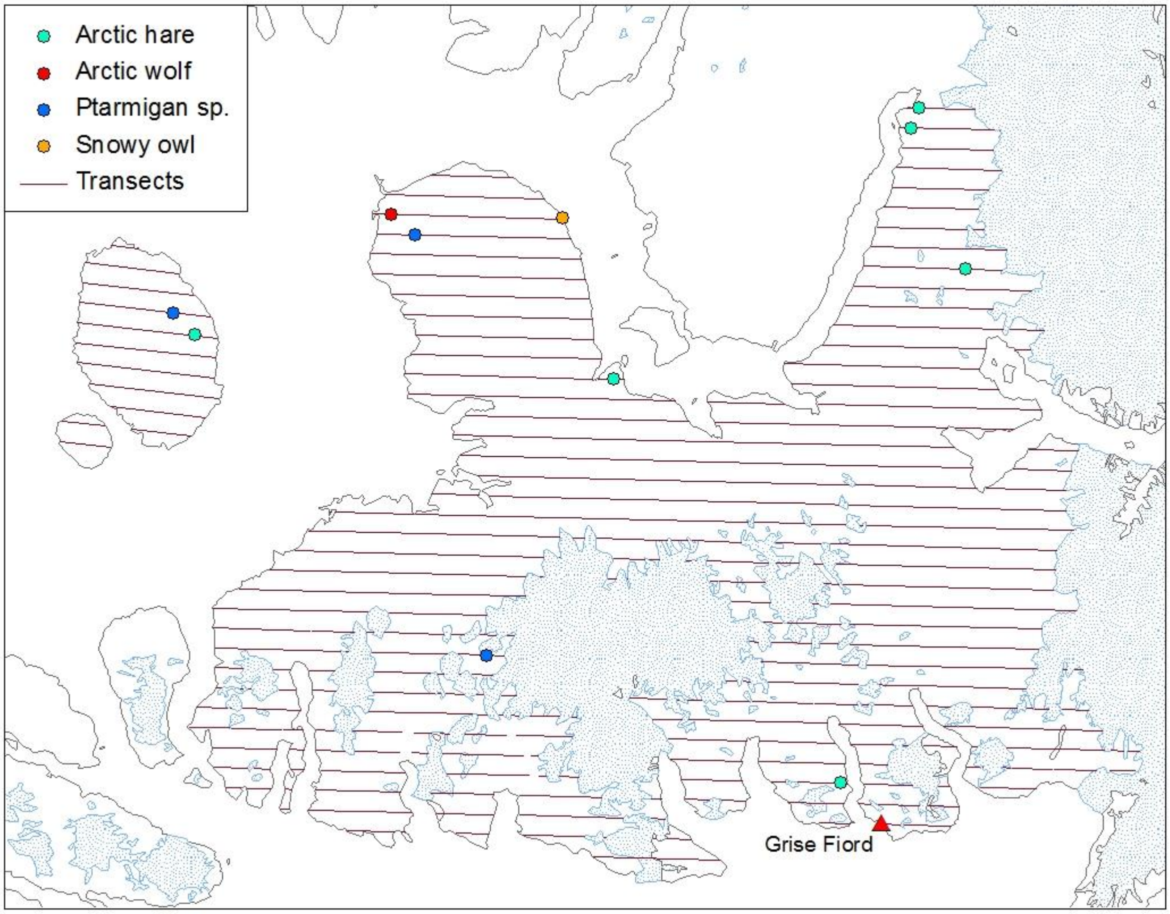


Figure 14. Incidental observations March 19-26, 2015 during a caribou/muskox survey of southern Ellesmere Island by Twin Otter. The hare observations at Baumann Fiord and north of Makinson Inlet were large herds. Two adult wolves were seen on Bjorne Peninsula.

Recent trends in abundance of Peary Caribou (*Rangifer tarandus pearyi*) and Muskoxen (*Ovibos moschatus*) in the Canadian Arctic Archipelago, Nunavut

Deborah A. Jenkins[1]
Mitch Campbell[2]
Grigor Hope [3]
Jaylene Goorts[1]
Philip McLoughlin[4]

[1]Wildlife Research Section, Department of Environment,
P.O. Box 400, Pond Inlet, NU X0A 0S0

[2] Wildlife Research Section, Department of Environment,
P.O. Box 400, Arviat NU X0A 0S0

[3]Department of Community and Government Services
P.O. Box 379, Pond Inlet, NU X0A 0S0

[4]Department of Biology, University of Saskatchewan,
112 Science Place, Saskatoon, SK S7N 5E2

2011

Wildlife Report, No.1, Version 2

Jenkins et al. 2011. Recent trends in abundance of Peary Caribou (*Rangifer tarandus pearyi*) and Muskoxen (*Ovibos moschatus*) in the Canadian Arctic Archipelago, Nunavut. Department of Environment, Government of Nunavut, Wildlife Report No. 1, Pond Inlet, Nunavut. 184 pp.

RECOMMENDATIONS TO GOVERNMENT

ABSTRACT

Updated information on the distribution and abundance for Peary caribou on Nunavut's High Arctic Islands estimates an across-island total of about 4,000 (aged 10 months or older) with variable trends in abundance between islands. The total abundance of muskoxen is estimated at 17,500 (aged one year or older). The estimates are from a multi-year survey program designed to address information gaps as previous information was up to 50 years old. Information from this study supports the development of Inuit Qaujimajatuqangit (IQ)- and scientifically-based management and monitoring plans. It also contributes to recovery planning as required under the 2011 addition of Peary caribou to Schedule 1 of the federal Species At Risk Act based on the 2004 national assessment as Endangered.

The population estimates are mostly based on line transect distance sampling methods designed to increase survey accuracy. The survey estimates were for caribou (10 months or older) as the surveys were almost all pre-calving (April-May). We surveyed the islands as island groups between 2001 and 2008. We estimated 187 caribou (95% CI 104–330 caribou) on Bathurst Island Complex in May, 2001 which is an increase since a die-off in the mid-1990s. Sightings during 2010 suggest the increase of Peary caribou on Bathurst Island has continued. We observed only a single, adult female caribou during the aerial survey of Cornwallis Island and Little Cornwallis Island in May, 2002 and on Devon Island in April/May 2008, we counted 17 caribou after flying 7985 km.

In May 2004, we did not see Peary caribou on Prince of Wales and Somerset islands which indicates no recovery from the severe decline between 1980 and 1995. The observation of possibly only one Peary caribou on Boothia Peninsula during a muskoxen survey in 2006 (M. Dumond, personal communication) gives emphasis to a caribou study on the Peninsula.

The total estimated abundance of caribou on Ellesmere Island (including Graham Island) is 1,021 caribou based on surveys of southern Ellesmere (219 caribou 95% CI 109-442) in May, 2005, and northern Ellesmere (802 caribou 95% CI 531 -1207) in May 2006. On Axel Heiberg Island in April 2007, we estimated 2,291 (95% CI 1,636 – 3,208). Due to the low occurrence of caribou on Amund Ringnes, Ellef Ringnes, King Christen, Cornwall, and Meighen Islands, we estimated the total abundance of Peary caribou as 282 (95% CI 157 – 505) for these islands. For Lougheed Island, 32 clusters of caribou were observed providing a density estimate of 262 caribou/1000 km^2.

For muskoxen, survey estimates were for animals one year or older, as the surveys coincided with calving (April-May). A total of 12,683 muskoxen were counted across the study area, including 1,492 new born calves. In May, 2001 we observed 7 clusters of muskoxen on Bathurst Island Complex for a minimum count of 82 muskoxen. We report a minimum count of 18 muskoxen during the aerial survey of Cornwallis and Little Cornwallis Island in May, 2002 and estimate 513 (95% CI 302 – 864) on Devon Island in April/May 2008.

For May 2004, we estimated 2,086 muskoxen (95% CI 1,582 – 2,746) on Prince of Wales Island and another 1,910 (95% CI 962 – 3,792) on Somerset Island. We estimated 456 (95% CI 312 – 670) on Southern Ellesmere in 2005, and observed 40

emaciated muskox carcasses during the survey. The estimated abundance of muskoxen on Northern Ellesmere was 8,115 (95% CI 6,632 – 9,930) for May 2006, and we noted high concentration of muskoxen with newborn calves on the Fosheim Peninsula. On Axel Heiberg Island in April 2007, we estimated 4,237 (95% CI 3,371 – 5,325) muskoxen and noted high concentrations east of the Princess Margaret Range. In contrast, due to the low occurrence of muskoxen on Amund Ringnes, Ellef Ringnes, King Christen, Cornwall, Meighen, and Lougheed islands we report a combined minimum count of 21 muskoxen for those islands.

***Key Words*:** Peary caribou, Muskoxen, Aerial Survey, Ground Survey, Nunavut, Distance Sampling, *Rangifer tarandus pearyi, Ovibos moschatus*

ᖃᓄᐃᓐᓇᓱᒋᔭᐅᓂᖓ

ᓄᑖᙳᖅᑎᓯᒪᑦᔪᑦ ᑐᑭᓯᒋᐊᕈᑎᒃᓴᑦ ᖃᑯᖅᑕᑯᓗᐃᑦ ᑐᒃᑐᑦ ᓇᓃᓐᓂᖏᑦ ᐅᓄᕐᓂᖏᓪᓗ ᓄᓇᕗᒻᒥᑦ ᖁᑦᓯᒃᑐᕐᒥᑦ ᕿᑭᖅᑕᖏᓐᓂᑦ ᓇᓚᐅᑦᓵᖅᓯᒪᔪᑦ ᕿᑭᖅᑕᐅᔪᓂᑦ ᑲᑎᓪᓗᒋᑦ ᐃᒻᒪᖔ 4,000 (10-ᓂᒃ ᑕᖅᕿᖃᖅᑐᑦ ᐅᖓᑖᓂᓘᓐᓃᑦ) ᐊᔾᔨᒌᙱᓂᖃᖅᓗᑎᒃ ᐅᓄᕐᓂᖏᑦ ᕿᑭᑦᑕᓂᒃ ᐊᔾᔨᒌᙱᑐᓂᒃ. ᑲᑎᓪᓗᒋᑦ ᐅᓄᕐᓂᖏᑦ ᐅᒥᖕᒪᐃᑦ ᓇᓚᐅᑦᓵᖅᑕᐅᓯᒪᔪᖅ 17,500 (ᐅᑭᐅᖃᖅᑐᑦ 1 ᐅᖓᑖᓂᓘᓐᓃᑦ). ᓇᓚᐅᑦᓵᖅᑕᐅᓯᒪᔪᑦ ᐊᑐᖅᑐᑦ ᐊᑕᐅᓯᐅᙱᑦᑐᕐᒥᒃ ᐅᑭᐅᓂᒃ ᖃᐅᔨᓴᕐᓂᐅᓯᒪᔪᓂᒃ ᐋᕐᕿᒃᓱᖅᑕᐅᓯᒪᔪᑦ ᑲᒪᒋᔭᖃᕐᓂᐊᕐᓗᑎᒃ ᑐᑭᓯᒋᐊᕈᑎᒃᓴᖃᙱᓂᐅᔪᓂᒃ ᑕᐃᒃᑯᐊ ᑭᖑᓪᓖᑦ ᑐᑭᓯᒋᐊᕈᑎᒃᓴᐅᓚᐅᖅᑐᑦ ᓄᑕᐅᙱᑎᒋᓚᐅᕐᒪᑖ 50 ᐅᑭᐅᓄᑦ ᑎᑭᓪᓗᒍ. ᑐᑭᓯᒋᐊᕈᑎᒃᓴᑦ ᑕᒡᕙᙵᑦ ᖃᐅᔨᓴᕐᓂᐅᔪᒥᒃ ᐃᑲᔪᖅᑐᐃᔪᖅ ᐱᕙᓪᓕᐊᓂᖏᓐᓂᒃ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖏᓐᓂᒃ – ᐊᒻᒪ ᖃᐅᔨᓴᕐᓂᓕᕆᓂᕐᒨᓕᖓᔪᓂᒃ ᐊᐅᓚᑦᓯᓂᕐᒧᒃ ᖃᐅᔨᓴᕐᓂᕐᒧᓪᓗ ᐸᕐᓇᐅᑎᓂᒃ. ᐃᑲᔪᖅᑐᐃᖕᒥᔪᖅ ᐅᑎᖅᐸᓪᓕᐊᓂᕐᒧᑦ ᐸᕐᓇᖕᓂᕐᒧᑦ ᐱᔭᕆᐊᖃᖅᑑᒐᒥ ᑕᒡᕙᓂ 2011-ᒥᑦ ᐃᓚᒋᐊᕐᓂᐅᔪᒥᒃ ᖃᑯᖅᑕᑯᓗᐃᑦ ᑐᒃᑐᓂᒃ ᐃᑖᒃᑯᑦ 1-ᒧᑦ ᒐᕙᒪᑐᖃᒃᑯᑦ ᐆᒪᔪᐃᑦ ᐅᓗᕆᐊᓇᖅᑐᒦᑦᑐᑦ ᒪᓕᒐᖅᔪᐊᕐᒥᑦ ᒪᓕᒃᓗᑎᒃ 2004-ᒥᑦ ᑲᓇᑕᓕᒫᒧᑦ ᖃᐅᔨᓴᕈᑕᐅᓚᐅᖅᑐᕐᒥᒃ ᐅᓗᕆᐊᓇᖅᑐᒦᓯᒋᔭᐅᓪᓗᑎᒃ.

ᐅᓄᕐᓂᖏᓐᓂᒃ ᓇᓚᐅᑦᓵᕐᓂᐅᔪᑦ ᒪᓕᓗᐊᖅᑐᑦ ᐊᑯᑦᑐᖅᑕᐅᓯᒪᓪᓗᑎᒃ ᓄᓇᑦ ᐅᖓᓯᖕᓂᖏᑎᒎᑦ ᖃᐅᔨᓴᕈᑎᖃᖅᓗᑎᒃ ᐋᕐᕿᒃᑕᐅᓯᒪᔪᑦ ᑕᒻᒪᙱᓐᓂᖅᓴᐅᓂᕐᒥᒃ ᓈᓴᕐᓂᐅᔪᕐᒥᒃ. ᓈᓴᕐᓂᐅᔫᒃᑯᑦ ᓇᓚᐅᑦᓵᖅᑕᐅᓯᒪᔪᑦ ᐃᓚᖅᑲᓚᐅᖅᑐᑦ ᑐᒃᑐᓂᒃ (10-ᓂᒃ ᑕᖅᕿᖃᖅᑐᑦ ᐅᖓᑖᓕᓘᓐᓃᑦ) ᓈᓴᕐᓂᐅᓚᐅᖅᑐᑦ ᑕᒪᐃᓐᓂᑲᓴᒃ ᑲᔪᓯᓚᐅᕐᒪᑕ ᓄᕐᓇᐊᓚᐅᖅᑎᓐᓇᒋᑦ (ᐄᐳᕈ-ᒪᐃ). ᓇᓴᓚᐅᖅᑐᒍᑦ ᕿᑭᖅᑕᕐᓂᑦ ᑲᑎᓯᒪᓂᐅᓪᓗᑎᒃ ᕿᑭᖅᑕᐅᔪᑦ ᐊᑯᓐᓂᖓᓐᓂᑦ 2001 ᐊᒻᒪ 2008. ᓇᓚᐅᑦᓵᖅᑐᒍᑦ 187 ᑐᒃᑐᑦ (95% *CI* 104-300 ᑐᒃᑐᑦ) ᑐᒃᑐᓯᐅᕐᕕᖕᒥᑦ ᒪᐃ, 2001-ᒥᑦ ᐊᒥᓱᙳᕐᓂᐅᓪᓗᓂ ᑕᒪᙵᑦ ᑐᖁᒐᕐᓂᐅᓚᐅᖅᓯᒪᔪᒥᒃ 1990-ᖏᓐᓂᑦ. ᑕᑯᔭᐅᑦᑕᕐᓂᐅᔪᑦ 2010-ᒥᑦ ᐃᓱᒪᒋᔭᐅᓚᖅᑐᖅ ᖃᑯᖅᑕᑯᓗᐃᑦ ᑐᒃᑐᑦ ᑐᒃᑐᓯᐅᕐᕕᖕᒥᑦ ᑲᔪᓯᖕᒪᑦ. ᑕᑯᓚᐅᖅᑐᑦ ᐊᑕᐅᓯᑐᐊᕐᒥᒃ ᐊᕐᓇᓪᓗᕐᒥᒃ ᑐᒃᑐᒥᒃ ᖃᖓᑕᔫᒃᑯᑦ ᓈᓴᕐᓂᖃᖅᑎᓪᓗᒋᑦ ᒪᕐᕈᓕᖅᑭᒥᑦ (*Cornwallis Island* ᐊᒻᒪ *Little Cornwallis Island*) ᒪᐃ, 2002-ᒥᑦ ᐊᒻᒪᓗ ᑕᓪᓗᕈᑎᒥᑦ ᐄᐳᕈ/ᒪᐃ 2008-ᒥᑦ, ᓈᓴᓚᐅᖅᑐᒍᑦ 17-ᓂᒃ ᑐᒃᑐᓂᒃ ᖃᖓᑕᓚᐅᖅᓱᑕ 7,985 ᑭᓛᒥᑕᓂᒃ.

ᒪᐃ 2004-ᒥᑦ, ᑕᑯᙱᓚᐅᖅᑐᒍᑦ ᖃᑯᖅᑕᑯᓗᐃᑦ ᑐᒃᑐᓂᒃ ᑭᙵᐃᓚᕐᒥᑦ ᐊᒻᒪ ᑰᕐᖓᓇᔫᑉ ᓄᓇᖓᓂᑦ ᑐᑭᓯᔾᔪᑕᐅᓪᓗᓂ ᑕᒪᓐᓇ ᐅᑎᖅᐸᓪᓕᐊᙱᓂᖏᓐᓂᒃ ᑕᐃᒪᙵᑦ ᐅᓄᕈᖕᓇᐃᒻᒪᕆᖕᓂᐅᓚᐅᖅᑐᕐᒥᒃ ᐊᑯᓐᓂᖓᓐᓂᑦ 1980 ᐊᒻᒪ 1995. ᑕᑯᓂᐅᓚᐅᖅᑐᖅ ᐃᒻᒪᖄ ᐊᑕᐅᓯᑐᐊᕐᒥᒃ ᖃᑯᖅᑕᑯᓗᒃ ᑐᒃᑐᒥᒃ ᐆᑎᐊᒥᑦ (*Boothia Peninsula*) ᐅᒥᖕᒪᖕᓂᒃ ᓈᓴᕐᓂᖅᑲᖅᑎᓪᓗᓂ 2006-ᒥᑦ (*M. Dumond*, ᓇᖕᒥᖕᓂᖅ ᑐᓴᖅᑎᓐᓂᓇᓚᐅᖅᑕᖓ) ᐱᒻᒪᕆᐅᓕᖅᑎᑦᓯᔪᖅ ᑐᒃᑐᓂᒃ ᖃᐅᔨᓴᕆᐊᖅᑲᕐᓂᐅᔪᙳᒃ ᑕᐃᑲᓂ.

ᑲᑎᓪᓗᒋᑦ ᓇᓚᐅᑦᔮᕐᓂᐅᔪᑦ ᑐᒃᑐᑦ ᐅᓄᕐᓂᖏᓐᓂᒃ ᐊᐅᔪᐃᑦᑐᕐᒥᐅᑦ ᕿᑭᖅᑕᖓᓂᒃ (ᐃᓚᒋᓪᓗᒍ ᒍᕌᒻ ᕿᑭᖅᑕᖅ *Graham Island*) 1,021 ᑐᒃᑐᑦ ᒪᓕᒃᑯᒋᑦ ᓈᓴᕐᓂᐅᓯᒪᔪᑦ ᐊᐅᔪᐃᑦᑐᕐᒥᐅᑦ ᕿᑭᖅᑕᖓᓂ ᓂᒋᖓᓂᒃ (219 ᑐᒃᑐᑦ 95% *CI* 109-442 ᑐᒃᑐᑦ) ᒪᐃ, 2005-ᒥᑦ, ᐊᒻᒪ ᐊᐅᔪᐃᑦᑐᕐᒥᐅᑦ ᕿᑭᖅᑕᖓᓂ ᐅᐊᖕᓇᖓᓂ (802 ᑐᒃᑐᑦ 95% *CI* 531 -1207 ᑐᒃᑐᑦ) ᒪᐃ, 2006-ᒥᑦ. ᐅᒥᖕᒪᑦ ᓄᓈᓂᑦ (*Axel Heiberg Island*) ᐄᐳᕈ 2007-ᒥᑦ, ᓇᓚᐅᑦᔮᓚᐅᖅᑐᒍᑦ 2,291 (95% *CI* 1,636 – 3,208). ᑐᒃᑐᖅᑲᕋᔪᙱᓗᐊᕐᓂᖏᓐᓂᒃ ᑖᒃᑯᐊ ᕿᑭᖅᑕᐅᔪᓂᒃ *Amund Ringnes, Ellef Ringnes, King Christen, Cornwall,* ᐊᒻᒪ *Meighen*, ᓇᓚᐅᑦᔮᖅᓯᒪᔪᒍᑦ ᑲᑎᓪᓗᒋᑦ ᐅᓄᕐᓂᖏᑦ ᖃᑯᖅᑕᑯᓗᐃᑦ ᑐᒃᑐᑦ 282-ᖑᔪᑦ (95% *CI* 157 – 505) ᑖᒃᑯᓇᓂ ᕿᑭᖅᑕᓂᑦ. ᓛᕼᐄᑦ ᕿᑭᖅᑕᕐᒥᑦ (*Lougheed Island*) 32 ᑲᑎᓯᒪᓂᐅᔪᑦ ᑐᒃᑐᑦ ᑕᑯᔭᐅᓚᐅᖅᑐᑦ ᓇᓚᐅᑦᔮᕈᑕᐅᓕᖅᑯᑎᒃ ᐃᒻᒪᖄ 262 ᑐᒃᑐᑦ/1,000 ᑭᓛᒥᑕᑦ ᐃᖅᑐᐊᖅᑐᑦ.

ᐅᒥᖕᒪᐃᑦᓕ, ᓈᓴᕐᓂᐅᓯᒪᔫᒃᑯᑦ ᓇᓚᐅᑦᔮᕐᓂᐅᓚᐅᖅᑐᑦ ᐅᑭᐅᖅᑲᖅᑐᓂᒃ 1 ᐅᖓᑖᓂᔫᓐᓃᑦ, ᓈᓴᕐᓂᕐᑲᓚᐅᕐᒪᑦ ᐊᑕᐅᑦᓯᒃᑯᑦ ᓄᕐᓇᐊᕐᓂᕐᑲᖅᑎᓪᓗᒋᑦ (ᐄᐳᕈ-ᒪᐃ). ᑲᑎᓪᓗᒋᑦ 12,683 ᐅᒥᖕᒪᐃᑦ ᓈᓴᖅᑕᐅᓚᐅᖅᑐᑦ ᓈᓴᕐᕕᓕᒫᒥᑦ, ᐃᓚᒋᓪᓗᒋᑦ 1,492 ᐃᓅᓕᓵᑦ ᓄᕐᕋᐃᑦ. ᒪᐃ, 2001-ᒥᑦ ᑕᑯᓚᐅᖅᑐᒍᑦ 7-ᓂᒃ ᑲᑎᓯᒪᓂᐅᔪᓂᒃ ᐅᒥᖕᒪᖕᓂᒃ ᑐᒃᑐᓯᐅᕐᕕᖕᒥᑦ ᐊᓪᓕᖅᐹᒥᒃ ᓈᓴᕐᓂᖅᑯᓂ 82 ᐅᒥᖕᒪᐃᑦ. ᐅᓂᒃᑳᖅᓯᒪᔪᒍᑦ ᐊᓪᓕᖅᐹᒥᒃ 18 ᐅᒥᖕᒪᐃᑦ ᖃᖕᖓᑕᓰᒃᑯᑦ ᓈᓴᕐᓂᖅᑲᖅᑎᓪᓗᑕ *Cornwallis* ᐊᒻᒪ *Little Cornwallis Island*-ᒥᑦ ᒪᐃ, 2002-ᒥᑦ ᐊᒻᒪ ᓇᓚᐅᑦᔮᖅᑯᑕ 513-ᓂᒃ (95% *CI* 302 – 864) ᑕᓪᓗᕈᑎᒥᑦ ᐄᐳᕈ/ᒪᐃ 2008-ᒥᑦ.

ᒪᐃ 2004-ᒧᑦ, ᓇᓚᐅᑦᔭᓚᐅᖅᑐᒍᑦ 2,086 ᐅᒥᖕᒪᕐᑲᖅᑯᓂ (95% *CI* 1,582 – 2,746) ᑭᙵᐃᓚᕐᒥᑦ ᐊᒻᒪᓗᒃᑲᓐᓂᖅ 1,910 (95% *CI* 962 – 3,792) ᑰᕐᖓᓇᔫᑉ ᓄᓇᖓᓂ. ᓇᓚᐅᑦᔭᓚᐅᖅᑐᒍᑦ 456-ᓂᒃ (95% *CI* 312 – 670) ᐊᐅᔪᐃᑦᑐᕐᒥᐅᑦ ᕿᑭᖅᑕᖓᓂ ᓂᒋᖓᓂ 2005-ᒥᑦ, ᐊᒻᒪ ᑕᑯᓪᓗᑕ 40-ᓂᒃ ᑐᖅᑲᖓᔪᓂᒃ ᐅᒥᖕᒪᕐᓂᒃ

ᓈᓴᕐᓂᕐᑲᕐᑎᓪᓗᑕ. ᓇᓚᐅᓪᓛᕐᑕᐅᓯᒪᔪᑦ ᐅᒥᖕᒪᐃᑦ ᐅᓄᕐᓂᖕᒋᑦ ᐊᐅᓱᐃᑦᑐᕐᒥᐅᑦ ᕿᑭᕐᑕᖕᒐᓂ ᐅᐊᖕᓇᖕᒐᓂ 8,115-ᖕᑑᓚᐅᕐᑐᑦ (95% *CI* 6,632 – 9,930) ᒪᐃ 2006-ᒧᑦ, ᐅᔾᔨᕆᔭᕐᑲᕐᓘᑕᓗ ᐅᓄᕐᓂᖕᒋᑦᑕ ᑲᑎᓯᒪᔪᑦ ᐅᒥᖕᒪᐃᑦ ᓄᕐᕋᕐᑲᕐᑐᑦ ᕗᓴᐃᒻᒥᑦ (*Fosheim Peninsula*). ᐅᒥᖕᒪᑦ ᓄᓈᑦᓂ ᐄᐳᕆ 2007-ᒥᑦ, ᓇᓚᐅᓪᓵᓚᐅᕐᑐᒍᑦ 4,237-ᓂᒃ (95% *CI* 3,371 – 5,325) ᐅᒥᖕᒪᖕᓂᒃ ᐅᔾᔨᕆᔭᕐᑲᕐᓘᑕᓗ ᐅᓄᕐᑐᓂᒃ ᑲᑎᓯᒪᔪᓂᒃ ᐳᕆᓐᓯᐊᓯ ᒫᑯᐃ ᐃᓂᕐᑲᕐᕕᖕᒥᑦ (*Princess Margaret*). ᐅᒥᖕᒪᒃᑕᕐᑲᓗᐊᖖᒋᓂᖕᒋᓐᓂᒃ ᕿᑭᕐᑕᓂᒃ *Amund Ringnes, Ellef Ringnes, King Christen, Cornwall, Meighen,* ᐊᒻᒪ *Lougheed* ᐅᓂᒃᑳᓚᐅᕐᑐᒍᑦ ᑲᑎᓪᓗᒋᑦ ᐊᓪᓚᕐᕚᒥᒃ ᓈᓴᕐᑕᐅᓂᖕᒋᓐᓂᒃ 21 ᐅᒥᖕᒪᐃᑦ ᑕᐃᒃᑯᓄᖕᒐ ᕿᑭᕐᑕᓄᑦ.

ᓇᓗᓇᐃᔾᑎᑦ ᑕᐃᔾᔨᑦ: ᕐᑲᕐᑯᕐᑕᑯᓗᐃᑦ ᑐᒃᑐᑦ, ᐅᒥᖕᒪᑦ, ᕐᑲᖕᒐᑕᓲᒃᑯᑦ ᓈᓴᕐᓂᕐᒃ, ᓄᓇᒃᑯᑦ ᓈᓴᕐᓂᕐᒃ, ᓄᓇᕗᑦ, ᐅᖕᒐᓯᖕᓂᒃᑯᑦ ᐆᒃᑐᕋᕆᑎᕐᑲᕐᓂᕐᒃ, *Rangifer tarandus pearyi, Ovibos moschatus*

ACKNOWLEDGEMENTS

Funding for this study was provided by the Department of Environment, Polar Continental Shelf Project, the Nunavut Wildlife Management Board, and the Habitat Stewardship Program. We are grateful to Mike Ferguson, who initiated this research project and designed and lead the first 5 years of the study. We thank him for comments on an early draft of this report. We are grateful to the Resolute Bay and Grise Fiord HTAs for on-going support and participation. Special thanks to Nancy Amarualik and the late Letia Noah for their assistance with logistics and local coordination. We are grateful to Mike Ferguson, the late Seeglook Akeeagok, Jeffrey Qaunaq, and Tabitha Mullin, for leading ground surveys from 2000 – 2006, and members of the ground crews, including: Tony Romito, Aleesuk Idlout, Peter Amarualik, Rodger Alluviniq, Joadamee Iqaluk, Norman Idlout, Samson Simeonie, Micheal Pudluk, Ross Pudluk, Steven Nungaq, Clyde Kalluk, Ely Allakarialuk, Hans Aronsen, Saroomie Manik, Enookie Idlout, Joadamee Iqaluk, Samson Simeonie, Steven Akeeagok, Ross Pudluk, Katsak Manik, Terrance Nungaq, Sam Idlout, Jeff Amarualik, Steven Amarualik, Peter Jr. Amarualik, Aron Qaunaq, David Watsko, Pauloosie Killiktee, Randy Pijamini, Mosha Kiguktak, Benjamin Akeeagok, Randy Pijamini, Jimmy Nungaq, and Patrick Audlaluk.

Aerial survey programs were lead by Mike Ferguson, Mitch Campbell and Debbie Jenkins. A special thanks to wildlife observers including Matthew Manik, Babah Kalluk, Samson Idlout, Joadamee Amagoalik, Martha Allakariallak, Mark Amaraulik, Lymieky Pijamini, Mosha Kiguktak, Jaypeetee Akeeagok, Tom Kiguktak, Seeglook Akeeagok, Jeffrey Qaunaq, Louis Jenvenne, Aron Qaunaq, Gary Mouland, Jason Hudson, Doug Stem, Jeffrey Amaraulik, and Peter Jr. Amaraulik. For the full list of aerial and ground survey participants, by year, see Appendix 1, Table A.

A very special thanks to our helicopter pilots, particularly John Innis, for his expertise and long term dedication to our Arctic research program. Thanks to the many mechanical engineers that kept us flying. This project benefited from the expertise and support of Polar Continental Shelf Project, particularly, Mike Kristjanson, Tim McCagherty, Barry Hough, and Dave Maloley. Thanks also to Karen Thombs, Dianne Fatiaki, Debbie Clouthier, JoAnne Edwards, George Benoit, Wally Benoite, and Tim Norman for their hospitality, for assistance with field preparations, and for feeding us so well over the years. Twin Otter support was possible due to PCSP, Ken Borek, and a highly skilled group of pilots.

A special thanks to Milissa Elliott and Jay McConnell for GIS support and mapping. Thanks to Pat Curry, Anne Gunn, and Sharina Dodsworth for providing helpful comments and suggestion on an early draft, and to Anne Gunn and Kim Poole for assisting with our historical tables. A special thanks to Alex Millar, Mike Mifflin, Dee Karadag, and David McCann for their support and encouragement.

PREFACE:

Section 5 and 6 of this report do not necessary represent the views of co-author G. Hope.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

Peary caribou (*Rangifer tarandus pearyi*) are a distinct caribou subspecies that occurs almost entirely on islands within the Canadian Arctic Archipelago. These ungulates live the farthest north of all *Rangifer* in North America, and are the smallest in stature and in population size (Banfield, 1961). In February 2011, Peary caribou were listed as Endangered under the federal Species at Risk Act, due to declines in abundance and expected changes in long-term weather patterns (Canada Gazette Part II, Vol 145, No4, 2011-02-16). This action has trigged recovery planning and current information on population abundance and trends is required. However, because of their remote location, widespread distribution, and the general inaccessibility of their range, research has been limited and foundation information on the distribution and abundance of Peary caribou is lacking for some portions of their range. Through this report we hope to address some information deficiencies and assist in the planning effort.

Endemic to Canada, the terrestrial range of Peary caribou is roughly 540,000 km^2 and extends across the Queen Elizabeth Islands in the north, and east from Banks Island to Somerset and the Boothia Peninsula in the south (Figure 1). Ice surrounds the islands for most of the year and caribou on some islands use the sea ice during seasonal migrations (Miller 1990b; Miller *et al*., 2005a). Although the range is vast, the area is characterized by extreme weather (Maxwell, 1981), long periods of darkness and large expanses of bare ground, ice and rock (Gould *et. al.,* 2002). The landscape is treeless and environmental conditions, which include a short growing season, approach the physiological tolerance limits of plants (Edlund and Alt, 1989; Edlund *et al*., 1990; Gould *et al.,* 2002). Except for a few northerly islands, muskoxen (O*vibos moschatus*) occur in sympatry with Peary caribou (Figure 2) and in the last 50 years have expanded their range and recolonized areas previously unoccupied (Gunn and Dragon, 1998; Taylor 2005).

In contrast, muskoxen were extirpated from much of their southern range by the early 1900s causing the Canadian Government to implement controls on muskox hunting and trading in 1917 (Urquhart, 1982). In remote areas, muskoxen continued to be used for subsistence (Urquhart, 1982) and since 1969 Inuit of northern Canada have been permitted to hunt muskoxen under a quota system. In general, this species has been recovering and in the Northwest Territories muskoxen have been listed as Secure (Working Group of General Status of NWT Species, 2006). Internationally, muskoxen have been assessed as Low Risk Least Concern by the IUCN (IUCN 2010). On some Arctic islands however, muskoxen, like Peary caribou, have experienced significant declines due to severe weather events (Miller *et al*., 1977a; Miller 1998; Gunn and Dragon 2002).

In 1961, Tener (1963) completed the first and only comprehensive survey of both Peary caribou and muskoxen across the Queen Elizabeth Islands in a single season and estimated approximately 25,845 Peary caribou and 7421 muskoxen. The majority of caribou (approximately 94%) were located in the western Queen Elizabeth Islands (i.e. Bathurst Island Complex, Cornwallis, Melville, Prince Patrick, Eglinton, Emerald, Borden, Mackenzie King, Brock). A consequence of this finding was that subsequent surveys were focused in that area. The first population estimates for the southern Arctic islands included a 1972 estimate of 11,000 caribou on Banks Island (Urquhart, 1973); 4512 caribou in 1980 on northwestern Victoria Island (Jakimchuk and Carruthers,

Figure 1: Peary caribou range across the Canadian Arctic. Modified from COSEWIC (2004).

1980), 5515 caribou on Prince of Wales and Somerset Islands (Fisher and Duncan, 1976, values converted to all caribou in COSEWIC, 2004) and 561 caribou on the Boothia Peninsula in 1974 (Fisher and Duncan, 1976). Thus, when the first estimates of abundance on the southern Arctic Islands are combined with estimates from the QEI, it's possible that as many as 48,000 Peary caribou occupied the entire range historically (COSEWIC 2004).

For muskoxen, Tener (1963) estimated 7421 muskoxen on the Queen Elizabeth Islands in 1961, while an additional 3800 were estimated on Banks Island during the first systematic survey in 1971-72 (Urquhart, 1973). For Victoria Island, the population was estimated at 908 animals in 1958-59 (Macpherson, 1961) while systematic surveys in 1974-75 resulted in a total population estimate of 600 for Prince of Wales and located no muskoxen on Somerset Island or the Boothia Peninsula (Fisher and Duncan, 1976). These surveys suggest that approximately 12,700 muskoxen occurred in sympatry with Peary caribou in the early 1960-70s.

Between 1961 and 1974, subsequent aerial surveys for the western Queen Elizabeth Islands measured severe declines in both species (Miller et al., 1977) and in 1979, Peary caribou were assigned the status of Threatened by the Committee on the Status of Endangered Wildlife in Canada (Gunn *et al.,* 1981; COSEWIC, 2004). Peary caribou on Banks Island and the High Arctic islands (i.e. the Queen Elizabeth Islands) were re-assessed as Endangered in 1991 and Peary caribou in the lower Arctic stayed as Threatened (Miller, 1990a). In May 2004, the entire subspecies *pearyi* was reassessed as Endangered (COSEWIC) due to continued declines and expected changes in long-term weather patterns. The Endangered status triggered extensive

Figure 2: Muskox range across the Canadian Arctic Archipelago. Modified from Urquhart (1982).

consultations after which the Governor General in Council, in February 2011, amended Schedule 1 of the Species at Risk Act, to include Peary caribou as Endangered (Canada Gazette Part II, Vol 145, No4, 2011-02-16).

The decline of Peary caribou is characterized by four major die-offs which were observed primarily in the western Queen Elizabeth Islands between 1970 and 1998, and involved the synchronous crash of muskoxen (Miller *et al*., 1977a; Miller, 1998; Miller and Gunn, 2001; Gunn and Dragon, 2002; Miller and Gunn, 2003b). Die-off events have been associated with deep snow and icing, which can limit access to forage, increase energy requirements and lead to extreme under-nutrition and death (Parker *et al*., 1975; Miller *et al.,* 1977a; Gunn *et al*., 1981; Parker *et al*., 1984; Miller, 1990a; Miller, 1998; Miller and Gunn, 2003b; COSEWIC, 2004; Miller and Barry, 2009). Observations by local Inuit are in agreement, reporting up to 2 inches of ice in some years (Taylor, 2005; Jenkins *et al.,* 2010a. 2010b).

Fragmented data shows that periods of decline and recovery vary among island populations, and that factors such as anthropogenic activities and landscape changes, predation, hunting and competition may also contribute to the fluctuation of caribou and muskox populations (Riewe, 1973; Miller, Gunn and Dragon 1998, Gunn *et al*., 2000; Miller and Gunn, 2001, Gunn and Dragon, 2002, Jenkins *et* al., 2010a). Inuit in Resolute Bay (Cornwallis Island) and Grise Fiord (Ellesmere Island) have identified exploration activities (i.e., oil and gas, coal and base minerals) as an additional stressor for caribou during some winters (Jenkins *et al.,* 2010a, Jenkins *et al.,* 2010b). They suggest that, during years of high snow accumulation, industrial activities can and have inhibited caribou from moving into areas that were vital for their survival (Jenkins *et al.,* 2010a, Jenkins et al., 2010b). Tews *et al*. (2007a) argued that density-dependent mechanisms may also be important but agreed with other authors that major fluctuations in Peary caribou abundance are likely driven mainly by unpredictable environmental perturbations. Finally, it is recognized that hunting and predation could dampen recovery and exacerbate Peary caribou declines, particularly when populations are small and vulnerable to extinction (Gunn and Decker, 1984; Miller, 1990a; Gunn and Ashevak, 1990; Gunn and Dragon, 2002). The effect of predation on population size is currently unknown (Miller, 1990a; Gunn and Dragon, 2002) and detailed records of caribou harvest (i.e., number harvested, location, date) are not available for most areas. Uncertainties for the future include the potential negative impacts of climate change, (Post and Stenseth, 1999; Miller *et al*., 2005; Tews *et al.,.* 2007a; Tews *et al.,* 2007b; Miller and Barry, 2009), industrial exploration, development, and shipping (Vors and Boyce, 2009; Poole *et al.,* 2010).

Climate induced changes are expected to be the most severe in the Arctic (Maxwell 1997; Anisimov *et al*. 2007, Prowse *et al.* 2009). For example, it is predicted that surface air temperatures will increase in the Arctic at twice the global rate (McBean *et al*. 2005, Anisimov *et al* 2007) and average seasonal precipitation will increase significantly across all seasons (Rinke and Dethloff 2008). Some associated changes include reduced sea ice cover, shifts in the temporal and spatial distribution and composition of vegetation, increased snow cover, and the increased frequency of icing events (Post and Stenseth 1999, Anisimov *et al*. 2007, Post et al. 2008, Rinke and Dethloff 2008, Vors and Boyce 2009). Notably, both the severity and frequency of extreme winter events is expected (ACIA 2005, Tews *et al*. 2007b).

Nunavummiut are concerned about the conservation of Peary caribou and their habitat (Jenkins *et al*., 2010a; Jenkins *et al*., 2010b). Caribou are of major cultural, traditional and economic importance to Inuit, they are a vital part of the Arctic ecosystem and a valued food source (Ferguson and Messier*,* 1997; Miller and Gunn, 2001; Taylor, 2005). In Nunavut, Peary caribou harvest has not been restricted through legislation. Instead, from 1975 to ca. 1989, the Resolute Bay Hunters and Trappers Association (HTA) imposed voluntary harvest restrictions for caribou on the Bathurst Island Complex (Miller, 1990; DoE 2005). This action was triggered by a decline in caribou during the winter of 1973-1974 (Miller, 1990; DoE, 2005a; Nancy Amarualik, personal communication, Sept 2010). The Iviq HTA of Grise Fiord also imposed a 10-year prohibition on Peary caribou harvest (1986-1996) on southern Ellesmere Island due to scarcity of animals in the 1980s (DoE 2005b). However, Inuit knowledge is that conflicting land-use activities (such as mineral exploration) pose a greater potential threat to Peary caribou and their habitat than hunting (Jenkins *et al.,* 2010b).

Ultimately, the Department of Environment (DoE) of the Government of Nunavut (GN) is responsible for the management and conservation of caribou and muskoxen within its jurisdiction. This responsibility is outlined in the Nunavut Land Claim Agreement 1993, Article 5 (Indian and Northern Affairs Canada, 1993). However, for many populations of Peary caribou and muskoxen in Nunavut, estimates of abundance have not been recorded since 1961. Other populations have been surveyed infrequently and information about them is highly fragmented (Miller, 1990a; Miller and Gunn, 2003b). This has created significant knowledge gaps, which poses challenges for wildlife management decision-making.

Due to the fact that populations can change drastically and quickly, lengthy delays between surveys are risky. For example, the Peary caribou on Prince of Wales and Somerset Islands were not surveyed during a 15-year period. It was found that the numbers had declined from about 6000 in 1980 to just a few caribou by 1995 (Gunn and Dragon, 1998). To assess whether the caribou had recovered from such low numbers, these islands were part of our survey program in 2004.

The north central and eastern Queen Elizabeth Islands have not been surveyed since 1961 (i.e., Ellef Ringnes, Amund Ringnes, Axel Heiberg) and only a small number of partial aerial surveys of Ellesmere Island have been completed (Riewe, 1973; Case and Ellsworth, 1991; Gauthier, 1996). Part of the delay was uncertainty about the most efficient and effective approach for an aerial survey in this mountainous and glaciate region. This challenge was discussed at a workshop held in Grise Fiord in 1997, when Inuit hunters and biologists examined survey techniques and explored the idea of combined ground and aerial surveys (DoE, GN unpublished).

Bathurst Island Complex has been re-surveyed relatively frequently and by the early 1990s, the surveys revealed that Peary caribou and muskoxen on Bathurst and its neighbouring islands had returned to levels that Tener (1963) reported for 1961 (Miller, 1997a). However, during three consecutive severe winters marked by icing and deeper snow (1994-95; 1995-96; 1996-97), Peary caribou and muskox abundance dropped and Peary caribou numbered less than 100 by 1997 (Miller, 1997a; Gunn and Dragon, 2002). Subsequent to 1997, there was a need to determine if Peary caribou numbers were recovering on Bathurst and its neighboring islands as the population is particularly important for Inuit from Resolute Bay.

The gaps in information and the need for Nunavummiut to have updated information on the status and recovery of Peary caribou and muskoxen led to a large scale survey program during April and May, 2001 through 2008. In this report, we present the results from the multi-year systematic line transect aerial survey and non-systematic ground survey of Peary caribou and muskoxen across the Canadian Arctic Archipelago in Nunavut. Specifically, we describe population abundance, distribution and productivity estimates for both ungulates across their range in Nunavut (except Melville Island and Boothia Peninsula). This report updates and replaces the previous work of McLoughlin *et al*., (2006).

2.0 METHODS

2.1 POPULATIONS

2.1.1 <u>Peary Caribou</u>

At the subspecies level, Peary caribou vary in relative skeletal size through north-south and east-west gradients (Manning 1960; Thomas *et al*., 1976, 1977; Thomas and Everson, 1982). This diversity has been attributed to the geographic and environmental variation (i.e. climate) that characterizes the Canadian Arctic Archipelago. Peary caribou are smaller and have a lighter-coloured pelage than other caribou subspecies, and they tend to occur in small herds of three to five animals although group size varies seasonally and tends to be greater later in summer (Miller *et al*., 1977). Owing to their low density, small group size, and extensive spatial distribution across islands, these caribou are generally referred to at the scale of 'populations' and not herds (Zittlau 2004).

Peary caribou are usually described as geographic (island) populations, defined by island or island complex boundaries (Gunn *et al*., 1997; Zittlau 2004). Grouping islands is necessary as some Peary caribou are known to make seasonal movements between islands (Miller *et al*., 1977b; Miller 1990b; Miller, 1995a; Miller, 2002; Miller and Barry, 2003; Miller et al. 2005a; Taylor 2005; Jenkins in prep.). We grouped the islands based on the literature (Tener, 1963; Gauthier, 1996; Gunn and Fournier, 2000; Gunn and Dragon, 2002; Miller and Gunn, 2003a; Zittlau, 2004; Miller *et al,*. 2005b; Taylor 2005; Gunn *et al,*. 2006, Miller and Barry 2009; Jenkins in prep) and refer to each population by the ‘Island Group’ name (Table 1, Figure 3). Each Island Group is comprised of multiple islands, which are detailed in Table A, Appendix 1. The level of information used to define each ‘Island Group’ varied, and in Table 1, we identify the ‘Island Groups’ within corresponding larger scale eco-units, metapopulations and conservation units (Miller, 1990a; Gunn *et al.,* 1997; Zittlau, 2004; Miller *et al.,* 2005b; Miller and Barry, 2009).

Melville Island and Boothia Peninsula were excluded from this study.

