

**A review of muskox observations from  
North and Northeast Greenland**



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Greenland Environmental Research Institute  
Tagensvej 135, 4.  
DK-2200 Copenhagen N  
Denmark  
Tlf.: +45 35 82 14 15 Fax: +45 35 82 14 20

# **A review of muskox observations from North and Northeast Greenland**

by

David Boertmann and Mads Forchhammer

## Reference

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## 1. SUMMARIES

### 1.1 English summary

This report presents a review of observations of muskoxen over the recent three decades in North and Northeast Greenland and an estimate of the size of the population. In total the population is estimated at 9500-12500 muskoxen. The largest numbers are found in Jameson Land, and c. 83 % of the population is found south of 75° N (Ardencable Fjord). In general, muskoxen now occur very dispersed north of 75°, following a serious decline in the region between 75° and 78° N probably in the early 1980s.

Fig. 8 shows the distribution and numbers of the muskoxen in 1991.

### 1.2 Dansk resumé

Fra moskusoksens naturlige udbredelsesområde i Nord og Nordøst Grønland foreligger der observationer af moskusokser af tre typer. 1/ Flybaserede mere eller mindre systematiske optællinger, 2/ optællinger foretaget af slædepatruljen Sirius samt 3/ mere eller mindre tilfældige optællinger foretaget af forskellige typer ekspeditioner til området.

De flybaserede optællinger dækker: Jameson Land med årlige optællinger i perioden 1982-1989 udført af Grønlands Miljøundersøgelser (GM), Nordgrønland i 1985 også udført af GM samt området mellem Kong Oscar Fjord og Skærfjorden i 1988 udført under Hjemmestyrets kortlægningsprojekt.

Slædepatruljen Sirius patruljerer i det meste af moskusoksens udbredelsesområde om efteråret og foråret. Slædeholdene skal notere alle moskusokser på deres vej, og observationerne fra 1961-1990 er blevet frigivet for nylig. Slædeholdene kører fortrinsvis langs kysterne og i de større dale.

De mere tilfældige optællinger stammer fra biologiske, arkæologiske og i særlig grad fra geologiske (Grønlands Geologiske Undersøgelse) ekspeditioner til Nord og Nordøst Grønland. Observationerne er generelt foretaget om sommeren. De ældste observationer er fra 1968.

Fig. 1 viser moskusoksens udbredelsesområde opdelt i en række regioner (romertal), og disse er igen opdelt i en række områder (bogstav-betegnelse efter romertallet). Fig. 2-7 viser regionerne med det højeste antal okser, der er observeret på de enkelte lokaliteter eller strækninger af Sirius (kort til venstre) og de øvrige ekspeditioner (kort til højre). Tallene på disse kort stammer fra en lang periode (1961-1990), og de kan ikke umiddelbart lægges sammen til totaltal for de enkelte områder. For de to nordlige regioner X og XI er der kun kort med Sirius-observationer, idet der foreligger meget få observationer siden de kort som er publiceret af Dietz & Andersen (1984) og Aastrup et al. (1986).

Tabel 1 viser bestandsestimater for de enkelte områder, baseret på de observationstal som der foreligger. Fig. 8 viser det samme grafisk.

Fig. 9 viser områder, hvor der gentagne gange er set mange okser på begrænsede lokaliteter om vinteren.

Den samlede bestand i Nord og Nordøst Grønland anslås til 9500-12500 i 1990, med ca 83 % af bestanden forekommende syd for Ardencable Fjord.

Dette tal er naturligvis behæftet med stor usikkerhed og må betragtes som et minimum. For visse regioner og områder er bestandstallet nok ganske rimeligt, nemlig der hvor der er foretaget flybaserede optællinger suppleret med optællinger foretaget fra jorden. Dette gælder Jameson Land (II g), Nordgrønland mellem Nyeboe Land og Independence Fjord (regionerne X og XI) og området mellem Ardencable Fjord og Skærfjorden (regionerne VI, VII og delvis VIII).

De anslåede bestandsstørrelser fra den vestlige del af region II og fra region IX er derimod usikre, fordi der kun foreligger meget gamle observationer eller der har været meget lille og geografisk begrænset aktivitet i områderne.

Det skal nævnes at bestanden i Nordøst Grønland siden begyndelsen af 1980'erne har været i tilbagegang. Undtaget er dog Jameson Land. Tilbagegangen har været meget drastisk i regionerne VI og VII. Dette er nærmere beskrevet i en anden artikel (Forchhammer & Boertmann in prep.).

### 1.3 Kalaallisut eqikkaarnera

Avannaarsuani Tunullu avannaani umimmaqarfinni umimmannik misissuisarnerit pingasunut immikkoortinneqarsinnaapput. 1/ Timmisartumik aaqqissuullugaanerusumik aaqqissuullugaannginnerusumilluunniit kisitsisarnerit, 2/ kisitsinerit qimussimik alapernaarsuisunik Sirius-imit ingerlanneqarsimasut kiisalu 3/ annertunerusumik annikinnerusumilluunniit nalaatsornerinnaanikkut kisitsinerit tamaani ilisimasassarsiorlutik angalasunit assigiinngitsunit ingerlanneqartarsimasut.

Timmisartumit kisitsisarnerit tassaapput: Jameson Landimi Kalaallit Nunaanni Avatangiisinut Misissuisoqarfimmit (GM) ukiumoortumik kisitsisarnerit ukiut 1982-1989 akornanni ingerlanneqarsimasut, Avannaarsuani 1985-mi GM-imit aamma ingerlanneqarsimasut kiisalu 1988-mi Kong Oscar Fjord-ip Skærfjord-illu akornanni Namminersornerullutik Oqartussat nuna assiliortitsineranut atatillugu kisitsinerit ingerlanneqarsimasut.

Qimussimik alapernaarsuisut Sirius ukiakkut upernaakkullu umimmaqarfiusup annertunersaani angalasarput. Qimussimik alapernaarsuisut angalanerminni umimmaat takusatik tamaasa allattortartussaavaat, ukiullu 1961-1990-illu akornanni takunnitarsimanerinek nalunaarsuinerit qanittukkut tamanut ammarneqarsimapput. Qimussimik alapersuisut sineriak qooqqullu annertunerit atuarlugit angalanerusarput.

Kisitsisarnerit nalaatsornerinnaanerit uumasunik misissuilluni, attackusiorluni ingammillu ujarassiorluni (Kalaallit Nunaanni Ujarassiortut Misissuisoqarfiat) Avannaarsuani Tunullu avannaani ilisimasassarsiorluninngaaneersuupput. Misissuinerit ataatsimut isigalugit aasaanerani pisarsimapput. Misissuinerillu pisoqaanerit 1968-meerput.



Fig. 1-mi umimmaqarfiit nunanut immikkoortunut (ruumamiut kisitsisaat) arlalinnut agguarneqarnerat takutinneqarpoq, taakkulu suli arlalinnut agguarneqarsimapput (ruumamiut kisitsisaasa kingornanni naqinneq). Fig. 2-7-mi umimmaqarfiunerpaat Siriusip piffinni ataasiakkaani imaluunniit ingerlavigisimasaani takunniffiusimasut takutinneqarput (nunap assinga saamerleq) ilisimasassarsiornernilu allani takunniffiusimasut (nunap assinga talerperleq). Nuna assingini taakkunani kisitsisit ukiuni arlalippassuarni misisuinernik tunngaveqarput (1961-1990) imaaliinnarlugillu piffiit ataasiakkaat ataatsimut katinnerannut ilanngunneqarsinnaanatik. Piffiit avannarpasinnerusut X aamma XI taamaallat Siriusip alapermaarsuinera kisiat tunngavigalugu nuna assiliaapput, tassa nuna assingi taakku Dietz & Andersen (1984) aamma Aastrup et al. (1986)-mit saqqummersinneqarnerisa kingorna misissuisarsimanerit ikittuararsuunerat pissutigalugu.

Tabel 1-imi piffinni ataasiakkaani umimmaat amerlassusaat missingersorneqarsimapput, taakkunanilu misissuisarnerni kisitsisit tunngavigineqarsimallutik. Fig. 8-mi assingi titartarlugit takutinneqarsimapput.

Fig. 9-mi nunani immikkoortuni piffiit aalajangersimasut ukiuunerani umimmappasuaqarfiusartut takutinneqarsimapput.

Avannaarsuani Tunullu avannaatungaani 1990-mi umimmaat 9500-12500-nik amerlassuseqartutut missingersorneqarsimapput, taakkulu 83 %-ti Ardencable Fjord-ip kujataatungaaniipput.

Kisitsilli taanna soorunami qularnartorujussuartut oqaatigisariaqarpoq minnerpaatullu isigisariaqarluni. Nunat immikkoortut piffiillu ilaat eqqarsaatigalugit amerlassusaat tutsuviginartutut oqaatigineqarsinnaagaluarpoq, tassa timmisartumiit nunamingaaniillu kisitsiffiusimasut eqqarsaatigalugit. Taakku tassaapput Jameson Land (II g), Avannaarsuanilu Nyeboe Land-ip Independence Fjord-illu akornanni (nunat immikkoortut X aamma XI) nunalu Ardencable Fjord-ip Skærfjord-illu akornanniittooq (nunat immikkoortut VI, VII ilaatigullu VIII).

Immikkoortut II-p IX-illu kitaatungaani amerlassusaannik missingersuusiat akerlianik qularnartutut isigisariaqarput, tassa tamaani misissuisarnerit qangarnisaavallaarnerat imaluunniit misissuiffiusimanngingajanneri tikinneqajuitsuunerilu pissutaallutik.

Oqaatigisariaqarpoq Tunup avannaani umimmaat 1980-kut aallartinnerisa kingorna ikileriarsimammata, Jameson Landi eqqaassanngikkaanni. Ikileriarnarat nunani immikkoortuni VI-mi VII-milu annertoorujussuusimavoq. Tamannalu nalunaarusiami allami (Forchhammer & Boertmann in prep.) saqqummersussami allaaserineqarsimavoq.

