MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. 170 · Nr. 5

THE DANISH
ZOOGEOGRAPHICAL INVESTIGATIONS IN GREENLAND

# ARCTIC ANIMALS IN RELATION TO CLIMATIC FLUCTUATIONS

BY

CHRISTIAN VIBE

WITH 101 FIGURES AND 3 TABLES IN THE TEXT

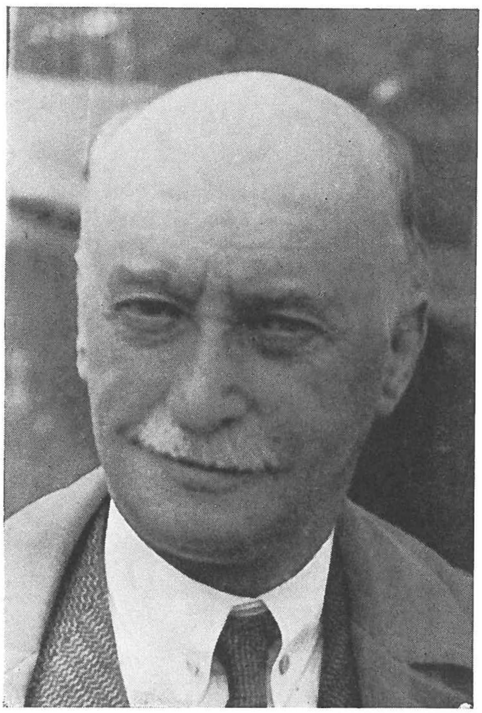
С РУССКИМ РЕЗЮМЕ

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
1967

In the memory of professor, dr. phil.

ADOLF SEVERIN JENSEN

in sincere appreciation of his warm interest in the scientific exploration of Greenland and in the prospects of her people.



1866–1953

"My ideal of a Greenlander is a man who goes a-sealing when there are seal to be had, and fishing when there are fish.

Once Denmark has brought the Greenlanders to a point where they have really gained dominion over land and sea, her mission in Greenland will have to be completed. Only then can we look confidently to the future of that fine country".

AD. S. JENSEN 1910

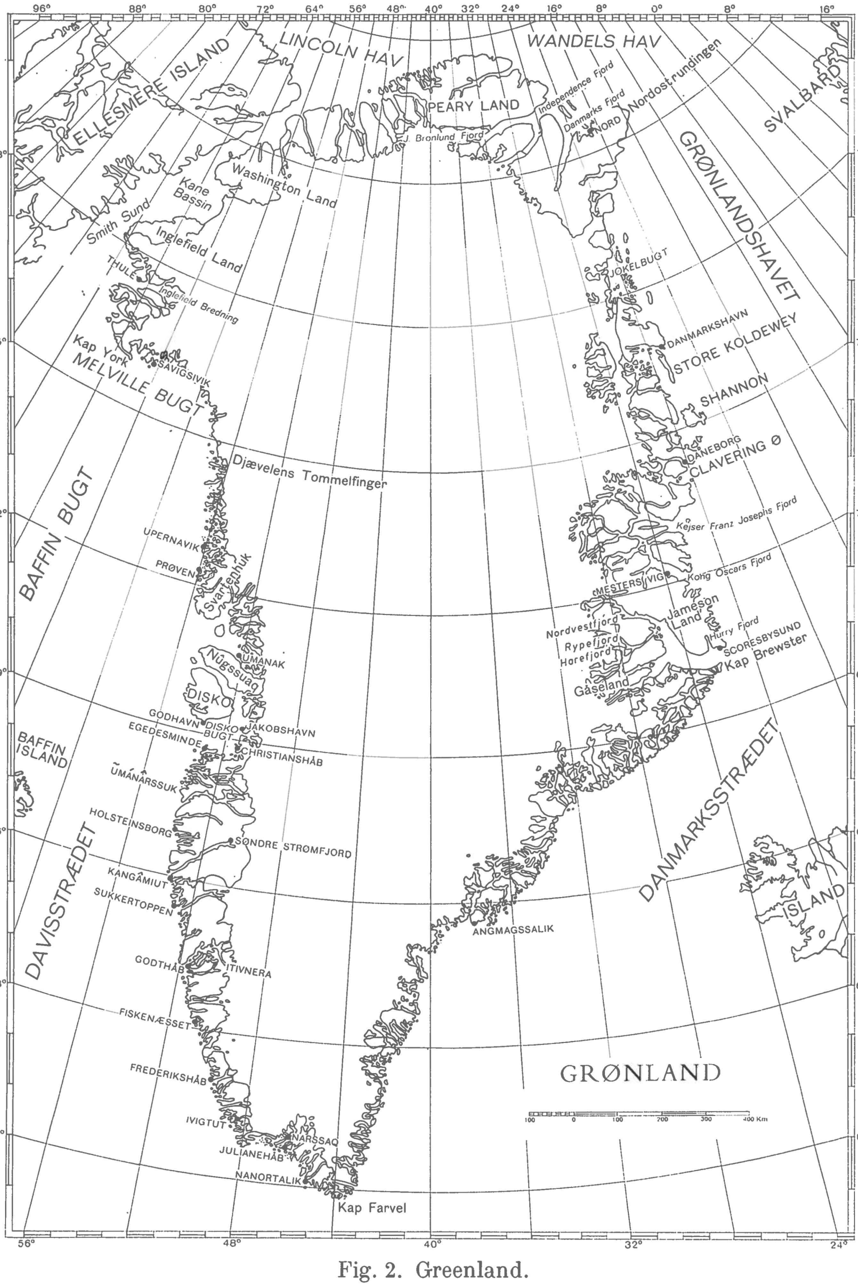



Fig. 2. Greenland.

# CONTENTS

## Abstract

A study of the East Greenland Ice in Davis Strait makes it possible to recognize *three main drift-ice stages* which play an important rôle for climate and ecology in all Greenland.

A). **The drift-ice stagnation stage** (approx. 1810–60). The East Greenland Ice does not advance far north into Davis Strait where the Canadian Current has a dominating influence. The climate of northern West Greenland is relatively cold, dry and stable. The populations of sea mammals and sea birds concentrate at central West Greenland. The winter climate is favourable for the Reindeer in central and northern West Greenland, and the population increases and culminates.

The population of white Arctic Fox increases and culminates in southeastern Canadian Arctic. The white percentage increases in West Greenland. The Cod occurs along the coast of southern West Greenland, but it is not abundant, except for short periods with little drift-ice.

The drift-ice is relatively stable throughout the winter off Northeast Greenland where the climate is favourable for the Reindeer and the Musk Ox. The populations increase.

B). **The drift-ice pulsation stage** (approx. 1860–1910). The ice of the Arctic Ocean drifts into the Atlantic in larger amounts than before. The East Greenland Current and the East Greenland Ice advance far north into Davis Strait either early or late in summer. The populations of sea mammals and sea birds decrease in central West Greenland. The climate becomes relatively unstable and wet. The wet winters are unfavourable for the Reindeer in West Greenland and the population decreases.

The population of white Arctic Fox decreases in Canadian Eastern Arctic and that of blue Arctic Fox increases in central and northern West Greenland. The white percentage stagnates or decreases in northern West Greenland. Cod occur only occasionally in short periods with early drift-ice in Davis Strait.

The drift-ice moves relatively fast off Northeast Greenland where the population of Musk Ox stagnates owing to wet winters. The Reindeer becomes extinct in Northeast Greenland.

The population of Greenland Whale stagnates in the Atlantic region.

C). **The drift-ice melting stage** (approx. 1910–1960?). The East Greenland Ice decreases in Davis Strait where the Irminger Current has a dominating influence on climate and production. The populations of sea mammals and sea birds increase in northern West Greenland and in East Greenland. The Reindeer population of West Greenland has ample summer grazing, but the winter pastures are often covered by snow and ice—and the population stagnates in all West Greenland, except for the short dry period 1910–20.

The population of white Arctic Fox increases and culminates in all eastern Canadian Arctic and in Northeast Greenland, and that of blue Arctic Fox in all West Greenland. The white percentage decreases in central and increases in northern West Greenland. Cod occur abundantly along the coast of West Greenland and multiply in Greenlandic waters. The population increases in periods with little or early drift-ice and decreases in periods with late drift-ice in Davis Strait.

Northeast Greenland has ample vegetation and the Musk Ox population usually thrives and increases, but is often threatened by catastrophes in wet autumns and winters when Greenland Sea has little or no drift-ice.

At present a new "drift-ice stagnation stage" is beginning (approx. 1960–?). (See also the summary p. 193).

## Synopsis

Studiet af Østgrønlandsisens fremtrængen i Davisstrædet gør det muligt at skelne mellem *tre vigtige drivisstadier*, der afløser hinanden, og som har afgørende indflydelse på klimaet og økologien overalt i Grønland.

A) **Drivis-stagnationsstadiet** (ca. 1810–60). Der er relativ ringe bevægelse i Polhavets drivis. Østgrønlandsisen trænger ikke ret langt nordpå i Davisstrædet, hvor Den canadiske Strøm har en dominerende indflydelse. Klimaet i det nordlige Vestgrønland er relativt koldt, tørt og stabilt. Bestandene af havpattedyr og søfugle koncentrerer sig langs kysterne af det centrale Vestgrønland.

Renen har gunstige overvintringsforhold i det centrale og nordlige Vestgrønland, hvor bestanden vokser og kulminerer. Opgangen i renbestanden gælder ikke områderne syd for Godthåb. Torsken forekommer langs kysterne af det sydlige Vestgrønland, men ikke talrigt, bortset fra korte perioder med ringe drivis.

Hvidrævebestanden kulminerer i de syd-østlige dele af arktisk Canada. Hvidprocenten tiltager i Vestgrønland.

Drivisdækket er relativt stabilt udfor Nordøstgrønland, hvor vinterklimaet er gunstigt for renen og moskusoksen. Bestandene tiltager.

B) **Drivis-pulsationsstadiet** (ca. 1860–1910). Polhavets drivis bryder op og driver ned i Atlanterhavet i større mængde end hidtil. Den østgrønlandske Strøm og Østgrønlandsisen trænger langt nordpå i Davisstrædet enten tidligt eller sent på sommeren. Bestandene af havpattedyr og søfugle aftager i de centrale områder af Vestgrønland. Klimaet bliver relativt vådt og ustabilt. De våde vintre er ugunstige for renen i Vestgrønland. Bestanden aftager til et minimum.

Hvidræven aftager i antal i de østlige egne af arktisk Canada, mens blåræven tiltager i antal i de centrale og nordlige egne af Vestgrønland. Hvidprocenten stagnerer eller aftager i det nordlige Vestgrønland. Torsken forekommer kun lejlighedsvis ved Vestgrønland i korte perioder med tidlig drivis.

Drivisen er i relativ hurtig bevægelse udfor Nordøstgrønland, hvor moskusoksebestanden stagnerer på grund af nedbørsrige vintre. Renen uddør i Nordøstgrønland.

Bestanden af grønlandshvaler stagnerer og går ned til et minimum i det atlantiske område.

C) **Bortsmeltningsstadiet** (ca. 1910–1960?). Mængden af Østgrønlandsis aftager i Davisstrædet, hvor Irmingerstrømmen får større indflydelse på klima og produktion. Bestandene af havpattedyr og søfugle vokser i Nordvestgrønland. Vestgrønlands rener har rigelig sommergræsning, men vintergræsgangene er hyppigt dækket af sne og is, hvorfor bestanden stagnerer, bortset fra en tør periode (1910–20), hvor en kortvarig fremgang i renbestanden også omfatter Frederikshåb distriktet.

Bestanden af hvidræve tiltager og kulminerer i hele det østlige arktiske Canada og i Nordøstgrønland. Blårævebestanden tiltager og kulminerer i hele Vestgrønland. Hvidprocenten aftager i det centrale og tiltager i det nordlige Vestgrønland.

Torsken forekommer talrigt langs kysten af Vestgrønland og yngler i grønlandske farvande. Torskefiskeriet er størst i perioder med ringe eller med tidlig drivis, mens det aftager i perioder med sen drivis i Davisstrædet.

Nordøstgrønland har rigelig vegetation, og moskusoksebestanden trives og øges, men mod periodens slutning har den ofte været truet af katastrofer i nedbørsrige vintre, hvor Grønlandshavet har haft ringe eller ingen drivis sent på efteråret.

Bortsmeltningsstadiet fortsætter umiddelbart i et nyt stagnationsstadium, der for tiden synes at være under udvikling (ca. 1960–?). Renbestanden er under vækst i Vestgrønland, og torskefiskeriet viser tegn på stagnation.

(Se også resuméet side 200).

## РЕЗЮМЕ

Изучение продвижения восточногренландского льда в проливе Дейвиса дает возможность различать три важные стадии дрейфующего льда, которые сменяют друг друга и оказывают решающее влияние на климат и экологию повсюду в Гренландии.

А/ СТАДИЯ ЗАСТОЯ ДРЕЙФУЮЩЕГО ЛЬДА /прибл. 1810–60/. Относительно небольшое движение в дрейфующем льде Северного Ледовитого океана. Лед восточной части Гренландии не продвигается делеко на север в проливе Дейвиса, где преобладает Канадское течение. Климат в северной части Западной Гренландии относительно холодный, сухой и устойчивый. Морские млекопитающие и морские птицы концентрируются вдоль берегов центральной западной Гренландии. Северный олень имеет благоприятные условия зимовки в центральной и северной частях Западной Гренландии, где его поголовье растет и кульминирует. О росте оленьего стада нельзя говорить в районах, расположенных к югу от Готхоба. Треска водится вдоль берегов южной части Западной Гренландии, но не в большом количестве, не считая коротких периодов с небольшим дрейфующим льдом. Белые песцы преобладают по численности в южной части арктической Канады. Процент белых песцов растет в Западной Гренландии. Покров дрейфующего льда относительно стабилен у берегов северовосточной Гренланлии, где зимний климат благоприятен для северного оленя и для мускусного быка. Поголовье растет.

Б/ СТАДИЯ ПУЛЬСАЦИИ ДРЕЙФУЮЩЕГО ЛЬДА /прибл. 1860–1910/. Дрейфующий лед Северного Ледовитого океана взламывается и лрейфует вниз в Атлантический океан в бо́льшем количестве, чем до сих пор. В проливе Дейвиса восточногренландское течение и восточногренландский лед проникают далеко на север в начале или в конце лета. Наличность морских млекопитающих и морских птиц уменьшается в центральных областях Западной Гренландии. Климат становится относителтно сырым и неустойчивым. Сырая зима неблагоприятна для северного оленя в Западной Гренландии. Поголовье уменьшается до минимума. Численность белых песцов падает в восточных областях арктической Канады, в то время как численность голубых песцов возрастает в центральных местностях Западной Гренландии. Процент белых песцов застаивается или уменьшается в Западной Гренландии. Треска появляется у берегов западной Гренландии только временами в короткие периоды с ранним дрейфующим льдом.

