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Background studies in Nuussuaq and Disko, West Greenland

NERI Tehnical Report, No.482

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David Boertmann (editor)

Data sheet

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Abstract:	Preliminar results of five background studies carried out in Nuussuaq and Disko in West Greenland are reported. Moulting and breeding geese were surveyed from aircraft, vegetation was analysed from satellite images, habitat use and dispersion of eiders was studied with satellite telemetry and abundance of caribou was studied.
Keywords:	West Greenland, background study, Canada goose, *Branta canadensis*, white-fronted goose, *Anser albifrons*, common eider, S*omateria mollissima*, king eider, *Somateria spectabilis,* caribou, *Rangifer tarandus*, Arctic char, *Salvelinus alpinus*, local knowledge, vegetation, remote sensing.
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Preface

This report describes five different studies contributing to the background information necessary for environmental impact assessment and regulation of oil exploration in the region Nuussuaq Peninsula and the northern part of Disko Island in West Greenland. Here, oil exploration is very likely to be initiated in the near future.

The Greenland Home Rule, Bureau of Minerals and Petroleum and the National Environmental Research Institute, Denmark together identified some important gaps in the background environmental knowledge concerning the region. Subsequently the Bureau granted four studies, which were carried out in 2003. One more study is included, as the Greenland Institute of Natural Resources kindly offered a survey report about caribou in Nuussuaq to be published in this report.

The presented results are in some cases preliminary, as more data will be obtained during 2004 (satellite tracking of eiders). The full data set will be presented in a scientific context once it is analysed.

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Sammenfatning

I de kommende år forventes olieefterforskning på det nordlige Disko og Nuussuaq Halvøen i Vestgrønland. Denne rapport sammenfatter en række biologiske undersøgelser fra dette område. Formålet med disse undersøgelser var at fremskaffe baggrundsmateriale til brug for regulering og miljøvurdering af aktiviteter i forbindelse med olieefterforskning.

Fem projekter omtales:
1. Optællinger af gæs på Nuussuaq og det nordlige Disko.
Som følge af Canadagåsens nylige indvandring til området sker der for tiden store ændringer i bestandene af de to gåsearter der nu yngler i området. Derfor var det påkrævet at foretage nye optællinger, selvom gæssene i store dele af området blev optalt i 1990'erne. De områder der tidligere var kendt som særligt vigtige for fældende og ynglende gæs, viste sig stadig at være af stor betydning, men rollerne mellem de to arter var byttet om. Den tidligere mest talrige art, den grønlandske blisgås, var nu langt mere fåtallig end Canadagåsen. Bestanden af blisgås er i tilbagegang, hvilket er sat i forbindelse med Canadagåsens fremgang, og denne optælling bidrager yderligere til den bekymring der er for blisgåsebestandens trivsel i Grønland.

2. Kortlægning af vegetation.
Der var behov for en kortlægning af vegetationen især på Nuussuaq halvøen. Vegetationen er kortlagt ved 'remote sensing' og verificering på landjorden. Sammenhængende og ofte fugtig vegetationsdække findes især i Aaffarsuaq-dalen, specielt på de nedre dele af fjeldsiderne og på de jævnt skrånende sider ud mod spidsen af Nuussuaq. De fugtige vegetationstyper er særligt sårbare overfor aktiviteter i forbindelse med olieefterforskning i den snefrie periode.

3. Fjeldørred i elvene på den nordvestlige del af Disko.
Lokale informanter oplyste under en interviewundersøgelse i 2002, at der kun var opgang af fjeldørred i få af elvene i dette område, som ligger temmelig afsides (se Olsvig & Mosbech 2003). For at verificere disse oplysninger blev en række elve undersøgt i september 2003. Undersøgelsen bekræftede manglen på fjeldørred i de pågældende elve på nordvestsiden af Disko.

4. Sporing af konge- og almindelig ederfugles bevægelser i efteråret og vinterhalvåret ved hjælp af satellitsendere.
Her i rapporten beskrives feltarbejdet med at indfange og forsyne kongeederfugle og almindelige ederfugle med satellitesendere. Arbejdet er led i et større samarbejde mellem danske, grønlandske og canadiske institutioner omkring indsamling af forvaltningsrelateret viden om de to fælles bestande af henholdsvis kongeederfugl og almindelig ederfugl. For at få indblik i almindelig ederfugls udnyttelse af kystnære habitater på Disko og Nuusuaq bidrog Råstofdirektoratet med finansiering af 7 satellitsendere. I alt blev henholdsvis 16 og 7 sendere sat på kongeederfugl og almindelig ederfugl i september i området omkring Mellemfjord og Nordfjord på Disko. Da senderne

giver mulighed for at spore fuglene i op til et år, præsenteres her kun kort der viser en række fugles bevægelser i efteråret og den tidlige vinter. Egentlige konklusioner må afvente analysen af alle indkomne informationer.

5. Forekomsten af rensdyr på Nuussuaq.
I april 2002 foretog Grønlands Naturinstitut en optælling af rensdyr på Nuussuaq. Der blev observeret i alt 1.164 dyr. Det er langt flere end der blev estimeret på baggrund af en optælling fra fly i 1995. I 2003 befandt rensdyrene sig næsten udelukkende på de inderste to tredjedele af halvøen. Det kan ikke udelukkes, at denne fordeling skyldtes at vegetationen på den yderste tredjedel var dækket af et tykt lag is fra en mild periode i december. Der er tale om to forskellige underarter af rensdyr på Nuussuaq: Dels den oprindelige vilde bestand, dels efterkommere af udsatte tamrener. Det ser ud til at de to typer holder sig adskilt. Der er ikke rensdyr på Disko i dag. Den oprindelige bestand uddøde omkring 1900, og selvom der blev udsat tamrener i 1960'erne er disse formentlig også væk nu (Meldgaard 1986).

Eqikkaaneq

Ukiuni aggersuni Kitaani Qeqertarsuup avannaata Nuussuullu nalaani uuliasiortoqarnissaa ilimagineqarpoq. Nalunaarusiami matumani tamaani pinngortitamik misissuinerit arlallit eqiterlugit allaaserineqarsimapput. Misissuinerni siunertaasimavoq uuliasiornermut atatillugu sulianut atatillugu aalajangersaanermut pinngortitamillu nalilersuinermi paasissutissanik tunngaviusussanik atorneqartussanik katersuineq.

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2. Ingammik Nuussuup naasoqassusaata nalunaarsorneqarnissaa pisariaqarsimavoq. Naasoqassusaa ”remote sensing” (qaammataasamit timmisartumilluunniit assilisat atorlugit) nalunaarsorneqarsimavoq nunamilu misissuinermi uppernarsarneqartarluni. Ingammik Aaffarsuup qooruani isugutagajuttumik eqimattumik naasoqarfeqarpoq, tassa qoororsuarmi tassani qaqqat sivingarngisa naqqani Nuussuullu nuuata tungaanut sivinganerni. Ingammik naasoqarfiit isugutagajuttut ukiup ilaani aputeqanngitsillugu uuliasiornermi mianernarnerupput.

3. Eqaluk Qeqertarsuup kitaata avannaata kuuini.
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4. Mitit siorakitsut siorartuullu ingerlaarnerat qaammataasanut nassitsissutit atorlugit ukiaanerani ukiuuneranilu ingerlaartarnerannik malittarinninneq. Matumani nalunaarusiami misissuineq eqqartorneqarpoq, soorlu mitit siorakitsut siorartuullu pisareriarlugit qaammataasatigut nassitsissutilersuineq. Suliaq tamanna qallunaat, kalaallit canadamiullu suliffeqarfiisa akornanni annertunerusumik suleqati-

giinnerannut ilaavoq, tamatumuunalu mitit siorakitsut siorartuullu eqqarsaatigalugit aqutsisoqarfiit ilisimasanik ataatsimoorlutik katersuinerannik siunertaqarluni. Aatsitassanut Ikummatissanullu Pisortaqarfik miternut siorartuunut arfineq marlunnut qaammataasanut nassitsissutinik aningaasaliissuteqarpoq, taamaalilluni Qeqertarsuarmi Nuussuarmilu mitit sinerissamut qanittumiittut piniagaanerat paasissutissarsiffiginiarlugu. Katillugit nassitsissutit 16-nit 7-lu mitinut siorakitsunut siorartuunullu septembarimi Qeqertarsuarmi Akulliit Kangersuullu kangerluisa eqqaanni ikkunneqarput. Nassitsissutit ukioq ataaseq tikillugu timmissanik malittarinnissinnaammata, matumani timmissat arlallit ukiaanerani ukiulerneranilu nikittarnerat naatsuinnarmik eqqartorneqarpoq. Misissuinermut atatillugu naliliinerit paasissutissat tamaasa pissarsiarineqareerpata saqqummiunneqarumaarput.

5. Nuussuarmi tuttoqassuseq. Aprilimi 2003-mi Pinngortitaleriffik Nuussuarmi tuttunik kisitsivoq. Tuttut 1.164-it takuneqarput. 1995-milu timmisartumit kisitsinermut sanilliullugu naatsorsuutigisamit amerlanerujussuullutik. 2003-mi tuttut Nuussuup qinngorpiaata pingajorarterutaata aappaaniiginnangajapput. Tamatumunngalu Nuussuup silarpasissuata pingajorarterutaata nunataa decembarimi mannguumanerata kinguneranik suli sermitaqarnerujussua pissutaanngitsorsimanavianngilaq. Nuussuarmi tuttut assigiinngitsut marluupput: Siullermik tuttut nujuartat, kiisalu tuttut nujuitsut inissinneqarsimasut kinguaavi. Tuttut taakku assigiinngitsut marluk immikkoorunarput. Qeqertarsuarmi ullumikkut tuttoqanngilaq. Qanga 1900-up nalaani tuttut nungussimapput, 1960-kunnilu tuttunik nujuitsuinik inissiisoqarsimagaluartoq aamma taakku maannakkut nungussimagunarput (Meldgaard 1986).

Summary

Five background studies carried out in the Disko and Nuussuaq area of West Greenland in 2003 are reported.

1. Moulting and breeding Greenland white-fronted geese and Canada geese were surveyed from helicopter on 15 and 18 July. The geese were mainly found in the inner part of the Aaffarsuaq Valley on Nussuaq and in the Nordfjord area on Disko, a distribution similar to previous counts in the region. However the two species had changed roles. Now Canada geese are more numerous than the Greenland white-fronted geese in this region of Greenland.

2. The vegetation on Nuussuaq peninsula was mapped using remote sensing. The vegetation maps show that the densest vegetation is found in the valley floors, along the coast and on the lower parts of the mountain slopes. Particularly in the extensive valley Aaffarsuaq and on the gentle slopes on the western part of the peninsula there are large areas with relatively lush and more or less moist vegetation types, which are highly sensitive to ground based activities such as driving with heavy equipment.

3. A survey of anadromous Arctic char in the rivers of northwest Disko.
Local information obtained in 2002 mentioned only one river with anadromeous Arctic char in that region. The other rivers were not indicated as holding Arctic char. However, this could be explained by the fact that rivers are situated in a remote and rarely visited area. To verify this distribution of anadromous Arctic char the rivers were surveyed in September 2003, and this survey confirmed the local information.

4. Satellite tracking of common and king eiders.
Here is presented a field report on the work. Conclusions must await analyses of the full data set, as the satellite transmitters are programmed to transmit through most of 2004. In the context of background information, it is expected that the birds will give information on habitat use and movements between habitats in the Disko and Nuusssuaq region. In total 16 king eiders and 7 common eiders were equipped with transmitters in September 2003 in the Mellemfjord and Nordfjord area of Disko. Some preliminary maps showing the movements of selected birds until December 2003 are presented in Figures 18-25.

5. Caribou occurrence in Nuussuaq Peninsula.
The Greenland Institute of Natural Resources performed a survey of caribou in Nuussuaq in April 2002. Two different kinds of caribou occur in the region: wild caribou and introduced feral reindeer. A minimum of 1,164 caribou / reindeer was observed. This is much more than a previous estimate of the population (1995: 400 animals), and most animals were found in the middle and eastern parts of the peninsula.

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1 Introduction

1.1 Background

The region between 69° N and 71° N has been designated by the Greenland Home Rule as the second most important area for oil exploration in Greenland (Råstofdirektoratet 2003). Some oil exploration activities have been carried out in the region e.g. in 1996 an exploration well was drilled on land. Although it proved dry, geological evidence indicates that there is a potential for oil, both on land and at sea.

Background data for evaluating the environmental impacts of oil exploration activities on land and in the coastal areas are generally at hand, but some data gaps still need to be addressed. Together with the Bureau of Minerals and Petroleum it was decided to carry out fieldwork to collect environmental data to fill some of the more acute data gaps from the terrestrial and coastal habitats. Fieldwork was carried out in 2003, and this report presents the results, although some are still preliminary.

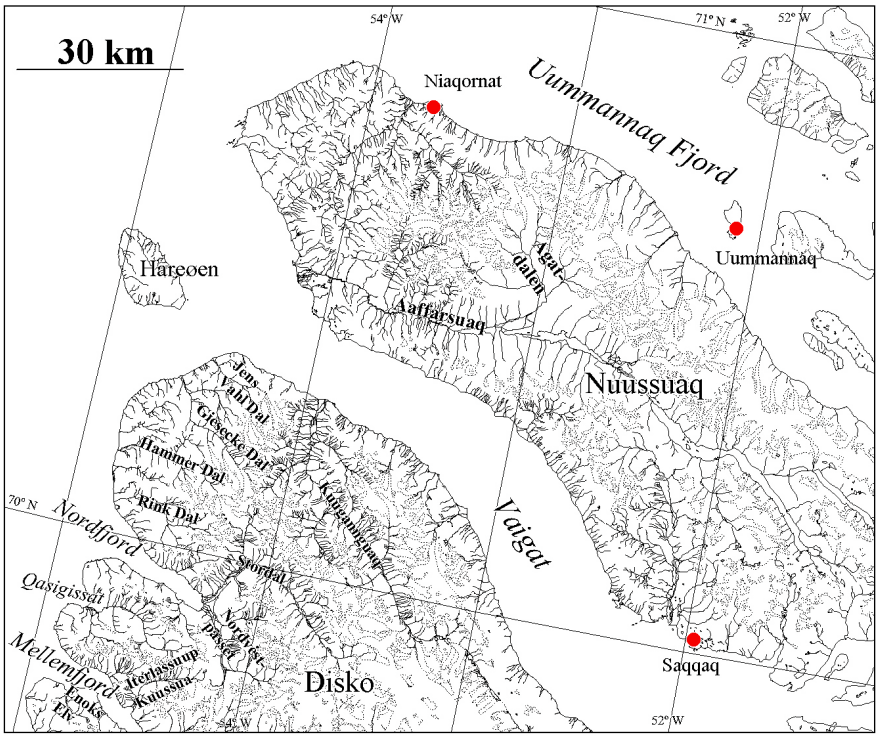

Figure 1. Overview of the study area with names of the most important sites indicated. Settlements and towns are marked with red dots.

The Greenland Home Rule, Bureau of Minerals and Petroleum financed these surveys and the preparation of the present report.

1.2 The study area

The study area comprises the western Nuussuaq Peninsula and northern Disko Island (Figure 1). In both areas seismic surveys are expected in the near future.

