

**2015 status Cape Atholl
Muskoxen**

(*Ovibos moschatus*)

Thule region Greenland



Title: 2015 status Cape Atholl muskoxen (*Ovibos moschatus*)
Thule region Greenland

Authors: Christine Cuyler¹, Kasim S. Virk², Thomas B. Clausen² and
Flemming H. Jensen²

¹Greenland Institute of Natural Resources, P.O. Box 570,
3900–Nuuk, Greenland
²SPE Box 140, 3970–Pituffik, Greenland

Series: Technical Report no. 96, 2016

Date of publication: 12 February, 2016

Publisher: Greenland Institute of Natural Resources
Financial support: Pituffik Citizen Council (*Pituffik Borgerråd*)

Cover photo: Kasim S. Virk: Adult muskox bull, August 2015, Cape Atholl.

ISBN: 87-91214-73-4
ISSN: 1397-6109
EAN: 9788791214738

Cited as: Cuyler, C., Virk, K.J., Clausen, T.B. & Jensen, F.H. 2016. 2015
status Cape Atholl muskoxen (*Ovibos moschatus*) Thule region
Greenland. Greenland Institute of Natural Resources. Technical
Report no. 96. 37 pp.

Contact address: The report is only available in electronic format. You can
download a PDF-file of the report at this homepage
http://www.natur.gl/publikationer/tekniske_rapporter

It is possible to achieve a print of the report here:
Greenland Institute of Natural Resources
P.O. Box 570
DK-3900 Nuuk
Greenland

Phone: +299 36 12 00
Fax: +299 36 12
E-mail: info@natur.gl
www.natur.gl

2015 Status Cape Atholl Muskoxen (*Ovibos moschatus*), Thule region Greenland

By

Christine Cuyler¹, Kasim S. Virk², Thomas B. Clausen & Flemming H. Jensen²

¹Greenland Institute of Natural Resources, P.O. Box 570, 3900–Nuuk, Greenland

²SPE Box 140, 3970–Pituffik, Greenland



Technical Report no. 96, 2016
Greenland Institute of Natural Resources

[Empty page]

Table of Contents

<i>Summary</i>	7
<i>Resume (Danish)</i>	8
<i>Eqikkaaneq (Greenlandic)</i>	9
<i>Introduction</i>	11
<i>Methods</i>	14
<i>Results</i>	17
<i>Discussion</i>	18
<i>Acknowledgements</i>	24
<i>References</i>	24

Figures

1.	Map of the Cape Atholl area, an area of approximately 880 km ² , showing Pituffik (Thule) Air Base and place names.	Page 11
2.	Map of the grid cells used during the 2015 aerial survey of the Cape Atholl area. Each square measures 3x3 km.	Page 14
3.	ATV reconnaissance route from Dundas to the coast of Cape Atholl. Route was driven one day before the aerial survey.	Page 15
4.	Map of the Cape Atholl 2015 survey's 407 km continuous survey line.	Page 16
5.	Location of muskoxen groups observed, and number animals per group, during the 2015 aerial survey of Cape Atholl area.	Page 18
6.	ATV's reconnaissance for muskoxen near the abandoned Marine Base on coast of Cape Atholl.	Page 32
7.	Adult muskox bull on hill side near the abandoned Marine Base at the coast of Cape Atholl.	Page 32
8.	A second adult muskox bull on hill side near the abandoned Marine Base at the coast of Cape Atholl.	Page 33
9.	A third adult muskox bull almost at the shore near the abandoned Marine Base at the coast of Cape Atholl.	Page 33
10.	Family group of muskoxen, adult cow, on hill side near the abandoned Marine Base at the coast of Cape Atholl.	Page 34
11.	At Dundas, Thomas Clausen preparing the Cessna 172 for survey.	Page 34
12.	View from the Cessna 172 of a typical valley with muskoxen dotted across the vegetation covered braided river plain.	Page 35
13.	Inside the Cessna 172 using the grid map to keep track of the flight route flown and location of muskox groups observed and their number.	Page 35
14.	A portion (total was 16) of the muskox group grazing in mid September near the Pituffik (Thule) Air Base's 12 th Space Warning Squadron (12 SWS) radar facility, which is ca. 15-18 km east of air base.	Page 36

Tables

1.	Cape Atholl muskoxen: historical local reports indicating population growth and changing distribution since their 1986 reintroduction.	Page 12
2.	Historical harvest quotas and seasons for Cape Atholl muskoxen.	Page 13
3.	Cape Atholl, 7 September 2015 muskoxen survey, results from survey flown by fixed-wing Cessna 172.	Page 17
4.	Muskox survey details for continuous line transects flown 7 September 2015.	Page 26

Appendices

1.	Raw Data	Page 26
2.	2015 local knowledge: Cape Atholl muskoxen	Page 27
3.	The 1986 muskoxen translocations to the Thule <i>Avanersuaq</i> region	Page 30
4.	Data sheet - Ikkinnerpaamik kisitsineq /tælling	Page 31
5.	Photos	Page 32

Summary

Muskoxen (*Ovibos moschatus*) were once indigenous to the Thule region, but were hunted to extinction in the 1800's. In 1986, seven juvenile muskoxen were translocated to Cape Atholl, an area of approximately 880 km² at about 76.5°N. Since then, the status of the population has only been known by local reports.

On 7 September 2015 the first fixed-wing aerial minimum count of the re-introduced Cape Atholl muskoxen population was done. The resulting minimum count observed 276 muskoxen, with an autumn calf percentage at 17.4%, and a density of 1.4 muskoxen per km² on habitat below 200m elevation. Current autumn distribution demonstrates that muskoxen have established themselves throughout the Cape Atholl area reaching north to Wolstenholme Fjord (*Uumaanap Kangerlua*). However, most were observed in the south west portion close to the site of their 1986 release.

Good foraging range, i.e., under 200m elevation, is limited to 202 km². Given the recommended stocking density at these elevations is 1-2 muskoxen per km², we estimate that the number of muskoxen the Cape Atholl range can sustain is approximately 300 animals. Past harvest quotas and resulting harvests have not prevented growth in muskoxen abundance. Today, Cape Atholl muskoxen exhibit increased dispersal, and there are reports that vegetation in the preferred habitat of the *Maniisergat* (Green Valley) is showing signs of overuse by muskoxen. Habitat conservation may be needed, since at 76.5°N the growing season for vegetation is short and regeneration slow following grazing.

Today, the muskoxen are near their estimated sustainable limit for Cape Atholl. To prevent overstocking on this small sized range, we recommend the following: a quota of 30 to 50 animals over the next three to five years; licenses with muskoxen sex and age specified (following percentages in past harvests); and protection of cows and calves.

Having a relatively small sustainable population in equilibrium with its range forage is preferable to steadily growing numbers on an increasingly depleted habitat. Fine tuning of future quotas and harvest seasons necessitates further minimum counts (including the calf %) and full harvest reporting. However,

current harvest reporting is incomplete and conducting future one-day aerial minimum counts, regardless of their frequency, hinges on the enthusiasm and financial resources of the Pituffik Citizen Council. Despite these constraints, we advise repeating minimum counts at least every three to five years to illuminate the effects of management actions taken.

Resume (Danish)

Moskusokser (*Ovibos moschatus*) var engang en del af den oprindelige fauna i Thule-regionen, men uddøde på grund af jagt i 1800-tallet. I 1986 blev syv unge moskusokser sat ud ved Kap Atholl (76.5°N) i et område på ca. 880 km². Bestandens tilstand har siden da kun været kendt af områdets lokale.

Den første minimumtælling af den re-introducerede moskusoksebestand ved Kap Atholl blev udført fra fly d. 7. september 2015. Der blev i alt observeret 276 moskusokser med en kalveandel på 17,4 % og en tæthed på 1,4 moskusokse pr. km² i områder, der ligger lavere end 200 m.o.h. Den aktuelle efterårsudbredelse viser, at moskusokser har etableret sig i Kap Atholl-området og videre nord og østover til Wolstenholme Fjord (*Uumaanap kangerlua*). De fleste dyr blev dog observeret i områdets sydvestlige del i nærheden af udsætningsområdet.

Områder, der ligger lavere end 200 m.o.h., giver gode græsningsarealer, men udgør kun 202 km² af Kap Atholl-bestandens udbredelsesområde. Da den anbefalede tæthed af moskusokser på disse arealer er 1-2 individer/km², kan Kap Atholl-området formodentlig bære ca. 300 dyr. Tidligere kvoter og fangst har ikke hindret bestanden at vokse, og i dag har moskusokserne ved Kap Atholl spredt sig så meget, at der er tegn på overgræsning ved dyrenes foretrukne arealer i *Maniisergat* (Grønnedal). Det er nødvendigt at beskytte græsningsarealet, fordi vækstsæsonen ved 76.5°N er kort, og regenerering af afgræsset vegetation er langsom.