Гренландский тюлень покидает бухту Диско и направляется к северу. Дрейфующий лед движется относительно быстро у берегов северовосточной Гренландии, где из-за большого количества осадков, выпадающих зимой, поголовье мускусного быка не растет. Северный олень вымирает в северовосточной Гренландии. Поголовье гренландского кита находится в застое и понижается до минимума в атлантической области.

В/ СТАДИЯ ТАЯНИЯ ЛЬДОВ /прибл. 1910–1960?/. Количество восточногренландского льда уменьшается в проливе Дейвиса, где все бо́льшее влияние на климат и промысел приобретает течение Ирмингера. Наличность морских млекопитающих и морских птиц растет в северозападной Гренландии. Северный олень в Западной Гренландии пользуется обильными летними пастбищами, но зимние пастбища часто покрыты снегом и льдом, вследствие чего

поголовье подвергается застою, не считая сухого периода /1910–20/, когда кратковременное увеличение наличности распространилось также и на район Фредериксхоб.

Наличность белых песцов увеличивается и кульминирует в северовосточной арктической Канаде и в северовосточной Гренландии. Количество голубых песцов увеличивается и кульминирует по всей Западной Гренландии. Процент белых песцов понижается в центральной части и увеличивается в северной части Западной Гренландии. Треска встречается в большом количестве вдоль побережья Западной Гренландии и размножается в гренландском фарватере. Улов трески больше всего в периоды с небольшим или ранним дрейфующим льдом в проливе Дейвиса, но уменьшается в периоды с поздним дрейфующим льдом. Северовосточная Гренландия имеет богатую растительность, и стадо мускусного быка здесь процветает, хотя к концу периода в зимы с большим количеством осадков, когда в Гренландском море поздней осенью совсем не было или было очень мало дрейфующего льда, ему часто угрожали каткстрофы.

Стадия таяния льдов вступает в новую стадию застоя, которая, повидимому, в настоящее время находится в процессе развития /прибл. с 1960–?/. Стадо северного оленя растет в Западной Гренландии, и промысел трески обнаруживает признаки застоя.

# PREFACE

The present author was fortunate enough to study during a period when Knud Rasmussen, Ejnar Mikkelsen, and Lauge Koch created new interest in Denmark in active exploration of Greenland, and when Ad. S. Jensen, R. Spärck, M. Degerbøl, and G. Thorson who were then, or later became, professors at the University of Copenhagen, projected this interest to the students.

During the summer of 1936, the author participated in Finn Salomonsen's expedition of natural history to the Upernavik and Thule districts, and he also took part in the Danish Thule and Ellesmere Island Expedition 1939–41 under J. van Hauen, the zoological committee members of which were M. Degerbøl and R. Spärck. The years 1941–45 were spent in Godthåb and on travels in West Greenland. In 1948, the Zoogeographical Investigations in Greenland (Grønlands zoogeografiske Undersøgelser) was founded on the initiative of M. Degerbøl and R. Spärck, with the present author as leader. The Ministry for Greenland (Ministeriet for Grønland) has since made funds available for annual expeditions.

A number of summer trips and a few winter travels to Greenland have since been accomplished: In 1948 to the Julianehåb district, Disko Bugt (1949), Godthåb district (1950), the Upernavik and Thule districts (1951), Sukkertoppen district (1952), Mesters Vig in East Greenland (1953), the Kong Oscars Fjord and Kejser Franz Josephs Fjord areas (1954), Nordre and Søndre Strømfjord (1955), Scoresby Sund (1956), Julianehåb district (1957), Central East Greenland (1958), Godthåb (1959), West Greenland and later Scoresby Sund (1961), Søndre Strømfjord (1962), Holsteinsborg district and later Scoresby Sund (1964), and 1965 to the central parts of West Greenland. In the summers of 1954, 1958, and 1965, Torben Andersen took part in the zoogeographical studies and made collections in Greenland, and has also assisted the author with the job of sorting and drawing. All expeditions have been sponsored by the Zoological Museum of Copenhagen University where the author has been employed since 1948.

The Zoogeographical Investigations has received exceptional assistance from Eske Brun, Department Head, who in the Ministry for Green-

land and in the Commission for Scientific Research in Greenland (Kommissionen for videnskabelige Undersøgelser i Grønland) has followed work in the field with great interest and assistance.

From former "Landsfoged" (Inspector) in Greenland, PH. ROSENDAHL, who has a thorough knowledge of hunting and fishing conditions in Greenland, much valuable information and help has been received in the procurement of material. Likewise, "Udstedsbestyrer" (Settlement Manager) H. JØRGENSEN has rendered a valuable contribution by copying the colonial accounts kept at the Copenhagen Record Office ("Rigsarkivet").

Many institutions, and the scientists working in same, have furthered the work through exchange of information and forwarding of material, namely: Den kongelige grønlandske Handel, Grønlands Fiskeriundersøgelser, Arktisk Institut, Det danske Meteorologiske Institut, Nationalmuseet, Geografisk Institut, Rigsarkivet, Det kongelige Bibliotek, Marinens Bibliotek, Universitetsbiblioteket – and abroad: Zoologisk Museum, Oslo; Tromsø Museum, Tromsø; Zoologiska Institutionen, Lund; Naturhistoriska Museet, Göteborg; Naturhistoriska Riksmuseet, Stockholm; Smithsonian Institution, Washington; Zoological Museum, Moscow, and British Museum, London. Skull material from Canada has been procured by A. LAURENT-CHRISTENSEN.

Further, the author is indebted to many scientists for valuable discussions: F.W. BRAESTRUP, M. DEGERBØL, H. JOHANSEN, PAUL M. HANSEN, G. HØPNER PETERSEN, C. A. JØRGENSEN, EIGIL KNUTH, LAUGE KOCH, HELGE LARSEN, J. MELDGAARD, A. WEIDICK, ULRIK MØHL, FINN SALOMONSEN, I. SESTOFT, C. L. VEBÆK, all from Denmark, and C. ELTON from England, A. W. F. BANFIELD, C. R. HARINGTON, A. H. MAC PHERSON, JOHN S. TENER from Canada, and F. H. FAY and MAX C. BREWER from Alaska, BIRGER RASMUSSEN, THOR LARSEN, MAGNAR NORDERHAUG and TORGER ØRITSLAND from Norway.

The translation into English was made by JØRGEN S. PLESNER, RIGMOR E. HOLBROOK and TOTO SØLLING, and the tables were drawn by TORBEN ANDERSEN and E. LEENDERS.

The translation of the Russian abstract was made by HANS JOHANSEN.

In addition to thanking the above mentioned persons and institutions, the author feels deeply indebted to numerous explorers and scientists whose results have been fundamental to this thesis, and whose works are listed in the bibliography.

# INTRODUCTION

The history of Greenland is a testimony of prosperity and poverty following each other in rapid succession. Oral as well as written records from the last centuries, and archaeological finds from the last four-five thousand years, unfold the same picture: The periods of prosperity, after a few scores or at most a few hundred years, were succeeded by correspondingly long periods of decline, when settlements, parts of the country, or all of Greenland were depopulated and lay uninhabited.

Since the peoples who have inhabited Greenland from time to time have all lived from the animals of the sea or land, or from domestic animals they had brought along, it must have been easy to procure these animals during the good periods, but very difficult or impossible during the bad periods.

The climatic fluctuations forced the sea mammals and sea birds of Greenland to look for new foraging grounds, during which they did not follow the coast from north to south, but crossed Baffin Bay and Davis Strait several times, as an immigration also took place from the coast of East Greenland to the sea north of Iceland. In all cases migration during changing climatic periods moved periodically toward Greenland and then away from Greenland again, leaving Man starving behind.

Due to these conditions, Man has frequently been forced to leave Greenland if possible, or has died out in the country. A number of animal species that are associated with the land or the coast have suffered the same fate during periods of extreme climatic fluctuations. Some have immigrated back, others have not. Examples we know today are the Wolf, the Wolverine and the Great Auk that formerly occurred in Greenland, but these are hardly the only ones. Possibilities of finding remains in the ground are very slight because sizeable excavations do not take place, nor is peat cut to any extent owing to the permafrost.

The best material for throwing light on animal life and climatic fluctuations of Greenland in the past, has been uncovered by the archaeologists in their excavations of Eskimo and Norse settlements, and considerable bone material has been brought home for determination by the specialists of the Zoological Museum in Copenhagen, i.e.: HERLUF WINGE, MAGNUS DEGERBØL, and ULRIK MØHL.

This bone material, as well as historical records, shows that the favourable game areas have in some periods been located in North Greenland, in other periods in Northeast or Southwest Greenland, and that the location of the good whaling and sealing grounds has varied a great deal through the ages.

The oldest evidence of land mammals existing in Greenland was brought to light by EIGIL KNUTH in Peary Land, where e.g. the Musk Ox lived some 4500 years ago and where several cultures emerged during the period 2500 B.C. to 500 B.C.

West and East Greenland did not become inhabitable for land game on a large scale until the shores of Baffin Bay and Greenland Sea became covered by ice that lay firm throughout autumn and winter, stabilizing the winter climate.

HELGE LARSEN, JØRGEN MELDGAARD, and THERKEL MATHIASSEN have revealed Reindeer cultures in West Greenland from the periods between approx. 1410 B.C. and 880 B.C. (Sarqaq Culture) and between approx. 100 B.C. and 410 A.D. (Dorset Culture), H. TAUBER 1964 p. 322. These were followed by a late Dorset Culture around 700, the Norse Culture in Southwest Greenland 985 to approx. 1500, and the Whaling Culture in Northwest Greenland approx. 900–1200, succeeded by related cultures up to the present time (TH. MATHIASSEN, E. HOLTVED and others).

All the above mentioned cultures emerged in Greenland in periods favourable for the animals, and disappeared in unfavourable periods. P. HARDER and AD. S. JENSEN (1910), and P. NØRLUND (1924) produced evidence showing that the changed living conditions for animals and Man in Greenland and surrounding seas were caused by climatic fluctuations.

F. W. BRAESTRUP (1941) shows in his work on the Arctic Fox in Greenland that the Greenland populations of Arctic Fox and Ptarmigan are subject to considerable yearly quantitative fluctuations. BRAESTRUP has found, in the records and accounts of the Royal Greenland Trade Department, important statistical material illustrating the bags of Arctic Fox in Greenland during a long succession of years (1793–1939) as well as the bags of Ptarmigan (1882–1939).

The present author has brought to light further material from the Greenland accounts, in particular regarding sea mammals, sea birds, and land mammals, demonstrating that during the course of time these animals have been subject to great quantitative fluctuations and great geographical shifts.

Accounts of sales to Greenlanders of rifles, gun powder, lead, etc. and changes in the numbers of inhabitants were also studied. See text p. 50 and graphs p. 100.

The graphs concerning products purchased from Greenlandic hunters are based on figures extracted from the following sources:

Koloniregnskaberne (beginning 1793), Rigsarkivet. Main source.
Skematiske Indberetninger (beginning 1861), kept in Rigsarkivet.
Meddelelser fra Direktoratet for den kongelige grønlandske Handel 1882–1908, published.
Beretninger og Kundgørelser vedrørende Kolonierne i Grønland 1909–37, published.
Beretninger vedrørende Grønland, beginning 1938, published.
Indberetninger fra kolonierne angående tilstandene i Grønland, beginning 1882, Rigsarkivet.
Sammendrag af Grønlands fangstlister (Hunting statistics), published in Greenland since 1862?, in Copenhagen since 1955.

All products from Greenland were monopolized commodities during all years up to 1950. However, the inhabitants have had a certain domestic consumption which cannot be seen from the records. Where the figure from one of the trading places is missing in the records for a single year, it is substituted in the graphs by the average of the one preceding it and the one succeeding it. Most of the figures from the years 1813–15 are missing owing to war with England.

Upernavik ceased to be an independent colony in 1790, was reestablished in 1805, but in 1814 the last Danes left the district and Upernavik did not become an independent colony again until 1826. During the periods when Upernavik was not independent, the skins from this colony presumably went to Godhavn. Angmagssalik and Scoresbysund in East Greenland were not established as colonies until 1894 and 1925, respectively, and Thule in North Greenland in 1910.

On the face of it, the quantitative fluctuations at different places run courses independent of each other; this, however, is not the case, in that a drop in one geographic area very often corresponds to a rise in another. All animals are dependent on the climate, the various factors of which may influence one biotope (e.g. the coast) favourably and at the same time another biotope (e.g. the tundra) unfavourably — and they may have a favourable effect in one geographic area and at the same time an unfavourable effect in another.

The study of these conditions has necessitated an extensive and time-consuming analysis of the natural conditions in and around Greenland during long periods and at all seasons.

Geographically, Greenland is an island which at the present time is partly covered by a gigantic ice cap, and surrounded by two cold surface currents and two warm deepsea currents. The two former are the Canadian Current in the northwest, and the East Greenland Current

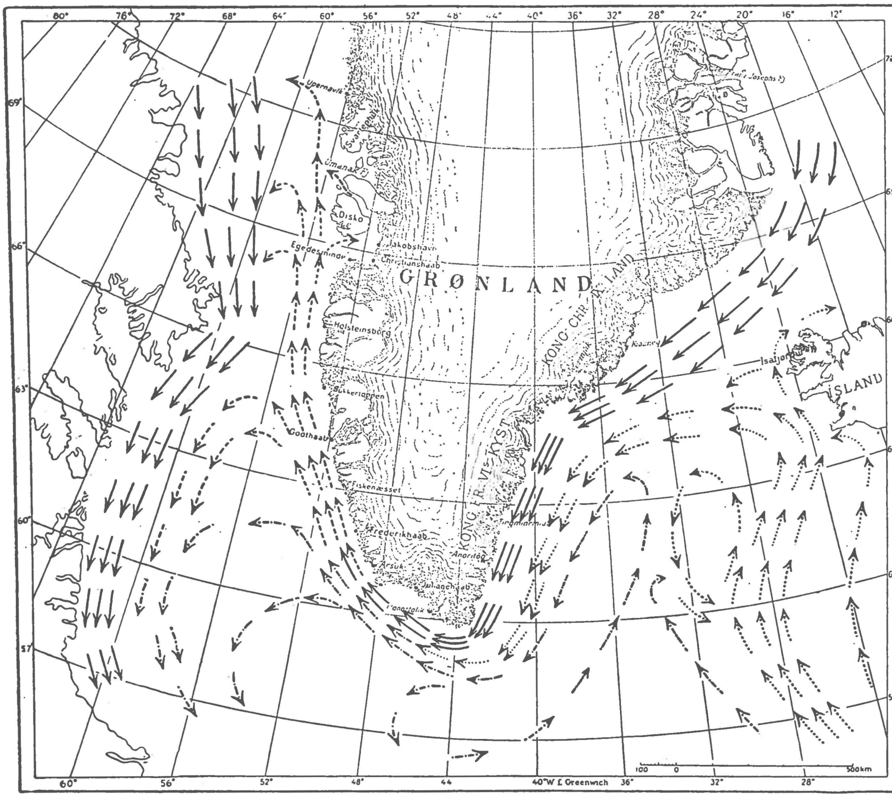



Fig. 3. Currents around South Greenland, simplified after KIILERICH, HERMANN and THOMSEN – here reproduced after P. M. HANSEN and HERMANN 1953 p. 8.