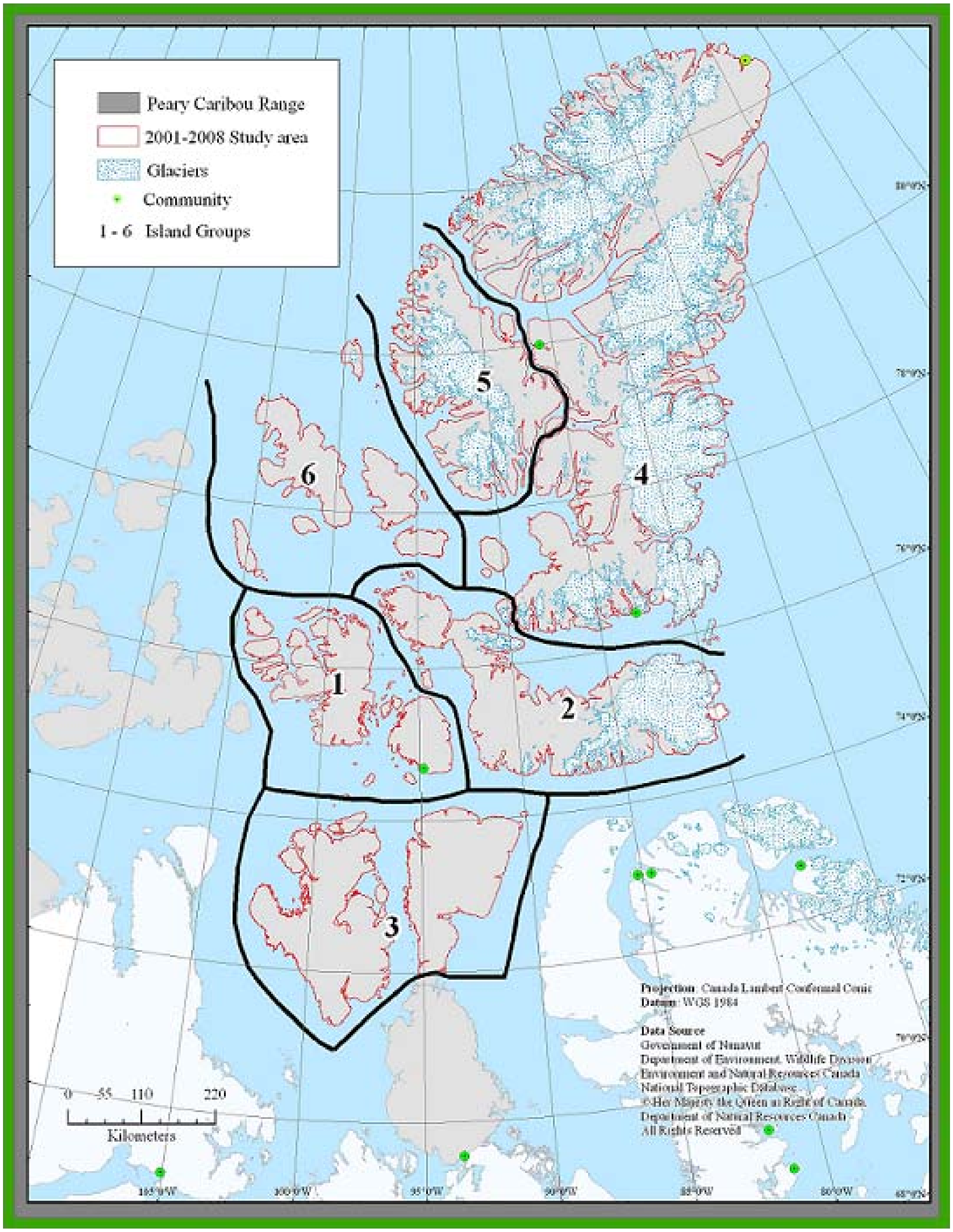


Figure 3: Organization of survey area into Island Groups; 1) Bathurst Island Group, 2) Devon Island Group, 3) Prince of Wales/Somerset Island Group, 4) Ellesmere Island Group, 5) Axel Heiberg Island Group, 6) Ringnes Island Group

Table 1: Peary caribou Island Groups in the Arctic Archipelago, Canada. Island Groups highlighted in blue, occur in Nunavut and were included in this study. Areas that occur (primarily) in the Northwest Territories are highlighted in gray.

		Organization as Applied to this Study		
Metapopulation (Conservation Unit)	**Ecounits**	**Island Group**	**Survey Area (SA)**	**Survey Year**
Western Queen Elizabeth Islands	South-central	The Bathurst Island Group	Bathurst Island Complex	2001
			Cornwallis/Little Cornwallis	2002
	Southwestern	Melville Island Group	n/a	n/a
	Northwestern	Prime Minister Island Group	n/a	n/a
Eastern Queen Elizabeth Islands	Eastern	Ellesmere Island Group	S. Ellesmere	2005
			N. Ellesmere	2006
		Axel Heiberg Island Group	Axel Heiberg	2007
		Devon Island Group	Devon	2008
			North Kent	2008
			Baillie Hamilton	2008
			Dundas/Margaret	2008
	North-central	Ringnes Island Group	Ellef Ringnes	2007
			Amund Ringnes	2007
			Cornwall	2007
			King Christian	2007
			Meighen	2007
			Lougheed	2007
Prince of Wales and Somerset Island Complex (includes Boothia)	n/a	Prince of Wales/Somerset Island Group	Prince of Wales (incl. Russell)	2004
			Somerset	2004
Boothia Peninsula	n/a	n/a	n/a	n/a
Banks Island - Northwestern Victoria Island	n/a	n/a	n/a	n/a
References		**References**		
Gunn *et al.* , 1997; Zittlau, 2004; COSEWIC, 2004	Miller, 1990a; Miller *et al.*, 2005b; Miller and Barry, 2009	Miller et al., 1977b; Miller 1990b; Gauthier, 1996; Gunn and Fournier, 2000; Miller 2002, Gunn and Dragon, 2002; Miller and Gunn, 2003b; Zittlau, 2004; Taylor, 2005; Miller et al. 2005a; Miller and Barry, 2009; Jenkins in prep.		

2.1.2 Muskoxen

We used the same Island Groups for muskoxen as we used for Peary caribou.

2.2 STUDY AREA

The Arctic Islands of Nunavut and the Northwest Territories, and the Boothia Peninsula (Nunavut), are the principle range of Peary caribou. The area lies within the Arctic Cordillera and Northern Arctic Ecozones of Canada, which are characterized by a severe climate, shallow soils, sparse dwarfed plant growth, and large areas of permanent ice or exposed bedrock (i.e., Edlund and Alt, 1989; Edlund, 1990; Natural Resources Canada, 2007). Our study area encompassed 25 major islands (area $\geq$ 200 km^2), 40 minor islands (area <200 km^2), and numerous smaller unnamed islands with a collective island landmass of approximately 407,599 km^2 (Figure 3; Table A, Appendix 1). The majority of these islands are uninhabited by humans. There are only two residential communities within the study area: Resolute Bay (74°41’51’’N, 094°49’56’’W) on Cornwallis Island and Grise Fiord (76°25’03’’N, 082°53’38’’W) on the southern coast of Ellesmere Island. The settlement of Alert is situated on the north coast of Ellesmere Island (82°30’05’’N, 062°20’20’’W) and functions as both a base for the Canadian Forces and an Environment Canada weather station (National Defence 2010). Eureka, located on the west central coast of Ellesmere Island (79°58’59’’N 85°56’59’’W), serves as a permanent research center and the site of an Environment Canada Weather Station (Environment Canada 2011).

The Bathurst Island Group --. This group of islands includes the Bathurst Island Complex (BIC), surveyed in 2001 and Cornwallis/Little Cornwallis Islands surveyed in 2002. The BIC (19,644 km^2) includes Bathurst Island and four major satellite islands (> 200 km^2; Cameron, Vanier, Alexander, Massey, and Helena), and three minor satellite islands (Table A, Appendix 1). The islands are low-lying with few areas exceeding 300 m elevation. The terrain is sparsely vegetated (Edlund, 1981; Edlund, 1983; Edlund and Alt 1989; Walker *et al*., 2005). Low-lying wetlands such as the Goodsir-Bracebridge Inlet have a higher cover of sedges and low-growing willows (Edlund and Alt 1989).

Cornwallis and Little Cornwallis islands (7,474 km^2 including small proximal islands), surveyed in 2002, are low-lying with uplands and hills below 300 m and mostly polar desert with sparse vegetation (Babb and Bliss, 1974). Portions of the western coastline and Eleanor Lake watershed (Cornwallis Island) support more diverse vegetation, including prostrate shrubs in moderately moist habitats, and sedges in the wet areas (Edlund and Alt, 1989)

Devon Island Group --. Devon Island (55,534 km^{2,};including small proximal islands) is characterized by several mountain ranges (e.g., Cunningham Mountains, Treuter Mountains, and the Douro Range), coastal lowlands, and extensive glaciers. The Devon Ice Cap covers a large portion of eastern Devon Island and reaches 1920 m in elevation (Statistics Canada 2010). Extensive uplands stretch west of the Ice Cap across central Devon Island. Low-lying areas occur in coastal areas, primarily along the north and western coast (the Truelove lowlands), but also Philpots Island (a peninsula), portions of the Grinnell Peninsula, Croker Bay, and Cape Sherard (Figure 4).

The landscape of this island is predominantly polar desert with sparse cover of vascular plants (Babb and Bliss, 1974; Edlund and Alt, 1989); however, coastal regions, such as the Truelove Lowlands and portions of the Grinnell Peninsula, support a greater diversity of vegetation dominated by prostrate shrubs (i.e. *Salix arctica* and/or *Dryas integrifolia*) and sedges (Edlund and Alt, 1989). North Kent, Dundas/Margaret, and Baille Hamilton Islands are part of the Island Group.

Figure 4: Devon Island Group.

Ellesmere Island Group *--.* Ellesmere Island is the largest of the Queen Elizabeth Islands (197,577 km^2). It is approximately 500 km wide and 800 km long (Figure 3). The island is largely covered by mountain ranges and glaciers that are separated by a series of east-west passes. Several glaciers flow into adjoining bays and fiords. These features fragment the island, particularly where the north end of Vendom Fiord approaches the Prince of Wales Ice Cap, and divides the southern portion of the island from the north. Graham (1,387 km^2) and Buckingham (137 km^2) islands were included in the survey (Figure 5) along with a number of small islands proximal to Ellesmere.

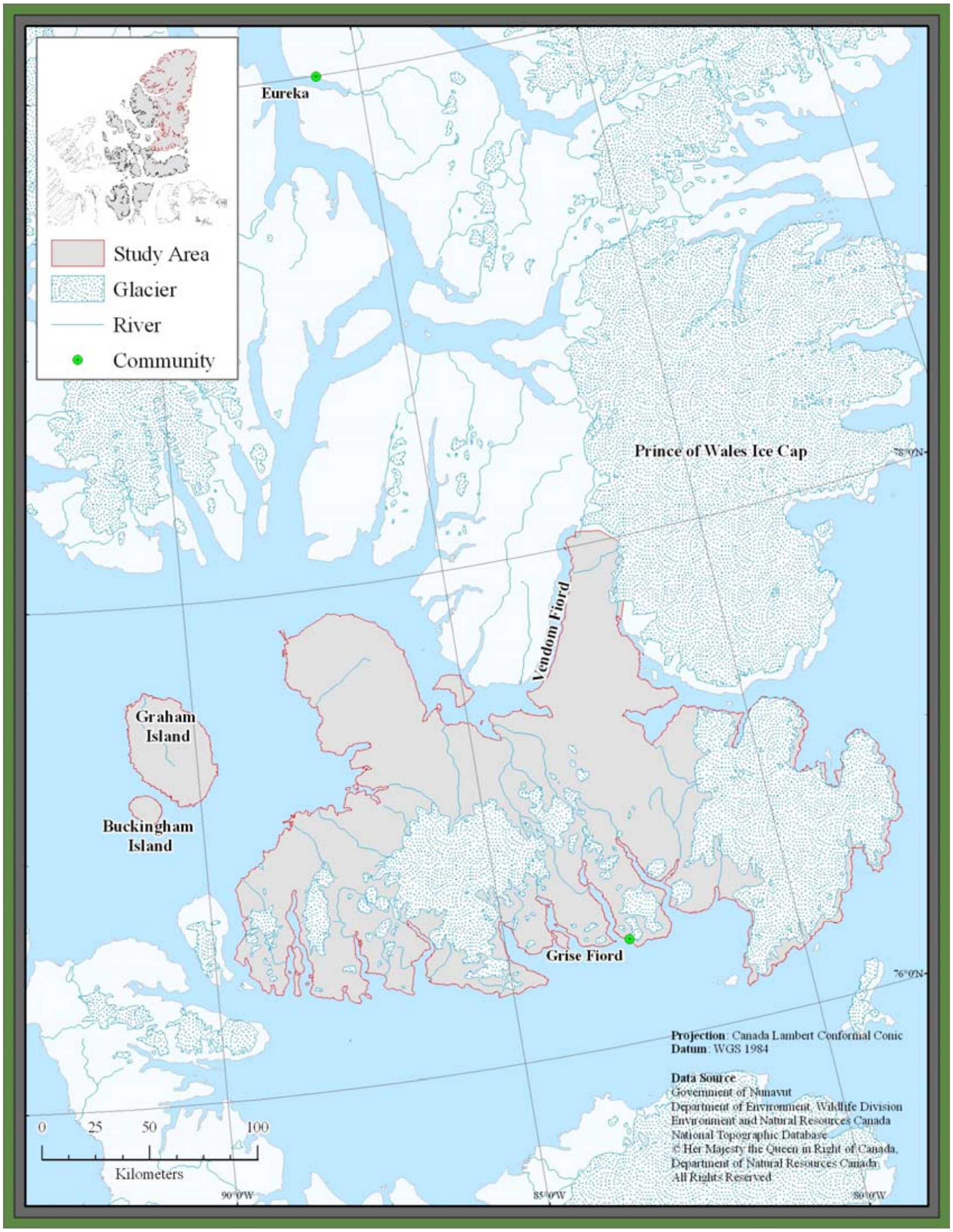


Figure 5: Southern Ellesmere survey area.

Axel Heiberg Group --. Axel Heiberg Island (42,319 km^2) is separated from Ellesmere Island by Nansen and Eureka Sound (Figure 3). This island is mountainous and includes the Princess Margaret Range, which runs north to south through its center. Large ice caps cover much of the landmass (e.g., Muller Ice Cap, Steacie Ice Cap) and spawn many glaciers that flow primarily to the west. Elevations on the island vary, with many mountains topping 1200 m. The highest point occurs centrally at Outlook Peak (2210 m; Statistics Canada 2010). East of the Princess Margaret Range, vegetation progresses from an herb-shrub transition zone at higher elevations to an enriched prostrate shrub zone along the low-lying coast. The plant flora can be diverse and dense, dominated by shrubs (i.e., *Salix arctica* and/or *Dryas integrifolia*) and sedge meadows (Edlund and Alt, 1989). West of the Princess Margaret Range, vegetation is less diverse with large areas of sparse herbaceous communities (Edlund and Alt, 1989).

Ringnes Island Group --***.*** Ellef Ringnes, Amund Ringnes, Lougheed, King Christian, Cornwall, and Meighen Islands are all situated to the west of Axel Heiberg Island and north of the Bathurst Island Complex. Lougheed Island (1,321 km^2), is the most westerly island in the study area and lacks significant topography (maximum elevation 124 m). The vegetation on Lougheed Island is described as entirely herbaceous (Edlund and Alt, 1989) with rich vegetation patches (Tener, 1963). Lougheed is the largest of five small islands that form the Findlay Group. Ellef Ringnes Island, approximate area 11,428 km^2, is sparsely vegetated with low plant diversity. The vegetation is almost entirely herbaceous, with few decumbent shrubs and sedges (Edlund and Alt, 1989). Portions of the island are hilly (i.e., Isachsen Dome, Dumbbells Dome, Baker Hill) with elevations reaching 263 m (Department of Natural Resources, 2006). King Christian Island is located southwest of Ellef Ringnes, has an area of 647 km^2, and is characterized by a dry central plateau and low coastline (Tener, 1963). Its vegetation is described as entirely herbaceous with low diversity (Edlund and Alt, 1989). Amund Ringnes Island, approximate area 5,299 km^2, is relatively low lying but features greater relief in the north. Elevations reach a maximum of 316 m and regional vegetation is entirely herbaceous. The southern half of the island supports more diverse vegetation, primarily herbaceous plants with some shrubs and sedges (Edlund and Alt, 1989). To the south of Amund Ringnes is Cornwall Island, a small hilly landmass with elevations rising to 350 m at Mt. Nicoley on the north-central coast (Tener 1963, Department of Natural Resources). Cornwall is also dominated by herbaceous vegetation (Edlund and Alt, 1989). Meighen Island (approximately 933 km^2), to the northeast of Amund Ringnes, is low-lying with sparse herbaceous vegetation and a large centrally located glacier (the Meighen Ice Cap) that reaches a maximum elevation of 265 m (Department of Natural Resources, 2006)

Prince of Wales/Somerset Island Group --. Prince of Wales (33,274 km^2) is a tundra-covered island that features many small inland lakes. Although the island is generally below 300 m in elevation, some uplands occur along the eastern coast and across the north. Russell Island and Prescott Island (included in the study area) are small proximal islands north and east of Prince of Wales, respectively. Somerset Island (24,548 km^2), separated from the Prince of Wales Island by Peel Sound, is hilly with extensive uplands (higher than 300 m elevation) throughout (Department of Natural Resources, 2000).

In addition to supporting caribou and muskoxen, many of the islands surveyed in this study are known habitat for polar bear (*Ursus maritimus*), arctic wolf (Canis lupus), arctic fox (*Alopex lagopus*), arctic hare (*Lepus arcticus*), snowy owls (*Bubo scandiacus*) and rock ptarmigan (*Lagopus muta*). Arctic wolves are known to prey on both caribou and muskoxen (Miller, 1993b; Mech, 2005).

2.3 SURVEY METHODS

Representatives from nearby communities were consulted to determine the most appropriate survey design. Given the extensive landmasses within the survey area, uncertain weather conditions, and rugged terrain, a combination of both ground and aerial survey methods were selected. The aerial survey design needed to balance between increasing estimate accuracy and precision with safety and logistical practicality. The design had to be standardized to be repeatable and to deal with low densities over large areas for two species with different sightability, which led us to select Distance Sampling methodology (Buckland et al., 2001; Thomas *et al.,* 2002)

2.3.1 Ground Survey

Ground surveys were conducted by hunters on snowmobiles from 2001-2006. The purpose of the ground surveys was to delineate specific areas occupied and unoccupied by caribou and muskoxen based on observations of recent tracks, foraging sites and animals. This information was provided to an aerial survey crew for the purpose of stratifying aerial survey effort. Specifically, ‘areas occupied’ by caribou and muskoxen were included in the aerial survey program, while areas ‘not occupied’ were excluded from the aerial survey and assigned an abundance of zero. When the terrain was too rugged for ground crews to be certain of wildlife occupancy, the area was surveyed using aerial methods.

Ground teams recorded all observations and their geographical locations in field books, including information on wildlife sightings, group size and location. Observations of animal sign were also recorded (e.g., tracks in snow, feeding sites) and samples were collected (e.g., fecal pellets or shed antlers). Hand-held GPS units (Garmin© GPSmap 76S) were used to record locations and to log the survey routes of each snowmobile (called track logs). GPS data were downloaded into a Geographical Information System (GIS). Field observations were entered into Microsoft Excel© spreadsheets and integrated with the survey track data. After 2004, the ground survey program continued but information was not used to direct the aerial survey program. In 2007 and 2008, ground surveys were discontinued due primarily to logistical constraints, including safety (rugged terrain, harsh weather) and remoteness.

2.3.2 Aerial Survey

Peary caribou and muskoxen are dispersed over large geographic areas. A complete census is not possible and abundance estimates are based on sampling methods. We used a distance sampling line transect aerial survey method (Buckland *et al*., 2001; Thomas *et al*., 2002) to estimate densities of Peary caribou and muskoxen for each of the island groups identified above. This was done using a systematic line-transect design with a random start location (Figure 6). Lines were spaced 5 km apart and ran east–west across the study site, except for Prince of Wales and Somerset

Islands, where transect spacing was 10 km (Figure 6). Transect spacing was selected to maximize aerial coverage with the limited available resources for the study. Transect orientation was parallel to lines of latitude with the first transect placed randomly.

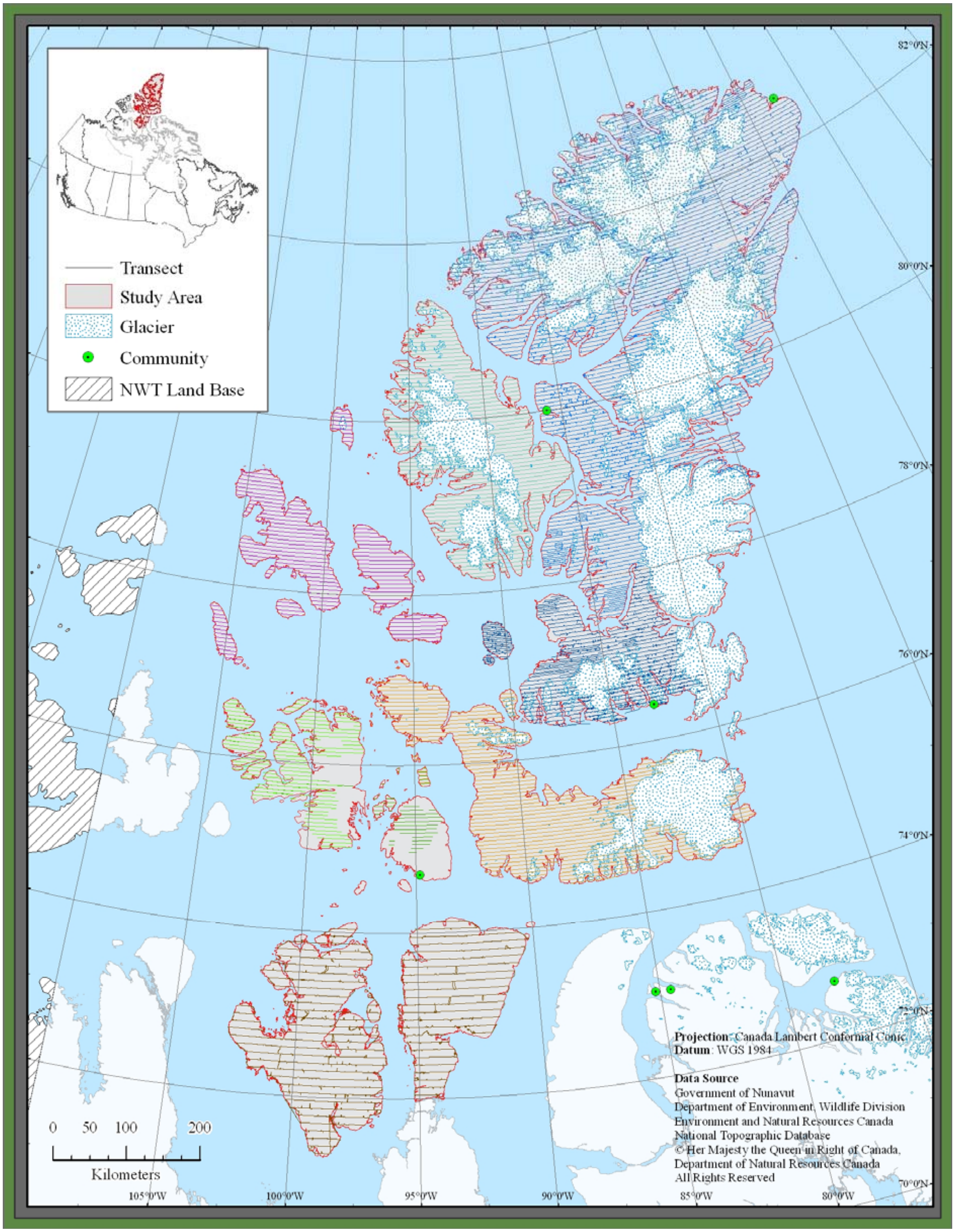


Figure 6: Systematic aerial line-transects for the aerial survey program 2001-2008.

From 2001 through 2008, the line-transect coordinates were imported into ArcView© (www.ESRI.com) and uploaded onto hand-held GPS units (Garmin© 76 and 269 from 2001-2004, Garmin© GPSmap 176 and 276C from 2005-2008) to assist the aircraft along the specified transects. Additionally, from 2005 to 2008, survey routes were plotted in Map Source© and uploaded to duplicate Garmin© GPSmap 176 and 276C units to aid the pilot in navigating each transect. In general, primary transects, identified as “A” transects, covered the entire land base with the exception of extensive ice fields or glaciers. For the initial aerial surveys (2001-2004), a concurrent ground surveys were used to inform aerial crews of areas “not occupied” by Peary caribou and muskoxen. These areas were eliminated from the aerial survey. As well, upon observing caribou along systematically random A transects, aerial crews also sampled additional lines along secondary transects (“B” transects) positioned midway between the primary transects. These additional transects were flown as a form of adaptive sampling, to intensify effort when caribou were seen. Because B transects were not systematically random in their occurrence and they were not part of the survey design across years, observations and flight effort from B transects were excluded from our analysis.

We flew line transects using a Bell 206L or Bell206L4 helicopter at about 120 m above ground level and at an average estimated speed of 130 km/hr. The survey team consisted of four observers, including the pilot. The pilot and forward observer focused on the transect line in front of the helicopter including a search area approximately 45 degrees to the right and left of the helicopter. The two rear observers focused to each side of the helicopter with forward overlap with the front observers’ search area. We collected wildlife observations with no fixed transect width (unbounded line transect; Buckland *et al.,* 2001).

Upon detection of target animals (individuals or social groups), the helicopter diverted to fly perpendicular to the transect line to the animals to record location, species, group size, and the sex and age of individuals. The helicopter then circled back to the transect line so that no portions of the line would be missed. From 2007 on, no sex and age classifications were attempted if newborns were present. Hereafter, we refer to each wildlife observation as a cluster, defined for our purposes as an individual animal or group of animals of the same species observed within roughly 100 m of each other. Animal care and safety were priorities, and observation time was kept to a minimum to reduce disturbance. In particular, for muskoxen clusters that included newborns, a first count and location were recorded, a photo was taken (to confirm information), and the aircraft then left the site. Clusters observed while not flying along transects (i.e., while ferrying) were recorded and identified as off-transect observations. We recorded all data in field books and locations as waypoints on hand-held GPS units (Garmin© 76, 269, 176 and/or 276C). The GPS units also recorded automatically the helicopter location every 20-30 seconds, which were downloaded as track logs for each flight. When animal care and environmental conditions permitted, fecal pellets from caribou and muskoxen were collected for genetic analysis (Jenkins in prep).

All survey work was initiated and completed between the months of March and May, when snow cover enhanced visibility of both animals and their sign (i.e. tracks, foraging sites, bedding sites, craters). Survey data were integrated into ArcMap 9.1© (a

Geographical Information System) and used to map the distribution of caribou and muskoxen clusters. The perpendicular distance of wildlife clusters from each transect and the actual transect lengths flown were measured in ArcMap 9.1© following Marques *et al*. (2006). To reduce measurement error, we used a North Pole Azimuthal Equidistant Coordinate System that was centered on each of the survey areas and a map scale of 1:180,000 for transect length measurements. For measurements involving wildlife clusters, the scale was always less than 1:5000.

During our field program we took care to meet the three key assumptions of distance sampling (below) in order to produce an unbiased estimate of density (Anderson *et al*., 2001; Buckland *et al*., 2001):

1) All animals of interest that were directly on the transect line were detected.

2) Animals of interest were detected at their initial location before they moved in response to the observer (i.e., away from the aircraft).

3) Perpendicular distance (x) from the transect line to each detected cluster was measured accurately.

To address assumption # 1, our survey platform (the helicopter) was designed with two forward-sitting observers who had a clear view and direct focus on the transect line ahead of the helicopter. Thus, it can be assumed that no caribou and muskoxen on the ground directly beneath our flight path were missed. This was reasonable given the platform design, but also the relatively large mobile animals of interest, the general occurrence of these animals in groups, the snowy-white backdrop we had for observing due to time of year, and the treeless environment.

Assumption #2 relates to the concern for the sampling of animals that move to hiding places when startled by observers or for animals that are attracted to the observer and move prior to being sited (Buckland *et al*., 2001). However, both the field protocols and study area were conducive to spotting wildlife prior to movement. That is, the open barren landscape allowed for early detection of animals, and a lack of features such as vegetation meant that animals did not have access to shelter for hiding. As well, forward observers on the survey tried to minimize location error by looking ahead of the helicopter as the area was searched. If movement occurred subsequent to initial sighting, the original location of detection was recorded. Animal movement was generally random and slow relative to the speed and direction of the helicopter, and this eliminated the likelihood of serious sampling issues. Finally, we found that wildlife generally did not run from the helicopter except when they were very close to the transect line; thus, animals were generally detected in advance of movement and their original locations were easily recorded. For muskoxen, animals generally did not run from the helicopter but instead formed defense circles. To minimize disturbance, particularly as newborns might have been present in muskox clusters, the helicopter climbed to a higher altitude as soon as the animals were observed. This reduced noise and made the group less apt to move.

Finally, to address the third assumption, we followed Marques *et al*. (2006) and relied on post-sampling analyses using a Geographical Information System (GIS) to determine the perpendicular distance of clusters (given by the overhead GPS position of the animal cluster at the point where first observed) to the plotted transect flown by the pilot. Measurement error was minimized by using a North Pole Azimuthal Equidistant Projection centered on the island group of interest.

2.3.3 Age and Sex Composition

To evaluate herd structure and recruitment, the helicopter, after waypointing the location of the initial cluster observation, reduced altitude and briefly over flew the cluster. All caribou sighted were sexed (male or female) and aged (newborn calves- less than 1 month of age; calves or ‘short yearlings’ - 10-12 months; yearling - 22-24 months; adult: older than 2 years). Sex was determined based on the presence or absence of a vulva patch and/or urine staining on the rump (Miller, 1991). Supplemental information on the presence/absence of antlers and their size and shape was relatively diagnostic. Non-pregnant barren-ground females typically shed their antlers in April but less is known about the timing of shedding antlers in Peary caribou (Miller, 1991)

For muskoxen, during most survey years, detailed sex and age information was not collected. This was a response to calving and the presence of newborn calves within muskoxen groups. Thus, most muskoxen were categorized in two age classes: newborn calves (less than 2 months) and adult (one year or older). In some surveys, calves or ‘short yearlings’ (the previous year’s calves, approximately 11-12 months) were recorded separately.

For both caribou and muskoxen, newborn calves were excluded from the analysis of density and abundance due to expected low survival rates.

2.4 ANALYSIS

2.4.1 Density and Abundance

To estimate population density, we followed Buckland *et al*. (2001) and used the software Program Distance, Version 5.0, Beta 3 (Thomas *et al*., 2005) to model the line-transect data for each species. We derived density estimates using Conventional Distance Sampling for line-transect data and detection function models (key function/series expansions) recommended by Buckland *et al*. (2001). Each density estimate was multiplied by the survey area to derive an abundance estimate. We defined the survey area as the area within which systematic line (A) transects were surveyed (Aars *et al.,* 2008).

Distance sampling method assumes that some animals will be missed and that the number of observations will diminish with perpendicular distance away from the transect line. In many field surveys, only a small percentage of the animals of interest are detected (Anderson *et al*., 2001; Buckland *et al*., 2001); however, unbiased estimates of density can still be made for these populations using distance sampling methods. Thus, although we knew that not all groups of caribou and muskoxen would be detected during a given survey, this method allowed the average proportion detected P_a to be estimated based on the perpendicular distance of animal clusters from the transect line. This was accomplished by computing a detection function g(x), where:

g(x) = the probability of detecting the animal (or, in this case, cluster of animals) given that it is at perpendicular distance x from the centerline of the transect being flown

and, P_a (the probability that a cluster in the survey area is detected):

$$\hat{P}_a = \frac{\int_0^w \hat{g}(x)dx}{w}$$

where $\hat{g}(x)$ is the estimated detection function and w is the strip width, or in this case the truncation distance. We used Program Distance v. 5.0 (Thomas *et al*., 2005) to calculate $\hat{g}(x)$, $\hat{P}_a$, and the estimated standard error (SE) of $\hat{P}_a$, the effective strip width (ESW, as defined below), as well as estimates of density (D, estimated as $\hat{D}$) and precision for the objects of interest. Here, $\hat{D}$ is estimated from standard line-transect theory:

$$\hat{D} = \frac{n}{2wL\hat{P}_a} \quad \text{or} \quad = n / (2 \times L \times ESW)$$

where n is the number of sightings, $\hat{P}_a$ is the estimated (average) proportion of objects detected within the covered region, L is the total length of the transect line, and ESW is the effective strip half-width (and can be substituted into the equation). This refers to distance on either side of the transect line where by as many objects are detected beyond the distance as are missed within it (Buckland *et al*. 2001, p424). $\hat{D}$ is, in effect, an estimate of the average density during the time of the survey and it is based on the total sampling effort.

As noted, observations in this study are clusters of animals. Therefore, the density of animals D is expressed as a product of the density of clusters $\hat{D}$ (above) multiplied by the average cluster size $E(s)$:

$$D = \hat{D} \times E(s)$$

The probability of detection may be a function of cluster size such that the sample of cluster size exhibits size bias. In the absence of size bias, we used $E(s)$ = the mean size of the detected clusters. When size bias was present, we used the regression method to estimate cluster size and correct for size bias (Buckland *et al*., 2001: 73-75). Buckland *et al*. (2001) presents details on the estimated sampling variance of D which is calculated using program Distance 5.0© (Thomas *et al*., 2005).

In order to model the detection function, we pooled data by species across all transect lines by survey area within island groups. Newborn calves were excluded from the analysis due to low expected survival rates. We considered several recommended models for the estimated detection function: half-normal (adjusted with cosine or Hermite polynomials), uniform (adjusted with cosine series or simple polynomial series), and hazard rates (adjusted with cosine series or simple polynomial series; Buckland *et al.,* 2001). Preliminary analysis allowed us to evaluate the distance data and the identification of an appropriate truncation distance which is recommended to delete outliers, to address size bias in detected clusters, and to facilitate modeling of the data (Buckland *et al*. 2001). In our final analysis, several robust models were tested and we used Akaike's Information Criterion (AIC) to select the model with best fit. We accepted the best-fit model if it had a non-significant goodness-of-fit value (χ^2) and a non-significant Kolmogorov-Smirnov Test. For a full description of modeling rationale and options available in program Distance 5.0©, consult Buckland *et al*. (2001) and Thomas *et al*., (2005).

2.4.2 Age and Sex Composition

When our data allowed, we estimated the proportion of calves in the population. For caribou, this was defined as the number of calves (or short yearlings) divided by the total number of caribou seen on transect. For muskoxen, this was defined as the number of newborn calves divided by the total number of muskoxen seen on transect.

The difference in approach between species was necessary as most surveys occurred during muskoxen calving and 1-2 months prior to caribou calving.

For caribou, we also determined adult sex ratios. This was defined as the number of adult males per 100 adult females.

3.0 RESULTS

3.1 STUDY AREA FINDINGS

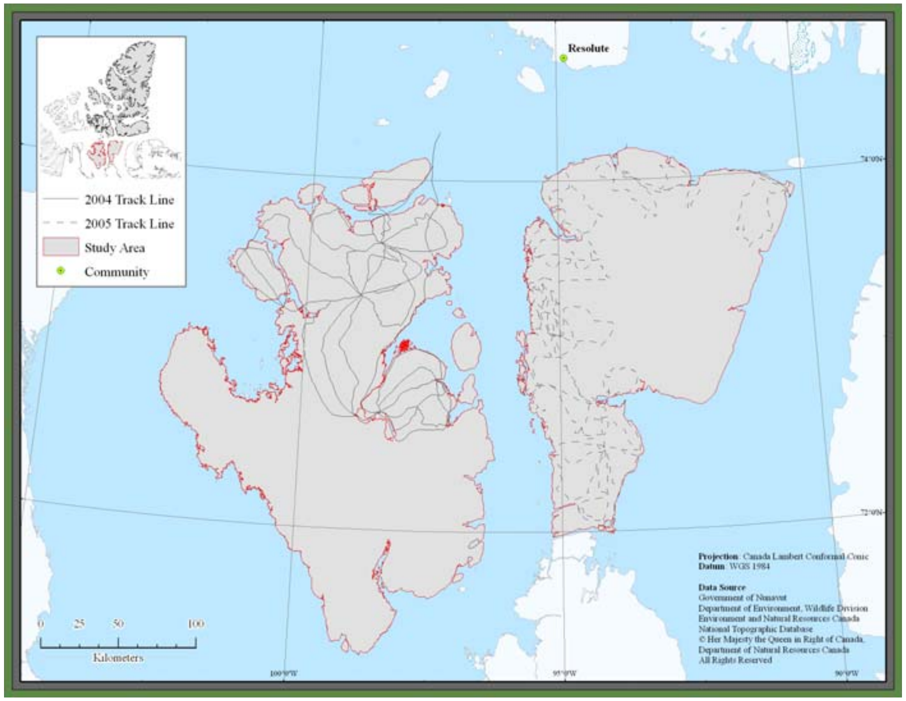
3.1.1 Ground Surveys

Ground surveys were completed in April-May of 2001, 2002, 2004, 2005 and 2006 on islands or portions of islands that originally corresponded with the aerial survey program. As noted, the original design was that information from ground teams would help direct the aerial survey effort; however, rugged terrain, harsh weather conditions, and areas of deep or no snow precluded some areas from being investigated on the ground. On occasion, whiteout conditions and severe winds made it impossible for ground crews to operate for days (Seeglook Akeeagok and Jeffrey Qaunaq, personal communication, September 2010). Thus, integration of the two methods was difficult and by 2004 the ground and aerial teams were working independently from a survey perspective. For example, Somerset Island was surveyed by aerial methods in 2004 and by ground methods in 2005. Ground surveys were not included in the 2007 and 2008 study program due to logistical constraints, including safety (rugged terrain, harsh weather) and remoteness.

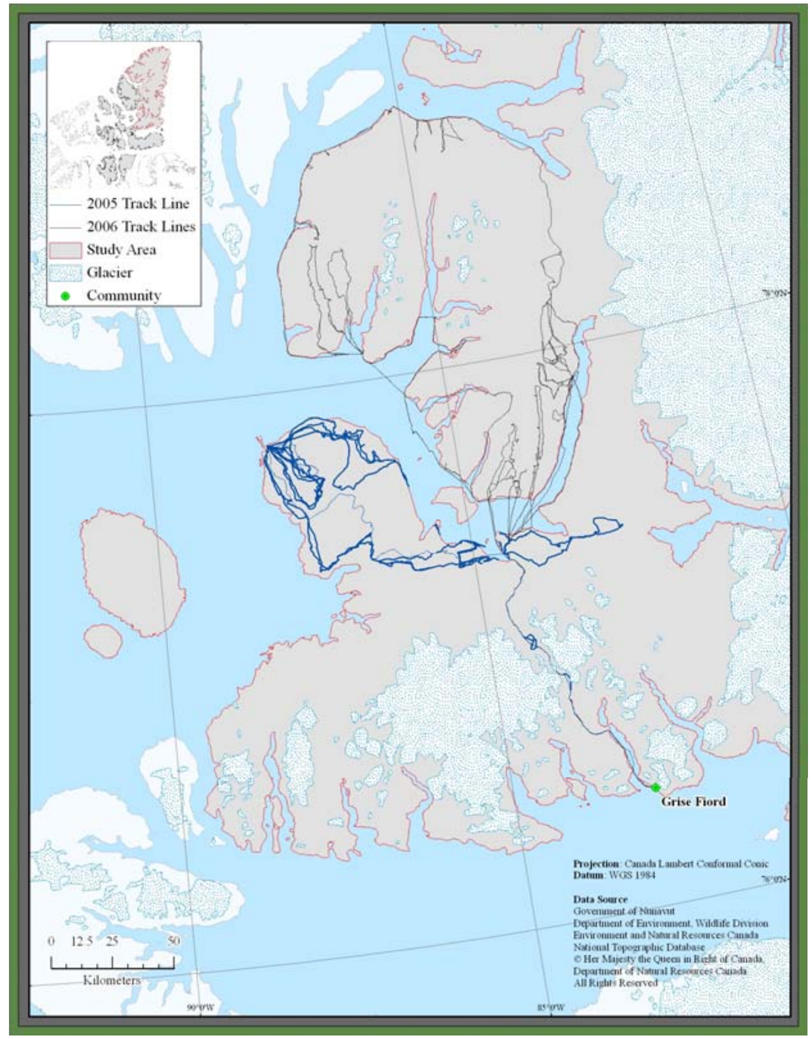
Overall, from 2001 through 2006, snowmobile teams logged a total of 18,513 km of survey track on Bathurst, Cornwallis, western Devon, Prince of Wales and Somerset Islands, and portions of Ellesmere Island (Figures 7-8). The teams observed 44 Peary caribou clusters (137 individual caribou; Table 2) and 110 clusters of muskoxen (605 individuals; Table 3).

A) **(B)**

Figure 7: Survey routes recorded by ground crews within 3 survey areas: (A) Bathurst Island Complex (2001) and (B) Cornwallis Group and Devon Island (2002).



A)



(B)

Figure 8: Survey routes recorded by ground crews within 4 survey areas: (A) Prince of Wales Island (2004), Somerset Island (2005), and (B) Southern Ellesmere Island (2005), and Northern Ellesmere Island (2006).

Table 2: Peary caribou ground survey results, 2001-2006.

Geographical Area	Year Surveyed	Distance (km)	Total # Clusters Observed	# of Caribou Observed	# Newborn Calves	COMPOSITION			Clusters per 1000 km travelled	Tracks Observed	Carcasses Observed	Feeding Areas Observed
						Male	Female	Unknown				
Bathurst Island	2001	3887	18(1)	46	4	13	12	25	4.6	20	0	7
Cornwallis Island	2002	1566	0	0	0	0	0	0	0	2	0	2
Devon Island	2002	3642	7(1)	18	4	6	4	12	1.9	5	2**	1
Prince of Wales Island	2004	1968	0	0	0	0	0	0	0	0	0	0
Somerset Island	2005	2864***	2	3	1	1	1	2	0.7	1	0	1
Ellesmere Island S.	2005	1662	6	17	^^	^^	^^	17	3.6	1	0	^
Ellesmere Island N.	2006	2924	11	44	0	8	19	17	3.8	13	3	^

Notes: ** These specimens were recorded as ' found a bone' so not neccessarily a carcass. *** Distance travelled as per snowmobile odometers was 2936 km. () Figures in brackets represent duplicate cluster observations. ^ Not recorded in the only area where caribou were present. ^^ Not recorded. # of Caribou Observed = number of caribou 10 months or older.

Table 3: Muskoxen ground survey results, 2001-2006.

Georaphical Area	Year Surveyed	Distance (km)	Total # Clusters Observed	# of Muskox Observed	# Newborn Calves	COMPOSITION			Clusters per 1000 km travelled	Tracks Observed	Carcasses Observed	Feeding Areas Observed	Feces Observed
						Male	Female	Unknown					
Bathurst Island	2001	3887	3	28	2	3	8	19	0.77	9	1	6	3
Cornwallis Island	2002	1566	8	22	0	4	3	15	5.11	6	0	9	1
Devon Island	2002	3642	11**	45**	9	3	3	48	3.02	3	0	2	1
Prince of Wales Island	2004	1968	14~	160	^	^	^	^	7.11	^	0	^	
Somerset Island	2005	2864***	24	134	****	^	^	^	6.98	3	17	2	9
Ellesmere Island S.	2005	1662	23	56	0	3	1	52	13.84	3	6	^	
Ellesmere Island N.	2006	2924	27	187	16	21	32	150	9.23	6	3	^	2

Notes: ** Includes one group of three, however no location was provided. *** Distance travelled as per snowmobile odometers was 2936km. **** 5 calves were recorded however it is unclear whether they were calves of the year or just turned 1 year old. ~ Includes one group of 6 muskoxen observed on the sea ice. () Figures in brackets represent duplicate cluster observations. ^ Not recorded. # of Muskox Observed = number of muskoxen one year or older.

3.1.2 Aerial Surveys

We flew 51,832 km on transect from April to May, 2001 to 2008. The survey area included the non-glaciated portion of 65 islands (plus small proximal unnamed islands: Appendix 1. Table A), in the six Island Groups (Figure 3).

Across the entire study area we tallied 398 observations of caribou that included 1,605 individual caribou (10 months or older) and 10 newborns. Although the timing of the survey work was designed as pre-calving, newborns were observed on Bathurst Island Complex as the survey was flown in late May 2001. The majority of Peary caribou clusters were in the eastern Queen Elizabeth Islands, primarily within the Axel Heiberg (31%) and Ellesmere (32%) Island Groups (Table 4, Figure 9). Abundance estimates were generated based on 305 observations of 1,336 caribou (10 months or older) that were seen on transect. Details are presented by survey area and Island Group in Table 4, Figure 9.

We tallied a total of 1,371 clusters of 11,191 muskoxen (1 year or older) and 1,492 newborn calves across the study area (Table 5, Figure 10). No muskoxen were observed on Ellef Ringnes, Meighen, and Lougheed Island in the Ringnes Island Group The number of clusters and the total number of individuals (both on- and off transect) are presented by survey area and Island Group in Table 5.

The majority of muskox clusters were observed in the eastern Queen Elizabeth Islands, primarily within the Ellesmere (57%) and Axel Heiberg (22%) Island Groups. Abundance estimates (Table 5) were generated based on 1,305 observations of 10,856 muskoxen (1 year of age or older).

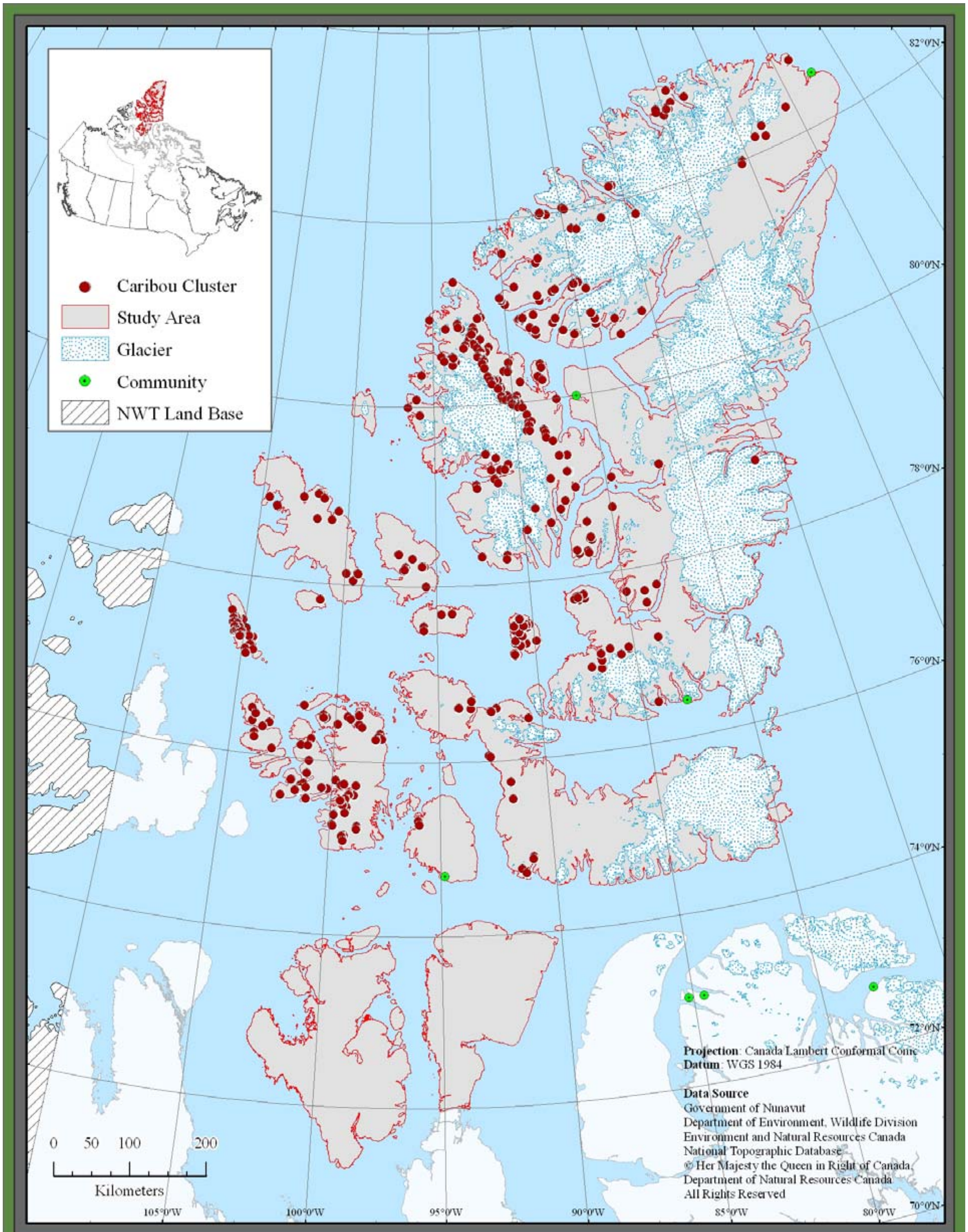


Figure 9: Peary caribou observations over the entire study area from 2001 to 2008.