1.3 The studies

The following studies were carried out in the summer / autumn 2003:

1. an aerial survey of moulting and breeding geese,

2. mapping of the terrestrial vegetation on Nuussuaq based on satellite images,

3. a survey for Arctic char in northwest Disko,

4. tracking of eider movements by satellite telemetry.

In addition to these studies, caribou occurrence in Nuussuaq is reported based on a field survey in April 2002 carried out by Greenland Institute of Natural Resources.

1.4 Acknowledgements

Permits to catch Arctic char were granted by the Ministry of Fisheries, Hunting, Business and Agriculture (Greenland Home Rule) and the municipality council of Qeqertarsuaq. Permit to catch eiders was granted by the Ministry of Environment and Nature (Greenland Home Rule). Frank Riget (NERI) gave advise on fish biology and Finn Jørgensen, Frederiksborg County (Denmark) gave us access to electro-fishing equipment. The eider field studies were carried out in collaboration with Greenland Institute of Natural Resources and the Royal Veterinary and Agriculture University, Denmark. The Danish Environmental Protection Agency (Danish Cooperation for Environment in the Arctic) partly financed the eider project. Finally Greenland Institute of Natural Resources allowed the inclusion of the caribou 2002 report. Finally the Bureau of Minerals and Petroleum financed the studies carried out in 2003.

2 Survey of moulting and breeding geese in Nuussuaq and north Disko

Jesper Madsen
National Environmental Research Institute

2.1 Introduction

Three species of geese occur in the area. Greenland white-fronted goose (*Anser albifrons flavirostris*), Canada goose (*Branta canadensis interior*) and Brent goose (*Branta bernicla hrota*). The Brent goose is a migrant visitor in spring and autumn and will not be dealt with here, but see accounts in Boertmann et al. (1997) and Boertmann & Glahder (1999).

The Greenland white-fronted goose is a special Greenland subspecies, which differs from other white-fronted geese both in morphology and ecology (Fox 2003). The population breeds exclusively in central West Greenland and winters in Scotland and Ireland. The population numbers about 25,000 individuals (Fox 2003), and it is decreasing. The reasons behind the decrease are not fully understood, but may be linked to the expansion of the population of the Canada goose in West Greenland (Fox 2003).

The Canada goose is a recent immigrant to West Greenland. During the recent two decades it has expanded considerably both in numbers and breeding range (Boertmann 1994, Fox et al. 1996). A result of this expansion is that Canada geese now occur in high numbers in traditional white-fronted goose habitats. There are indications of competitive interactions between the species, which seem to displace the white-fronted geese (Kristiansen & Jarrett 2002).

Both white-fronted geese and Canada geese breed in the study region, where they prefer the wide river valleys with lush wetland vegetation. Besides the breeding birds large numbers of non-breeding (mainly immature) birds spend the summer in the same habitats, where they perform flight feather moult. Because the flight feathers are shed simultaneously the geese loose the ability to fly for about three weeks, while the new flight feathers are growing. These non-breeding birds usually occur in large flocks, while the breeding pairs with chicks occur more dispersed in the habitats. Also the breeding adult birds loose the ability to fly, and this happens when the chicks are small.

Geese are particularly sensitive to disturbance from all kinds of human activities (e.g. Madsen 1984, Mosbech & Glahder 1991).

2.2 Methods

A helicopter survey of geese was performed on Nuussuaq and north Disko on 15 and 18 July 2003, respectively. From previous surveys (Glahder 1999), the area is known as a major breeding and moulting area for Greenland white-fronted geese and Canada geese.

A Bell 222 helicopter was used for the survey. One observer was positioned in the left front seat observing geese in front of and to the left of the helicopter and one observer was positioned in the right back seat observing to the right of the helicopter. Flight speed was 60-80 knots and altitude c. 200 m above ground during observations. By the aid of binoculars (10x), the species composition of goose flocks was identified and numbers of families, brood sizes (where possible) and number of non-breeding birds were recorded. By the aid of a GPS, the position of flocks was recorded, and all observations and positions were recorded on a dictaphone. On both survey days, the weather was bright and calm.

Table 1. Numbers of geese observed in five areas on Nuussuaq and north Disko in 1992, 1995, 2001 and 2003, respectively. Cf. Figure 2.

			Greenland white-fronted goose				**Canada goose**			
Year	**Sub-areas**	**Survey platform**	**Non-breeders**	**Breeders**	**Pulli**	**Total**	**Non-breeders**	**Breeders**	**Pulli**	**Total**
2003	a - Nuussuaq, Saqqaq	Helicopter	0	0	0	0	0	0	0	0
	b - Nuussuaq, upper	Helicopter	203	26	52	281	329	60	120	509
	c - Nuussuaq, delta	Helicopter	0	0	0	0	35	4	10	49
	d - Disko, north coast	Helicopter	89	0	0	89	0	40	80	120
	e - Disko, Nordfjord	Helicopter	92	0	0	92	290	32	64	386
	Total 2003					**462**				**1,064**
2001	e - Disko, Nordfjord	Land	395	46	55	496	962	220	352	1534
1995	a – Nuussuaq, Saqqaq	Aircraft*	105	0	0	105	0	0	0	0
	b – Nuussuaq, upper	Aircraft*	687	6	14	707	19	0	0	19
	c - Nuussuaq, delta	Aircraft*	190	0	0	190	147	0	0	147
	d - Disko, north coast	Aircraft*	53	0	0	53	0	0	0	0
	e - Disko, Nordfjord	Aircraft*	513	8	18	539	156	6	12	174
	Total 1995					**1,593**				**340**
1992	a - Nuussuaq, Saqqaq	Aircraft*	17	0	0	17	0	0	0	0
	b - Nuussuaq, upper	Aircraft*	637	20	19	676	0	0	0	0
	c - Nuussuaq, delta	Aircraft*	45	0	0	45	0	0	0	0
	d - Disko, north coast	Aircraft*	0	0	0	0	0	0	0	0
	e - Disko, Nordfjord	Aircraft*	168	0	0	168	82	0	0	82
	Total 1992					**906**				**82**

* fixed-wing aircraft

2.3 Results

The surveyed areas are shown in Figure 2. For the purpose of comparison with previous surveys, the area is subdivided into five sub-areas, in which comparable surveys have been carried out.

In total 462 Greenland white-fronted geese and 1,064 Canada geese were observed (Table 1). On Nuussuaq, geese were concentrated around the central lakes and the river in the upper valley (Figure 3). Smaller flocks were observed in the river delta. On north Disko geese were absent from the valleys. Flocks were observed along the coast. In Nordfjord flocks of geese were observed in Stordal and Nordvestpasset. Greenland white-fronted geese were most numerous in the upper Nuussuaq valley, and this was the only site where families were observed. This area also held the largest concentration of Canada geese. However, family flocks of Canada geese were observed on both Nuussuaq, north Disko and in Nordfjord. Average brood size for Canada geese was 4.7 (n=11), for white-fronted geese, the brood size in three broods was 4, 4 and 5 young, respectively.

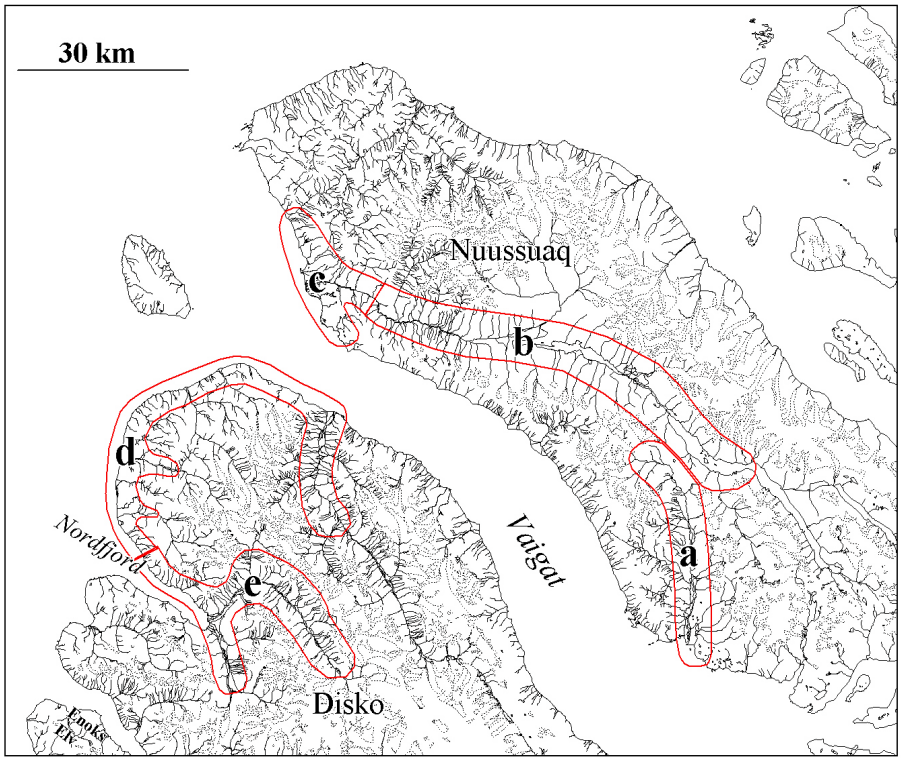

Figure 2. Survey area divided in 5 sub-areas, which were surveyed in 1992, 1995 and 2003. Area e was also surveyed in 2001. a = Nuussuaq, Saqqaq, b = Nuussuaq, upper, c = Nuussuaq, delta, d = Disko, north coast and e = Disko, Nordfjord.

In 1992 Canada geese were absent from the area, except from a flock of 82 individuals in Nordfjord (Table 1). In 1995 Canada geese had dispersed, but the Greenland white-fronted geese were still the more numerous of the two. In 2003 the Canada geese were outnumbering the white-fronted geese, and the number of white-fronted geese had decreased in four of five sub-areas.

2.4 Discussion

In Table 1 a land-based survey of geese in Nordfjord from 2001 is included (Boertmann & Egevang 2002). The number of geese observed was much higher than what was observed in aerial surveys. This may either reflect large between-year variation in numbers or, more likely, an underestimation using aerial surveys. Nevertheless, in relative terms the time-series from Nordfjord shows that Canada geese became the most abundant species between 1995 and 2001.

Kristiansen & Jarrett (2002) have shown that in one regularly surveyed area in West Greenland, the Canada goose displaced the Greenland white-fronted goose from territories where they had formerly been the only herbivorous waterfowl species present. Aerial surveys of extensive areas showed that despite favouring the same geographic region, the two species were less likely to occur together than by chance, suggesting some spatial segregation at a large spatial scale (Malecki et al. 2000). Although the precise mechanism causing the widespread displacement of breeding and non-breeding white-fronted geese by Canada geese remains unknown, the expansion in numbers of Canada geese in West Greenland seems to affect the Greenland white-fronted goose in a negative direction. The process seems to be rapid and ongoing.

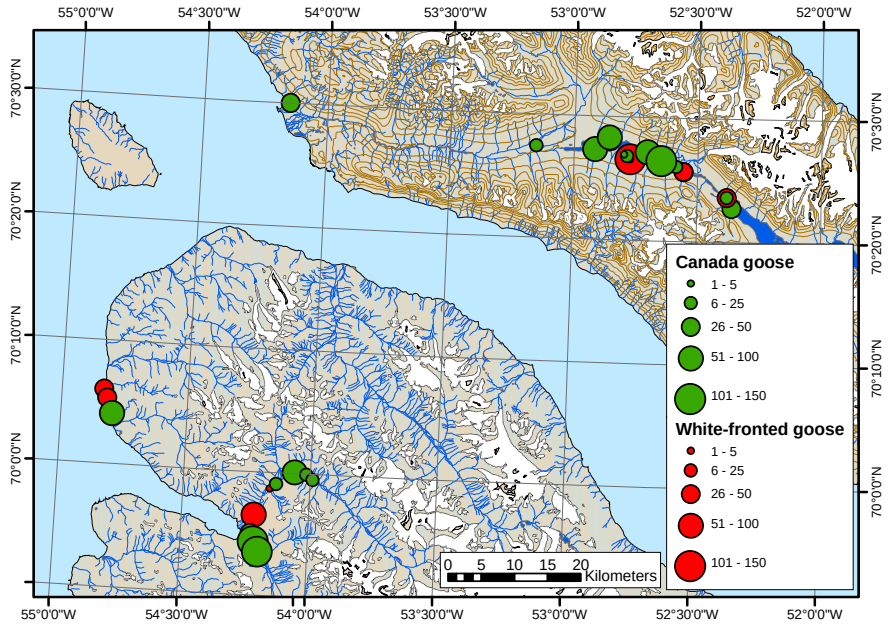

Figure 3. Distribution of Greenland white-fronted geese and Canada geese in Nuussuaq and north Disko, 15-18 July 2003.

3 Vegetation studies

Mikkel Tamstorf
National Environmental Research Institute

3.1 Introduction

This study comprises only the Nuussuaq Peninsula, and the focus is on the Aaffarsuaq Valley, which is where seismic activities most likely will take place.

Nuussuaq is located just north of the floristic low arctic border (Fredskild 1996). This implies that the vegetation on Nuussuaq is lower and more sparse with a higher amount of high arctic species (e.g. *Braya purpurascens, Festuca baffiensis, Eriophorum triste*) than just a little to the south in the Disko-Ilulissat area.

3.2 Methods

3.2.1 Normalised Difference Vegetation Index (NDVI)

NDVI is an index developed as an indicator of the level of greenness of the vegetation and is widely used for monitoring vegetation characteristics and differences. NDVI is calculated as the difference in reflection between the near-infrared (NIR) and the red spectral bands using the following equation (Rouse et al. 1973):

$$\frac{\sigma_{NIR} - \sigma_{RED}}{\sigma_{NIR} + \sigma_{RED}}$$

where σ_{NIR} is the reflection at the near-infrared wavelength (Landsat band 4) and σ_{RED} is the reflection at the red wavelength (Landsat band 3).

A vegetation map has been produced from the satellite imagery from 12 July 2001 and field observations from 1996 (Boertmann unpubl. Mosbech unpubl.) and 2003 (Madsen; field observations 16-18 July 2003). The map has been created using the K-Means unsupervised classification method (Research Systems Inc. 2003) with the 6 short-wave channels of the Landsat image. Atmospheric and topographic correction was done using the ATCOR3 software (Richter 1997).

NDVI was used on land to mask all cover types with vegetation (NDVI > 0.1) in order for these to be classified. The unsupervised classification was then performed on these areas resulting in 8 classes. The classes were analysed for greenness (NDVI) and surface moisture using a moisture index, II (II, infrared index, is similar to NDVI but uses band 5 and 4 from the Landsat ETM+ sensor to enhance areas with higher surface moisture (Jensen 2000)). Based on the analysis with information from the field observations it was possible to combine some of the 8 classes resulting in 5 final vegetation related classes on Nuussuaq. The five classes were grouped after surface moisture from dry over moist to wet and after greenness from low

greenness over medium to high greenness. The five classes are: “Wet – High Greenness”, “Wet – Low Greenness”, “Moist – Medium Greenness”, “Dry – Medium Greenness” and “Dry – Low Greenness”.

3.3 Results

Figure 4 shows an overview of Nuussuaq with a Landsat-7 ETM+ satellite image (acquired on 12 July 2001) draped on the map. The image is a false colour composite of band 7, 4 and 2 in the red, green and blue colour channel, respectively. This enhances the contrast between vegetated and bare surfaces shown in green and red colours, respectively. Nuussuaq is dominated by the high mountain ranges north and south of the east-west oriented Aaffarsuaq Valley. The main part of the vegetation is located in the lower parts beneath 600 m.a.s.l. with the large slopes near the delta and the north slopes in the valley being the most densely vegetated. In the Aaffarsuaq Valley below 600 m the vegetation covers approximately 55 percent of the area.