I dag er moskusoksebestanden ved Kap Atholl nær det estimerede bæredygtige antal, og for at forhindre nedslidning af vegetationen på det lille græsningsareal anbefaler vi følgende: En fangstkvote på 30-50 moskusokser over de næste 3-5 år; licenser med specificeret køn og alder på moskusokser (i lyset af fangstfordeling i tidligere efterårsjagter); beskyttelse af køer og kalve.

Det er at foretrække at have en relativt lille, stabil bestand, der er i balance med vegetationsgrundlaget, frem for en bestand i vækst på et mere og mere ødelagt vegetationsgrundlag. Fintuning af fremtidige fangstkvoter og jagtsæsoner kræver flere minimumtællinger (inklusive kalve-andel) og fuldstændig fangstrapportering. Den nuværende fangstrapportering er ufuldstændig, og fremtidige minimumtællinger fra fly afhænger af både engagement hos og bevilling fra Pituffik Borgerråd. Trods disse begrænsninger anbefaler vi, at minimumtællinger gentages mindst hvert tredje eller femte år for at belyse konsekvenserne af den forvaltning, der bliver vedtaget.

Eqikkaaneq (Greenlandic)

Umimmaat (*Ovibos moschatus*) Siornagut Avanersuarmi uumasooqatigiit akornanni uummasuusimagaluartut 1800-kkut ingerlaneranni piniarneqarnerat pissutaalluni nungutitaasimapput. Umimmaat piaqqat arfineq-marluk Kap Atholl-imut (Avannarpasisuseq 76.5°N) 880 km²-inik annertussusilimmut 1986-mi nuunneqarput. Tamatuma kingorna qanoq ingerlasimanersut taamaallaat tamaani najugaqartunit ilisimaneqarpoq.

Umimmaat Kap Atholl-imut eqquteqqinneqarsimasut takusat tunngavigalugit amerlassusiliinermi kisitsineq siullesq 2015-imi septemberip 7-anni pivoq. Tassani umimmaat 276-it takuneqarput, taakkunannga 17,4 %-it piaraallutik, agguaqatigiissillugulu kvadratkilometerimi ataatsimi nunami 200 meterinit pukkineruserumi umimmaat 1,4-nik amerlassuseqarlutik. Ukiakkut taamaalinerani pissutsit takutippaat umimmaat Kap Atholl-ip eqqaaniit avannamut kangimullu Uummannap Kangerlua (*Wolstenholme Fjord*) tikillugu siammarsimasut. Amerlanerpaalli nunap tamatuma kujataa-kangiani umimmalersueqqaarfiusumi nassaassaasimapput.

Nuna 200 meterinit pukkineruseroq ivigartorfigissuuvoq, kisiannili tamanna umimmaat Kap Atholl-imut nuunneqarsimasut siammarfigisimasaanni 202 kvadratkilometeriinnarnik annertussuseqarpoq. Siunnersuutigineqartoq malillugu umimmaat tamaani ataaseq marlulluunniit kvadratkilometerimi ataatsimi uumaniartussaammata Kap Atholl-ip eqqaani umimmaat 300-t missaaniittut tamaani uumasinnaasimapput. Siornatigut killilersuisarneq

piniarnerlu umimmaat amerliartornissaanut akornutaasimangillat, ullumikkullu Kap Atholl-ip eqqaani ima siammarsimatigilerput allaat umimmaat neriniarfinnaavat, Maniiseqqat (*Grønnedal*), nerriniarfigineqarpallaarluni mangiarneqarpallaalersimavoq. Ivigartorfiusartup illersorneqarnissaa pingaarpoq - 76.5°N avannarpasissuseqartumi piffissaq naasut naaffigisinnaasaat sivikippoq, ivigartorfiusimasullu naaniaqqittarnerat kigaatsuinnarmik pisarluni.

Kap Atholl-ip eqqaani umimmaat ullumikkut amerlassusaat oqimaaqatigiissumik ingerlatsisoqarnissaata missaaniippoq, ivigartorfineqarsinnaasullu annikitsuinnaap naasuisa mangiarneqarpallaarnissaat pinngitsoorniarlugu ima siunnersuuteqarpugut: Umimmaat 30-niit 50-inut amerlassuseqartut ukiuni tulliuuttuni pingasuniit tallimanut sivisussuseqartumi pisassiissutigineqarsinnaapput. Piniarnermut allagartani umimmaat arnaviaanersut angutiviaanersulluunniit aammalu qassinik ukioqarnersut nalunaarsorneqassaaq (tassa siornagut ukiakkut piniarnermi qanoq agguataarneqarsimanersut najoqqutaralugu). Arnavissat piarallit eqqissisimatinneqassapput.

Ajunnginnerpaassaaq umimmaat amerlavallaaratik amerlassutsimikkullu nikerarpallaanngitsumik amerlassuseqarpata, naasoqarneranut tunngaviusumut oqimaaqatigiissuseqartumik - tassa naasoqarneranik tunngaveqanngitsumik amerliartuinnartitsinissaq pinngitsoorniarlugu. Siunissami pisarineqarsinnaatitaasut piffissallu piniarfiusinnaatitaasut nakkutigineqaqqissaarnissaat anguniarlugu takusat tunngavigalugit umimmannik kisitsinerit amerlanerusut pisariaqartinneqarput (tassungalu ilaavoq piaqqat amerlassusaannik ilisimasaqalernissaq), kiisalu piniarnermut tunngasunik paasissutissat sukumiisut atorfissaqartinneqarlutik. Maannamut piniarnermut atatillugu nalunaarusiortarneq amigartumik ingerlanneqarpoq, siunissamilu timmisartut atorlugit takusat tunngavigalugit kisitsinerit ingerlanneqassappata Pituffimmi Borgerrådit piumassuseqarlutik suleqataanissaat aammalu aningaasaliinissaat atorfissaqartinneqarpoq. Taaneqartut kinguarsaataagaluartut siunnersuutigaarput takusat tunngavigalugit amerlassusiliinerit ukiut pingasukkaarlugit imaluunniit tallimakkaarlugit ingerlanneqaqqittassasut, taamaaliornikkut nakkutilliinerit aalajangiunneqartut qanoq kinguneqarnersut takuneqarsinnaalissammat.

Introduction

Cape Atholl (ca. 76°30' N; 69° W (Fig. 1)), known locally as *Kangaarsuk*, is in the Thule *Avanersuaq* region of northwest Greenland and has similar latitude to southern Ellesmere Island, Canada. During the 1800's the indigenous muskoxen of the Thule *Avanersuaq* region were driven to extinction by a combination of Polar Eskimos in the south and American and English expeditions in the north (Vibe 1986). By the 1970's muskoxen had not been reported between Hall Land (ca. 82°N) and Cape York (76°N) since 1876 (Vibe 1986). During the 1980's -1990's the Greenland government translocated muskoxen to several locations in Greenland, including the Thule *Avanersuaq* region, where in 1986 muskoxen were re-introduced at three locations, Cape Atholl, McCormick Fjord and Inglefield Land (Boertmann *et al.* 1992). Cape Atholl received seven juveniles (5 females and 2 males) on the 11th of July 1986 (Vibe 1986; Burnham 1997; Cuyler & Mølgaard 2002) (Table 1).

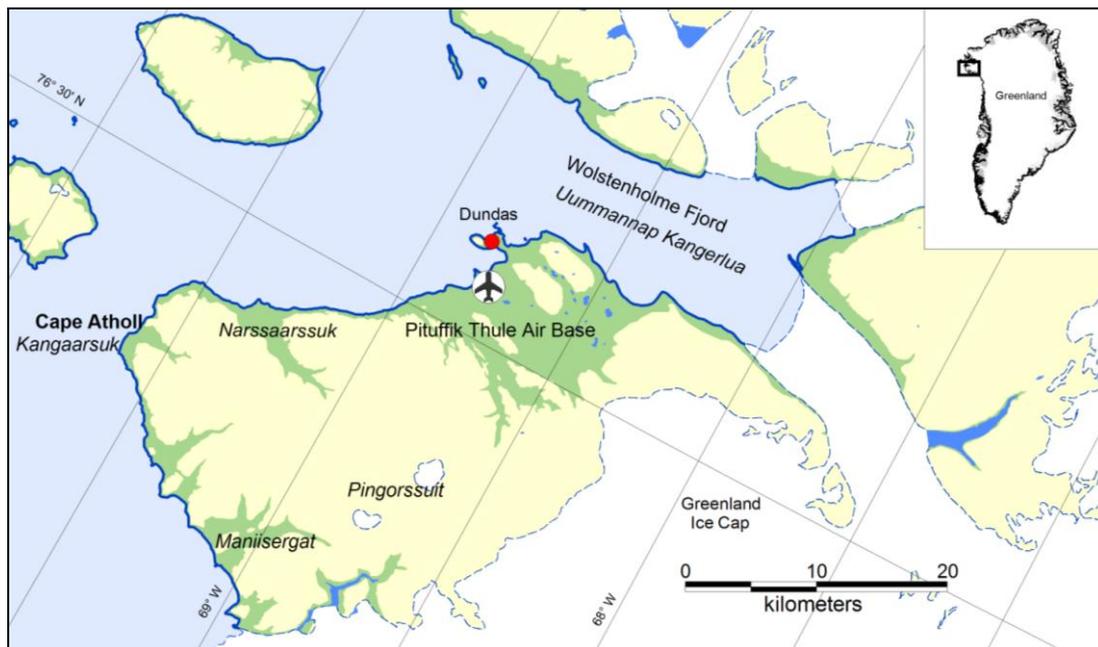


Figure 1. Map of the Cape Atholl area, an area of approximately 880 km², showing Pituffik (Thule) Air Base and place names. Elevations above 200 meters are light yellow and below 200 m are green.