## 2. PREFACE

This report is in fact the basis of a work published earlier (Boertmann et al. 1992). It gives, however, much more details which may be a useful tool in future management of the muskoxen in North and Northeast Greenland. Recently, one of the authors (DB) became employed at the Greenland Environmental Research Institute (GERI), and as the manuscript was nearly finished at that time, it was obvious to publish it as a report from the institute. Moreover, the data is relevant to the work carried out by the institute.

The analysis of the observations made by the sledgopatrol Sirius was financed by the Commission for Scientific Research in Greenland, and the field work carried out in 1988 and 1989 during the Greenland Home Rule mapping programme in Northeast Greenland was financed by Aage V. Jensen Charity Foundation.

### 3. INTRODUCTION

In 1988 the Greenland Home Rule initiated a biological mapping programme in Northeast Greenland which included an aerial survey (Bay & Boertmann 1989). One of the most surprising results of the survey was that muskoxen (*Ovibos moschatus*) almost had disappeared from large areas where they were numerous only a decade ago. This decline was confirmed by ground based observations made by geologists (Higgins 1988). With the coming research station at Zackenberg and the ZERO-programme in Northeast Greenland in mind, it became relevant to analyse this decline in details, and to make a population status as a basis for future population studies in North and Northeast Greenland. The key to such an analysis was the dog-sledge patrol Sirius. This is a naval unit, which during the late autumn and the early spring patrols, by means of dog-sledges, from the northern parts of Jameson Land and Liverpool Land in the south to Hall Land in the North. This area forms most of the natural range of muskoxen today. In total, the sledge teams travel about 16500 km annually (Sirius-coordinator 1983), mainly along coasts and through lowland valleys.

The unit was founded during World War II with local trappers as staff. Their task were to find, report, and later also to fight German weather stations in Northeast Greenland. After the war, the dog-sledge patrol became a true military unit, and today the patrols also serve as a kind of rangers in the North and Northeast Greenland National Park.

The sledge-teams are instructed to record all observations of mammals, including muskoxen. Recently, their observations from the period 1960 to 1990, previously classified, became available. With this valuable material, supplemented with many other observations and surveys, it became possible to estimate the population size in North and Northeast Greenland, and also to evaluate the population trends over the last three decades (Boertmann et al. 1992, Forchhammer & Boertmann in prep.). In this report we will present the basic data and try to estimate the local populations in North and Northeast Greenland.

#### 4. MATERIALS & METHODS

Observations of muskoxen in North and Northeast Greenland are of three types:

1/ Airborne surveys: the population in Jameson Land has been monitored carefully by GERI every year in the period 1982-1989 (Aastrup 1990). In North Greenland, between Humboldt Gletscher and Independence Fjord, GERI surveyed the population in 1985 (Aastrup et al. 1986). A third aerial survey was conducted in the region between Kong Oscar Fjord and Germania Land in 1988 (Bay & Boertmann 1989).

2/ The Sirius material (1961-1990) consists of a total of 3435 observations, but 262 were deleted, because they are without locality or numbers of muskoxen. This makes 3173 observations available for analysis. Since 1977, all observations have been plotted on maps with indication of date and hour, and sometimes with number of calves. Some observations concern several herds. One major disadvantage is that Sirius gives no information of their travelling routes, so negative observations are not available. However, we are often able to interpret the routes based on our local knowledge and on the muskox observations. Almost all observations are made during the early winter (September to November) and during late winter and spring (March to May). A few are from mid-winter (December to January) and early summer (June). The Sirius material is now kept in a database, which is updated annually, and which is kept by the authors

3/ Additional observations have been supplied by several, mainly geological and biological expeditions to North and Northeast Greenland (Ferns 1977, Meltofte 1979, Halliday & Higgs 1981, Patterson 1984, Lundbye 1986, Stemmerik 1987, Cabot et al. 1988, Higgins 1988, Sittler 1988, Bay & Boertmann 1989, Bennike et al. 1989, Boertmann et al. 1990, Klein & Bay 1990, Bay 1992, Sittler et al. undated). Finally, many unpublished reports, particularly from the expeditions of the Geological Survey of Greenland, are included. All these additional observations are ground based or made from helicopters or aircrafts on flights from camp to camp or during geological survey.

In total, an updated and rather detailed quantitative information on muskoxen from most parts of the natural range exists. However, from the western part of the Scoresby Sund

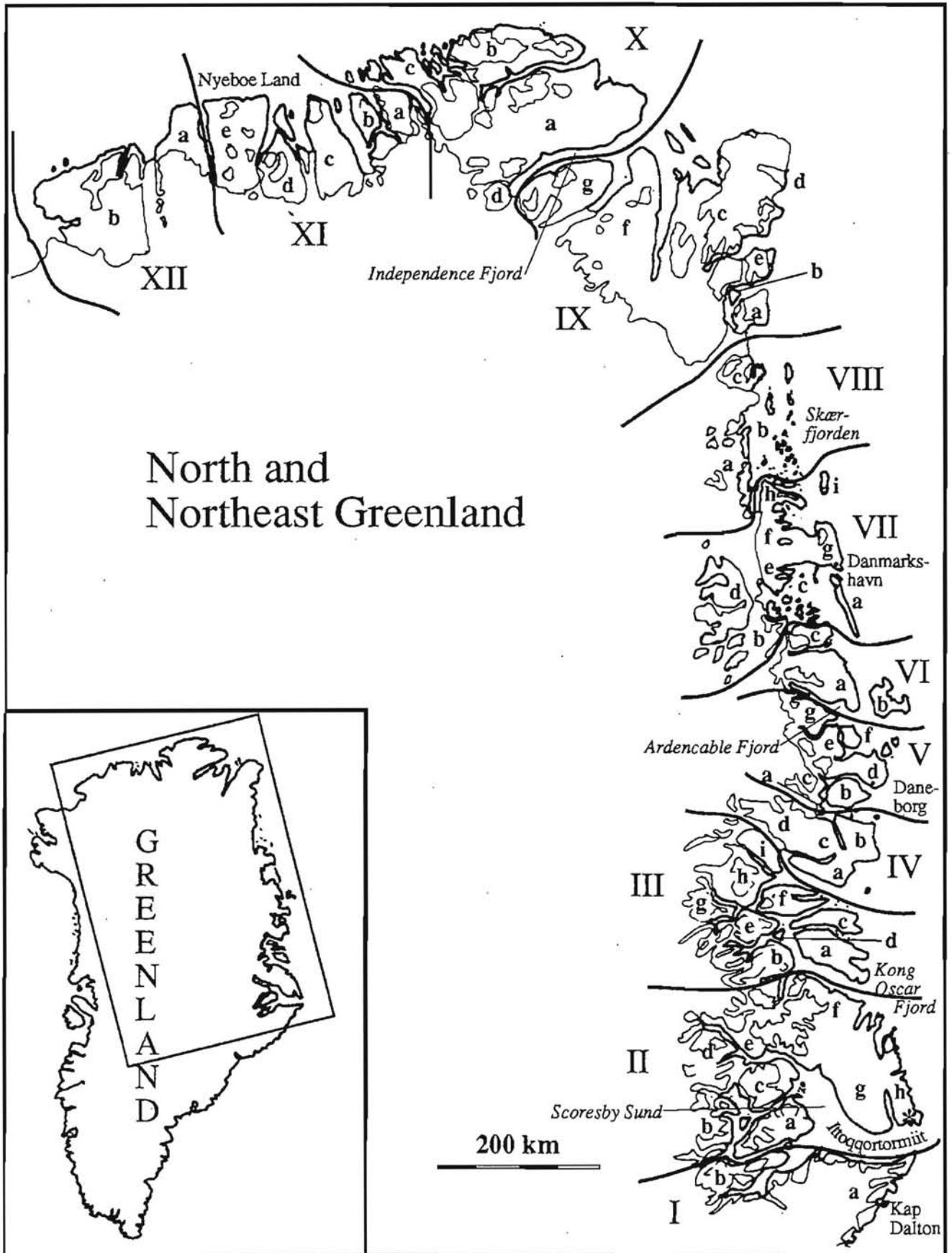


Fig. 1. North and Northeast Greenland with regions (Roman numerals) and areas (letter) referred to in the text.

area (Region II a-e) and the region between Kronprins Christian Land and Independence Fjord (Region IX) there are only scanty recent information.

It is difficult to evaluate and compare the efficiency of the different surveys and counts. In Jameson Land observers missed up to 30% of the muskoxen during aerial surveys (Aastrup & Mosbech in press). Probably much more will be missed, when the muskoxen are recorded during e.g. airborne geological surveying. The presented estimates, which are educated guesses, are therefore based on the maximum numbers recorded in the different localities in each area.

The muskox range is divided into twelve geographical regions (Roman numerals in Fig. 1), which again are divided in areas (the letter code following the Roman numeral in Fig. 1). These regions and areas are usually bordered by fiords or glaciers, which the muskoxen (except straggling bulls) rarely cross, even in winter (Sirius pers. comm.).

In Table 1 "Total" refer to the pooled maximum numbers from different routes travelled by Sirius (or localities in case of additional expeditions) in each area during all observation seasons. "Season" refer to the highest number recorded in each area during one season: winter in case of Sirius and summer in case of the expeditions. If Sirius has patrolled a route more than once during a winter, the highest numbers recorded during one trip is used. The same is the case regarding the additional expeditions. In Figs 2-7 the highest number seen on a locality or a route is plotted.

## 5. RESULTS

### 5.1 Distribution and numbers

Figs 2-7 show the distribution of the Sirius observations and the additional observations. Table 1 summarize the resulting estimates from all areas and regions. In total, 9500-12500 muskoxen are estimated to live in North and Northeast Greenland with c. 83 % south of Ardencaple Fjord (75°N).

In general, the muskoxen occur in all more or less level areas with a reasonable vegetation cover from Scoresby Sund in the south to Nyeboe Land in the North. The density is highly variable from the dense populations in Jameson Land to the very dispersed populations in northern Northeast Greenland and in North Greenland. Even on remote islands and nunataqs stragglers (usually bulls) sometimes occur, for example on Bontekoe Ø and Jackson Ø (both Region IV), Île de France (VII i), Kilen (XI d) and Prinsesse Thyra Ø (Region XI).