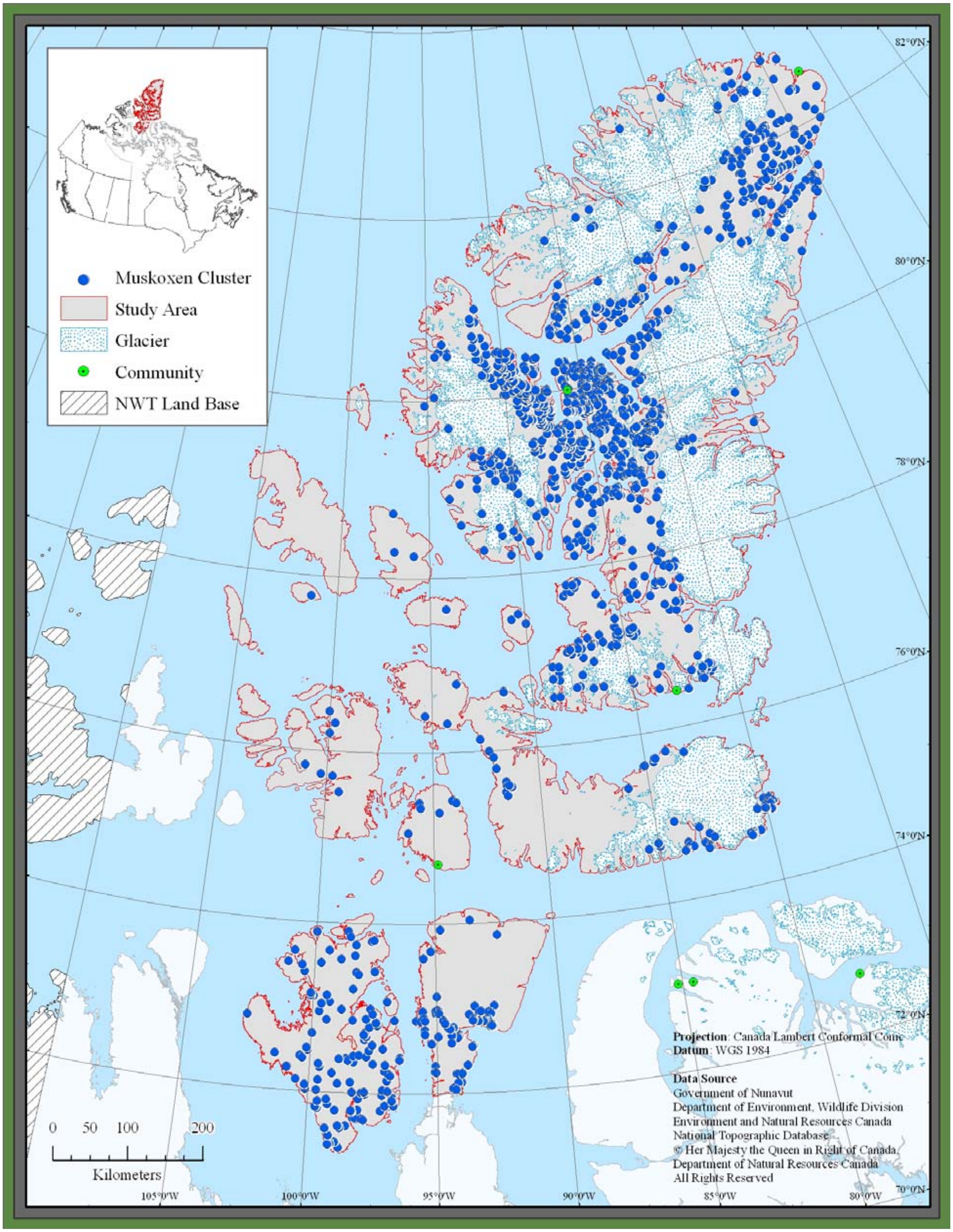


Figure 10: Muskox observations over the entire study area from 2001 to 2008.

Table 4: Peary caribou aerial survey observations, density and abundance estimates for 2001-2008, by Island Group.

STUDY AREA	Area (km sq)	Year	DATE		Effort (m)	ALL OBSERVATIONS			ON-TRANSECT			OFF-TRANSECT			B-TRANSECT (OFF)			Density	95% CI		CV	Abund.	95% CI	
			Start	Finish		# Cls.	# PC	# NB	# Cls.	# PC	# NB	# Cls.	# PC	# NB	# Cls.	# PC	# NB		LCI	UCI			LCI	UCI
Bathurst Island Group																								
Bathurst Island Complex	15,307	2001	15-May	31-May	2886113	67	152	10	24	52	5	8	11	0	35	89	5	0.0095	0.0053	0.0168	0.2957	145	81	257
Adjusted BIC	*19,644	" "	" "	" "	" "													" "	" "	" "	" "	*187	104	330
Cornwallis	3,411	2002	10-May	11-May	618640	1	1	0	1	1	0	0	0	0	0	0	0	1	Min Count			1	Min Count	
Devon Island Group																								
Baillie Hamilton	290	2002	28-May	28-May	54200	0	0	0	0	0	0	0	0	0	0	0	0	0	Min Count			0	Min Count	
West Devon	12,316	2002	08-May	30-May	2217730	13	35	0	5	18	0	3	6	0	5	11	0	35	Min Count			**40	Adjusted Min Count	
Devon	39,731	2008	22-Apr	10-May	7985397	4	17	0	4	17	0	0	0	0	N/A	N/A	N/A	17	Min Count			17	Min Count	
North Kent	440	2008	22-Apr	10-May	83115	0	0	0	0	0	0		0	0	N/A	N/A	N/A	0	Min Count			0	Min Count	
Baillie Hamilton	290	2008	22-Apr	10-May	53320	0	0	0	0	0	0		0	0	N/A	N/A	N/A	0	Min Count			0	Min Count	
Dundas/Margaret	61	2008	22-Apr	10-May	13577	0	0	0	0	0	0		0	0	N/A	N/A	N/A	0	Min Count			0	Min Count	
Prince of Wales - Somerset Island Group																								
Prince of Wales	34,765	2004	10-Apr	18-Apr	3430308	0	0	0	0	0	0	0	0	0	0	0	0	0	Min Count			0	Min Count	
Somerset	24,549	2004	20-Apr	25-Apr	2420364	0	0	0	0	0	0	0	0	0	0	0	0	0	Min Count			0	Min Count	
Ellesmere Island Group																								
S Ellesmere	23,767	2005	04-May	30-May	4299116	41	118	0	19	57	0	0	0	0	22	61	0	0.0092	0.0046	0.0186	0.3609	219	109	442
N Ellesmere	96,567	2006	06-Apr	22-May	17535130	86	413	0	72	344	0	2	7	0	12	62	0	0.0083	0.0055	0.0125	0.2103	802	531	1207
Axel Heiberg Island Group																								
Axel Heiberg	30,877	2007	19-Apr	03-May	5871988	124	658	0	120	642	0	4	16	0	N/A	N/A	N/A	0.0742	0.053	0.1039	0.172	2291	1636	3208
Ringnes Island Group																								
Amund Ringnes	5,364	2007	15-Apr	17-Apr	1063944	9	26	0	9	26	0	0	0	0	N/A	N/A	N/A							
Cornwall Island	2,273	2007	19-Apr	19-Apr	448344	4	16	0	4	16	0	0	0	0	N/A	N/A	N/A							
Ellef Ringnes	11,549	2007	06-Apr	15-Apr	2275504	16	32	0	14	26	0	2	6	0	N/A	N/A	N/A							
King Christian	647	2007	14-Apr	14-Apr	117421	1	6	0	1	6	0	0	0	0	N/A	N/A	N/A							
Meighen	849	2007	22-Apr	22-Apr	170546	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A							
Pooled Results	**20,682**				**4075759**	**30**	**80**	**0**	**28**	**74**	**0**	**2**	**6**	**0**	**N/A**	**N/A**	**N/A**	**0.0136**	**0.0076**	**0.02442**	**0.3**	**282**	**157**	**505**
Lougheed	1,415	2007	13-Apr	13-Apr	286882	32	131	0	32	131	0	0	0	0	N/A	N/A	N/A	0.2626	0.145	0.475	0.3	372	205	672

Notes: # Cls.= number of Peary caribou clusters. #PC= number of Peary caribou 10 months or older. # NB = number of newborn calves.
**Adjusted based on ground and aerial observations outside the aerial survey area on Bathurst Island. Area adjusted to incorporate all of Bathurst Island.*
*** Adjusted based on ground observations outside aerial survey area. The survey area could not be adjusted as the boundaries of the ground survey were not known.*

Table 5: Muskox aerial survey observations, density and abundance estimates for 2001-2008, by Island Group.

STUDY AREA	Area (km sq)	Year	DATE		Effort (m)	ALL OBSERVATIONS			ON-TRANSECT			OFF-TRANSECT			B-TRANSECT (OFF)			Density	95% CI		CV	Abund.	95%CL	
			Start	Finish		# Cls.	# MX	# NB	# Cls.	# MX	# NB	# Cls.	# MX	# NB	# Cls.	# MX	# NB		LCI	UCI			LCI	UCI
Bathurst Island Group																								
Bathurst Island Complex	15,307	2001	15-May	31-May	2886113	7	82	21	3	32	8	1	10	6	3	40	7	82	Min Count			82	Min Count	
Cornwallis	3411	2002	10-May	11-May	618640	7	18	0	5	15	0	0	0	0	2	3	0	18	Min Count					
Cornwallis (All)	7474**	" "																				22*	Adjusted Min Count	
Devon Island Group																								
West Devon	12316	2002	08-May	30-May	2217730	10	68	7	9	59	7	0	0	0	1	9	0	68	Min Count			68	Min Count	
Baillie Hamilton	290	2002	28-May	28-May	54200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Devon	39,731	2008	22-Apr	10-May	7985397	69	391	61	61	354	58	8	37	3	N/A	N/A	N/A	0.0129	0.0076	0.0218	0.267	513	302	864
North Kent	440	2008	22-Apr	10-May	83115	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	0	Min Count			0		
Baillie Hamilton	290	2008	22-Apr	10-May	53320	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	0	Min Count			0		
Dundas/Margaret	61	2008	22-Apr	10-May	13577	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	0	Min Count			0		
Prince of Wales - Somerset Island Group																								
Prince of Wales	34,765	2004	10-Apr	18-Apr	3430308	111	1483	27	111	1483	27	0	0	0	0	0	0	0.0600	0.0455	0.0790	0.1386	2086	1582	2746
Somerset	24,549	2004	20-Apr	25-Apr	2420364	69	988	47	66	967	46	3	21	1	0	0	0	0.0778	0.0392	0.1545	0.3466	1910	962	3792
Ellesmere Island Group																								
S Ellesmere	23,767	2005	04-May	30-May	4299116	118	316	2	99	273	2	2	4	0	17	39	0	0.0192	0.0131	0.0282	0.1939	456	312	670
N Ellesmere	96,567	2006	06-Apr	22-May	17535130	666	5127	927	645	4999	907	14	77	9	7	51	11	0.0840	0.0687	0.1028	0.1028	8115	6632	9930
Axel Heiberg Island Group																								
Axel Heiberg	30,877	2007	19-Apr	03-May	5871988	309	2697	400	301	2653	396	8	44	4	N/A	N/A	N/A	0.1372	0.1092	0.1725	0.1162	4237	3371	5325
Ringnes Island Group																								
Amund Ringnes	5,364	2007	15-Apr	17-Apr	1063944	3	13	0	3	13	0	0	0	0	N/A	N/A	N/A	13	Min Count			13	Min Count	
Cornwall Island	2,273	2007	19-Apr	19-Apr	448344	1	6	0	1	6	0	0	0	0	N/A	N/A	N/A	6	Min Count			6	Min Count	
Ellef Ringnes	11,549	2007	06-Apr	15-Apr	2275504	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	0	Min Count			0	Min Count	
King Christian	647	2007	14-Apr	14-Apr	117421	1	2	0	1	2	0	0	0	0	N/A	N/A	N/A	2	Min Count			2	Min Count	
Meighen	849	2007	22-Apr	22-Apr	170546	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	0	Min Count			0	Min Count	
Lougheed Group	1,415	2007	13-Apr	13-Apr	286882	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	0	Min Count			0	Min Count	

Notes: #Cls. = # of muskox clusters. #MX = number of muskoxen one year or older. #BN = number of newborn calves.

** Adjustment based on ground observations outside aerial survey area.*

*** Additional Area was surveyed using ground methods*

3.2 SURVEY FINDINGS BY ISLAND GROUP

3.2.1 Bathurst Island Group

(Survey Areas - *Bathurst Island Complex, and Cornwallis Group*)

3.2.1.1 Bathurst Island Complex Survey Area

Caribou

Ground Survey: In 2001, crews traveled 3,887 km^2 (Figure 11) on the Bathurst Island Complex (BIC) and observed 18 clusters of Peary caribou representing 50 individuals (4.6 clusters/1000 km surveyed) (Figure 11). Two clusters (four animals in total) were observed in areas that were excluded from the aerial survey. Tracks were recorded on 20 occasions and seven feeding sites were noted (Table 3).

Aerial Survey: The BIC aerial survey was conducted May 15-31, 2001. The total length of A transects flown was 2,886 km and the total area surveyed was approximately 15,305 km^2 (Table 4, Figure 12). The remaining area (approximately 4,339 km^2) was not surveyed based on information from concurrent ground surveys. A total of 24 clusters of caribou were observed on transect, including 24 female and 11 male adults, two yearlings, 15 calves or ‘short yearlings’ and five newborns. The first newborn observed was spotted on May 27, 2001. The proportion of calves or ‘short yearlings’ is 29% of those animals seen on transect (excluding newborns). The ratio of adult males to females was 46:100.

An additional 43 caribou clusters were observed off transect (not including those seen while ferrying to site), and these represented 100 caribou (10 months or older) and five newborns. These 105 caribou were located by following tracks, by maintaining a 1 km field of vision on either side of the transect (by eliminating topography) and by flying additional transects in areas where caribou were detected (G.Hope, personal communication, April 14, 2011). Given the flight effort to investigate caribou sightings and sign, and to eliminate topography as an obstacle to observations, the combination of on- and off-transect observations provides a thorough count of caribou in the survey area.

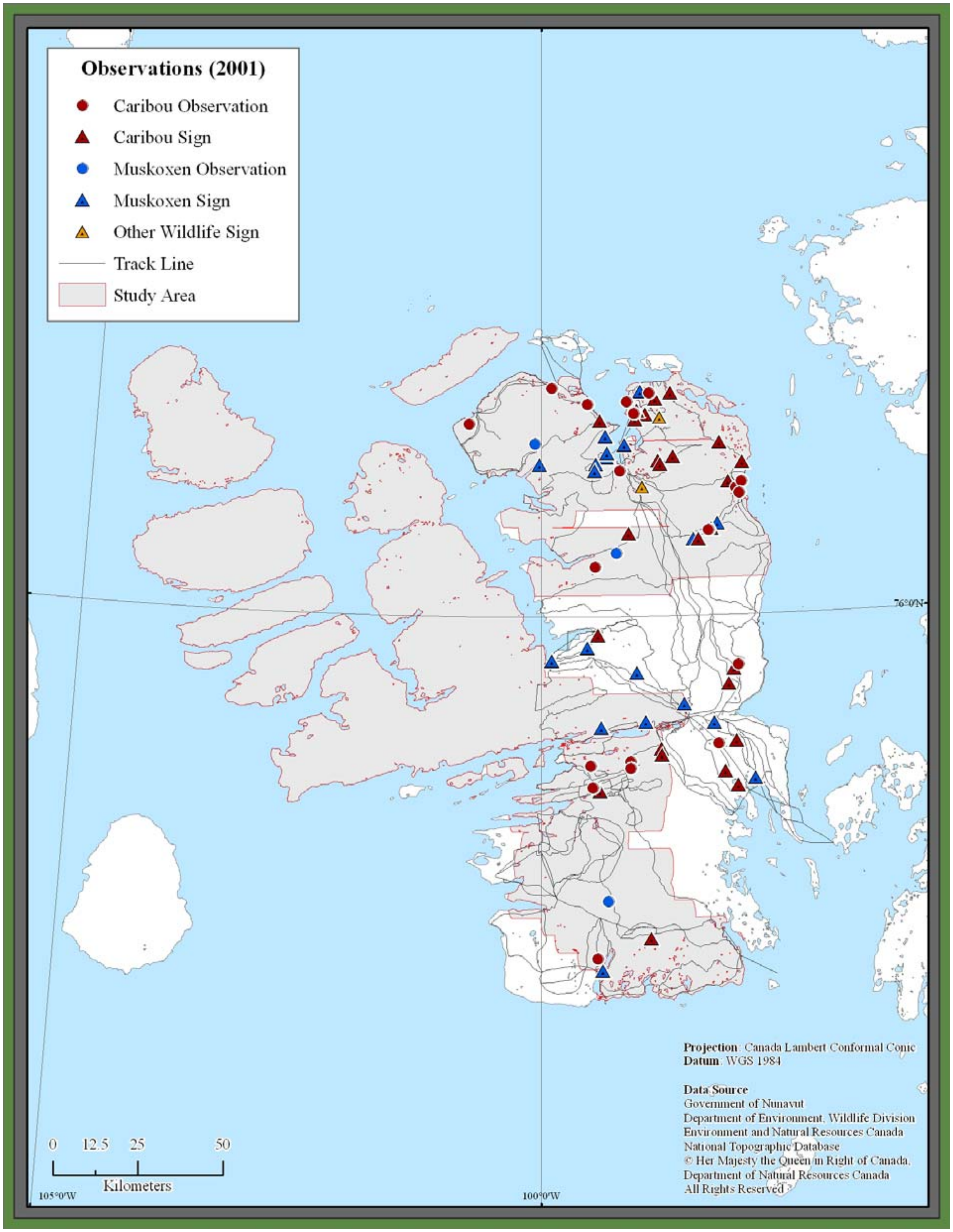


Figure 11: Ground survey observations within the Bathurst Island Complex (BIC) survey areas, 2001.

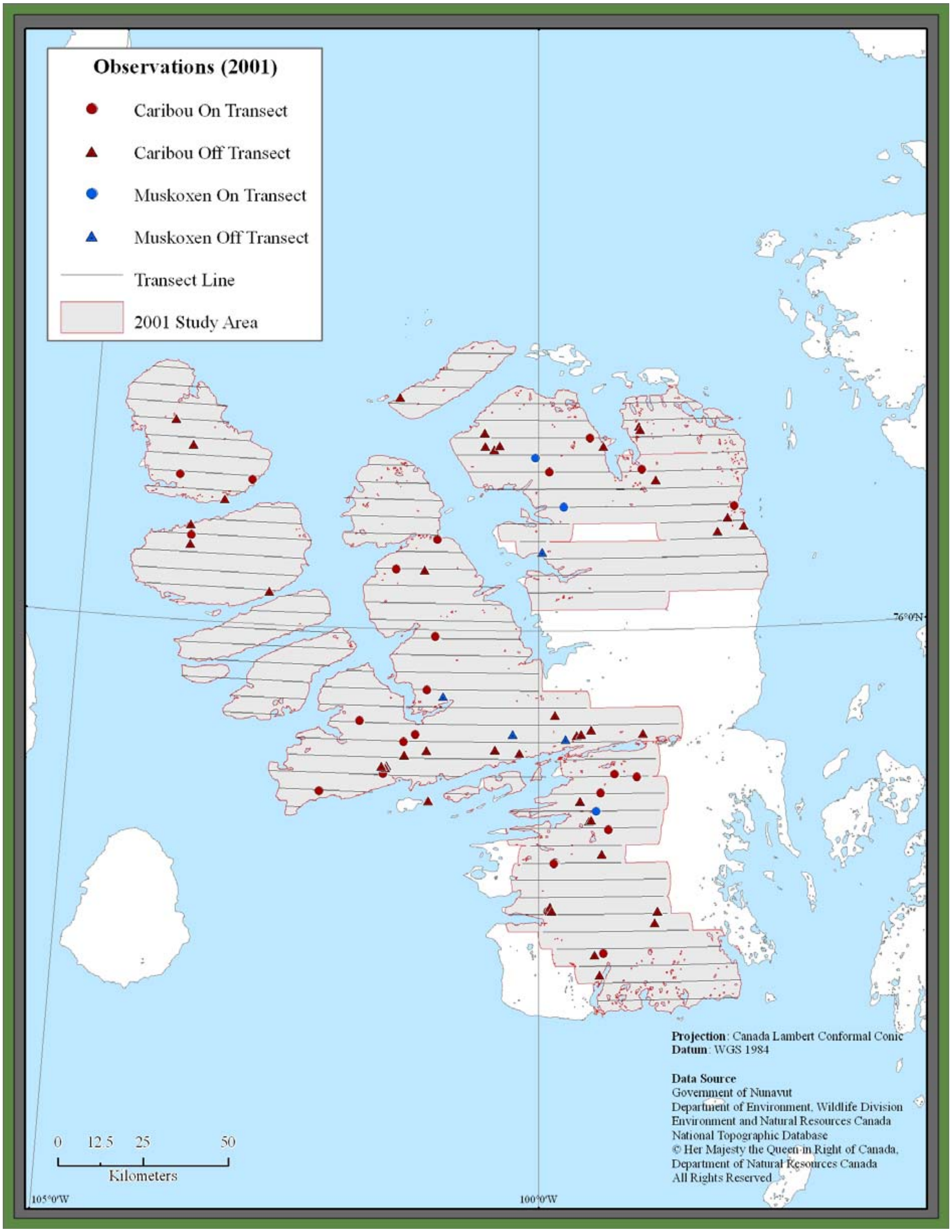


Figure 12: Aerial survey observations of Peary caribou and muskoxen clusters for the Bathurst Island Complex (BIC) survey area, 2001.

After fitting all recommended models to the data, the uniform key model with single order cosine adjustment was selected (Table 6). The selected model was characterized by a small shoulder (Figure 13) and a non-significant Chi-square Goodness of Fit test, suggesting good fit of the data (χ^2 =0.8164, p= 0.6486)

We estimated the probability of detecting a cluster of caribou on either side of the transect line as P_a = 0.660 (95% CI 0.472–0.922) and estimated the effective strip width (ESW) to be 876 m (95% CI 627–1224 m). The mean cluster size for the BIC survey area was 2.08 caribou/cluster (SE 0.29), and this was the smallest cluster size noted for all survey areas**.** The estimated density of caribou inhabiting the BIC survey area was 9.5 caribou/1000 km^2 (95% CI 5.3–16.8 caribou/1000 km^2) or 145 caribou (95% CI 77-260) approximately 10 months of age and older.

The original survey design specified that non-surveyed areas would represent space 'not occupied by caribou' and result in counts of zero caribou. On Bathurst Island, data from the ground survey indicates that there were some caribou in these areas (two non-repeat groups representing 4 caribou were detected) as did observations collected by aerial crew during flights to and from Bathurst Island (5 non-repeating observations representing 10 caribou). To address this, we applied the results (the density estimate) obtained in the covered areas across the non-surveyed areas of Bathurst Island and assumed that the detection function would be similar. This is reasonable given the lack of topography and barren landscape. Thus, the BIC area increased to 19,644 $km^{2,}$ and generated an abundance estimate of 187 caribou (95% CI 104-330).

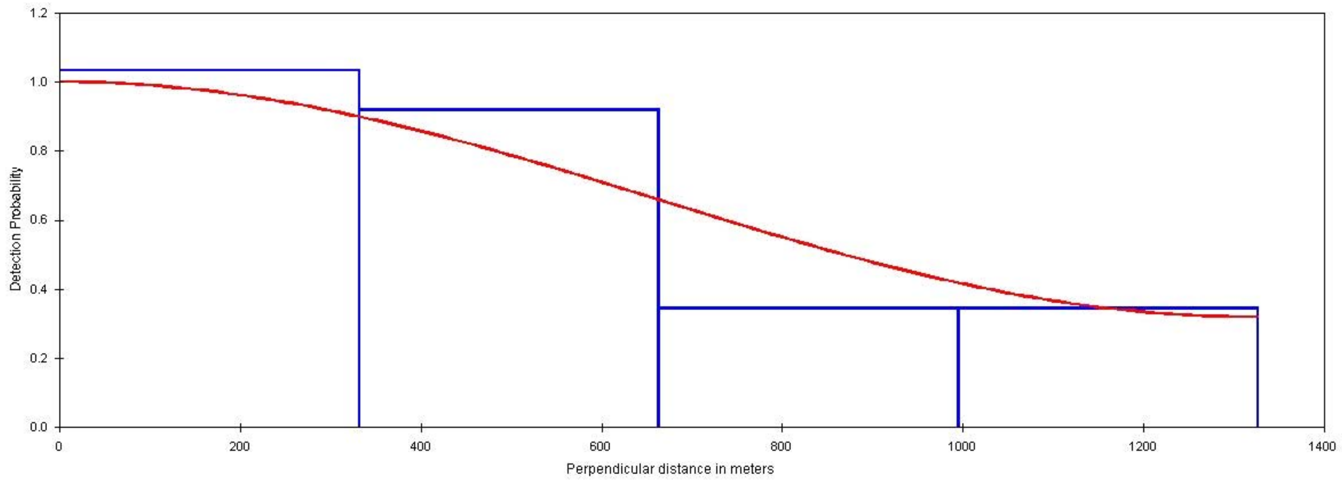


Figure 13: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of Peary caribou observed within the Bathurst Island Complex survey area, May 2001. The g(x) is estimated using a uniform model with cosine adjustment. Bin size is 332 m.

Table 6: Summary of candidate models used in the line-transect analysis for Peary caribou of the Bathurst Island Complex survey area, May 2001. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Bathurst Island Complex - Peary caribou					Density	95% CI		
Name	**Par**	**Delta AIC**	**AIC**	**ESW (m)**	**(caribou/km^2)**	**LCI**	**UCI**	**CV**
Uniform Cosine	1	0.00	329.28	875.75	0.0095	0.0053	0.0169	0.296
Half-normal Hermite Poly	1	0.83	330.11	929.97	0.0089	0.0050	0.0160	0.299
Half-normal Cosine	1	0.83	330.11	929.97	0.0084	0.0047	0.0150	0.297
Uniform Simple Poly	0	1.49	330.77	1327.00	0.0063	0.0039	0.0102	0.247
Hazard-rate Simple Poly	2	1.79	331.07	649.40	0.0102	0.0041	0.0252	0.472
Hazard-rate Cosine	2	1.79	331.07	649.40	0.0102	0.0041	0.0252	0.472

Muskoxen

Ground Survey: Ground crews reported seeing 3 clusters of muskoxen for a total of 30 animals after driving 3,887 km on the BIC or 0.77 clusters/1000 km traveled. Observations of muskox sign were also reported, including one carcass (Table 3, Figure 11).

Aerial Survey: A total of three clusters of muskoxen were observed on transect (Table 5, Figure 12) which included 32 muskoxen (one year or older) and eight newborn calves. The proportion of newborn calves was 20% of those animals seen on transect. Four additional groups were identified as off transect; these were observed while investigating other clusters, or following tracks, or when flying B transects

The scarcity of muskoxen and the overall lack of observations prevented calculating a density estimate. Instead, we report a minimum count of 82 muskoxen (one year or older) for the BIC survey area in 2001.

3.2.1.2 Cornwallis Survey Area

Caribou

Ground Survey: The ground crew observed no caribou during 1,566 km (Table 2, Figure 14) of snowmobile travel on Cornwallis Island in 2002. However, the crew recorded four observations of caribou sign, including two feeding sites and two observations of caribou tracks.

Aerial Survey: We flew 619 km of transect on May 10-11, 2002 during the aerial survey of Cornwallis, Little Cornwallis, Milne, Crozier and Baring Islands (Figure 15) and observed only two clusters of Peary caribou (Table 4). Field notes indicate that these clusters may, be a duplicate count of a single adult female caribou. No other caribou or their sign (e.g., incidental observations) were observed from the air. Some areas of Cornwallis Island were excluded from the aerial survey based on ground reconnaissance. These areas were identified as ”not occupied by caribou” with zero observations of caribou or caribou sign.

The observation of the single caribou limits the results to a minimum count of one caribou (10 months or older) in the Cornwallis Island Group survey area during 2002.

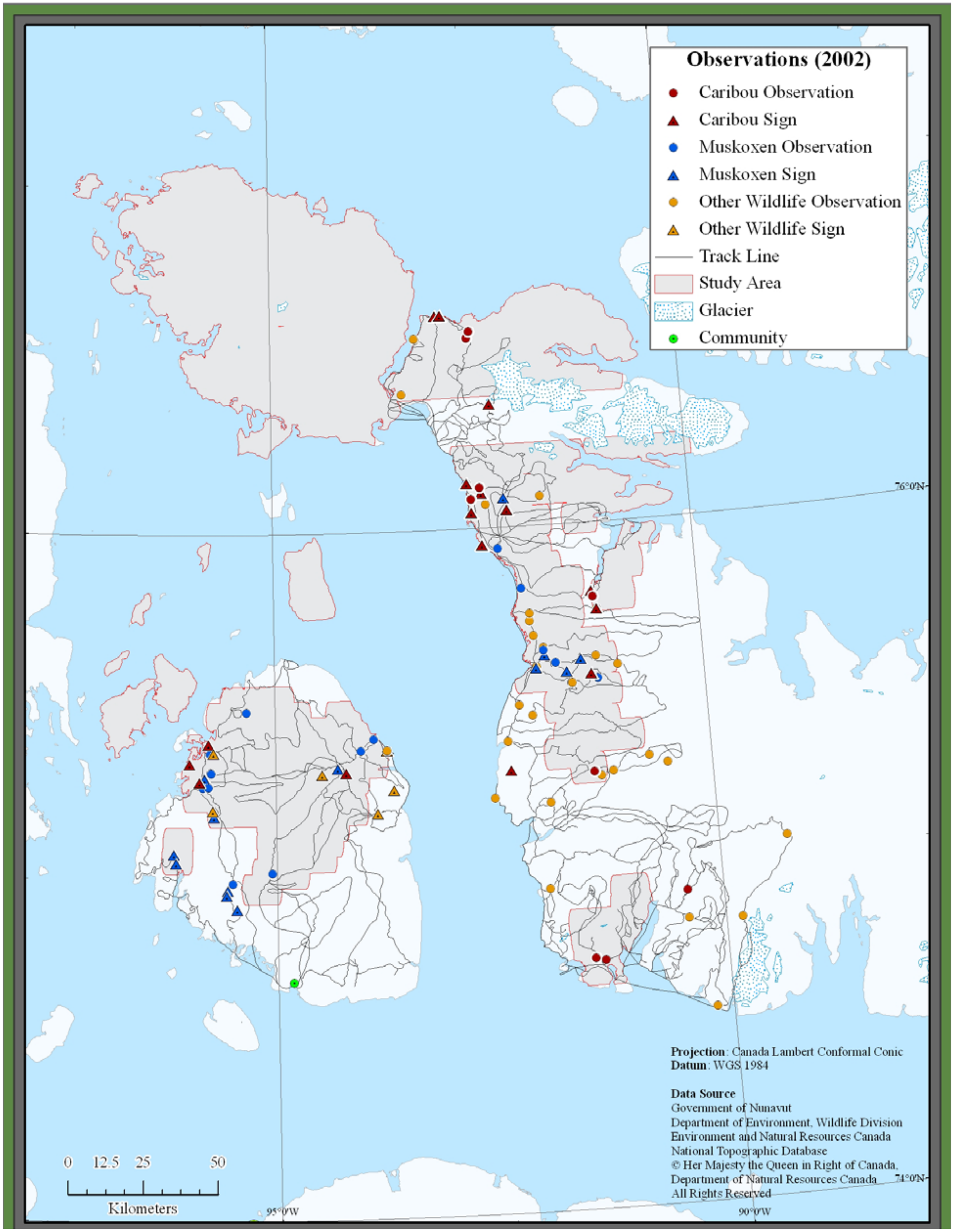


Figure 14: Ground survey observations within the Cornwallis Group and W. Devon survey area, 2002

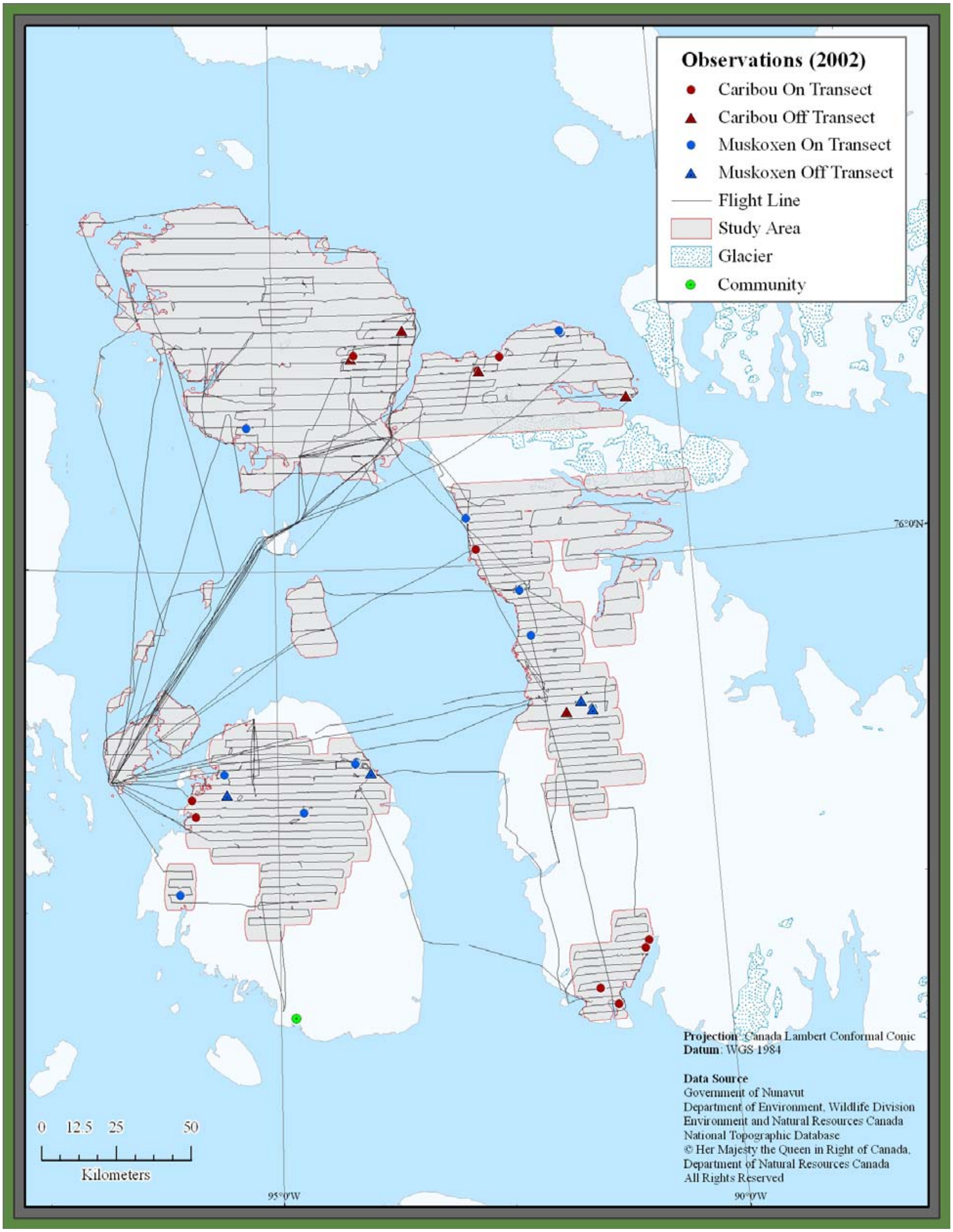


Figure 15: Aerial observations of Peary caribou and muskoxen clusters for the Cornwallis Group and W. Devon survey area, 2002.

Muskoxen

Ground Survey: In driving 1,566 km on Cornwallis Island, the ground crew observed eight clusters of muskoxen with 22 animals total (Table 3), or 5.11 clusters per 1000 km traveled. The crew also reported six observations of muskox tracks and nine feeding areas (Figure 14). One cluster of 4 adults and one newborn was observed in an area not surveyed by aerial methods. A minimum count of 4 is therefore reported for this area.

Aerial Survey: A total of seven clusters of muskoxen (18 animals with no newborns) were observed within the survey area during 619 km of flying (Table 5, Figure 15). Five of these clusters were observed on transect which is too few to derive a density estimate. Instead, we report a minimum count of 22 animals for the Cornwallis Island Group survey area in 2002, a figure which incorporates results from both the ground and aerial survey.

Of the muskoxen observed on transect, 15 were adults (1 year or older) and there were zero newborn calves. The proportion of newborn calves was 0% of those animals seen on transect

3.2.2 Devon Island Group

(Survey Areas - Devon, North Kent, Ballie Hamilton, and Dundas/Margaret Islands)

3.2.2.1 Devon Island Survey Area

Caribou

Ground Survey: After driving 3,642 km in 2002, the ground crew observed seven separate clusters of caribou for a total of 22 animals. This represents approximately 1.9 clusters/1000 km of ground surveyed. Caribou sign was also recorded, with tracks observed on five occasions, carcasses (or bones) recorded twice, and one feeding site noted (Table 2, Figure 14). One group of 5 caribou was observed in an area not surveyed by aerial methods in 2002.

Aerial Survey: Portions of the western coast of Devon Island were surveyed by air on May 8-30, 2002. A total of 2,218 km of (A) transects were flown and observations of Peary caribou and muskoxen recorded. Additional observations were collected during flights of secondary (B) transects and when following tracks (Figure 16). Within the survey area defined by the systematic A-transect design (12,316 km^2), 13 non-repeated clusters of Peary caribou were observed but only five of these were on transect (Figure 15). The total number of caribou was 35 animals (Table 4), with 18 seen on transect. Composition as estimated from the air was eight female and four male adults, three yearlings, three calves or ‘short yearlings’ and zero newborns. The proportion of calve or ‘short yearlings’ is 17% of those animals seen on transect. The ratio of adult males to females is 50:100.

Baille Hamilton Island was also surveyed in 2002 as part of the Devon Island Group (54 km of transect) and no caribou were observed.

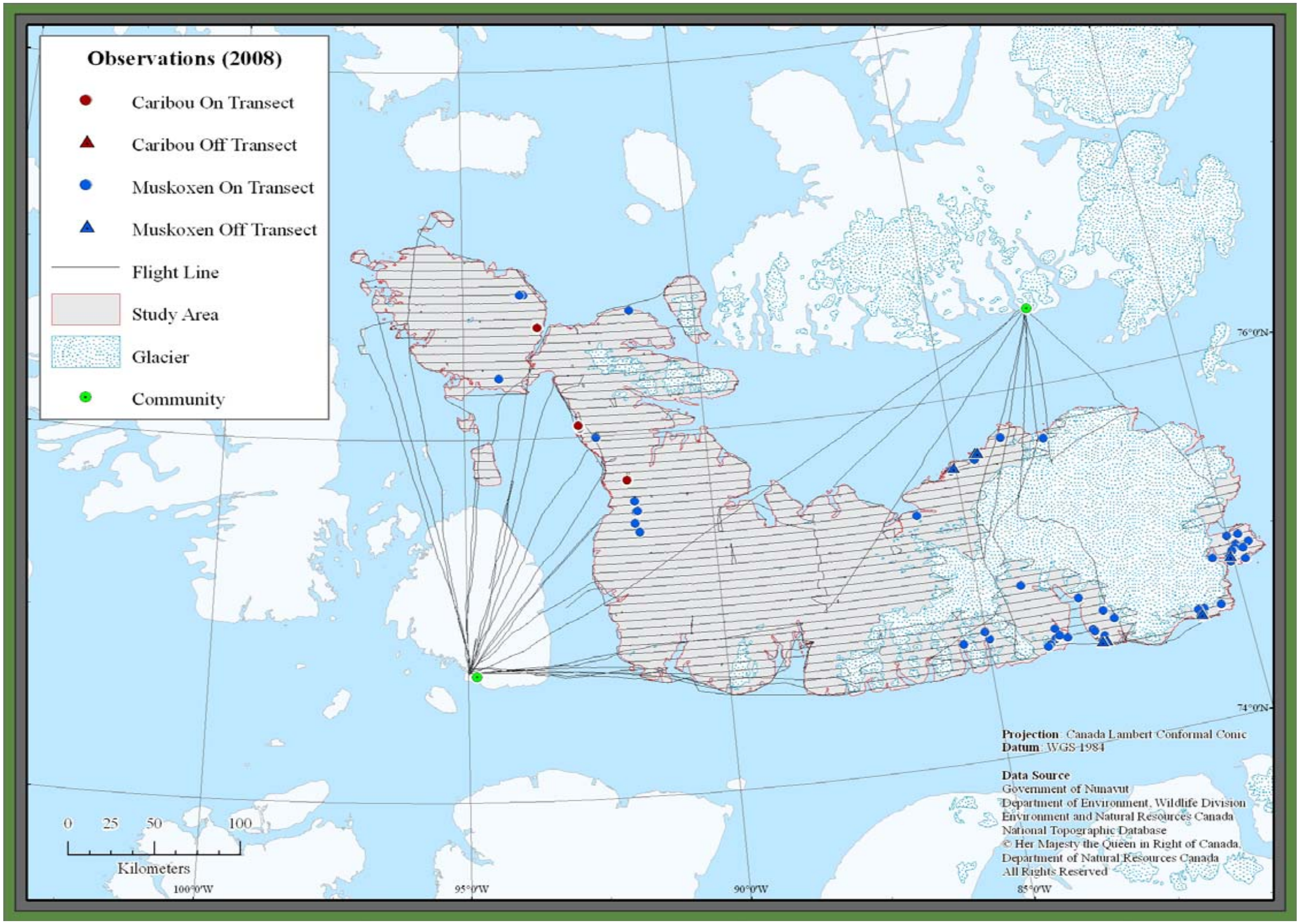


Figure 16: Aerial survey observations of Peary caribou and muskoxen clusters for the Devon Island Group, 2008.

Since there were so few observations of caribou clusters on transect, we were unable to use distance sampling methods to estimate caribou density. We report a minimum count of 40 caribou for the western coast of Devon Island in 2002. This result incorporates ground survey observations of caribou beyond the aerial survey area.

Given the overall size of Devon Island, the limited survey area covered in 2002, and Inuit reports of Peary caribou inhabiting other areas of the island (e.g., the Truelove Lowlands; Taylor 2005), a complete island survey was undertaken between April 22 and May 10, 2008. Flight effort (7,985 km) was applied systematically to all non-glaciated areas of Devon Island and small proximal islands (see Table 4). Additional flights totaling 150 km were made over North Kent, Baille Hamilton, Dundas and Margaret islands (Figure 16). Together, all flights yielded four observations of Peary caribou clusters representing 17 caribou in total, with all observations on transect and located in western Devon Island. Composition was eight female and 6 male adults, two yearlings, 1 calf or ‘short yearling’ and zero newborns. The proportion of calves or ‘short yearlings’ is 6 % of those animals seen on transect. The ratio of adult males to females is 75:100.

The scarcity of caribou and insufficient number of observations precluded estimation of population density and abundance. We report a minimum count of 17 caribou for the Devon Island Group in 2008.

Muskoxen

Ground Survey: After driving 3642 km in May 2002, 11 observations of muskoxen (a total of 54 animals including nine newborns) were recorded in west Devon Island (Table 3). This represents 3.02 clusters/1000 km traveled.

Aerial Survey: Portions of the west coast of Devon Island were surveyed by air from May 8-30, 2002. A total of 2,218 km of A transect were flown and 9 clusters of muskoxen, including 59 adults (one year or older) and 7 newborn calves were reported on transect. Unfortunately, due to the small number of observations, a density estimate could not be derived for muskoxen in this part of the Devon Island Group.

In 2008, as described above for caribou, the aerial survey was expanded across Devon Island (39,731 km^2, including small proximal islands) and to large off-shore islands (North Kent, Baille Hamilton, Dundas and Margaret; 945 km^2 in total for these). Between April 22 and May 10 of 2008, 61 observations of muskoxen were recorded on transect (354 adults [1 year or older] and 58 newborns): the proportion of newborn calves was 14%.

For analysis of muskoxen abundance in the Devon Island Group, we excluded the steep-walled islands of Baille Hamilton, North Kent, Dundas and Margaret, where no muskoxen were observed. We truncated the largest 10% of the distance data to address outliers and facilitate fitting the detection function. We selected the uniform model with single-order cosine adjustment as the best model (Table 7, Figure 17). This model had a non-significant goodness-of fit value (χ^2 = 0.5931, p= 0.74338), which indicated good fit of the data.

We estimated the probability of detecting a cluster of muskoxen within the defined area as P_a = 0.578 (95% CI 0.498-0.670). The estimated ESW was 1,143 m (95% CI 986-1326 m). The expected cluster size was 4.21 muskoxen/cluster (SE 0.49), whereas mean cluster size was 5.51 muskoxen/cluster (SE 0.52). The estimated density of muskoxen was 12.9 /1000 km^2 (95% CI 7.6-21.8/1000 km^2). Based on findings in the survey area (39,731 km^2) we estimated that there were 513 muskoxen one year or older (95%CI 302-864) throughout the Devon Island Group.

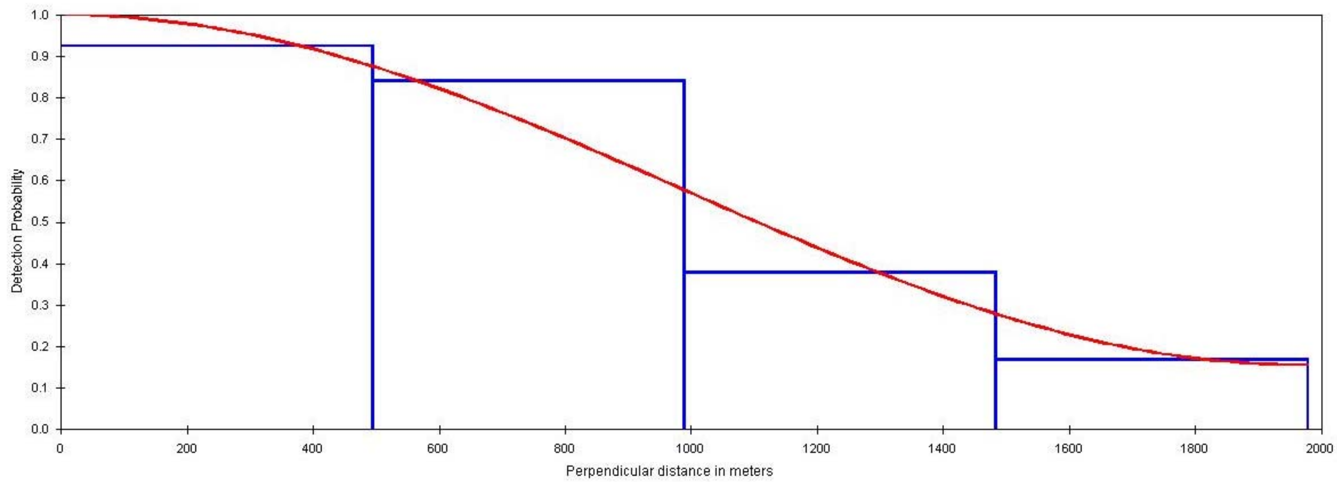


Figure 17: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of muskoxen in the Devon Island Group survey area, April-May 2008. The g(x) is estimated using a uniform model with cosine adjustment. Bin size is 495 m.

Table 7: Summary of candidate models used in the line-transect analysis for muskoxen of the Devon Island Group survey area, April-May 2008. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Devon - Muskoxen					**Density**			
Name	**Par**	**Delta AIC**	**AIC**	**ESW (m)**	**Caribou/km^2**	**95% LCI**	**95% UCI**	**CV**
Uniform Cosine	1	0.00	818.94	1143.65	0.0129	0.0077	0.0218	0.267
Uniform Simple Poly	2	0.98	819.92	1126.65	0.0132	0.0076	0.0230	0.285
Half-normal Hermite Poly	1	1.47	820.41	1135.07	0.0130	0.0076	0.0222	0.275
Half-normal Cosine	1	1.47	820.41	1135.07	0.0130	0.0076	0.0222	0.275
Hazard-rate Simple Poly	2	1.67	820.61	1113.23	0.0137	0.0076	0.0248	0.307
Hazard-rate Cosine	2	1.67	820.61	1113.23	0.0137	0.0076	0.0248	0.307

<u>3.2.3 Prince of Wales – Somerset Island Group</u>
(*Survey Areas* - *Prince of* Wales*, Russell, and Somerset islands*)

3.2.3.1 Prince of Wales Survey Area (incl. Russell Island)

Caribou

Ground Survey: Ground surveyors reported no caribou or caribou sign during 1,968 km of snowmobile travel on Prince of Wales Island during April 2004 (zero clusters/1000 km of ground surveyed) (Table 2, Figure 18).