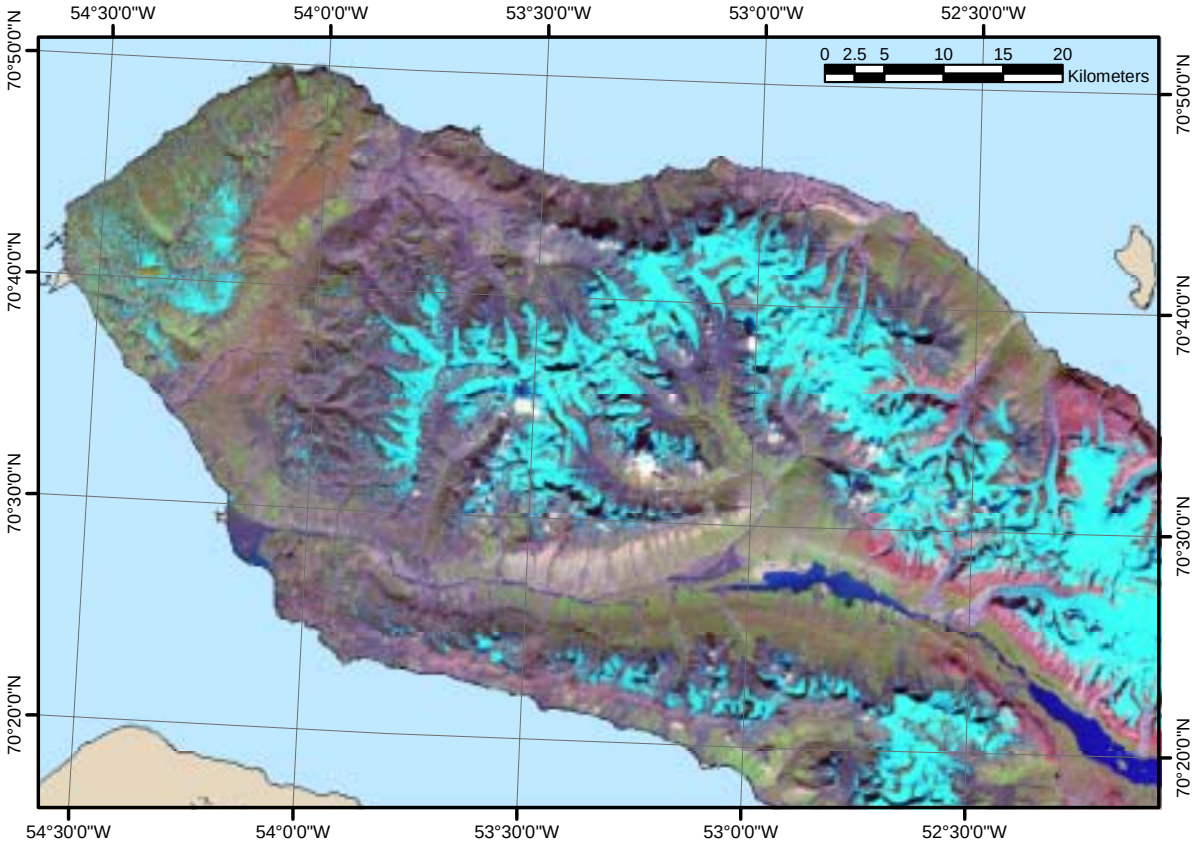

Figure 4. False-colour image of Nuussuaq from 12 July 2001. The image is a composite of Landsat-7 ETM+ band 7, 4 and 2 in the red, green and blue channels, respectively. This combination enhances vegetation in green colours, bare areas in brown and red, snow in light blue and water in darker blue colours (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

Figures 5 to 7 show NDVI for Nuussuaq and two sub areas of the Aaffarsuaq Valley area. The two sub areas show the coastal part (Figure 6) and the inland part from the Aaffarsuaq Valley to the large lake area in the centre of Nuussuaq (Figure 7).

Two large areas with high greenness (orange to red colours) are found in the lowland part of northwest Nuussuaq and the inner part of the Aaffarsuaq Valley (Figure 5). Two smaller areas (northeast slopes of Nuussuaq around 52°30' W and the south facing slopes around 53° W) are also distinct on Figure 5. Values reach 0.7, which indicates very dense vegetation, mostly in the form of grasslands, lush dwarf shrub heath, fens and some herb slopes.

The NDVI image of the coastal part of the Aaffarsuaq Valley seen in Figure 6 is dominated by the southwest facing slopes north of the delta west of 54° W and several smaller areas south of the river, east of 54° W. The start of an area with very dense vegetation on the north facing slopes of the Aaffarsuaq Valley are seen just east of 53°30' W. These areas cover the slope to within less than hundred meters from the river.

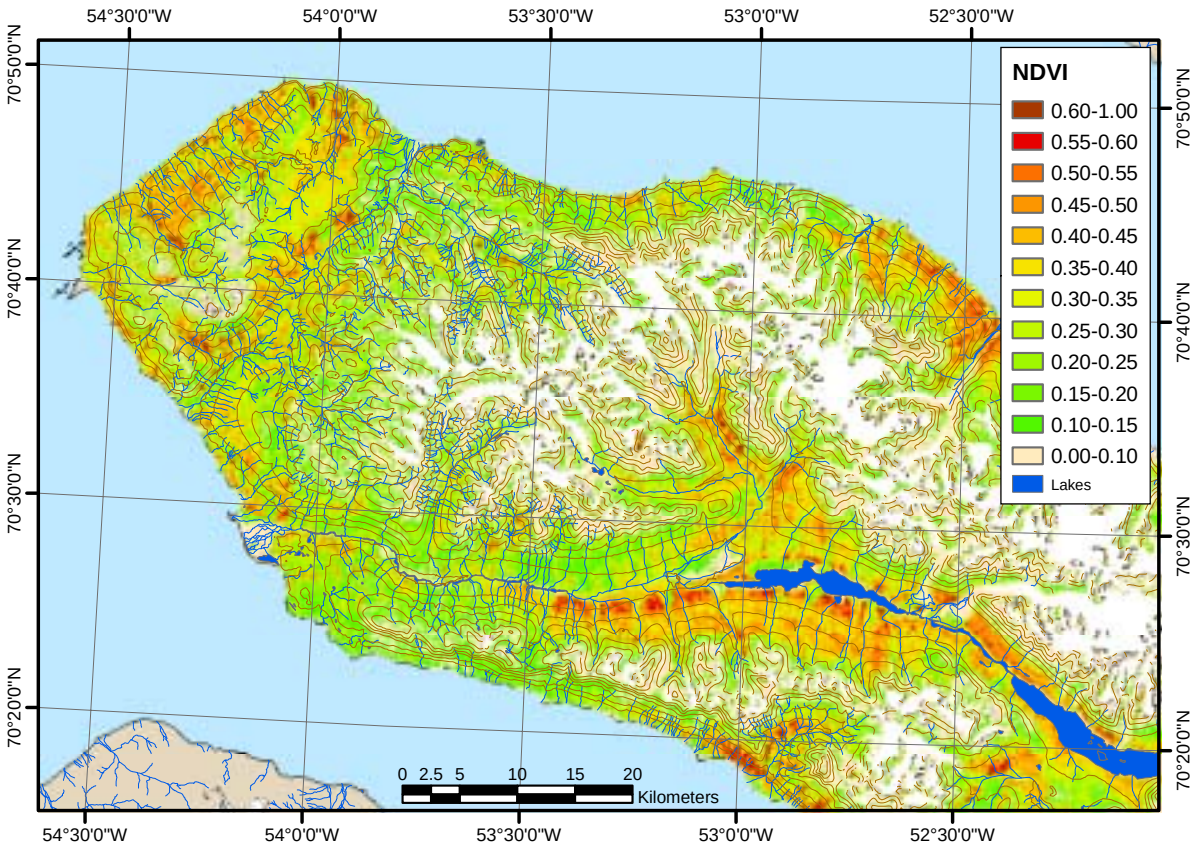

Figure 5. Normalised Difference Vegetation Index (NDVI) for Nuussuaq 12 July 2001. Light brown indicates no vegetation. NDVI scaled with green indicating sparse, low vegetation, yellow for intermediate growth and red for vigorous and dense vegetation (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

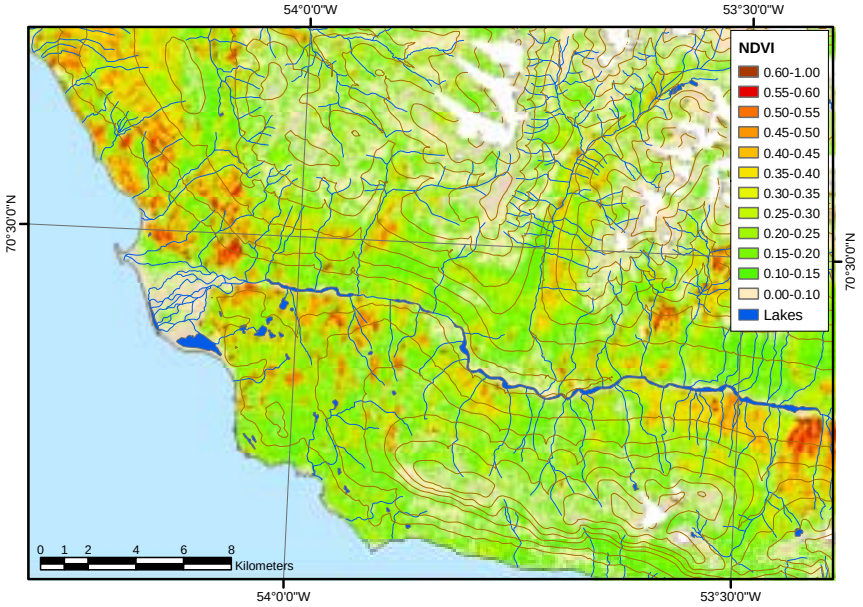

Figure 6. Normalised Difference Vegetation Index (NDVI) for western part of Aaffarsuaq Valley on Nuussuaq 12 July 2001. Light brown indicates no vegetation. NDVI scaled with green indicating sparse, low vegetation, yellow for intermediate growth and red for vigorous and dense vegetation (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

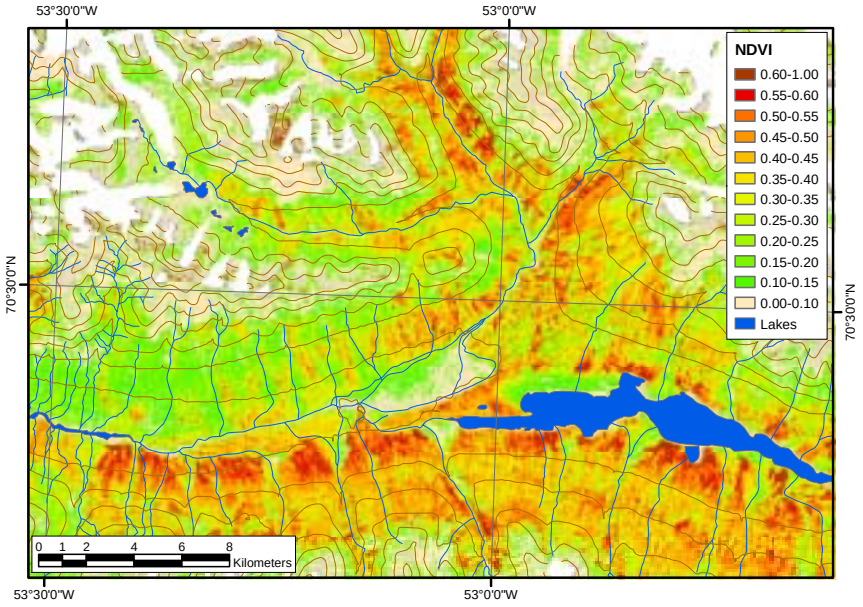

Figure 7. Normalised Difference Vegetation Index (NDVI) for eastern part of Aaffarsuaq Valley on Nuussuaq 12 July 2001. Light brown indicates no vegetation. NDVI scaled with green indicating sparse, low vegetation, yellow for intermediate growth and red for vigorous and dense vegetation (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

The high-NDVI north-facing slopes in the narrow valley are dominating in the inland as shown in Figure 7. The south-facing slopes in the narrow valley are characterised by relative low NDVI's below 0.3 with few areas of 0.4 or higher. This pattern changes somewhat when the valley broadens around 53° W and the south-facing slopes show larger areas with higher values of NDVI. The upper end of the smaller valley towards the north (Agat Dal) is characterised by very

luxurious and dense vegetation (NDVI > 0.5) especially on the west-facing slopes north of 70°30' N.

Field observations from the delta and lower valley system carried out in 1996 and 2003 were used to verify the vegetation map, but there were too few observations to perform an actual accuracy assessment. This should be kept in mind when using the map. However, some major distinctions are possible from the grouping resulting in a possible vegetation type classification. Therefore, the group of "Wet - High greenness" will probably be grassland and fens especially in the coastal areas turning into a luxurious dwarf shrub heath and fens in the inland. Differences between fen and grassland can normally be found through the *Eriophorum scheuchzeri* common in fens due to the high water flow, while *Eriophorum triste* is more dominant on the slightly drier grassland. Dwarf shrubs (*Salix arctica*) are more abundant in grassland, especially in tussocky areas, The "Wet - Low greenness" will likely be snow bed and similar areas below large snow patches and very wet areas related to streams and around lakes. The third group, "Moist - Medium greenness" will mostly be dwarf shrub heaths with varying species (*Salix arctica, Cassiope tetragona, Dryas* sp. etc.). The two dry groups are divided in medium greenness, probably with several types of dry grasslands, dry dwarf shrub heaths and lichen heaths, and low greenness, probably with steppe and fell field types.

Figure 8 show the land cover classes of Nuussuaq. The "Wet - High Greenness" group is the most abundant type in Nuussuaq with a high degree of cover in the lowland and valley areas. The abundance of each of the five vegetation types within Aaffarsuaq Valley is shown in Table 2.

Table 2. Abundance of vegetation types within the Aaffarsuaq Valley.

	Area (km^2)	**% of vegetated area**
Wet - High greenness	142.3	48.3
Wet - Low greenness	43.5	14.8
Moist - Medium greenness	76.5	26.0
Dry - Medium greenness	13.8	4.7
Dry - Low greenness	18.5	6.3

Almost 50% of the vegetated areas are covered by the wet and luxurious grassland, luxuriant dwarf shrub heath, fen or herb-slopes. Dwarf shrub heath ("Moist - Medium greenness") and snow bed vegetation ("Wet - Low greenness") covers around 25% and 15%, respectively. The two dry types cover around 10% of the vegetated area.