Similar to all other translocations, the Cape Atholl juveniles originated from the West Greenland muskoxen population at *Kangerlussuaq* (*Søndre Strømfjord*), which itself was the successful result of the 1963-1965 introduction of 27 juveniles captured from the indigenous muskoxen population in north-eastern Greenland (Vibe 1971).

Immediately after the 1986 translocation of muskoxen to Cape Atholl, a period of harvest prohibition followed (Boertmann *et al.* 1992) and lasted 15 years. During this period, two small government culls occurred to examine severely overgrown hooves (Burnham 1997; Cuyler & Mølgaard 2002) (Table 2). Finally, in 2001 harvests regulated by quotas and seasons began, initially with a quota of five animals, specifically old with severely overgrown hooves.

Table 1. Cape Atholl muskoxen: historical local reports indicating population growth and changing distribution since their 1986 reintroduction. Note lack of observations after 2003.

Year	Location	Observed Muskox number	Calf number	Calf %
1986 ^{a,b}	Maniisergat	7	0	0
1990	Maniisergat	7	0	0
1991	Maniisergat	7	2	28.6
1993	Inner Narsaarsuk (Pingorssuit)	6	?	
1994 ^a		19 (+1 lone bull)	7	35.0
1995 ^a		24 (+2 lone bulls)	7	26.9
1996 ^a	Maniisergat	33	8	24.2
1997 ^c	Maniisergat + Narsaarsuk	32 + 12 (+3 lone bulls)	7 + 5	25.5
1998	Maniisergat	10 (+4 lone bulls)	1	7.1
2001	Maniisergat	18 (+3 lone bulls)	5	23.8
2002		Ca. 30 - 35		
2002 ^c		51	14	27.5
2003	Maniisergat	40 + 12 (+5 lone bulls)	5 + 2	12.3

^a Burnham 1997

^b Cuyler & Mølgaard 2002

^c Greenland Government, Directorate for Environment & Nature – overgrown hooves in both valleys.

Initially, the distribution of the fledgling Cape Atholl population was highly localized and resided solely in the *Maniisergat* (Green Valley), where they utilized the lush vegetation growing under the bird colonies (Burnham 1996). Calves were regularly observed following 1991 and by 1993 muskoxen distribution had expanded to include the *Narsaarsuk* Valley. In 1997 the original single herd appeared to have split, with separate groups observed in both the *Maniisergat* and *Narsaarsuk* valleys. These two valleys were still heavily used in 1998 when all age classes exhibited exemplary winter body condition and almost no tooth wear, including even on a 13-year old cow (Cuyler & Mølgaard 2002). The muskoxen now moved more frequently and for greater distances (Burnham pers. comm.). Expansion of their range continued. Local reports from the Peregrine Fund are lacking after 2003 (Table 1), because they ceased to work in the *Maniisergat* area. Still, by spring 2015 muskoxen had expanded north and were present at Wolstenholme Fjord (*Uumaanap Kangerdlua*), and groups of muskoxen were observed to the east and north of the Pituffik (Thule) Air Base.

Table 2. Historical harvest quotas and seasons for Cape Atholl muskoxen. Reported shot is incomplete following 2000, and five years completely lack hunter reporting. Blank cells indicate an absence of data.

Year	Season	Commercial Quota	Reported shot
1986	Hunting prohibited	0	0
1990	Hunting prohibited	0	0
1991	Hunting prohibited	0	0
1993	Hunting prohibited	0	0
1994	Hunting prohibited	0	0
1995	Hunting prohibited	0	0
1996 ^a	Autumn cull 1 bull: examined hooves	0	1
1997	Hunting prohibited	0	0
1998 ^b	April cull: overgrown hooves study	15	14
1999	Hunting prohibited	0	0
2000	Hunting prohibited	0	0
2001 ^c		5	3
2002 ^c		5	
2003 ^c		5	
2004/2005 ^c	1 Aug - 30 Sept 2004, 1-31 March 2005	7	
2005/2006	1 Aug - 15 Nov 2005, 1 Jan - 30 Apr 2006		2
2006/2007			
2007/2008 ^c	1 Aug 2007 - 30 Apr 2008	15	11
2008/2009 ^c	1 Aug 2008 - 30 Apr 2009	15	2
2009/2010 ^c	1 Aug 2009 - 30 Apr 2010	15	
2010/2011 ^c	1 Aug 2010 - 30 Apr 2011	15	15
2011/2012 ^c	1 Aug 2011 - 30 Apr 2012	15	3
2012/2013	1 Aug 2012 - 30 Apr 2013	15	10
2013/2014 ^c	1 Aug 2013 - 30 Apr 2014	15	7
2014/2015	1 Aug 2014 - 30 Apr 2015	15	8

^a Burnham 1997

^b Cuyler & Mølgaard 2002

^c Directorate for Hunting, Fishing & Agriculture, unpublished data.

With only local observations to go on, the Cape Atholl muskoxen population size has been unknown for the past +25 years. The same is true for calf production. Permitted harvest quotas since 2001 have been conservative, while with each year more muskoxen were being observed ever further from Cape Atholl and the *Maniisergat* (Green Valley). All harvest quotas were allocated to commercial hunters, with no allocation to sport hunters. The seemingly growing number of muskoxen around the Pituffik Thule Air Base convinced resident sport hunters that the Cape Atholl muskoxen quota might be raised, permitting some allocation to sport hunters. Since changes to harvest quotas are often based on updated knowledge of herd size and this was unknown for Cape Atholl muskoxen, a survey for abundance was necessary. The local Pituffik Citizen Council coordinated with the Greenland government and the Greenland Institute for Natural Resources to bring about an aerial survey minimum count of the Cape Atholl muskoxen.

Present survey

In September 2015 an aerial fixed-wing minimum count survey of the Cape Atholl area was completed. This report presents the results of the first ever minimum count survey of Cape Atholl muskoxen since their release in 1986, and includes the total count, autumn distribution and calf percentage.