### 5.2 The regions

**Region I** is south of the normal range of muskoxen. However, stragglers (bulls) or footprints from stragglers are sometimes recorded as far south as Kap Dalton on the Blosseville Kyst (Vibe 1967, Pedersen 1974, Sandell & Sandell 1991).

In **Region II**, the coverage is excellent in Jameson Land and southeastern Scoresby Land (II g) due to GERI's monitoring during 1982-1989 (Aastrup 1990). From the western part (II a, b, c, d, e) observations are only available from 1968-70, when most of the major lowlands were visited by geologists and biologists (Pedersen 1974, Higgins pers. comm.), and also from 1984, 1987, and 1988 a few observations have been reported (GERI 1987b, Born pers. comm., Mortensen pers. comm.). The northern part

of Scoresby Land (II f) is regularly patrolled by Sirius and some expeditions also have reported sightings of muskoxen in 1968-70, 1974, 1979, 1980, 1982, and 1989 (Ferns 1977, Sittler 1988, Halliday & Higgs 1981, Patterson 1984, Higgins pers. comm., S nderholm pers. comm.). From Liverpool Land (II h) and central Scoresby Land there are very few observations available (Sirius). The low Sirius figures from Jameson Land (II g) and Liverpool Land (II h) are explained by the fact that Sirius only patrols in the northern margins of these areas. The southernmost population is found on Danmark  .

In **Region III** the coverage is fairly good. The islands Traill   (III a), Geographical Society   (III c) and Ymer   (III f) and the eastern parts of Lyell Land (III b), Suess Land (III e), Andr e Land (III h), and Strindberg Land (III i) have been visited by several biological and geological expeditions in 1968-70, 1974, 1975, 1979, 1980, 1982, 1984, 1986, 1988, 1989, and 1990 (Ferns 1977, Halliday & Higgs 1981, Stemmerik 1987, Sittler 1988, Sittler et al. undated, Finnbj rnsson, pers. comm., Higgins pers. comm., Lauritzen pers. comm., S nderholm pers. comm.) and regularly by Sirius. In 1988 Bay & Boertmann (1989) surveyed the eastern parts from aircraft. However, there are no or only little information from Fr nkel Land (III g) and the western parts of the above mentioned areas. These areas are very alpine with extensive glaciation, and probably very few muskoxen occur there.

**Region IV** includes Gauss Halv  (IV a), Hold With Hope (IV b), Hudson Land (IV c) and Ole R mer Land (IV d). These will be dealt with as a unit, because no natural boundaries are obvious. During the winter 1983/84 Sirius recorded significantly more muskoxen than usual. This 1984-figure was probably fairly close to the real population number, because that winter Sirius travelled through all major valleys and along most of the suitable coasts. Some expeditions have counted muskoxen in the region in 1976, 1988, and 1990 (Melfo te 1979, Dennis pers. comm., Higgins pers. comm., Stemmerik pers. comm., S nderholm pers. comm.), and Bay & Boertmann (1989) surveyed in 1988 the eastern parts from aircraft.

**Region V** is fairly good covered. Sirius travels in most lowland parts of Wollaston Forland and A.P. Olsen Land and along the coasts of the other areas. Some of these have recently been visited or surveyed by expeditions (Halliday & Higgs 1981, Higgins 1988 & pers. comm., Finnbj rnsson pers. comm., Stemmerik pers. comm., Lea & Roy pers.



comm.), which mainly have worked in the inland during 1976, 1980, 1983, 1988 and 1990. In 1988 Bay & Boertmann (1989) surveyed some of the major lowlands from aircraft.

The lowlands in **Region VI** were almost completely surveyed in 1988 and 1989. In 1988 an aerial survey was conducted (Bay & Boertmann 1989) and extensive archaeological, biological and geological field work was carried out in 1988 and 1989 (Higgins 1988, Boertmann et al. 1990). The Sirius figures from Region VI in Table 1 are from observations made before 1980. Since then, Sirius has only recorded very few muskoxen: 4 in Hochstetter Forland in 1984 and 10 on Shannon in 1984, although they patrol in the areas every year.

**Region VII** was like Region VI surveyed, partly from the air, by archaeologists, geologists and biologists in 1988, 1989 and also in 1990 (Bay & Boertmann 1989, Boertmann et al. 1990, Bay 1992, Knuth pers. comm.). Almost all lowlands have been visited during these years. The Sirius figures from Dronning Louise Land (VII d) are low, because Sirius only pay very brief visits to this remote area. In Germania Land (VII e, f, g, h) the most recent observations made by Sirius were in 1980, though they travel through the region each spring. Very few were found during the 1988-1990 expeditions and only in the western part (VII e, f). During 1969-1975 muskoxen were common around the weatherstation Danmarkshavn, and for example were c. 200 seen during 1969 and c. 100 in 1975 (Meltote pers. comm.). Since the beginning of the 1980s muskoxen have been very scarce in the Danmarkshavn-area, and only four were seen in 1991 (Olesen pers. comm.).

The coverage of **Region VIII** is fairly good. Hertugen af Orléans Land (VIII a) was surveyed from air and ground in 1989 and 1990 (Boertmann et al. 1990, Bay 1992), and Lambert Land was visited by expeditions in 1979, 1980, 1986 and 1990 (Lundbye 1986, Bay 1992, Higgins pers. comm.). The difference between the Sirius figures and the expedition figures from Lambert Land is due to the fact that Sirius never visits the southwestern lowland, where expeditions have reported many muskoxen.

The coverage of **Region IX** is poor. Sirius travels mainly along the coasts and in a few valleys. Expeditions have visited Kronsprins Christian Land (IX c) in particular, but large

inland areas are more or less unexplored. The great difference between the Sirius and expedition figures from J.C. Christensen Land (IX g) is explained by the fact that Sirius never travels inland where geologists worked in 1978.

In **Region X** an aerial survey was conducted in 1985 (Aastrup et al. 1986). Sirius travels both inland and along the coasts, and many expeditions have visited the region (see Dietz & Andersen 1984, Bennike et al. 1989). Hence, the coverage is good.

In Nansen Land (X a), the most recent observation of 55 muskoxen (in 1991, Klein pers. comm.) is plotted on Fig. 8. These were seen in the most favourable locality, Siriuspasset. However, many more have been recorded previously in that locality. In spring 1980 Sirius recorded 94 muskoxen. The following spring 132 were recorded, and during the intervening summer 200 were seen (Dietz & Andersen 1980). The occurrence of wolves (*Canis lupus*) - sometimes breeding (Dawes et al. 1986, Sirius pers. comm.), might be the reason to the rather low numbers seen in the area in 1985 (16, Aastrup et al. 1986) and 1991 (see above).

No map with summer figures are presented from Region X, There are only a few observations from 1987 and 1991 (Klein & Bay 1990, Klein pers. comm.) available, since the maps presented by Dietz & Andersen (1984) and Aastrup et al. (1986).

**Region XI** was also surveyed from the air in 1985 (Aastrup et al. 1986) and some expeditions (Dietz & Andersen 1984, Bennike et al. 1989) have covered large areas during 1979-83 and 1984-85. These observations together with those of Sirius makes the coverage good. Freuchen Land (XI a) is patrolled by Sirius along the northern coast, and no expeditions have reported muskoxen from the area. However, the major part is covered by an ice cap, and only very few muskoxen are likely to occur there. No observations since the maps of Dietz & Andersen (1984) and Aastrup et al. (1986) have been available, so a map with summer figures is not presented here.

**Region XII** is outside the present day range of muskoxen, and none were seen during the aerial survey in 1985 (Aastrup et al. 1986). However, muskoxen have been recorded during the last century in Hall Land (XII a) by Bessels (1875) and Fielden (1877). In Washington Land (XII b) muskoxen were reported in 1962 and a small population might

exist (Aastrup et al. 1986), but until further evidence is obtained, the muskoxen is considered as absent from Washington Land.

### 5.3 Areas with winter concentrations

Fig. 9 shows where Sirius and GERI have found concentrations of muskoxen during several winters. The most important areas are found in northwestern Jameson Land (II f), on Ymer Ø (III f), in Hudson Land (IV c), Ole Rømer Land (IV d), Wollaston Forland (V d), and Nansen Land (X c).

The large concentrations encountered in the eastern parts of Region VI and VII do not occur today, as the muskoxen have been nearly absent from these areas since 1980.

Table 1. Muskox population estimates in areas and regions in North and Northeast Greenland. "Total" and "season" are explained in the text.

Area and region	Sirius		Expeditions		Estimate
	total	season	total	season	
Blosseville Kyst (I a)	-	-	-	stragglers	0
Gåse Land (I b)	-	-	-	stragglers	0
<u>REGION I</u>					<u>0</u>
Milne Land (II a)	-	-	117	93(1969*)	100-150
Vestfjord-Harefjord (II b)	-	-	111	111(1969*)	150-200
Renland (II c)	-	-	503	503(1969*)	500-600
Hink Land (II d)	-	-	104	104(1969*)	c. 150
Nathorst Land (II e)	-	-	200	182(1969*)	c. 300
Scoresby Land (II f)	83	22 (1974)	78	46(1982)	c. 100
Jameson Land** (II g)	70	32(1990)	-	2950-3600 (1989)	2950-3600
Liverpool Land (II h)	18	18(1984)	-	-	c. 50
<u>Region II</u>					<u>4300-5150</u>
Trail Ø (III a)	154	85(1980/81)	162	95(1986)	c. 150
Lyell Land(III b)	25	20(1979/80)	28	18(1982)	c. 50
Geographical Society Ø (III c)	254	150(1982/83)	178	153(1984)	c. 200
Suess Land and Ella Ø (III d, e)	142	67(1986/87)	250	168(1970)	150-200
Ymer Ø (III f)	704	288(1984/85)	310	139(1986)	300-500
Fränkel Land (III g)	-	-	30	30(1990)	c. 50
Andrée Land (III h)	148	76(1982/83)	276	247(1972)	200-300
Strindberg Land (III i)	73	40(1988/89)	51	38(1982)	50-100
<u>Region III</u>					<u>1150-1550</u>
<u>Region IV</u>	2905	1288(1983/84)	750	610(1988)	<u>1200-1700</u>
Blosseville Bjerg (V a)	89	53(1978/79)	-	-	50-100
Clavering Ø (V b)	342	170(82/83)	117	115(1988)	150-250
Payer Land (V c)	183	158(1984/85)	-	-	150-200
Wollaston Forland (V d)	996	348(1983/84)	812	400(1980)	500-800
Th. Thomsen Land (V e)	123	37(1981/82)	96	85(1990)	100-200
Kuhn Ø (V f)	88	48 (1981/82)	94	94(1990)	100-150
C.H. Ostenfeld Land (V g)	12	5(1969/70)	48	25(1976)	25-50
<u>Region V</u>					<u>1075-1750</u>
Hochstetter Forland (VI a)	369	165(1971)	see text	see text	50-100
Shannon (VI b)	190	150(1978)	see text	see text	5-10
Adolf S. Jensen Land (VI c)	21	8(1975)	6	6(1983)	0-10
<u>Region VI</u>					<u>55-120</u>

Table 1 cont.