⟨———— Arctic water. (Canadian Current and East Greenland Current.)
⟨·········· Atlantic water. (Irminger Current.)
⟨·–·–·–·– Subarctic mixed water.
⟨– – – – – – – West Greenland Current.

in the east and southwest. The two latter are the return current of the North Atlantic Drift in the northeast, where it runs underneath the East Greenland Current, and the Irminger Current in the southwest, where it runs underneath the East Greenland Current northwards in Davis Strait.

The East Greenland Current and the Irminger Current normally mix along the coast of West Greenland, (but apparently not always to the same degree). The preferred feeding ground of the Arctic sea mammals and sea birds in Davis Strait seems to be the area where the Irminger water meets the water of the Canadian Current. In certain periods this area has been situated far north in Davis Strait, in others far south.

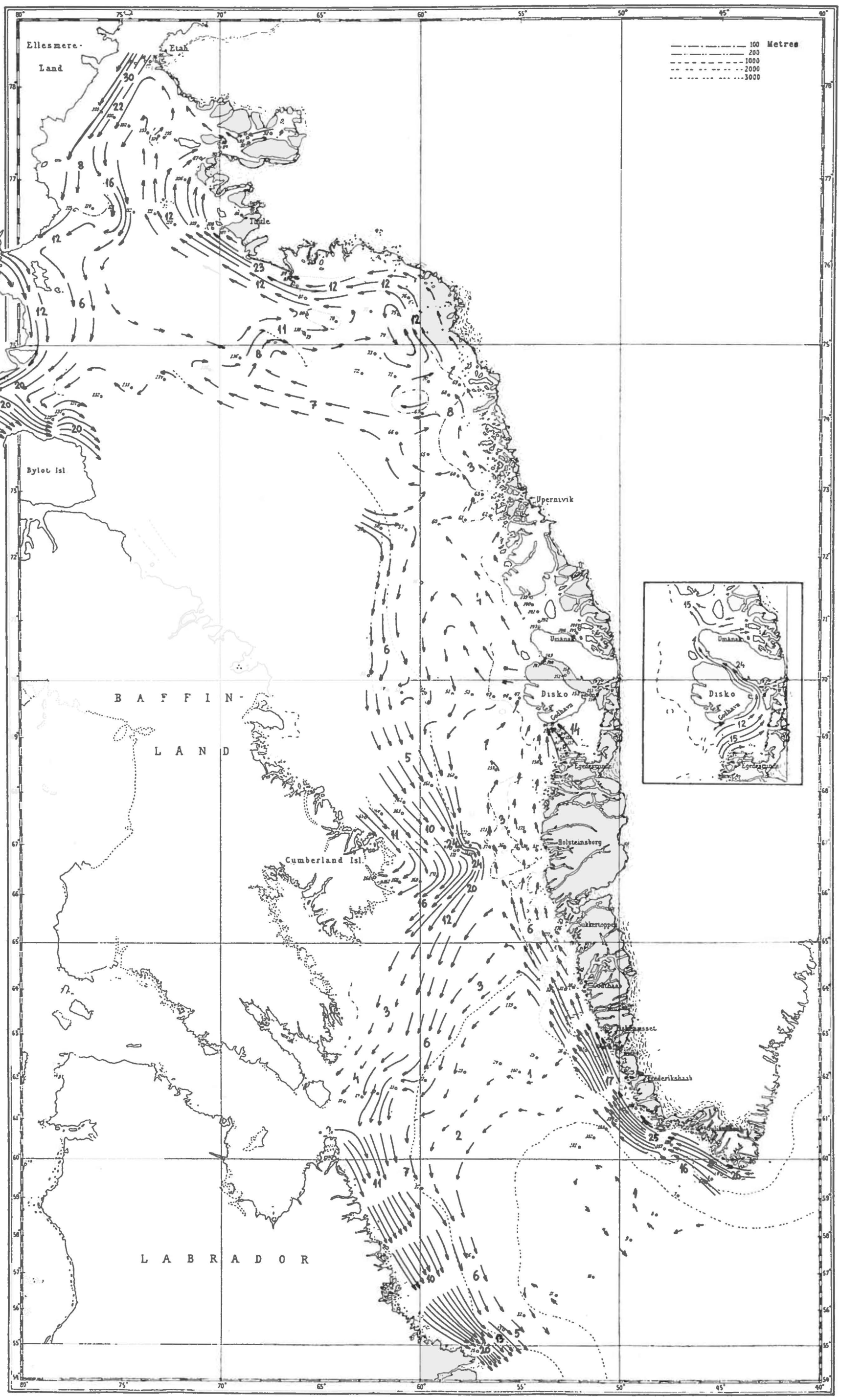



Fig. 4. The currents at the sea surface in Baffin Bay and Davis Strait. Reproduced after ALF B. KIILERICH 1939 Plate 3.

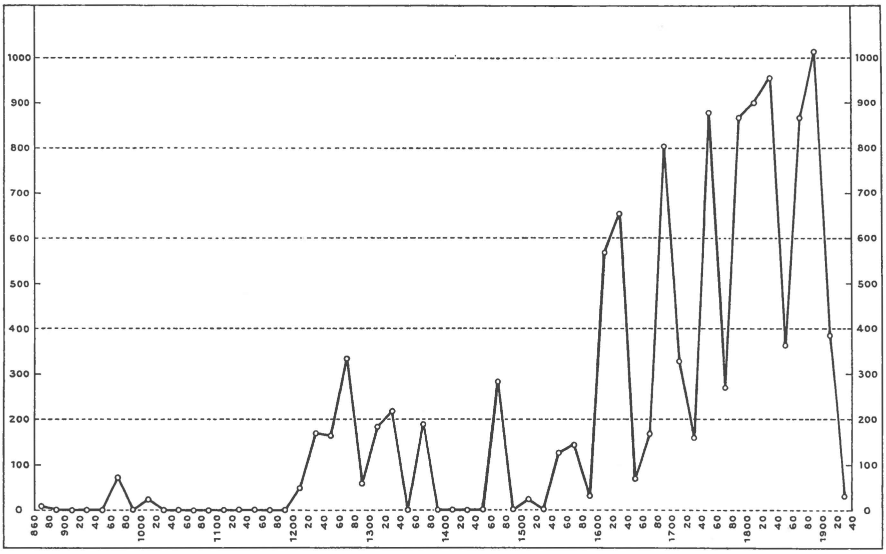


Fig. 5. Curve showing the number of weeks with ice multiplied by the number of areas with ice around Iceland for twenty-year periods, from 865 to 1939. After LAUGE KOCH 1945 p. 259.

At the present time, the two cold surface currents carry great amounts of drift-ice from the Arctic Ocean into the Atlantic and Davis Strait. The drift-ice varies in quantity from year to year. During certain epochs of time it appears not to have reached South Greenland at all, while in others it has occurred in great volume. The time of year of its main arrival has alternated between early spring and late summer (or between winter and summer). It is shown in the present paper that this alternation causes serious ecological disturbances in Davis Strait and surrounding land areas.

In their studies on drift-ice TH. THORODDSEN (1916–17), C. I. H. SPEERSCHNEIDER (1931) and LAUGE KOCH (1945) have brought to light much valuable material to elucidate the intensity and duration of the drift-ice periods of the last millennium. The works of these authors, together with studies of temperature, precipitation and wind activity, have been an important clue to the understanding of many of the natural conditions which determine the fluctuations in number of the Arctic and Atlantic species in Greenland, and their shifting geographical distribution.

Since 1876 observations have been carried out on the surface temperature of the sea in Davis Strait during the sailing season. The material has been worked up by JENS SMED (1947) and F. HERMANN (1953 and 1965). Unfortunately, observations from the winter period are scarce.

# THE EAST GREENLAND ICE AND THE BAFFIN BAY ICE

**The East Greenland Ice** (also called "Storisen") has been the object of a thorough study by TH. THORODDSEN, 1884 and 1916–17 and later by LAUGE KOCH, 1945, who in "The East Greenland Ice" has collected and discussed the available information on drift-ice, its origin in the Arctic Ocean and its varying occurrence off Iceland from the Landnám epoch until the present time, i.e. 865–1939. These studies show that during certain periods of years the drift-ice did not occur at all at Iceland, while at other times it blocked smaller or larger stretches of the coast, see fig. 5.

The occurrence of East Greenland Ice off West Greenland has been discussed by C. I. H. SPEERSCHNEIDER, 1931, who in "The State of the Ice in Davis Strait" has given an outline of the drift-ice in Davis Strait 1820–1930, "based on a scale of 0–10".

In general, SPEERSCHNEIDER arrives at the conclusion "that the period 1820–60 was poor in ice, the period 1860–1900 was rich in ice, and then again a period poor in ice from 1900– ".

As SPEERSCHNEIDER's curve is partly based on a personal evaluation of the material collected on the ice conditions, it is unfortunately not possible to extend it beyond 1930. This author has therefore set up a curve showing merely the average advance of the drift-ice into Davis Strait in nautical miles northwest of Kap Farvel during the months of May–June–July–August. For the years 1820–1896, the data have been deduced from SPEERSCHNEIDER's treatise (where data are missing for one or more months, the average from the months in the preceding and succeeding years has been used). For the years 1897–1957, the information has been measured from the ice maps of Nautisk-Meteorologisk Årbog. The period 1940–45 has not been published; this material has been prepared by M. LORCK.

This new curve, showing in miles the advance of the East Greenland Ice in Davis Strait, deviates little from SPEERSCHNEIDER's curve "based on a scale of 0–10", and it can be extended at any time. Fig. 8 shows the curves for August and May respectively, in 3-year sliding averages, and at the bottom, in a 31-year sliding average for the entire summer, i.e. May + June + July + August.

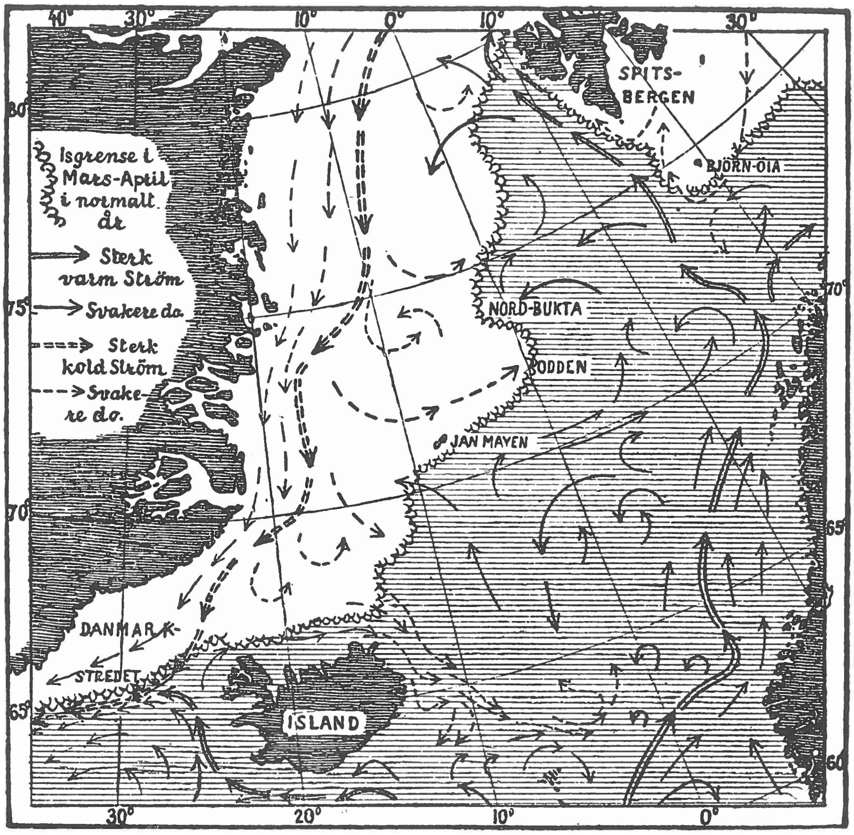



Fig. 6. Currents and ice conditions in Greenland Sea.
After FRIDTJOF NANSEN 1924.

The curves here shown give no information on the vertical or horizontal extension of the drift-ice. They do, however, give a good picture of how much the northwards drift of the East Greenland Ice into Davis Strait varies through the summer and from year to year.

Three drift-ice stages are recognized, i. e., (A) **stagnation stage** 1810–60, (B) **pulsation stage** 1860–1910, and (C) **melting stage** 1910–60, fig. 8 bottom. These drift-ice stages play an important rôle for climate and ecology in all Greenland (as summarized p. 7) and in all Arctic (as summarized pp. 94–99). See also fig. 42 A–B–C.

The "pulsation stage" is the start of a warmer climate with increasingly Atlantic conditions in Davis Strait. (The effect of inflow of Atlantic water into the Arctic Ocean is demonstrated by M. RODEWALD 1955 p. 96).

In his work on the ice in Davis Strait 1931 SPEERSCHNEIDER states that in the years when the drift-ice comes in large quantities early in the summer, it will come in smaller quantities late in the summer.