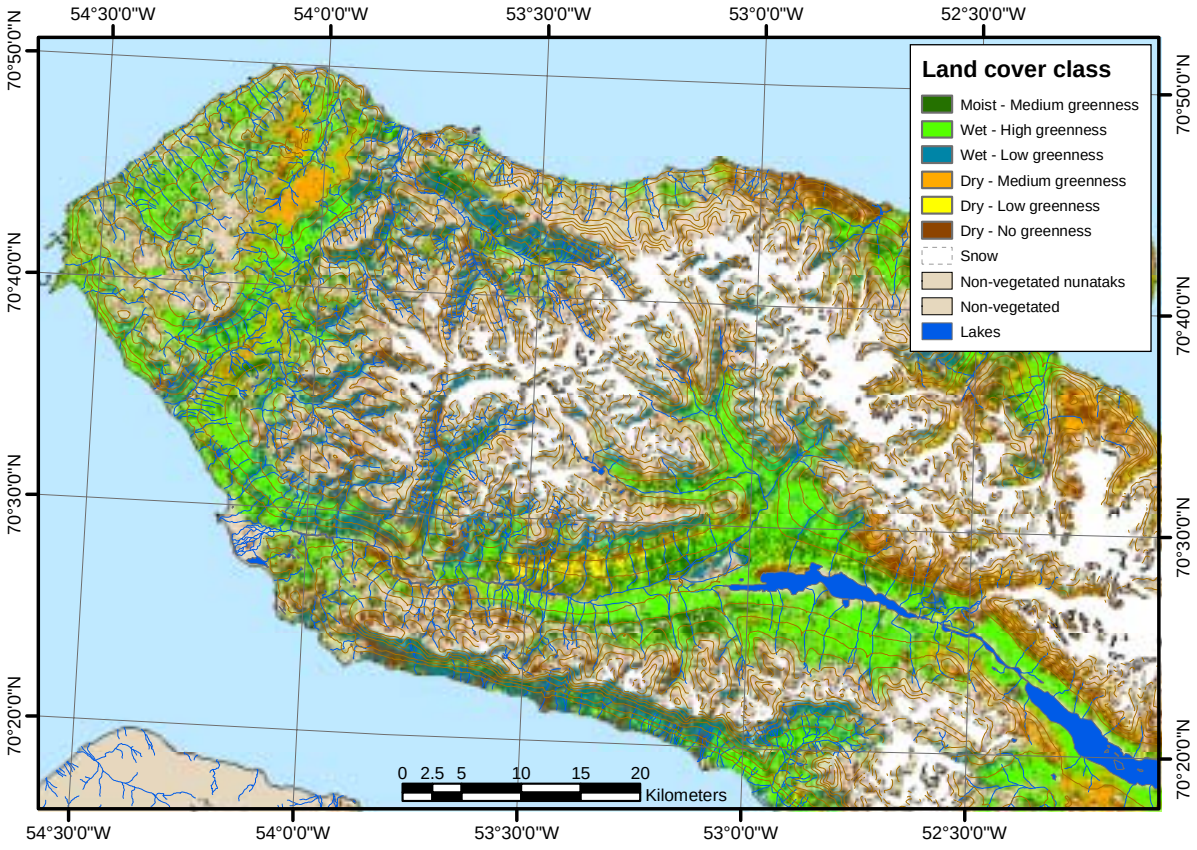

Figure 8. Land cover map for Nuussuaq based on Landsat-7 ETM+ imagery from 12 July 2001.Vegetation is divided in five groups likely representing the following vegetation types: Moist - Medium greenness: Dwarf shrub heath with varying species. Wet - High greenness: Grassland and fens in the coastal areas and luxurious dwarf shrub heath and fens in the inland. Wet - Low greenness: Snow and river bed vegetation. Dry - Medium greenness: Dry grasslands, steppe or fell fields. Dry - Low greenness: Fell fields. Dry - No greenness: Abrasion plateau and gravel plains with extremely sparse vegetation. In addition, non-vegetated areas are classified in ice-surrounded areas (nunataks) and other areas (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

The land cover in the coastal part of the Aaffarsuaq Valley and inland Aaffarsuaq Valley is shown in Figure 9 and 10, respectively. The brown class is the relative large homogenous gravel plains. They may have some vegetation limited to a few scattered species. The light brown group covers the remainder of the non-vegetated areas apart from snow and water. This group is typical boulder and rocky outcrops that may have a cover of lichens but also areas with frequent erosion from flooding (in the delta) or avalanches or areas subjected to very late or perennial snow cover, especially at higher elevations.

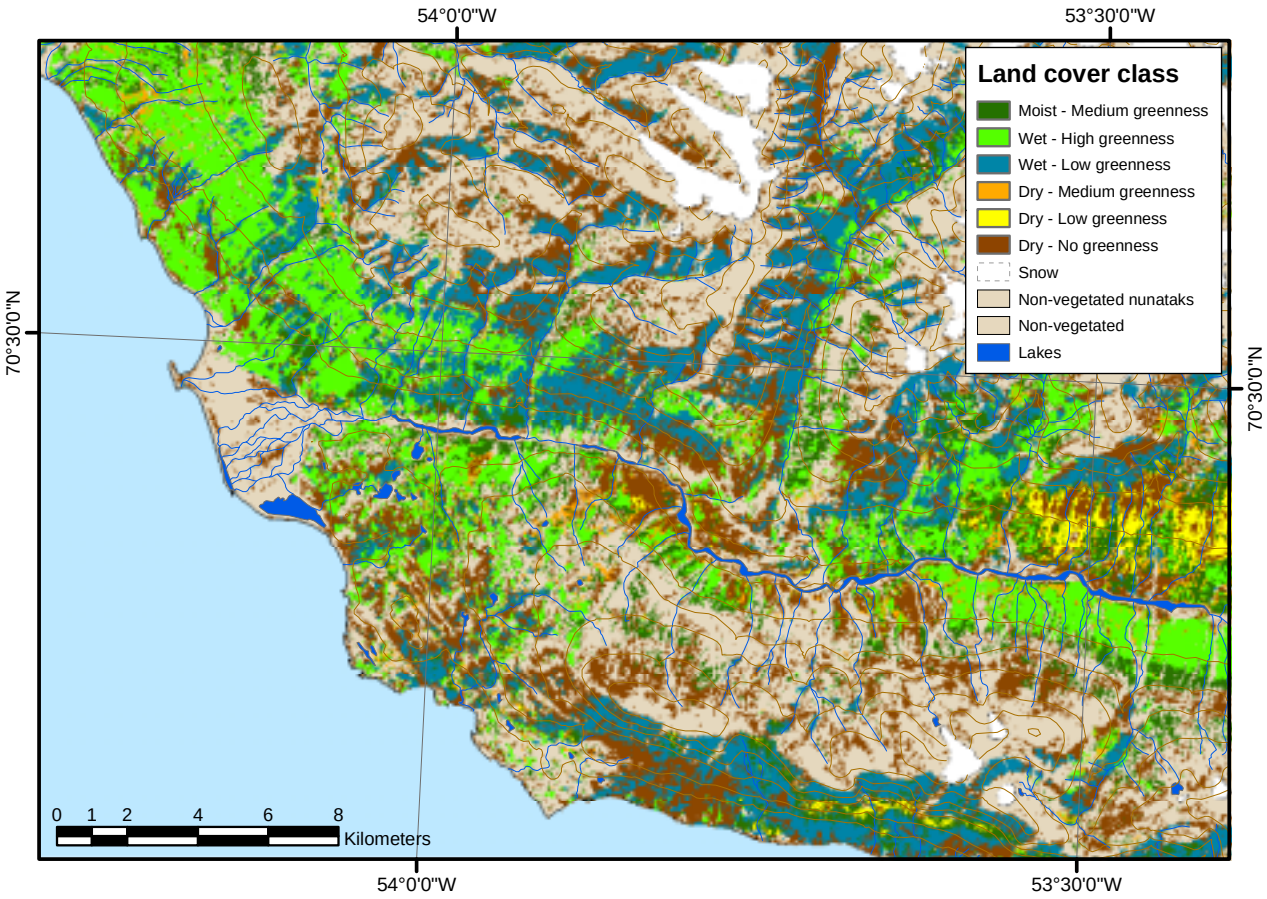

Figure 9. Land cover map for western part of Aaffarsuaq Valley on Nuussuaq based on Landsat-7 ETM+ imagery from 12 July 2001.Vegetation is divided in five groups likely representing the following vegetation types: Moist - Medium greenness: Dwarf shrub heath with varying species. Wet - High greenness: Grassland and fens in the coastal areas and luxurious dwarf shrub heath and fens in the inland. Wet - Low greenness: Snow and river bed vegetation. Dry - Medium greenness: Dry grasslands, steppe or fell fields. Dry - Low greenness: Fell fields. Dry - No greenness: Abrasion plateau and gravel plains with extremely sparse vegetation. In addition non-vegetated areas are classified in ice-surrounded areas (nunataks) and other areas (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

The land cover map is draped on a digital terrain model in Figure 11 to give another perspective of the location of the land cover classes in the Aaffarsuaq Valley. The extensive grasslands or luxuriant dwarf shrub heath at the valley floor extending a little up the slopes is very dominant on the south side of the river while the north side shows a more diverse pattern.

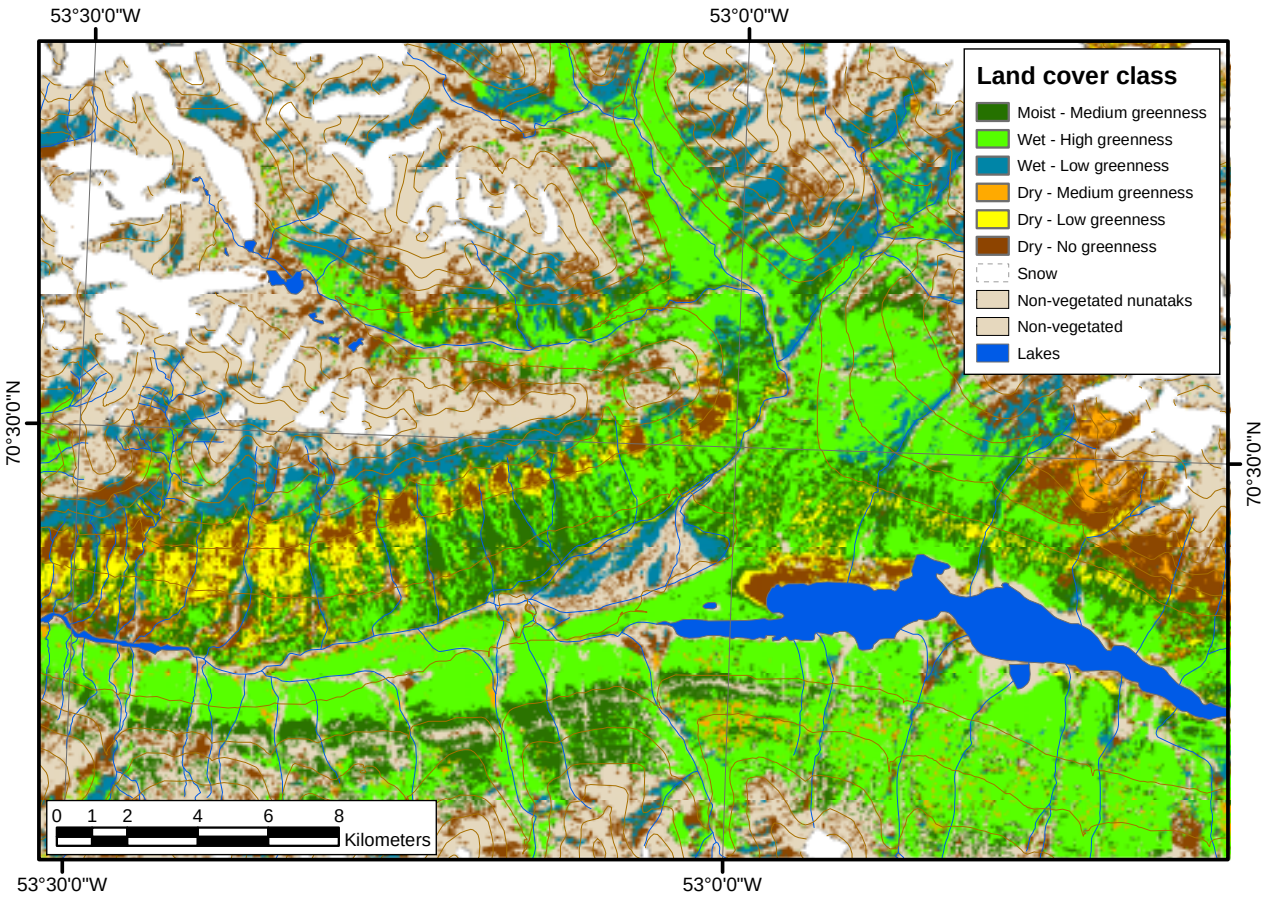

Figure 10. Land cover map for eastern part of Aaffarsuaq Valley on Nuussuaq based on Landsat-7 ETM+ imagery from 12 July 2001.Vegetation is divided in five groups likely representing the following vegetation types: Moist - Medium greenness: Dwarf shrub heath with varying species. Wet - High greenness: Grassland and fens in the coastal areas and luxurious dwarf shrub heath and fens in the inland. Wet - Low greenness: Snow and river bed vegetation. Dry - Medium greenness: Dry grasslands, steppe or fell fields. Dry - Low greenness: Fell fields. Dry - No greenness: Abrasion plateau and gravel plains with extremely sparse vegetation.In addition, non-vegetated areas are classified in ice-surrounded areas (nunataks) and other areas (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

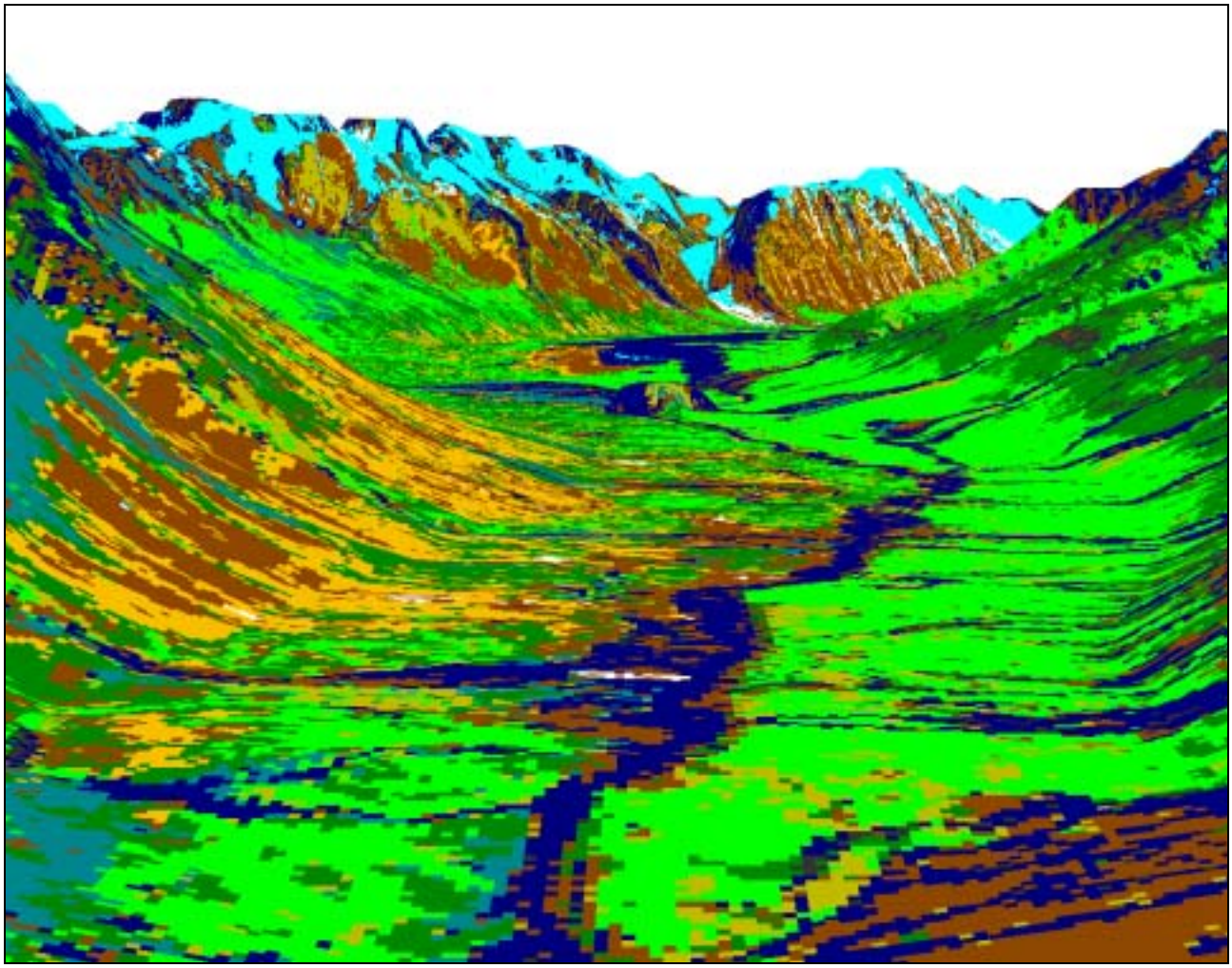

Figure 11. The land cover classification draped on the digital terrain model for Nuussuaq. View is from approx. 53º30' W; 70º25' N looking towards east through the Aaffarsuaq Valley with a vertical exaggeration of 3 and pixel size of 30 m. Please see Figure 7 for legend (light blue: snow cover). Notice the large grassland / rich dwarf shrub heath areas on the south side of the river (right in the image).