Aerial Survey: An aerial survey of Prince of Wales Island, as well as Russell, Prescott, and Pandora Islands, was completed April10-18, 2004. A total of 3,430 km of A transect was flown across the islands and we saw no Peary caribou (Table 4, Figure 19).

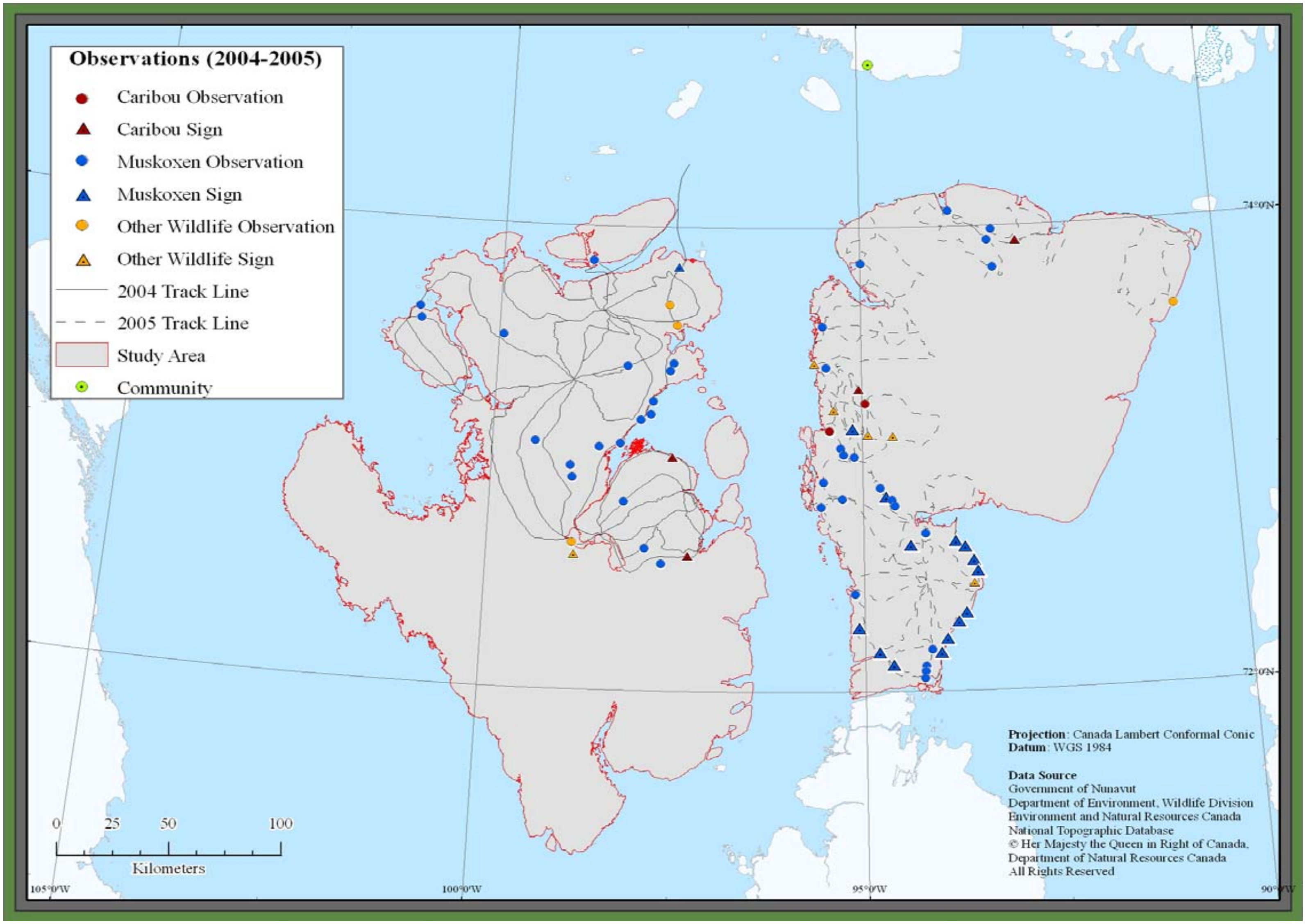


Figure 18: Ground survey observations within the Prince of Wales (2004) and Somerset Island (2005) survey areas.

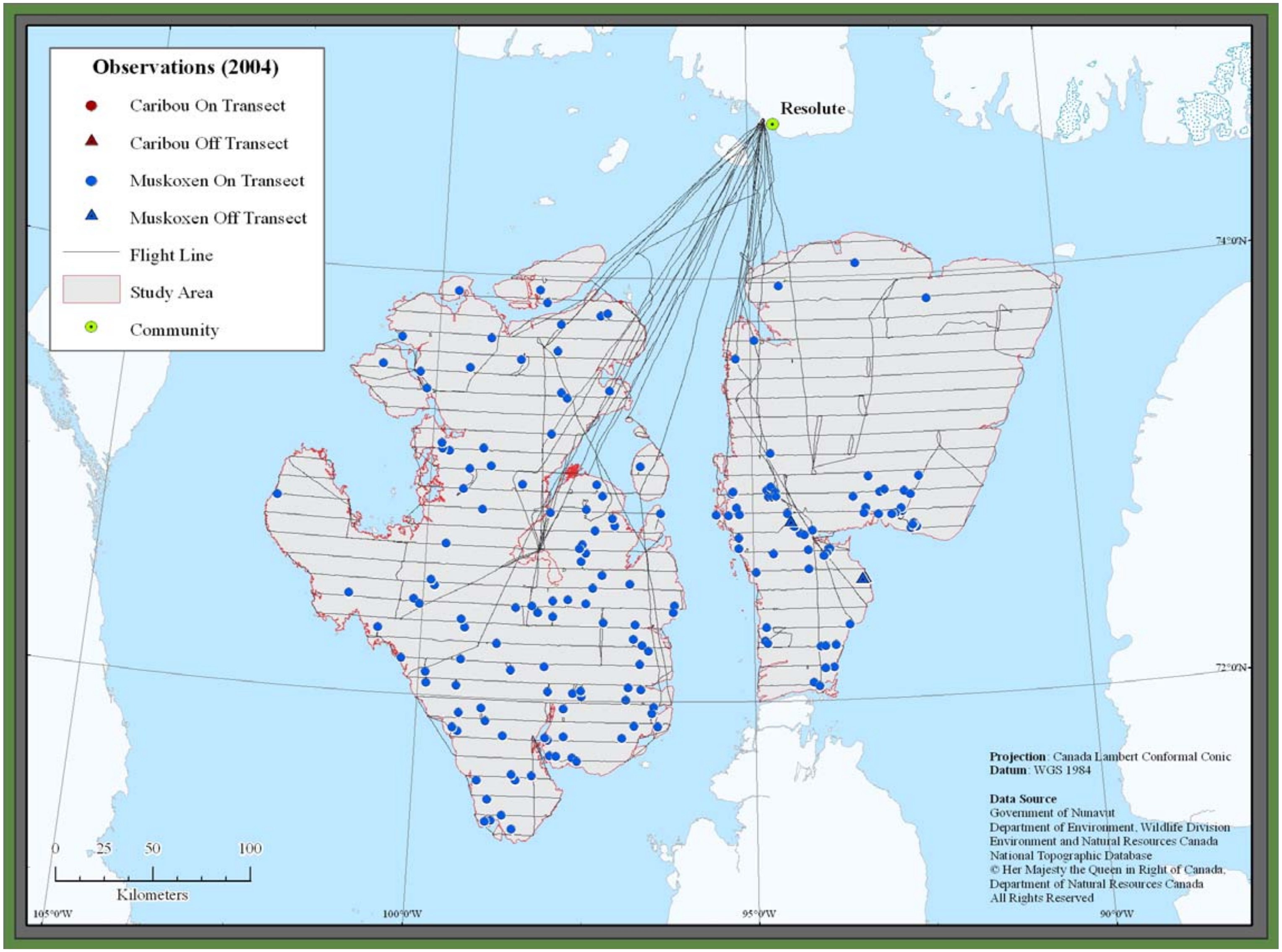


Figure 19: Aerial survey observations of Peary caribou and muskoxen clusters for the Prince of Wales - Somerset Island Group, 2004.

Muskoxen

Ground Survey: The ground crew recorded 14 clusters of muskoxen (160 individuals) on Prince of Wales Island during 1,968 km of snowmobiling in 2004 (Table 3, Figure 18). This represents an encounter rate of 7.11 muskoxen clusters/1000 km traveled. No other observations were recorded.

Aerial Survey: In April 2004, 111 clusters of muskoxen were observed on transect, in the Prince of Wales Island Group survey area with totals of 1,483 muskoxen (1 year or older) and 27 newborn calves (Table 5, Figure 19). The proportion of calves was 2%.

Preliminary analysis supported 5% truncation of the distance data. After truncation, the uniform key model with simple polynomial adjustment was selected as the final detection function (Table 8, Figure 20). The overall model χ^2 was non-significant, suggesting good fit of the data (χ^2 = 7.9149, p= 0.8491)

The probability of detecting a cluster of muskoxen in the defined area on either side of the transect in the Prince of Wales Island Group survey area was estimated as P_a = 0.736 (95% CI 0.656-0.827). The ESW was estimated to be 3438.5 m (95% CI 3062.5-3860.7 m). The expected cluster size was estimated at 13.39 muskoxen/cluster (SE 1.10), whereas mean cluster size was 13.49 muskoxen/cluster (SE 0.82).

The estimated density of muskoxen was 60/1000 km^2 (95% CI 45.5-79.0/1000 km^2). Given the survey area of 34,765 km^2 the estimated abundance was 2,086 (95% CI 1,582-2,746) muskoxen (one year and older) for the Prince of Wales Island Group in 2004.

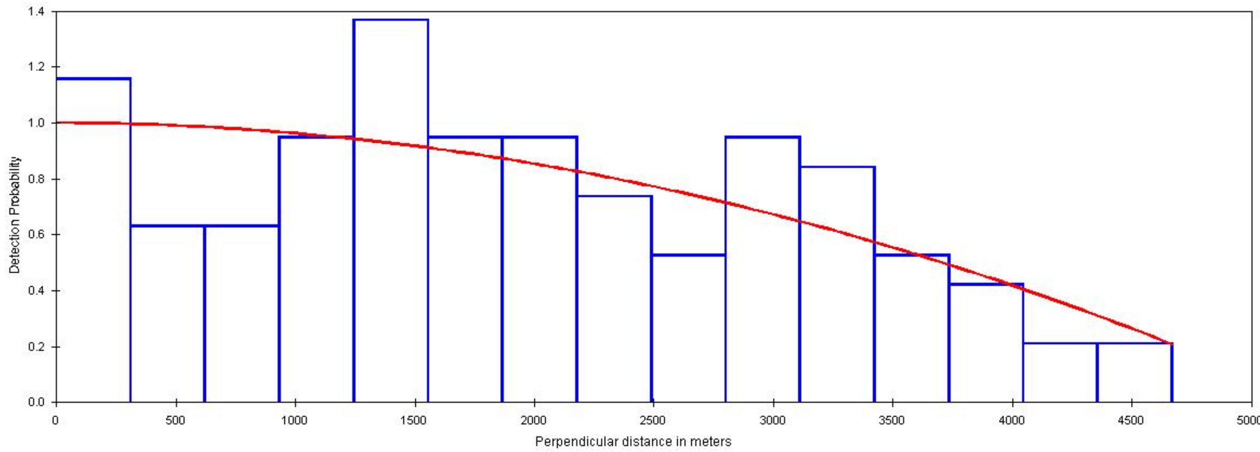


Figure 20: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of muskoxen observed within in the Prince of Wales Island survey area, April 2004. The g(x) is estimated using a uniform model with simple polynomial adjustment. Bin size is 311 m.

Table 8: Summary of candidate models used in the line-transect analysis for muskoxen of the Prince of Wales Island survey area, April 2004. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Prince of Wales - Muskoxen					**Density**			
Name	**Par**	**Delta AIC**	**AIC**	**ESW (m)**	**Caribou/Km²**	**95% LCI**	**95% UCI**	**CV**
Uniform Simple Poly	1	0.00	1764.18	3438.54	0.0600	0.0456	0.0790	0.139
Half-normal Hermite Poly	1	0.91	1765.09	3320.02	0.0622	0.0454	0.0851	0.159
Half-normal Cosine	1	0.91	1765.09	3320.02	0.0622	0.0454	0.0851	0.159
Hazard-rate Simple Poly	2	1.28	1765.46	3804.92	0.0542	0.0410	0.0718	0.142
Hazard-rate Cosine	2	1.28	1765.46	3804.92	0.0542	0.0410	0.0718	0.142
Uniform Cosine	2	1.93	1766.11	3457.14	0.0597	0.0403	0.0884	0.201

3.2.3.2 Somerset Island Survey Area

Caribou

Ground Survey: Ground surveyors observed two clusters of caribou (four individuals) during 2,863 km of travel on Somerset Island in 2005. This represents 0.7 clusters/1000 km of ground surveyed. One set of caribou tracks and one feeding site were also recorded (Table 2; Figure 18).

Aerial Survey: During April 20-25, 2004, an aerial survey of total transect length 2,420 km was conducted on Somerset Island. The survey crew detected no Peary caribou.

Muskoxen

Ground Survey: The ground crew reported 24 clusters of muskoxen (134 individuals) on Somerset Island in 2005. Given a survey effort of 2863 km, the estimated encounter rate is 6.98 clusters/1000 km. The crew observed 17 muskox carcasses (Table 3, Figure 18).

Aerial Survey: The aerial survey crew observed 66 clusters of muskoxen on transect in April 2004, representing 967 muskoxen (1 year or older) and 46 newborn calves (Table 5, Figure 19). The proportion of newborn calves was 5%.

Preliminary analysis of the distance data revealed no obvious outliers and right truncation at the largest observed distance from transect was applied. The uniform key model with single cosine adjustment was selected as the final detection function, with the lowest AIC score and a non-significant χ^2 value that suggested good fit of the data (χ^2 = 2.5576, p= 0.95899; Figure 21, Table 9)

The probability of detecting a cluster of muskoxen within the Somerset Island survey area was estimated as P_a = 0.610 (95% CI 0.511-0.729). The estimated ESW was 2193.9 m (95% CI 1836.5-2620.9 m). The expected cluster size was estimated at 12.5 muskoxen (SE= 1.35), whereas mean cluster size was 14.6 muskoxen (SE 1.49). The estimated density of muskoxen (one year and older) was 77.7/1000 km^2 (95% CI 39.2-154.5/1000 km^2). Based on finding in the Somerset Island survey area (24,549 km^2), the abundance estimate for muskoxen (one year and older) in 2004 was 1,910 (95% CI 962-3,792).

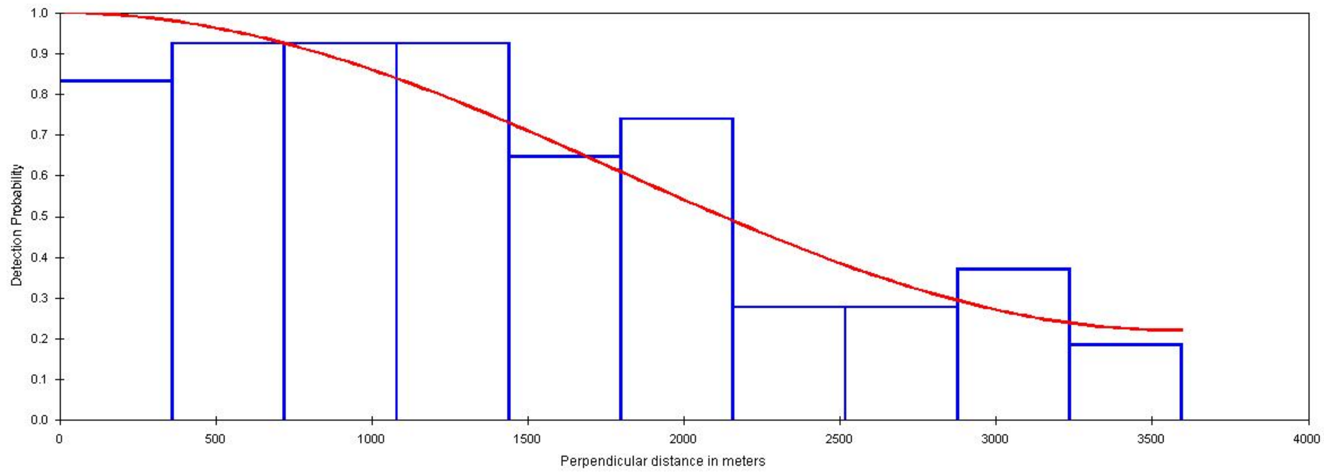


Figure 21: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of muskoxen in the Somerset Island survey area, April 2004. The g(x) is estimated using a uniform model with cosine adjustment. Bin size is 360 m.

Table 9: Summary of candidate models used in the line-transect analysis for muskoxen in the Somerset Island survey area, April 2004. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Somerset - Muskoxen **Name**	**Par**	**Delta AIC**	**AIC**	**ESW (m)**	**Density Caribou/km²**	**95% LCI**	**95% UCI**	**CV**
Uniform Cosine	1	0.00	1069.07	2193.90	0.0778	0.0392	0.1545	0.347
Half-normal Hermite Poly	1	0.07	1069.14	2256.73	0.0764	0.0381	0.1529	0.352
Half-normal Cosine	1	0.07	1069.14	2256.73	0.0764	0.0381	0.1529	0.352
Uniform Simple Poly	1	1.15	1070.23	2553.26	0.0700	0.0357	0.1374	0.339
Hazard-rate Simple Poly	2	1.37	1070.45	2436.85	0.0732	0.0363	0.1476	0.357
Hazard-rate Cosine	2	1.37	1070.45	2436.85	0.0732	0.0363	0.1476	0.357

<u>3.2.4 Ellesmere Island Group</u>

(Survey Areas - S. Ellesmere (incl. Graham Island) and N. Ellesmere)

3.2.4.1 Southern Ellesmere Island Survey Area

Caribou

Ground Survey: In 2005, ground crews traveled 1,662 km on southern Ellesmere Island, primarily on the Bjorne Peninsula north of the Sydcap Icecap. Harsh weather and difficult terrain limited travel to other areas. The crews observed six clusters of caribou (17 individuals) for an encounter rate of 3.6 clusters/1000 km (Table 2, Figure 22).

Aerial Survey: In May 4-30, 2005, we flew a total of 4,299 km of A transect distributed across southern Ellesmere Island and Graham Island (Figure 23). The survey area encompassed the entire landmass except glaciers and ice fields. During the flights, 19 clusters of caribou were observed on transect, representing a total of 57 caribou (Table 4). The majority of observations were made on Graham Island. The composition was 36 female and 17 male adults, 3 yearlings, zero calves or ‘short yearlings’, and zero newborns.   We recorded one adult of unknown sex. The proportion of calves or ‘short yearlings’ was zero, and the ratio of adult males to females was 47:100.

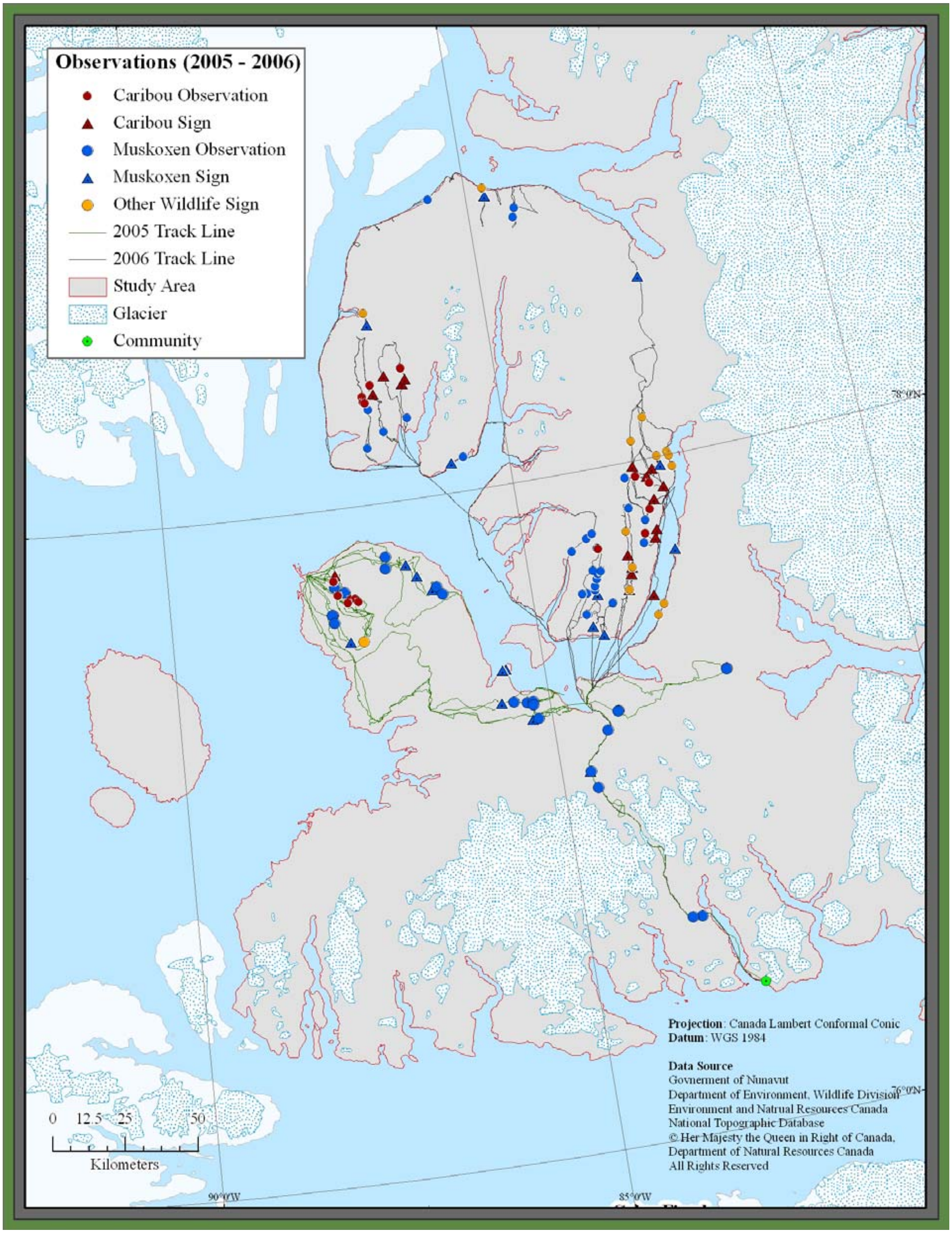


Figure 22: Ground survey observations within the Southern Ellesmere survey area, (2005) and Northern Ellesmere survey area (2006).

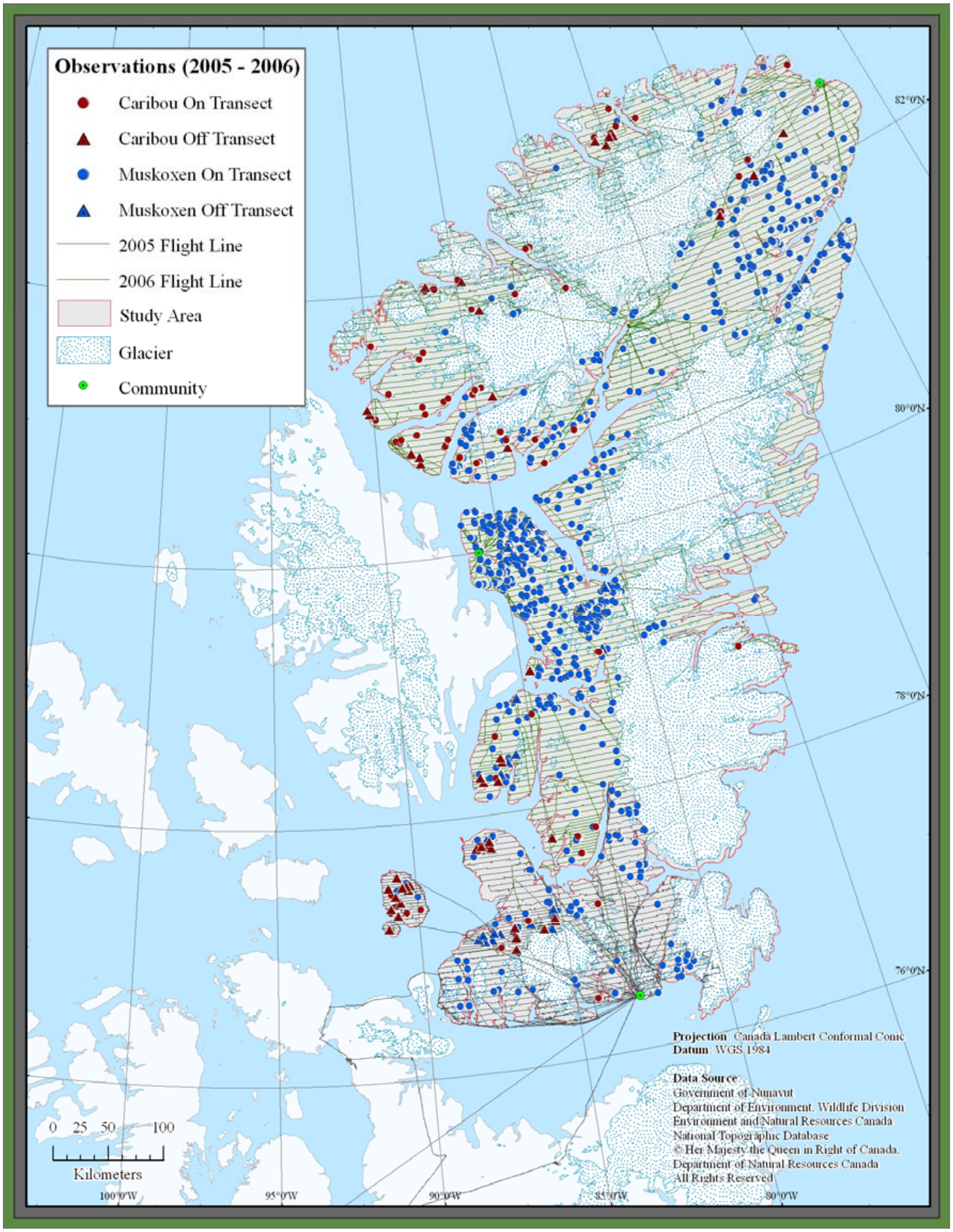


Figure 23: Peary caribou and muskox observations reported for aerial surveys of Southern Ellesmere survey area (2005) and Northern Ellesmere survey areas (2006).

Owing to the small number of observations and absence of outliers, the distance data were truncated at the largest distance from the transect line. We ran all recommended models (Buckland et al., 2001; Figure 24, Table 10) and the uniform key model with single-order cosine adjustment was selected as the final detection function. The selected model was non-significant, suggesting good fit of the data (χ^2 = 0.2394, p= 0.88720).

We estimated the probability of detecting a cluster of caribou on either side of any given transect line as P_a = 0.633 (95% CI 0.440–0.910). The ESW was estimated to be 655 m (95% CI 456–942 m). The expected cluster size was 2.75 caribou/cluster (SE 0.39), whereas mean cluster size was 3.0 caribou/cluster (SE 0.34). The estimated density of caribou in the Southern Ellesmere Island survey area was 9.2/1000 km^2 (95% CI 4.6–18.6/1000 km^2). Based on the area surveyed (23,767 km^2), the estimated abundance of caribou (10 months or older) throughout Southern Ellesmere Island in 2005 was 219 (95% CI 109-442).

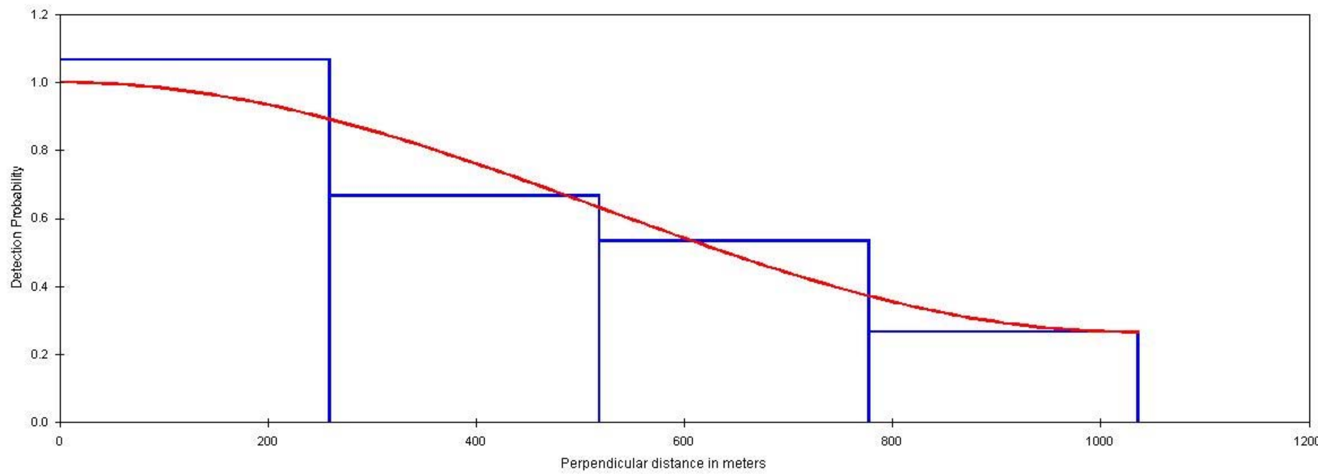


Figure 24: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of Peary caribou in the Southern Ellesmere Island survey area, May 2005. The g(x) is estimated using a uniform model with single cosine adjustment. Bin size is 259 m.

Table 10: Summary of candidate models used in the line-transect analysis for Peary caribou of the Southern Ellesmere Island survey area, May 2005. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Southern Ellesmere - Peary Caribou					Density			
Name	**Par**	**Delta AIC**	**AIC**	**ESW (m)**	**Carbiou/km^2**	**95% LCI**	**95% UCI**	**CV**
Uniform Cosine	1	0.00	262.28	655.76	0.0092	0.0046	0.0186	0.361
Half-normal Hermite Poly	1	0.32	262.60	676.39	0.0091	0.0045	0.0185	0.367
Half-normal Cosine	1	0.32	262.60	676.39	0.0091	0.0045	0.0185	0.367
Uniform Simple Poly	1	1.02	263.30	780.66	0.0082	0.0042	0.0157	0.338
Hazard-rate Simple Poly	2	1.20	263.49	486.09	0.0113	0.0034	0.0375	0.640
Hazard-rate Cosine	2	1.20	263.49	486.09	0.0113	0.0034	0.0375	0.640

Muskoxen

Ground Survey: In 2005, ground crews traveled 1,662 km in the south of Ellesmere Island, primarily on the Bjorne Peninsula north of the Sydcap Icecap. Harsh weather and difficult terrain limited travel to other areas. The crews observed 23 clusters of muskoxen (56 individuals) for an encounter rate of 13.84 clusters/1000 km traveled (Table 3, Figure 22). They also observed six carcasses.

Aerial Survey: In 2005, during 4,299 km of flying in the southern part of Ellesmere Island (Figure 23), we observed 99 muskoxen clusters with 273 muskoxen (1 year or older) and two newborns, all on transect (Table 4). The proportion of newborn calves is 2 %. Preliminary evaluation of the distance data supported truncating the largest 5% of these data. The half-normal key model with Hermite polynomial adjustment was selected as the final detection function, with the lowest AIC score and a non-significant $\chi 2$ that suggested good fit of the data ($\chi 2$ = 10.877, p= 0.5395; Figure 25, Table 11).

We estimated the probability of detecting a cluster of muskoxen on either side of any given transect line as P_a = 0.695 (95% CI 0.573–0.844). The estimated ESW was 1540.5 m (95% CI 1269.1–1869.9 m). The expected cluster size for the Southern Ellesmere Island survey area was 2.77 muskoxen/cluster (SE 0.20), whereas mean cluster size was 2.71 muskoxen/cluster (SE 0.38). The estimated density of muskoxen in the Southern Ellesmere Island survey area was 19.2/1000 km^2 (95% CI 13.1-

128.2/1000 km^2). Based on findings in this survey area (23,767 km^2), the estimated abundance of muskoxen (one year and older) throughout Southern Ellesmere Island in May 2005 was 456 (95% CI 312-670).

Notably, 19 separate clusters of muskox carcasses (20 carcasses total) were observed on transect during the aerial survey; a total of 40 muskox carcasses were reported during the 2005 aerial survey (Campbell 2006). Two observations of single adult muskoxen in very poor condition or dying were excluded from the analysis.

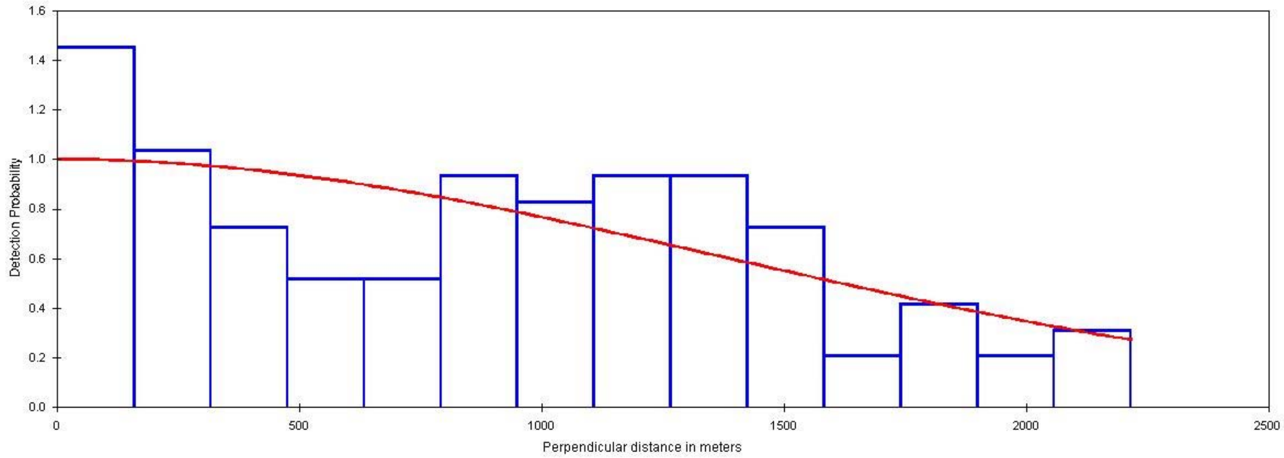


Figure 25: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of muskoxen in the Southern Ellesmere survey area, May 2005. The g(x) is estimated using a half-normal model with Hermite polynomial adjustment. Bin size is 158 m.

Table 11: Summary of candidate models used in the line-transect analysis for muskoxen of the Southern Ellesmere survey area, May, 2005. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Southern Ellesmere - Muskoxen					**Density**			
Name	**Par**	**Delta AIC**	**AIC**	**ESW (m)**	**Caribou/km^2**	**95% LCI**	**95% UCI**	**CV**
Half-normal Hermite Poly	1	0.00	1438.82	1540.49	0.0192	0.0131	0.0282	0.194
Half-normal Cosine	1	0.00	1438.82	1540.49	0.0192	0.0131	0.0282	0.194
Uniform Simple Poly	1	0.12	1438.94	1639.92	0.0181	0.0127	0.0257	0.178
Uniform Cosine	1	0.53	1439.36	1479.07	0.0201	0.0137	0.0292	0.192
Hazard-rate Simple Poly	2	0.89	1439.72	1748.81	0.0170	0.0118	0.0244	0.185
Hazard-rate Cosine	2	0.89	1439.72	1748.81	0.0170	0.0118	0.0244	0.185

3.2.4.2 Northern Ellesmere Island Survey Area

Caribou

Ground Survey: In 2006, ground crews snowmobiled 2,924 km in the northern part of Ellesmere Island, primarily on the Svendson Peninsula and observed 11 clusters of Peary caribou (44 individuals, Figure 22) for an encounter rate of 3.8 clusters/1000 km traveled. They also reported finding three caribou carcasses (Table 2). Travel in northern Ellesmere was limited by the remote location, harsh weather and terrain (Jeffery Qaunaq, personal communication, Sept 2010).

Aerial Survey: Crews flew a total of 17,535 km of A transects across the northern part of Ellesmere Island in 2006 (Figure 23). They recorded 72 clusters of caribou on transect with a total of 344 individual caribou, including 191 female and 108 male adults, 26 yearlings, zero calves or 'short yearlings', and zero newborns. An additional 19 unclassified adults were recorded. The survey team also recorded an additional 14 caribou clusters off transect (Table 4). The proportion of calves or 'short yearlings' was 0% of those animals seen on transect. The ratio of adult males to females was 56:100

To facilitate modeling of the data, we truncated distance observations at 1500 m, where detection probability was approximately 0.15 (Buckland *et al*., 2001). A half-normal key model with single cosine adjustment was selected as the final detection function (Table 12). The selected model was characterized by a small shoulder (Figure

26) and the overall model was non-significant, suggesting good fit of the data (χ^2 = 3.4776, p= 0.32368).

We estimated the probability of detecting a caribou cluster on either side of any given A transect line in the Northern Ellesmere Island survey area as P_a = 0.59057 (95% CI 0.48100–0.72500). The ESW was estimated to be 885.85 m (95% CI 721.51–1087.6 m). The expected cluster size was 4.10 caribou/cluster (SE 0.39), whereas mean cluster size was 4.57 caribou/cluster (SE 0.38). The estimated density of caribou in the Northern Ellesmere Island survey area was 8.3/1000 km^2 (95% CI 5.5-12.5/1000 km^2). Based on the area surveyed (96,567 km^2), our abundance estimate for caribou (10 months or older) throughout Northern Ellesmere Island in 2006 was 802 animals (95% CI 531-1207).

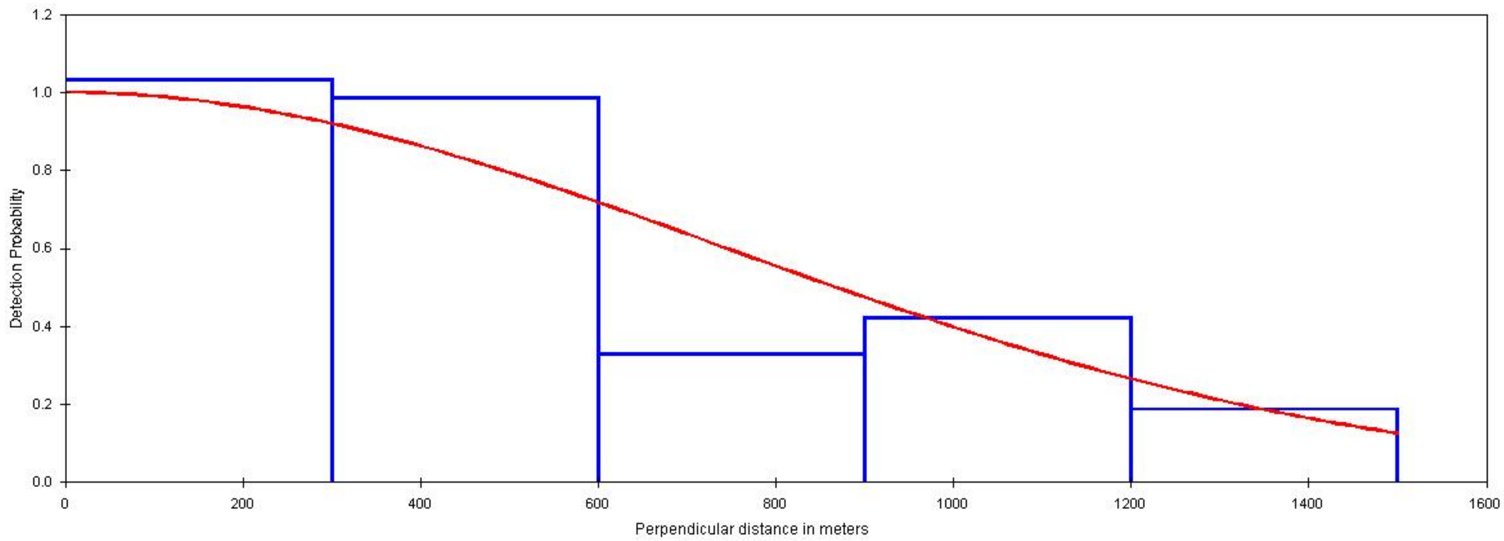


Figure 26: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of Peary caribou observed within the Northern Ellesmere survey area for April-May 2006. The g(x) is estimated using a half-normal key with cosine adjustment. Bin size is 300 m.

Table 12: Summary of candidate models used in the line-transect analysis for Peary caribou of the Northern Ellesmere survey area, April-May 2006. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Northern Ellesmere - Peary caribou Name	Par	Delta AIC	AIC	ESW (m)	Density Caribou/km^2	95% LCI	95% UCI	CV
Half-normal Cosine	1	0.00	906.60	885.85	0.0083	0.0055	0.0125	0.210
Half-normal Hermite Poly	1	0.00	906.60	885.85	0.0083	0.0055	0.0125	0.210
Uniform Cosine	1	0.29	906.89	891.02	0.0082	0.0056	0.0122	0.202
Uniform Simple Poly	1	1.22	907.82	1011.54	0.0076	0.0053	0.0111	0.191
Hazard-rate Simple Poly	2	1.51	908.11	791.05	0.0088	0.0050	0.0153	0.289
Hazard-rate Cosine	2	1.51	908.11	791.05	0.0088	0.0050	0.0153	0.289

Muskoxen

Ground Survey: In 2006, ground crews snowmobiled 2,924 km of the northern portion of Ellesmere Island, primarily on the Svendson Peninsula, and observed 27 clusters of muskoxen (203 individuals: Figure 22) for an encounter rate of 9.2 clusters/1000 km traveled. They also recorded three muskox carcasses (Table 3). Additional travel in the region was limited by the remote location, harsh weather and terrain (Jeffery Qaunaq, personal communication, Sept 2010)

Aerial Survey: Flights were conducted totaling 17,535 km of A transects across the north of Ellesmere Island (Figure 23) in 2006. The crews observed 645 clusters of muskoxen on transect with totals of 4,999 muskoxen (1 year or older) and 907 newborn calves (Table 5). Based on preliminary analysis of the observations, 5% of the observations farthest from the transect line were discarded. A half-normal key model with single cosine adjustment was selected as the final detection function (Table 13). The selected model was characterized by a shoulder (Figure 27) and the overall model was non-significant, suggesting good fit of the data (χ^2 = 2.4211, p = 0.93292).

We estimated the probability of detecting a cluster of muskoxen on either side of any given A transect as P_a = 0.494 (95% CI 0.445-0.549). The estimated ESW was 1381.7 m (95% CI 1244.4-1534.1 m). The expected cluster size was calculated at 6.64 muskoxen (SE 0.25), whereas mean cluster size was 7.51 muskoxen. The estimated density for muskoxen in the Northern Ellesmere Island survey area is 84.0/1000 km^2

(95% CI 68.7-102.8/1000 km^2). Based on the non-glaciated survey area (96,567 km^2), our estimate for abundance of muskoxen (one year and older) throughout Northern Ellesmere Island in 2006 was 8,115 (95% CI 6,632-9,930).

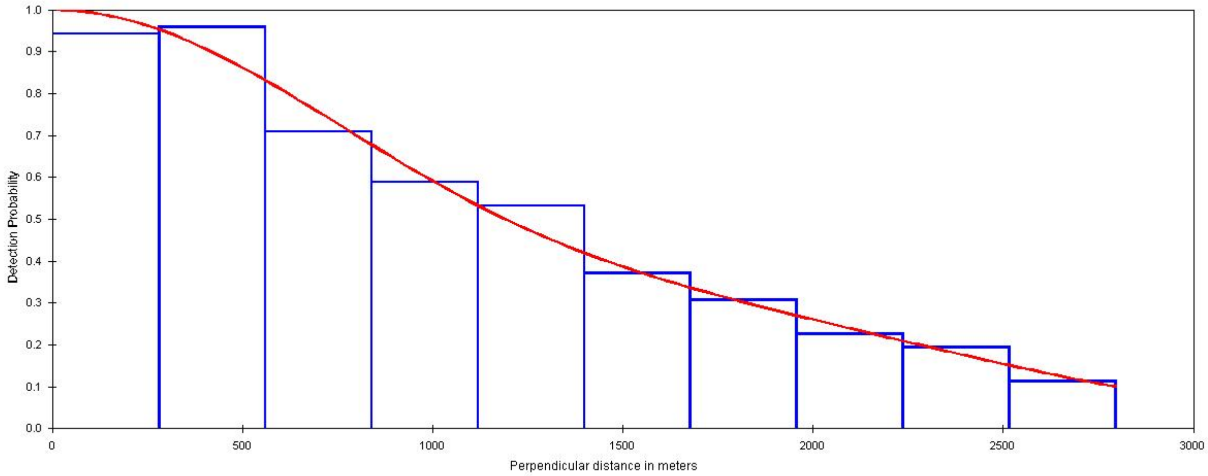


Figure 27: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of muskoxen in the Northern Ellesmere survey area, April-May 2006. The g(x) is estimated using a half-normal model with cosine adjustment. Bin size is 280 m.

Table 13: Summary of candidate models used in the line-transect analysis for muskoxen of the Northern Ellesmere survey area, April-May 2006. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Northern Ellesmere - Muskoxen					**Density**			
Name	**Par**	**Delta AIC**	**AIC**	**ESW (m)**	**Caribou/km^2**	**95% LCI**	**95% UCI**	**CV**
Half-normal Cosine	2	0.00	9518.26	1381.69	0.0840	0.0687	0.1028	0.103
Uniform Cosine	3	0.99	9519.25	1362.46	0.0848	0.0691	0.1040	0.104
Hazard-rate Simple Poly	3	1.88	9520.14	1432.48	0.0819	0.0658	0.1018	0.111
Hazard-rate Cosine	2	2.14	9520.40	1442.23	0.0816	0.0664	0.1003	0.105
Half-normal Hermite	1	4.16	9522.42	1550.12	0.0778	0.0647	0.0935	0.093
Uniform Simple Poly	3	5.65	9523.91	1491.84	0.0798	0.0660	0.0966	0.097

<u>3.2.5 Axel Heiberg Island Group</u>
(Survey Area - Axel Heiberg Island)

3.2.5.1 Axel Heiberg Survey Area

Caribou

Ground Survey: A ground survey was not completed within this Island Group.

Aerial Survey: In total 5,872 km of transect were flown across the Axel Heiberg Island Group in 2007 (Figure 28). We observed 120 clusters of caribou on transect, with a total of 642 individual caribou that included 379 female and 242 male adults (possibly some yearlings and short yearlings), 17 calves or ‘short yearlings’, and zero newborns. In addition, 4 adults of unknown sex where recorded. The proportion of calves or ‘short yearlings’ is uncertain as some groups were not aged due to rugged terrain and animal care protocols. The ratio of adult males to females is 64:100 (but may include members from other cohorts). An additional four caribou clusters were observed off transect (Table 4).

After preliminary analysis of the distance data, observations exceeding 1400 m from transect were discarded to address outliers. Several robust models were run and the half-normal key model with single-order cosine adjustment was selected as the final detection function in accordance with AIC (Figure 29, Table 14). The Chi-square goodness-of-fit test was non-significant, suggesting good fit of the data (χ^2 = 2.21, p= 0.69634).