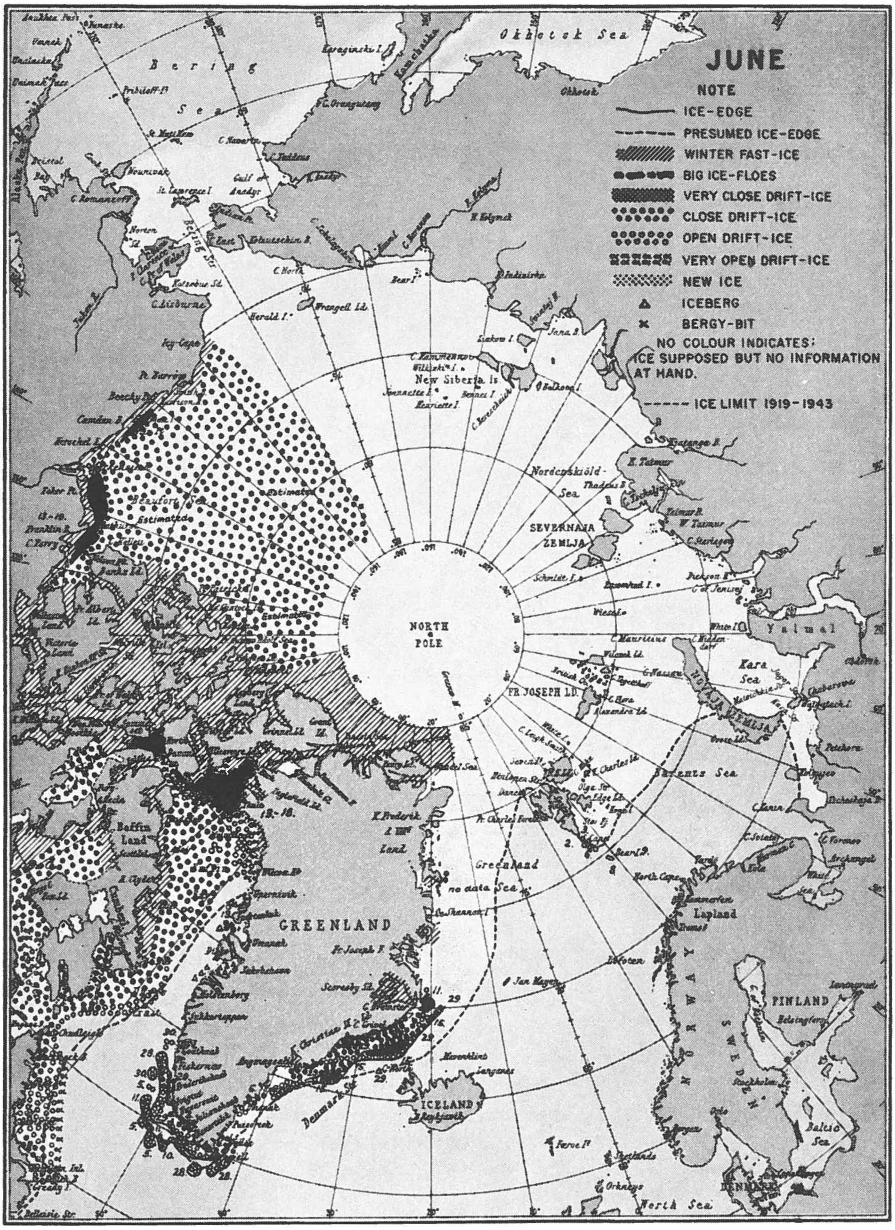



Fig. 7. The state of the ice in the Arctic seas in June 1955. After Nautisk-Meteorologisk Årbog 1955. The black areas in the drift-ice in Beaufort Sea and northern Baffin Bay indicate open water.

The alternation between early and late drift-ice is shown in fig. 8 (3-year sliding averages), and in fig. 9 (10-year sliding averages).

The curves fig. 9 demonstrate that since 1860 every second sun spot maximum coincides with a drift-ice maximum in May and a minimum

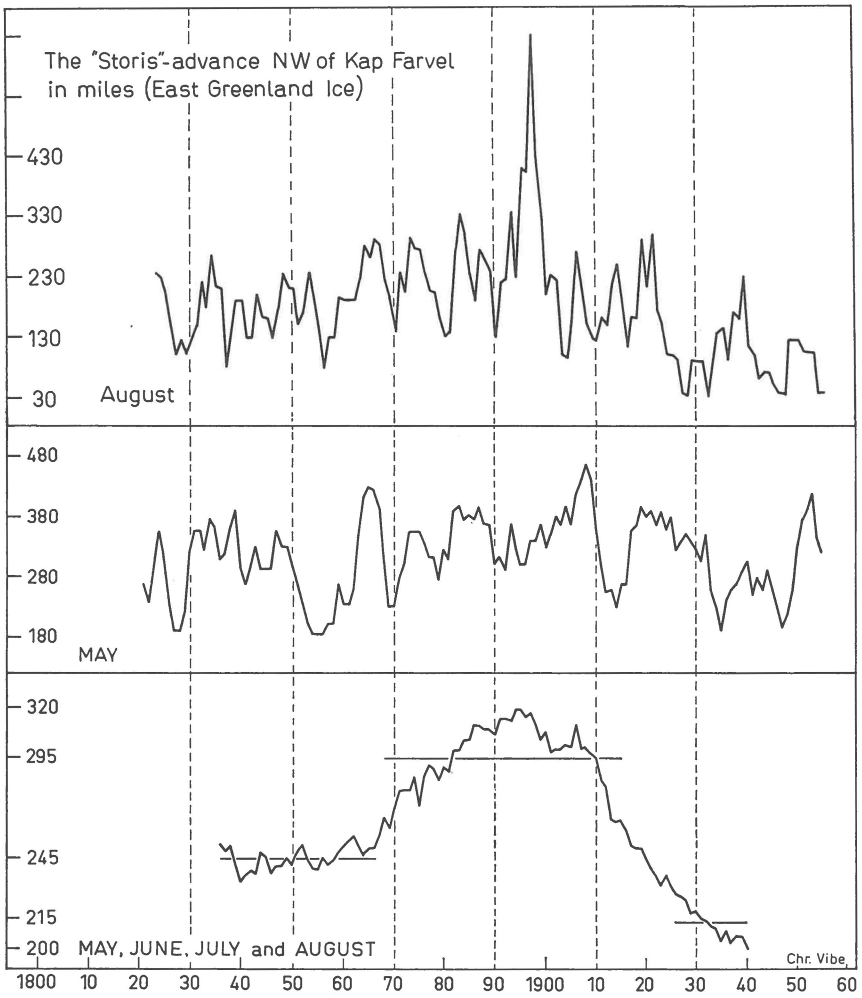



Fig. 8. The advance of the East Greenland Ice in Davis Strait in 3-year (August and May) and 31-year (May, June, July and August) sliding averages.
The lines at the bottom cover different drift-ice stages. On the following pages the "stagnation stage", the "pulsation stage", and the "melting stage" cover the years 1810–60; 1860–1910, and 1910–60, respectively.

in August. Hence, periods with early drift-ice occurs with intervals of 22 years, alternating with late drift-ice. This fact is especially clear during the pulsation and melting stages (1860–1960?), 4–11 in fig. 9. Before 1860 the rhythm seems to be different.

The acceleration of the drift-ice late in summer may create open water in the Greenland Sea and much precipitation in Northeast Greenland in the autumn. This often results in catastrophes for the Musk Ox population in that part of Greenland, see pp. 186–192.

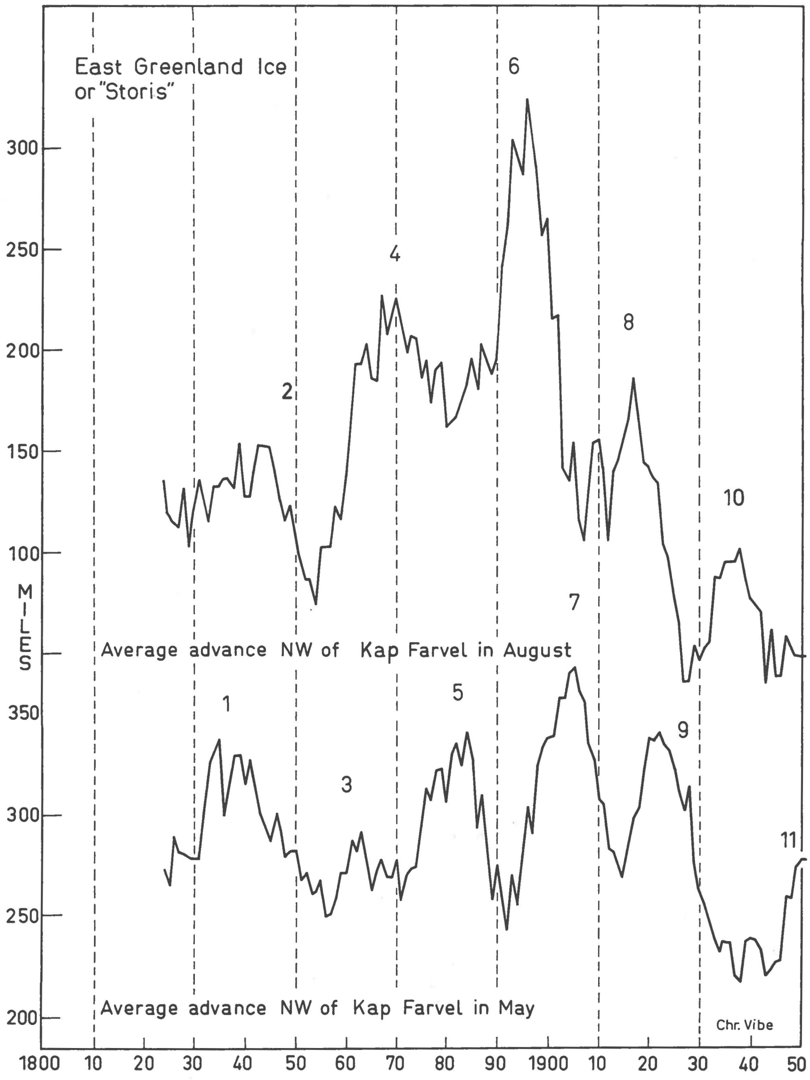



Fig. 9. The advance of the East Greenland Ice in Davis Strait (May and August) in 10-year sliding averages. The numerals 1–11 indicate the sun spot maxima 1837 to 1947.

Around 1855 the occurrence of East Greenland Ice in Davis Strait was remarkably small, fig. 10. The ice fields stayed north of Iceland.

The climate in northern West Greenland was cold and dry. The catch of Blue Arctic Fox was extremely small in Disko Bugt and in all northwestern Greenland.

During the drift-ice stagnation stages the late drift-ice rarely advances far north in Davis Strait, so the winter climate in northern and central West Greenland is mainly dominated by the Baffin Bay Ice. The

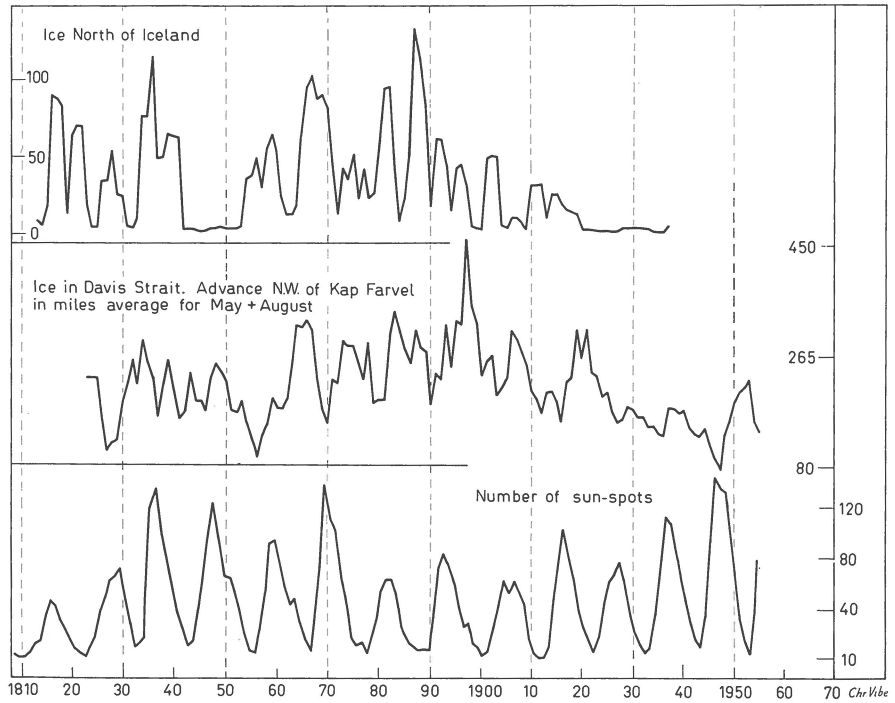



Fig. 10. The curve "Ice North of Iceland" is based on figures from LAUGE KOCH 1945 p. 256–57. It shows (in 3-year sliding averages) the number of weeks with ice multiplied by the number of areas with ice around Iceland. The curve "Ice in Davis Strait" shows (in 3-year sliding averages) the periods when ice occurs both early and late in summer.

The figures to the right of the sun-spot curve are the so-called "Wolf-figures". (Each sun-spot of a certain size is counted as one, and each group of sun-spots is counted as 10. F. HOYLE 1962 p. 216).

precipitation is low, as for instance around 1810–1860, a good Reindeer period. But the animal populations of the coast and sea stagnate during the cold winters.

During pulsation stages the late drift-ice advances far north in Davis Strait. The winter climate in northern and central West Greenland is dominated by the East Greenland Ice and the mixed West Greenland Current, and too much moisture reaches the inland pastures, e. g. around 1865 and 1895, difficult periods for the Reindeer population, fig. 91.

The years following August drift-ice periods were very cold in Scandinavia. (Trondheim had cold winters around 1840, 1870, 1900, 1920, and 1940, A. RØSTAD 1955 p. 15).

The white percentage of Arctic Fox in Southwest Greenland was high in periods with drift-ice late in summer in Davis Strait, and the number of Greenland Whale and Arctic Eider declined catastrophically in the periods when the late drift-ice advanced far north in the Strait.