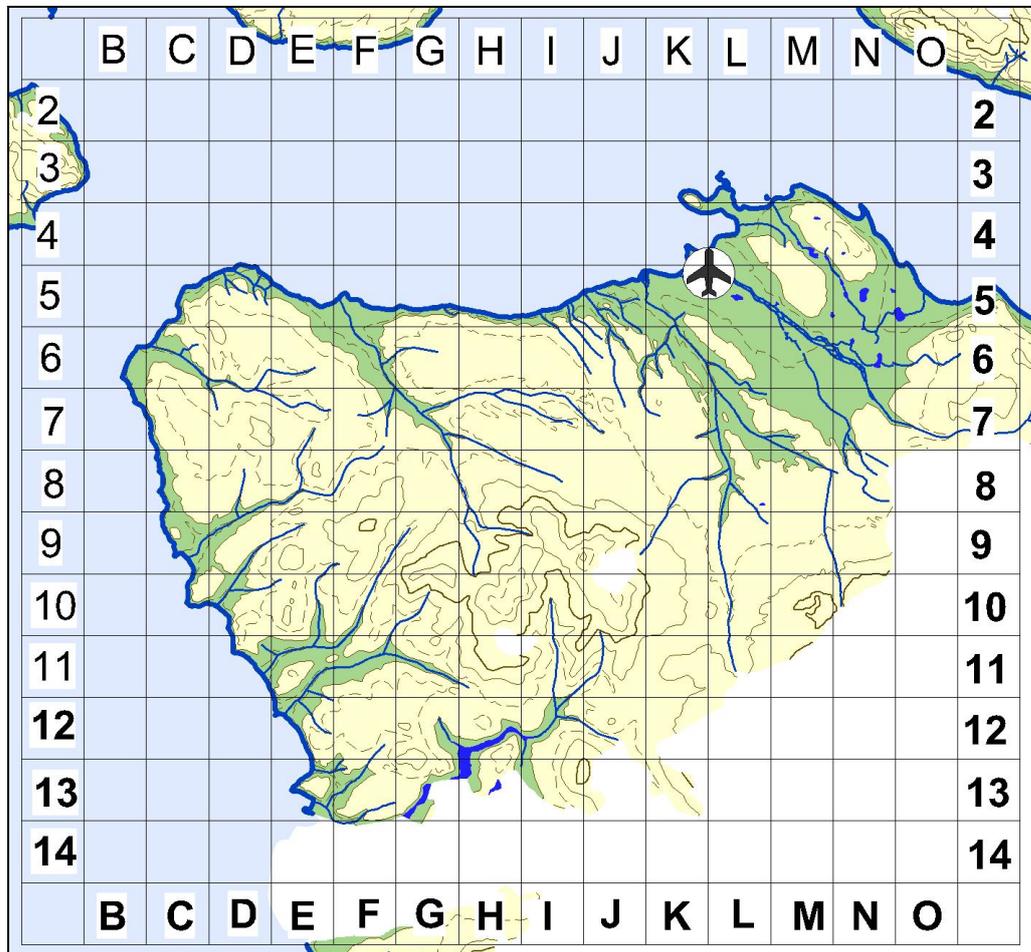


Figure 2. Map of the grid cells used during the 2015 aerial survey of the Cape Atholl area. Each square measures 3x3 km.

Methods

Study area

The Cape Atholl area is a peninsula isolated by the surrounding sea and Ice Cap. Cape Atholl itself is the point furthest west ($76^{\circ} 19'N$, $69^{\circ} 22'W$) on the peninsula, where since 1951 the United States Air Force's Pituffik ('the place where dogs are tied') Thule Air Base is located ($76^{\circ} 32'N$, $68^{\circ} 45'W$).

Permanent population at the Pituffik Air Base in 2005 was 235 persons. Cape Atholl is ca. 1,200 km north of the Arctic Circle and about 1,500 from the

North Pole. At these northern latitudes, the sun is above the horizon from the end of April to the end of August, and below the horizon from the end of November to early February. Also, located within the High Arctic, snow and storm winds can occur at any time year round. Climate for January-March show temperatures averaging from -19° to -28°C with only 5 mm precipitation. Similarly July-August temperatures average $+7^{\circ}$ to $+2^{\circ}\text{C}$ with 18 to 25 mm precipitation. The Cape Atholl area is currently calculated to ca 880 km², which includes lakes and rivers but excludes glaciers and Ice Cap. The area contains rolling hills and valleys where elevations over 200 m make up ca. 77% of the area (seldom > 460 m), the remaining 23% lies below 200 m. The arctic tundra vegetation is sparse, likely owing to the brief cold growing season and lack of water. An exception are the dense lush grassy expanses under the dovekie/little auk (*Alle alle*) bird colonies, especially in the *Maniisergat* ($76^{\circ} 20' \text{N}$, $68^{\circ} 52' \text{W}$), also aptly known as Green Valley. Throughout the area are arctic willow (*Salix*) and dwarf birch (*Betula nana*), which are common but widely dispersed at low elevations, and the typical varieties of arctic flowering species, grasses, sedges, mosses and lichens.

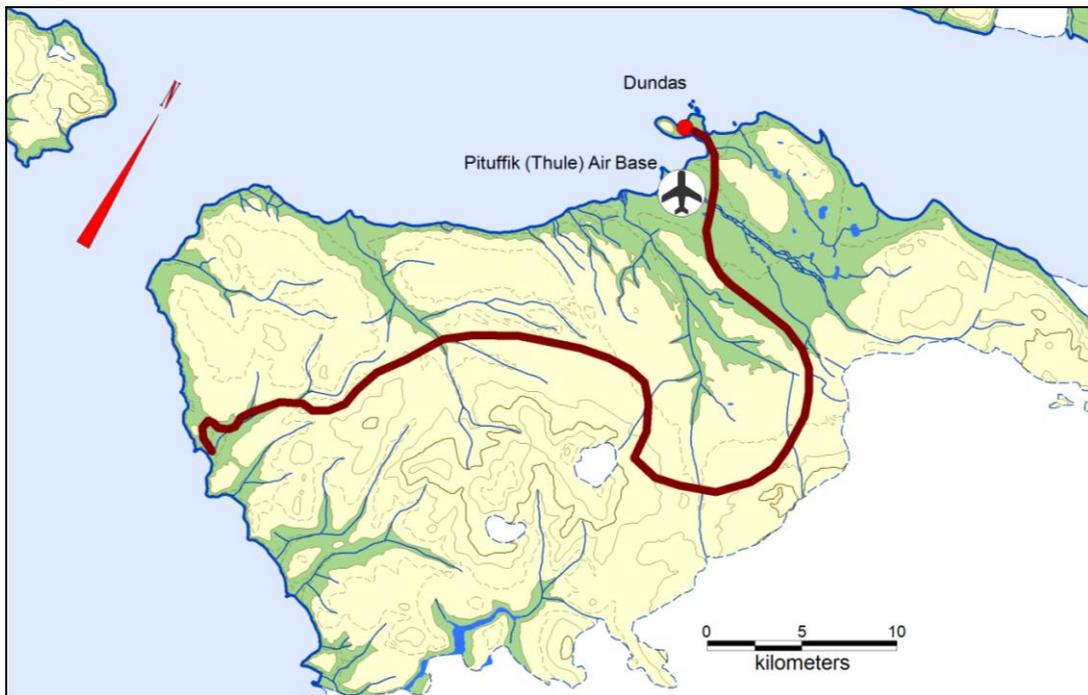


Figure 3. ATV reconnaissance route from Dundas to the coast of Cape Atholl. Route was driven one day before the aerial survey.

Survey design

A Cessna 172, single engine, 4-seat, high wing, fixed-wing air craft was used to fly a survey over the Cape Atholl area. In addition to the pilot, there were

two observers, one on either side of the airplane. All participants were local to the Pituffik (Thule) Air Base. Survey altitude varied and was about 400m \pm 100. Cruising flight speed was 175 km per hour. Strip width varied, although it may have been approximately 500 m to either side of the back and forth ('spaghetti-line') transects. Since density distribution of the muskoxen was unknown the survey was flown without dividing Cape Atholl into areas of high and low muskoxen occurrence. One day prior to the aerial survey, reconnaissance by ATV along the track route to the abandoned Marine Base located on the coast of Cape Atholl was tried to evaluate usefulness of ATV's for counts of muskoxen in the area. It was determined that not enough terrain could be observed by ATV for this to be a useful method.

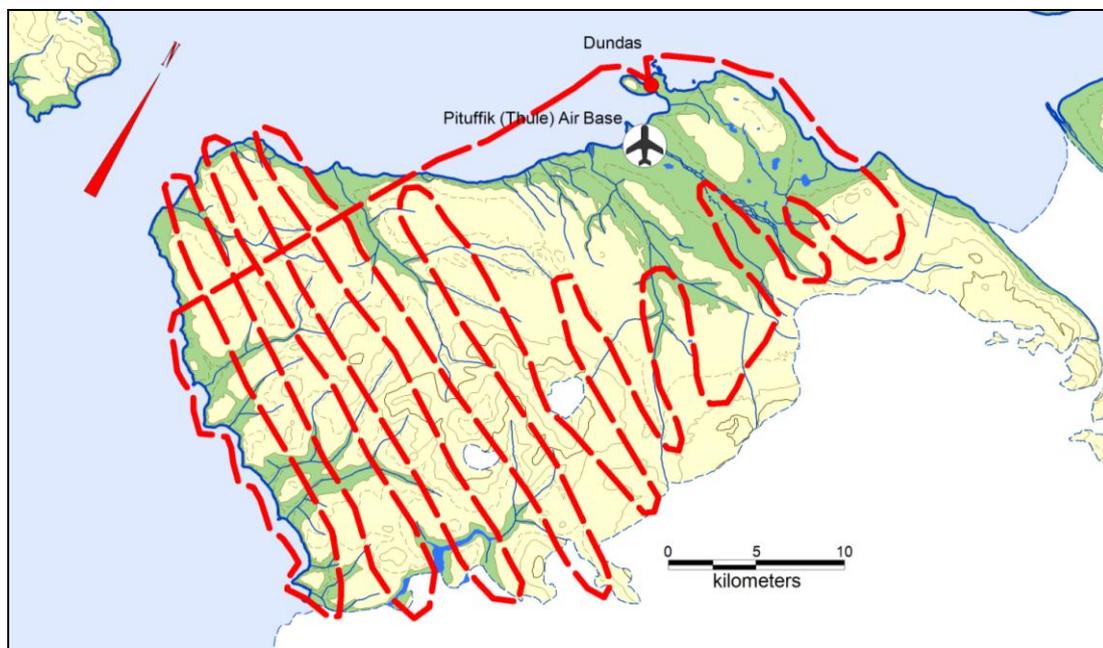


Figure 4. Map of the Cape Atholl 2015 survey's 407 km continuous survey line. The survey first flew southwest and then ran multiple 'parallel' lines, starting and finishing at the Dundas air strip.