Area and region	Sirius		Expeditions		Estimate
	total	season	total	season	
Store Koldewey (VII a)	32	30(1970)	3	3(1988)	0-10
Rechnitzer Land (VII b)	-	-	25	17(1989)	c. 20
Islands in Dove Bugt (VII c)	11	11(1975)	3	3(1988)	5-10
Dronning Louise Land (VII d)	3	3(1984)	186	186(1989)	200-250
Germania Land (VII e, f, g, h)	370	100(1974)	120	120(1989)	150-200
<u>Region VII</u>					<u>375-490</u>
Hertugen af Orléans Land (VIII a)	4	3(1985)	15	11(1990)	c. 25
Islands in Jøkelbugten (VIII b)	19	10(1980)	4	4(1990)	5-10
Lambert Land (VIII c)	6	3(1988)	79	43(1984)	50-75
<u>Region VIII</u>					<u>80-110</u>
Hovgaard Ø (IX a)	9	5(1979)	15	15(1990)	5-10
Lynn Ø (IX b)	12	12(1969)	-	-	0-10
Kronprins Christian Land (IX c, d)	185	60(1976)	99	36(1978)	100-150
Mylius Erichsen Land (IX f)	149	63(1978)	68	59(1978)	60-100
J.C. Christensen Land (IX g)	3	3(1968)	134	134(1978)	150-200
<u>Region IX</u>					<u>315-470</u>
<u>Region X, Peary Land (X a, b)</u>	628	182(1981)	-	520-690(1985)	<u>500-700</u>
Freuchen Land (XI a)	7	7(1976)	-	-	5-10
Nares Land (XI b)	41	28(1983)	-	65-100(1985)	90-130
Wulff Land (XI c)	83	32(1989)	-	150(1985)	c. 150
Warning Land (XI d)	-	-	-	15-25(1985)	15-25
Nyeboe Land (XI e)	29	29(1989)	-	25-40(1985)	25-40
<u>Region XI</u>					<u>285-355</u>
Hall Land (XII)	-	-	0	0	0
Washington Land	-	-	0	0	0
<u>Region XII</u>					<u>0</u>
<u>North and Northeast Greenland</u>					<u>9335-12395</u>

\* 1968-1970, \*\* incl. Ørsted Dal and Schuckert Dal.

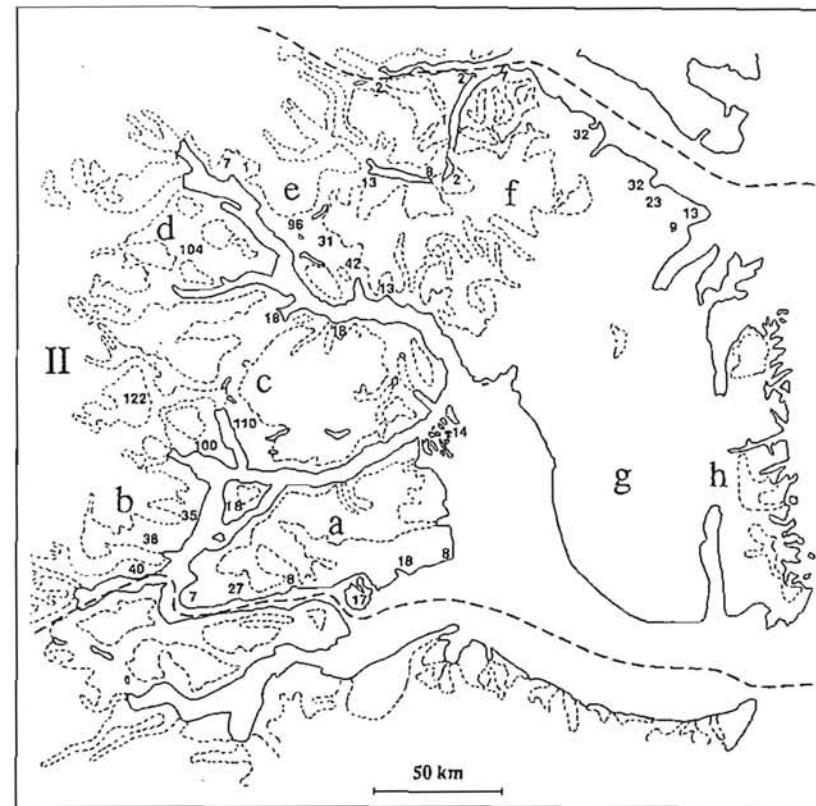
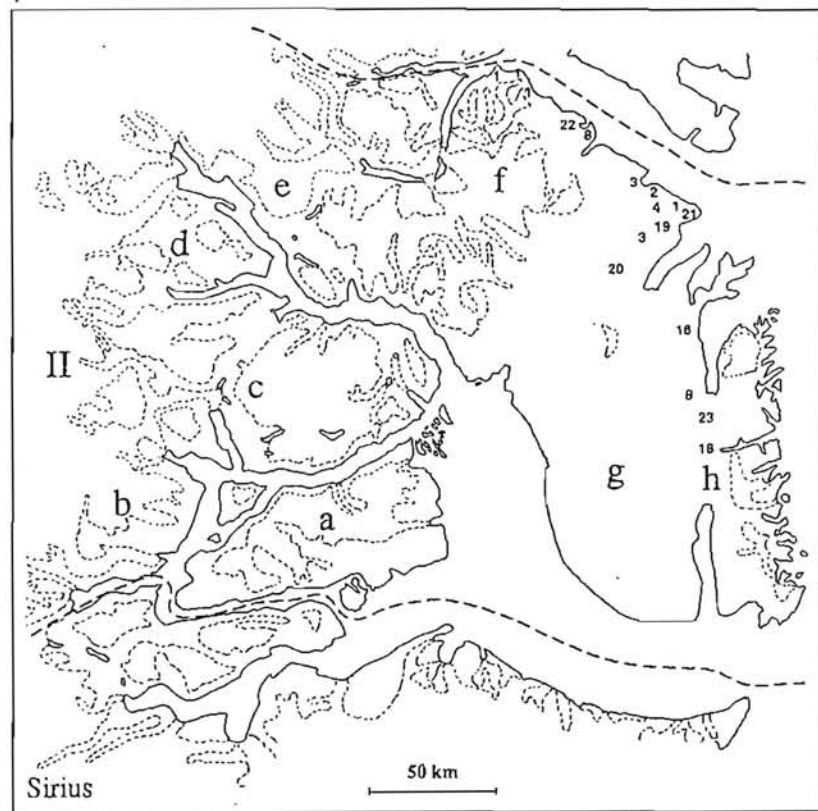


Fig. 2. Distribution of muskox observations made by Sirius (left map) during 1961-1990 and different expeditions (right map) in Region II. a = Milne Land, b = land between Vestfjord and Harefjord, c = Renland, d = Hink Land, e = Nathorst Land, f = Scoresby Land, g = Jameson Land, and h = Liverpool Land. It is the highest number recorded on the localities which are plotted. Dotted lines indicate routes on which the muskoxen were recorded. Observations made by expeditions are from 1968-1970 (Pedersen 1974, Higgins pers. comm.), 1974 (Ferns 1977), 1980 (Halliday & Higgs 1981), 1982 (Patterson 1984), 1984 (Born pers. comm.), 1985 (Mortensen pers. comm.), and 1987 (Glahder pers. comm.). The aerial surveys performed by GERI in Jameson Land and Scoresby Land are not plotted, but see reports from GERI (Aastrup 1990).