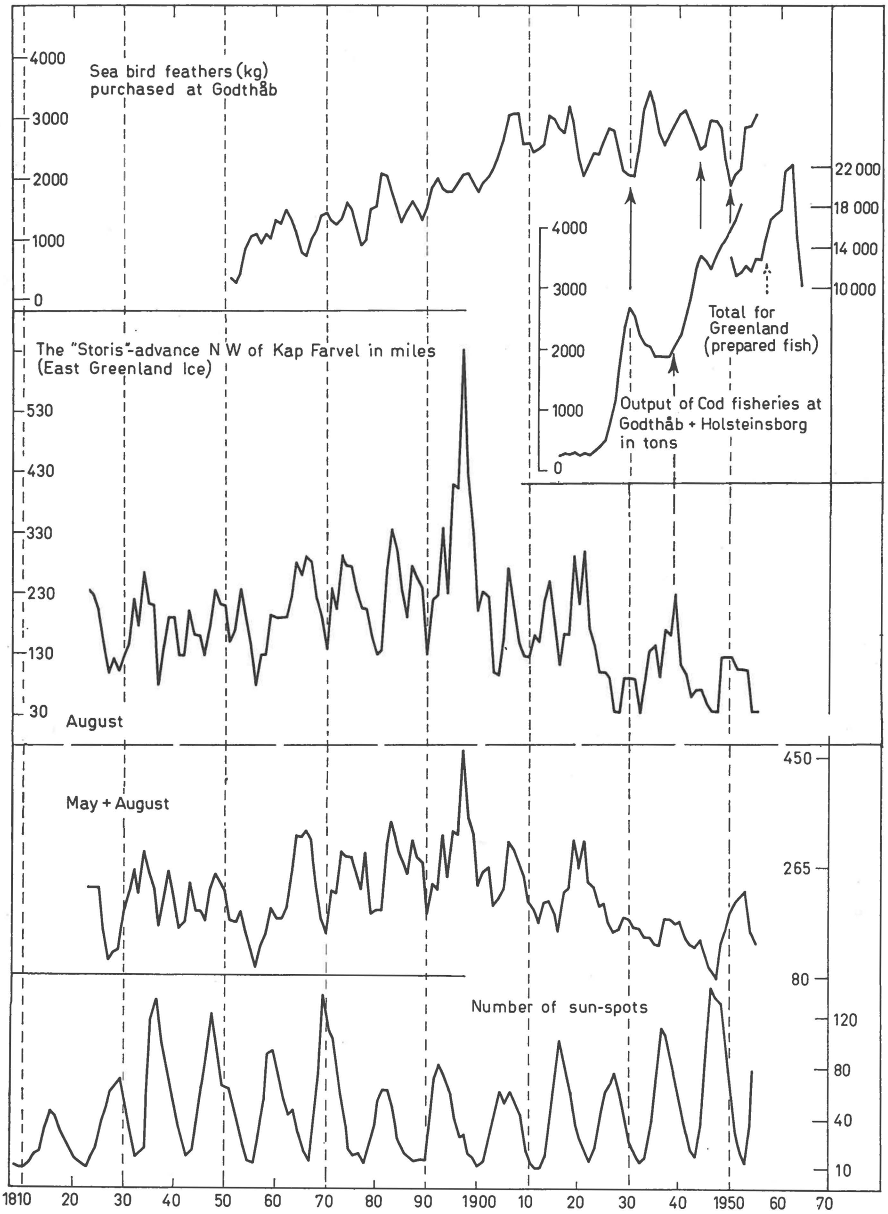



Fig. 11. The curve "Output of Cod Fisheries" is based on Paul Hansen 1953 p. 62–63 (here in 3-year sliding averages). The last part of the curve is based on figures obtained from Den kongelige grønlandske Handel 1964.
The sea bird curve and the two ice curves are in 3-year sliding averages.

Fig. 10 shows a curve (in 3-year sliding averages) of the advance of the drift-ice in Davis Strait in early and in late summer (May + August). This shows two or three drift-ice advances between the sun-spot maxima.

These drift-ice curves of 5–6 years or 3–4 years are presumed to cause the corresponding biological curves in certain areas of the Arctic.

The four characteristic biological curves in West Greenland, i.e. the appr. 22-year curve (Eider fig. 26), the 11-year curve (Ptarmigan fig. 84, Harp Seal fig. 42), the 5–6 year curve (Ringed Seal fig. 32 and 33, and sea birds fig. 31), and the 3–4 year curve (white Arctic Fox fig. 79) appear to lead back to the double sun-spot curve, the sun-spot curve proper, half the curve, and one third of it.[1])

The rhythm of the different biological curves seems to be constant during the duration of a drift-ice stage, but it may alter at the beginning of a new stage.

Attention must therefore be directed toward the *influence of the sun-spots on the movements of the North Atlantic low-pressure area, the influence of this on drift-ice and sea currents, and the time of the year, when this influence is strongest.*

Fig. 10 shows further the alternating occurrence of the drift-ice off Iceland and in Davis Strait.

Fig. 11 shows curves of the August drift-ice in Davis Strait, the catch of Cod at Godthåb + Holsteinsborg (P. M. HANSEN 1953) and for all of Greenland and the purchases of sea bird feathers at Godthåb.

The years with few sea birds at Godthåb are years with much drift-ice in both May and August. The years with few Cod at Godthåb + Holsteinsborg are years with much drift-ice in August.

When the good Cod fishery declinced around 1940, it was owing to the fact that before 1940 the East Greenland Ice arrived mostly late in summer (August), i.e. *outside the normal season*, and the summer temperature in Southwest Greenland remained low. The balance in the production of the sea was disturbed.

*We may expect a serious decline in the Cod fisheries in all periods with drift-ice late in summer—and especially during a pulsation stage.*

The observation material (SPEERSCHNEIDER 1931 and "Nautisk-Meteorologisk Årbog") available on the **Baffin Bay Ice**, which in Greenland is called "Vestisen", indicates that this ice lies closest to the Greenland coast (Holsteinsborg-Egedesminde-Disko) during cold winters. It drifts onto the coast in the winter and remains there until fairly late in spring and influences the air temperature, Dec., Jan., Febr. in fig. 16. Simultaneously the East Greenland Ice arrives late in Davis Strait. There are many calm days at Upernavik and the populations of sea birds in Northwest Greenland decrease, fig. 30.

[1]) HUXLEY 1927 related the lemming cycles to a component of the sun spot cycle equal in length to one third of the main cycle (MACLULICH 1936 p. 234).

# TEMPERATURE, PRECIPITATION, AND WIND ACTIVITY

From the meteorological material available from Greenland in the archives of Det danske Meteorologiske Institut, in "Collectanea Meteorologica" and in "Meteorologisk Aarbog", it is possible to form a picture of the fluctuations of **temperature** in Greenland, reaching far back into the past (Godthåb since 1784, Upernavik since 1832, Jakobshavn since 1840, Ivigtut since 1866, and Angmagssalik since 1894). There have been some interruptions; however, since 1873 we have regular, three-times daily observations from the stations mentioned, with the exception of Angmagssalik, which was not started until 1894.

These observations give an interesting and broad view of the variations from south to north along the long west coast, and for all seasons of the year. On the following pages (figs. 12–16 and fig. 18) they are shown in curves of 10-year sliding averages. Missing monthly averages, occurring now and then in the series, have been replaced by the averages for the corresponding months of the preceding and following year. In some cases, observations are missing for one or more days of the month. In producing these curves it has not been the purpose to give a meteorological evaluation of the available material, but only to present it in a sufficiently clear form, in order that it may be used as a basis of comparison for the biological curves.

The general upward trend of the curves from 1890 is far more pronounced at the two northern stations than at the two southern ones; +7°C and +3°C for the winter temperature, respectively, while the summer temperature everywhere shows a more gradual increase of approximately 1.5°C during the same span of time.

A comparison of the curves fig. 17 from four stations shows that previous to 1899 there is but slight agreement between the curves, which have a decided tendency to run in opposite directions.

Between 1899 and 1923, obvious *4-year cycles* will be noted *in the winter temperature* at Upernavik, a tendency which is also traceable at the other stations.

After 1923, the temperature at all stations is higher than during former periods. Here the 4-year cycles are obscured by longer periods, which is also true of the winter time. The fluctuations are deep and have

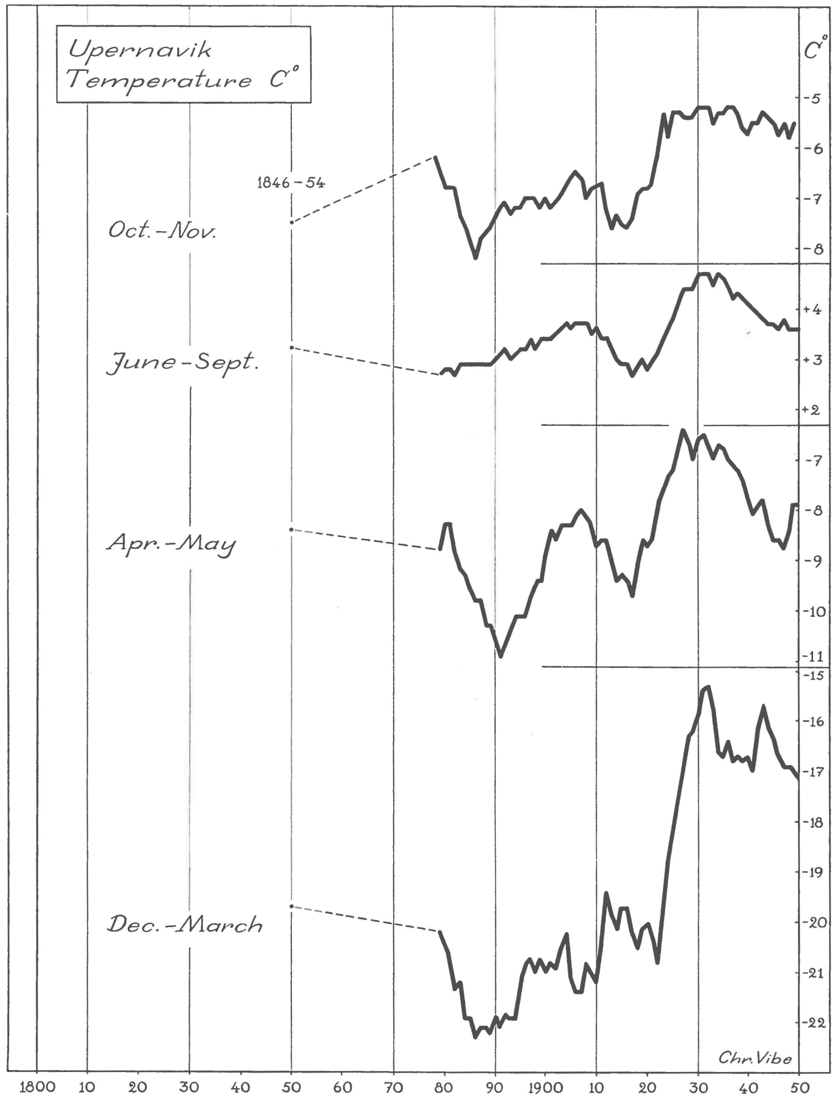



Fig. 12. Air temperature curves for Upernavik in 10-year sliding averages. (No observations available from Upernavik April 1944 to Oct. 1945. Therefore the last part of the Upernavik curves shows an average of only 8 years for the summer and 9 years for the winter months.)

a tendency toward a deviating (often contrary) rhythm from the southerly to the northerly stations. The Atlantic climate penetrates farther north in Davis Strait than before.

Both the approx. 4-year winter cycle and the longer-termed summer cycles of temperature (5–6 years and 11 years) can be recognized in numerous biological curves.

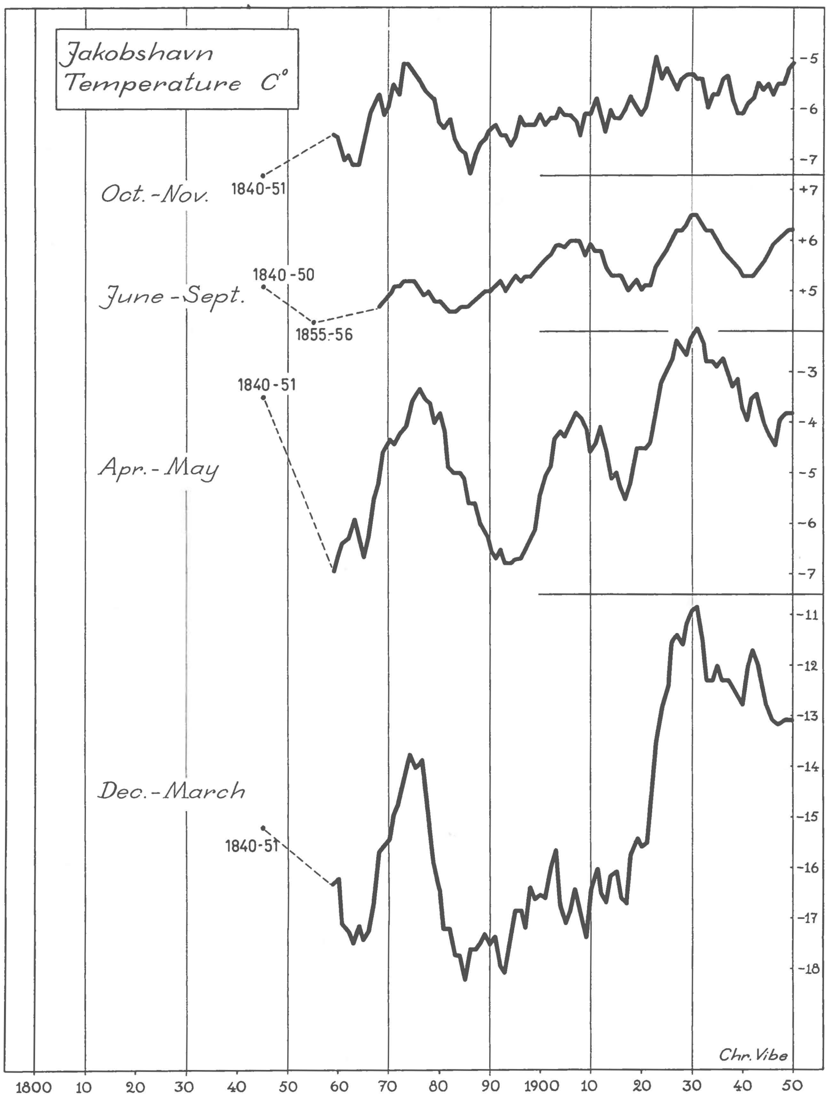



Fig. 13. Air temperature curves for Jakobshavn in 10-year sliding averages.

In Northwest Greenland (Upernavik) there is a rise in the summer temperature (July) at every sun-spot maximum and at every minimum. In Southwest Greenland (Godthåb) the rise is absent at every second sun-spot maximum, i.e., in periods with drift-ice late in summer, around 1895, 1918 and 1938.