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4 Survey of Arctic char (*Salvelinus alpinus*) rivers on northwest Disko

Anders Mosbech and Helene Nyegaard
National Environmental Research Institute

4.1 Introduction

In 2002 an interview study concerning the fish resources in the shallow waters of West Greenland was carried out (Olsvig & Mosbech 2003). This survey also included rivers with a population of anadromous Arctic char ('char river'). To supplement and verify these results, a survey of char rivers on north-west Disko Island was carried out in September 2003. This area is relatively isolated, and thus the local knowledge about the actual occurrence of char from the interviews may not be fully adequate. The results of the interview study in 2002 concerning char on north-west Disko was summarised on maps, which are included here for western Disko Island (Figures 12, 13).

If rivers shall support a spawning population of anadromous char some important features must be at hand: waterfalls or other obstacles must not prevent the char from migrating up the river to the spawning areas; there must be suitable spawning areas with a substrate of gravel or pebbles and with sufficient current throughout the winter to provide oxygen to the fertilised eggs; deep pools, which do not freeze to the bottom and have a continuous water flow, must be present. Arctic char spend the winter in such pools.

4.2 Methods

The survey was performed by walking along the rivers, observing and fishing for char in suitable pools. Arctic char were caught with fishing rod and in one case with electro-fishing equipment (Figure 16).

Five rivers were surveyed, including one that was classified as a char spawning river by the locals. It was the plan to survey more rivers, e.g. Kuuganguaq, which is also classified as a char-spawning river, but due to strong winds this was not possible. River locations are shown in Figure 1.

4.3 Results

4.3.1 Enoks Elv, Ivisaaqut Kuuat

Position of river mouth: 69°04' N, 54°08' W.
Date: 10 September, 2003.
Water temperature: 3.5° C, 11:10 hrs. – 3-400 m from river mouth.

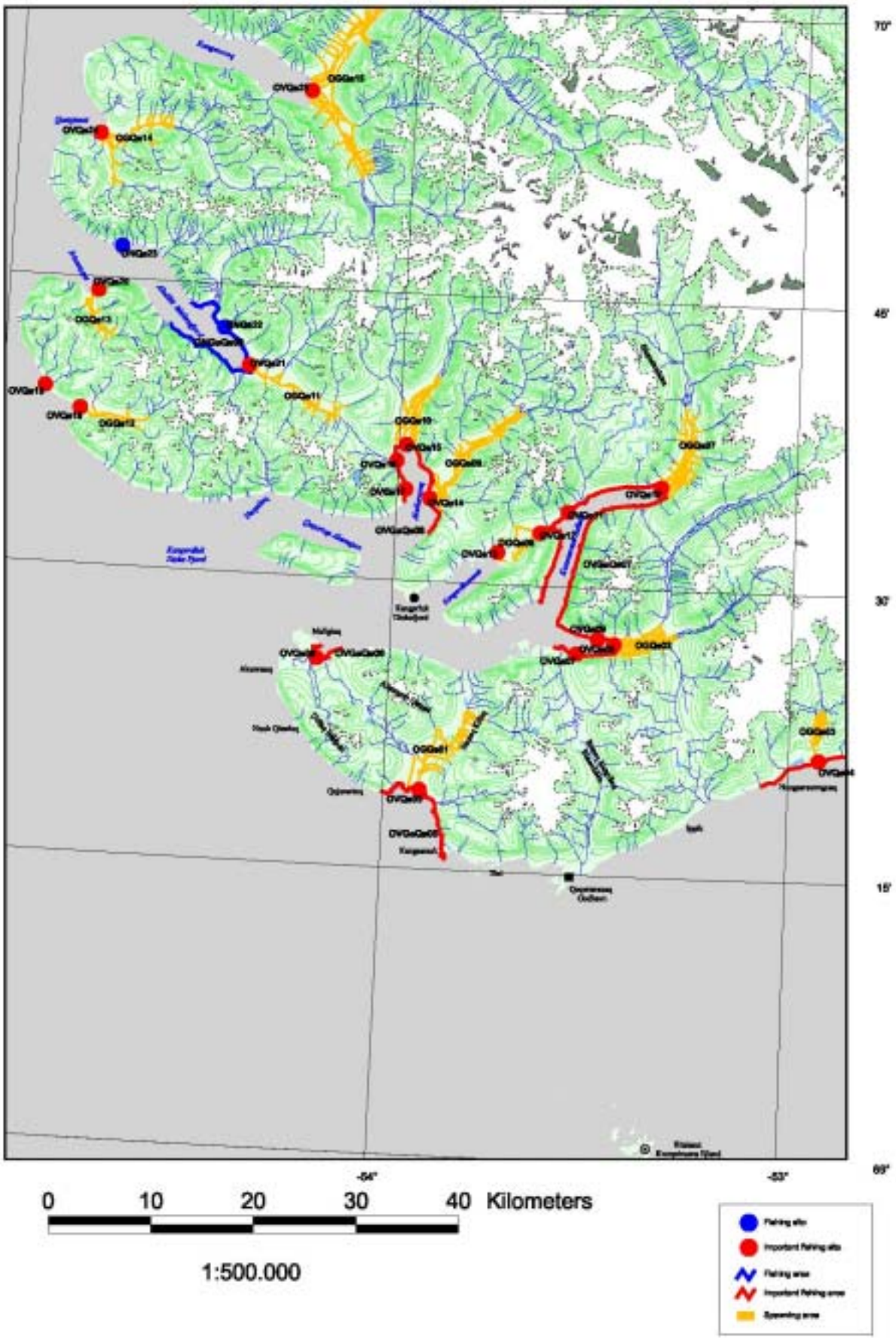

Figure 12. Fishing and spawning areas for Arctic char in southern and western Disko, based on local information obtained in 2002 (figure from Olsvig & Mosbech 2003).

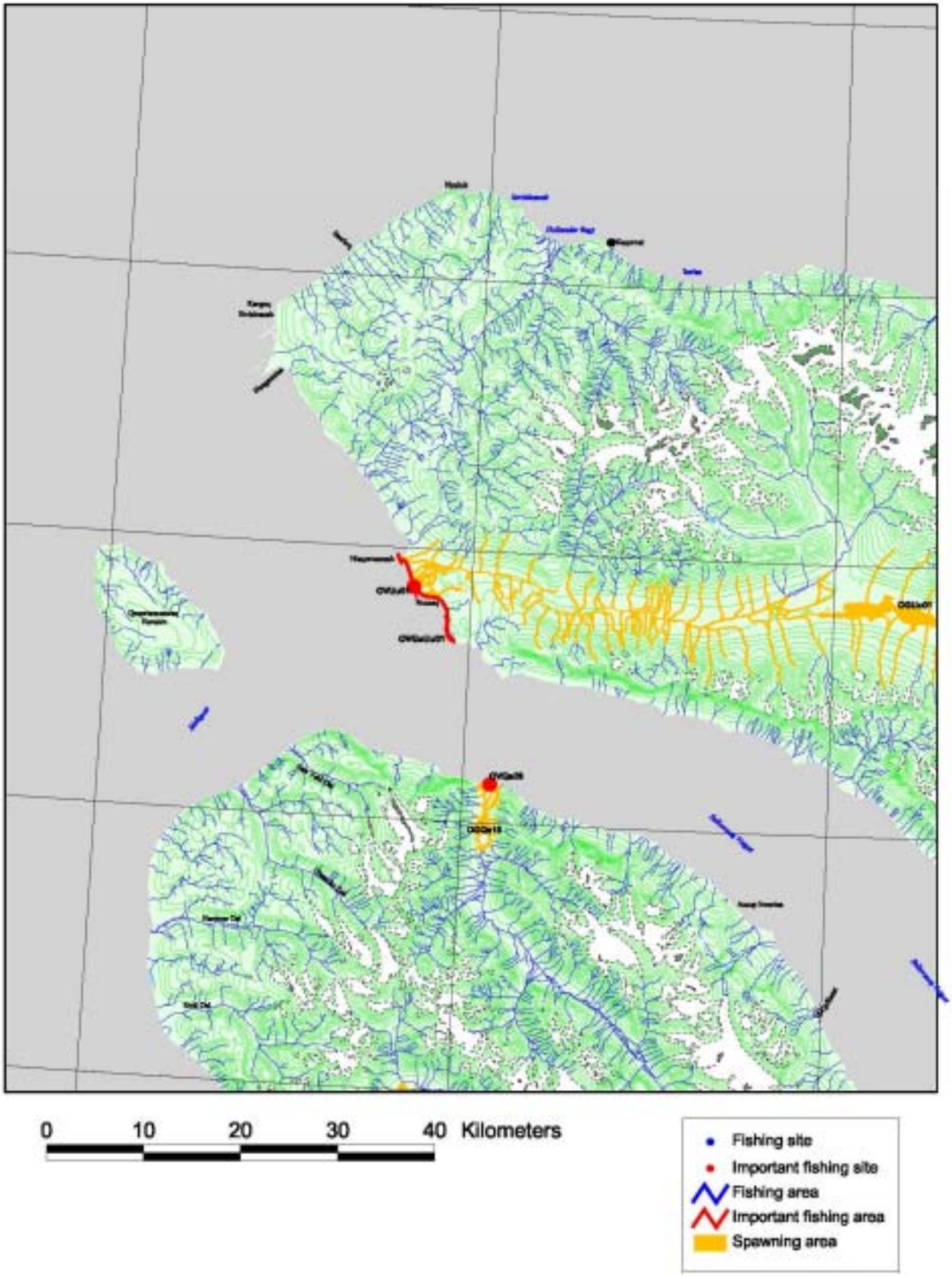

Figure 13. Fishing and spawning areas for Arctic char in northwest Disko and western Nuussuaq, based on local information obtained in 2002 (figure from Olsvig & Mosbech 2003).

Description of the river

Part 1, the river mouth

Enoks Elv estuary heads in a 3-5 m wide, 0.5-2 m deep channel. The outermost part flows over a sandbank, which has a depth of less than 0.5 m. The river is bounded by mountain slopes to the east and sandbanks on the west. There is a 50-60 m long pool, flooded with salt water at extreme flood tide, just inside the river mouth.

Part 2, 0-1,000 m upstream

This portion of the river does not differ noticeably from the first part. The speed of the current was estimated to be low. The bottom material consists of rocks / stones and in the presence of rapids also of gravel / sand and pebbles.

Part 3, 1,000-3,000 m upstream

The river changes and is bounded to east by low (5 m) hills instead of mountainsides. The river is steeper and alternates between rapids, no less than 0.5 m in depth, and deeper pools (0.5-2 m). From the topographical map it can be interpreted that the uppermost reaches of the river begins c. 10 km from the river mouth at an altitude of 400 m.

Occurrence of char

Fry

The first fry was observed in running water 7-800 m up the river. The size of fry varied with the features of the river. Small fry (<5 cm) were observed everywhere, while larger fry (5-15 cm) were observed in pools with a minimum depth of 0.2-0.4 m.

Figure 14. Ten of the 18 char that were caught and measured in Enoks Elv. The char in the middle of the left row shows old wounds from gill nets. From top left it is fish ID M1, F6, F7, F8 and F9; from top right it is fish ID F1, F2, F3, F4 and F5; cf. Table 3.

Adults

21 adult, anadromous char in spawning attires were caught at 11 hrs and 02 hrs in the first large pool (Figure 14). The adult fish were 20-50 cm and except for two fish at 20 cm, all were 34 cm or more in length (Table 3). All fish longer than 34 cm were females with roe, except for one male with milk and clearly active testicles. No ecto- or endoparasites were observed, and all fish had a clear layer of mucus. Many more fish were observed. In the smaller pools further up in part 3, one adult female was caught. It did not differ from the females described above.

Table 3. Length and sex of 18 Arctic char caught in Enoks Elv. M = male, F = female.

ID and sex	Length (cm)	ID and sex	Length (cm)
M	35	F9	40
F1	48	F10	43
F2	46	F11	44
F3	42	F12	50
F4	43	F13	40
F5	43	F14	41
F6	40	F15	40
F7	49	F16	41
F8	44	F17	38

Conclusion

There was a healthy population of anadromous char in Enoks Elv. This is consistent with information from the interview study, where the river was classified as a spawning river with important fishing areas along the adjacent coasts (Figure 12).

4.3.2 Iterlassuup Kuussua

Position of river mouth: 69°08' N, 54°05' W.
Date: 9 September, 2003.
Water temperature: 6° C, 15:00 hrs – western waterway.

Description of the river

Part 1, the river delta

The river ends in several smaller streams with a bottom material consisting of small rocks and gravel / sand. All these streams end in a wide tidal flat (Figure 15), which is flooded with salt water at high tide.

Figure 15. Left: The delta at the Iterlassuup Kuussua. The area is flooded with salt water at high tide. Right: Part 2 of the river, 500-4,000 m from the river mouth. The western waterway is closest, and furthest away the eastern waterway which has much less water.

Part 2, 500-4,000 m

The river separates in two parts, an eastern and a western waterway (Figures 15, 16). The eastern waterway carry less water, which is clear with sandy bottom. This waterway consists of many flat rapids and pools with a maximum depth of 0.5 m. The western waterway has turbid water with a visibility of 30-40 cm, and there are large rocks on the bottom. The river runs in a wide valley (300 m across) bounded by mountains (up to 1,000 m) on both sides. From these several tributaries join the river in the valley. The topographical map indicates that the river has its origin from a lake 700 m above sea level c. 13 km from the river mouth.