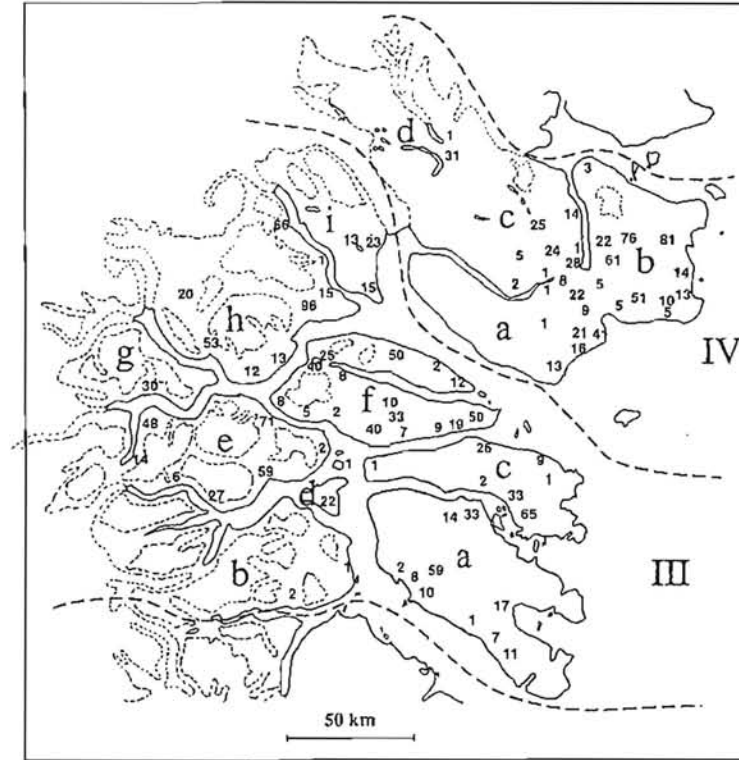
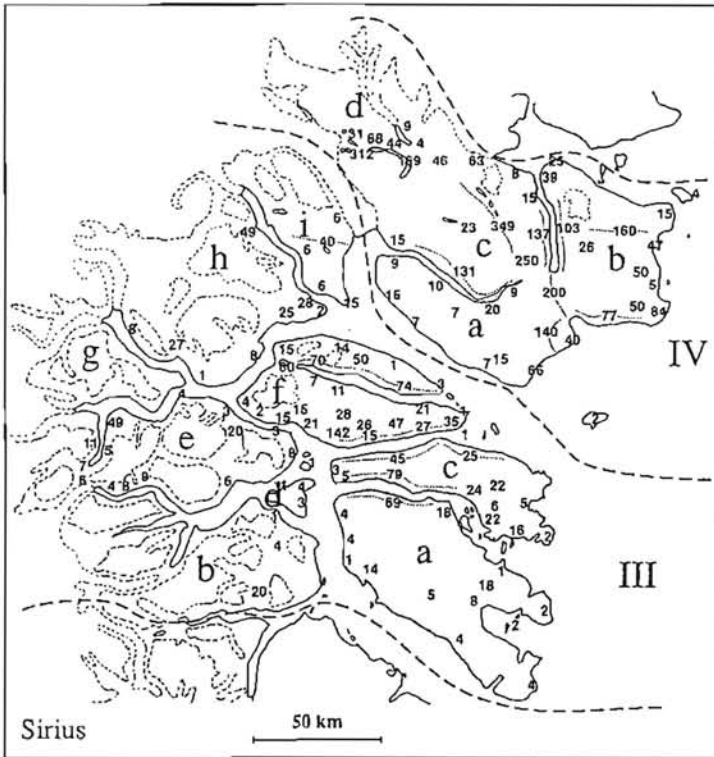


Fig. 3. Distribution of muskox observations made by Sirius (left map) during 1961-1990 and different expeditions (right map) in Region III and IV. III a = Traill Ø, III b = Lyell Land, III c = Geographical Society Ø, III d = Ella Ø and Maria Ø, III e = Suess Land, III f = Ymer Ø, III g = Fränkel Land, III h = Andrée Land, and III i = Strindberg Land. IV a = Gauss Halvø, IV b = Hold With Hope, IV c = Hudson Land, and IV d = Ole Rømer Land. It is the highest number recorded on the localities which are plotted. Dotted lines indicate routes on which the muskoxen were recorded. Observations made by expeditions are from 1968-70 (Higgins pers. comm.), 1974 (Ferns 1977), 1975 (Lauritzen pers. comm.), 1979 (Sittler 1988), 1980 (Halliday & Higgs 1981), 1982 and 1984 (Sittler 1988), 1986 (Stemmerik 1987), 1988 (Dennis undated, Sittler et al. undated, Sønnerholm pers. comm., Stemmerik pers. comm.), 1989 (Sittler et al. undated Sønnerholm pers. comm.), and 1990 (Sittler et al. undated, Higgins pers. comm.). Some aerial counts performed in 1976 and 1988 (Meltofte 1979, Bay & Boertmann 1989) are not included.

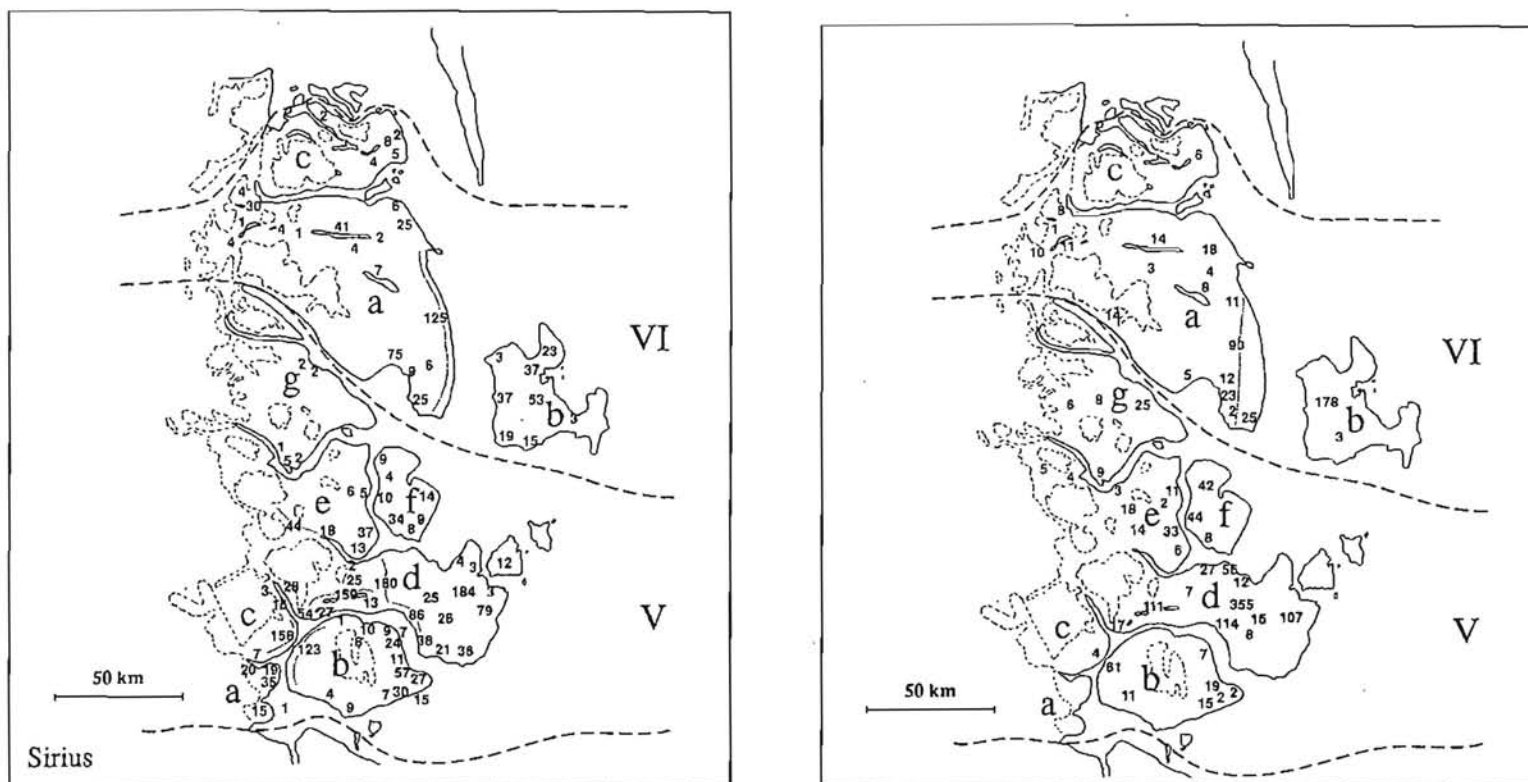


Fig. 4. Distribution of muskox observations made by Sirius (left map) during 1961-1990 and different expeditions (right map) in Region V and VI. V a = Blossville Bjerg and Jordan Hill, V b = Clavering Ø, V c = Payer Land, V d = Wollaston Forland and A.P. Olsen Land, V e = Th. Thomsen Land, V f = Kuhn Ø, V g = C.H. Ostenfeld Land. VI a = Hochstetter Forland, VI b Shannon, and VI c = Adolf S. Jensen Land. It is the highest number recorded on the localities which are plotted. Dotted lines indicate routes on which the muskoxen were recorded. Observations made by expeditions are from 1976 (Meltote 1979), 1980 (Halliday & Higgs 1981), 1983 (Finnbjørnsson pers. comm.), 1988 (Higgins 1988, Bay & Boertmann 1989, Stemmerik pers. comm.), and 1990 (Bay 1992, Higgins pers. comm., Lea & Roy pers. comm.).