Late drift-ice mostly succeeds cold winters in West Greenland, but in Northeast Greenland and northern Iceland the autumn and winters may be warm and abnormal because the late moving drift-ice leaves the

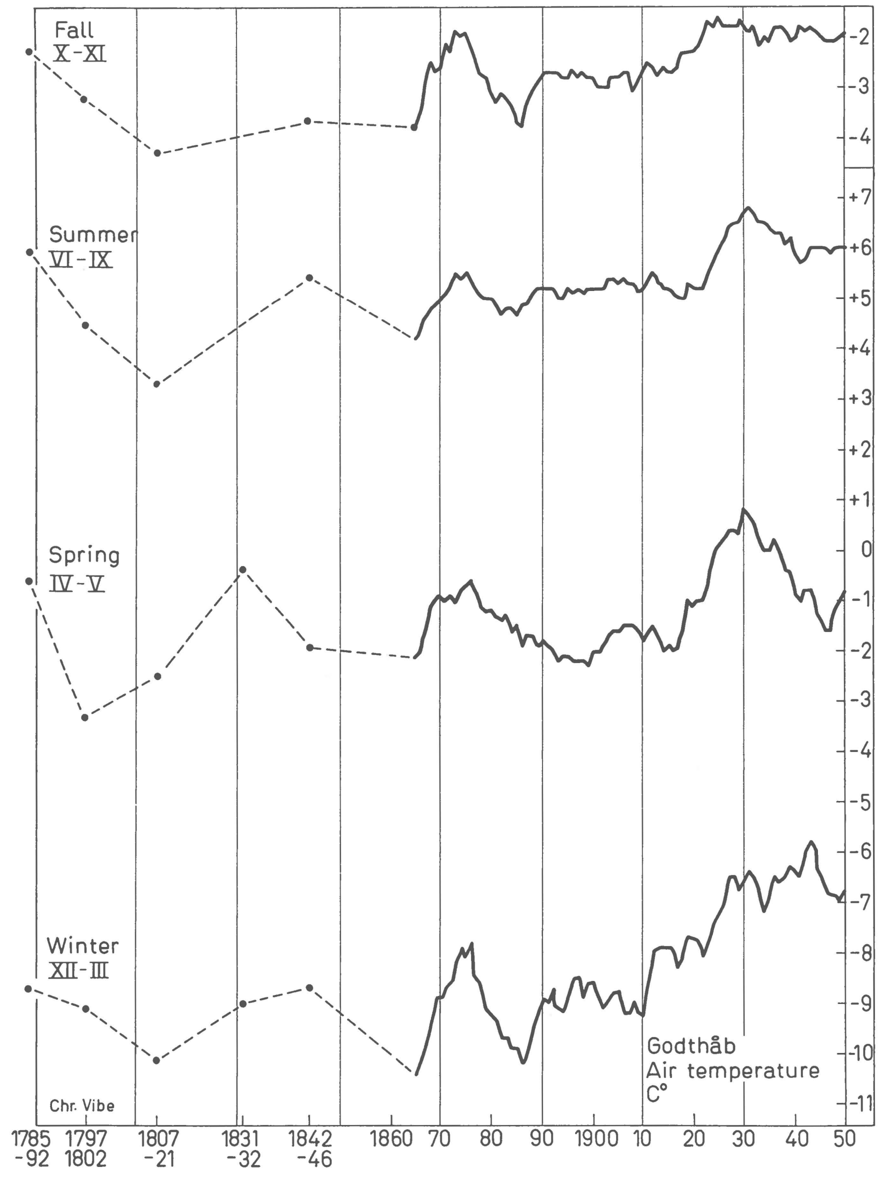



Fig. 14. Air temperature curves for Godthåb in 10-year sliding averages. Before 1865 the averages are based on a varying number of years, as indicated at bottom.

Greenland Sea partially open. This favours winter precipitation, ice-covering of the pastures, and Musk Ox catastrophes.

Measuring **precipitation** has always been difficult in Arctic regions with heavy storms and drift-snow. The present author, therefore, has chosen to show the *number of days* with precipitation, in that no special

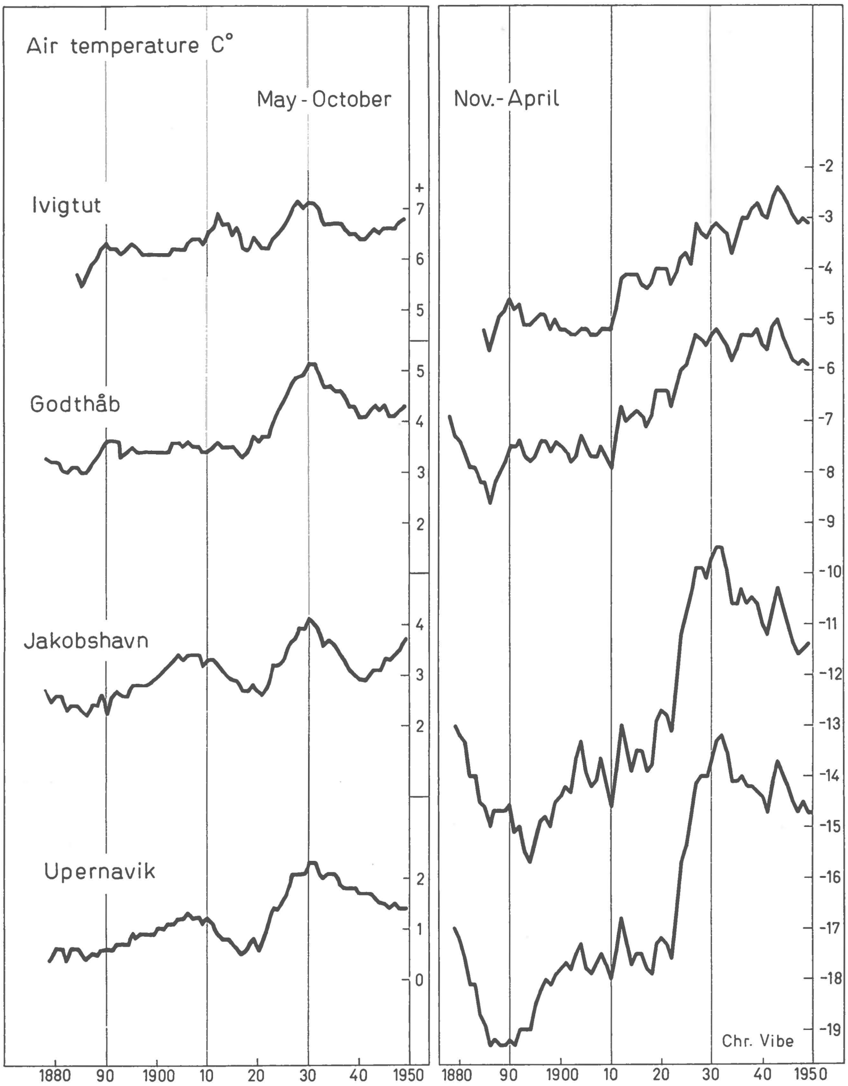



Fig. 15. Air temperature curves for four stations in West Greenland in 10-year sliding averages. To the left the summer season, to the right the winter season.

technique has been required in order for Greenlandic observers to make a note of them (figs. 20–24). Even the oldest series of observations often include the specification of "days of precipitation". Observations may be missing in the series for individual days or months, in which case they have been estimated by comparison with the periods immediately before and after.

In fig. 24 are shown two alternating curves giving number of yearly days of precipitation at Upernavik and Ivigtut, respectively, in 3-year

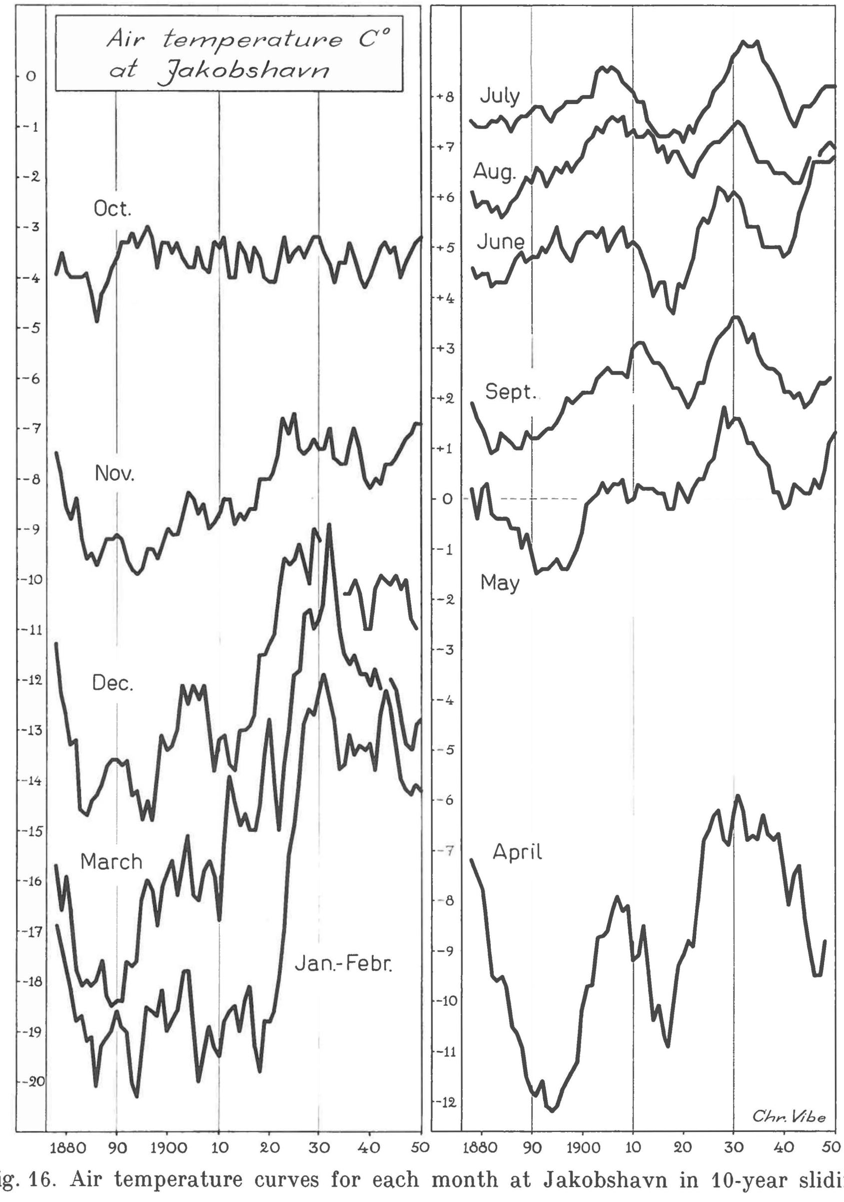



Fig. 16. Air temperature curves for each month at Jakobshavn in 10-year sliding averages.

sliding averages. Comparing these curves to that of the sun-spots, we find Upernavik's precipitation curve mostly alternates with the sun-spot curve, while that of Ivigtut usually parallels the sun-spot curve. Ivigtut's precipitation cycle of about 11 years further shows a marked trend toward separating into two minor cycles, in that the curve of Northwest Greenland also makes itself felt to some extent in South-

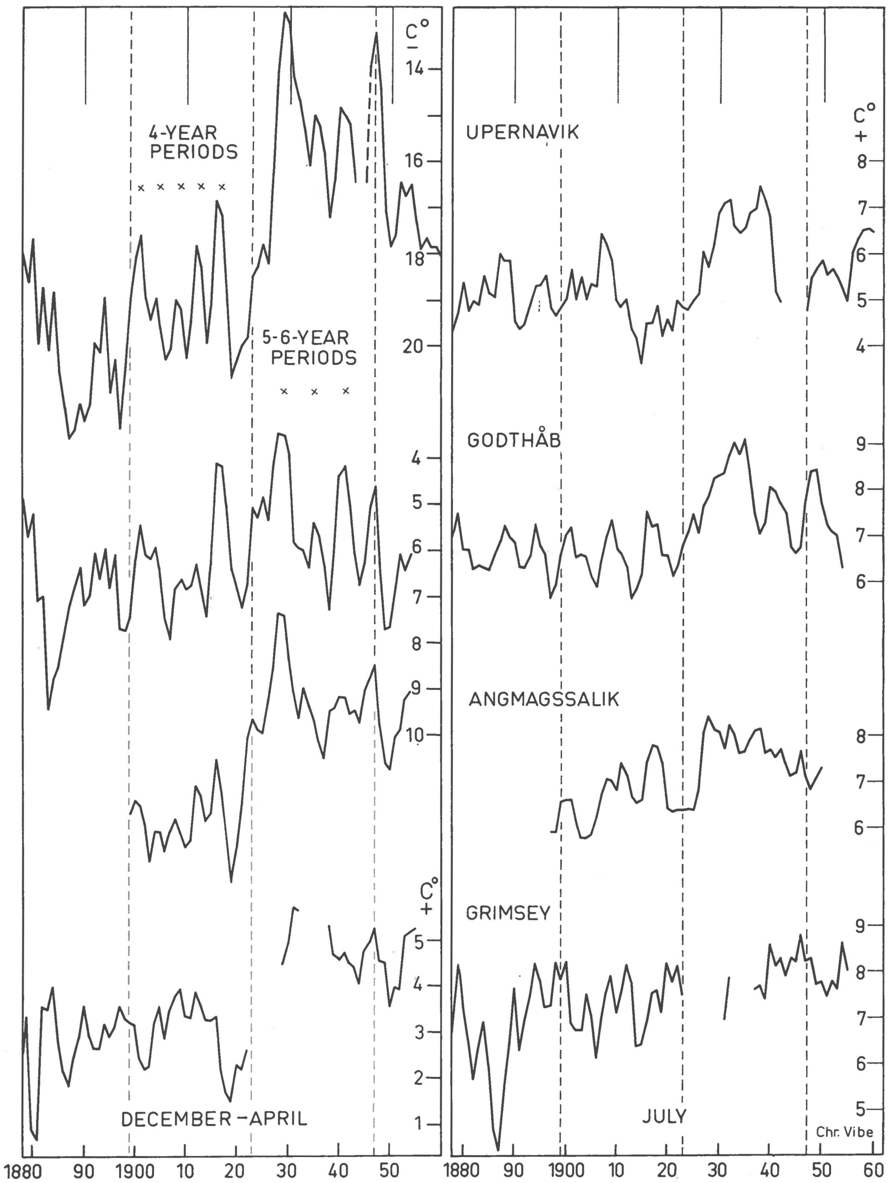



Fig. 17. Air temperature curves in 3-year sliding averages for December to April (left) and July (right) at Upernavik and Godthåb in West Greenland, Angmagssalik in Southeast Greenland and Grimsey on the north coast of Iceland. Note that the figures for the three upper curves (left) are negative.

west Greenland. This is best observed during the period 1930–40. The 5–6 year biological curve in West Greenland, therefore, appears to be the product of a dual influence from two different low-pressure areas, whereby an originally 11-year curve is divided into two.