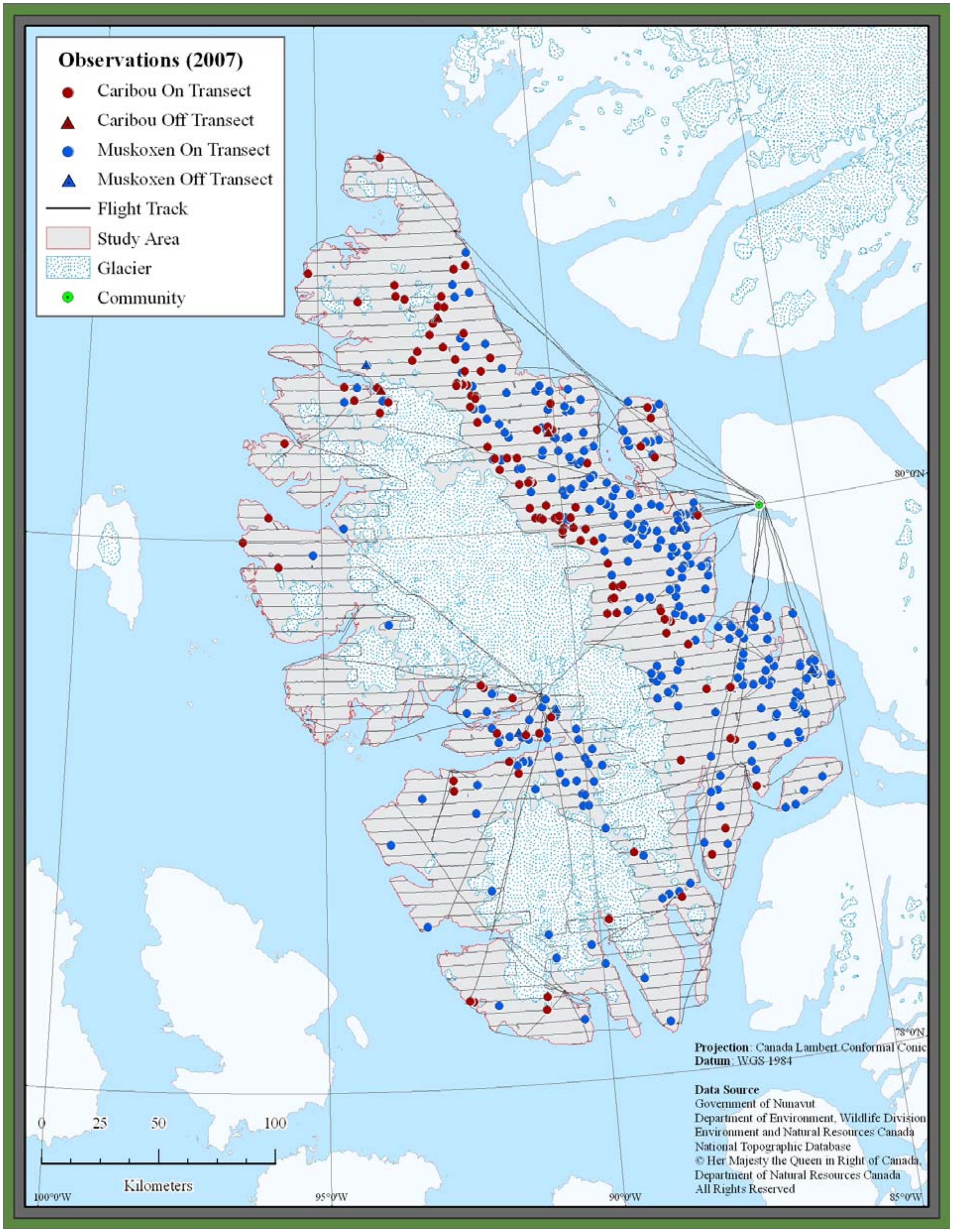


Figure 28: Aerial survey observations of Peary caribou and muskoxen clusters for the Axel Heiberg Island Group, 2007.

We estimated the probability of detecting a cluster of caribou on either side of any given A transect line as P_a = 0.402 (95% CI 0.325–0.498). The ESW was calculated as 563.59 m (95% CI 455.72–696.99 m). Mean cluster size was 5.31 caribou/cluster (SE 0.32), which was the largest value for this parameter among all survey strata in our entire study. The estimated density of caribou (approximately 10 months or older) in the Axel Heiberg Island Group survey area was 74.2/1000 km^2 (95% CI 53.1–103.9/1000 km^2). Based on the survey area of 30,877 km^2, the estimated abundance of Peary caribou inhabiting the Axel Heiberg Island Group in 2007 was 2,291 (95% CI 1,636-3,208).

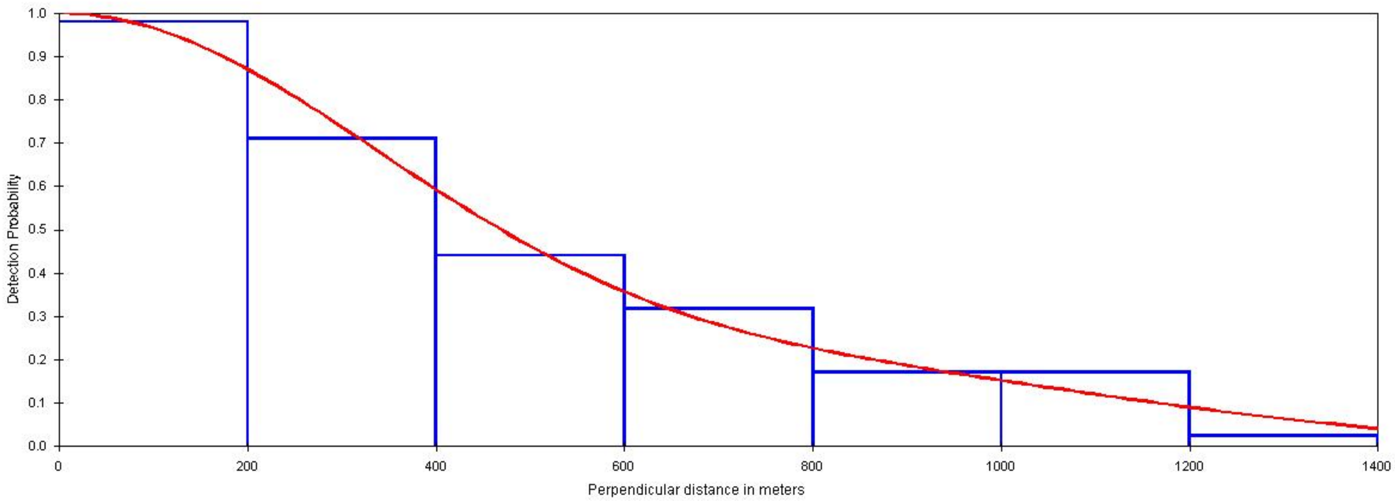


Figure 29: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of Peary caribou in the Axel Heiberg Island Group, April-May 2007. The g(x) is estimated using a uniform model with cosine adjustment. Bin size is 200 m.

Table 14: Summary of candidate models used in the line-transect analysis (October, 2009) for Peary caribou of the Axel Heiberg Island Group, April-May 2007. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Axel Heiberg - Peary caribou Name	Par	Delta AIC	AIC	ESW (m)	Density Caribou/km^2	95% LCI	95% UCI	CV
Half-normal Cosine	2	0.00	1601.01	563.59	0.0742	0.0531	0.1039	0.172
Half-normal Hermite Poly	1	0.49	1601.50	655.79	0.0666	0.0496	0.0893	0.150
Uniform Cosine	3	0.72	1601.72	538.29	0.0769	0.0549	0.1077	0.172
Hazard-rate Simple Poly	2	1.78	1602.78	644.24	0.0686	0.0490	0.0960	0.172
Hazard-rate Cosine	2	1.78	1602.78	644.24	0.0686	0.0490	0.0960	0.172
Uniform Simple Poly	1	8.52	1609.53	853.86	0.0543	0.0414	0.0712	0.138

Muskoxen

Ground Survey: A ground survey was not completed within the Axel Heiberg Island Group.

Aerial Survey: In total 5,872 km of transect were flown across the Axel Heiberg Island Group in 2007 (Figure 28). During the survey, 301 clusters of muskoxen were observed on-transect, with totals of 2,653 muskoxen (1 year or older) and 396 newborn calves (Table 5). We encountered our first newborn on April 22, 2007 and the overall proportion of newborn calves was 13%.

Analysis of the distance data supported 5% right truncation. We considered several robust models of the detection function (Table 15, Figure 30) and used AIC, which identified a half-normal key function with Hermite polynomial adjustment as the best model. A non-significant goodness-of-fit test ($\chi 2 = 9.0817$, $p = 0.82578$) supported model selection.

We estimated the probability of detecting a muskox cluster on either side of an A transect as $P_a = 0.636$ (95%CI 0.573-0.705). The ESW was calculated as 1547.6 (95%CI 1395-1716.9). The expected cluster size was estimated at 8.68 muskoxen/cluster (SE 0.53), whereas the mean cluster size was 8.69 muskoxen/cluster (SE 0.43). The estimated density of muskoxen in the Axel Heiberg Island Group survey area was 137.2 muskoxen/1000 km^2 (95%CI 109.2 –172.5). Based on the area surveyed (30,877 km^2), the estimated abundance of muskoxen (1 year and older) throughout the Axel Heiberg Island Group in 2007 was 4,237 (95% CI 3,371-5,325).

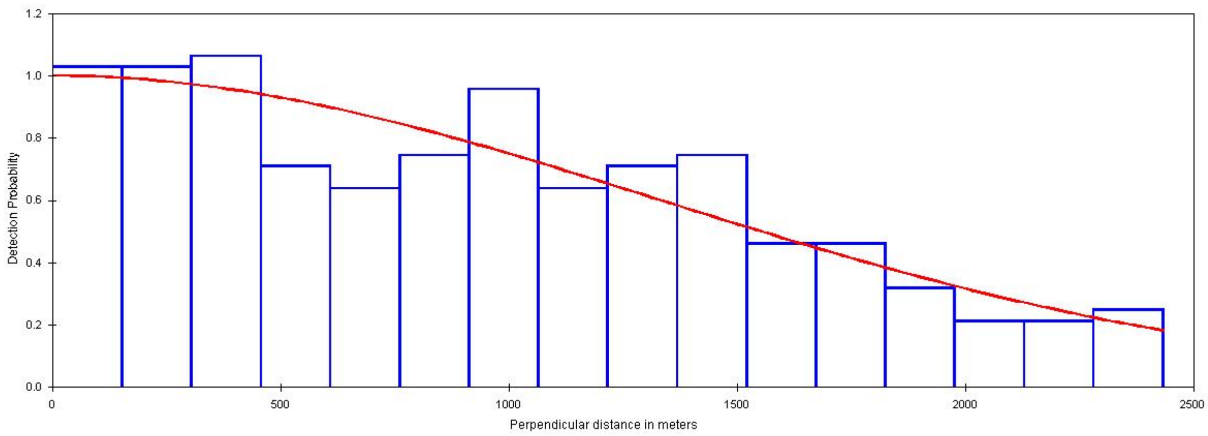


Figure 30: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of muskoxen in the Axel Heiberg Island Group survey area in April-May 2007. The g(x) is estimated using a half-normal model with Hermite polynomial adjustment. Bin size is 152 m.

Table 15: Summary of candidate models used in the line-transect analysis for muskoxen of the Axel Heiberg Island Group survey area, April-May 2007. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Axel Heiberg - Muskoxen Name	Par	Delta AIC	AIC	ESW (m)	Density Caribou/km²	95% LCI	95% UCI	CV
Half-normal Hermite Poly	1	0.00	4421.99	1547.60	0.1372	0.1092	0.1725	0.116
Half-normal Cosine	1	0.00	4421.99	1547.60	0.1372	0.1092	0.1725	0.116
Uniform Cosine	1	0.28	4422.27	1496.33	0.1419	0.1137	0.1772	0.113
Uniform Simple Poly	3	0.64	4422.63	1661.92	0.1278	0.0989	0.1651	0.131
Hazard-rate Simple Poly	2	1.90	4423.89	1756.59	0.1209	0.0964	0.1517	0.115
Hazard-rate Cosine	2	1.90	4423.89	1756.59	0.1209	0.0964	0.1517	0.115

3.2.6 Ringnes Island Group

(Survey Areas - *Ellef Ringnes, Amund Ringnes, Cornwall, King Christian, Meighen, and Lougheed Islands)*

3.2.6.1 Ellef Ringnes, Amund Ringnes, Cornwall, King Christian, and Meighen Survey Area

Caribou

Ground Survey: A ground survey was not completed in 2007 for this survey area.

Aerial Survey: During April 6-22, 2007, we flew 4,076 km of transect across Ellef Ringnes, Amund Ringnes, Cornwall, King Christian, and Meighen Islands (Figure 31). The survey area encompassed all the landmasses except glaciers and ice fields. The crew observed 28 clusters of caribou (74 individual caribou) on transect, with a range of 0-14 observations per island (Table 4). The composition estimated from on-transect observations was 32 female and 32 male adults (possibly included some yearlings), 10 calves or 'short yearlings' and zero newborns. The proportion of calves or 'short yearlings' was 14% of those animals seen on transect. The ratio of adult males to females is 100:100.

We pooled the data across these islands and post-stratified our analysis by island to estimate a combined detection function, cluster size, and density. As preliminary analysis revealed no obvious outliers, we truncated the distance data at the largest perpendicular distance from the transect (Table 16, Figure 32). The uniform model with cosine adjustment was identified as the best model, characterized by a pronounced shoulder and a non-significant $\chi 2$, suggesting good fit of the data ($\chi 2$ = 0.6741, p= 0.95448). The probability of detecting a cluster of caribou on either side of the A transects was P_a = 0.575 (95% CI 0.453-0.729). The ESW was estimated at 665.59 m (95%CI524.96-843.88 m). The expected cluster size was 2.72 caribou/cluster (SE 0.35), whereas mean cluster size was 2.64 caribou/cluster (SE 0.28).

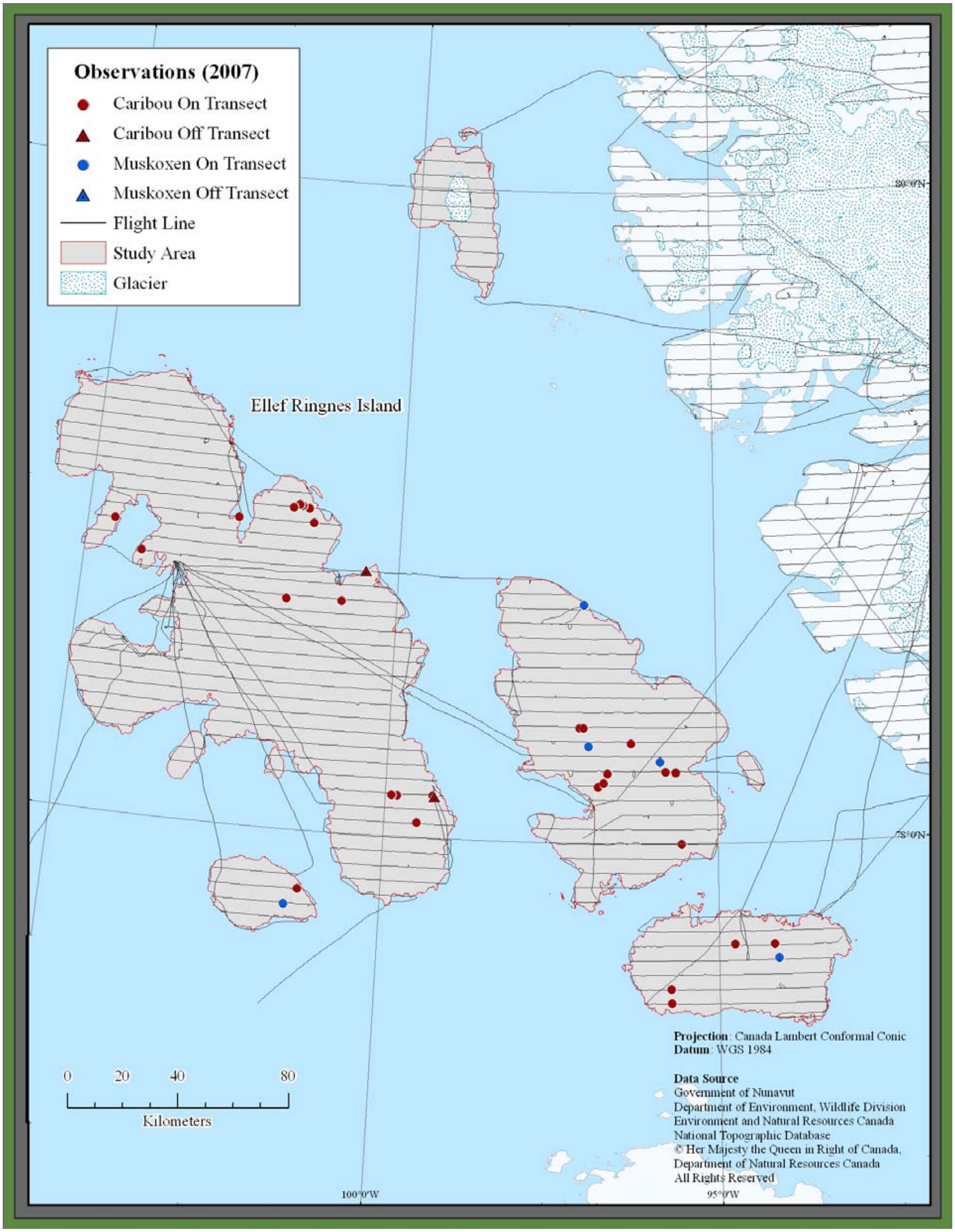


Figure 31: Aerial survey observations of Peary caribou and muskoxen clusters for the Ringnes Island Group survey area, 2007.

The estimated density of caribou detected in the Ringnes Island Group survey area was 13.6/1000 km^2 (95% CI 7.6-24.4/1000 km^2) and the estimated abundance of caribou (10 months or older) on the five islands in 2007 was 282 caribou (95% CI 157-505). Density estimates for each island were derived but not reported due to high uncertainty. This was a consequence of low encounter rates, small sample size, and the low number of observations per island.

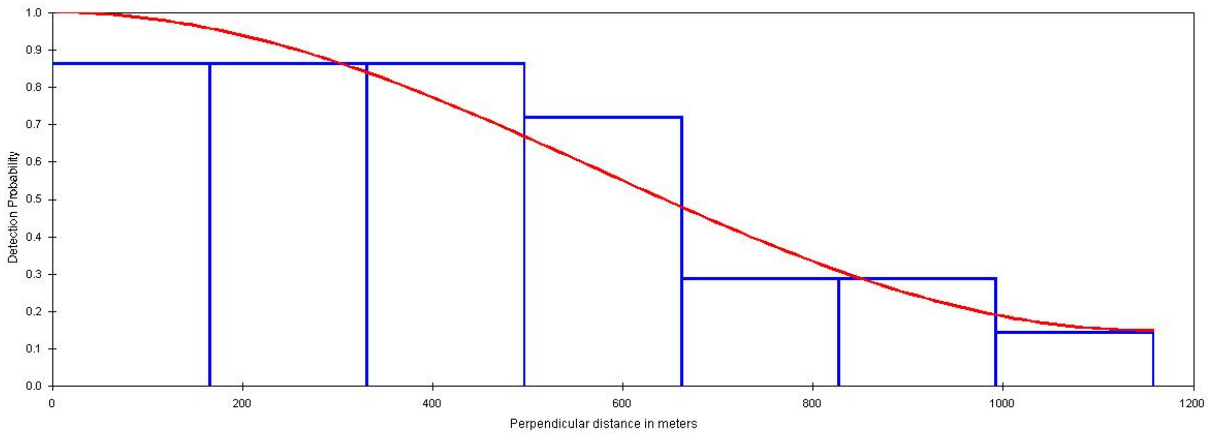


Figure 32: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of Peary caribou on the Ringnes Island Group survey area in April 2007. The g(x) is estimated using a uniform model with cosine adjustment. Bin size is 165 m.

Table 16: Summary of candidate models used in the line-transect analysis for Peary caribou of the Ringnes Island Group survey area, April 2007. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Ellef, Amund, King Christian, Cornwall, Meighen - Peary caribou Name	Par	Delta AIC	AIC	ESW (m)	Density Caribou/km^2	95% LCI	95% UCI	CV
Uniform Cosine	1	0.00	389.21	665.59	0.0136	0.0076	0.0244	0.300
Half-normal Hermite Poly	1	0.41	389.62	685.33	0.0132	0.0071	0.0246	0.319
Half-normal Cosine	1	0.41	389.62	685.33	0.0132	0.0071	0.0246	0.319
Uniform Simple Poly	2	1.58	390.79	655.67	0.0138	0.0075	0.0257	0.319
Hazard-rate Simple Poly	2	1.93	391.14	783.53	0.0116	0.0063	0.0214	0.318
Hazard-rate Cosine	2	1.93	391.14	783.53	0.0116	0.0063	0.0214	0.318

Muskoxen

Ground Survey: A ground survey was not completed in 2007

Aerial Survey: Throughout 4,076 km of transect flown across the five islands in the Ringnes Island Group in April 2007 (Figure 31), five clusters of muskoxen were observed (Ellef Ringnes zero clusters, Amund Ringnes three clusters, King Christian one cluster, Cornwall one cluster, and Meighen zero clusters) for a total of 21 individuals (one year and older). No newborn calves were observed. Due to scarcity of muskoxen and the small number of observations, it was not possible to derive a density estimate for this survey area. Instead, we report a minimum count of muskoxen for each island surveyed (Table 5).

3.2.6.2 Lougheed Island Survey Area

Caribou

Ground Survey: A ground survey was not carried out in the Lougheed Island Group.

Aerial Survey: On April 13, 2007 we flew 287 km across the Lougheed Island Group and observed 32 clusters of caribou (131 individuals) on transect (Figure 33). Composition was 62 female and 51 male adult caribou (possibly included yearlings), 18 calves or ‘short yearlings’ and zero newborns. The proportion of calves or ‘short yearlings' is 14% of those animals seen on transect. The ratio of adult males to females was 82:100

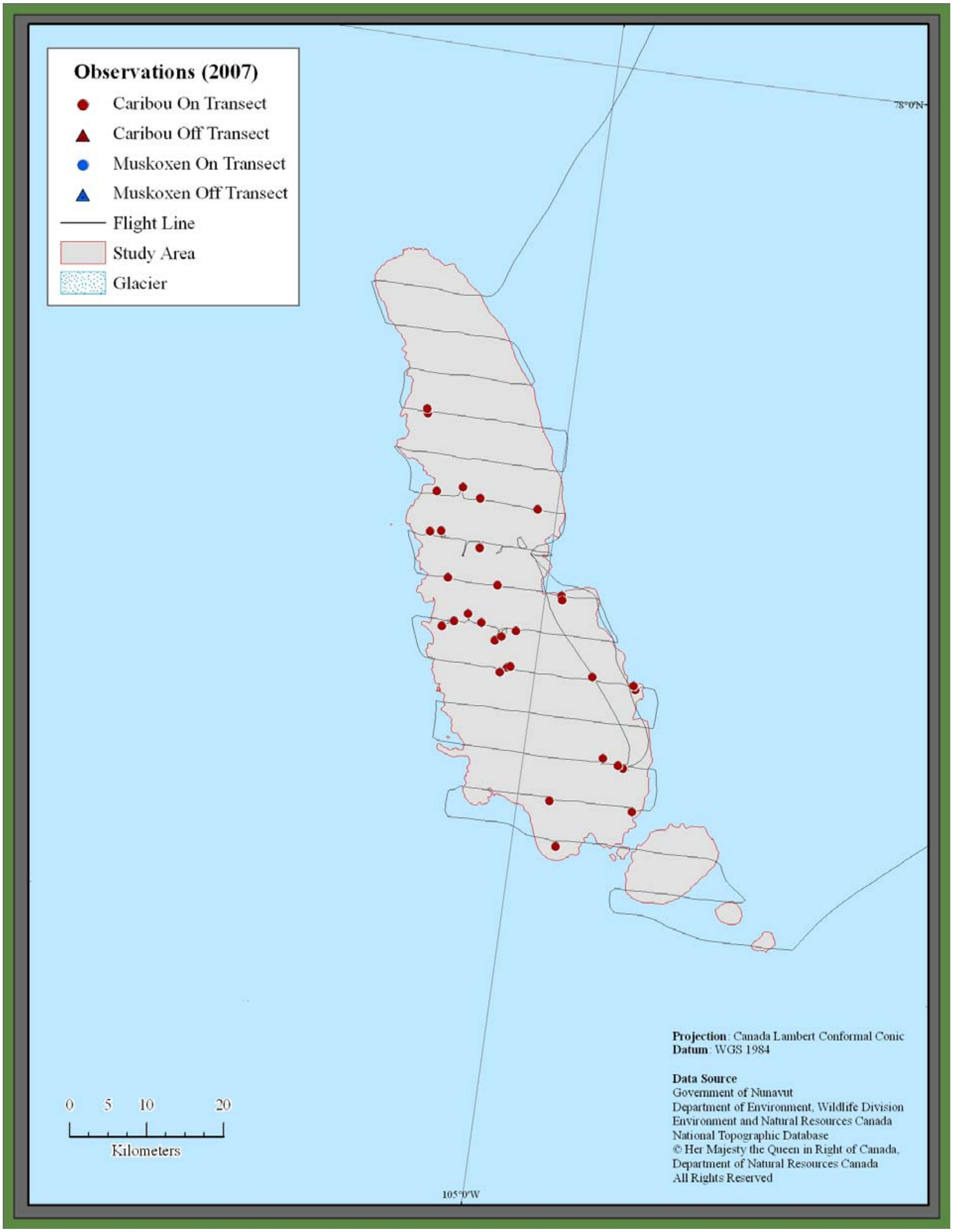


Figure 33: Peary caribou and muskox observations reported for aerial surveys of the Lougheed Island survey area in 2007.

For analysis, we applied 5% right truncation to address outliers (Buckland et al., 2001). From a series of models, we selected the uniform key model with single-order cosine adjustment as the final detection function (Table 17). This model was characterized by a small shoulder (Figure 34) and the Chi-square goodness-of-fit test was non-significant, suggesting good fit of the data (χ^2 = 0.1679, p= 0.98260).

The probability of detecting a cluster of caribou within the defined area on each side of the transect was estimated as P_a = 0.59524 (95%CI 0.47108-0.75212). The expected cluster size was 3.31 caribou/cluster (SE= 0.52), whereas mean cluster size was 4.07 caribou/cluster (SE 0.55). The ESW was estimated as 658.93 m (95% CI 521.49-832.6 m). The estimated density of caribou in the Lougheed Island Group survey area was 262.6/1000 km^2 (95% CI 145-475 caribou/1000 km^2). Based on the area surveyed (1,415 km^2), the estimated abundance of Peary caribou throughout the Lougheed Island Group in 2007 was 372 (95%CI 205-672).

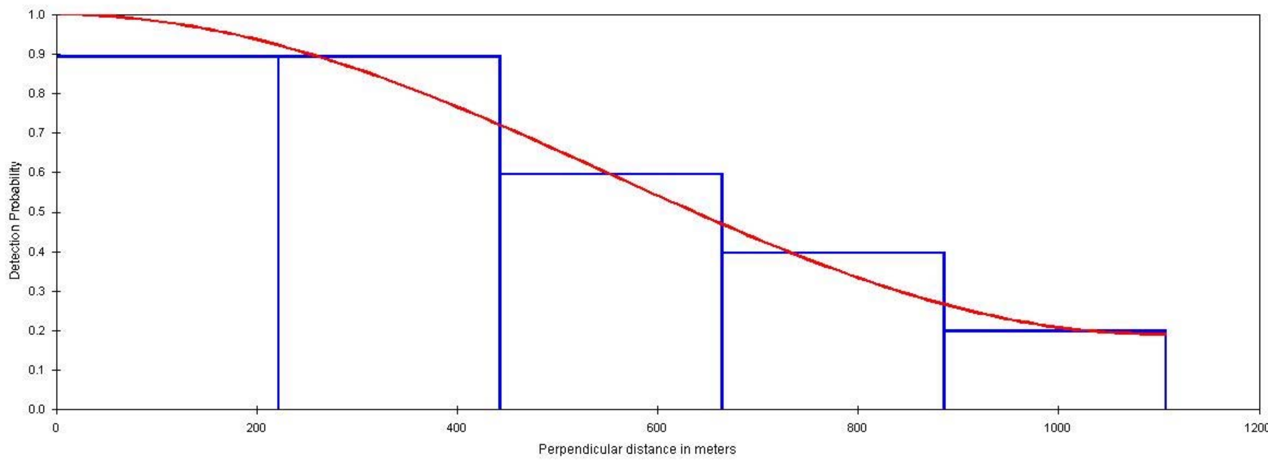


Figure 34: Detection probability (continuous line) plot and histogram of perpendicular distances from the transect line for clusters of Peary caribou in the Lougheed Island survey area, April 2007. The g(x) is estimated using a uniform model with cosine adjustment. Bin size is 221.

Table 17: Summary of candidate models used in the line-transect analysis for Peary caribou of the Lougheed Island survey area, April 2007. The parameter Delta i AIC refers to the change in AIC between model i and the model with lowest AIC score.

Lougheed - Peary caribou					**Denisty**			
Name	**Par**	**Delta AIC**	**AIC**	**ESW (m)**	**Caribou/km^2**	**95% LCI**	**95% UCI**	**CV**
Uniform Cosine	1	0.00	414.82	658.93	0.2626	0.1451	0.4754	0.300
Half-normal Hermite Poly	1	0.93	415.75	679.74	0.2616	0.1414	0.4839	0.312
Half-normal Cosine	1	0.93	415.75	679.74	0.2616	0.1414	0.4839	0.312
Uniform Simple Poly	2	1.35	416.17	643.55	0.2698	0.1400	0.5199	0.336
Hazard-rate Simple Poly	2	2.50	417.32	707.80	0.2681	0.1374	0.5230	0.343
Hazard-rate Cosine	2	2.50	417.32	707.80	0.2681	0.1374	0.5230	0.343

Muskoxen

Ground Survey: A ground survey was not carried out in the Lougheed Island Group.

Aerial Survey: No muskoxen were observed in the Lougheed Island Group survey area during the 2007 aerial survey (Table 5, Figure 33).

4.0 DISCUSSION

4.1 OVERVIEW

In 1961, Tener (1963) estimated that there were 25,845 Peary caribou and 7,421 muskoxen across the Queen Elizabeth Islands (QEI). For the QEI that are within Nunavut, Tener's estimates were 6,414 Peary caribou, distributed primarily in the Bathurst Island Complex (BIC; 56%), and 6,421 muskoxen, distributed on Ellesmere Island (62%), the BIC (19%) and Axel Heiberg Island (16%). Prince of Wales and Somerset Island, south of the QEI, were not surveyed until 1974. Results indicated that an additional 1,285 Peary caribou and 564 muskoxen occupied these islands (Fischer and Duncan, 1976). Our study reveals that the abundance and distribution of Peary caribou and muskoxen within the Arctic Archipelago, Nunavut has changed dramatically over the last five decades.

We estimated that there are approximately 4000 Peary caribou (combining estimates and minimum counts) within the 2001-2008 study area; the majority of which occurred within the Axel Heiberg Island Group (2,291 95% CI 1,636-3,208; 55%). For muskoxen, we estimated that the study area hosted approximately 17,500 (combining distance sampling estimates and minimum counts), with the majority in the Ellesmere Island Group, primarily the northern Ellesmere survey area (8115 95% CI 6632-9930; 47%). In contrast to Tener (1963), we found less than 5% of Peary caribou and 1% of muskoxen within the BIC. Trends in abundance by island group are discussed in detail in separate sections below.

Evaluating trends in abundance from 1961-2008 was hampered by differences in survey methods and design, and we discuss these issues in section 5.0 Management Implications. Notably, these challenges are not uncommon (Good 2007) and we present a history of the existing data, recognizing that 1) no other population estimates directly comparable to this study are available; 2) past estimates are generally based on strip sampling; 3) some past estimates are based on few data collected using low coverage.

4.2 PEARY CARIBOU

4.2.1 Bathurst Island Group

(Survey Areas - Bathurst Island Complex, Cornwallis Group)

Bathurst Island Complex

Within the QEI, the BIC has likely received the greatest interest and resources in terms of structured research programs, including 15 aerial surveys (including ours) between 1961 and 2001(Tener, 1963; Miller *et al*., 1977a; Fischer and Duncan, 1976; Ferguson, 1991; Miller, 1987a, 1989, 1992, 1993a, 1994, 1995b, 1997a, 1998; Gunn and Dragon, 2002). In part, this is a consequence of Teners' 1961 results, which highlighted the importance of the BIC to Peary caribou (Tener 1963). Interest has also focused on the BIC due to its importance as a caribou hunting area for the community of Resolute Bay (in the 1960s and 1970s, and again starting in the 1990s: Ferguson, 1991; Miller, 1993a, Miller 1995b), due to oil and gas exploration and development such as on Cameron Island (Bent Horn operation 1984-1996) and lead-zinc deposits on

Bathurst and Little Cornwallis (Babb and Bliss, 1974; Miller, 1977; Taylor, 2005), and planning for Tuktusiuqvialuk National Park.

Our results suggest that the Peary caribou population of the BIC has increased from the 1997 estimate of 78 ± 26 1-year-old and older caribou (Gunn and Dragon, 2002). However our estimated number is still small in relation to historical values that estimate a population size as large as 3,565 individuals (including calves) in 1961 and again in 1994 (Tener, 1963; Miller 1998).

Although evaluation of trends in abundance is complicated by differences in survey design and the inclusion or exclusion of calves, overall patterns are discernable. In the past four decades, the Peary caribou population on the BIC has fluctuated with steep declines in 1973-74, and again in 1995-1997. The first two surveys of the BIC were separated by 12 years (1961-1973) and revealed an 83% reduction in this caribou population from 3,565 (including calves; Tener, 1963) to 608 (including calves; Miller *et al*., 1977a). Late winter and summer surveys in 1973 and 1974 identified a further reduction in caribou numbers to 228 (no calves were observed) in August 1974 (Miller *et al*., 1977a). This additional 62% decline was attributed to deep snow cover and icing, which caused widespread mortality and resulted in little or no reproductive success (Miller *et al*., 1977a). Subsequent surveys from 1985 to 1994 indicated a slow increase in population size, and by 1994 Peary caribou were estimated at 3100 on the BIC (Miller, 1998).

Aerial surveys in 1995, 1996, and 1997 revealed a second die-off with an all-time low estimate of 78 caribou in 1997 (Gunn and Dragon, 2002). Based on carcass counts, it was estimated that 85% of the overall decline was directly related to caribou mortality (and not movement) and coincided with exceedingly severe winter and spring conditions (deep snow and icing; Miller and Gunn, 2003a, 2003b).

Our estimate for the BIC survey area suggests that this population of caribou has increased since 1997. The annual rate of population increase (λ) over the 4 years between these estimates is 24% (λ = 1.24) although the 1997 and 2001 estimates of abundance may not be directly comparable. However, the finite rate of Increase suggested by this finding is not unexpected for the initial years of growth in a population that is well below carrying capacity and strongly female-biased in composition (Heard, 1990). The recent die-off (1994-97) was biased toward male and younger caribou and the surviving population in 1998 was 75% females (Miller and Gunn 2003b). Notably, the annual finite rate of increase for caribou immediately following the 1973-74 die-off is unknown, as comparable data for the BIC is not available until 1985. Abundance estimates for the period from 1985 to 1993 (Miller 1987a, 1989, 1992, 1993a, 1994, 1995b) indicate average annual rates of increase (λ) ranging from 1.103 (1975-1988) to 1.399 (1990-1993) (Table B, Appendix 1).

Bergerud (1978), suggested the annual rate of increase of λ = 1.35 (r = 0.30) as the Malthusian rate of increase for caribou (i.e., intrinsic natural rate of population growth in the absence of all density-dependent effects). Based on this, potentially, the

Peary caribou population on the BIC could return to levels experienced in the early 1960s and early 1990s (i.e., roughly 3,000 animals) in the next 10 to 15 years and in the absence of severe weather or other environmental conditions including predation. However, it took roughly 20 years before caribou abundance recovered from lows recorded in 1974. Observations made by the Bathurst Island National Park negotiating team during a reconnaissance flight across northern Bathurst Island in September 2010 (300-350 caribou counted) support an increasing trend (Joadamee Amagoalik, personal communications, Sept. 21, 2011).

The proportion of short yearlings (10-12 months) among caribou seen on transect in May 2001 was 29%. This is in line with historical values and generally supports an increasing trend although mortality rates are unknown. In June-July 1961, Tener (1963) reported that 19.8% of the caribou seen on-transect (on the BIC) were calves, while Miller *et al*. (1977a) observed no caribou calves during an aerial survey in August 1974. Between 1975 and 1993, when there was an overall increase in the BIC caribou population the proportions of calves observed were variable but ranged from 19% to 29% (Ferguson, 1981; Miller 1987a, 1989, 1992, 1993a, 1994, 1995b). Based on this, our 29% observed in the 2001 survey could be a sign of initial recovery

Since the 1950s, Inuit in Resolute Bay have harvested Peary caribou from the BIC and Cornwallis Island. In the early 1970s however, hunters reported animals in very poor condition and starving (Taylor, 2005). Concerned with the low abundance and poor condition of animals, the HTO suspended their harvesting of caribou on Bathurst Island in 1975 (Taylor, 2005). Harvesting was re-initiated in the late 1980s and has continued since that time (Taylor, 2005; Nancy Amarualik, personal communication, Sept 21, 2010). In the mid 1990s, hunters observed many caribou and muskoxen carcasses on Bathurst Island following freezing rain during the winter (Taylor, 2005). As much as 5 cm of ice was observed by local residents during the winter of 1995-96 (Jenkins *et al*., 2010a) and harvesters had to traveled to other islands (i.e., Somerset and Prince of Wales Islands) to support subsistence harvesting (Taylor, 2005). More recently, hunters have resumed harvesting on Bathurst Island, where they are able to successfully locate and harvest enough caribou to meet their needs (Nancy Amarualik, personal communication, Sept. 21, 2010). To date, harvest reporting has not been required and our limited harvest records (voluntary reports of harvest) are not sufficient to assess the potential impact of harvesting on population trends.

We note that our estimate of abundance of Peary caribou on Bathurst Island (187 95% CI 104–330) is low compared to the preliminary estimates of abundance independently calculated (using the same data) previously by McLoughlin *et al*. (2006) (272 95% CI 185–400 caribou), and M. Ferguson (279 with 95% CI 166–503; provided as a personal communication in COSEWIC 2004). This is likely because past analysis were derived with the inclusion of data from B-transects, which biased density estimates upwards. The inclusion of B-transects violated assumptions of random sampling, since B-transects were only flown after caribou were observed on A-transects. Thus, systematically increasing the effort in areas where animals are known to occur (areas of higher animal density) leads to the overestimation of abundance using conventional line transect estimators (Pollard *et al.,* 2002). Notably, both estimates are within our confidence intervals.

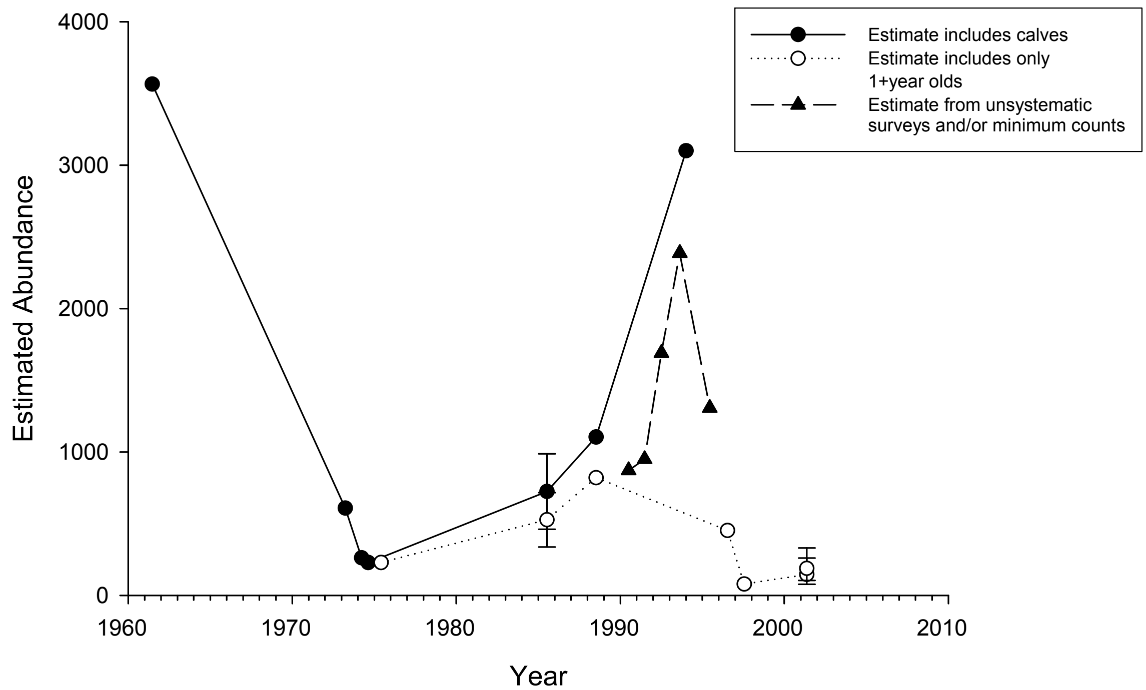


Figure 35: Peary caribou abundance for Bathurst Island Complex, 1961-2001. See Table B, Appendix 1 for information regarding survey details.

Cornwallis Survey Area

Peary caribou on the Cornwallis Island Group are probably migrants from adjacent Bathurst Island possibly seasonally as well as during severe winters (Miller 1998, Taylor 2005). During May 2001, the only observation of live caribou in the survey area was on northwest Cornwallis Island. Previous estimates that include both Cornwallis Island and Little Cornwallis Island are limited to summer 1961 and 1988, when 43 and 51caribou (with calves) were estimated, respectively; all animals were observed on Cornwallis Island (Tener, 1963; Miller, 1989). Additional surveys of Little

Cornwallis in 1973 and 1974, produced estimates of 8 and 12 caribou, respectively, with no calves observed (Miller *et al*., 1977a).

Although it is possible that higher numbers of caribou were present on Cornwallis Island prior to the settlement of Resolute Bay in 1953, RCMP records suggest that only a few caribou occurred on the island prior to 1950s (DIANA 1947-1950 in Taylor, 2005). By the mid- to late 1960s, Inuit reported that it was difficult to find caribou on this island and that none were observed from 1990 to 2003 (Taylor, 2005). These observations are consistent with our ground and aerial survey results from 2002. Notably, in October 1995, severe weather conditions on Bathurst Island may have forced the movement of approximately 100 caribou from Bathurst to Cornwallis Island near Resolute Bay, where they were harvested (Struzik, 1996; Miller, 1998; Taylor, 2005). Thus, it is likely that Cornwallis and Little Cornwallis Islands have historically provided important range to small numbers of resident caribou, but also to temporary migrants that leave Bathurst Island during unfavourable weather events with poor forage conditions.

4.2.2 Devon Island Group

(Survey areas – Devon Island, Baille Hamilton, Dundas/Margaret, North Kent)

The number of Peary caribou on Devon Island is extremely low (minimum count of 17 in 2008). The reasons for this are not immediately evident and historical information is limited. Only irregular surveys have been carried out and, to our knowledge, a full island survey has not been completed since 1961 (Tener, 1963). Most previous surveys have focused on muskoxen and the coastal wetland areas that they principally occupy (Freeman, 1971; Hubert, 1977; Pattie, 1990; Case, 1992). Tener (1963) estimated about 150 caribou on Devon Island in 1961. Inuit knowledge indicates that there have been caribou on the northeastern coast of Devon Island, on the Grinnell Peninsula, and that they can reliably be found along the western coast of the island (Taylor, 2005).

Minimum counts for western Devon Island in 2002 suggested that caribou numbers were low. These findings are consistent with our results for Bathurst Island Complex (2001) and Cornwallis Island Group (2002). However, movement patterns for caribou on Devon Island are not well understood and it was possible that there were caribou in other areas of the island at that time (e.g., the Truelove Lowlands; Taylor, 2005). Our extended survey coverage in 2008 yielded a minimum count of 17 caribou, confirming the extremely low abundance of caribou across Devon Island.

4.2.3 Ellesmere Island Group

(Survey Areas - Southern Ellesmere, Northern Ellesmere Island)

The Ellesmere Island Group makes up 41% of Nunavut's Peary caribou range (based on our study area). Our results revealed extremely low densities for Peary caribou (8-9 caribou/1000 km^2; north and south Ellesmere Island). Historical surveys of Ellesmere Island are infrequent and limited in their spatial coverage. Results from the first aerial survey in 1961 (Tener, 1963) suggested that there were approximately 200 caribou on Ellesmere Island; however, a mathematical estimate was not derived due to the small number of observations and low survey coverage. No island-wide aerial survey was undertaken since 1961.

Surveys in 1973 (Riewe, 1973) and 1989 (Case and Ellsworth, 1991) focused on southern Ellesmere (south from the Svendson Peninsula). The stratified survey in 1989 provided density estimates ranging from 6 caribou/km^2 on the Svendsen Peninsula stratum to lows of 2 caribou/1000 km^2 on the Bjorne Peninsula, on the area between Vendom Fiord and Makinson Inlet, and on Ellesmere Island south of Baumann Fiord (Case and Ellesworth, 1991). Overall, the estimated abundance was 89 caribou (90% CI 37-141) on southern Ellesmere Island in 1989 (Case and Ellesworth, 1991).

Our estimate for southern Ellesmere (9.2 caribou/1000 km^2 or 219 caribou) included Graham Island, which Inuit knowledge (Taylor 2005) and Riewe (1973) identified as Peary caribou range. We observed few caribou clusters which led to a low density estimate with wide confidence intervals (95% CI 4.6-18.6 caribou/1,000 km^2). Densities on Graham Island appeared higher than on the mainland, but data were not sufficient to derive local density estimates. In the early 1990s, the emaciated carcasses of one caribou and two muskoxen were observed on the sea ice off the west side of Bjorne Peninsula, and Inuit from Grise Fiord reported seeing caribou on Graham Island in the mid-1990s (Taylor, 2005). In the winter of 2002, additional observations of dead animals were reported after freezing rain that likely limited access to forage. However, by 2003, Inuit believed that numbers of caribou on southern Ellesmere were increasing (Taylor, 2005).

During our survey on southern Ellesmere in 2005, we observed 40 emaciated muskoxen carcasses and at the same time, hunters of Grise Fiord also reported muskoxen in poor condition (Campbell, 2006). No observations of Peary caribou carcasses were recorded by our aerial or ground crews. Weather conditions were identified as a possible causative factor (Jenkins *et al.* 2010b) although some local Inuit do not believe that snow and ice play a significant role in the population dynamics of Peary caribou on southern Ellesmere. Inuit knowledge indicates that muskoxen have difficulties in deep snow conditions and are sometimes found dead or dying of starvation, whereas caribou are rarely found in this condition (Jenkins *et al*., 2010b). Inuit state that the reason for this is that caribou seek refuge in high-elevation areas where precipitation is reduced and vegetation more exposed (Jenkins *et al*., 2010b). Miller *et al*. (2005a) have also postulated that the large rugged land base on Ellesmere and other eastern islands may be of great importance in the persistence of Peary caribou because of the numerous micro niches that are available. Due to the rugged terrain, most of Ellesmere Island experiences different climatic conditions than other arctic islands (Maxwell 1981). This includes reduced influence from cyclonic systems which plague islands such as Bathurst and Cornwallis (Maxwell 1981)

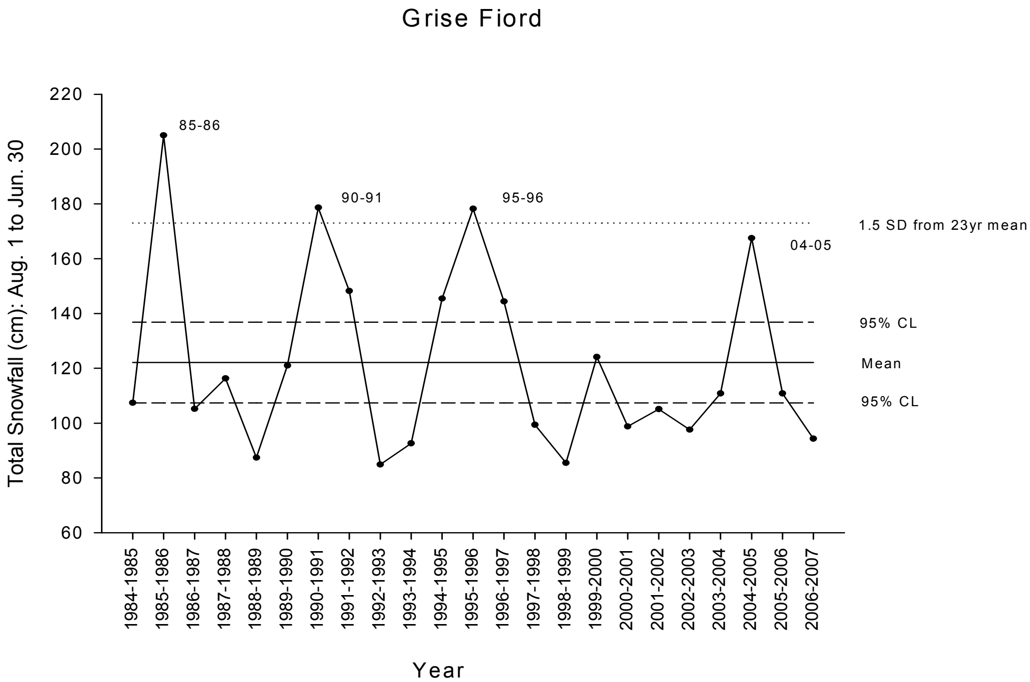
Lack of data limits our ability to drawing conclusions about any trends in abundance on Ellesmere Island. Our combined abundance estimate for the Ellesmere Island Group is approximately 1,000 animals, and this is comparable to the extrapolation presented in COSEWIC (2004). The estimated abundance is higher on northern Ellesmere than in the south, and this is explained in part by the larger area and the larger clusters we observed.