Occurrence of char

Several sticklebacks (*Gasterosteus aculeatus*) and stickleback fry were observed in part 1 of the river, but there were no char or fry. In part 2 some char fry were observed (<13 cm) and one of these was caught with the electro-fishing equipment (Figure 16). It had clear parr-marks, which means that it had not yet smoltified, in preparation to enter salt water. If it is an anadromous char, judging by its size, it would not smoltify until next year.

Figure 16. Top left: Main waterway of Iterlassuup Kuussua 3 km from the river mouth. Bottom left: Char fry caught with electro-fishing equipment. Right: Electro-fishing equipment, which attract and immobilise fish without harming them.

Conclusion

There is a population of char in this river, but we cannot say for certain whether it is anadromous or land-locked char. If present, the population of anadromous char is small. The river was not classified as a spawning river during the interview study. The coast of the inner

Mellemfjord, and thus also the bay with this river, was classified as a gill net fishing area for char. These char, however, may come from the river in the head of the fjord, which was classified as a spawning river (Figure 12).

4.3.3 Rink Dal River, Inussuup Kuua

Position of river mouth: 70°02' N, 54°47' W.
Date: 17 September, 2003.
Water temperature: Ice on quiet pools.

Description of the river
Part 1, the river mouth
The river has a large, deep estuary, which is possible to enter with a dinghy (Figure 17). Above the mouth, the river narrows into a main waterway with several smaller streams. The main waterway has a maximum depth of 30-40 cm without any deeper pools and is 1-4 m wide. The bottom material consists of sand and gravel, while the water is clear and the current rapid.

Part 2, 1,000-3,000 m
About 1,000 m upriver, all streams are gathered into one 2-10 m wide waterway that runs between two cliffs (25 m apart). The water is clear and fast flowing. The following 2 km the river alternates between several flat rapids and shallow pools, where the current still runs with high speed (Figure 17). The river is never deeper than 30-50 cm for rapids and 60-70 cm in pools.

Figure 17. Rink Dal River. Left: Part 1, the river mouth. Right: Part 2 of the river.

The uppermost position taken was 70°03' N, 54°43' W, which is 2.65 km from the river mouth. Further upstream the river looks similar to part 2 until c. 7 km from the river mouth. Over the next 8 km to the source 1,400 m above sea level the river is very steep.

Occurrence of char
No char or any other fish were observed, although the river was clear with a good overview.

Conclusion
There are probably no anadromous char in Rink Dal River, since there are no suitable pools, where the char can overwinter.

The river was not classified as an Arctic char spawning river during the interview study, nor was the adjacent coast mentioned as a gill net fishing area for char.

4.3.4 Hammer Dal River

Position of river mouth: 70°01' N, 54°08' W.
Date: 17 September, 2003.
Water temperature: 3.6° C at 6 hrs.

Description of the river
Part 1, the river mouth
The river has a large, deep (50-70 m) estuary, which is easily accessible by dinghy. Just inside the mouth there is a large pool, which is flooded with salt water during extreme high tide. The river narrows following the pool and continues in a single waterway, 30-40 cm deep and 1-4 m wide. There are no pools in the river, and the current is high speed. The bottom material consists of rocks and gravel and the water is clear.

Part 2, 500-2,500 m
The river runs in a single 2-10 m wide waterway between two cliffs. It flows over several flat rapids and shallow pools, not deeper than 30-50 cm and where the current is still strong. This continues for a distance for c. 8 km from the river mouth. Further on the river rises ever more steeply over the next 8 km to the source 1,200 m above sea level - as judged from the topographical map.

Occurrence of char
No char or any other fish were observed in part one, and a single stickleback was observed in part 2.

Conclusion
There are most likely no anadromous char in the river, since there are no suitable pools, where the char can overwinter.

In agreement with this, the river was not classified as a char-spawning river during the interview study, nor was the adjacent coast mentioned as a gill fishing area for Arctic char.

4.3.5 Jens Vahl Dal River, Napassulissuup Kuua

Position of river mouth: 70°03' N, 54°05' W.
Date: 20 September, 2003.
Water temperature: 0-1° C at 7 hrs.

Description of the river
The river runs in a single 25 m wide waterway. The bottom material consists of rocks, and the measured current was 1.2 m/s. The river runs steeply for the first kilometre with a maximum depth of 0.5 m and without deep pools. From the topographical map it can be observed that the river has its origin about 10 km distant from the river mouth. There are no lakes along the river.

Occurrence of char
No char or any other fish were observed in the river.

Conclusion
There are most likely no anadromous char in the river, since there are no suitable pools, where the char can overwinter.

In agreement with this, the river was not classified as a spawning river to char during the interview study nor was the adjacent coast mentioned as an area of gill fishing for char.

4.4 Conclusions

The survey of Arctic char rivers on Disko Island confirmed that Enoks Elv was a char-spawning river and that it had a healthy population of spawning char. This population possibly contributes to the gill net fishery along the coast near the mouth of the river. Local fishermen classified this coast as an important fishing area (Olsvig & Mosbech 2003) (Figure 12).

Furthermore it was found that three rivers on the north-western part of Disko, Jens Vahl Dal river, Hammer Dal river and Rink Dal river, did not hold spawning anadromous Arctic char. This is consistent with the results of the interview study. The local fishermen did not indicate that these rivers were spawning grounds or that the adjacent coasts were gill net fishing areas for Arctic char. In a river on the north coast of Mellemfjord, Iterlassup Kuususua, char fry was observed. But whether these represented anadromous or land-locked char was not ascertained. This river was not classified as a spawning river during the interview study.

The three rivers without char on the northwest coast of Disko were all very steep and there were no lakes to supply oxygen rich water throughout the winter. These rivers apparently have a high spring and summer flow but almost no or low flow during winter. It is therefore concluded that these rivers are not suitable as spawning rivers for anadromous Arctic char.

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5 Satellite tracking of eiders (*Somateria spp.*)

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National Environmental Research Institute and
Annette Flagstad, Royal Veterinary and Agriculture University, Denmark.

5.1 Introduction

The project financed by the Bureau of Minerals and Petroleum (BMP) became a part of an extensive study, which have the purpose to create the necessary knowledge for sustainable management of the common eider and the king eider populations in West Greenland by

- identifying the key areas and
- linking breeding, moulting and wintering areas.

Because the knowledge on habitat use and movements of the common eider in the area was limited, the BMP-financed project addressed home range and habitat selection of this species, which is numerous along the coasts of Disko (see below).

5.1.1 Background

King eider (*Somateria spectabilis*)
West Greenland is an important moulting, staging and wintering area for king eiders. Most of these breed in northeastern Canada and some in northwestern Greenland, while king eiders do not breed in West Greenland.

The number of king eiders that moult in western Greenland has declined during the last 50 years. Based on aerial surveys of post-breeding king eiders in 1993-1995 it was estimated that 30-40,000 birds moult in western Greenland, which is a considerably decline compared to estimates of 200,000 from the 1950's (Mosbech & Boertmann 1999). Ground surveys of breeding king eiders in Rasmussens Lowlands, eastern Canadian Arctic, revealed an 86% decrease in king eider abundance from 1976 to 1994-1995 (Gratto-Travor et al. 1998).

Surveys in Southwest Greenland suggest that about 300,000 king eiders were wintering in open water areas in the 1990's (Mosbech & Johnson 1999). This is however a very rough estimate, and we do not yet know if there is a general and significant trend in the number of king eiders in the wintering area. The movements of the birds within the wintering area is one among others issues where knowledge is lacking.

The waters along the west coast of Disko are the most important moulting area to king eiders in West Greenland (Mosbech & Boertmann 1999). In July-September the area holds mainly moulting birds and in October/November and May there are many staging birds.

Common eider (*Somateria mollissima*)
Every winter about 460,000 common eiders stay in the sea along the coast of Southwest Greenland (Merkel et al. 2002, Boertmann et al. in print). Only a few thousand birds remain and breed in that region, while the majority move to Canada (80-90 %) or northward to Northwest Greenland to breed. Southwest Greenland is an internationally important wintering site for common eiders, and also to many other seabird populations (Boertmann et al. in print).

During the past 3 years Greenland Institute of Natural Resources (GINR) has studied the breeding population of common eiders in West Greenland. In a report from GINR from 2001 it was estimated that the total number of breeding pairs in West Greenland now is only 12,000-15,000 (Merkel 2002). Based on trade book keeping it was estimated that 150 years ago down from around 110,000 nests was collected in West Greenland. A comparison between the 2002 estimate of breeding numbers and surveys of common eider colonies about 40 years ago reveals that the numbers of common eider has declined dramatically since then. It was for example estimated that the breeding population in the municipalities of Ilulissat, Uummannaq and Upernavik has decreased by about 80 % compared with historical records (Merkel 2002).

The main causes for this heavy reduction appears to be excessive non-sustainable exploitation of the population. This exploitation is especially hunting during late winter and spring and to some extent illegal egg collection and illegal hunting during the breeding season.

The coastal waters along western Disko and the tip of Nuussuaq Peninsula are important to common eiders: mainly in the autumn and spring when numerous birds stage there. In summer a few pairs breed at the coasts of Disko and moreover there are some colonies in the archipelagos off the tip of Nuussuaq (Boertmann et al. 1996, Merkel 2002).

5.2 Methods

Birds were caught one at a time while escape diving. Specially designed floating nets were set from boats during sailing (>10 knots) in front of a diving bird and in the anticipated diving direction. The nets had very little weight at the bottom so a bird caught in the net could surface and breathe. The birds were immediately freed from the net and put in a transport and holding box of plywood or cardboard. The nets were designed by Ebbe Bøgebjerg, NERI, for black scooters (pers. comm.) and used with a few modifications for eiders in Greenland. The nets were modified from floating Daconet® monofil cod nets 3.3 meters deep, 41 meters long, equipped with floats and a light lead line and had a mesh size of 55 mm.

Birds were kept in plywood or cardboard boxes fitted with absorbing nappies prior to and after surgery.

Prior to surgery bird were ringed, weighed and measured. Measurements followed Gilchrist (2003).

The satellite transmitters (PTT's - Platform Transmitter Terminals) were Microwaves pressure proof implantable PTT-100 weighing approximately 50 g. The PTT's have battery for approximately 700 transmission hours. To get as detailed information as possible some PTT's were programmed with fast duty cycles giving detailed information on local movements. Others were programmed with slow duty cycles, which should allow them to give information for the following year.

Ten of the 23 PTT's were a modified version fitted with pressure transducers developed in co-operation with Microwave.

All PTT's were sterilised in 70 % medical alcohol (12 hours) and fitted with a mesh (vicryl XX, Johnson and Johnson). On 20 of the PTT's the mesh were glued (Histoacryl®) to the PTT, while the mesh was sewed around 3 of the PTT's because we ran out of glue. Finally a 1/1 dacron cuff was attached just proximate to the transmitter body and fixed with a 5-10 mm piece of heat shrink attached to the antenna.

The PTT's were then implanted into the body cavity by surgery of the birds. Operations were performed in a tent heated by a kerosene oven (outdoor temperature -2 to 10° C, tent temp. 10-25° C). Birds were anaesthetised with Isoflourane (Scheering Ploug) (induction: 3-4 % in 2,000 ml O_2/min., maintenance 2-4 % in 1,500 ml O_2/min.) in a modified Bains System. Electrocardiogram (ECG) was employed to monitor heart rate and excitability used for regulation of anaesthesia. The body core temperature was measured through an anal probe and used for regulating the birds heat loss. An electric heating pad was placed under the bird and an infrared heating lamp placed above the bird.

The implantation of the PTT was performed according to Korschgen et al. (1996) with few modifications:

- Prior to anaesthesia neutral liniment (80 % Vaseline, 20 % paraffin oil) was used to prevent corneal drying.
- Feather removal was avoided in the abdominal incision site (linea alba; abdomen midline)
- The PTT was sewed to the coelomic cavity using 2-3 interrupted knots to a vicryl mesh glued by histoacryl to the PTT.
- At the antenna exit a hemostase was used to penetrate the subcutis, peritoneal muscle layer, and peritoneum and the antenna was pulled through the skin until cuff was fixed tight to the peritoneum.

- The PTT cuff was fixed tightly to peritoneum with a single interrupted knot. Thereby only the antenna (heatshrink coated) was permeating the skin.
- The antenna exit was placed as cranial and dorsal to the Os ischium as possible.
- Enrofloxacine (Baytril®; 0.3 ml i.m.) was used as the only antibiotic.

Birds were released close to the capture site 2-16 hours after surgery.

5.3 Results

5.3.1 Implantations

Seven common eiders and 16 king eiders had PTT's implanted in September 2003 (Table 4). All 23 implantations were completed successfully and birds were released 2-16 hours after surgery. All released birds swimmed, dived or flew immediately after the release.

5.3.2 Satellite tracking preliminary results

Data from the implanted PTT's is coming in continuously via ARGOS and displayed on the NERI website with an automatic mapping system. Updated results from the satellite tracking can be seen at:

http:\\eider_tracking.dmu.dk.

Examples from the website of the eider movements up to 12 December are given below.

Table 4. Overview of the 23 satellite implanted birds and their PTT's.

Species	Sex	PTT 2003 ID	PTT Duty cycle, hrs	PTT type	Capture site	Ring no.	Surgery	Release	Depth PTT start
ke	m	e6932	4 on, 30 off		NF	3077654	13/9/03 1:15	13/9/03 8:15	
ce	m	e23167	4 on, 60 off	40 m-depth	NF	3077658	13/09/2003 17:49	14/09/2003 7:00	13/09/2003 18:08
ke	f	e23170	6 on, 122 off		NF	3077657	13/09/2003 16:45	14/09/2003 7:00	
ce	m	e23171	4 on, 60 off	40 m-depth	MF	3077647	09/09/2003 0:50	09/09/2003 8:30	09/09/2003 1:15
ke	f	e23323	6 on, 122 off		NF	3077655	13/09/2003 18:55	14/09/2003 7:00	
ce	m	e30057	4 on, 30 off		NF	3077649	12/09/2003 15:00	12/09/2003 19:00	
ke	f	e41179	6 on, 60 off	40 m-depth	MF	3077642	06/09/2003 21:40	07/09/2003 6:30	06/09/2003 22:07
ke	m	e41180	6 on, 60 off	40 m-depth	MF	3077645	07/09/2003 11:54	07/09/2003 15:00	07/09/2003 12:14
ke	m	e41181	6 on, 60 off	40 m-depth	NF	3077648	12/09/2003 12:40	12/09/2003 19:00	12/09/2003 13:00
ke	m	e41182	6 on, 60 off	40 m-depth	NF	3077650	12/09/2003 16:15	12/09/2003 19:00	12/09/2003 15:50
ke	m	e41183	6 on, 60 off	40 m-depth	MF	3077646	07/09/2003 20:00	08/09/2003 0:30	07/09/2003 20:29
ke	f	e41184	6 on, 60 off	40 m-depth	MF	3077641	06/09/2003 9:44	06/09/2003 13:00	06/09/2003 10:12
ce	m	e41185	6 on, 60 off	20 m-depth	MF	3077640	05/09/2003 13:00	05/09/2003 16:30	05/09/2003 13:44
ce	m	e41186	6 on, 60 off	20 m-depth	MF	3077644	07/09/2003 0:58	07/09/2003 6:30	07/09/2003 0:41
ke	m	e41187	4 on, 30 off		NF	3077653	12/09/2003 23:30	13/09/2003 8:15	
ce	m	e41188	4 on, 30 off		MF	3077643	06/09/2003 23:00	07/09/2003 6:30	
ke	m	e41189	4 on, 30 off		NF	3077660	14/09/2003 17:00	14/09/2003 22:30	
ke	m	e41190	4 on, 30 off		NF	3088049	16/09/2003 11:30	16/09/2003 15:00	
ke	m	e41191	4 on, 60 off		NF	3077663	14/09/2003 22:30	15/09/2003 2:30	
ke	m	e41193	4 on, 60 off		NF	3088050	15/09/2003 12:15	15/09/2003 20:00	
ce	m	e41194	4 on, 60 off		NF	3077661	14/09/2003 15:00	14/09/2003 22:30	
ke	f	e41195	6 on, 122 off		NF	3077651	12/09/2003 17:35	12/09/2003 21:30	
ke	f	e41196	6 on, 122 off		NF	3077652	12/09/2003 21:14	13/09/2003 8:15	

ke: king eider, ce: common eider, m: male, f: female, NF: Nordfjord, MF: Mellemfjord.