The aerial survey was a minimum count survey, meaning the expected result would be the minimum number of animals in the Cape Atholl area. Minimum counts are also known as 'total' counts, and represent a minimum estimate of the actual prevalence of the surveyed animals. Although an aerial minimum count increases area coverage and reduces 'dead ground' caused by topography, there will always be overlooked animals that are not included in the count. Double counting (counting the same group or individual twice) was avoided by surveying the entire Cape Atholl area in one day.

Muskoxen observations were given consecutive ID numbers. When a group of muskoxen was encountered, the following were recorded; grid cell position (letter + number (Fig. 2)), total number muskoxen in group (including calves), and the number of calves (age < 1 year). Calves were identified by their small body size.

Results

The one-day reconnaissance made it obvious that terrain and topography render ATV's useless as a vehicle for minimum counts in autumn. Only an aerial survey would permit access to all of the area. However, ATV use resulted in several photos of muskoxen observed in the vicinity of the abandoned Marine Base on the coast of Cape Atholl (Appendix 3). The ATV reconnaissance also observed some animals limping or moving strangely and slowly.

The 2015 aerial survey took about 2½ hours on one day, the 7th of September, when ca. 407 km of continuous survey line were flown (Fig. 3, Table 1). Survey altitude was approximately 1000 to 1500 feet (ca. 300-500 m). Maintained cruising speed averaged about 175 km per hour.

Table 3. Cape Atholl, 7 September 2015 muskoxen survey, results from survey flown by fixed-wing Cessna 172.

Parameter	Cape Atholl Muskoxen Survey
Continuous survey line distance (km)	407
Survey line width (km)	1 (2x 500m)
Cape Atholl area (km ²)	880
Survey area (km ²)	407
Coverage %	46 %
Altitude (m)	300-500
Air Speed (km per hr)	175
Number of muskox groups observed	29
Average group size	9.5 ± 7.0 SD
Median group size	8
Max group size	30
Min group size	1
Total muskox observed	276
Calves among total	48
Minimum calf %	17.4

Group size averaged 10 individuals, with the largest group being 30 animals the smallest being solitary animals (Table 3). The latter instance occurred four

times. In general, groups comprised both adults and calves (Table 4). Of the 29 groups observed, only six lacked a calf or calves. Calves were found in groups across the entire survey area.

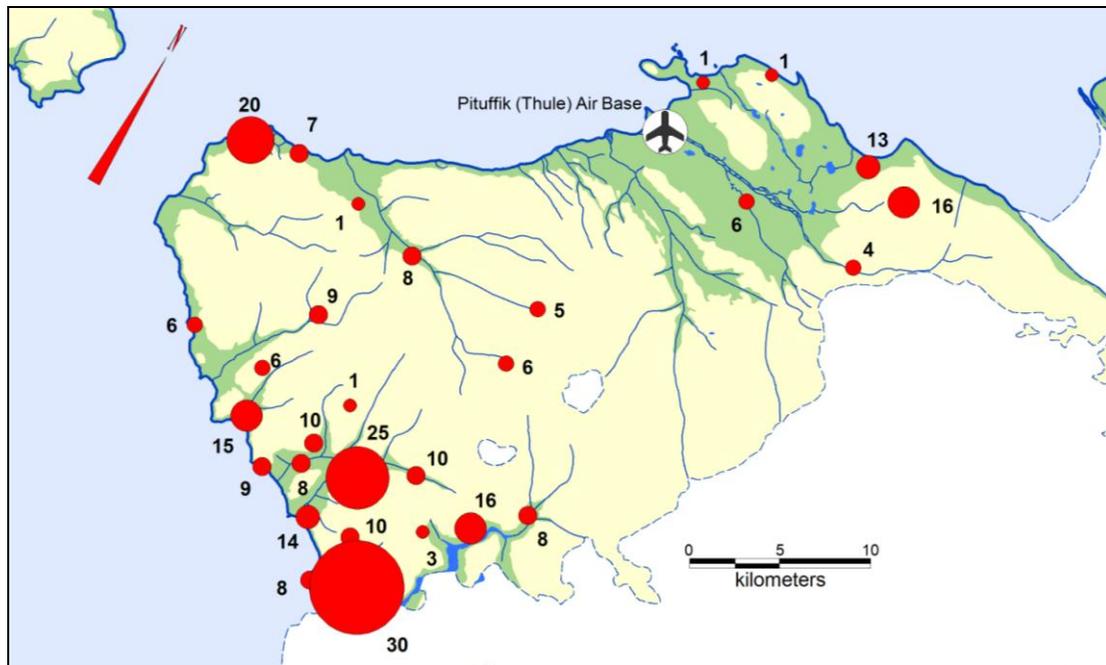


Figure 5. Locations of muskoxen groups observed, and number animals per group, during the 2015 aerial survey of Cape Atholl area.

Muskoxen distribution was uneven across the Cape Atholl area (Fig. 4). Of the 29 groups observed, 23 were observed within a 20 km radius of their original release site at Cape Atholl. Those 23 groups constituted 85% of the total number seen. The remaining 15% had expanded north onto ranges east of the Pituffik Thule Air Base, to a maximum distance of 40 km from the original release site.

Discussion

Overgrown hooves

Hoof hyperplasia was first described by Burnham (1996) and Cuyler & Mølgaard (2002) as endemic among the wild Cape Atholl muskoxen population in the 1990's. The former proposed that the overgrown hooves developed due to the lush summer pastures, e.g., those under the *Maniisergat* bird cliffs, which resulted in a sedentary lifestyle, while the pasture's spongy nature provided insufficient hoof wear. However, Cuyler & Mølgaard's (2002) anatomical observations resembled true hoof hyperplasia as exhibited in

mouflon sheep (*Ovis orientalis*) (Volmer 2003), where the hooves on all four legs are simultaneously affected, including the dew claws, which are never affected by wear and abrasion. Affected animals sampled (n=14) exhibited exemplary body fat reserves, large body size, almost no tooth wear despite advanced age and no outward signs of disease (Cuyler & Mølgaard 2002), and pathological examination of their hooves ruled out the latter (Volmer unpublished). Genetic defects were also suspected. Investigations comparing the amino-acids in the hoof keratin of overgrown hyperplastic and healthy normal hooves revealed significant differences ($p = 0.003$) (Volmer, Hecht & Cuyler unpublished). Further investigation will be needed to clarify the connections and mechanisms of the observed hyperplasia in muskoxen at Cape Atholl.

The altitude and speed of the 2015 aerial survey did not permit close observation of the muskoxen, and no instances of overgrown hooves were seen. Further, this study's ATV reconnaissance observed no obvious instances of hoof hyperplasia, although a few animals had difficulty walking and may have been afflicted. In contrast, 15 to 20 years ago overgrown hooves were endemic. To ascertain whether the situation is different today will require further field observations with the sole purpose of finding hyperplasia.

Abundance & distribution

This population began with 7 animals. The closest neighbouring population is far to the north in Inglefield Land, and given natural barriers, emigration and immigration are assumed to have been zero. On September 2015 there were a minimum of 276 muskoxen. This population has also begun spreading northward across Cap Atholl over the last decade. Since 2005 single animals began appearing in the vicinity of the Pituffik (Thule) Air Base, 2014 saw small groups, and then 2015 saw the first large mixed groups (Thorbjørn Jørgensen pers. comm.; Fig. 14). In contrast to the past, when muskoxen were typically only seen from the point of Cape Atholl and down to the Pituffik Glacier, now muskoxen can be observed along the entire coast line starting already from the Pituffik (Thule) Air Base. Local reports of increasing abundance and expansion of the Cape Atholl muskoxen population were confirmed by this survey.

Habitat & recommended muskoxen density

Habitat conservation may be the wise path. The entire Cape Atholl area is small, about 880 km². Specifically at this high northern latitude, however, not all of the 880 km² is suitable muskoxen foraging habitat. Greenland studies have shown that muskoxen body size and reproduction hinge on their range's nutritional condition and their density upon it (Olesen *et al.* 1994, Lyberth *et al.* 2007). West Greenland muskoxen are known to prefer low elevation habitat (Olesen 1993). From the Canadian arctic, studies indicate that the best muskoxen habitat is below an elevation of 200m (Thomas *et al.* 1981). Further that this habitat can support just 1-2 muskoxen per km² on a year round basis, and most importantly, only if the winters are not too severe (Thomas *et al.* 1981). At present, this is the best estimate for a muskoxen stocking density in the high arctic.