On Ellesmere, calf or short yearling recruitment was low in 2005 (no short yearlings among 57 caribou classified) and in 2006 (no short yearlings among 344 caribou classified). The 2004-2005 winter was marked by high snowfall, which may have reduced survival for the 2004-cohort and may have carried over to influence pregnancy rates and/or calf survival for the 2005 cohort as by early spring 2006, short yearlings were 0% and yearlings were only 7 %. Cow condition, which affects pregnancy rates (especially for young cows) and calf birth weights and hence calf survival, is influenced by food availability (Thomas 1982; Cameron *et al*., 1993). Thomas (1982) found a direct relationship between the fertility of female Peary caribou and fat reserves in late winter. The same author concluded that reproduction in Peary caribou in the western QEI nearly ceased from 1973-1974 to 1975-1976 because of the poor physical condition of female caribou. In barrenground caribou, early calf survival has also been linked to late-term maternal conditions (Cameron *et al*., 1993; Adam, 2003). Adams (1995, 2003) found that fat deposition and skeletal growth of caribou neonates were inversely related to late winter severity and that calves were smaller at birth following severe winters. Additionally, severe winter conditions were associated with reduced calf survival and increased calf susceptibility to predation (Adams, 1995).

In the western QEI, calf production has been proximately related to snow depth, the duration of snow cover from previous winters, and the occurrence of ground-fast ice

(Miller *et al*., 1977; Thomas, 1982; Ferguson, 1991; Miller and Gunn, 2003b). For example, Miller and Gunn (2003b) found that major to near-total calf crop losses in the western QEI were associated with winters that featured significantly greater than average total snowfall (measured between Sept-June). At Grise Fiord and Eureka, total snowfall in 2004-05 was greater than the 24-year mean annual snowfall recorded at each of these locations (Figure 36). Assuming these conditions were widespread on Ellesmere Island, significant snowfall may explain the lack of calf recruitment we observed in late winter 2005 and 2006.

(A)



(B)

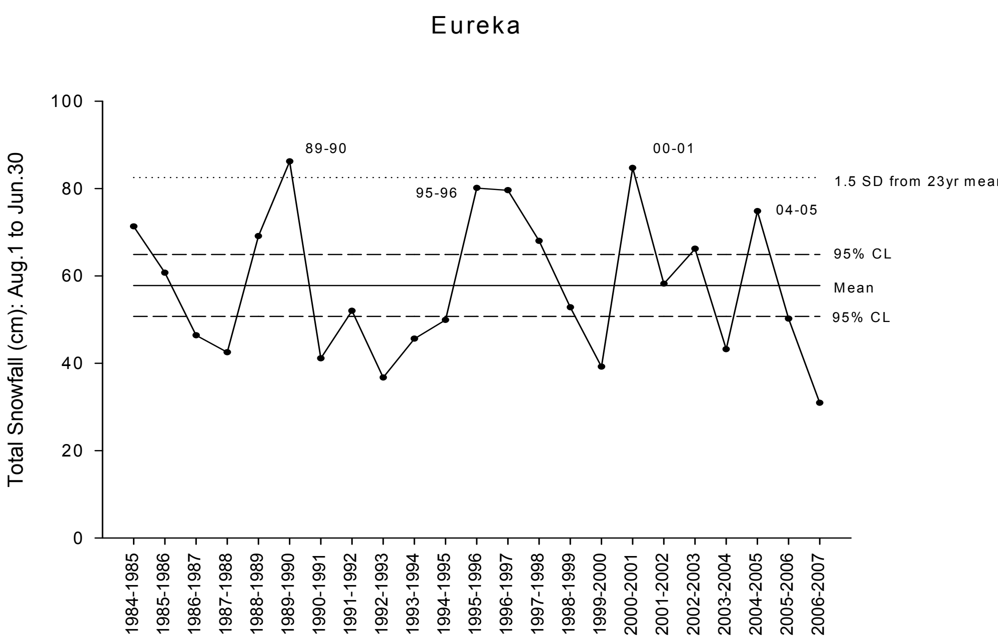


Figure 36: Total snowfall (cm) at Grise Fiord (A) and Eureka (B) from August 1 through June 30 (autumn through spring) by year from 1984 to 2007. Data obtained from Environment Canada (2010).

Historical values of calf production on Ellesmere Island are both variable and few. In 1961, Tener (1963) estimated the proportion of calves at 10.8 % for Ellesmere.Island while the proportion of calves in southern Ellesmere has ranged from 5.5 % in July 1973 (Riewe, 1973) to 22.0% in 1989 (Case and Ellsworth, 1991).

Aerial observations of caribou clusters in the Ellesmere Island Group suggest that population composition may be strongly female-biased in both southern and northern Ellesmere, although the average group size is larger in northern Ellesmere (4.6 (SE 0.37) vs. 3 (SE 0.34) caribou, respectively). The literature suggests that, in populations of *Rangifer* and other cervids, female-biased sex ratios may reflect greater mortality of males from a variety of factors including severe weather (Bergerud, 1971; Miller and Gunn 2003b; Barboza *et al*., 2004). For example, male caribou invest in reproduction at the same time as plant production declines; thus, body reserves may not be sufficient to support rutting activities as well as winter survival (Weladji *et al*., 2002; Barboza *et al*., 2004). Male-skewed harvesting is not a suspected factor, as much of the survey area is beyond the hunting range for Inuit harvesters (NWMB Data 1996-2001; Taylor, 2005).

4.2.4 Prince of Wales – Somerset Island Group

(Survey areas - Prince of Wales Island, Somerset Island)

During the 2004 aerial survey, we observed no Peary caribou on the Prince of Wales/Somerset Islands (POW/SI) Group. These results are consistent with ground surveys of Prince of Wales Island in 2004 and Somerset Island in 2005, in which crews reported only four caribou after traveling a combined distance of 4,831 km.

Peary caribou in the POW/SI Group declined from an estimated 5,682 caribou (one year or older) in 1974 (Fischer and Duncan, 1976) to a minimum count of two in 1996 (Miller, 1997b). Our results indicate that there has been no recovery since 1996.

Based on survey results from 1980 (5,097 caribou one year or older), Gunn and Decker (1984) concluded that this population was likely stable or declining slightly based on low recruitment and relatively high annual harvest (150-250 caribou per year). By the late 1980's and early 1990s, Inuit hunters had observed a decrease in the abundance of caribou and found it difficult to locate caribou for harvesting (Taylor, 2005, Gunn *et al*., 2006). Subsequent surveys in 1995 and 1996 yielded critically low numbers: seven caribou in 1995 (Gunn and Dragon 1998) and two caribou in 1996 (Miller, 1997b). Due to the 15-year delay between aerial survey studies, the causes for the significant decline could not be determined with certainty (Gunn *et al*., 2006).

Several factors likely explain the decline in caribou numbers through the 1980s and 1990s: 1) reduced survival rates for breeding females and calves (in the first year of life); 2) continued harvesting; 3) increased wolf predation (hypothesized as a consequence of increasing muskoxen numbers; Gunn *et al*., 2006). Contributing factors may have changed during the decline. It is possible that the severe winters of 1989-90 and 1994-95 extended to this island group and affected caribou numbers. Unfortunately, weather information for Prince of Wales/Somerset is not available although it is in the same climate region as Bathurst Island Group (Maxwell 1981).

Gunn and Dragon (1998) indicated that information on the abundance of predators, their diet, predation rates, and other parameters was not available for the POW/SI Group. However, the authors suggested that the increasing abundance of muskoxen (1980-1995) could likely support a higher number of wolves in the area.

In addition to predation, the POW/SI Group may have been subject to increased harvest during 1980-1995. As mentioned above (BIC section), Resolute Bay hunters instituted a voluntary hunting ban on Bathurst Island caribou from 1975-1989 and this resulted in a shift of harvesting activities to Prince of Wales and Somerset islands. This harvest pressure may have escalated when a voluntary hunting ban on southern Ellesmere Island caused the community of Grise Fiord to purchase caribou meat from the Resolute Bay Hunters and Trappers Association (Miller, 1990a). During this period, Inuit hunters from Taloyoak (Spence Bay) were also harvesting caribou on Prince of Wales and Somerset Islands (Gunn and Decker, 1984) as well as on the Boothia Peninsula. Based on the fact that an unknown portion of Peary caribou from the POW/SI Group used the Boothia Peninsula as part of their winter range, Miller (1990a) suggested that the high annual caribou harvest at Taloyoak (about 1000) could have impacted the POW/SI Group.

Inuit knowledge indicates that the decline in caribou on the POW/SI Group was associated with natural events, including overabundance in the 1980s (Taylor, 2005) predation, and weather (Gunn *et al.,* 2006). In the early 1980s, caribou were abundant on Prince of Wales, Somerset, and the smaller coastal islands (Taylor 2005). By the mid-1980s, hunters were observing tapeworm cysts (*Taenia krabbei*) in the muscle tissue of caribou from both Prince of Wales and Somerset Islands (Taylor, 2005; Jenkins *et al*., 2010a) and noticed muskoxen in areas previously occupied by caribou. Since wolves are the other host for this tape-worm, it is possible that wolf abundance and hence, predation, had increased in relation to the larger prey base (Gunn and Dragon, 1998; Gunn *et al.,* 2006). Hunters also observed carcasses of caribou and muskoxen on Somerset Island and Prince of Wales in the early 1990's following a period of freezing rain in the fall. Similarly, in 1989 Inuit reported that caribou harvested from Somerset Island were skinny (Taylor 2005) and that 21 dead caribou had been observed on the west coast of Somerset in March and May (Letter from Josh Hunter to M. Ferguson, 1989 in Gunn *et al*., 2006).

Assessment of potential limiting factors for the Prince of Wale/Somerset population is complicated by the fact that some Peary caribou also use or historically used Boothia Peninsula in the winter (Miller *et al.,* 2005b). Additionally, there are also some Peary caribou that are unique to Boothia Peninsula (Zittlau 2004). We know little about the spatial extent of Boothia Peary caribou, their current abundance, or interchange that occurs between this population and the Peary caribou of the POW/SI Group. Gunn and Dragon (1998) estimated 6,658 caribou (SE 1,728) on Boothia in July-

August 1995, but the surveyors did not differentiate between Peary and barrenground caribou that are known to occupy the area (Campbell, 2006 – NEM report on file). Miller (1997b) observed no Peary caribou on the northwest portion of Boothia in 1996 but did not survey the remainder of the Peninsula. During a muskoxen survey on the Boothia Peninsula in 2006, one caribou morphologically similar to Peary caribou was observed (Dumond, unpublished data).

The paucity of monitoring data between 1980 and 1995 make it difficult to evaluate with certainty the cause of the decline within the Prince of Wale/Somerset Group though it is clear that immediate management action will have to be taken if we are to conserve this population into the future.

4.2.5 Axel Heiberg Island Group

Our survey results are higher than the only previous description of caribou abundance for Axel Heiberg Island. Having surveyed less than 3% of the ice free area of Axel Heiberg, Tener (1963) estimated about 300 caribou on the island in 1961. No other surveys of the island have occurred since that time. Lack of data and this 50-year gap in monitoring make it impossible to discuss population status or trends for Peary caribou on Axel Heiberg Island.

The relative abundance of both caribou and muskoxen was greatest east of the Princess Margaret Range where snow cover appeared to be less than the western coast during the May 2007 survey. As mentioned previously, much of the central part of the island is permanently covered in ice (Muller Ice Cap and Steacie Ice Cap), and this, in conjunction with the central mountain range may fragment the population. Further research is needed to evaluate this.

The Axel Heiberg Group currently supports the largest population of Peary caribou in Nunavut, with an estimated 2,291 animals (95% CI 1636-3208) based on our 2007 survey results. This population accounts for more than 55% of the total estimated Peary caribou population in our entire study area. This may be a consequence of the local climate (Maxwell, 1981), biomass and diversity of vegetation (Edlund and Alt, 1989), the varied topography, and isolation from human disturbance (Taylor, 2005).

Axel Heiberg Island, particularly the eastern portion, may be a natural refugium for Peary caribou, much like the western coast of Ellesmere Island functions as a refugium for muskoxen (Thomas *et al.,* 1981; Ferguson, 1995). Eastern Axel Heiberg, including the central mountains, is in Climate Region V (Maxwell, 1981). Region V also includes most of Ellesmere Island (except the southeastern and northern coasts), and is distinguished by rugged mountainous terrain. Notably, west central Ellesmere Island and the eastern portion of Axel Heiberg are almost completely surrounded by mountains which provide protection from cyclonic activities and result in a rain shadow effect (Maxwell 1981). Hence, this ‘interior’ area of Region V is characterized by low precipitation, a wide temperature range (Maxwell, 1981) and is generally snow free by early to mid-June (Edlund and Alt, 1989). Consequently, vegetation is rich along the eastern coast of Axel Heiberg, transitioning from an enriched prostrate shrub zone at low elevations to a lower-diversity herb-shrub transition zone at high elevations (Edlund and Alt, 1989). In combination, the climate, diverse vegetation, and varied topography may be of benefit to Peary caribou, particularly in the face of accelerated climate change.

4.2.6 Ringnes Island Group

(Survey Areas - Ellef Ringnes, Amund Ringnes, King Christian, Cornwall, Meighen, Lougheed Islands)

Our 2007 survey of the Ringnes Island Group was the first concerted attempt to assess Peary caribou abundance in this region since Tener's work in 1961, and we estimated a total of 654 caribou. It is difficult to track populations in this area due to its remoteness and of these islands, only irregular surveys of Lougheed Island have occurred in the past five decades.

Our combined abundance estimate for Ellef Ringnes, Amund Ringnes, Cornwall, Meighen, and King Christian islands (282 caribou 95%CI 157-505) was much lower than the 1961 estimate of 832 caribou for these islands (Meighen excluded) (Tener, 1963). Our flight effort (i.e., linear distance flown) was double that of the 1961 survey (3,905 km vs. 1,953 km, respectively), and observer effort was also greater than in the 1961 survey (four observers vs. one, respectively). Thus, our systematic sampling design was robust and supported the detection of caribou.

Lougheed Island was surveyed in 1961, 1973, 1974, 1985, and most recently in 1997 (Tener, 1963; Miller *et al*., 1977a; Miller, 1987; Gunn and Dragon, 2002). Results from these investigations suggest that caribou abundance has fluctuated over time, with data indicating an overall reduction from an estimated 1,324 in summer 1961 (Tener, 1963) to 56 in April 1973 (Miller *et al*., 1977a). Only one caribou was observed in April 1974 (Miller *et al*., 1977a), and no caribou were reported by Miller (1987a) during an aerial survey in July 1985. Gunn and Dragon (2002) estimated 101 caribou (one year and older, SE 73) for Lougheed Island in July 1997, compared to our estimate of 372 (95% CI 205-672) in April 2007. Although not directly comparable our estimate suggests that either caribou are increasing on Lougheed Island or that its use is seasonal. From the existing data no patterns of seasonal use are discernable and caribou movement within this Island Group is unknown.

Overall, we caution that it is difficult to interpret population trends within this Island Group as survey information is limited, typical seasonal movement patterns are unknown, and surveys (e.g., Lougheed Island) have occurred at different times of year. Nonetheless, the overall proportion of calves (14%) that we observed is encouraging given the extreme northern latitude and the small calf crops we recorded for other survey areas.

Although Taylor (2005) documented Inuit knowledge on Peary caribou in Nunavut from 16 interviewees (all from Grise Fiord or Resolute Bay), the observations and information did not extend to the Ringnes Island Group. This likely reflects the remoteness of the area, which makes it inaccessible to most Inuit hunters (Taylor, 2005).

4.3 MUSKOXEN

4.3.1 Bathurst Island Group

(Survey Areas - Bathurst Island Complex, Cornwallis Group)

Bathurst Island Complex

In 1961, the Bathurst Island Complex had the second largest estimated population of muskoxen in the Queen Elizabeth Islands (1161, including calves). This figure included an estimated 25 muskoxen on the Governor General Islands after observing 3 animals (Tener, 1963).

Since the 1960s, muskox abundance on the BIC has fluctuated in parallel with Peary caribou abundance. There was a 40% decline from 1961 to 1973, followed by a significant die-off (approximately 75%) during the winter of 1973-74 (Miller *et al*., 1977). The number of muskoxen estimated on BIC then increased from 1974 to 1994 reaching levels similar to those recorded in 1961. Between 1995 and 1997, numbers declined by approximately 96% based on minimum counts and systematic surveys (Miller *et al*., 1977a; Ferguson, 1991; Miller, 1987a, 1989, 1995b, 1997a, 1998; Gunn and Dragon, 2002; Table C, Appendix 1).

This study followed the lowest ever estimate of muskoxen abundance for Bathurst Island Complex (124 $\pm$ SE 45, including calves; Gunn and Dragon, 2002), recorded in 1997. Also, aerial surveys in July of 1996 and 1997 suggested complete failure of the muskoxen calf crop on Bathurst Island Complex (Miller, 1998; Gunn and Dragon 2002). Our minimum count of 82 muskoxen (excluding newborn calves) or 103 (with newborn calves) suggests that although the population remains at low numbers, it is likely stable or increasing. We caution that although the sample size was small, the proportion of calves (ca. 20%) was encouraging.

In 2001, we did not observe muskoxen on any of the satellite islands which make up the Bathurst Island Complex (Cameron, Ile Vanier, Massey, Isle Marc, Alexander, Helena, Table 5). Muskoxen use of those islands has varied historically (Appendix 1, Table 3) although no muskoxen have ever been recorded on Ile Marc or Helena and only low counts of muskoxen have periodically been recorded on Vanier, Cameron, Massey, and Alexander (Tener, 1963; Miller, 1987a; 1989).

Cornwallis Survey Area

Few studies of muskoxen abundance have incorporated the Cornwallis Island Group. In 1961, Tener (1963) estimated 50 muskoxen on Cornwallis Island and reported no muskoxen on Little Cornwallis. The islands were not surveyed again as a pair until 1988, when estimates were 70 muskoxen on Cornwallis and zero on Little Cornwallis (Miller, 1989). Although our results are not directly comparable, the low number of animals observed during our aerial survey in 2002 (minimum count 18) suggests that this population has not grown.

Aerial surveys of Little Cornwallis Island in 1973 and 1974 demonstrated that small numbers of muskoxen occupied this island in the past. From April 1973 to August 1974, estimated abundance on Little Cornwallis dropped from 40 muskoxen to 12 (Miller *et al*., 1977a).

No regular seasonal large-scale movement of muskoxen to Little Cornwallis Island has been documented although movement between islands must occur for recolonization. The temporal and spatial scales of these movements are unknown. Limited radio telemetry data for muskoxen on Devon, Cornwallis and Bathurst Islands for the period 2003-2006 indicates no movement between these islands and no use of Little Cornwallis Island (Jenkins, in prep). The absence of muskoxen from Little Cornwallis in 1988 and 2001 suggests that either muskoxen have not permanently recolonized the island or that they were simply not present at the time of the survey.

4.3.2 Devon Island Group

(Survey Areas – Devon Island, Baille Hamilton, Dundas/Margaret, North Kent)

Tener (1963) completed the first aerial survey of Devon Island in 1961 and covered approximately 6% of the habitable portion of the island. After observing no muskoxen on transect and 23 animals off transect, Tener (1963) estimated that no more than 200 animals occupied the island. Since 1961, only infrequent partial surveys have been done. Freeman (1971) estimated 450 muskoxen on the Grinnell Peninsula and northern coast of Devon Island using ground sightings from 1966-1967. The same study yielded an estimate of 230 to 300 muskoxen from the north coast lowlands along the shore of Bear Bay. From 1970 to 1973, Hubert (1977) counted between 116 and 278 muskoxen on the north coast lowlands from Sverdrup Inlet to Sverdrup Glacier. Pattie (1990) investigated the same area roughly a decade later and documented a marked decline in muskoxen over 3 years, with estimates of 188 in 1984 and 76 in 1987.

In 1980, an aerial survey of the lowlands of southern and western Devon Island located 32 muskoxen in the Croker Bay/Dundas area, 14 in the Philpots Island area, and 46 inland from Baring Bay (Decker unpublished, in Case, 1992). Case (1992) surveyed lowland areas along the north, south, and western coasts of Devon Island and observed 366 muskoxen. A minimum estimate of 400 animals was subsequently established for Devon Island at that time (Case, 1992).

Based on our 2008 survey, muskoxen continue to inhabit discrete and highly fragmented low-lying areas of Devon Island. The majority of muskoxen were located along the southeastern coast of Devon Island, including Philpots Island where we counted 142 muskoxen including calves. This contrasts with previous reports that have indicated greatest abundance along the northeastern coast of Devon.

Inuit have consistently observed muskoxen on Devon Island, principally on the coastal lowlands in the northeast (the Truelove Lowlands) but also along the western coast (Baring Bay and Dragleybeck Inlet areas), on eastern Grinnell Peninsula, and along the southeastern coast (Dundas Harbour area)(Taylor, 2005). Our results suggest a decline in muskoxen along the northeast coast and increased muskoxen numbers in the east and southeast portions of the island.

4.3.3 Prince of Wales – Somerset Island Group

(Survey Areas - Prince of Wales Island, Somerset Island)

Prince of Wales (incl. Russell Island)

Our results suggest a significant overall decline in the Prince of Wales Island Group muskoxen population, from an estimated 5,257 (SE 414) in 1995 (Gunn and Dragon, 1998) to our estimate of 2,086 (95% CI 1582-2746) in 2004 (Table 4). This is a drop of approximately 60%.

The cause of this decline is unknown as there is a paucity of biological and abiotic data for this area. Inuit knowledge recorded by Taylor (2005) does not directly refer to a decline of muskoxen on Prince of Wales Island. The possible emigration of muskoxen from Prince of Wales Island to Somerset Island is documented as well as the loss of muskoxen on both Prince of Wales and Somerset in relation to freezing rain in the early 1990s (Taylor 2005). Regardless of these events, Inuit observations suggest that muskoxen numbers continued to rise on both islands in the early 2000s (Taylor, 2005).

The overall decline referred to above is consistent with other recent scientific studies in the western Arctic Archipelago that revealed a rapid drop in muskox abundance between 2001 and 2005 on Northwestern Victoria Island (Nagy *et al*., 2009a) and Banks Island (Nagy *et al*., 2009b). According to Nagy *et al*. (2009a, 2009b), it is likely that the principle cause of these declines was winter icing events.

Unfortunately, we are unable to determine the severity, timing or cause of the decline due to the paucity of survey data; specifically a 9 year gap in monitoring between 1995 and 2004.

Somerset Island

Muskox population studies on Somerset Island have been limited. The first aerial surveys in 1974 and 1975 located no muskoxen on Somerset Island (Fischer and Duncan, 1976). In 1980, three groups of muskoxen where counted on the island for a total of 29 animals with no calves (Gunn and Decker, 1984). No population estimate was derived from that assessment. The next aerial survey was not completed until 1995 when the abundance of muskoxen (one year or older) was estimated at 1,140 (SE 260) (Gunn and Dragon, 1998).

The results from our 2004 survey, although not directly comparable to the above, suggest that the population is likely stable with an estimated 1,910 (95% CI 962-3792) muskoxen (one year or older). The newborn calf crop appears low (5%), however, this finding is confounded by the timing of the survey. The survey was conducted in mid-April, which coincides with the beginning of calving. For muskoxen, calving can extend from April into June (Gray, 1987). In comparison, the proportion of yearlings was 13%, which is encouraging.

<u>4.3.4 Ellesmere Island Group</u>
(*Survey area - Southern Ellesmere, Northern Ellesmere)*

Northern Ellesmere Island

The results from our 2006 survey indicate that Northern Ellesmere Island supports the largest abundance of muskoxen in the entire study area, with 47% of the total estimated muskoxen population. The estimated density for Northern Ellesmere Island (84.0 muskoxen/1000 km^2 , 95% CI 68.7-102.8) was second only to the density on Axel Heiberg Island (137.2 muskoxen/1000km^2 , 95% CI 109.2 – 172.5). We observed muskoxen across the entire survey area, from the Svendson Peninsula in the south to areas north of Alert. Concentrations of animals were seen on the Lake Hazen-Alert Plateau, Raanes Peninsula, Svendson Peninsula, and along the north and southern coasts of Greely Fiord.

During our survey, the largest concentration of muskoxen was detected on the Fosheim Peninsula, and this is consistent with findings from the first aerial survey of Ellesmere Island in 1961 (Tener, 1963). The Fosheim Peninsula has previously been identified as a Wildlife Area of Special Interest (WASI) because of its special features, high biological diversity, and significance to muskoxen (Ferguson, 1995). During our aerial survey of Northern Ellesmere Island (April 6 to May 22, 2006), 56% of all the muskoxen that we observed on transect were on the Fosheim Peninsula (3,292 muskoxen), and of these 66% of the groups had newborns. Previous assessments on the Fosheim Peninsula in 1960 and 1961 yielded counts of 312 and 227 muskoxen, respectively (Tener, 1963).

The Fosheim Peninsula is considered an arctic refugium (Thomas *et al*., 1981) in the sense that it may support muskoxen even during periods of unfavourable climatic conditions in the Arctic Archipelago. In other words, animals may survive here when environmental conditions elsewhere are unfavourable for survival (Mackey *et al*., 2008). This also means that the muskoxen on the Fosheim Peninsula may be a source of animals that disperse and colonize or reoccupy other areas of less ideal habitat (e.g., areas where unfavourable climatic conditions may have extinguished local populations: Thomas *et al*., 1981).

We report a muskox newborn calf crop of 15% for Northern Ellesmere Island in 2006 however, this is likely a low estimate as the survey commenced in early April, before the expected onset of calving. Tener (1963) estimated the proportion of calves for Ellesmere at 12.4 % in June 1961, while calf crop ranged from 14% and 23% in Sverdrup Pass between 1981-1984 (Henry *et al*., 1986). This is comparable to our results for Southern Ellesmere where the proportion of newborn calves was only 1% in 2005 (May 4-May30: this study).

Tener (1963) reported approximately 4,000 animals for the entire island in 1961, and estimated that approximately 1,000 of these inhabited the Fosheim Peninsula and

Lake Hazen Alert Plateau. Our estimate of 8,115 (95% CI 6,632-9,930) is for Northern Ellesmere Island, which we defined as the area north of Vendom Fiord. Consequently, either Tener (1963) underestimated and or muskoxen in northern Ellesmere Island have increased since 1961.

Southern Ellesmere Island Group

Previous surveys of Ellesmere are few and limited in their spatial coverage. (Tener 1963) estimated that in 1961 Ellesmere had more muskoxen than the rest of the Queen Elizabeth Islands in total (ca. 4000 vs. 3421 respectively). Subsequent surveys were mostly limited to southern Ellesmere, where muskox harvesting was important to residents of Grise Fiord. Case and Ellsworth (1991) divided the area into five strata and reported density estimates ranging from a high of 121 muskoxen/1000km^2 on the Bjorne Peninsula to a low of 63.0 muskoxen/1000 km^2 in the area south and east of Bjorne Peninsula and Baumann Fiord. The resulting overall population estimate for 1989 (in an area comparable to our survey area minus Graham Island) was approximately 1,670 muskoxen (Strata I, III, IV, and V; Case and Ellsworth, 1991).

Our 2005 estimate for southern Ellesmere, 19.2 muskoxen/1000 km^2 or 456 muskoxen (95% CI 312-670) included Graham Island where a total of 8 muskoxen with no calves were observed in 3 groups on-transect. Thus, although not directly comparable, this information suggests that there has been a decline in the muskoxen population of Southern Ellesmere Island since 1989.

In the early 1990s, Inuit observed the emaciated carcasses of two dead muskoxen and a dead caribou on the sea ice off the west side of Bjorne Peninsula (Taylor, 2005). Further, in the winter of 2002, additional local observations of dead animals were reported after freezing rain that apparently limited access to forage (Taylor, 2005). During our aerial survey (2005), 40 emaciated muskoxen were observed across the study area and frequent reports of muskoxen in poor and/or starving condition were described by the hunters of Grise Fiord as well as the aerial survey crew (Campbell, 2006). Weather conditions were identified as a possible factor and local Inuit suggest that muskoxen have difficulties in deep snow conditions and are sometimes found dead or dying due to starvation (Jenkins *et al*., 2010b).

Only two newborn calves were observed across Southern Ellesmere Island in our 2005 aerial survey, which is a concern. On Ellesmere, Tener (1963) estimated 12.4 % muskox calves in 1961, second only to Melville Island at 17.22 %. The percentage of muskox calves on the Bjorne Peninsula in July 1973 was 15% (Riewe, 1973), and across southern Ellesmere was 17.3% in 1989 (Case and Ellsworth, 1991). Although the direct cause of the low calf crop is unknown, severe weather events have been identified as the primary cause of major to near-total calf crop losses in other muskoxen populations (i.e. particularly harsh winters of 1973/74, 1994/95, 1995/96 and 1996/97; Miller *et al*., 1977a; Miller 1997a, 1998; Gunn and Dragon, 2002). Miller and Gunn (2003b) found that all four of these winters were characterized by significantly greater total snowfall (as measured between September and June). This is consistent with snow records for Grise Fiord and Eureka for the winter of 2004-05 (Figure 36).

Deep snow can severely restrict access to forage which impacts survival and reproduction (Miller and Gunn, 2003b; Taylor, 2005). Indeed, snow cover has repeatedly been implicated in significant over-winter mortality of muskoxen (Parker *et al*., 1975; Miller *et al.,* 1977; Parker, 1978; Gunn *et al*., 1989; Miller and Gunn, 2003b). Local hunters on southern Ellesmere report that muskoxen have difficulty in deep snow and they sometimes come across muskoxen that have died of starvation (Taylor, 2005; Jenkins *et al*., 2010b).

Schaefer and Messier (1995) found that muskoxen on Victoria Island exhibited consistent preference for thin or soft snow cover and greater forage abundance when studied across a nested hierarchy of spatial scales from population range to travel routes, to feeding sites, to feeding crates and finally to diet. Rettie and Messier (2000) have suggested that selection patterns are linked to limiting factors. Specifically, limiting factors which are most important to a species will influence selection at coarser spatial scales while those less important will influence fine-scale decisions. Thus, for muskoxen, snow cover and snow hardness appear to be limiting factors, as muskoxen consistently selected for thinner and softer snow across spatial scales (Schaefer and Messier, 1995).

4.3.5 Axel Heiberg Island Group

Tener (1963) provided preliminary estimates of 1,000 muskoxen for Axel Heiberg Island in 1961. During an aerial reconnaissance survey in July 1973, 866 muskoxen were counted between Stang Bay and Whitsunday Bay on eastern Axel Heiberg, an area known as Mokka Fiord (Ferguson, 1995). Our 2007 results (4237 95% CI 3371-5325 muskoxen one year or older) indicate that muskoxen have likely increased since the 1961 survey although we caution that coverage in 1961 was low (<3%).

Our estimated proportion of newborn calves (13%) is likely biased low as the 2007 survey was completed in early May, before calving ended (Tener, 1965; Gray, 1987). For the eastern Arctic historical estimates of calf crop are limited. Calf percentages for the Fosheim Peninsula varied between 0 and 14.2 in 1954 and 1960 (Tener, 1965) while reported values for Sverdrup Pass range from 14% in 1984 to 23% in 1983 (Henry *et al*., 1986). At a larger spatial scale, Tener (1963) reported the proportion of calves on Ellesmere and Axel Heiberg in 1961 as 12.4 % and 7.3 % respectively. Overall, our data indicates that Axel Heiberg Island supports a larger population of muskoxen than was previously thought. Current trends are impossible to determine due to the lack of survey data. However, our results show that Axel Heiberg Island supports the highest density of muskoxen in the Arctic Archipelago, Nunavut and next to northern Ellesmere, the largest population. Notably, this muskox population is sympatric with the largest Peary caribou population in Nunavut.

4.3.6 Ringnes Island Group

(Survey area - Ellef Ringnes, Amund Ringnes, King Christian, Cornwall, Meighen, and Lougheed)

With the exception of Lougheed Island, our survey was the first since 1961 (Tener, 1963) to estimate muskoxen abundance across the Ringnes Island Group. Like Tener (1963), we observed, in 2007, too few muskoxen to derive a population estimate for individual islands. Tener (1963) provided a preliminary estimate of 10 animals for Amund Ringnes Island based on observation of four bull muskoxen. He observed no muskoxen on Ellef Ringnes, Lougheed, King Christian, or Cornwall Islands (Tener, 1963).

Our combined minimum count of 21 animals for the Ringnes Island Group suggests that these islands are still on the periphery of muskoxen range. No muskoxen were observed on Ellef Ringnes, Lougheed, and Meighen Islands. No communities harvest muskoxen from these islands.

5.0 IMPLICATIONS FOR MANAGEMENT

5.1 SURVEY DESIGN

We designed the surveys to be accurate by using Distance Sampling methodology which allowed us to model the probability of detection. The approach relaxes the assumption that we saw and counted every individual within a certain distance of the transects, which is the case with strip transects (Buckland et al. 2001). Thus, we made the strip very wide (unbounded), expected not to detect all the animals (except for those on or very close to the transect), and recorded all observations regardless of distance from the transect. This approach, particularly suited to populations of animals that are sparsely distributed over large areas (Buckland *et al*., 2001; Buckland *et al*., 2004), can increase the number of detections, resulting in a greater sample size (n) and more precise density estimates (Buckland *et al.,* 2001). We also designed the surveys to be relatively precise by flying enough transects (k) and by ensuring that the transects covered entire non-glaciated island areas so that both caribou and muskoxen had a chance of being seen and counted.

The analysis of abundance and trends in population size is important in wildlife management and our survey is a baseline against which future surveys can be compared. The analysis of trends requires density and abundance estimates with sufficient power to detect change over time. Attention to survey design is important in achieving this objective (Buckland *et. al.,* 2001; Zerbini 2006) and with *a priori* knowledge of encounter rates (e.g. number of caribou per 1,000 km flown), we will be able to estimate the line length (effort) necessary to achieve desired precision and design transect coverage accordingly.

This study demonstrates that for some populations, large scale surveys will be necessary to apply sufficient effort to yield an adequate sample size. Notably if the sample is too small, then precision is poor (Buckland *et. al.,* 2001). Abundance estimates with low and/or variable precision can constrain wildlife management and approaches to improve precision should be evaluated. Thus, future surveys of small populations would also benefit from reconnaissance surveys, to determine when and if encounter rates will support a full scale survey, and what effort is necessary to generate the required precision.

One approach to increasing precision is to use stratification. For example, stratification of Distance Sampling data through *a priori* methods or through post stratification, should be considered. Another promising alternative includes multiple covariate distance sampling (MCDS), which uses multiple covariates in the estimation of detection probability and has the advantage of potentially providing a more precise estimate than stratification (Buckland *et. al*. 2001; Marques *et al*., 2003; Zerbini 2006).

Notably, our shift in methodology from the previously used strip transect to distance sampling has limited our ability to measure population trends as comparative data is not available. However, the benefits of distance sampling, including associated possibilities of increased precision with improved survey design and MCDS, have significant positive implications for wildlife management (Marques *et al*. 2003; Marques *et. al*., 2006; Buckland *et al.* 2004; Zerbini 2006; Aars *et. al.* 2008)

5.2 SURVEY SCALE

Until additional information on population boundaries becomes available, future surveys of Peary caribou should continue at the scale of Island Groups. This approach recognizes what we know about inter-island movements and population structure, and increases the likelihood of detecting real changes in caribou and muskoxen numbers (Gunn *et al.* 1997; Zittlau 2004; Miller *et al*., 2005b).

Defining populations requires understanding of genetics, geographic distribution and demography (Wells and Richmond 1995). The collection and analyses of data on genetics and distribution is underway although considerable effort is required to complete the analyses. Currently, population structure is being evaluated using microsatellite DNA from 300 Peary caribou samples collected from six island groups during the recently completed surveys, as well as previous research efforts. This is the first time that many of these areas have been sampled as previous analyses were limited in areas sampled (Zittlau, 2004; Petersen *et al.,* 2010). With 16 to 18 locus genotypes from Peary caribou, the variation within and between island groups is being exposed (Jenkins in prep). Similar research is underway for muskoxen. Movement and space use are also being analyzed for a small sample of radio-collared Peary caribou and muskoxen on Devon Island, Cornwallis Island and the Bathurst Island Complex (Jenkins in prep).

5.3 SURVEY FREQUENCY, MONITORING, AND MANAGEMENT PROGRAMS

In the Arctic Archipelago, the lack of routine monitoring is likely the greatest impediment to evaluating trends in abundance. Our study highlights the paucity of monitoring data for most island groups of Peary caribou and muskoxen. Monitoring is particularly important in areas where populations are small, environmental stochasticity is high, and where there is interest in harvesting (Miller and Barry, 2009).

Small populations are of great conservation concern due to the potential risk of inbreeding and genetic drift, and the resulting loss of genetic variability. This may reduce the ability of caribou and muskoxen to respond to future environmental and anthropogenic changes (Caughley and Gunn 1996; Zittlau, 2004).

When caribou and muskoxen population sizes are severely reduced, the risk of extinction is greater due to natural variation or chance (demographic stochasticity, environmental stochasticity, genetic stochasticity; Caughley and Gunn, 1996; Krebs, 2001, Zittlau, 2004). Such populations are also more vulnerable to additional pressures, such as human harvest, industrial activities (mineral and petroleum exploration and development), and climate change (Caughley and Gunn, 1996; Gunn *et al*., 2006; Mackey *et al*., 2008).

Peary caribou and muskoxen are important to local communities and an adequate monitoring program is not in place to inform communities on the status of local populations and determine sustainable harvest levels. When populations are low, it is important to maintain the maximum number of animals to minimize vulnerability and allow for the fastest possible recovery (Miller and Gunn, 2003a).

Similarly, formal monitoring programs to detect large-scale changes in the abundance and distribution of Peary caribou and muskoxen are lacking as are comprehensive management programs to initiate appropriate conservation measures when / if numbers become unsustainably low. Peary caribou and muskoxen populations are subject to abrupt changes in size, and adaptive and collaborative measures are necessary to detect fluctuations in population size, to monitor population parameters, to establish and communicate sustainable harvest levels, and to evaluate the effects of predation, harvesting, land use activities and other natural and anthropogenic factors (Miller and Gunn, 2003b; Miller and Barry, 2009; Prowse *et al*., 2009). At present, muskox harvesting occurs under a quota system however, a formal harvest management system for Peary caribou has not yet been applied. While some HTAs (Hunter and Trapper Associations) have implemented voluntary harvest restrictions for certain populations in the past, further action should be taken. Given the significant reduction of some Peary caribou populations, and the importance of caribou to local communities and the ecosystem at large, a formal and comprehensive management system should be developed in conjunction with the local HTAs (Jenkins *et al*. 2010a, 2010b).

5.4 COMMUNITY-BASED MONITORING

Local harvesters have unique knowledge and skill, and a shared interest in preservation of viable wildlife populations (Ferguson *et al.,* 1997;Taylor, 2005; Brook *et* *al.,* 2009, Curry 2009, Jenkins 2009, Jenkins *et al*., 2010a, 2010b). Local harvesters have on-going contact with caribou and muskoxen and can provide important information on these species and on the ecosystem at large. The implications for management are to ensure that a collaborative program is strengthened and to make certain that Inuit knowledge is integrated into management planning.

A community based monitoring program will address some of the unique challenges of conducting northern research (i.e. information exchange, remote location), while engaging community members, wildlife managers, and scientists in a collaborative effort that combines resources and knowledge (Meier *et al.*, 2006; Brook *et al.,* 2009; Jenkins 2009; Merkel 2010). Communities in the Arctic Islands want input into scientific studies and to participate and develop research programs that address their needs and concerns (Jenkins *et al.,* 2010a, 2010b). This study was built on the shared understanding that population monitoring is critical to wildlife management and conservation. Members of the Resolute Bay and Grise Fiord Hunting and Trapping Associations were strong proponents for the ground surveys which were valuable. Their information (i.e. observations of caribou and muskoxen, group composition, wildlife sign) was used to assess the aerial survey results and led to the collection of non-invasive samples for DNA and diet analyses.

Environmental conditions, particularly, unfavourable snow and ice conditions, have been identified as a principle limiting factor of Peary caribou (Miller and Gunn, 2003a, 2003b; Miller and Barry 2009). Thus, ecological monitoring should be a priority and can be based on observations collected by Inuit hunters. A program to systematically collect those observations is an essential component of a Peary caribou conservation program.

5.5 LAND-USE PLANNING

Conservation and management planning for caribou will be ineffective without consideration for their range (McCarthy *et al.,* 1998; Miller and Gunn, 2003a, Hummel and Ray, 2008; Jenkins *et al.,* 2010b). Peary caribou are at low numbers; they experience stochastic fluctuations in their environment and they exhibit significant fluctuations in population size due to these events (Miller and Barry 2009). Thus, additional stressors that negatively impact habitat quality and/or quantity are of concern. Scientists and Inuit agree that conservation of habitat, including sea ice, is important (Miller and Gunn 2003a; Jenkins *et al*. 2010b). Inuit knowledge is that the overall range of Peary caribou must be considered given that intact habitat is necessary at all times of the caribou life cycle and that life requirements change throughout the year (Japettee Akeeagok, in Jenkins *et al.,* 2010b). Miller and Gunn (2003a) explain that *'the protection of the caribou range during the stressful part of the year will be of little value if the caribou cannot subsequently make back their body condition, make new growth and build up their body reserves during the favourable time of the year. Thus, caribou need to have sufficient amounts of forage and space available during all seasons of the year to foster their year-round long term survival.*'

The management implications are to ensure that Peary caribou ecology and conservation are integrated into land-use planning. This has started with an assessment of Peary caribou distribution and habitat use based on the data from the aerial surveys.

5.6 CLIMATE CHANGE

Climate change may act as a significant factor in population dynamics and numerous studies have highlighted the sensitivity of Peary caribou and muskoxen to climate. Historical data shows that Peary caribou and muskoxen in the High Arctic have experienced significant declines due to unfavourable weather conditions (Miller *et. al.,* 1977a; Miller, 1995b, Miller and Gunn, 2003b; Miller and Barry, 2009; Tews, 2007a) and climate warming may exacerbate these events (Tews *et al*., 2007b; Barber *et al*., 2008; Vors and Boyce, 2009).

Tews *et al*., (2007b) found that some populations of Peary caribou will be at a greater risk of extinction if the frequency and intensity of poor winter conditions increases. Populations such as those on Axel Heiberg and Ellesmere Island may be less vulnerable given the complexity of niches afforded by topographic relief (Miller *et al.,* 2005b; Jenkins *et al*., 2010b).

Some Peary caribou depend on perennial ice to access portions of their annual range, or to expand their range when they are displaced by severe winter events (Miller, 1990b, Miller *et al*., 2005a). Recent trends suggest a reduction in sea-ice over most of the Arctic Basin and a marked basin-wide thinning in sea-ice (Barber *et al.,* 2008). Scientists have already identified a tendency for fast ice areas to melt earlier and freeze up later (Barber *et al.,* 2008). Miller *et al*. (2005a) has suggested that increases in the ice-free period could critically modify the timing and even the opportunity for seasonal migrations between islands.

Another potential impact of thinning ice, and a shorter ice season, is an extension in the shipping season. There is increasing interest in shipping lanes through Arctic waters due to thinning ice and the decreasing extent of sea ice (Kubat *et al.,* 2007, Somanathan *et al*., 2009, Ho 2010). Ships are constructed that can manage ice year round and the feasibility of shipping in Canada's Arctic is under consideration (Ho 2010).

Ship traffic through the ice covered channels could influence or interrupt caribou movement (i.e. regular seasonal movements, desperation movements) and/or increase the risks for caribou crossing the ice (of injury or death to caribou), as well as affect the timing, pattern and structure of sea ice formation and breakup (Miller, 1990a, 1990b; Miller *et al.,* 2005a; Poole *et al.,* 2010). .

The potential consequences of climate change for caribou and muskoxen are extensive and are driven by changes in temperature, precipitation, land/water use, sea ice, vegetation, atmospheric carbon dioxide concentrations, invasive species, insects, disease and ecosystem dynamics to name a few (Sala *et al.,* 2000; Mackey *et al.,* 2008). Positive responses to climate change are possible (Nemanin *et al.,* 2003) which would include higher levels of plant biomass and a longer snow-free season. However; most trends suggest that stress will increase for many species and ecosystems (Mackey *et al*., 2008).

The management implications are to develop research and monitoring programs to help us understand and measure the impacts of climate change on caribou and muskoxen ecology, population dynamics, space use and movement. Another implication is to integrate the uncertainty of climate change and potential environmental impacts into land use planning and wildlife management.

6.0 ISLAND-GROUP MANAGEMENT RECOMMENDATIONS

Management and monitoring programs for caribou and muskoxen in the Arctic Islands should be developed in consultation with local communities (Jenkins *et al.* 2010a, 2010b). The following information is offered for consideration in this process.

6.1 PEARY CARIBOU

6.1.1 Bathurst Island Group

The Bathurst Island Complex and Cornwallis Island are a frequently used hunting area for residents of Resolute Bay. Our survey results suggest that the Peary caribou abundance was low in 2001 although the survey and subsequent sightings appear to indicate some recovery. Regular surveys of the Bathurst Island Complex, including Cornwallis Island should be undertaken to update this estimate and allow for the monitoring of population trends and harvest to be managed for long term sustainable use. Reports of unusual movements or carcasses should be investigated and treated as a trigger for island-wide surveys. Support for continuing the process for a national park on the Governor General Islands and northern Bathurst Island will protect ranges including wintering and calving areas for Peary caribou. The proposed national park also has to be part of a framework to provide a resilient landscape for Peary caribou throughout their seasonal cycle. The marine component (i.e. sea ice) of Peary caribou habitat should be recognized in these designations.

6.1.2 Devon Island Group

Harvesting of caribou on Devon Island continues (Jenkins *et al*., 2010b) and limited harvest reports suggest that, for the period of 1996-2001, harvest efforts focused on the north coast of Devon (Grise Fiord, NWMB data 1996-2001), with some effort by Resolute Bay harvesters on the western coast (Resolute Bay, NWMB data 1996-2001).

We have no evidence that Devon Island receives migrants from adjacent caribou populations (e.g., Somerset, Cornwallis, or Ellesmere Island; Taylor, 2005) and at extremely low numbers, risks increase through demographic, genetic, and environmental stochasticity (Caughley and Gunn, 1996; Krebs 2001). Given our results of low abundance and unknown trend, caribou on Devon Island will require careful monitoring and management to support recovery and determine trends.

6.1.3 Ellesmere Island Group

Since the mid-1990s, Inuit from Grise Fiord have annually harvested between 20 and 66 Peary caribou on southern Ellesmere Island (DoE Unpublished Data, Priest and Usher, 2004). Harvest information since the mid-1990s has been provided voluntarily. As such, it is not complete and may underestimate the actual harvest requirements.