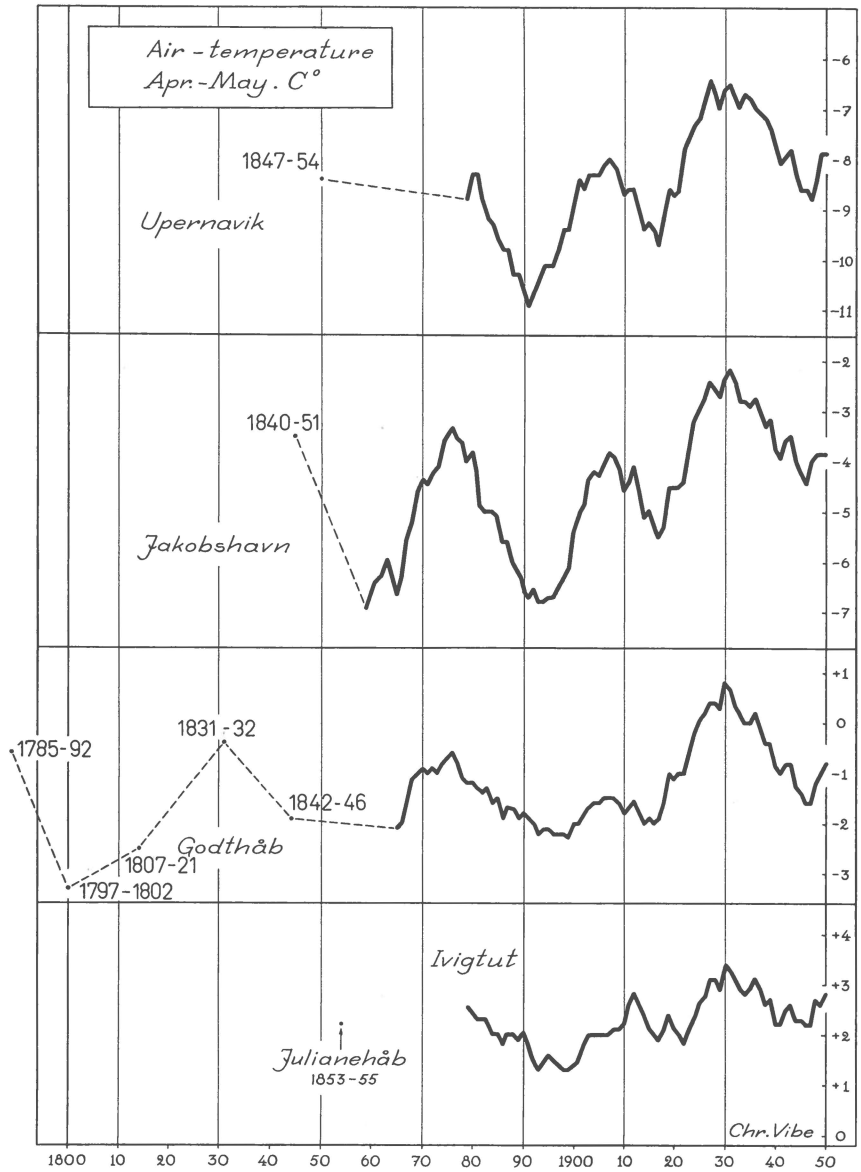



Fig. 18. Spring air temperature curves for four stations in West Greenland in 10-year sliding averages.

The bottom curve fig. 22 shows the advance of the drift-ice in Davis Strait late in the summer (August); the curve above it shows the total days with precipitation in December through March, average for Jakobshavn + Godthåb. It is seen that south of Disko Bugt late drift-ice is followed by predominantly dry winters, and early drift-ice

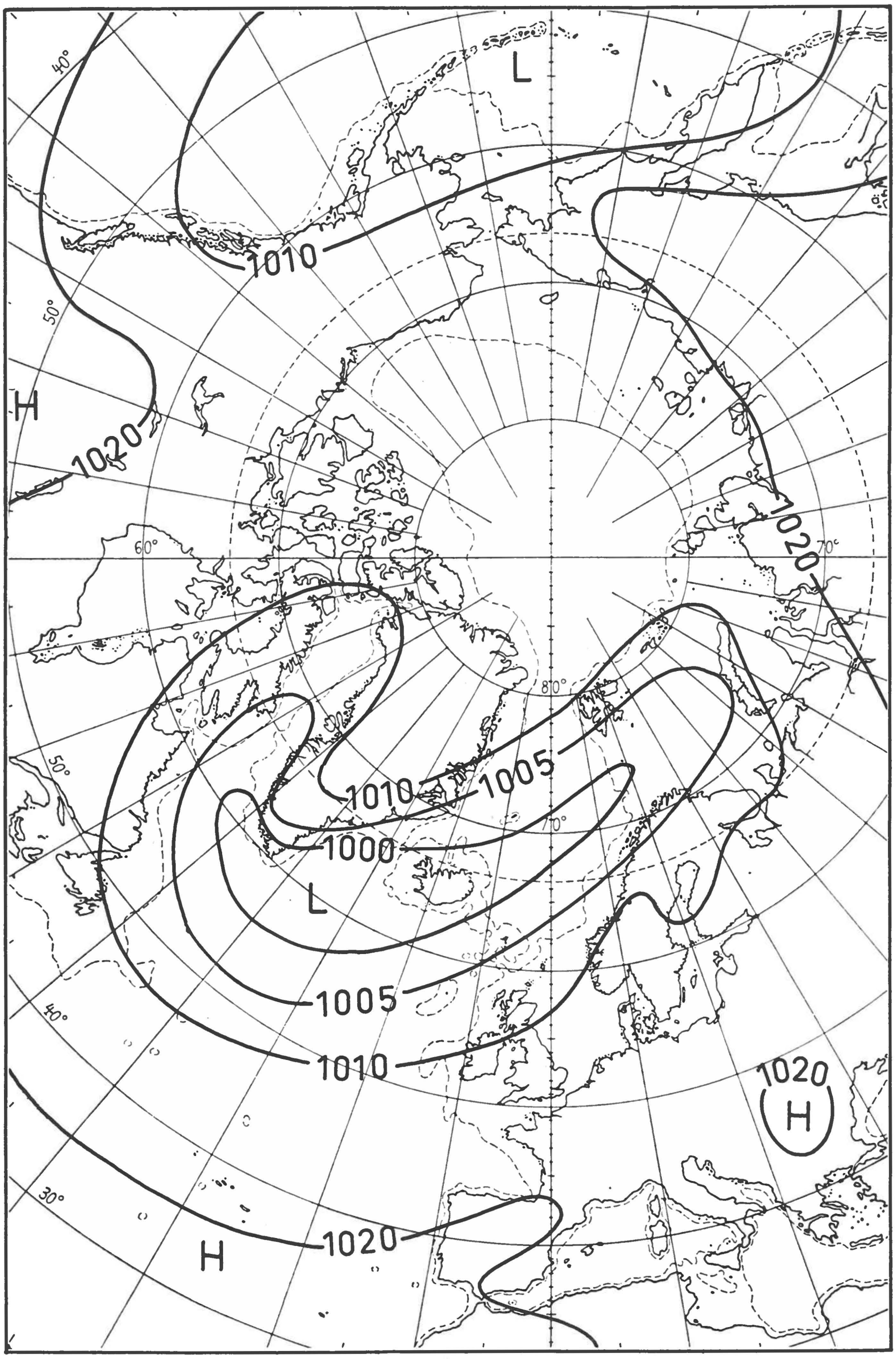



Fig. 19. The atmospheric pressure (mbar) around Iceland-Greenland in January. Simplified after W. WERENSKIOLD 1948 p. 142.

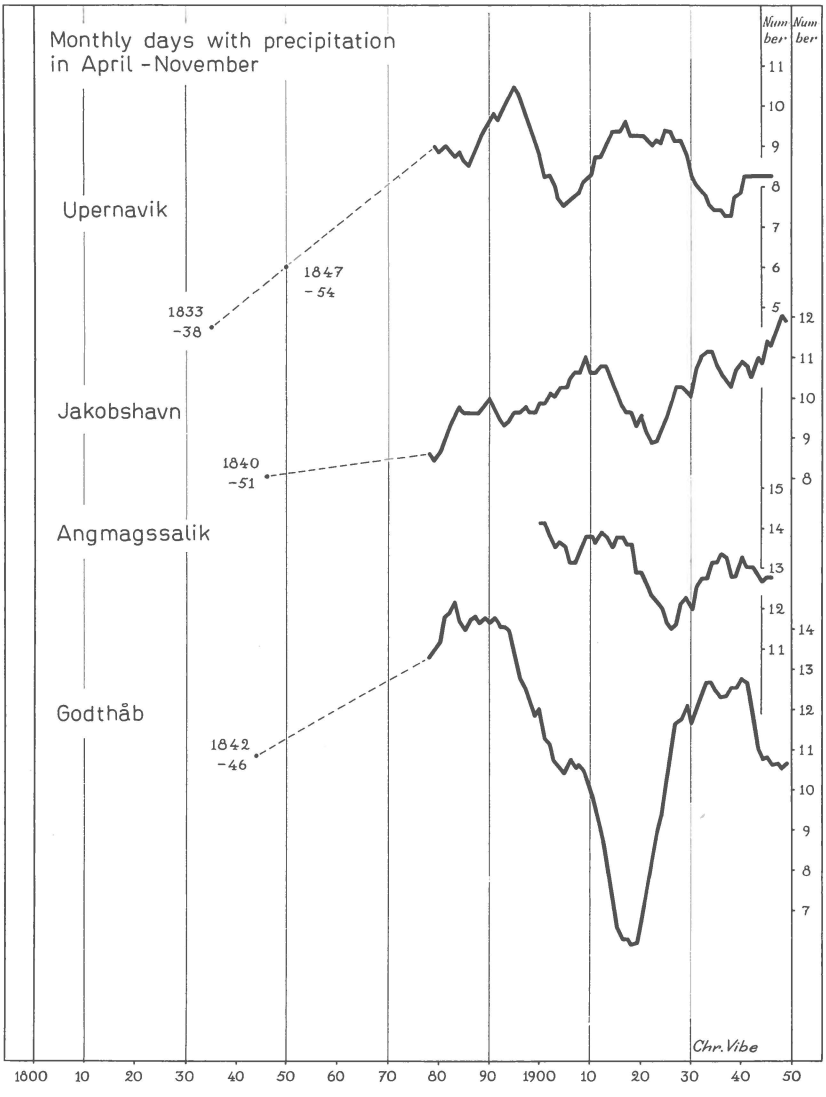



Fig. 20. No. of days per month with precipitation during the summer period April to November in 10-year sliding averages. Note that the curve for Upernavik tends to alternate with the curves from the southern stations. (No observations available from Upernavik for April 1944 to October 1945. Thus, the last part of this curve shows an average of only 8 years).

is preceded by wet winters. North of Disko Bugt (at Upernavik or still farther north) these conditions tend to be opposite.

In fig. 25 are shown the two different areas of West Greenland where the precipitation alternates. The southern area presumably also includes

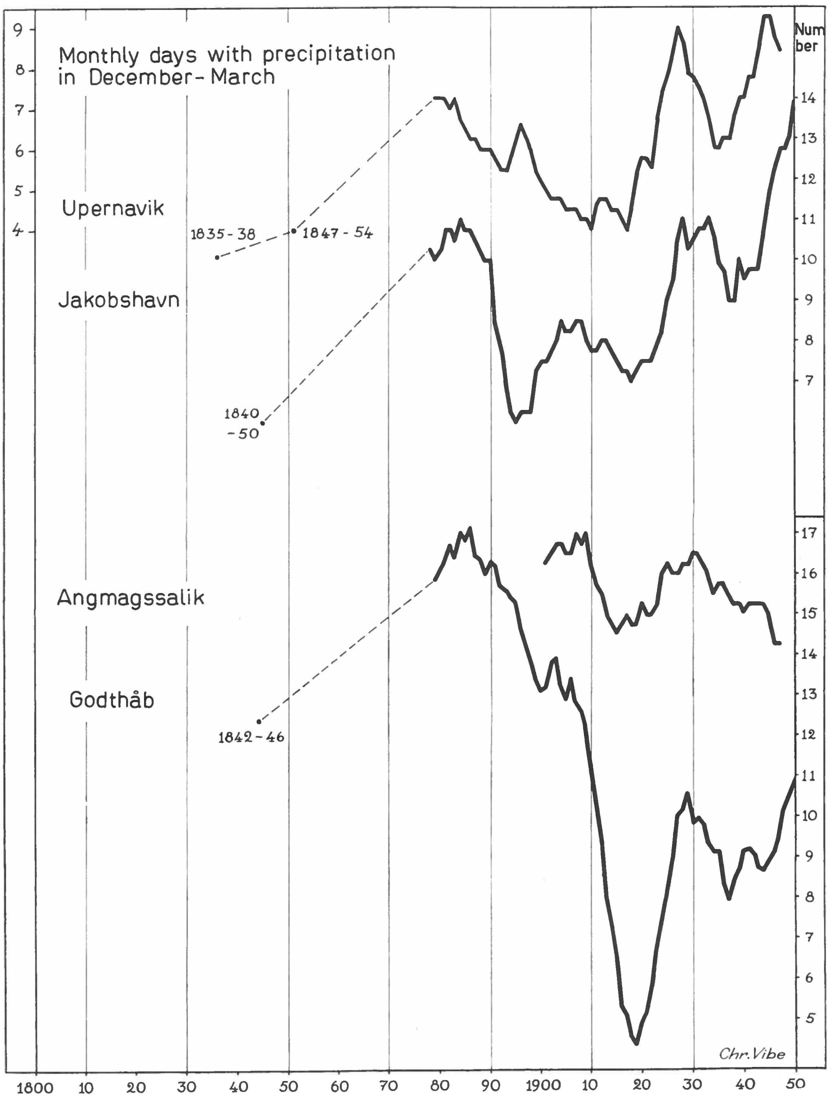



Fig. 21. No. of days per month with precipitation during the winter period December to March in 10-year sliding averages. (No observations available from Upernavik April 1944 to October 1945. Thus, the latter part of this curve shows an average of only 9 years).