Elevations below 200m at Cape Atholl involve just 202 km² of habitat, and the quality, quantity and availability of the forage vegetation are unknown. Using the stocking density of 1-2 muskoxen per km² (notwithstanding extreme weather events), the current study's density of 1.4 muskoxen may be sustainable if the habitat is good. This would suggest that a population size in the vicinity of 300 animals, or less, may be sufficient to allow forage regeneration. The annual bird guano (fertilizer) deposited under the bird cliffs in the *Maniisergat* Valley likely promotes conditions favourable to vegetation regeneration following grazing. This may account for the large number of muskoxen observations here and in similar nearby valleys. Conditions will not be as productive in areas with few or no bird cliffs.

Alternately, it is possible that the current habitat is depleted relative to its unused condition prior to the release of muskoxen in 1986. Perhaps 300 muskoxen would now be too many for Cape Atholl. Recent local observations for the *Maniisergat* (Green Valley) describe willows and tundra torn up ('ploughed') in swathes alongside rivers, and the grass in the 'green' areas appearing lawn mowed and overgrazed (Thorbjørn Jørgensen, Max Franklin and Kurt Burnham pers. comm.; Appendix 5). This isolated high arctic range, of only 202 km² forage, may be overstocked, which would be unfortunate, since abundant available nutritious vegetation is the primary foundation for a viable muskoxen population on Cape Atholl.

Hunter harvest & natural mortality

Hunter harvesting began in 2001, and although hunter reports for each animal are mandatory, actual reports received for any one hunting season has varied from zero to almost complete. The Greenland Institute of Natural Resources is aware of unreported harvest and the shooting of entire family groups. In the 2014-2015 hunting season the quota was 15 muskoxen, but only 8 were reported killed. Full hunter reporting is important if harvest quotas are increased.

Natural mortality, as opposed to hunter harvest, may result from among other things, starvation, accidents, disease, injury, predators, and in the absence of the latter, old age related factors that feed back into the first four. Mortality owing to predation by large predators (including polar bears) is suspected in the Cape Atholl area, but unknown in scope. Predation may be low because of the infrequent predator presence, owing in part to their being shot before ever making it as far south as Cape Atholl. For example a lone wolf (the first in decades and most likely originating from Canada's Ellesmere Island) was shot January 2016 at the small settlement of Siorapaluk, which is about 160 km and two fjords to the north of Cape Atholl. Stochastic events and density dependent effects notwithstanding, while assuming an average age at death as 15 years for a natural mortality of 6-7%, and using the current total count of 276 muskoxen, then the natural adult mortality for Cape Atholl muskoxen may be in the vicinity of 16 to 19 animals annually.

Trends in calf production

In the 1990's, according to local reports, calves made up 25-35% of all animals observed (Table 1) in summer. We assume these earlier observations are reliable, since anyone can pick out calves, owing to their considerably smaller size relative to other muskoxen. This study's observed autumn 2015 calf percentage, however, was a modest 17.4%. Cape Atholl's early values appear similar to the Kangerlussuaq muskoxen calf production (24%) observed during their initial period of herd growth (Clausen 1993), while today's result is similar to recent declined calf production at Kangerlussuaq, (Cuyler unpublished). Perhaps Cape Atholl muskoxen are also experiencing a declining trend in calf production. If true, future calf production rates may not much exceed this study's observed autumn 2015 calf percentage.

At 17.4%, calf production can be considered sufficient. Disregarding possible severe weather events for the 2015-2016 winter (e.g., abnormally deep snow, rain-on-snow, icing, thaw-refreeze), and given a maximum natural winter mortality of 19 animals, coupled with a maximum harvest totalling 15 shot dead (i.e., ignoring possible unreported poaching), the expected pre-calving population would then be about 242 muskoxen and result in a spring 2016 calf production of about 51 calves.

Management implications

To date there have been no studies of muskoxen grazing impacts on vegetation at Cape Atholl, or elsewhere in Greenland. Meanwhile, overgrazing at some locations has become noticeable to the casual observer (Appendix 5). There may be reason to be concerned about habitat conservation. We have only a general recommended stocking density based on studies in Canada that are over 35-years old. How well that stocking density describes when these herbivores are in equilibrium with their range's capacity to rejuvenate at Cape Atholl is unknown. With approximately 50 new calves expected in the spring of 2016, raising the hunting quota could harvest this production and be a step towards curbing herd growth and maintaining the recommended stocking capacity. It is important to maintain a harvestable Cape Atholl muskoxen population and conserve the habitat they are dependent upon. We recommend that the 2016 hunting quota be, as a minimum, doubled to become 30 muskoxen. In light of the fact that reported harvests have often fallen short of actual quotas and may reflect low harvesting, we suggest the quota actually be increased up to 40-50 muskoxen. This number would approach annual calf recruitment, which is the "interest-on-your-capital", and thus better ensure halting further population growth. Setting a hunting quota higher than the desired number for harvesting, is one technique to achieve that goal, specifically in locations like Cape Atholl where weather conditions can prevent hunter access to the area for much of the hunting season.

Given the projected calving production for 2016 and conservative estimate of mortality, a harvest of 30-50 animals annually for the next 5 years might be supportable. However, if new information emerges to indicate the development of either a much larger or smaller population, then further quota adjustment would be required.

If there is to be an increased quota on this relatively small population, then possible hunter harvest bias is best avoided. Calf production and genetic variability (such as it is) are priorities. Removing too many of one sex or age class could have negative impacts on the future abundance and genetic variability of this population. Here is an opportunity to let past harvests guide us. From 2001 to 2014, a total of 71 muskoxen, which included all age classes, were reported harvested on Cape Atholl (Cuyler unpublished). This total harvest included 56% adults, 48% sub-adults and 4% calves (age < 1-year). The harvested sex ratio was approximately 50:50 for both adults and calf age classes. Among sub-adults, however, it was the juvenile males that were most often selected by hunters relative to juvenile females, 74% and 26% respectively within their age class.

Shooting of entire family groups is not recommended. We recommend that each hunting licence stipulate a specific age-class and sex to be taken. Given this survey's results, it is apparent that past harvest selection has provided room for population growth. Until further data is obtainable, the allocation of age/sex on licences could initially pattern itself on the percentages for harvested age and sex in the above paragraph; with the exception that protection from hunting is extended to cows with a calf-at-heel (age < 1-year) and calves.

Monitoring improvements

The September 2015 count provides only a 'snap-shot' of the minimum abundance, distribution and autumn calf recruitment for the Cape Atholl muskoxen population. Although a herd size estimate cannot be made directly from this one count owing to the unknown and variable strip width, this could be changed by either a time-series of counts or improved methods. A time-series of minimum counts would constitute a reliable index of trends, e.g., increasing, decreasing or stable herd size, while the number of calves relative to the total number observed would indicate expected future trends in abundance. Alternately, if methods were improved so that the strip width was measured and kept constant for the entire survey, then the counts could provide a simple strip width population estimate of the entire area. Further changes to methods could include replacing the present east-west orientation of transects with a north-south axis. The east-west axis is appropriate for the shape of the area surveyed. However, given our new knowledge that Cape Atholl muskoxen distribution follows a north-south gradient, which may

reflect an important habitat gradient, future surveys may use a north-south transect axis.

Monitoring frequency

Fine tuning of future quotas and harvest seasons will necessitate further minimum counts (including the calf %) and full harvest reporting. However, current harvest reporting is incomplete and conducting future one-day aerial minimum counts, regardless of their frequency, hinges on the enthusiasm and financial resources of the Pituffik Citizen Council. In a perfect world, surveys would be repeated in the same season every year or at least every second or third year. Realistically however, as a minimum, a one-day survey every three to five years is advised.

Acknowledgements

This survey would never have happened without the engagement of the Pituffik Citizen Council. We sincerely thank the pilot Steen Svensson and Pituffik Flying Club for providing their Cessna 172. This project was financed by the Pituffik Citizen Council, Pituffik Air Base, Greenland. Grateful thanks for ideological support from the Nordic Resource Management project 2015. We thank Wendy Loya and Lars Witting for review of the manuscript, and Gogie McCullough for proof reading.