Looking at the common eider tracking results an interesting picture emerges where the birds are very stationary within a small home range for several weeks and then move on to a new area and stay for some weeks again.

Looking at the king eider tracking results it appears that king eiders are more stationary within the moulting areas. And it is obvious that the northern part of Store Hellefiskebanke is a very important staging area after completion of wing moult at western Disko. Based on these results a ship based eider survey was conducted at Store Hellefiske-banke in November 2003 (NERI unpubl.). The survey was conducted from the fishery inspection vessel Agdleq, and several thousand king eiders were located there.

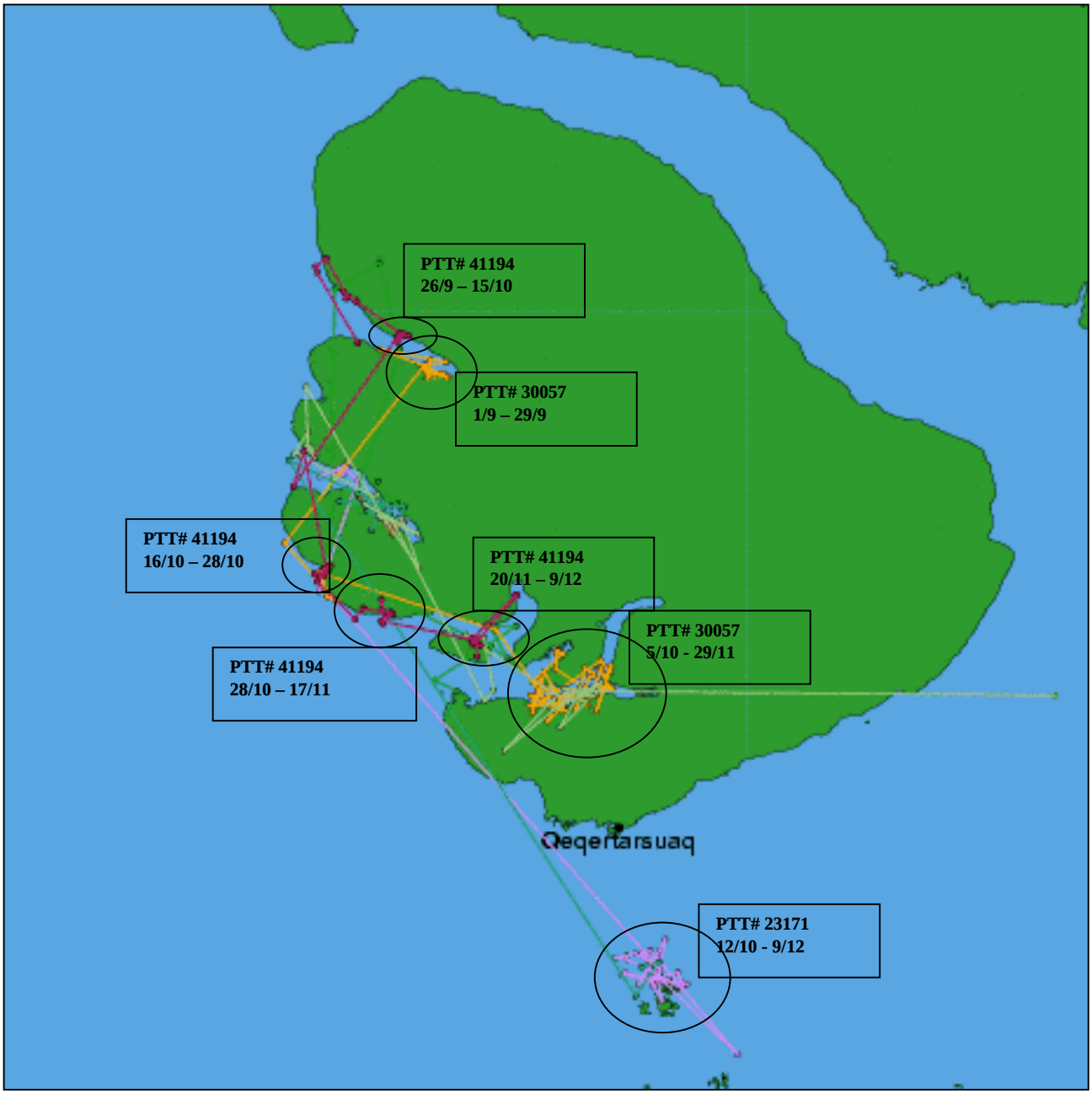

Figure 18. Satellite tracking of 7 common eiders at Disko Island, Greenland. The map shows tracking (standard locations) in the period from 7/9 to 9/12 2003. At which time all the PTT's were still active. 3 PTT's (# 23171; #30057; #41194) are shown with date marks, indicating periods when the birds staged within the circle for a longer period of time.

Figure 19. Satellite tracking of a common eider (PTT# 30057) at Disko Island, Greenland. The map shows tracking (standard locations) in the period from 12/9 to 9/12 2003. At deadline of the present report, the PTT was still active.

Figure 20. Satellite tracking of a common eider (PTT# 41194) at Disko Island, Greenland. The map shows tracking (standard locations) in the period from 14/9 to 9/12 2003. At deadline of the present report, the PTT was still active.

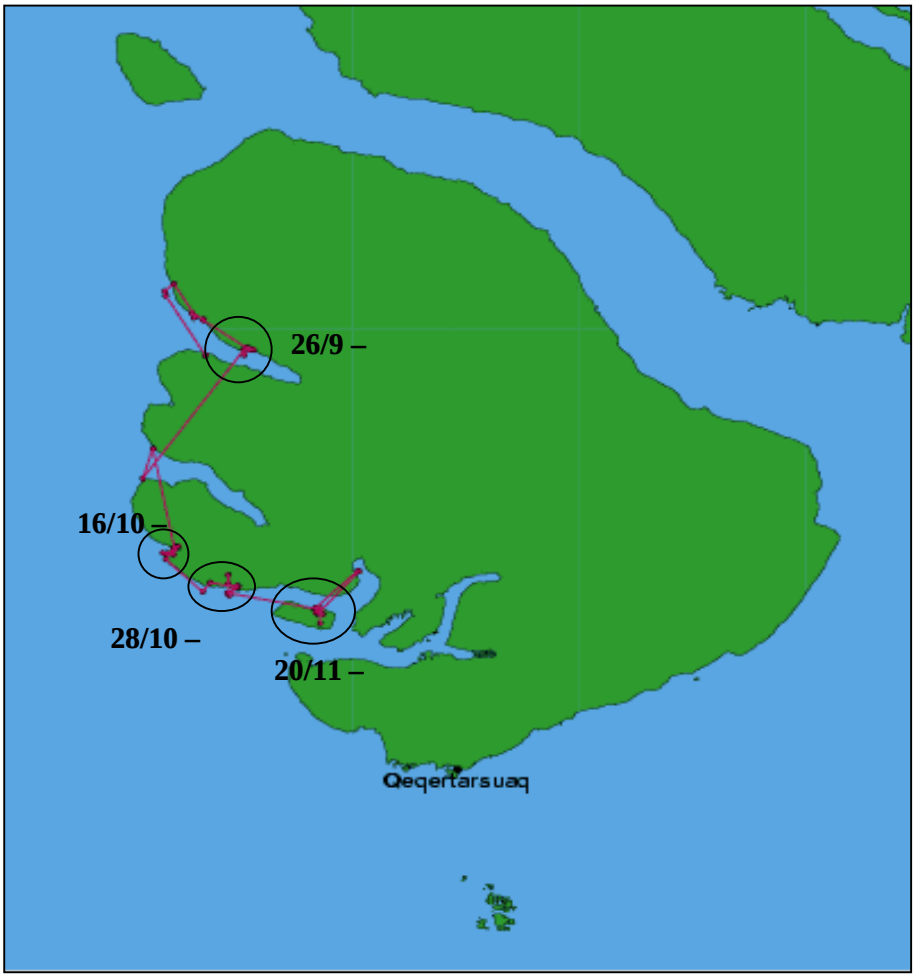

Figure 21. Satellite tracking of a common eider (PTT# 23171) at Disko Island, Greenland. The map shows tracking (standard locations) in the period from 9/9 to 9/12 2003. At deadline of the present report, the PTT was still active.

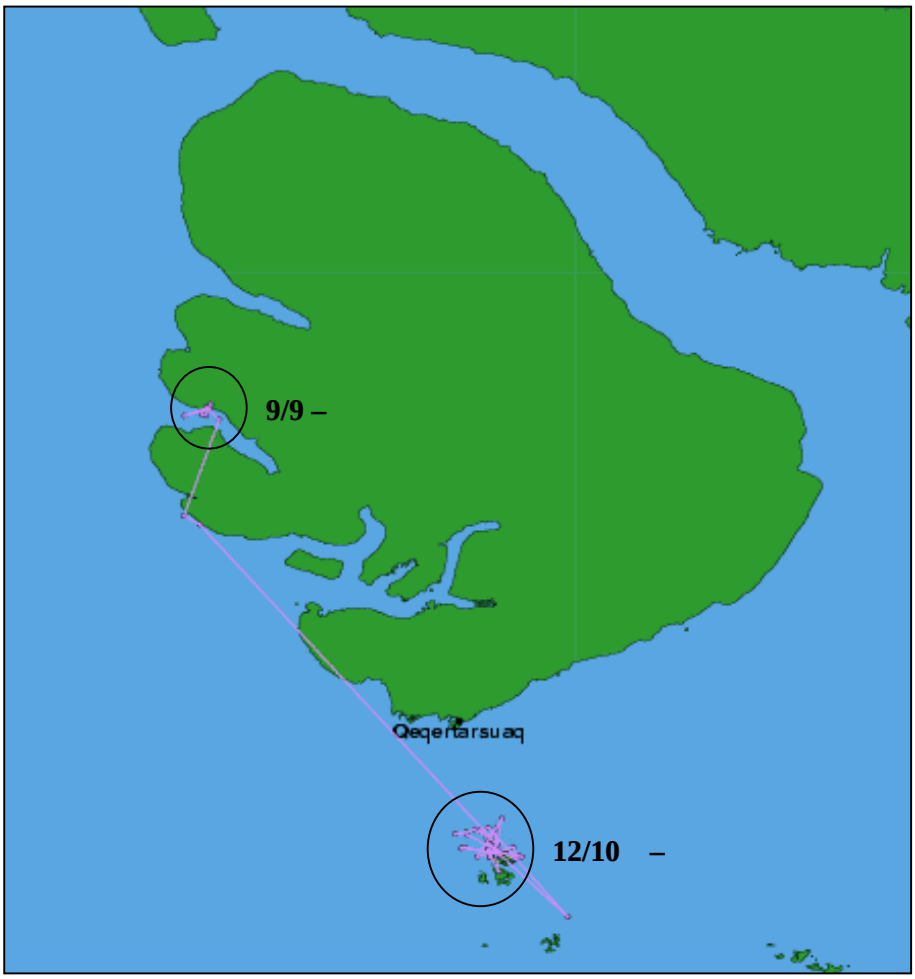

Figure 22. Tracking of 16 king eiders which had satellite transmitters implanted at Disko Island. The map shows tracking (standard locations) in the period from 7/9 to 9/12 2003. At which time the PTT's were still active.

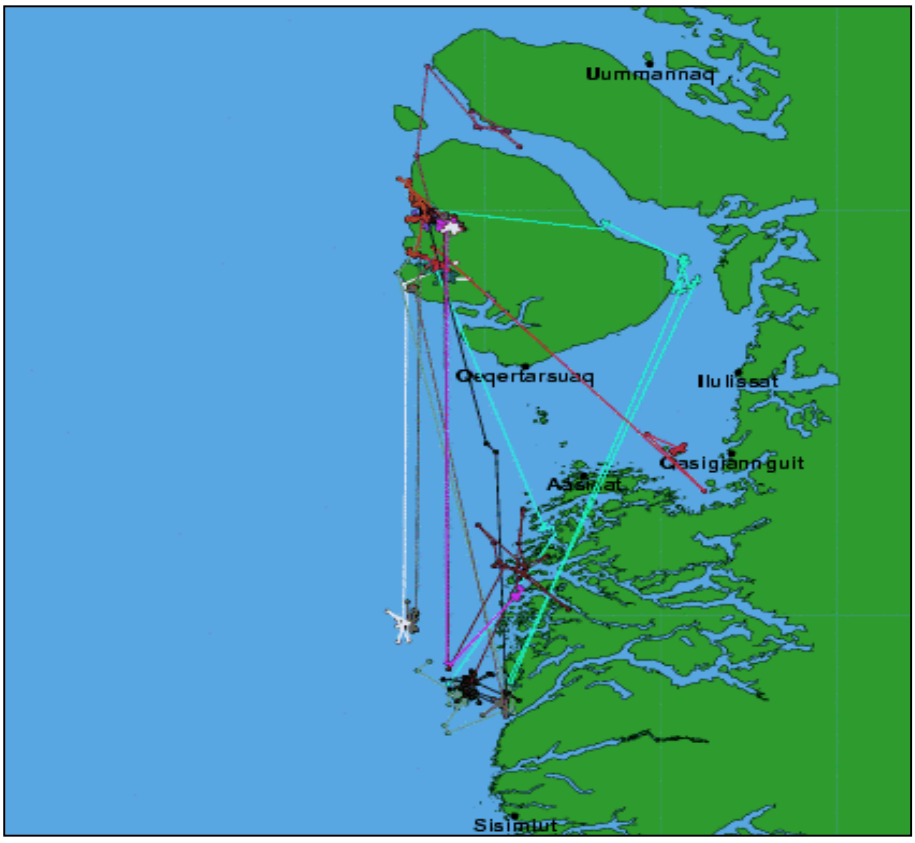

Figure 23. Satellite tracking of 16 king eiders at Disko, Greenland. The map shows tracking (standard locations) in the period from 7/9 to 10/10 2003 at which time the PTT's were still active. Soon hereafter most of the birds initiated their migration southward to Store Hellefiskebanke, see next figure (24).

Figure 24. Satellite tracking (standard locations) of 10 king eiders. The map shows birds staging off the mouth of the fjord Afersiorfik and an offshore bank (Store Hellefiskebanke), in the period from 12/10 to 12/12 2003 at which time the PTT's were still active.