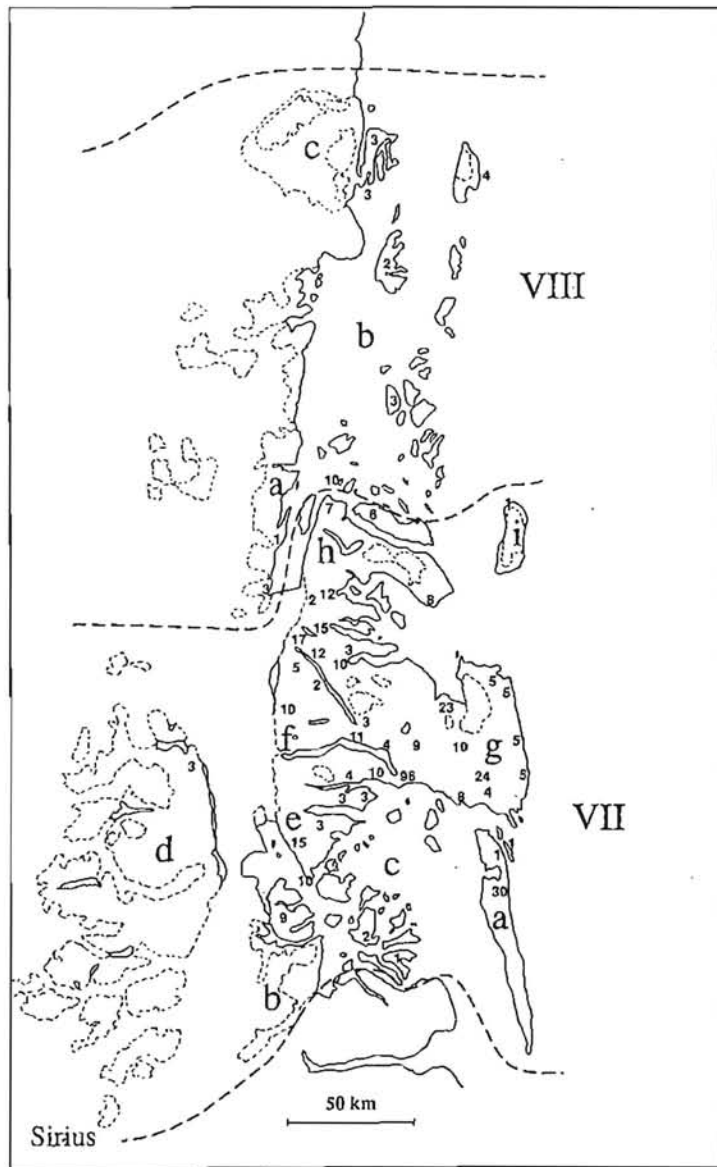
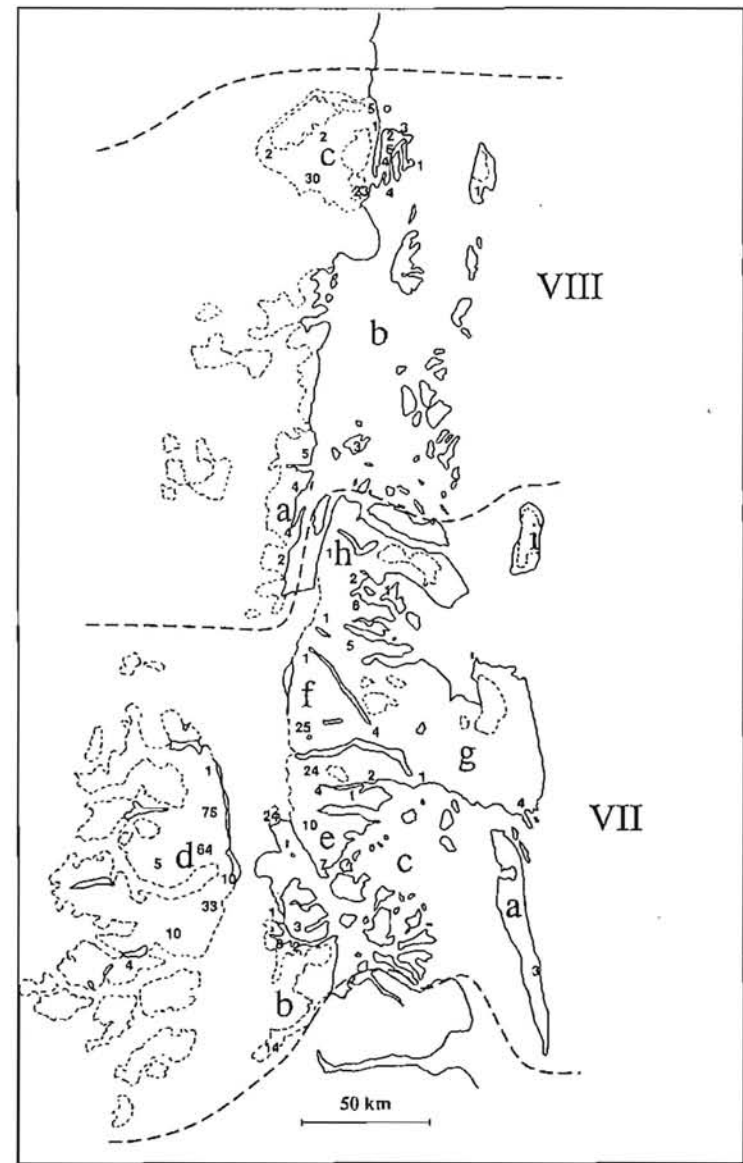


Fig. 5. Distribution of muskox observations made by Sirius (left map) during 1961-1990 and different expeditions (right map) in Region VII and VIII. VII a = Store Koldewey, VII b = Rechnitzer Land, VII c = Dove Bugt, VII d = Dronning Louise Land, VII e, f, g, h = Germania Land, and VII i = Île de France. VIII a = Hertugen af Orleans Land, VIII b = Jøkelbugten, and VIII c = Lambert Land. It is the highest number recorded on the localities which are plotted. Dotted lines indicate the routes on which the muskoxen were recorded. Observations made by expeditions are from 1980 (Higgins pers. comm.), 1984 (Lundbye 1986), 1987 (Cabot et al. 1988), 1988 (Bay & Boertmann 1989), 1989 (Boertmann et al. 1990), 1990 (Bay 1992), and 1991 (Olesen pers. comm.).



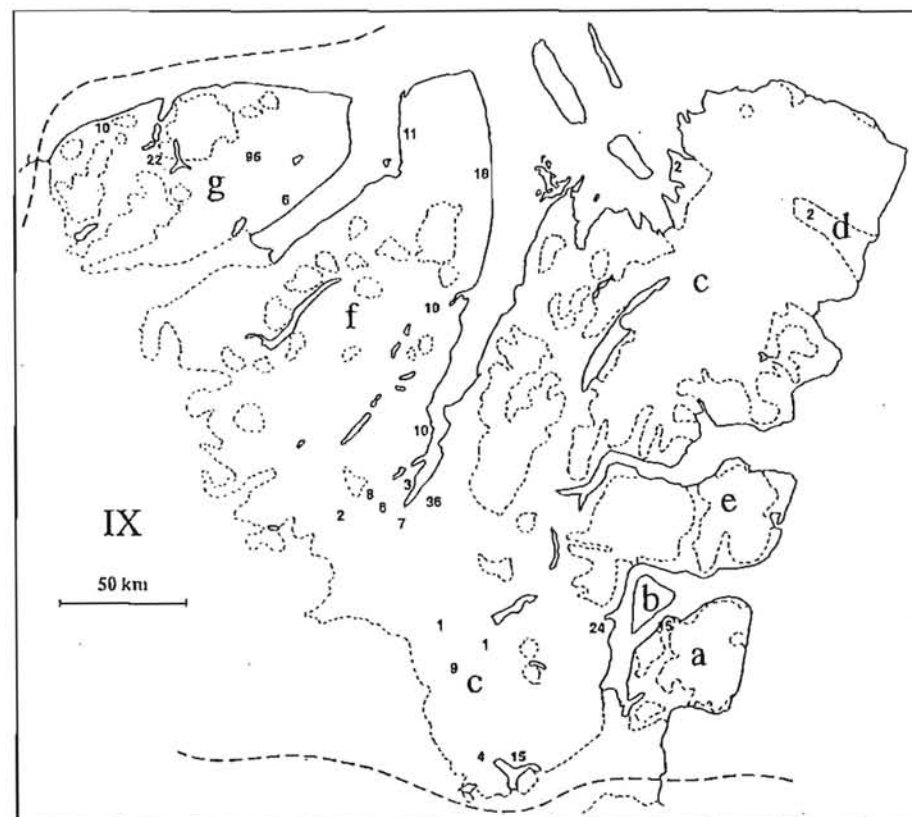
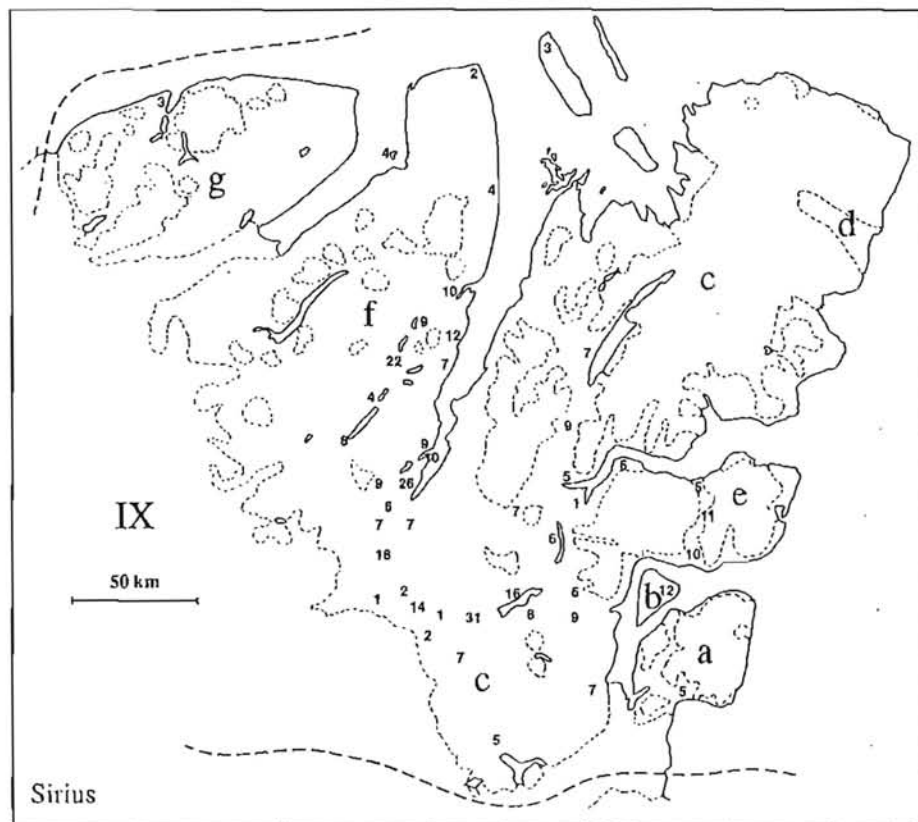


Fig. 6. Distribution of muskox observations made by Sirius (left map) during 1961-1990 and different expeditions (right map) in Region IX. a = Hovgaard Ø, b = Lynn Ø, c = Kronprins Christian Land, d = Kilen, e = Holm Land. It is the highest number recorded on the localities which are plotted. Observations made by expeditions are from 1978 (Higgins pers. comm.), 1984 (Lundbye 1986), 1979 and 1980 (Hjort pers. comm.), 1985 (Hjort pers. comm.), 1986 (Mølgaard pers. comm.), 1987 (Klein & Bay 1990), and 1989 (Rasmussen 1990).