Population trends suggest that the reported harvest level may not be sustainable over the long term. To maintain a harvestable population on southern Ellesmere, management initiatives are required to reduce losses and compensate for low calf recruitment. Management initiatives should be developed in consultation with the local community and be linked to routine monitoring of the Island Group (Jenkins *et al.,* 2010 a, 2010b).

6.1.4 Prince of Wales/Somerset Island Group

Peary caribou numbers continue to be extremely low suggesting that recovery is uncertain and immediate measures to conserve caribou on Prince of Wales/Somerset group are necessary. Because some Peary caribou on POW/SI are known to use Boothia Peninsula in the winter, these measures should also include the Peninsula. The conservation of this inter-island population must involve the full spatial extent of caribou range and all communities that harvest Peary caribou within the geographic area. Further work is needed to evaluate the population of Peary caribou on Boothia and to understand the interchange that occurs between Boothia Peary caribou and POW/SI Complex. All future caribou surveys of Prince of Wales and Somerset Island should include the Boothia Peninsula and, during these surveys, efforts should be made to distinguish between Peary and Barrenground caribou.

6.1.5 Axel Heiberg Island Group

Axel Heiberg Island is the largest remaining population of Peary caribou in Nunavut (and the NWT). Interest in the conservation of unique features and ecosystems on Axel Heiberg have been identified previously (Zoltai *et al.,* 1981; Ferguson, 1995) and portions of the island have been listed for consideration as a World Heritage Site (DoE 2006). Given the diverse vegetation, varied topography, and protection from cyclonic activity (primarily, in the east; Maxwell, 1981; Alt and Edlund,1983), Axel

Heiberg Island is of national interest in the conservation and recovery of Peary caribou, particularly in the face of accelerated climate change. Given that a fundamental goal of wildlife management is the maintenance of wildlife habitat, the designation of Axel Heiberg Island for wildlife conservation is recommended. The benefits include provision of sites for environmental monitoring (Ferguson, 1995) and ecological research where anthropogenic influences on wildlife and their habitat are limited.

6.1.6 Ringnes Island Group

Although this Island Group forms part of the northern extent of Peary caribou range, the area supports the third largest abundance of caribou. Miller et al., 2005 identify the area as a low density reserve that can benefit the recovery and long-term persistence of Peary caribou. This study highlights the importance of Lougheed Island, and that further research is necessary to understand habitat characteristics, and caribou space use and movement.

6.2 MUSKOXEN

6.2.1 Bathurst Island Group

Bathurst Island Complex Survey Area - The BIC is currently identified as Muskoxen Management Unit MX-01 and the current harvest quota is 40 animals per season. Typically, less than half that quota is used annually (DoE data, 1990-2009) but the current quota will impede any recovery in muskox abundance and consultations are needed to collaborate on the harvest level. This is important as human activities are increasing in the High Arctic and this could intensify interest in the harvesting of muskoxen.

Cornwallis Survey Area - The Cornwallis Island Group is not within the boundaries of any of Nunavut's current Muskoxen Management Units. Nonetheless, DoE harvesting records indicate that muskoxen have been harvested on Cornwallis Island, primarily for sport hunts out of Resolute Bay. Our results provide no evidence that the nearest harvest management unit should be expanded to include the Cornwallis Island Group.

6.2.2 Devon Island Group

The Devon Island Group is part of Muskoxen Management Unit 5 (MX-05) and three communities harvest muskoxen in this region: Grise Fiord, Resolute Bay, and Arctic Bay. Based on our findings, we believe that the current quota of 15 muskoxen for MX-05 is sustainable.

6.2.3 Ellesmere Island Group

Northern Ellesmere Survey Area - During our survey, the largest concentration of muskoxen was detected on the Fosheim Peninsula, and this is consistent with findings from the first aerial survey of Ellesmere Island in 1961 (Tener, 1963). The Fosheim Peninsula has previously been identified as a Wildlife Area of Special Interest (WASI) because of its special features, high biological diversity, and significance to muskoxen

(Ferguson, 1995). The results of our study support this designation and emphasize the critical value of this habitat to muskoxen and their young.

Southern Ellesmere Island - The people of Grise Fiord (including sport hunters) harvest muskoxen across southern Ellesmere Island, primarily south of Baumann Fiord (in what is currently MX-02), but also in areas west and east of the community (i.e. MX-03 and MX-04, respectively). In combination, the combined annual quota of 74 muskoxen has been identified for these areas. Our results demonstrate that the majority of muskoxen were distributed north of the designated muskoxen management units, with low densities and numbers across southern Ellesmere Island. Additionally, animals unable to stand or run were observed frequently in 2005 and over 40 emaciated recently dead carcasses were observed throughout the survey area (Campbell 2006). Thus, the current quota, non-quota limitations and management units should be reviewed with the local HTA. Efforts to redirect harvesting pressure to areas in Northern Ellesmere should be considered.

6.2.4 Prince of Wales - Somerest Island Group

Prince of Wales Survey Area - The population of muskoxen on the Prince of Wales Group is harvested primarily by hunters from Resolute Bay. The quota for Prince of Wales Group is currently combined with Somerset Islands at 20 animals. An independent quota should be established for the Prince of Wales Island Group given that muskoxen are likely a separate population based on sea and ice conditions and their effects as an obstacle to regular movements (Gunn and Jenkins, 2006). That is, muskoxen can swim but rarely do (Tener 1965, Gunn and Adamczewski, 2003) and seasonal movements of muskoxen between Prince of Wales Island Group and Somerset Island have not been documented (Miller *et al*., 1977b; Taylor, 2005). Limited information from marked or radio-collared muskoxen in other areas of the high Arctic revealed no seasonal inter-island movements and there are few observations of muskoxen crossing sea ice (Miller *et al.,* 1977a; Taylor, 2005; Gunn and Jenkins, 2006; Jenkins in prep). The decline measured on Prince of Wales Island is a concern and regular monitoring is necessary to direct management action.

Somerset Island Survey Area **-** Muskoxen on Somerset Island have mainly been harvested by hunters from Resolute Bay and occasionally by hunters from Arctic Bay. As noted above, the current quota of 20 is for both the Prince of Wales and Somerset Island. An independent quota should be established for Somerset Island muskoxen given that this is likely a separate population based on the sea and ice conditions and its impacts on movement. Muskoxen on Somerset Island are not known to make seasonal inter-island movements (Taylor, 2005). Although muskoxen must have crossed the sea ice on occasion to colonize or recolonize islands in the Arctic Archipelago, the spatial and temporal scale of these movements is likely beyond the time frame that harvest management actions must target.

6.2.5 Axel Heiberg

No communities are known to harvest muskoxen from Axel Heiberg Island. Axel Heiberg Island has the second largest muskoxen population in the Arctic Archipelago, Nunavut. Interest in the conservation of unique features and ecosystems on Axel Heiberg have been identified previously (Zoltai *et al.,* 1981; Ferguson, 1995) and portions of the island have been listed for consideration as a World Heritage Site (DoE 2006). Concentrations of muskoxen east of the Princess Margaret Islands have been highlighted as a Wildlife Areas of Special Interest (Ferguson, 1995). Given the diverse vegetation, varied topography, and protection from cyclonic activity, primarily in the east; (Maxwell, 1981; Alt and Edlund,1983), Axel Heiberg Island may be of national interest in the conservation of biological diversity in the Arctic Archipelago, particularly in the face of accelerated climate change.

6.2.6 Ringnes Island Group

Muskoxen are at extremely low numbers and absent from a number of these islands. This, in combination with the high northern latitude and sparse vegetation, Edlund and Alt (1989) suggest that the area may be unable to sustain large numbers of muskoxen year round.

6.0 LITERATURE CITED

Aars, J., T.A. Marques, S.T. Buckland, M. Andersen, S. Belikov, A. Boltunov, O. Wiig. 2008. Estimating the Barents Sea polar bear subpopulation size. Marine Mammal Science.<http://www.creem.stand.ac.uk/sb/Aard%20et%20al%20MMS%202008.pdf>. Accessed 18 Sept. 2010.

Adams, L. G. 2003. Marrow fat deposition and skeletal growth in caribou calves. Journal of Wildlife Managment 67(1): 20-24.

Adams, L. G., F. J. Singer and B. W. Dale. 1995. Caribou calf mortality in Denali National Park, Alaska. Journal of Wildlife Managment 59(3): 584-594.

AICA. 2005. Arctic climate impact assessment. Cambridge University Press, Cambridge, UK.

Anderson, D. R., K. P. Burnham, B. C. Lubow, L. Thomas, P. S. Corn, P. A. Medica and R. W. Marlo. 2001. Field trials of line transect methods applied to estimation of Desert Tortoise abundance. Journal of Wildlife Management 65(3): 583-597.

Anisimov, O.A., V.A. Lobanov, S.A. Reneva, N.I. Shiklomanov, T.J. Zhang and F.E. Nelson. 2007. Uncertainties in gridded air temperature fields and effects on predictive active layer modelling. Journal of Geophysical Research – Earth Surface 112(F2).

Babb, T. A. and L. C. Bliss. 1974. Susceptibility to environmental impact in the Queen Elizabeth Islands. Arctic 27(3): 234-237.

Banfield, A.W.F. 1961. A revision of the Reindeer and caribou, genus Rangifer. Bulletin, Natl. Museum of Canada, Biological Service No 66.

Barber, D. G., J. V. Lukovich, J. Keogak, S. Baryluk, L. Fortier and G. H. R. Henry. 2008. The changing climate of the Arctic. Arctic 61 (Suppl. 1): 7-26.

Barboza, P. S., D. W. Hartbauer, W. E. Hauer and J. E. Blake. 2004. Polygynous mating impairs body condition and homeostasis in male reindeer *(Rangifer tarandus tarandus*). Journal of Comparative Physiological B 174: 309-317.

Bergerud, A. T. 1971. The population dynamics of Newfoundland caribou. Wildlife Monographs 25: 55 pp.

Bergerud, A. T. 1978. Caribou. Pp. 55-60 in J. L. Schmidt and D. L. Gilbert. Big game of North America: ecology and management. Stackpole Books, Harrisburg, PA.

Brook, R. K., S. J. Kutz, A. M. Veitch, R. A. Popko and B. T. Elkin. 2009. Fostering community-based wildlife health monitoring and research in the Canadian North. EcoHealth 6(2): 266-278.

Buckland, A. T., K.P. Burnham, J.L. Laake, D.L. Borchers, L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, New York.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers and L. T. Thomas. 2004. Advanced distance sampling: estimating abundance of biological populations. Oxford University Press, New York.

Cameron, R.D., W.T. Smith, S.G. Fancy, K.L. Gerhart and R.G. White. 1993. Calving success of female caribou in relation to body weight. Canadian Journal of Zoology 71: 480-486.

Campbell, M. W. 2006. Summary report to Nunavut co-managers. Department of Environment, Wildlife Research Division, Government of Nunavut, Arviat, NU.

Case, R. 1992. Distribution and abundance of muskoxen on Devon Island, NWT, August 1990. Northwest Territories Department of Renewable Resources Manuscript Report No. 58, Yellowknife, NWT.

Case, R. and T. Ellsworth. 1991. Distribution and abundance of muskoxen and Peary caribou on southern Ellesmere Island, NWT, July 1989. Northwest Territories Department of Renewable Resources Manuscript Report No. 41, Yellowknife, NWT.

Caughley, G. and A. Gunn. 1996. Conservation biology in theory and practice. Blackwell Science, Cambridge, UK.

COSEWIC. 2004. COSEWIC assessment and update status report on the Peary caribou Rangifer tarandus pearyi and the barren-ground caribou Rangifer tarandus groenlandicus (Dolphin and Union population) in Canada. Committee on the Status of Endangered Wildlife in Canada Ottawa, ON.

Curry, P. 2009. Caribou herds and Arctic communities: exploring a new tool for caribou health monitoring. INFONORTH: 495-499.

Department of Natural Resources. 2006. VFR navigation chart: Hazen Strait. 4th Edition. Aeronautical Information, Geomatics Canada.

Department of Natural Resources. 2000. VFR navigation chart: Resolute. 4th Edition. Aeronautical Information, Geomatics Canada.

DoE. 2004b. High Arctic Peary caribou management plan. Draft 5. Department of Environment, Government of Nunavut, and Iviq Hunters and Trappers Association, Grise Fiord, NU.

DoE. 2004a. High Arctic Peary caribou management plan. 5th Draft. Department of Environment, Government of Nunavut, and Resolute Bay Hunters and Trappers Association, Resolute Bay, NU.`

Dumond, M. 2006. Muskoxen abundance and distribution, and caribou distribution and calving areas on Boothia Peninsula, Nunavut. Nunavut Department of Environment Field Work Summary, Kuglutuk, NU.

Edlund, S.A. 1983. Bioclimatic zonation in a high arctic region: Central Queen Elizabeth Islands. Pp. 381-390, In, Curren Research Part A, Geological Survey of Canada Paper 83-1A.

Edlund, S. A. and B. T. Alt. 1989. Regional congruence of vegetation and summer climate patterns in the Queen Elizabeth Islands, Northwest Territories, Canada Arctic 42(1): 3-23.

Edlund, S. A., M. K. Woo and K. L. Young. 1990. Climate, hydrology and vegetation patterns Hot Weather Creek, Ellesmere-Island, Arctic Canada. Nordic Hydrology 21(4-5): 273-286.

Environment Canada. 2010. National climate data and information archive. <http://climate.weatheroffice.gc.ca/climateData/canada_e.html>. Accessed 15 Feb. 2011.

Environment Canada. 2010. Weatheroffice: Nunavut. <http://texte.meteo.gc.ca/forecast/canada/index_e.html?id=nu>. Accessed 8 Oct. 2010.

Ferguson, M. A. D. 1991. Peary caribou and muskoxen on Bathurst Island, Northwest Territories, from 1961-1981. Northwest Territories Department of Renewable Resources File Report No. 88, Yellowknife, NWT.

Ferguson, M.A.D. and F. Messier. 1997. Collection and analysis of traditional ecological knowledge about a population of Arctic Tundra caribou. Arctic 50(1): 17-28.

Ferguson, R. S. 1995. Wildlife areas of special interest to the Department of Renewable Resources in the Nunavut Settlement Area. Northwest Territories Department of Renewable Resources, Wildlife Managment Division Yellowknife, NT.

Fischer, C. A. and E. A. Duncan. 1976. Ecological studies of caribou and muskoxen in t he Arctic archipelago and Northern Keewatin. Renewable Resources Consulting Services Ltd. Edmonton, Alberta.

Fournier, B. and A. Gunn. 1998. Muskox numbers and distribution in the Northwest Territories 1997. Northwest Territories Department of Renewable Resources File Report No. 121, Yellowknife, NWT.

Fraser, P., A. Gunn and B. McLean. 1992. Abundance and distribution of Peary caribou and muskoxen on Banks Island, N.W.T., June 1991. Northwest Territories Department of Renewable Resources Manuscript Report No. 63, Yellowknife, NWT.

Freeman, M. M. R. 1971. Population characteristics of muskoxen in the Jones Sound Region of the Northwest Territories. Journal of Wildlife Management 35(1): 104-108.

Gauthier, L. 1996. Observations of wildlife on Ellesmere and Axel Heiberg islands between June 12-21, 1995. Northwest Territories Department of Renewable Resources Manuscript Report No. 86, Pond Inlet, NT.

Good, R. E., R. M. Nielson, H. Sawyer and L. L. McDonald. 2007. A population estimate for golden eagles in the Western United States. Journal of Wildlife Management 71(2): 395-402.

Gould, W. A., S. Edlund, S. Zoltai, M. Raynolds, D. A. Walker and H. Maier. 2002. Canadian Arctic vegetation mapping. International Journal of Remote Sensing 23(21): 4597-4609.

Gray, D.R. 1987. The muskoxen of Polar Bear Pass. National Museum of Natural Sciences, National Museum of Canada. Fitzhenry and Whiteside, Markham, Ontario.

Gunn, A. 2005. The decline of caribou on northwest Victoria Island: a review. Northwest Territories Department of Resources, Wildlife and Economic Development Draft File Report No. 38, Yellowknife, NWT.

Gunn, A. and J. Adamczewski. 2003. Muskox. *In* Eds G. Felhamer, B.A. Chapman, and J.A. Chapman. Wild Mammals. The John Hopkins University Press, Baltimore.

Gunn, A., J. Adamczewski and B. Elkin. 1991. Commercial harvesting of muskoxen in the Northwest Territories, In: Renecker, L.A. and R.J. Hudson. Wildlife production; conservation and sustainable development. University of Fairbanks, Fairbanks, Alaska.

Gunn, A. and J. Ashevak. 1990. Distribution, abundance and history of caribou and muskoxen north and south of the Boothia Isthmus, NWT, May-June 1985. Northwest Territories Department of Renewable Resources File Report No. 90, Coppermine, NWT.

Gunn, A. and R. Decker. 1984. Numbers and distributions of Peary caribou and muskoxen in July 1980, on Prince of Wales, Russell, and Somerset Islands, N.W.T. Northwest Territories Department of Renewable Resources File Report No. 38, Yellowknife, NWT.

Gunn, A. and J. Dragon. 1998. Status of the caribou and muskoxen populations within the Prince of Wales Island-Somerset Island-Boothia Peninsula Complex, NWT, July-August 1995. Northwest Territories Department of Resourses, Wildlife and Economic Developement File Report No. 122, Yellowknife, NT.

Gunn, A. and J. Dragon. 2002. Peary caribou and muskox abundance and distribution on the Western Queen Elizabeth Islands, Northwest Territories and Nunavut (June-July 1997). Northwest Territories Department of Resources, Wildlife and Economic Development File Report No. 130, Yellowknife, NT.

Gunn, A. and B. Fournier. 2000. Identification and substantiation of caribou calving grounds on the NWT mainland and islands. Northwest Territories Department of Resources, Wildlife and Economic Development File Report No. 123, Yellowknife, NT.

Gunn, A. and D. Jenkins, 2006. Muskoxen Management in Baffin: Working Draft. Department of Environment, Government of Nunavut, Technical Report Series.

Gunn, A. and J. Lee. 2000. Distribution and abundance of muskoxen on Northeast Victoria Island, NWT. Northwest Territories Department of Resources, Wildlife, and Economic Development Development Manuscript No. 119, Yellowknife, NT.

Gunn, A., F. L. Miller, S. J. Barry and A. Buchan. 2006. A near-total decline in caribou on Prince of Wales, Somerset, and Russell Islands, Canadian Arctic. Arctic 59(1): 1-13.

Gunn, A., F. L. Miller and B. McLean. 1989. Evidence for and possible causes of increased mortality of bull muskoxen during severe winters. Canadian Journal of Zoology 67: 1106-1111.

Gunn, A., F. L. Miller and J. Nishi. 2000. Status of endangered and threatened caribou on Canada's arctic islands. Rangifer(Special Issue No. 12): 39-50.

Gunn, A., F. L. Miller, C. Shank and C. Strobeck. 1997. National recovery plan for Peary caribou and Arctic-Island caribou. Population and habitat viability assessment (PHVA) for the Peary caribou (*Rangifer tarandus pearyi*). Conservation Breeding Specialist Group.

Gunn, A., F. L. Miller and D. C. Thomas. 1981. The current status and future of Peary caribou (*Rangifer tarandus pearyi*) on the Arctic islands of Canada. Biological Conservation 19: 283-296.

Gunn, A. and B. Patterson. In Press. Abundance and distribution of muskoxen on southeastern Victoria Island. Nunavut, 1988-1999. Northwest Territories Department of Renewable Resources File Report No. 36, Yellowknife, NT.

Heard, D.C. 1990. The intrinsic rate of increase of reindeer and caribou populations in arctic environments. Rangifer Special Issue No. 3: 169-173.

Heard, D. C. 1992. Distribution and abundance of caribou and muskoxen on northwestern Victoria Island Northwest Territories. Northwest Territories Department of Renewable Resources Manuscript Report No. 60, Yellowknife, NT.

Henry G., B. Freedman and J. Svoboda. 1986. Survey of vegetated areas and muskox populations in East-central Ellesmere Island. Arctic 39(1): 78-81.

Ho, J. 2010. The implications of Arctic sea ice decline on shipping. Marine Policy 34: 713-715.

Hubert, B. A. 1977. Estimated productivity of muskox on Truelove Lowland. Pp. 467-491 in L. C. Bliss. Truelove Lowland, Devon Island, Canada: a High Arctic ecosystem. University of Alberta Press, Edmonton, AB.

Hummel, M. and J.C. Ray. 2008. Caribou and the north: a shared future. A Dundurn Press, Toronto, ON.

Indian and Northern Affairs Canada. 1993. Agreement between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in right of Canada. Ottawa, Canada.

IUCN. 2010. IUCN red list of threatened species. Version 2010.4. <www.iucnredlist.org.> Accessed on 20 Feb. 2011.

Jackimchuk, R. D. and D. R. Carruthers. 1980. Caribou and muskoxen on Victoria Island NWT. R.D. Jakimchuk Management Associates Ltd. for Polar Gas Project, Sidney, British Columbia.

Jenkins, D. 2009. The Distribution and Abundance of Peary caribou and Muskoxen on Devon Island, Nunavut. Nunavut Department of Environment Interim Report, Pond Inlet, NU.

Jenkins, D. 2009. Caribou health monitoring: caribou sample collection for disease monitoring and genetic analysis. Department of Environment, Government of Nunavut Interim Progress Report, Pond Inlet, NU.

Jenkins, D., P. Curry, A. Millar, D. Karadag and S. Akeeagok. 2010a. Peary caribou workshop: sharing what we know about caribou. Resolute Bay, Summary Report. Department of Environment, Government of Nunavut.

Jenkins, D., P. Curry, A. Millar, D. Karadag and S. Akeeagok. 2010b. Peary caribou workshop: sharing what we know about caribou. Grise Fiord, Summary Report. Department of Environment, Government of Nunavut.

Jingfors, K. 1984. Abundance, composition and distribution of muskoxen on Southeastern Victoria Island. Northwest Territories Department of Renewable Resources File Report No. 36, Yellowknife, NWT.

Jingfors, K. 1985. Abundance and distribution of muskoxen on Northwestern Victoria Island. Northwest Territories Department of Renewable Resources File Report No. 47, Yellowknife, NWT.

Kevan, P. G. 1974. Peary caribou and muskoxen on Banks Island. Arctic 27: 256-264.

Krebs, C. J. 2001. Ecology: the experimental analysis of distribution and abundance. Fifth Edition. The University of British Columbia. Benjamin Cummings: An Imprint of Addison Wesley Longman, Inc., San Francisco, CA.

Kubat, I., R. Gorman, A. Collins and G.W. Timco. 2007. Climate change impact on Canadian northern shipping regulations. Marine Technology 44(4): 245-253(9).

Latour, P. 1985. Population estimates for Peary caribou and muskoxen on Banks Island in 1982. Northwest Territories Department of Renewable Resources File Report No. 49, Yellowknife, NWT.

Mackey, B. G., J. E. M. Watson, G. Hope and S. Gilmore. 2008. Climate change, biodiversity conservation, and the role of protected areas: an Australian perspective. Biodiversity 9(3&4): 11-18.

Macpherson, A.H. 1961. On the abundance and distribution of certain mammals in the western Canadian Arctic Islands in 1958-59. The Arctic Circular 14: 1-17.

Manning, T. H. 1960. The relationship of the Peary and Barren Ground caribou. Arctic Institute of North America Technical Paper No. 4.

Marques, F.F.C. and S.T. Buckland. 2003. Incorporating covariates into standard line transect analyses. Biometrics 59: 924-935.

Marques, T. A., M. Andersen, S. Christensen-Dalsgaard, S. Belikov, A. Boltunov, O. Wiig, S. T. Buckland and J. Aars. 2006. The use of global positioning systems to record distances in a helicopter line-transect survey. Wildlife Society Bulletin 34(4): 759-763.

Marques, T.A., L.A. Thomas, S.G. Fancy, S.T. Buckland. 2007. Improving estimates of bird density using multiple-covariate distance sampling. The Auk 124 (4): 1229-1243.

Maxwell, J. B. 1981. Climatic regions of the Canadian Arctic Islands. Arctic 34(3): 225-240.

McBean, G.G., V. Alekssev, D. Chen, E. Forland, J. Fyfe and P.Y. Groisman. 2005. Arctic climate past and present. Pp. 21-60 in Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK.

McCarthy, A., R. Blouch, D. Moore, C.M. Wemmer. 1998. Deer: status survey and conservation action plan. IUCN, Gland, Switzerland.

McLean, B., K. Jingfors and R. Case. 1986. Abundance and distribution of muskoxen and caribou on Banks Island, July 1985. Northwest Territories Department of Renewable Resources File Report No. 64, Inuvik, NWT.

McLean, B. D. 1992. Abundance and distribution of caribou on Banks Island, NWT July 1987. Northwest Territories Department of Renewable Resources File Report No. 95, Inuvik, NWT.

McLean, B. D. and P. Fraser. 1992. Abundance and distribution of Peary caribou and muskoxen on Banks Island, NWT June 1989. Northwest Territories Department of Renewable Resources File Report No. 106, Inuvik, NWT.

McLoughlin, P. D., M. Campbell, M. A. D. Ferguson, G. Hope, J. Pameolik, M. Setterington, M. K. Taylor and F. Messier. 2006. Density, distribution and composition of Peary caribou (Rangifer tarandrus pearyi) populations of the High Arctic Islands, Nunavut. Nunavut Department of Environment Interim Wildlife Report 1, Iqaluit, NU.

Mech, L. D. 2005. Decline and recovery of a High Arctic wolf-prey system. Arctic 58(3): 305-307.

Meier, W. N., J. Stroeve and S. Gearhead. 2006. Bridging perspectives from remote sensing and Inuit communities on changing sea-ice cover in the Baffin Bay region. Annals of Glaciology 44: 433-438.

Merkel, F. R. 2010. Evidence of recent population recovery in Common eiders breeding in Western Greenland. Journal of Wildlife Managment 74(8): 1869-1874.

Miller, F. L. 1987a. Peary caribou and muskoxen on Bathurst, Alexander, Marc, Massey, Vanier, Cameron, Helena, Lougheed, and Edmund Wlaker Islands, Northwest Territories, July 1985. Canadian Wildlife Service, Prairie and Northern Region Technical Report Series No. 20, Edmonton, AB.

Miller, F. 1987b. Peary caribou and muskoxen on Prince Patrick Island, Eglinton Island, and Emerald Isle, Northwest Territories, July 1986. Canadian Wildlife Service, Prairie and Northern Region Technical Report Series No. 29, Edmonton, AB.

Miller, F. L. 1988. Peary caribou and muskoxen on Melville and Byam Martin islands, Northwest Territories, July 1987. Canadian Wildlife Service, Prairie and Northern Region Technical Report Series No. 37, Edmonton, AB.

Miller, F. L. 1989. Reevaluation of the status of Peary caribou and muskox populations within the Bathurst Island complex, Northwest Territories, July 1988. Canadian Wildlife Service, Prairie and Northern Range Technical Report No. 78, Edmonton, AB.

Miller, F. L. 1990a. Peary caribou status report. Canadian Wildlife Service Edmonton, AB.

Miller, F. L. 1990b. Inter-island movements of Peary caribou: a review and appraisement of their ecological importance. Pp. 608-632 in C. R. Harington. Canada's Missing Dimension - Science and History in the Canadian Arctic Islands. Canadian Museum of Nature, Vol. 2, Ottawa, ON.

Miller, F. L. 1991. Peary caribou calving and postcalving periods; Bathurst Island complex, Northwest Territories, 1989. Canadian Wildlife Service, Prairie and Northern Region Technical Report Series No. 118, Edmonton, AB.

Miller, F. L. 1992. Peary caribou calving and postcalving periods, Bathurst Island complex, Northwest Territories, 1990. Canadian Wildlife Services, Prairie and Northern Region Technical Report Series No. 151, Edmonton, AB.

Miller, F. L. 1993a. Peary caribou calving and postcalving periods, Bathurst Island complex, Northwest Territories, 1991. Canadian Wildlife Service, Prairie and Northern Region Technical Report Series No. 166, Edmonton, AB.

Miller, F. L. 1993b. Status of wolves in the Canadian Arctic archipelago. Canadian Wildlife Service Technical Report Series, Edmonton, AB.

Miller, F. L. 1994. Peary caribou calving and postcalving periods, Bathurst Island complex, Northwest Territories, 1992. Canadian Wildlife Service, Prairie and Northern Region Technical Report Series No. 186, Edmonton, AB.

Miller, F. L. 1995a. Inter-island water crossings by Peary caribou, south-central Queen Elizabeth Islands. Arctic 48(1): 8-12.

Miller, F. L. 1995b. Peary caribou conservation studies, Bathurst Island complex, Northwest Territories, July-August 1993. Canadian Wildlife Service, Prairie & Northern region Technical Report Series No.230, Edmonton, AB.

Miller, F. L. 1997a. Peary caribou conservation studies, Bathurst Island Complex, Northwest Territories, April-August 1994 and June-July 1995. Canadian Wildlife Service, Prairie and Northern Region Technical Report Series No. 295, Edmonton, AB.

Miller, F. L. 1997b. Late winter absence of caribou on Prince of Wales, Russell, and Somerset islands, Northwest Territories, April-May 1996. Canadian Wildlife Service, Prarie and Northern Region Technical Report Series No. 291, Edmonton, AB.

Miller, F. L. 1998. Status of Peary caribou and muskox populations within the Bathurst Island Complex, south-central Queen Elizabeth Islands, Northwest Territories, July 1996. Canadian Wildlife Service, Prairie & Northern Region Technical Report Series No. 317, Edmonton, AB.

Miller, F.L. 2002. Multi-island seasonal home range use by two Peary caribou, Canadian High Arctic Islands, Nunavut, 1993-1994. Arctic 55(2): 133-142.

Miller, F.L. and S.J. Barry. 2003. Single-island home range use by four female Peary caribou, Bathurst Island, Canadian High Arctic, 1993-94. Rangifer Special Issue 14: 267-281.

Miller, F. L. and S. J. Barry. 2009. Long-term control of Peary caribou numbers by unpredictable, exceptionally severe snow or ice conditions in a non-equilibrium grazing system. Arctic 62(2): 175-189.

Miller, F. L., S. J. Barry and W. A. Calvert. 2005a. Sea-ice crossings by caribou in the south-central Canadian Arctic archipelago and their ecological importance. Rangifer(Special Issue 16): 77-88.

Miller, F. L., S. J. Barry and W. A. Calvert. 2005b Conservation of Peary caribou based on a recalculation of the 1961 aerial survey on the Queen Elizabeth Islands, Arctic Canada. Rangifer (Special Issue No. 16): 65-75.

Miller, F. L. and A. Gunn. 2003a. Status, population fluctuations and ecological relationships of Peary caribou on the Queen Elizabeth Islands: Implications for their survival. Rangifer (Special Issue No.14): 213-226.

Miller, F. L. and A. Gunn. 2003b. Catastrophic die-off of Peary caribou on the western Queen Elizabeth Islands, Canadian High Arctic. Arctic 56(4): 381-390.

Miller, F. L., R. H. Russell and A. Gunn. 1977a. Distribution, movements, and numbers of Peary caribou and muskoxen on Western Queen Elizabeth Islands, NWT 1972-74. Canadian Wildlife Service Report Series No. 40, Edmonton, AB.

Miller, F.L., R.H. Russell and A. Gunn. 1977b. Inter-island movements of Peary caribou (*Rangifer tarandus pearyi*) on Western Queen Elizabeth Islands, Arctic Canada. Canadian Journal of Zoology 55(6): 1029-1037.

Ministry of Northern Affairs Canada. 1993. Agreement between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in right of Canada. <http://www.gov.nu.ca/hr/site/doc/nlca.pdf>. Accessed 10 Nov. 2010.

Nagy, J. A., A. Gunn and W. H. Wright. 2009a. Population estimates for Peary caribou (Minto Inlet herd), Dolphin and Union caribou and muskox on Northwest Victoria Island, NT, July 2005. Northwest Territories Department of Environment and Natural Resources Manuscript Report No. 203, Inuvik, NT.

Nagy, J. A., A. Gunn and W. H. Wright. 2009b. Population estimates for Peary caribou and muskox on Banks Island, NT, August 2005. Northwest Territories Department of Environment and Natural Resources Manuscript Report No. 200, Inuvik, NT.

Nagy, J. A., A. Gunn and W. H. Wright. 2009c. Population estimates for Peary caribou and muskox on Banks Island, NT, August 1992. Northwest Territories Department of Environment and Natural Resources Manuscript Report No. 198, Inuvik, NT.

Nagy, J. A., N. Larter and W. H. Wright. 2006. Population estimates for Peary caribou and muskox on Banks Island, NT, July 2001. Northwest Territories Department of Environment and Natural Resources Manuscript Report No. 199, Inuvik, NT.

Nagy, J. A., N. Larter and W. H. Wright. 2009d. Population estimates for Peary caribou (Minto Inlet herd), Dolphin and Union caribou and muskox on northwest Victoria Island, NT, July 1998. Northwest Territories Department of Environment and Natural Resources Manuscript Report No. 202, Inuvik, NT.

Nagy, J. A., N. Larter and W. H. Wright. 2009e. Population estimates for Peary Caribou (Minto Inlet herd), Dolphin and Union caribou and muskox on northwest Victoria Island, NT, July 2001. . Northwest Territories Department of Environment and Natural Resources Manuscript Report No. 201, Inuvik, NT.

Nagy, J. A., P. Latour and W. H. Wright. 2009f. Population estimates for Peary caribou and muskox on Banks Island, NT, July 1982: a retrospective analysis. Northwest

Territories Department of Environment and Natural Resources Manuscript Report No. 197, Inuvik, NT.

National Defence. 2010. CFS Alert: history. <http://www.airforce.forces.gc.ca/8w-8e/alert/page-eng.asp?id=1106>. Accessed 8 Oct. 2010.

Natural Resources Canada. 2007. The atlas of Canada. <http://atlas.nrcan.gc.ca/auth/english/maps/environment/ecology/framework/terrestrialecozones>. Accessed 7 Oct. 2010.

Nishi, J. and L. Buckland. 2000. An aerial survey of caribou on western Victoria Island (5-17 June 1994). Northwest Territories Department of Resources, Wildlife, and Economic Development File Report No. 128,

Nemani, R.R., C.D. Keeling, H. Hashimoto, M. Jolly, S.C. Piper, C.J. Tucker, R.B. Myneni and S.W. Running. 2003. Climate driven increases in global terrestrial net primary production from 1982 to 1999. Science 300: 1560-1563.

Parker, G. R. 1978. The diets of muskoxen and Peary caribou on some islands in the Canadian High Arctic. Canadian Wildlife Service Occasional Paper No. 35, Edmonton, AB.

Parker, K.L., C.T. Robbins and T.A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. Journal of Wildlife Management 48(2):474-488.

Parker, G. R. and R. K. Ross. 1976. Summer habitat use by muskoxen (Ovibos moschatus) and Peary caribou (*Rangifer tarandus peari*) in the Canadian High Arcitc. Polarforschung 46(1): 12-25.

Parker, G.R., D.C. Thomas, E. Broughton and D.R. Gray. 1975. Crashes of muskox and Peary caribou populations in 1973-74 on the Parry Islands, Arctic Canada. Canadian Wildlife Service Progress Notes No. 56.

Pattie, D. L. 1990 Muskox (Ovibos moschatus Zimmermann) populations on the Notherneast Coast of Devon Island. Northern Institude of Technology: 633-641.

Petersen, S. D., M. Manseau and P. J. Wilson. 2010. Bottlenecks, isolation, and life at the northern range limit: Peary caribou on Ellesmere Island, Canada. Journal of Mammalogy 91(3): 698-711.

Pollard, H.J., D. Palka and S.T. Buckland. 2002. Adaptive line transect sampling. Biometrics 58: 862-870.

Poole, K. G., A. Gunn, B. R. Patterson and M. Dumond. 2010. Sea ice and migration of the Dolphin and Union caribou herd in the Canadian Arctic: an uncertain future. Arctic 63(4): 414-428.

Post, E., C. Pedersen, C.C. Wilmers and M.C. Forchhammer. 2008. Warming plant phenology and the spatial dimensions of trophic mismatch for large herbivores. Proceedings of the Royal Society B-Biological Sciences 275 (1646):2005-2013.

Post, E. and N.C. Stenseth. 1999. Climatic variability, plant phenology, and northern ungulates. Ecology 80(4):1322-1339.

Priest, H. and P.J. Usher. 2004. The Nunavut wildlife harvest study. Nunavut Wildlife Management Board, Iqaluit, NU, Canada.

Prowse, T. D., C. Furgal, F. J. Wrona and J. D. Reist. 2009. Implications of Climate Change for Northern Canada: Freshwater, Marine, and Terrestrial Ecosystems. Royal Swedish Academy of Sciences 38(5): 282-289.

Rettie, W. J. and F. Messier. 2000. Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. Ecography 23: 466-478.

Riewe, R. R. 1973. Final report on a survey of ungulate poplutions on the Bjorne Peninsula, Ellesmere Island. Determination of numbers and distribution and assessment of the effects of seismic activities on the behaviour of these populations. Univeristy of Manitoba, Winnipeg, for Department of Indian and Northern Affairs Ottawa, ON.

Rinke, A. and K. Dethloff. 2008. Simulated circum-Arctic climate changes by the end of the 21st century. Global and Planetary Change 62(1-2):173-186.

Sala, O.E., F.S. Chapin III, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kingzig, R. Leemans, D.M. Lodge, H. A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker and D.H. Wall. 2000. Global biodiversity scenarios for the year 2100. Science 287: 1770-1774.

Schaefer, J. A. and F. Messier. 1995. Habitat selection as a hierarchy; the spacial scales of winter foraging by muskoxen. Ecography 18(4): 333-344.

Somanathan, S., P. Flynn and J. Szymanski. 2009. The Northwest Passage: a simulation. Transportation Research Part A 43: 127-135.

Statistics Canada. 2010. The land: principle heights by range or region. <http://www.statcan.gc.ca/kits-trousses/cyb-adc1999/ecozone/edu04_0092k-eng.htm>. Accessed 13 Sept. 2010.

Struzik, E. (1996). An Edmonton scientist solves the cruel riddle of dying muskoxen and endangered Peary Caribou. Southam Newspapers, September 21, 1996. Edmonton, Alberta.

Taylor, A. D. M. 2005. Inuit Qaujimajatuqangit about popuation changes and ecology of Peary caribou and muskoxen on the High Arctic Islands of Nunavut. MA Thesis. Queen's University, Kingston, Ontario.

Tener, J. S. 1963. Queen Elizabeth Islands game survey, 1961. Canadian Wildlife Service Occasional Paper No. 4.

Tener, J. S. 1965. Muskoxen in Canada a biological and taxonomic review. Northern Affairs and National Resources, Ottawa, ON.

Tews, J., M. Ferguson and L. Fahrig. 2007a. Modeling density dependence and climatic disturbance in caribou: a case study from the Bathurst Island complex, Candian High Arctic. Journal of Zoology 272: 209-217.

Tews, J., M. A. D. Ferguson and L. Fahrig. 2007b. Potential net effects of climate change on High Arctic Peary caribou: Lessons from a spatially explicit simulation model. Ecological Modelling 207: 85-98.

Thomas, D. C. 1982. The relationship between fertility and fat reserves of Peary caribou. Can. J. Zool. 60: 597-602.

Thomas, D. C. and P. Everson. 1982. Geographic variation in caribou on the Canadian arctic islands. Canadian Journal of Zoology 60(10): 2442-2454.

Thomas, D. C., F. L. Miller, R. H. Russell and G. R. Parker. 1981. The Bailey Point region and other muskox refugia in the Canadian Arctic: a short review. Arctic 34(1): 34-36.

Thomas, D. C., R. H. Russell, E. Broughton, E. J. Edmonds and A. Gunn. 1977. Further studies of two populations of Peary caribou in the Canadian Arctic. Canadian Wildlife Service No. 80.

Thomas, D. C., R. H. Russell, E. Broughton and P. L. Madore. 1976. Investigations of Peary caribou populations on Canadian Arctic islands. Canadian Wildlife Service Progress Notes No. 64, Edmonton, Alberta.

Thomas, L., S. T. Buckland, K. P. Burnham, D. R. Anderson, J. L. Laake, D. L. Borchers and S. Strindberg. 2002. In, El-Shaarawi, A.H. and W. W. Piegorsch. Distance Sampling in Encyclopedia of Environmetrics. John Wiley & Sons, Ltd., Chichester.

Thomas, L., J. L. Laake, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Hedley, J. H. Pollard, J. R. B. Bishop and T. A. Marques. 2005. Distance 5.0. Release "X"1. from www.ruwpa.stand.ac.uk/distance/.

Urquhart, D. R. 1973. Oil exploration and Banks Island wildlife: a guidline for the preservation of caribou, muskox, and arctic fox populations on Banks Island, N.W.T. Northwest Territories Game Management Division Yellowknife, NWT.

Urquhart, D. R. 1982. Life history and current status of muskox in the NWT. Northwest Territories Department of Renewable Resources Yellowknife, NWT.

Vincent, D. and A. Gunn. 1981. Population increase of muskoxen on Banks Island and implications for competition with Peary caribou. Arctic 34: 175-179.

Vors, L. S. and M. S. Boyce. 2009. Global declines of caribou and reindeer. Global Change Biology 15: 2626-2633.

Walker, D. A., M. K. Raynolds, F. J. A. Daniëls, E. Einarsson, A. Elvebakk, W. A. Gould, A. E. Katenin, S. S. Kholod, C. J. Markon, E. S. Melnikov, N. G. Moskalenko, S. S. Talbot and B. A. Yurtsev. 2005. The circumpolar Arctic vegetation map. Journal of Vegetation Science 16: 267-282.

Weladji, R. B., D. R. Klein, O. Holand and A. Mysterud. 2002a. Comparative response of Rangifer tarandus and other northern ungulates to climatic variability. Rangifer 22(1): 29-46.

Weladji, R.B., A. Mysterud, O. Holand and D. Lenvik. 2002b. Age-related reproductive effort in reindeer (*Rangifer tarandus*): evidence of senescence. Oecologia 131: 79-82.

Wells, J. and M. Richmond. 1995. Populations, metapopulations, and species populations: what are they and who should care? Wildlife Society Bulletin 23(3): 458-462.

Working Group on General Status of NWT Species. 2006. NWT species 2006-2010 – general status ranks of wild species in the Northwest Territories, Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT.

Zerbini, A. 2006. Improving precision in multiple covariate distance sampling: a case study with whales in Alaska. PhD Thesis. University of Washington. Seattle, Washington.

Zittlau, K. A. 2004. Population genetic analyses of North American caribou (Rangifer tarandus). Ph.D. Dissertation. University of Alberta, Edmonton, AB, Canada.

Zoltai, S.C., P.N. Boothroyd, and G.W. Scotter. 1981. A natural resource survey of eastern Axel Heiberg Island, Northwest Territories. Parks Canada.

APPENDIX 1

Table A: Survey Area Calculations

Island (Group)	Year Surveyed	Area (km sq.)	Glaciated Area	Habitat (Survey Area)	Totals Only	Projection Specifics	Datum
Bathurst Island Group							
Bathurst Island Survey Area							
Bathurst Is.(survey area only)	2001	11693	0	11693			
Cameron	2001	1066	0	1066		CM101W; LoO76N	WGS1984
Vanier	2001	1136	0	1136			
Massey	2001	436	0	436			
Isle Marc	2001	57	0	57			
Alexander	2001	484	0	484			
Helena	2001	328	0	328			
Unnamed Bracebridge Inlet	2001	88	0	88			
Loney	2001	19	0	19			
Bathurst Is. Complex Survey		15307		15307			
Bathurst Island (all)	2001	16030	0	16030		CM101W; LoO76N	WGS1984
Cameron	2001	1066	0	1066			
Vanier	2001	1136	0	1136			
Massey	2001	436	0	436			
Isle Marc	2001	57	0	57			
Alexander	2001	484	0	484			
Helena	2001	328	0	328			
Unnamed Bracebridge Inlet	2001	88	0	88			
Loney	2001	19	0	19			
Bathurst Island Complex (all)	Adjusted	19644		19644	19644		

Table A: Con't.

Island (Group)	Year Surveyed	Area (km sq.)	Glaciated Area	Habitat (Survey Area)	Totals Only	Projection Specifics	Datum
Bathurst Island Group Con't.							
Cornwallis Survey Area							
Cornwallis Survey Area	2002	2949	0	2949		CM90W; LoO75N	WGS1984
Little Cornwallis	2002	381	0	381			
Milne	2002	25	0	25			
Crozier	2002	35	0	35			
Baring	2002	21	0	21			
Cornwallis Survey Area		3411		3411			
Cornwallis (All)	2002	7012	0	7012		CM90W; LoO75N	WGS1984
Little Cornwallis	2002	381	0	381			
Milne	2002	25	0	25			
Crozier	2002	35	0	35			
Baring	2002	21	0	21			
Cornwallis Group (All)	Adjusted	7474		7474	7474	CM90W; LoO75N	WGS1984

Table A: Con't.

Island (Group)	Year Surveyed	Area (km sq.)	Glaciated Area	Habitat (Survey Area)	Totals Only	Projection Specifics	Datum
Devon Island Group							
Western Devon Survey Area							
West Devon	2002	12316		12316			
Devon Island Survey Area							
Devon (includes Philpots Is.)	2002	55534	15993	39541		CM88W; LoO76N	WGS1984
Table&Ekins	2002	68	0	68			
Crescent	2002						
Pioneer	2002						
Spit	2002						
Herbert	2002						
John Barrow	2002						
Kerr	2002						
Fairholme	2002						
Isle of Mists	2002						
Hyde Parker	2002						
Dyer	2002						
Princess Royal Island	2002						
3 unnamed Islands	2002						
Total Small Islands	2002	122	0	122			
Survey Area Total	2008	55724		39731	39731		
North Kent	2008	594	154	440	440	CM88W; LoO76N	WGS1984
Baillie Hamilton	2008	290	0	290	290	CM88W; LoO76N	WGS1984
Dundas	2008	51	0	51	51	CM88W; LoO76N	WGS1984
Margaret	2008	10	0	10	10	CM88W; LoO76N	WGS1984

Table A: Con't.

Island (Group)	Year Surveyed	Area (km sq.)	Glaciated Area	Habitat (Survey Area)	Totals Only	Projection Specifics	Datum
Prince of Wales - Somerset Island Group							
Prince of Wales Survey Area							
Prince of Wales	2004	33274	0	33274		CM96W; LoO73N	WGS1984
Russell	2004	937	0	937			
Prescott Island	2004	412	0	412			
Pandora Island	2004	142	0	142			
Survey Area Total		34765		34765	34765		
Somerset Island Survey Area							
Somerset	2004	24549	0	24549	24549	CM96W; LoO73N	WGS1984
Ellesmere Island Group							
North Ellesmere Survey Area							
N Ellesmere	2006	165649	69399	96250		CM80W; LoO80N	WGS1984
Hoved Island	2006	115	0	115			
Pim Island	2006	84	0	84			
Krueger Island	2006	30	0	30			
Bromley Island	2006	26	0	26			
Marvin Islands	2006	9	2	7			
Miller Island	2006	19	0	19			
Bellot	2006	16	0	16			
(Small unnamed)	2006	20	0	20			
(Total small islands only)	2006			317			
Survey Area Total		165968		96567	96567		

Table A: Con't.

Island (Group)	Year Surveyed	Area (km sq.)	Glaciated Area	Habitat (Survey Area)	Totals Only	Projection Specifics	Datum
Ellesmere Island Group Con't.							
South Ellesmere Survey Area							
South Ellesmere	2005	31929	9723	22206		CM80W; LoO80N	WGS1984
Landslip Island	2005	36	0	36			
Graham	2005	1388	0	1388			
Buckingham	2005	137	0	137			
Survey Area Total		33490		23767	23767		
Axel Heiberg Island Group							
Axel Heiberg Survey Area							
Axel Heiberg	2007	42319	11974	30344		CM91W; LoO80N	WGS1984
Stor Island	2007	315	0	315			
Bjarnason	2007	128	0	128			
Ulvingen	2007	84	0	84			
Small Unnamed	2007	5	0	5			
Survey Area Total		42851		30877	30877		
Ringnes Island Group							
Ellef Ringnes Survey Area							
Ellef Ringnes	2007	11428	0	11428		CM100W; LoO79N	WGS1984
Thor	2007	121	0	121			
Survey Area Total		11549		11549	11549		
Amund Ringnes Survey Area							
Amund Ringnes	2007	5300	0	5299		CM100W; LoO79N	WGS1984
Haig Thomas	2007	65	0	65			
Survey AreaTotal		5364		5364	5364		

Table A: Con't.