References

- Boertmann, D., Forchhammer, M. Olesen, C.R., Aastrup, P. and Thing, H. 1992. The Greenland muskox population status 1990. *Rangifer*. 12(1): 5-12.
- Burnham W. 1996. Progress Report 1996: Thule Greenland Project. *The Peregrine Fund*, 566 W. Flying Hawk Lane, Boise, Idaho 83709, USA. 10 pp.
- Burnham W. 1997. Progress Report 1997: High Arctic Institute Pituffik, Greenland. *The Peregrine Fund*, 566 W. Flying Hawk Lane, Boise, Idaho 83709, USA.
- Cuyler L.C. & Mølgaard H.S. 2002. Overgrown hooves from muskoxen (*Ovibos moschatus*) of Kangaarsuk (Cape Atholl) Northwest Greenland. *Greenland Institute of Natural Resources*. Technical report No. 41. 30 pp.

- Lyberth B., Landa A., Nagy J., Loison A., Olesen C. R., Gunn A. & Forchhammer M. C. 2007. Muskoxen in the high Arctic-temporal and spatial differences in body size. *Journal of Zoology*. 272: 227-234.
- Olesen C.R. 1993. Rapid population increase in an introduced muskox population, West Greenland. *Rangifer*. 13(1): 27-32.
- Olesen C.R., Thing H. & Aastrup. 1994. Growth of wild muskoxen under two nutritional regimes in Greenland. *Rangifer*. 14(1): 3-10.
- Thomas D.C., Miller F.L., Russel R.H. and Parker G.R. 1981. The Bailey Point region and other muskox refugia in the Canadian Arctic: a short review. *Arctic*. 34(1): 34-36.
- Vibe C. 1967. Arctic animals in relation to climatic fluctuations. *Meddelelser om Grønland*. Kommissionen for Videnskabelige Undersøgelser i Grønland, Vol. 170 (5): Pages 153-162.
- Vibe C. 1971. Moskusoksen. - In: A. Nørrevang, T.J. Meyer and S. Christensen (eds.), *Danmarks natur, Grønland og Færøerne*. Politikens Forlag. Pages 401-404. (in Danish)
- Vibe C. 1981. Landpattedyr: moskusoksen. - In: A. Nørrevang and J. Lundø (eds.), *Grønlands natur*. Politikens Forlag. Pages 479-482. (in Danish)
- Vibe C. 1986. Tilbage til de gamle græsgange. *Augut*. Pages 6-7. (in Danish)
- Volmar K & Herzog A. 2003. Diagnostik, Differentialdiagnostik und Sanierungsmöglichkeiten von Klauenerkrankungen beim Muffelwild – eine Übersicht. *Beitr. Jagd- und Wildforschung* 28: 337-344.

Appendix 1

Raw Data

7 September 2015 fixed-wing aerial survey of muskoxen in the Cape Atholl area, Thule region, Greenland.

Table 4. Muskox survey details for continuous line transects flown 7 September 2015.

Grid Cell	Observation #	Group Size	Calves
C-8	1	6	1
D-11	2	9	2
E-13	3	8	1
F-13	4	30	7
E-12	5	14	3
E-11	6	8	2
D-10	7	15	3
D-9	8	6	1
E-10	9	10	1
F-11	10	25	6
F-12	11	10	2
G-12	12	3	0
F-10	13	1	0
D-5	14	20	4
E-8	15	9	1
G-11	16	10	1
H-12	17	16	2
I-12	18	8	1
E-5	19	7	1
F-6	20	1	0
G-7	21	8	1
I-9	22	6	1
I-8	23	5	1
M-6	24	6	1
O-7	25	4	0
O-5	26	13	2
N-4	27	1	0
L-4	28	1	0
P-6	29	16	3
	SUM	276	48
	Calf %		17.4 %

Appendix 2

2015 local knowledge: Cape Atholl muskoxen

Thorbjørn Jørgensen (Pituffik Air Base)

Generally we see more Musk ox in the Green Valley (*Maniisergat*), Bird Valley and at the Pituffik Glacier than towards the actually point of Cape Atholl. So, below are predominantly our observations for the Green and Bird Valleys.

My first trip to the Green Valley was in 2005. Back then the muskoxen trails were already plentiful. They tend to choose soft areas to walk over rather than more rocky areas. Typically trails follow all along the rivers, and they also like the side valleys as well. When disturbed, they typically tend to move up and gather on hill tops in groups. Perhaps they feel these spots are the most protected one's, as they always flee to hilltops when they feel threatened and begin running away.

Several 'eating' spots along the rivers in the Green and Bird valleys are visible now, e.g., where the willows have been torn up and / or eaten. These torn up patches are typically a swath which is ca. 12-15 feet and up to 4-6 feet wide. Given the patch size it appears they are eating in groups at these spots. They tend to 'carve' into the willows moving up the hill side. The result is a somewhat flat plateau they stand on, as they carve/eat into the more vertical side ahead of them. This is in rough terms. The numbers of patches I do not know, but very many can be found. Some are newer than others. Some contained fresh 'fecal clumps' on the created flat plateau area.

Trampling actually appears very limited. Some footsteps can be observed on their eating spots. Also the vegetation appears to be slightly flattened (but no singular footsteps) at the gathering points on hill tops. So trampling is not a general characteristic impacting the landscape of the Green and Bird valleys.

Still, the muskoxen do function as 'lawn movers'. This is especially seen in the nice vegetation areas at the mouth of the Green and Bird Valleys. However, since the grass looks green and healthy, there may be a good natural balance and no problem. We often choose these grassy areas as camp sites.

This summer 2015, in early August, I hiked alone the entire Green Valley all the way back and forth during one night. This gave me a good opportunity to observe the muskoxen, who appear to like to sleep (lie down) when the sun is low. In contrast to previous years, muskoxen groups are more numerous, but each group is smaller in number. I must have come across at least 10-15 groups and some solitaires. So what I am trying to say is that they were more scattered than what I expected, given what I am used to seeing in previous years. Group size was from 1 to 20 muskoxen. Their distribution covered the entire valley.

Also, in 2015 we saw a dead calf near the beach. This calf was possibly killed by a polar bear. The last two summers we have met polar bears while we camped out in the Green Valley. So I am sure they are catching-on to the good deal that muskoxen meat could be.

Since 2005, we have had solitary muskoxen coming around east of the Pituffik Air base. We assume these have been single old males - but I did not check. In 2014 we

first observed a small (3-5 individuals) summer group of musk ox in the area. Then the summer of 2015 broke all records regarding group numbers of muskoxen near the base. We had a permanent flock of 12-13 muskoxen in the area. These included calves, mothers, group leaders and everything.

For the first time 3 years ago (ca. March 2012), I saw clear evidence of the muskoxen eating spots / craters in the snow east of the Pituffik Air Base. So this indicated to me that they overwinter in this area now. That year, I also saw eating craters in the snow on the North Mountain within a mile from "secret place". I was out twice this winter (spring 2015), but did not see any eating craters in the snow. Given the few muskoxen tracks seen, I am uncertain whether the herd overwintered close to the Pituffik Air Base or moved back to the Green Valley area.

Max Franklin- Peregrine Fund field staff 2015

The following observations arose during the hike Sønni and I took to Green Valley (*Maniisergat*) this summer 2015.

There are now many muskoxen trails within and near Green Valley in any areas of significant vegetation growth. Many of trails were quite well developed and easy to walk on. There were smaller trails that were probably about 1 foot wide and larger trails that were ca. 1.5 - 2 feet wide. All trails were well trodden, being sunken into the ground relative to the surrounding soil by about 6 inches.

While on the hike we did not notice any places where willows were destroyed, and Sønni did not make any comments regarding this either.

Meanwhile, we did come across several locations in the valley where it appeared that the ground had been thoroughly trampled. In these areas or sometimes close to them there were also locations where the tundra was very torn up.

Overgrazing was visible. There were many signs of overgrazing within the Green Valley and on the beach by the sea. This typically took the form of grasses eaten down to the ground and again, torn up tundra. The damage from the torn up tundra was particularly noticeable - there were often large swathes of ground especially by the river shores where giant chunks of tundra had been uprooted or where it looked as if someone had just 'plowed' the soil.

Kurt Burnham - Peregrine Fund 2015

The Peregrine Fund stopped working in the Green Valley (*Maniisergat*) around 2002-2004, which is why our reports ceased. Previously, we had established a large base camp there.

Noteworthy regarding muskox distribution, is that as yet, we have not seen muskoxen to the south of Pituffik glacier, e.g., on the York Peninsula. I expect someday muskoxen will cross in front of that glacier when the sea ice is frozen and thus obtain access to the York peninsula's coastal vegetation. There appears to be

lots of new good habitat along the York Peninsula (we survey it each year) that could support muskoxen.

In regards to torn up tundra, this is most often found along streams and river, where the muskoxen generally create large areas where they tear out the tundra, sometimes 10 meters long and 2-4 meters high. I have not walked around too much in recent years but the others that provided info seem to think overgrazing is becoming an issue.