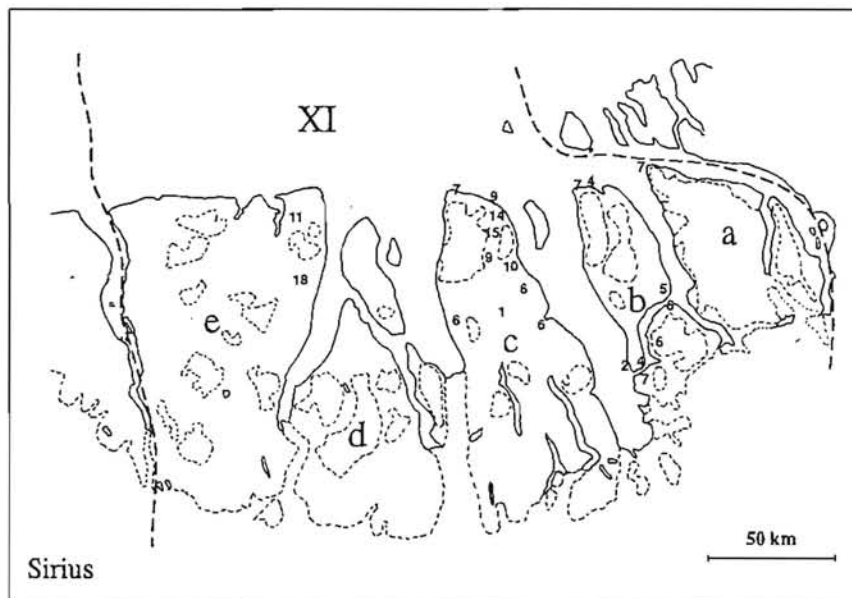
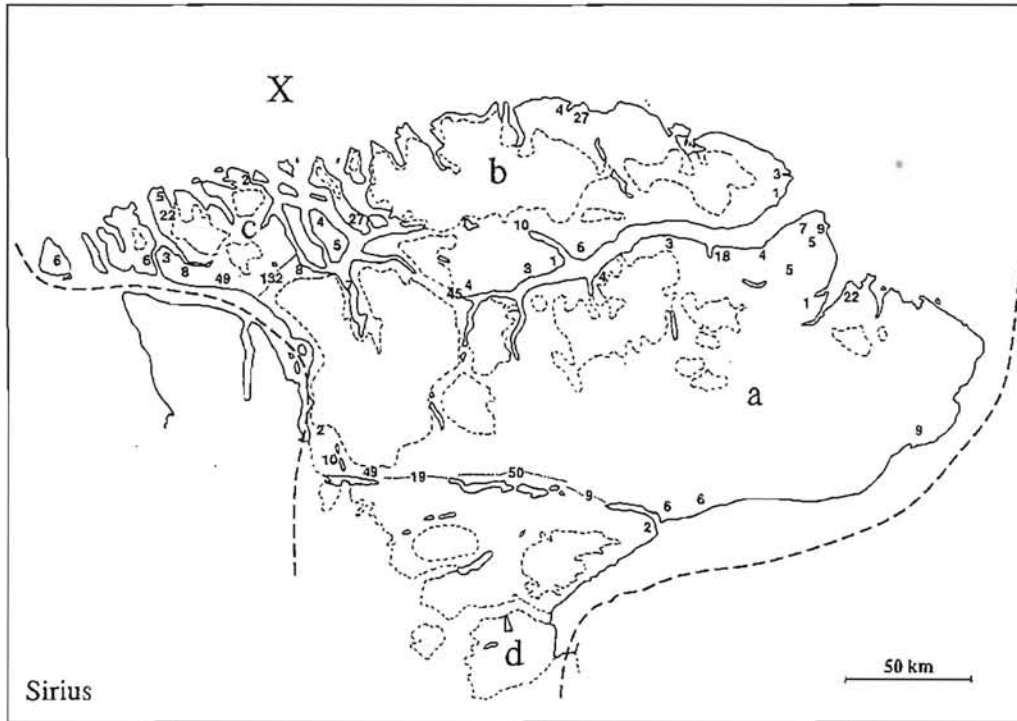


Fig. 7. Distribution of muskox observations made by Sirius during 1961-1990 in Region X (upper map) and Region XI (lower map). X a, b = Peary Land, X c = Nansen Land, and X d = Vildt Land. XI a = Freuchen Land, XI b = Nares Land, XI c = Wulff Land, XI d = Warming Land, and XI e = Nyeboe Land. It is the highest number recorded on the localities which are plotted. Dotted lines indicate the routes on which the muskoxen were recorded.

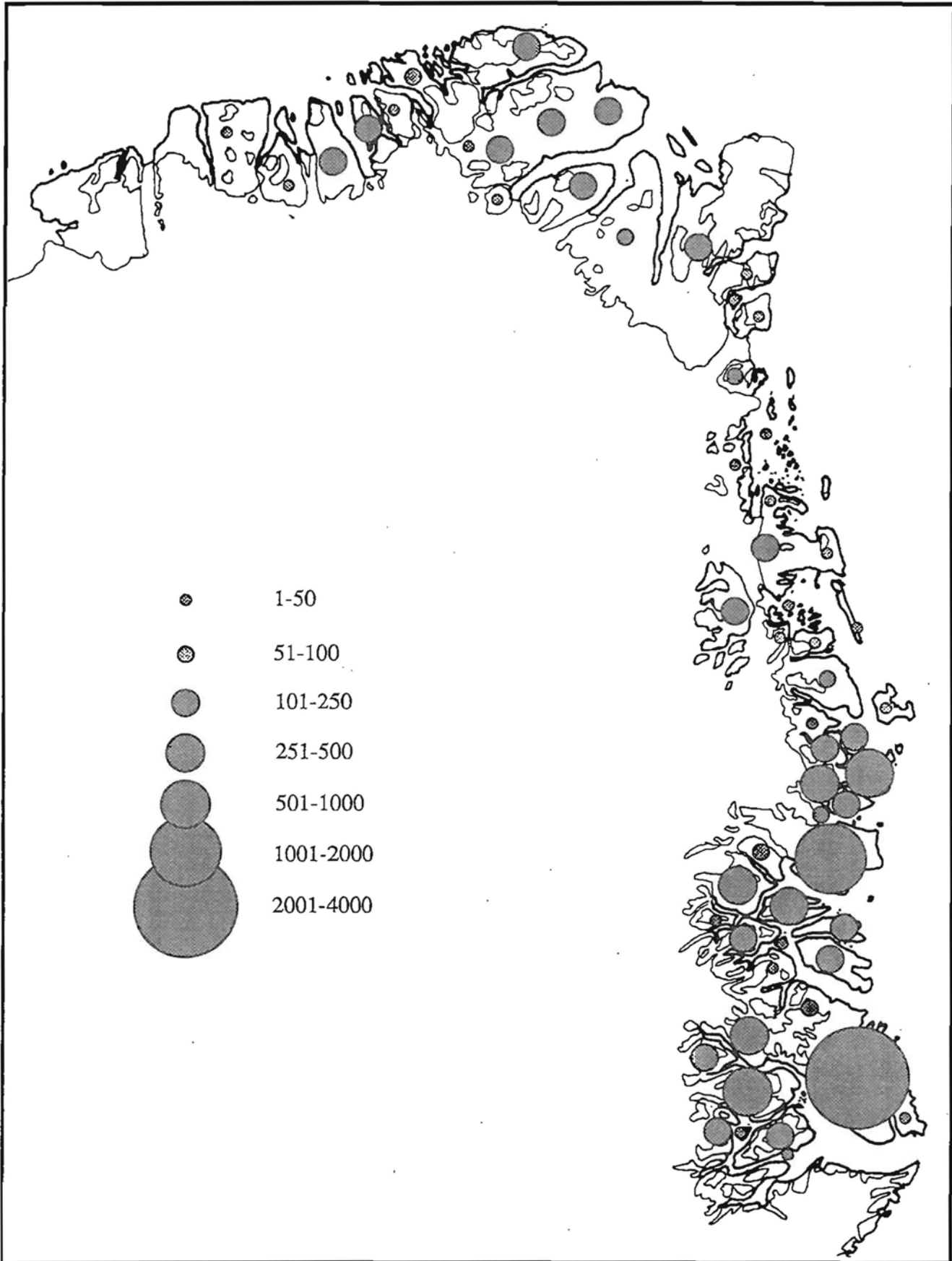


Fig. 8. Distribution and numbers of muskoxen in North and Northeast Greenland.