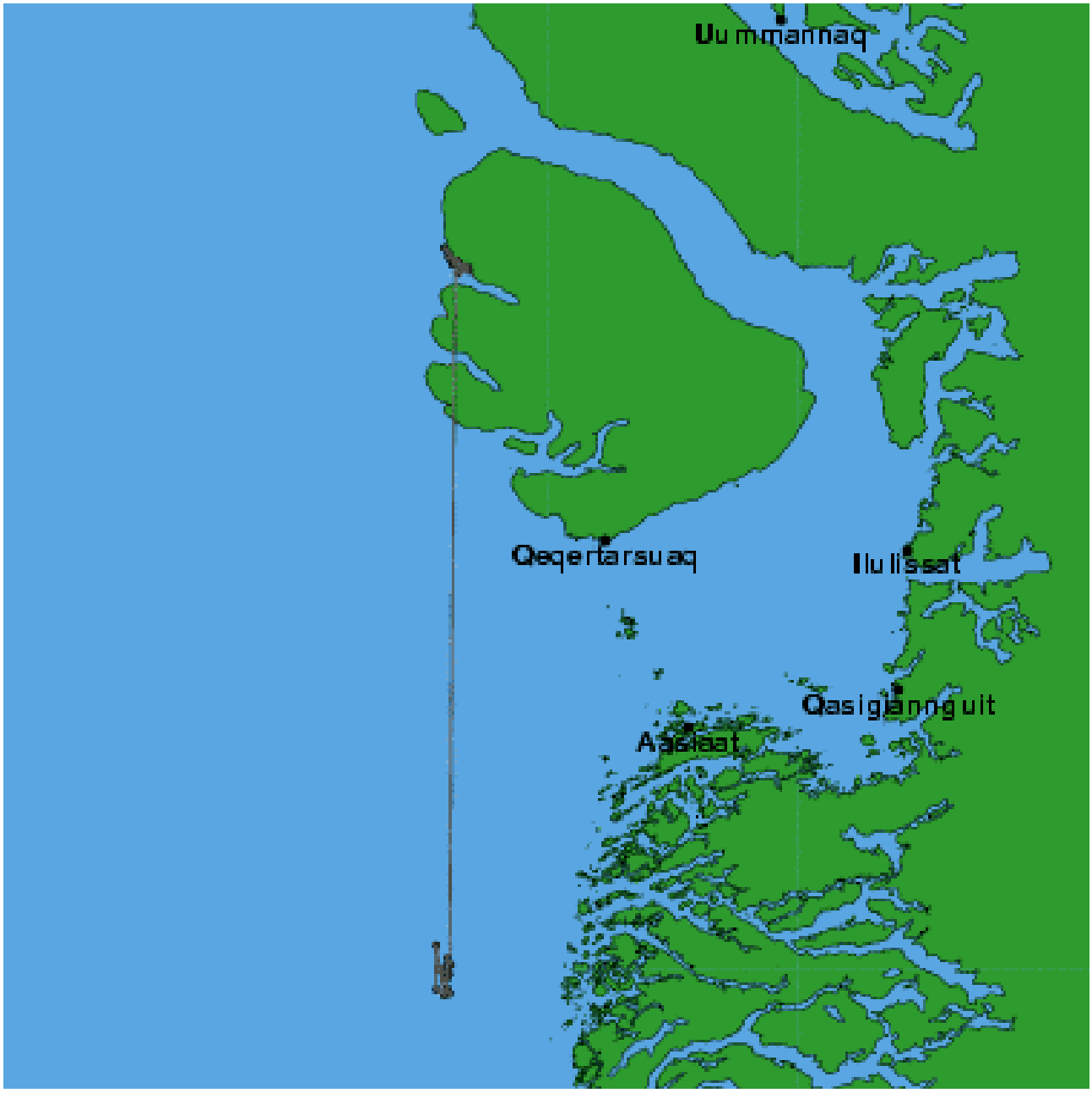

Figure 25. Satellite tracking of a king eider (PTT# 23323) from Disko Island. The map shows tracking (standard locations) in the period from 7/9 to 12/12 2003. The bird was staging within a relatively small range at Nordfjord, Disko, until 30 October. Hereafter it flew to an offshore bank (Store Hellefiskebanke), where it was located from 2 November until 12 December when the map was produced - at which time the PTT's were still active.

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6 Caribou (*Rangifer tarandus*) in Nuussuaq

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6.1 Introduction

Today both caribou and reindeer inhabit the Nuussuaq Peninsula, however, this was not always the case. Prior to 1968 only native wild caribou (*Rangifer tarandus groenlandicus*) were present. In 1968 only 15 to 25 individuals were presumed remaining of the wild population (Meldgaard 1986), therefore 10 semi-domestic reindeer (*Rangifer tarandus tarandus*) were introduced to the peninsula. These animals originated from Godthåbsfjord's Itivnera / Kapisillit reindeer herding district, which was established in 1952 with a shipment of reindeer from northern Norway. The 10 semi-domestic reindeer were released into the eastern portion of the Nuussuaq Peninsula in the vicinity of the large lake, Boyes Sø (Figure 26). They were never intended for animal husbandry, but were to become feral and secure the region's hunters a meat resource for future harvests. This appears a success. Meanwhile, wild native caribou number seems to have recovered somewhat. These two sub-species of *Rangifer* now share the Nuussuaq Peninsula. There is some suggestion of spatial segregation.

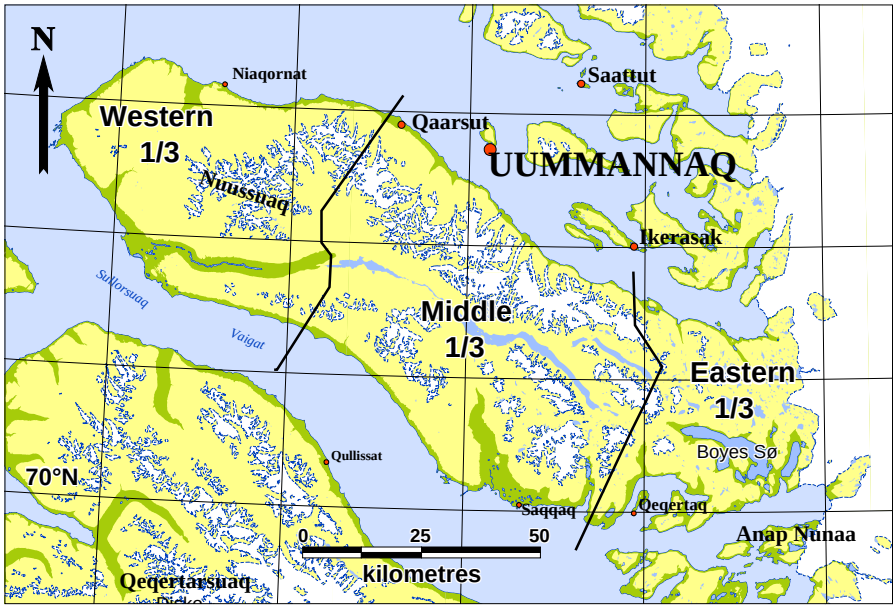

Figure 26. Nuussuaq Peninsula (70° - 71° N) divided into rough thirds: Western, Middle and Eastern.

There are no caribou on Disko today. The original population disappeared around 1900, and introduced caribou have not succeeded in re-establishing the population (Meldgaard 1986).

6.2 Population status

From a presumed 15 to 25 wild caribou and 10 semi-domestic reindeer in 1968, 27 years later, an aerial survey in 1995 registered 161 animals, which included 18 calves, i.e., age < 1 year. This resulted in a population estimate of approximately 400 animals. This estimate remained until 2002, when a snowmobile ground survey of the peninsula was done to obtain a minimum count.

The ground survey in late April 2002 observed a minimum count of 1,164 individuals. A population estimate was statistically impossible from this data. The total included 324 calves, for a calf percentage of 27.8 %. Since these calves were almost 1-year of age, at which time their mortality rate becomes similar to mature animals, this was an excellent recruitment rate for an ungulate population.

Body condition in April 2002 was subjectively ascertained as prime. All animals appeared round and fat at a time of year when some individuals in other populations of *Rangifer* may clearly show backbone and ribs. Almost without exception, females possessed relatively well-developed antlers, which were without any shreds of velvet remaining. All of the above and the high recruitment rate indicate a healthy population capable of increasing in number.

6.3 Late winter distribution

The peninsula roughly follows an east-west orientation. In late April 2002 caribou and reindeer were observed over the entire peninsula, however, the western 1/3 was scarcely used (Table 5). The greatest concentrations were in the middle and specifically the eastern third of the peninsula. Snow in the middle third was often a deep (60 to 90 cm) loose powder, with no ground layer of ice. The situation was similar in the eastern third, except snow conditions also included extremely windblown areas of either stone-hard snow or rocky expanses blown bare of snow. In both the middle and eastern thirds, valley bottoms were the primary habitat, followed by valley slopes or elevated plateaus. A few animals were observed at high elevations. South facing slopes and plains were conspicuous for their high utilisation by caribou/reindeer. The high preference for south facing ground was likely related to the thinner snow layer and relatively large amounts of bare ground, which were present on areas with a southerly aspect. Obtaining food from these locations would require a minimum of energy expenditure. Whether the vegetation at these locations differed from others, e.g., north-facing slopes, is currently unknown, but differences are suspected. Macro-lichens preferred by caribou /reindeer (*Cladina spp., Cetraria spp.*) were present and being grazed.

Table 5. Caribou / reindeer density on the Nuussuaq Peninsula based on ground survey minimum counts of late April 2002.

Area	Survey area km²	Number observed	Average group size ± SD	Density /km²
Western 1 / 3	• 390	4	1 to 3	• 0.01
Middle 1 / 3	• 726	449	8 ± 8	• 0.6
Eastern 1 / 3	• 420	711	40 ± 64	• 1.8
Total	• 1,506	1,164	-	• 0.8[2]

Although caribou / reindeer concentration in the middle and eastern portions of the Nuussuaq Peninsula may be the typical late winter distribution, it is also possible that 2002 was an exception. In the western 1 / 3 a ground ice layer occurred, and this was overlaid by 70 cm of hard packed snow. The thick ground layer of ice was caused by an unusual and heavy December 2001 rainstorm, which was followed by below freezing temperatures for the rest of the winter. The ground ice ended abruptly at the western most edge of the middle 1 / 3. Given the ground ice layer and deep hard snow covering the western 1 / 3 of the peninsula in April 2002, it was not surprising to find so few animals present, since obtaining food would have been serious work for the caribou / reindeer.

6.4 Segregation of caribou and feral reindeer

Subjective consideration of the animals observed in April 2002 suggests that the two sub-species have remained relatively segregated since introduction of the reindeer in 1968. Behaviour and morphology characteristic to semi-domestic reindeers are most typical among the animals inhabiting the most easterly 1 / 3 of the peninsula, e.g.:

1) Unusually large calf size, i.e., close to adult size. This suggests calves are born in May, which is typical of semi-domestic reindeer, rather than June, which is typical for the native caribou. An extra month allows for greater growth during their first summer, range conditions permitting.
2) Antlered females included adults and calves, and antlers were unusually large and well developed on both. Female calves of native caribou generally never possess antlers.
3) Pelt coloration was generally a dark brown, although pale grey / white is typical for native caribou in late winter.
4) Aggregation was prevalent among the animals in the eastern third of the peninsula. Group size averaged 40 ± 64. The three largest aggregations observed were 63, 206 and 213 animals respectively. These large groups moved and behaved as cohesive "herd" units. In contrast, aggregation is not typical for native wild West Greenland caribou where average group size may be 3 to 6 animals, regardless of density or population size.

By comparison, animals in the middle third of the peninsula were similar in appearance and behaviour to other native wild caribou in West Greenland, e.g., calves were noticeably smaller in size than adults, few adult females possessed antlers and no female calves did,

fur coloration was always pale grey/white and group size averaged 8 ± 8 SD.

If these behavioural and morphological differences truly reflect sub-species segregation, then in April 2002 a minimum of 449 native wild caribou inhabited the middle portion of the Nuussuaq Peninsula, while a minimum of 711 feral reindeer lived in the eastern portion in close proximity to the Ice Cap (Table 5). The suggested spatial segregation of the two sub-species is interesting from a behavioural perspective, since it may be voluntary. In future, however, if both populations continue to increase in abundance, then a greater frequency of genetic mixing may be expected.

6.5 Location of important winter and calving areas

Caribou and feral reindeer distribution and resource use outside of the late winter period investigated are unknown. Although information specific for Nuussuaq Peninsula is not available, educated guesses may be made based on information obtained from two other caribou populations in West Greenland, i.e., the Kangerlussuaq-Sisimiut and Akia-Maniitsoq. Satellite tracking investigations revealed that for these two populations important winter areas typically were at elevations below 300 metres, while calving occurred at elevations above 300 metres and often in close proximity to the Ice Cap. Until now the feral reindeer of Nuussuaq Peninsula appear to have restricted themselves to the eastern 1/3, if true then their critical calving area(s) are also likely within the eastern 1/3, above 300 m and near the Ice Cap. The middle 1/3 of Nuussuaq Peninsula is characterised by enormous elevation changes, and glaciers cover much of the region's high elevations. Female caribou inhabiting the middle 1/3 likely move up the mountains, the preferred calving locations being elevations above 300 m and near glaciers.

Peak calving typically occurs in May for reindeer, and June for caribou. Human activity or disturbance within critical calving areas in the month preceding, during or immediately following calving can be detrimental to calf survival.

During a helicopter survey in June 1996 for a drill site for an oil exploration well in Nuussuaq, 9 caribou were observed in the upper and central part of the Aaffarsuaq Valley, the westernmost at 15 km from the river mouth (Boertmann unpubl.). The survey covered the entire Aaffarsuaq Valley and Agat Dal.

During the goose surveys in mid-July 2003, not a single caribou was observed in the goose counting areas (Figure 2) on Nuussuaq Peninsula. Fresh tracks were however observed throughout the lowlands.

7 Conclusions

The goose survey showed that the previously known important breeding and moulting habitats are still used extensively by the Greenland white-fronted geese and Canada geese. The relative abundance of these two species, however, have changed; now the Canada goose is the most numerous. This gives reason for concern about the population of Greenland white-fronted goose. Studies, which can elucidate the mechanisms working between the two species, are needed, e.g. for obtaining the relevant data to manage the populations. In an oil exploration / goose protection context it will be important to localise and protect habitats where the Greenland white-fronted goose thrive.

The vegetation studies have identified areas where the vegetation is dense and more or less moist. These are also the habitats most vulnerable to the driving with heavy equipment for oil exploration activities during the snow free periods. However, we still lack a proper ground truthing of the satellite data, i.e. field identification of which plant communities are represented by the different classes on the maps.

The survey for Arctic char spawning rivers confirmed the local information, which NERI previously obtained during interviews with local fishermen and hunters.

The eider studies are still ongoing and the satellite transmitters implanted in the birds will hopefully send positions during much of 2004. The results presented in this report are therefore preliminary and not complete. The full data set will be analysed and subsequently presented later as a scientific paper.

The caribou survey in 2002, showed that the majority of the population inhabit the eastern portion of the Nuussuaq Peninsula. Few were observed in the western third, which is the area of interest for oil exploration. This distribution pattern, however, may be the result of unfavourable conditions in the winter of 2001 / 2002, which may have been unique in the westernmost parts of the peninsula. Further seasonal changes in caribou distribution, e.g. when they are more dispersed, are unknown. Similarly no information exists on critical concentration areas such as calving grounds.

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