Island (Group)	Year Surveyed	Area (km sq.)	Glaciated Area	Habitat (Survey Area)	Totals Only	Projection Specifics	Datum
Ringnes Island Group Con't.							
Cornwall Survey Area							
Cornwall	2007	2273	0	2273	2273	CM100W; LoO79N	WGS1984
King Christian Survey Area							
King Christian	2007	647	0	647	647	CM100W; LoO79N	WGS1984
Meighen Survey Area							
Meighen	2007	933	93	840		CM100W; LoO79N	WGS1984
Perley	2007	9	0	9			
Survey Area Total		943		849	849		
Lougheed Island Survey Area							
Lougheed	2007	1319	0	1319		CM105W; LoO77N	WGS1984
Edmund Walker	2007	82	0	82			WGS1984
Grosvenor	2007	7	0	7			WGS1984
Patterson	2007	5	0	5			WGS1984
Stupart	2007	2	0	2			
Survey Area Total		1415		1415	1415		
Total Ringnes Islands Group Survey Area				20682			
Arctic Island Study Area		**407600**			**300261**	**CM84W; LoO73N**	**WGS1984**

Note: All calculations conducted in the North Pole Lambert Azmimuthal Equal Area Projection; Datum 1984. The Projection was centered on each island or island group to increase precision.

APPENDIX 1: Table B: Historical Peary caribou surveys and abundance estimates.

		Estimate incl. calves			Estimate 1+ year					Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Minimum total counts; unsystematic surveys	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Bathurst Island Group																
Bathurst Island																
1961	19 Jun -7 Jul	2723						unk								Tener 1963
1973	29 Mar-3 Apr	527	79					N		-0.137	0.872					Miller et al. 1977
1974	25-31 Mar	226	59					N		-0.847	0.429	-0.191	0.826			Miller et al. 1977
1974	25-26 Aug				231	130		0								Miller et al. 1977
1981	10-13 Aug	289	93		234			19		0.002	1.002					Ferguson 1991
1985	10-25 Jul	495		253-737	352		184-521	26		0.102	1.107					Miller 1987a
1988	15-21 Jul	821	138		611	99		28		0.184	1.202	0.069	1.072			Miller 1989
1990	6-10 Jul							20	655						920min. Search effort	Miller 1992
1991	27-30 Jun							24	584	-0.115	0.892				547min. Search effort	Miller 1993
1992	5, 7, 8 Jul							29	1428	0.894	2.445				1025min. Search effort	Miller 1994
1993	17-21 Aug							28	2273	0.465	1.592	0.415	1.514		1765min. Serach effort	Miller 1995
1995	7-11 Jul							11	1084	-0.370	0.691			48	1107min. Search effort	Miller 1997a
1996	21-25 Jul				443	108		0						(287+/-68)		Miller 1998
1997	21-24 Jul				74	25		0		-1.790	0.167			(82+/-18)		Gunn and Dragon 2002
Ile Vanier																
1961	19 Jun -7 Jul	396						unk								Tener 1963
1973	4-Apr	20						N		-0.249	0.780					Miller et al. 1977
1974	1-Apr	15						N								Miller et al. 1977
1985	10-25 Jul	67		0-153	60		0-133	25								Miller 1987a
1988	13-Jul	85		29-140	63		25-101	25								Miller 1989
1989	22-Jul	72	34		55	23		21				-0.061	0.941			Miller 1991
1990	10-Jul							7	43						160min. Search effort	Miller 1992
1991	4-Jul							11	28						121min. Search effort	Miller 1993
1992	6-Jul							17	18						89min. Search effort	Miller 1994
1995	24-Jun							6	34					0	78min. Search effort	Miller 1997
1996	26-Jul				9	6		0						(224+/-54)		Miller 1998
1997	21-Jul				0			0				-0.501	0.606	(95+/-26)		Gunn and Dragon 2002
Cameron																
1961	19 Jun -7 Jul	235						unk								Tener 1963
1973	3-Apr	8						N		-0.282	0.755					Miller et al. 1977
1974	4-Apr	20						N								Miller et al. 1977
1985	10-25 Jul	51		0-131	47		0-122	7								Miller 1987a
1988	13-Jul	9		0-19	9		0-19	0								Miller 1989
1989	22-Jul	7	5		7	5		0				-0.125	0.882			Miller 1991
1990	17-Jun							0	13						50min. Search effort	Miller 1992
1991	5-Jul							0	2						182min. Search effort	Miller 1993
1992	21-Jun							0	5						151min. Search effort	Miller 1994
1995	24-Jun							0	0					7		Miller 1997
1996	26-Jul				0			0	0					(606+/-139)		Miller 1998
1997	21-22 Jul				0			0				-0.243	0.784	(188+/-30)		Gunn and Dragon 2002

Table B. Con't.: Historical Peary caribou surveys and abundance estimates.

		Estimate incl. calves			Estimate 1+ year					Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Minimum total counts; unsystematic surveys	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Bathurst Island Group																
Massey																
1961	19 Jun -7 Jul	13						unk								Tener 1963
1973	4-Apr	44						N		0.102	1.107					Miller et al. 1977
1974	1-Apr	0						N								Miller et al. 1977
1985	10-25 Jul	76		26-126	43		18-69	35								Miller 1987a
1988	14-Jul	84		39-131	55		23-87	36								Miller 1989
1989	22-Jul	108	27		68	17.4		39				0.076	1.079			Miller 1991
1990	7-Jul							27	56						91min. Search effort	Miller 1992
1991	4-Jul							33	123						91min. Search effort	Miller 1993
1992	6-Jul							33	101						82min. Search effort	Miller 1994
1993	16-Aug							43	28						65min. Search effort	Miller 1995
1995	24-Jun							41	49					0	61min. Search effort	Miller 1997
1996	26-Jul				0			0	0					(27+/-14)		Miller 1998
1997	21-Jul				4			0				-0.354	0.702	(13+/-11)		Gunn and Dragon 2002
Alexander																
1961	19 Jun -7 Jul	198						unk								Tener 1963
1973	4-Apr	0						N								Miller et al. 1977
1974	1-Apr	0						N								Miller et al. 1977
1985	10-25 Jul	38		0-136	27		0-95	21								Miller 1987a
1988	14-Jul	31		2.4-60	26		0.4-51	11								Miller 1989
1989	22-Jul	31	9.4		26	7.5		31				-0.066	0.936			Miller 1991
1990	8-Jul							14	113						107min. Search effort	Miller 1992
1991	4-Jul							15	82						106min. Search effort	Miller 1993
1992	6-Jul							26	92						98min. Search effort	Miller 1994
1993	16-Aug							22	63						65min. Search effort	Miller 1995
1995	24-Jun							11	84					0	87min. Search effort	Miller 1997
1996	13-Jul							0	4					2		Miller 1998
1997	21-Jul				0			0				-0.407	0.665	(5+/-5)		Gunn and Dragon 2002
Ile Marc																
1961															Not mentioned in report	Tener 1963
1973	4-Apr	9						N								Miller et al. 1977
1974	1-Apr	0						N								Miller et al. 1977
1985	10-25 Jul	NA						25	4							Miller 1987a
1988	14-Jul	4		0-10	4		0-10	0								Miller 1989
1989	22-Jul	8	5.5		8	5.5		0								Miller 1991
1990	15-Jun							0	15						16min. Search effort	Miller 1992
1991	7-Jul							20	5						16min. Search effort	Miller 1993
1992	6-Jul							11	5						8min. Search effort	Miller 1994
1993	16-Aug							17	23						22min. Search effort	Miller 1995
1995	24-Jun							14	7					0	28min. Search effort	Miller 1997
1996	26-Jul							0	0					2		Miller 1998
1997	21-Jul				0			0						(25+/-29)		Gunn and Dragon 2002

Table B. Con't.: Historical Peary caribou surveys and abundance estimates.

		Estimate incl. calves			Estimate 1+ year					Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Minimum total counts; unsystematic surveys	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Bathurst Island Group																
Helena																
1961															included in Bathurst	Tener 1963
1973	03-Apr	0			0			N								Miller et al. 1977
1974	31-Mar	4			4			N								Miller et al. 1977
1985	10-25 Jul	0						0								Miller 1987a
1988	20-Jul	17		0-42	12		0-28	25								Miller 1989
1990	24-Jun							9	23							Miller 1992
1991	07-Jun							27	22						50min. Search effort	Miller 1993
1992	27 Jun-5 Jul							28	46						66min. Search effort	Miller 1994
1995	18-Jun							2	49					0	72min. Search effort	Miller 1997
1997	22-Jul				0			0						0		Gunn and Dragon 2002
Bathurst Island Complex (Bathurst, Vanier, Cameron Alexander, Massey, and Marc)																
1961	19 Jun-7 Jul	3565						20								Tener 1963
1973	29 Mar-4 Apr	608						N		-0.147	0.863					Miller et al. 1977
1974	25 Mar-4 Apr	261						N		-0.846	0.429					Miller et al. 1977
1974	18-25 Aug	228						unk				-0.212	0.809			Miller et al. 1977
1975	Jun				228											Fischer and Duncan 1976 in Ferguson 1991
1985	10-25 Jul	724		460-987	526		337-716	24		0.084	1.087					Miller 1987a
1988	11-21 Jul	1103	146		820	105		27		0.148	1.160	0.098	1.103		Includes Cornwallis Island	Miller 1989
1990	6-10 July							19	871							Miller 1992
1991	27 Jun-5 Jul							22	949	0.086	1.090				1478min. Search effort	Miller 1993
1992	5-8 Jul							29	1690	0.577	1.781				1368min. Search effort	Miller 1994
1993	16-24 Aug							28	2387	0.345	1.412	0.336	1.399		Not including Cameron, Vanier, 1943min. Search effort	Miller 1995
1994		3100													Unsystematic estimate, increased by 100 to allow for possible numbers on Cornwallis Is.	Miller 1998 (Table 24)
1995	17 Jun-11 Jul							12	1307	-0.301	0.740			55	1433min. Search effort	Miller 1997a
1996	13-26 Jul				452			N						(1143+/-164)		Miller 1998
1997	21-24 Jul				78			0		-1.757	0.173			(408+/-53)		Gunn and Dragon 2002
2001	15-31 May				145		77-260					0.155	1.168			Jenkins et al. 2011
2001	15-31 May				187		104-330					estimate	1.24		Extrapolated to unsurveyed	Jenkins et al. 2011

Table B. Con't.: Historical Peary caribou surveys and abundance estimates.

		Estimate incl. calves			Estimate 1+ year					Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Minimum total counts; unsystematic surveys	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Bathurst Island Group																
Cornwallis																
1961	14-16 Jun	43						unk								Tener 1963
1988	11, 12 Jul	51		0-107	40		0-88	23		0.006	1.006					Miller 1989
2002	10-11 May	1						0		-0.281	0.755					Jenkins et al. 2011
Little Cornwallis																
1961	16-Jun	0						0								Tener 1963
1973	1-Apr	8						N								Miller et al. 1977
1974	23-Mar	0						N								Miller et al. 1977
1974	25-Aug	12						0								Miller et al. 1977
1988	12-Jul	0						0								Miller 1989
2002	10-11 May	0						0								Jenkins et al. 2011
Devon Island Group																
Devon Island																
1961	10-17 Jun	150						0							Extrapolation	Tener 1963
1990	3-7 Aug	0													Coastal lowlands	Case 1992
2002	8-30 May								35						West Devon	Jenkins et al. 2011
2008	22 Apr-10 May								17						All of Devon	Jenkins et al. 2011
Prince of Wales - Somerset Island Group																
Prince of Wales																
1974	18-Jun	1040														Fischer and Duncan 1976
1974	29-30 Jul	5437														Fischer and Duncan 1976
1975	13-16 Apr	2360														C. Elliott (CWS) in Gunn and Decker 1984
1975	4-14 Apr	581														Fischer and Duncan 1976
1975	Jun	3768										-0.367	0.693			Fischer and Duncan 1976
1980	12-22 Jul				3952	474		16		0.010	1.010					Gunn and Decker 1984
1995	21 Jul-3 Aug				NA				5							Gunn and Dragon 1998
1996	28 Apr-3 May				NA				0			-0.518	0.596			Miller 1997b
2004	10-18 Apr				0				0						Systematic	Jenkins et al. 2011
Somerset																
1974	3-9 Jun	245														Fischer and Duncan 1976 in Gunn and Decker 1984
1975	18-30 Mar	645														Fischer and Duncan 1976 in Gunn and Decker 1984
1975	23-24 Jun	903										1.304	3.686			Fischer and Duncan 1976 in Gunn and Decker 1984
1980	12-22 Jul				561	146		14		-0.095	0.909					Gunn and Decker 1984
1995	21 Jul-3 Aug				NA				2							Gunn and Dragon 1998
1996	28 Apr-3 May				NA				2			-0.352	0.703			Miller 1997b
2004	20-25 Apr				0				0						Systematic	Jenkins et al. 2011

Table B. Con't.: Historical Peary caribou surveys and abundance estimates.

		Estimate incl. calves			Estimate 1+ year					Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Minimum total counts; unsystematic surveys	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Prince of Wales - Somerset Island Group																
Russell																
1975	4-14 Apr				0											Fischer and Duncan 1976 in Gunn and Decker 1984
1975	Jun				159											Fischer and Duncan 1976 in Gunn and Decker 1984
1975	Jul				89											Fischer and Duncan 1976 in Gunn and Decker 1984
1980	12-22 Jul				584	90		11		0.376	1.457					Gunn and Decker 1984
1995	21 Jul-3 Aug				0					-0.425	0.654					Gunn and Dragon 1998
1996	28 Apr-3 May				NA				0							Miller 1997b
2004	10-18 Apr				0				0						Systematic	Jenkins et al. 2011
Boothia																
Boothia (some surveys refer to combined estimates for Peary caribou and barrenground caribou)																
1974	18 May-20 Jun	626													Estimate from 3 strata combined, surveyed over time period	Fischer and Duncan 1976
1974	1-3 Aug	561														Fischer and Duncan 1976
1975	18-25 Mar	1109														Fischer and Duncan 1976
1975	5-12 Jun	1739														Fischer and Duncan 1976
1985					4831	543										Gunn and Ashevak 1990 in Gunn and Dragon 1998
1995	21 Jul-3 Aug				6658	1728										Gunn and Dragon 1998
1996									0						Unsystematic (northwest)	Miller 1997
Ellesmere Island Group																
Ellesmere																
Entire Ellesmere Is.																
1961	30 Jul-11 Aug	200						11							Extrapolation	Tener 1963
Southern Ellesmere																
1973									150						Southeast unsystematic	Riewe 1973
1989	17-23 Jul	89	31					22				-0.029	0.971		Southern Ellesmere	Case and Ellsworth 1991
2005	4-30 May				219		109-442			0.064	1.066				Includes Graham Island	Jenkins et al. 2011
Northern Ellesmere																
2006	6 Apr-22 May				802		531-1207									Jenkins et al. 2011
Graham																
2005	4-30 May	See Southern Ellesmere Is.														Jenkins et al. 2011
Axel Heiberg Island Group																
Axel Heiberg																
1961	2-3 Aug	300						14							Extrapolation	Tener 1963

Table B. Con't.: Historical Peary caribou surveys and abundance estimates.

		Estimate incl. calves			Estimate 1+ year					Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Minimum total counts; unsystematic surveys	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Ringnes Island Group																
Ellef Ringnes																
1961	14-Aug	114						Y								Tener 1963
2007	6-15 Apr	See below														Jenkins et al. 2011
Amund Ringnes																
1961	15-Aug	452						Y								Tener 1963
2007	15-17 Apr	See below														Jenkins et al. 2011
Cornwall																
1961	15-Aug	266						25								Tener 1963
2007	19 Apr	See below														Jenkins et al. 2011
King Christian																
1961	15-Aug	too few							3							Tener 1963
2007	14 Apr	See below														Jenkins et al. 2011
Meighen																
2007	22 Apr	0							0							Jenkins et al. 2011
Ellef Ringnes, Amund Ringnes, Cornwall, King Christian, and Meighen Islands																
2007	6-22 Apr				282		157-505								None on Meighen	Jenkins et al. 2011
Lougheed																
1961	18-Aug	1324						22								Tener 1963
1973	03-Apr	56								-0.264	0.768					Miller et al. 1977
1974	04-Apr	0							1	-4.025	0.018					Miller et al. 1977
1985	10-25 Jul	0							2						1 cow-calf pair	Miller 1987a
1997	21-Jul				101	73				0.385	1.469			(28+/-29)		Gunn and Dragon 2002
2007	13 Apr				372		205-672			0.130	1.139					Jenkins et al. 2011
Prime Minister Island Group (Northwest Territories)																
Mackenzie King																
1961	17-Aug	2192			(1710)			22								Tener 1963
1973	15-Apr	NA						N	3							Miller et al. 1977
1974	11-Apr	60						N				-0.277	0.758			Miller et al. 1977
1997	18-Jul				36	22		25						(24+/-14)	1 cow-calf pair	Gunn and Dragon 2002
Brock																
1961	17-Aug	190						unk							Partial survey fog -	Tener 1963
1973	15-Apr	24						N		-0.172	0.842					Miller et al. 1977
1997	18-Jul	0						0						0		Gunn and Dragon 2002
Borden																
1961	17-Aug	1630			(1271)			22								Tener 1963
1973	14-15 Apr	16						N		-0.385	0.680					Miller et al. 1977

Table 2. Con't.: Historical Peary caribou surveys and abundance estimates.

		Estimate incl. calves			Estimate 1+ year					Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Minimum total counts; unsystematic surveys	Exponential rate of change	Lambda	Exponenti al rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Melville Island Group (Northwest Territories)																
Melville																
1961	8-22 Jul	12799						19								Tener 1963
1972	20 Mar-6 Apr	705	159					N								Miller et al. 1977
1972	13-24 Aug	2551	724					0		-0.147	0.864				Only strata I-VI	Miller et al. 1977
1973	19 Mar-7 Apr	1648	181					N								Miller et al. 1977
1973	5 Jul-2 Aug	3425	618					12		0.295	1.343					Miller et al. 1977
1974	4-21 Aug	1679	NA					1		-0.713	0.490				Extrapolated for 3 missed strata	Miller et al. 1977
1987	1-22 Jul	943	126		729	104		19		-0.044	0.957					Miller 1988
1997	2-20 Jul	787	97					0		-0.018	0.982	-0.077	0.925	(150+/-48)		Gunn and Dragon 2002
Byam Martin																
1972	22-23 Mar	4	3					N								Miller et al. 1977
1972	7-Aug	86	65					0								Miller et al. 1977
1973	27-Mar	34	13					N								Miller et al. 1977
1973	15-Jul	43	36					11								Miller et al. 1977
1974	1-Apr	6	2					N								Miller et al. 1977
1974	20-Aug	6	4					0				-1.331	0.264			Miller et al. 1977
1987	8-Jul	98	37		70	26		19		0.215	1.240					Miller 1988
1997	20-Jul	0						0		-0.425	0.654			(26+/-11)		Gunn and Dragon 2002
Prince Patrick																
1961	23-24 Jul	2254						20								Tener 1963
1973	8-15 Apr	1381	269					N								Miller et al. 1977
1973	28 Jul-21 Aug	807	259					11		-0.086	0.918					Miller et al. 1977
1974	10-16 Apr	1049	212					N								Miller et al. 1977
1974	18-25 Jul	621	177					7		-0.262	0.770					Miller et al. 1977
1986	4-13 Jul	151		12-182	106		11-114	30		-0.118	0.889					Miller 1987b
1997	29 Jun-1 Jul	84	34					0		-0.053	0.948	-0.091	0.913	(178+/-37)		Gunn and Dragon 2002
Eglinton																
1961	24-Jul	204						*31*							4 calves observed	Tener 1963
1972	4-Apr	574	122					N								Miller et al. 1977
1972	10-Aug	83	59					0		-0.082	0.921					Miller et al. 1977
1973	8-Apr	90	15					N								Miller et al. 1977
1973	8-Aug	12	9					0		-1.934	0.145					Miller et al. 1977
1974	Apr	301	60					N								Miller et al. 1977
1974	25-Jul	18	10					4		0.405	1.500				1 calf observed	Miller et al. 1977
1986	4-Jul	79		0-229	65		0-183	18		0.123	1.131					Miller 1987b
1997	2-Jul	0						0		-0.397	0.672	-0.148	0.863	0		Gunn and Dragon 2002
Emerald																
1961	24-Jul	161						3								Tener 1963
1973	15-Apr	0						N								Miller et al. 1977
1973	30-Jul	39						N		-0.118	0.889					Miller et al. 1977
1974	17-Apr	12						N								Miller et al. 1977
1986	4-Jul	14		0-49	11		0-37	25		-0.079	0.924					Miller 1987b
1997	19-Jul	0						0		-0.240	0.787	-0.141	0.868	(17+/-16)		Gunn and Dragon 2002

Table 2. Con't.: Historical Peary caribou surveys and abundance estimates.

		Estimate incl. calves			Estimate 1+ year					Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Minimum total counts; unsystematic surveys	Exponential rate of change	Lambda	Exponenti al rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Banks Island (Northwest Territories)																
Banks																
1970	23-28 Jun	5300													Northern Banks	Kevan 1974
1972	Sep	12098						17		0.413	1.511					Urquhart 1973
1979-80					8000-9000					-0.032	0.968					Vincent and Gunn 1981
1982	4-10 Jul				7233	998									Calves not recorded	Latour 1985
1982	4-10 Jul				9036		6110-11370			0.031	1.031				Retrospective	Nagy et al. 2009a
1985	6-14 Jul				5000	910		15		-0.197	0.821				Calves likely minimum est.	McLean et al. 1986
1987	27-30 Jun				4500	660		23		-0.053	0.949					McLean 1992
1989	22-28 Jun				2600	340		26		-0.274	0.760			(300)	29 carcasses observed	McLean and Fraser 1992
1990	14-19 Sep				526	302		11		-	-					McLean et al. 1992
1991	27 Jun-3 Jul				888	151		5		-0.537	0.584			(60)	6 carcasses observed	Fraser at al. 1992
1992	21-30 Aug				1018	133	748-1288	29		0.137	1.146	-0.218	0.804	2		Nagy et al. 2009b
1994	Jul				742	132		8		-0.158	0.854			7		Nagy et al. 2006a
1998	Jul				451	60		19		-0.124	0.883			0		Nagy et al. 2006b
2001	7-15 Jul				1142	155	818-1466	26		0.304	1.355			0		Nagy et al. 2006
2005	24 Jul-1 Aug				929	143	640-1218	19		-0.052	0.950			0		Nagy et al. 2009c
2010	17-26 Jul				1097		754-1440	25		0.033	1.034					Davison et al. in prep.
Victoria Island (Northwest Territories)																
NW Victoria																
1980	5-20 Aug	4512	988												St A NW Victoria	Jakimchuk and Carruthers 1980
1987	Jun	3500			2600		Extrapolation	27							Extrapolation	Gunn 2005
1987	Jun				(643)	(172)	On CG only									Gunn and Fournier 2000
1992	24-26 Mar				170	54	116-224				0.766					Heard 1992
1993	18-20 Mar				144	22										Gunn 2005
1993	13-15 Jun				20	-		5		-2.140	0.118				Total observed; 1 calf	Gunn 2005
1994	5-17 June				39	28				0.668	1.950	-0.400	0.670		St IV of western Victoria	Nishi and Buckland 2000
1998	early Jul				95	29	35-155	12		0.223	1.249			0		Nagy et al. 2009d
2001	16-21 Jul				204	50	101-307	24		0.255	1.290			0		Nagy et al. 2009e
2005	6-8 Jul				66	30	5-127	28		-0.282	0.754			0		Nagy et al. 2009f
2010	28 Jul-15 Aug				150		46-254	12		0.093	1.097					Davison et al. in prep.

APPENDIX 1: Table C: Historical Muskox survey and abundance estimates.

		Estimate incl. calves			Estimate 1+ year						Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Off transect sightings or (minimal count)	% Change	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Bathurst Island Group																	
Bathurst Island																	
1961	18Jun-7 Jul	1136						9									Tener 1963
1973	29 Mar-3 Apr	672	194					N			-0.046	0.955					Miller et al. 1977
1974	25-26 Aug	164	70					0									Miller et al. 1977
1981	10-13 Aug	208						16			0.034	1.035	-0.086	0.918			Ferguson 1991
1985	10-25 Jul	521		230-812	418		191-645	17			0.230	1.258					Miller 1987a
1988	18-21 Jul	503	108		423	83		12			-0.012	0.988					Miller 1989
1993	17-20 Aug							18	(888)							Min. count	Miller 1995 App. 7
1995	17 Jun-12 Jul							4	(760)	14					45	Min. count	Miller 1997 App 3
1996	13-20 Jul	425			425	136		0							(625+/-215)		Miller 1998
1997	21-24 Jul	124			124	45		0	(36)	-96	-1.232	0.292			21		Gunn and Dragon 2002
2001	15-31 May							20	(82)							Calves based on 8 ca 32 ad	Jenkins et al. 2011
Ile Vanier																	
1961	18Jun-7 Jul	0															Tener 1963
1973	4-Apr	NA						N	6								Miller et al. 1977
1974	1-Apr	NA						N	5								Miller et al. 1977
1985	10-25 Jul	0							1								Miller 1987a
1988	13-Jul	6		0-12	6		0-12	0									Miller 1989
1995	17 Jun-12 Jul	NA						0	11						0		Miller 1997
1996	26-Jul	0													0		Miller 1998
1997	21-Jul	0													0		Gunn and Dragon 2002
2001	15-31 May	NA							0								Jenkins et al. 2011
Cameron																	
1961	18Jun-7 Jul	25						0								included Alexander	Tener 1963
1973	3 Apr	0						N	(5)								Miller et al. 1977
1974	4 Apr	0						N	(2)						3		Miller et al. 1977
1985	10-25 Jul	0							2								Miller 1987a
1988	13-Jul	7		0-15	7		0-15	0									Miller 1989
1995	17 Jun-12 Jul	NA						0	14						1		Miller 1997
1996	26-Jul	0													(17+/-13)		Miller 1998
1997	21-22 Jul	0													0		Gunn and Dragon 2002
2001	15-31 May	0							0								Jenkins et al. 2011

Table C. Con't.: Historical Muskox survey and abundance estimates.

		Estimate incl. calves			Estimate 1+ year						Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Off transect sightings or (minimal count)	% Change	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Bathurst Island Group																	
Massey																	
1961	18Jun-7 Jul	0															Tener 1963
1973	4 Apr	0							0								Miller et al. 1977
1974	1 Apr	0							0								Miller et al. 1977
1985	10-25 Jul	0															Miller 1987a
1988	14-Jul	0															Miller 1989
1995	17 Jun-12 Jul	NA						10	10						0		Miller 1997
1996	26-Jul	0													0		Miller 1998
1997	21-Jul	0													0		Gunn and Dragon 2002
2001	15-31 May	0							0								Jenkins et al. 2011
Alexander																	
1961	18Jun-7 Jul	0						0								Included with Cameron	Tener 1963
1973	4 Apr	0						N	9								Miller et al. 1977
1974	1 Apr	0						N	2								Miller et al. 1977
1985	10-25 Jul	27		0-86	27		0-86	21									Miller 1987a
1988	14-Jul	6		0-14	6		0-14	0									Miller 1989
1995	17 Jun-12 Jul	NA						0	46						4		Miller 1997
1996	26-Jul	0							6						0		Miller 1998
1997	21-Jul	0													0		Gunn and Dragon 2002
2001	15-31 May	0							0								Jenkins et al. 2011
Ile Marc																	
1961	18 Jun-7 Jul	NA														Not mentioned in report	Tener 1963
1973	4 Apr	0							0								Miller et al. 1977
1974	1 Apr	0							0								Miller et al. 1977
1985	10-25 Jul	0															Miller 1987a
1988	14 Jul	0															Miller 1989
1995	17 Jun-12 Jul	0													0		Miller 1997
1997	21 Jul	0													0		Gunn and Dragon 2002
2001	15-31 May	0							0								Jenkins et al. 2011
Helena																	
1961	18Jun-7 Jul	NA															
1973	3-Apr	0															Miller et al. 1977
1974	31-Mar	0															Miller et al. 1977
1985	10-25 Jul	0															Miller 1987a
1988	20-Jul	0															Miller 1989
1995	17 Jun-12 Jul	0													0		Miller 1997
1997	22-Jul	0													0		Gunn and Dragon 2002
2001	15-31 May	0							0								Jenkins et al. 2011

Table C. Con't.: Historical Muskox survey and abundance estimates.

		Estimate incl. calves			Estimate 1+ year						Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Off transect sightings or (minimal count)	% Change	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Bathurst Island Group																	
Bathurst Island Complex																	
1961	18Jun-7 Jul	1161						9								Includes GG Islands	Tener 1963
1973	29 Mar-3 Apr	672	194					N			-0.046	0.955					Miller et al. 1977 in Miller 1998
1974	25-26 Aug	164	70					0								includes 20 secondary satellite islands; excludes Cornwallis Island	Miller et al. 1977 in Miller 1998
1981	10-13 Aug																
1985	10-25 Jul	545		259-830				17								estimate for nine-island survey area	Miller 1987a in Miller 1998
1988	18-21 Jul	592	108		423	83		12			-0.012	0.988					Miller 1989 in Miller 1998
1993	17-20 Aug	1200						18									Miller 1995 in Miller 1998
1995	17 Jun-12 Jul	980														With or Without calves??	Miller 1998
1996	13-20 Jul				500										(625+/-215)	guestimate	Miller 1998
1997	21-24 Jul				124	45		0									Gunn and Dragon 2002
2001	15-31 May							20	(82)								Jenkins et al. 2011
Cornwallis																	
1961	14-16 Jun	50						0								Extrapolation	Tener 1963
1988	11, 12 Jul	70	34					19			0.012	1.013					Miller 1989
2002	10-11 May							0	(18)								Jenkins et al. 2011
Little Cornwallis																	
1961	16-Jun	0															Tener 1963
1973	01-Apr	40						N			0.307	1.360					Miller et al. 1977
1974	23-Mar	20						N									Miller et al. 1977
1974	25-Aug	12						0									Miller et al. 1977
1988	12-Jul	0											-0.246	0.782			Miller 1989
2002	10-11 May	0						0	0								Jenkins et al. 2011
Devon Island Group																	
Devon Island																	
1961	10, 12, 17 Jun								(200)							Extrapolation	Tener 1963
1967									(450)							North Devon Is.	Freeman 1971
1980									(400)				0.036	1.037		unsystematic	Decker unpubl in Urquhart 1982
1990	3-7 Aug	400						13								Coastal lowlands	Case 1992
2008	22 Apr-10 May				513		302-864	14								Systematic	Jenkins et al. 2011

Table C. Con't.: Historical Muskox survey and abundance estimates.

		Estimate incl. calves			Estimate 1+ year						Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Off transect sightings or (minimal count)	% Change	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Prince of Wales - Somerset Island Group																	
Prince of Wales																	
1974	18-Jun				564												Fischer and Duncan 1976 in Gunn and Decker 1984
1974	29-30 Jul				872			7-14									Fischer and Duncan 1976 in Gunn and Decker 1984
1975	4-14 Apr				2381												Fischer and Duncan 1976 in Gunn and Decker 1984
1975	13-16 Apr				907			15									C. Elliott in Gunn and Decker 1984
1975	Jun				313			11-15			-0.589	0.555					Fischer and Duncan 1976 in Gunn and Decker 1984
1980	12-22 Jul				1126	276		10-12			0.256	1.292					Gunn and Decker 1984
1995	21 Jul-3 Aug	5157	414					N								Includes 68 on Pandora	Gunn and Dragon 1998
2004	10-18 Apr				2086		1582-2746						0.026	1.026		Includes Russell and Pandora	Jenkins et al. 2011
Somerset																	
1974	3-9 Jun				0												Fischer and Duncan 1976 in Gunn and Decker 1984
1975	18-30 Mar				0												Fischer and Duncan 1976 in Gunn and Decker 1984
1975	23-24 Jun				0												Fischer and Duncan 1976 in Gunn and Decker 1984
1980	12-22 Jul				NA			0								29 MX seen; no estimate	Gunn and Decker 1984
1995	21 Jul-3 Aug				1140	260							0.352	1.422			Gunn and Dragon 1998
2004	20-25 Apr				1910		962-3792				0.057	1.059					Jenkins et al. 2011
Russell																	
1975	4-14 Apr				0												Fischer and Duncan 1976 in Gunn and Decker 1984
1975	13-16 Apr																C. Elliott in Gunn and Decker 1984
1975	Jun				0												Fischer and Duncan 1976 in Gunn and Decker 1984
1975	Jul				0												In Gunn and Decker 1980
1980	12-22 Jul				0			0									Gunn and Decker 1984
1995	21 Jul-3 Aug				102	54					0.308	1.361					Gunn and Dragon 1998

Table C. Con't.: Historical Muskox survey and abundance estimates.

		Estimate incl. calves			Estimate 1+ year						Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Off transect sightings or (minimal count)	% Change	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Boothia																	
Boothia																	
1974	18 May-20 Jun				0												Fischer and Duncan 1976
1974	1-3 Aug				0												Fischer and Duncan 1976
1975	18-25 Mar				0												Fischer and Duncan 1976
1975	5-12 Jun				0												Fischer and Duncan 1976
1985	31 May-3 Jun				0												Gunn and Ashevak 1990
Ellesmere Island Group																	
Ellesmere																	
Whole island																	
1961	30 Jul-7 Aug							12	(4000)							Extrapolation	Tener 1963
S. Ellesmere																	
1967									(470)		-0.357	0.700					Freeman 1971
1973	Jul	1060														southeast unsystematic	Riewe 1973
1989	17-23 Jul	2020	285					17			0.040	1.041				Southern Ellesmere	Case and Ellsworth 1991
2005	4-30 May				456		312-670								20	Syst. incl Graham	Jenkins et al. 2011
N. Ellesmere																	
2006	6 Apr-22 May				8115		6632-9930	18								Systematic	Jenkins et al. 2011
Graham																	
1967									(50)								Freeman 1971
Axel Heiberg Island Group																	
Axel Heiberg																	
1961	2-3 Aug							7	(1000)							Extrapolation	Tener 1963
2007	19 Apr-3 May				4237		3371-5323										Jenkins et al. 2011
Ringnes Island Group																	
Ellef Ringnes																	
1961	14-Aug	0															Tener 1963
Amund Ringnes																	
1961	15-Aug	4						0									Tener 1963
Cornwall																	
1961	15-Aug	0															Tener 1963
Ellef Ringnes, Amund Ringnes, Cornwall, King Christian, and Meighen Islands																	
2007	6-22 Apr								(21)								Jenkins et al. 2011

Table C. Con't.: Historical Muskox survey and abundance estimates.

		Estimate incl. calves			Estimate 1+ year						Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Off transect sightings or (minimal count)	% Change	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Ringnes Island Group																	
Lougheed																	
1961	18-Aug	0															Tener 1963
1973	3 Apr	0															Miller et al. 1977
1974	4 Apr	0															Miller et al. 1977
1985	10-25 Jul	0															Miller 1987a
1997	21 Jul	0															Gunn and Dragon 2002
2007	13 Apr	0															Jenkins et al. 2011
Prime Minister Island Group (Northwest Territories)																	
Mackenzie King																	
1961	18Jun-7 Jul	0															Tener 1963
1973	15-Apr	0															Miller et al. 1977
1974	11-Apr	0							6								Miller et al. 1977
1997	18-Jul	0															Gunn and Dragon 2002
Brock																	
1961	18Jun-7 Jul	0														partial survey fog -	Tener 1963
1973	15-Apr	0															Miller et al. 1977
1997	18-Jul	0															Gunn and Dragon 2002
Borden																	
1961	18Jun-7 Jul	0															Tener 1963
1973	14-15 Apr	0															Miller et al. 1977
Melville Island Group (Northwest Territories)																	
Melville																	
1961	8-22 Jul	1000						17								Extrapolation	Tener 1963
1972	20 Mar-6 Apr	3394	478					N			0.111	1.117					Miller et al. 1977
1972	13-24 Aug	NA						10								986+/-264 only strata I-VI	Miller et al. 1977
1973	19 Mar-7 Apr	3025	455					N			-0.115	0.891					Miller et al. 1977
1973	5 Jul-2 Aug	3171	627					19									Miller et al. 1977
1974	4-21 Aug	2390	412					10			-0.283	0.754				extrapolated for 3 missed strata	Miller et al. 1977
1987	1-22 Jul	5652	464		4761	373		15			0.066	1.068	0.067	1.069			Miller 1988
1997	2-20 Jul				2258	268		0			-0.075	0.928			32		Gunn and Dragon 2002

Table C. Con't.: Historical Muskox survey and abundance estimates.

		Estimate incl. calves			Estimate 1+ year						Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Off transect sightings or (minimal count)	% Change	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Melville Island Group (Northwest Territories)																	
Byam Martin																	
1972	22-23 Mar	151	132					N									Miller et al. 1977
1972	7-Aug	61	61					2									Miller et al. 1977
1973	27-Mar	8	6					N									Miller et al. 1977
1973	15-Jul	117	84					24			0.651	1.918					Miller et al. 1977
1974	1-Apr	28	8					N							8		Miller et al. 1977
1974	20-Aug	NA						0	8								Miller et al. 1977
1987	8-Jul	100	61		96	59		3					-0.027	0.973			Miller 1988
1997	20-Jul				0			0			-0.461	0.631			1		Gunn and Dragon 2002
Prince Patrick																	
1961	23-24 Jul	0						0									Tener 1963
1973	8-15 Apr	86	43					N									Miller et al. 1977
1973	28 Jul-21 Aug	152	101					16			0.419	1.520					Miller et al. 1977
1974	10-16 Apr	91	57					N									Miller et al. 1977
1974	18-25 Jul	114	63					6			-0.288	0.750					Miller et al. 1977
1986	4-13 Jul	62		7-154	62		7-154	0			-0.051	0.951	0.165	1.179	6		Miller 1987b
1997	29 Jun-1 Jul				96	42		0			0.040	1.041			3		Gunn and Dragon 2002
Eglinton																	
1961	24-Jul	0						*0*									Tener 1963
1972	4-Apr	12	10					N									Miller et al. 1977
1972	10-Aug	4	4					7			0.126	1.134					Miller et al. 1977
1973	8-Apr	22	14					N									Miller et al. 1977
1973	8-Aug	26	18					14			1.872	6.500					Miller et al. 1977
1974	Apr	44	18					N									Miller et al. 1977
1974	25-Jul	16	11					19			-0.486	0.615					Miller et al. 1977
1986	4-Jul	101		7-195	94		6-181	7			0.154	1.166	0.185	1.203			Miller 1987b
1997	2-Jul				37	21		0			-0.085	0.919					Gunn and Dragon 2002
Emerald																	
1961	24-Jul	0						0									Tener 1963
1973	15-Apr	0						0									Miller et al. 1977
1973	30-Jul	0						0									Miller et al. 1977
1974	17-Apr	0						0									Miller et al. 1977
1986	4-Jul	0						0									Miller 1987b
1997	19-Jul	0						0									Gunn and Dragon 2002

Table C. Con't.: Historical Muskox survey and abundance estimates.

		Estimate incl. calves			Estimate 1+ year						Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Off transect sightings or (minimal count)	% Change	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Banks Island (Northwest Territories)																	
Banks																	
1970	23-28 Jun				1567											Northern Banks	Kevan 1974
1972					3800						0.443	1.557					Urquhart 1973
1980	Mar 1979-80	18328	4132		N											Over 2 years	Vincent and Gunn 1981
1982	4-10 Jul				9393	1054									30		Latour 1985
1982	4-10 Jul				12481		9433-14913				0.119	1.126				Retrospective	Nagy et al. 2009a
1985	6-14 Jul				25700	2050		12			0.241	1.272			20		McLean et al. 1986
1989	22-28 Jun				34270	2360		13			0.072	1.075			120 (685)		McLean and Fraser 1992
1991	27 Jun-3 Jul				47670	3971		15			0.165	1.179			(80)		Fraser at al. 1992
1992	21-30 Aug				53526	1968	49494-57558	17			0.116	1.123			35		Nagy et al. 2009b
1994					64680	2009					0.095	1.099					Fig. 6 in Nagy et al. 2006
1998					~46000						-0.085	0.918					Fig. 6 in Nagy et al. 2006
2001	7-15 Jul				68585	3452	65133-72037	15			0.133	1.142	0.122	1.130	31		Nagy et al. 2006
2005	24 Jul-1 Aug				47209	1978	43212-51206	10			-0.093	0.911			Not counted	2004 icing event	Nagy et al. 2009c
2010	17-26 Jul				36676		32645-40707	10			-0.050	0.951	-0.07	0.933			Davison et al. in prep
Victoria Island (Northwest Territories)																	
NW Victoria (survey areas didn't always match)																	
1980					9540			27									Jakimchuk and Carruthers 1980
1983	8-17 Aug				6430	498		16			-0.132	0.877					Jingfors 1985
1989	19-31 Aug				12850	1260		10			0.115	1.122					Gunn unpubl in Fournier and Gunn 1998
1992	24-26 Mar	8900	820		N											Minto Inlet area north	Heard 1992
1994	5-16 Jun				19989	3786		--			0.088	1.092	0.053	1.054		From Fournier and Gunn 1998	Nishi in Fournier and Gunn 1998
1998	early Jul				18795	1393	402-20188	18			-0.015	0.985			4		Nagy et al. 2009d
2001	16-21 Jul				19282	1607	061-22503	11			0.009	1.009			0		Nagy et al. 2009e
2005	6-8 Jul				12062	1051	906-14218	15			-0.117	0.889			0		Nagy et al. 2009f
2010	28 Jun-15 Aug				11442		9805-13079	1			-0.011	0.990	-0.035	0.966		31 calves/2273 adults	Davison et al. in prep

Table C. Con't.: Historical Muskox survey and abundance estimates.

		Estimate incl. calves			Estimate 1+ year						Consecutive surveys		Range of surveys				
Survey Year	Season	Estimate incl. calves	SE	95% CI	Estimate 1+ year	SE	95% CI	% Calves or Not Observed	Off transect sightings or (minimal count)	% Change	Exponential rate of change	Lambda	Exponential rate of change	Lambda	Carcass counts (estimates)	Survey Comments	Reference
Victoria Island (Northwest Territories)																	
SW Victoria (survey areas didn't always match)																	
1980					896	387										From Fournier and Gunn 1998	Jakimchuk and Carruthers 1980
1983					135	51					-0.631	0.532				From Fournier and Gunn 1998	Poole 1985
1988	Mar	1072	129													From Fournier and Gunn 1998	Gunn in prep
1993	Mar	2008	356								0.126	1.134				From Fournier and Gunn 1998	Gunn in prep
1994	10-17 Jun				3934	1225							0.106	1.111		From Fournier and Gunn 1998	Nishi in prep
SE Victoria																	
1980					1760			27								From Fournier and Gunn 1998	Jakimchuk and Carruthers 1980
1983	13-19 Mar	3300	345					16									Jingfors 1984
1988	21 Mar-3 Apr	13031	1121					N			0.275	1.316				Repeated Jingfors survey area	Gunn and Patterson in prep
1993	6-10 Mar	12563	1254					N			-0.007	0.993				Repeated Jingfors survey area	Gunn and Patterson in prep
1999	12-20 Mar	18290	1100					N			0.063	1.065	0.107	1.113		Repeated Jingfors survey area	Gunn and Patterson in prep
NE Victoria																	
1990	10-17 Aug				5451	521		11									Gunn and Lee 2000

APPENDIX 2:

Participants in the Peary Caribou & Muskoxen Ground Surveys, 2001-2006

Bathurst Island 2001

Resolute Bay HTA	Department of Sustainable Development
Norman Idlout	Tabitha Mullin
Samson Simeonie	Seeglook Akeeagok
Micheal Pudluk	
Ross Pudluk	
Steven Nungaq	
Clyde Kalluk	
Ely Allakarialuk	

Cornwallis Island 2002

Resolute Bay HTA	Department of Sustainable Development
Norman Idlout	Tabitha Mullin
Hans Aronsen	Seeglook Akeeagok
Ross Pudluk	
Saroomie Manik	
Enookie Idlout	
Joadamee Iqaluk	

West Devon Island 2002

Resolute Bay HTA	Department of Sustainable Development
Norman Idlout	Tabitha Mullin
Samson Simeonie	Seeglook Akeeagok
Hans Aronsen	
Steven Akeeagok (Iviq HTO, Grise Fiord)	
Joadamee Iqaluk	
Enookie Idlout	
Ross Pudluk	
Katsak Manik (Replaced Enookie Idlout)	
Terrance Nungaq (Replaced Hans Aronsen)	

Prince of Wales Island 2004

Resolute Bay HTA	Department of Sustainable Development
Norman Idlout	Tabitha Mullin
Sam Idlout	
Clyde Kalluk	
Steven Nungaq	
Jeff Amarualik	
Peter Jr Amarualik	
Stevie Amarualik	
Joadamee Iqaluk	

<u>Participants in the Peary Caribou & Muskoxen Ground Surveys, 2001-2006 Cont'd</u>

Somerset Island 2005

Resolute Bay HTA	Department of Environment
Norman Idlout	Tabitha Mullin
Samson Simeonie	
Stevie Amarualik	
Peter Jr. Amarualik	

Southern Ellesmere Island 2005

Iviq HTO, Grise Fiord	Department of Environment
Aron Qaunaq	Jeffrey Qaunaq
David Watsko	
Steven Akeeagok	
Pauloosie Killiktee	
Randy Pijamini	
Mosha Kiguktak	

Southern Ellesmere Island 2006

Iviq HTO, Grise Fiord	Department of Environment
Pauloosie Killiktee	Seeglook Akeeagok
Benjamin Akeeagok	
Randy Pijamini	
Jimmy Nungaq	
Patrick Audlaluk	

Participants in the Peary Caribou & Muskoxen Aerial Surveys, 2001-2008

Bathurst Island 2001

Resolute Bay HTA	Department of Sustainable Development
Matthew Manik	Mike Ferguson
Babah Kalluk	Grigor Hope
Samson Idlout	

Cornwallis Island 2002

Resolute Bay HTA	Department of Sustainable Development
Joadamee Amagoalik	Mike Ferguson
	Grigor Hope

West Devon Island 2002

Resolute Bay HTA	Department of Sustainable Development
Joadamee Amagoalik	Mike Ferguson
	Grigor Hope

Prince of Wales Island & Somerset Island 2004

Resolute Bay HTA	Department of Sustainable Development
Martha Allakariallak	Mike Ferguson
Mark Amaraulik	Grigor Hope

Southern Ellesmere Island 2005

Iviq HTO, Grise Fiord	Department of Environment	RCMP
Lymieky Pijamini	Mitch Campbell	Louis Jenvenne
Mosha Kiguktak	Grigor Hope	
Jaypeetee Akeeagok	Mike Ferguson	
Tom Kiguktak	Seeglook Akeeagok	
	Jeffrey Qaunaq	

Ellesmere Island 2006

Iviq HTO, Grise Fiord	Department of Environment	Parks Canada
Aron Qaunaq	Mitch Campbell	Gary Mouland
	Grigor Hope	Jason Hudson
		Doug Stern

Ellef & Amund Ringnes, Lougheed, King Christian, Cornwall & Axel Heiberg Islands 2007

Iviq HTO, Grise Fiord	Department of Environment
Tom Kiguktak	Debbie Jenkins
	Grigor Hope
	Mitch Campbell

Devon Island 2008

Resolute Bay HTA	Department of Environment	Iviq HTO, Grise Fiord
Jeffrey Amaraulik	Debbie Jenkins	Tom Kiguktak
Peter Jr. Amaraulik	Grigor Hope	
Tom Kiguktak		