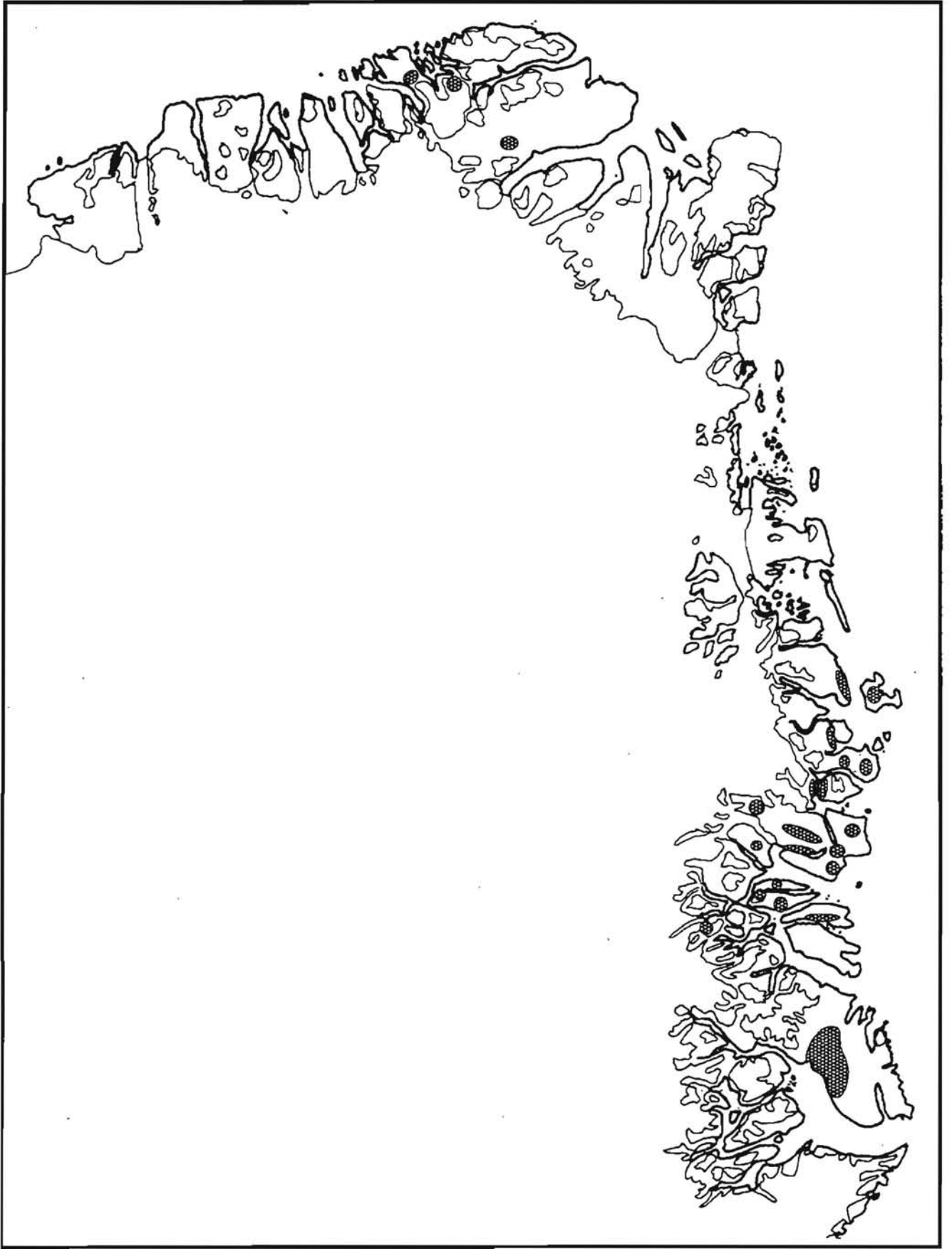


Fig. 9. Areas where Sirius and GERI several times have recorded concentrations of muskoxen during winter and spring.

## 6. DISCUSSION

### 6.1 Population estimate

The estimate at 9500-12500 muskoxen in North and Northeast Greenland must be considered as a minimum. More efficient surveys particularly in the western part of Region II and in the Regions III-V, will probably reveal larger population numbers. Nevertheless, the present material does not allow higher estimates.

The estimates from each area are biased in many ways. In some areas only minor parts of the potential muskoxen habitats have been surveyed or visited, and the observed numbers can be much smaller than the real. Another bias is multiple registrations of the same animals in different localities, because observations over many years are pooled in the "total" figure. It is very likely that muskoxen recorded by Sirius one winter can be recorded in other localities by expeditions the following summer or by Sirius during later winters. This is of course, most likely to occur in areas with a dense muskox population and high expedition or Sirius activity, or in areas where favourable localities are distant and situated on the usual Sirius routes. In such areas the "total" figure probably represents an over estimate and the "season" figure usually an under estimate. In areas with low muskox density and low Sirius activity even the "total" figure may be an under estimate because the likelihood of Sirius/muskoxen encounters is low. This is supported by aerial surveys which in such areas have revealed much higher numbers, as for example in Region XI.

Area and region estimates which we assess as safe, are those where aerial surveys have been conducted recently supported by extensive ground based work. Such areas are Jameson Land (II g) and the regions VI, VII, VIII, X, and XI.

Fairly safe population estimates are given from areas recently visited by expeditions and with a high Sirius activity. We assess, that the estimates from Region III, IV, and V are fairly safe.

Poor estimates are given from the western part of Region II due to no Sirius information and additional observations more than 20 years old. Also the estimate from Region IX is poor because Sirius mainly travels along the coasts and the expedition activity has been low.

## 6.2 Previous population estimates

The most recent assessment on the muskox population in North and Northeast Greenland was at 20000 in 1983 (Thing et al. 1984). This was, however, to a large degree, based on inadequate data, but may have been fairly accurate because the population in general has decreased since then (Forchhammer & Boertmann in prep.).

Another total estimate, based on even more inadequate data, was at 6000-10000 muskoxen in 1974, of which 33-50 % occurred south of Ella Ø (Vibe in Pedersen 1974). This estimate is rather similar to the present and with a similar distribution (44-49 % of the population is now estimated to occur south of Ella Ø). It was, however, probably an under-estimate, because the population seemed to be thriving and peaked in the years before 1980 (Forchhammer & Boertmann in prep.). In the mid-1950s Vibe (1958) estimated the total population at 5000-10000 muskoxen and he mentioned that before the disastrous winters in the period 1938-54 it probably was almost twice as high. Jennov (1945) estimated the population south of 78°N at 17000 in 1938.

Regional population estimates are given for Region II by Pedersen (1974). He assessed the western part (II a-e) to hold about 2750 muskoxen and Jameson Land (II g) to hold 5000. Both may be rather exaggerated because no correction for multiple observations of the same herds and individuals is apparent from his material. Patterson (1984) estimated the population in northern Scoresby Land to 450. Northern Scoresby Land is, in the present context divided, so the one part belongs to Jameson Land and the other part is separate (II f). However, the estimate by Patterson is in accordance with the present. Sittler (1988) estimated the population between 72° and 74° N at 1000-1500. This area

covers most of Region III and the southern part of Region IV. With this in mind, Sittlers estimate is similar to the present.

In Hochstetter Forland (VI a) and on Shannon (VI b), muskoxen have previously been abundant. Pedersen (1936) and Jenov (1945) reports thousands of muskoxen, and in 1976 Meltofte (1979) estimated the population at a few hundred in Hochstetter Forland and max. 300 on Shannon. Almost no muskoxen are found in these two areas today.

The population in Region VIII is very small, and the major part is found in Lambert Land (VIII c) (Bay 1992). The remaining part of the region, Hertugen af Orléans Land (VIII a) and the islands in Jøkelbugten (VIII b), have a very restricted geographical distribution and are characterised by an extremely sparse vegetation (Bay & Fredskild 1992). In these areas very few muskoxen have been recorded, and the region could possibly function as a gene flow barrier, separating the population in North Greenland from the population in Northeast Greenland (Henrichsen 1982).

In 1947-50 the muskox population in Peary Land was estimated at 2000-3000 based on observations of 445 muskoxen (Johnsen 1953). This estimate seems to be exaggerated, and can be explained by the fact that Johnsen mainly visited areas, which today are known as some of the best muskox terrains in the area and extrapolated rather uncritically. However, a population decline until 1960 cannot be ruled out. After 1960 the population seems to be stable (Forchhammer & Boertmann in prep.).

### 6.3 Trends

The population in Jameson Land (II e) is probably more or less stable, perhaps due to the hunting pressure from the settlement Ittoqqortoormiit. The hunting pressure has, however, been increasing over the last decades resulting in increased scarcity of muskoxen close to the occupied areas, viz. the southwestern coasts of Liverpool Land (II h) and Jameson Land (II g) (Sandell & Sandell 1991).



In the other parts of Northeast Greenland, muskoxen have in general been decreasing since the early 1980s. This decline is described in details in another paper (Forchhammer & Boertmann in prep.). The most serious decline has occurred in region VI and VII. Previously, large numbers were found in these regions, but they have deserted the coastal parts (Hochstetter Forland (VI a) and eastern Germania Land (VII g)), and remain in rather small numbers in the continental areas adjacent to the inland ice, like the caribou (*Rangifer tarandus*) in West Greenland during population declines (Meldgaard 1986). The only area where a rather large and probably thriving muskox population exists within these two regions is Dronning Louise Land (VII d), a remote nunataq area.

The continental areas, where a part of the population survives disastrous winters are termed "habitation areas" (Skoog 1968, quoted from Meldgaard 1986 p. 64), "refugia" (Thomas et al. 1981), or "protected areas" (Henrichsen 1982). None of these terms are convenient and one (refugia) is usually used in another meaning, so we propose the term "surviving areas" instead. The surviving areas for muskoxen in Northeast Greenland are sometimes the same as where the winter concentrations occur (Fig. 9) e.g. the Krumme Langsø area in Ole Rømer Land (IV d).

How large was the population then, before the decline ? According to our analysis (Forchhammer & Boertmann in prep.), the population in general had a favourable period from the early 1960s to the mid 1980s. Some thousands probably lived in Region VI and VII, where the decline since then has been most serious. As an educated guess, we believe that the population counted 15000-20000 muskoxen in the early 1970s. A number which is within the limits of Vibe's (1958) population estimate (10000-20000) during the peak before 1938.

## 7. MANAGEMENT

The muskoxen are probably most vulnerable to human disturbance during winter and spring. During winter they may assemble in certain areas and in spring the calves are born. Fig. 9 shows all areas where many muskoxen repeatedly have been recorded in relatively small areas during these seasons. A few of these areas only hold very few muskoxen today, e.g. Hochstetter Forland (VI a) and Shannon (VI b), but they might become wintering areas again if the population recovers. On the other hand, many winter and spring concentration areas are probably not detected, due to the inaccessibility during that time of the year, for example in Dronning Louise Land (VII d). The most important winter areas known are probably the northwestern part of Jameson Land (II g) where up to 1800 have been recorded, and the Krumme Langsø area in Ole Rømer Land (IV d) where up to 560 have been recorded. This last mentioned area has an extremely continental climate and the vegetation is dominated by *Kobresia* steppe (Fredskild & Mogensen 1991) which probably is more or less snow free in the winter.

In case of mineral or hydrocarbon exploration, such areas need regulation of human activities during winter and spring, like those stipulated in Jameson Land during the oil exploration in 1982-1990 (GERI 1987a).

## 8. ACKNOWLEDGEMENT

We would not have been able to write this paper without the contributions made by the sledge patrol Sirius. Particularly, the former commander M.N. Guldbrandsen and the present commander P. Norit have been of valuable help. H. Meltofte was a prime factor during the cooperation with Sirius, and during the initiation of the present work. We are also very grateful to all who have contributed with unpublished observations of muskoxen: geologists, biologist and many more. Many institutions have helped during our stays in Northeast Greenland: the Geological Survey of Greenland, the Greenland Environmental Research Institute, the Zoological Museum in Copenhagen, the National Survey and Cadastre - Denmark, and the Greenland Home Rule. Peter Aastrup kindly read and criticized an early draft of the manuscript and Hans Kristian Olsen prepared the summary in Greenlandic. The analysis of the Sirius material was granted by the Commission for Scientific Research in Greenland (J. nr. 0.234-90).

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