Perhaps of the most interest regarding the summer of 2015, is that we saw more muskoxen along the coast than ever before. During our regular survey for falcons we saw muskoxen much more frequently along the entire coast, starting already at the Pituffik (Thule) Air Base and continuing all the way to the Pituffik glacier. Previously, we usually saw muskoxen starting around the point of Cape Atholl, and then from there down the coast south to the Pituffik glacier. This past summer we saw single males and smaller groups of 2-3 animals at 4-5 different locations. It was a noticeable change from the past, as several of us commented on it and how different it was.

It seems that the United States Air Force (USAF) may be getting a bit worried about the muskoxen that now occur near the Pituffik (Thule) Air Base. I was recently contacted by a USAF wildlife biologist who will be traveling to Thule to access the wildlife situation in regards to the Air Base, perhaps the greater numbers of muskoxen near the base, or polar bears, are behind this.

It is amazing how well the muskoxen are doing and they seem to really be spreading out and still increasing in number. Around Pituffik (Thule) Air Base there is still a lot of habitat to expand into and I would guess that area could support many more animals, and south of Pituffik glacier also has some great habitat. The Booth Sound area might also provide habitat for muskoxen someday.

Appendix 3

The 1986 muskoxen translocations to the Thule Avanersuaq region

In contrast to the rest of Greenland's western coast, muskoxen had once been indigenous in the Thule region. These were reintroduced in 1986, when there occurred translocations to three different areas in the Thule *Avanersuaq* region: Cape Atholl, Mac Cormick Fjord and Inglefield Land. All muskoxen translocated to the Thule *Avanersuaq* region originated from the *Kangerlussuaq* muskoxen population in the *Kangerlussuaq* Fjord (*Søndre Strømfjord*) region, West Greenland. The muskoxen population at *Kangerlussuaq* was itself the successful result of 27 juveniles taken from northeast Greenland and released at *Kangerlussuaq* in 1962-1965.

The 1986 Thule *Avanersuaq* translocations occurred by first air and then ship as follows (Vibe 1986, Christian Vibe pers. comm., Erik Eriksen unpublished data):

- 1) 1986 July 11, **Cape Atholl** *Kangaarsuk* (ca.76°N, Dundas *Pituffik* area)
 - 7 muskoxen, which included 2 males and 5 females, all yearlings
- 2) 1986 July 12-20, **Mac Cormick Fjord** *Iterlassuaq* (ca.78°N, Thule *Qaanaaq*)
 - 6 muskoxen, which included 2 males and 4 females, all yearlings
 - *Qaanaaq* community nearby; by spring 1987 animals extirpated.
- 3) 1986 July 12-20, **Inglefield Land** *Avannarliit* (78°-79°N, Thule *Qaanaaq*)
 - 14 muskoxen, which included 4 males and 10 females, all yearlings, were released at *Rensselaer Bugt* (Rensselaer Bay).

Muskox Translocation Expedition Participants:

Christian Vibe (Project Leader), Erik Eriksen (Veterinarian), Christian Lacoppidan (Pilot), Jeppe Möhl (Taxidermist), Torben Christiansen (Forest Ranger), Steen Malmquist (Airport Director, *Søndre Strømfjord*), Ûssarqaq Qujaukitsoq (Member of Parliament for Thule (+2 dogs)), Hans Iversen (Member of Parliament for Ilulissat (+4 dogs)).

Dr. Philos. Christian Vibe, project leader for the muskox translocation to Thule *Avanersuaq*, gave the following account (pers comm):

The muskoxen were captured between 2 – 6 July 1986 in the *Søndre Strømfjord*/*Kangerlussuaq* region (ca. 67° N, 51° W). The live-capture was accomplished using 6 dogs, helicopters and darts with immobilisation drugs. All were 14-months old at the time of capture/release. Unlike the *Kangerlussuaq* introductions of 1962-1965, there was no over-wintering at the Copenhagen Zoo, Denmark, prior to release. On 11 July 1986, the captive yearlings were flown to the Pituffik Thule Air Base. Over the subsequent two weeks the muskox yearlings were transported by ship for release at three locations in the Thule *Avanersuaq* region. Ûssarqaq Qujaukitsoq (Member of Parliament) had, in agreement with the Thule Municipal Council, decided on the three areas where the "introduced" muskoxen were to be released, Cape Atholl, Mac Cormick Fjord and Inglefield Land, because Ûssarqaq knew these areas well.

Appendix 4

Data Sheet

Umimmaat / Moskus Cape Atholl 76.5°N_Thule Grønland
Ikinnerpaamik kisitsineq / tælling

Ulloq	Sumiiffik	Normu	Umimmaat Amerlassuiat	Piaaraq inunngorpoq 2015	Allat
Dato	Kort Felt	Observation Nr.	Total Antal i gruppen	Født: 2015 KALVE	Andet
		1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			
		9			
		10			
		11			
		12			
		13			
		14			
		15			
		16			
		17			
		18			
		19			
		20			
		21			
		22			
		23			
		24			
		25			

Appendix 5
Photos



Figure 6. ATV's reconnaissance for muskoxen near the abandoned Marine Base on coast of Cape Atholl. Photo Kasim Virk.



Figure 7. Adult muskox bull on hill side near the abandoned Marine Base at the coast of Cape Atholl. Photo Kasim Virk.



Figure 8. A second adult muskox bull on hill side near the abandoned Marine Base at the coast of Cape Atholl. Photo Kasim Virk.

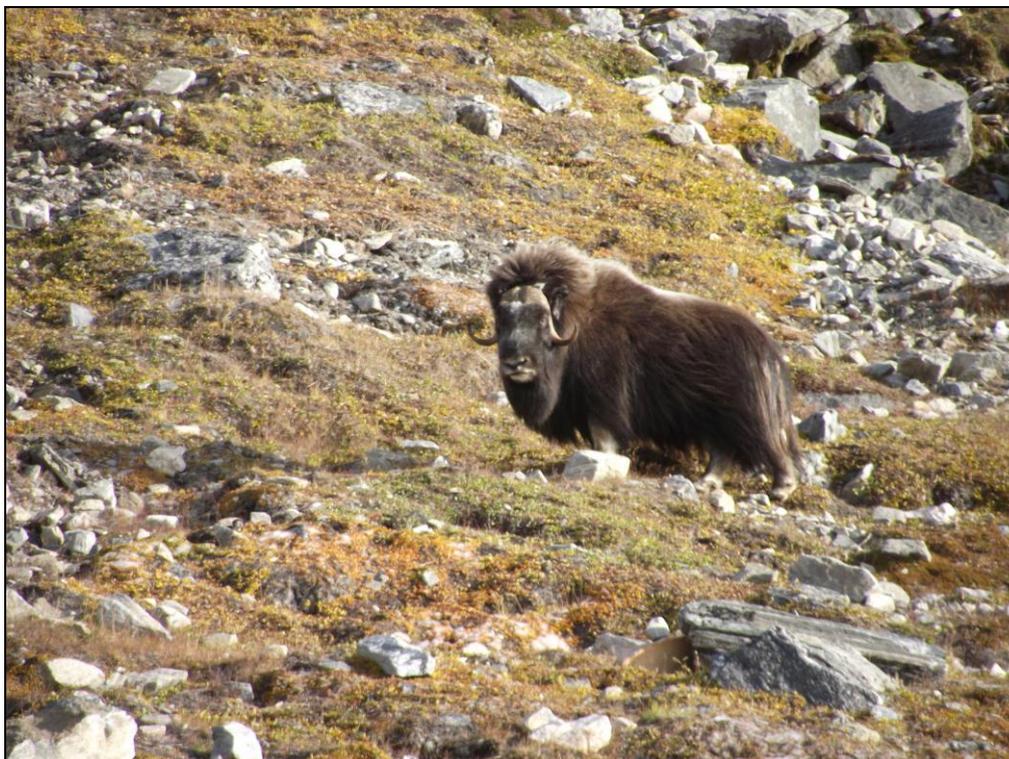


Figure 9. A third adult muskox bull almost at the shore near the abandoned Marine Base at the coast of Cape Atholl. Photo Kasim Virk.



Figure 10. Family group of muskoxen, adult cow, on hill side near the abandoned Marine Base at the coast of Cape Atholl. Photo Kasim Virk.



Figure 11. At Dundas, Thomas Clausen preparing the Cessna 172 for survey. Photo Kasim Virk.



Figure 12. View from the Cessna 172 of a typical valley with muskoxen dotted across the vegetation covered braided river plain. Photo Kasim Virk.



Figure 13. Inside the Cessna 172 using the grid map to keep track of the flight route flown and location of muskox groups observed and their number. Photo Kasim Virk.



Figure 14. A portion (total was 16) of the muskox group grazing in mid September 2015 near the Pituffik (Thule) Air Base's 12th Space Warning Squadron (12 SWS) radar facility, which is ca. 15-18 km east of the air base. Photo Kasim Virk.

[Empty page]