Southeast Greenland. The northern area presumably also includes Baffin Island and parts of the Northwest Passage. The truly Arctic continental area of Greenland is limited to the lands between Humboldt Bræ and Nordostrundingen. There, the climate is constantly Arctic-continental, winter precipitation being very low and winter

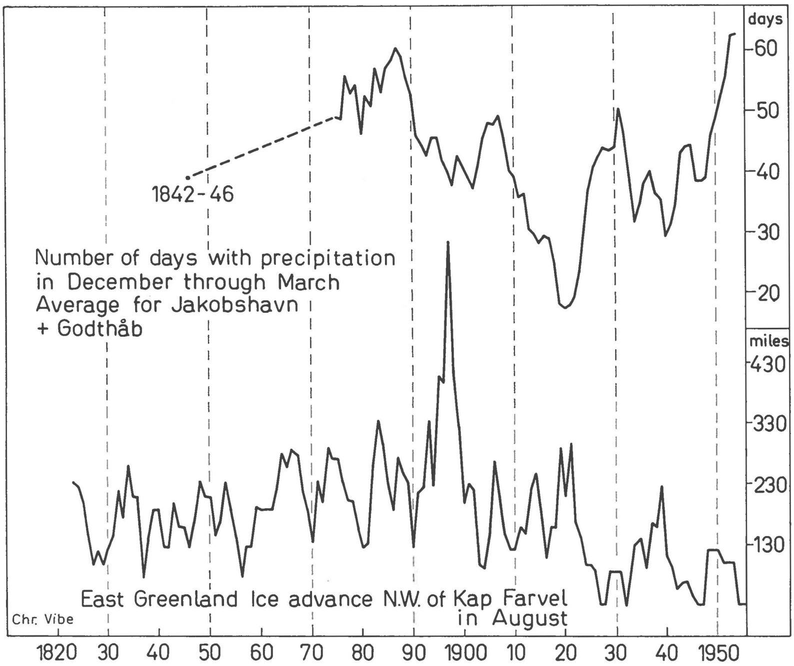



Fig. 22. Both curves in 3-year sliding averages. Note that the number of days with winter precipitation tends to alternate with the advance of drift-ice late in summer.

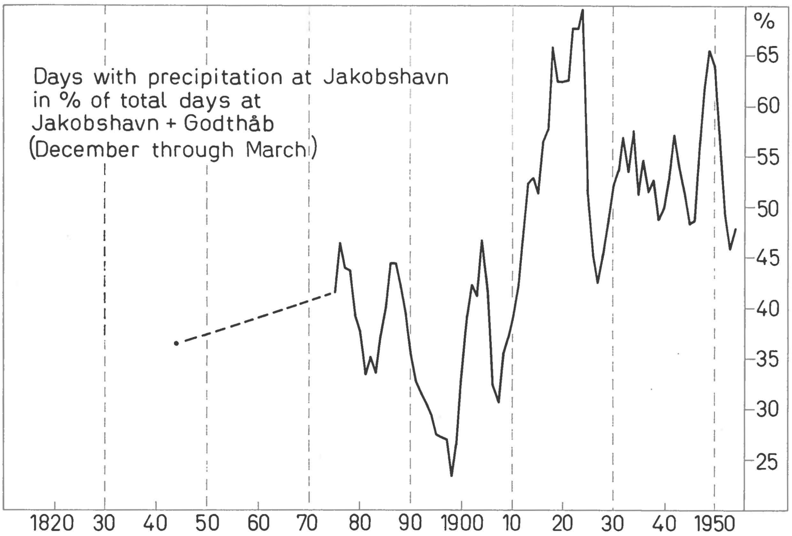



Fig. 23. This curve is based on the same numerical material as the precipitation curve shown in fig. 22.

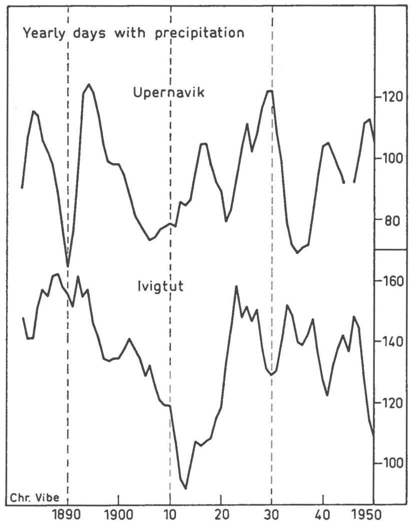



Fig. 24. No. of days per year with precipitation at Upernavik (Northwest Greenland) and Ivigtut (Southwest Greenland) in 3-year sliding averages. Note that the curves tend to alternate.

thaws with rain and subsequent glaciation of the country exceedingly rare. Without such climatic conditions in northern Greenland, the Musk Ox would not have been able to survive until to-day.

In the following will be given some meteorological data from the literature which play an essential part in the living conditions and distribution of the Greenland fauna.

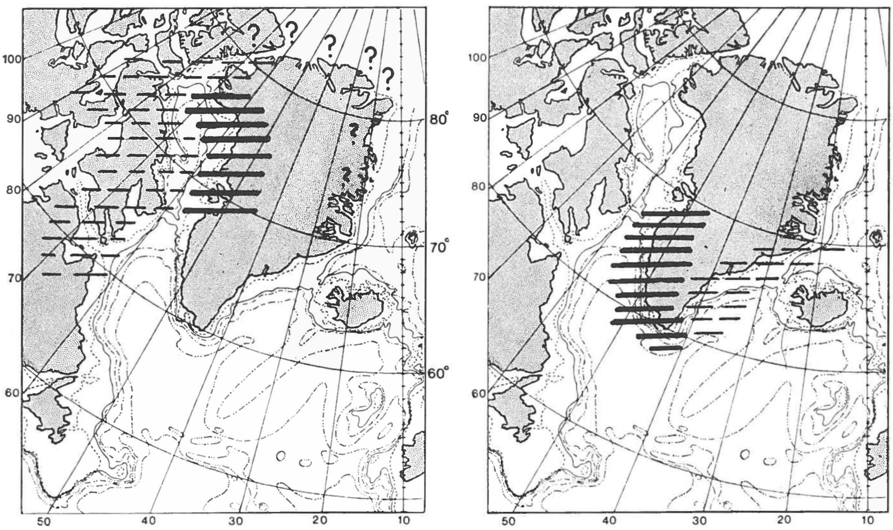


Fig. 25. Maps showing the two areas where precipitation tends to alternate. Broken lines indicate the supposed extension of each area.

**The Foehn Winds:** HELGE PETERSEN writes (1950, pag. 140): "When an air current blows over an enormous obstacle like Greenland, it may ... follow the contours of the obstacle and blow up the incline on one side and down the decline on the other side... the air being raised and lowered respectively over the two coasts, and this will... cause respectively a lowering or raising of the temperature of 10°C per km difference in altitude. The cooling, however, will not be that substantial, since it causes formation of precipitation, which on its side reduces the cooling effect to as little as 5°C per km altitude; on the other hand, the warming during the descent always reaches full development, and if it is the same air mass first rising under development of precipitation, and then descending, it will be seen that it "gains" 5°C in heat for each km it has been raised originally. Such a wind which has been warmed up by first having been lifted under development of precipitation and then again lowered, is called "Foehn", and it will be understood that the surface form of Greenland must provide excellent conditions for its occurrence. It may be, either that the wind has passed right across the ice cap, or that it has blown up the coastal mountains at an angle in one place, then later downward at an angle in another place....The Foehn is always very dry".

Such foehn winds, which are frequent in many places in Greenland, have during the winter, a great deal of influence on the conditions of mountain game. Where they blow down the mountains as hot, dry winds, they make the snow evaporate and melt and expose the vegetation, which is of advantage to sheep farming in the Julianehåb district — and to the Reindeer in Central West Greenland, see figs. 95–97.

HELGE PETERSEN also mentions another case of hot winds during the winter (1950, page 141): "However, very striking rises in temperature may also take place in winter, which are not due to foehn wind, namely an 'overflushing' of mild air from lower latitudes; but even though this may also cause a change from frost to thaw, even at the more northerly stations, still such cases distinguish themselves from the foehn in that the sudden, short-term rises in temperature do not occur, and usually these overflushings are accompanied by precipitation, or at least by humid weather, in contradistinction to the dry weather of the foehn."

Such overflushings of mild air *in connection with thaw and precipitation* are dangerous to game, as the subsequent frost will freeze the wet snow into an often impenetrable ice crust. Both too much snow, and a covering of ice over the mountain fields, will make it difficult for mountain animals to find nourishment.

# THE ARCTIC EIDER IN WEST GREENLAND

The Arctic Eider (*Somateria mollissima borealis* (Brehm)) breeds along all of West Greenland — as far north as Hall Land, and in East Greenland as far north as Germanialand (Salomonsen 1950). It is not equally numerous in all places, being least numerous in East Greenland. It occurs in largest numbers as a breeding bird on three stretches of the coast facing Davis Strait and Baffin Bay: between Godthåb and Egedesminde, between Svartenhuk and Holms Ø, and between Kap York and Smith Sund. In the following these areas are called: the south field, the centre field, and the north field, respectively. The fields are, incidentally, the same as those used by the Walrus, an animal, which like the Eider, requires large areas with slight depth: 0 — appr. 80 m. for the Walrus (Vibe 1950), and 0 — appr. 46 m. for the Eider (Holbøll 1842–43).

In winter, the Eider leaves the northern breeding fields and goes south to the coast between Egedesminde and Kap Farvel. This wintering field is shared with the King Eider (*Somateria spectabilis* L.). Both Eider and King Eider are eagerly hunted in the wintering grounds. Formerly, without limitation, eggs and down were collected in the breeding fields of the Eider, which often breeds in colonies; while the King Eider, which breeds in a scattered manner inland, nearly always has total peace during breeding time.

When, after 1880, down production fell to a minimum and did not rise during the following decades, it was feared that hunting, combined with the enormous collection of down and eggs, would end in the extermination of the Eider in West Greenland. Consequently, in 1924, preservation regulations were introduced for Southwest Greenland as far as Nordre Strømfjord; in 1929 for Northwest Greenland, up to Melville Bugt, and in 1931 for the area north of Melville Bugt.

Eiders and their nests were hereafter protected in Southwest Greenland from May 20th (in 1926, changed to June 1st) to August 31st. In Northwest Greenland, nests and brooding birds were protected from June 25th to August 15th, while the shooting of Eider in passage continued to be permitted. Mass catch by net, and mass catch of moulting birds, was forbidden. In North Greenland the Eider were protected from

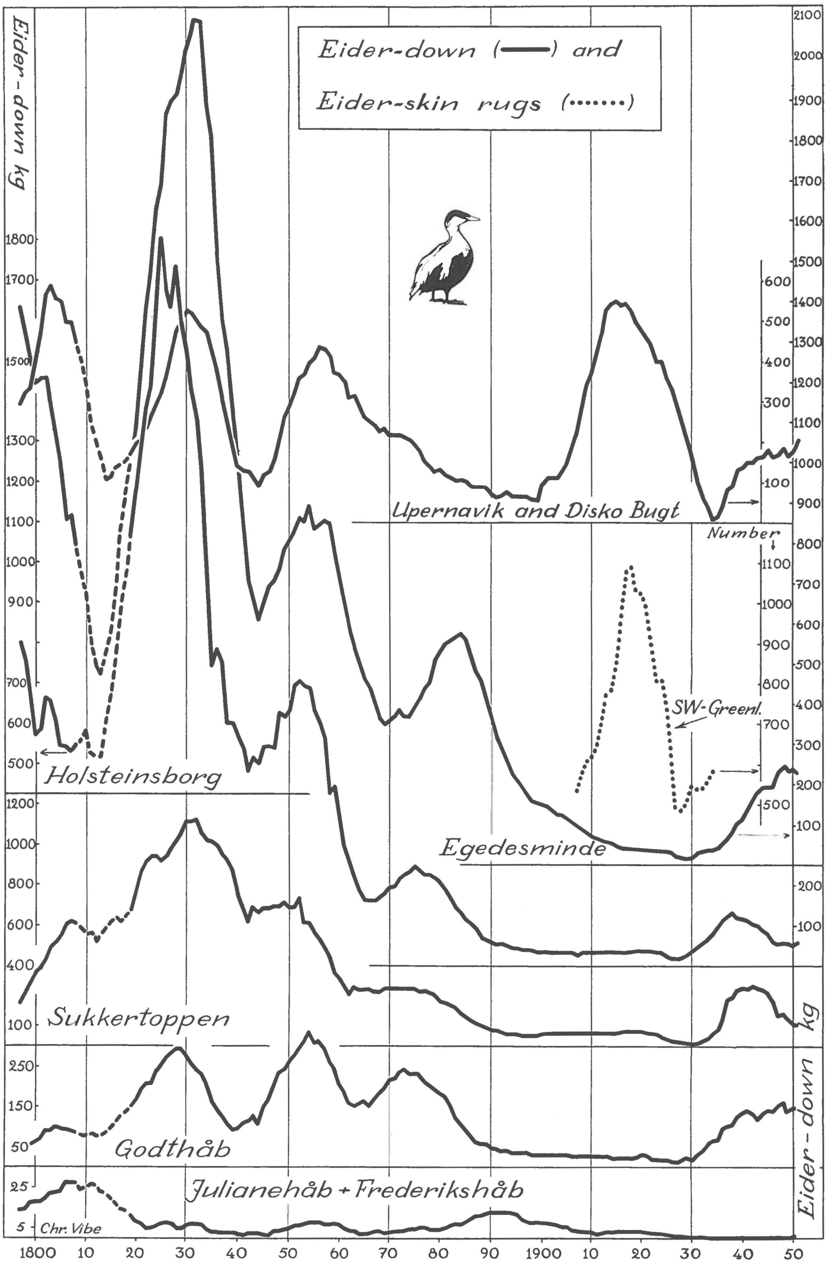



Fig. 26. Purchases of Eider-down and Eider-skin rugs in West Greenland in 10-year sliding averages.

the time of their arrival in the district until September 1st. Eider eggs and down could be collected only once before June 17th. With minor changes, these rules have been in force ever since.

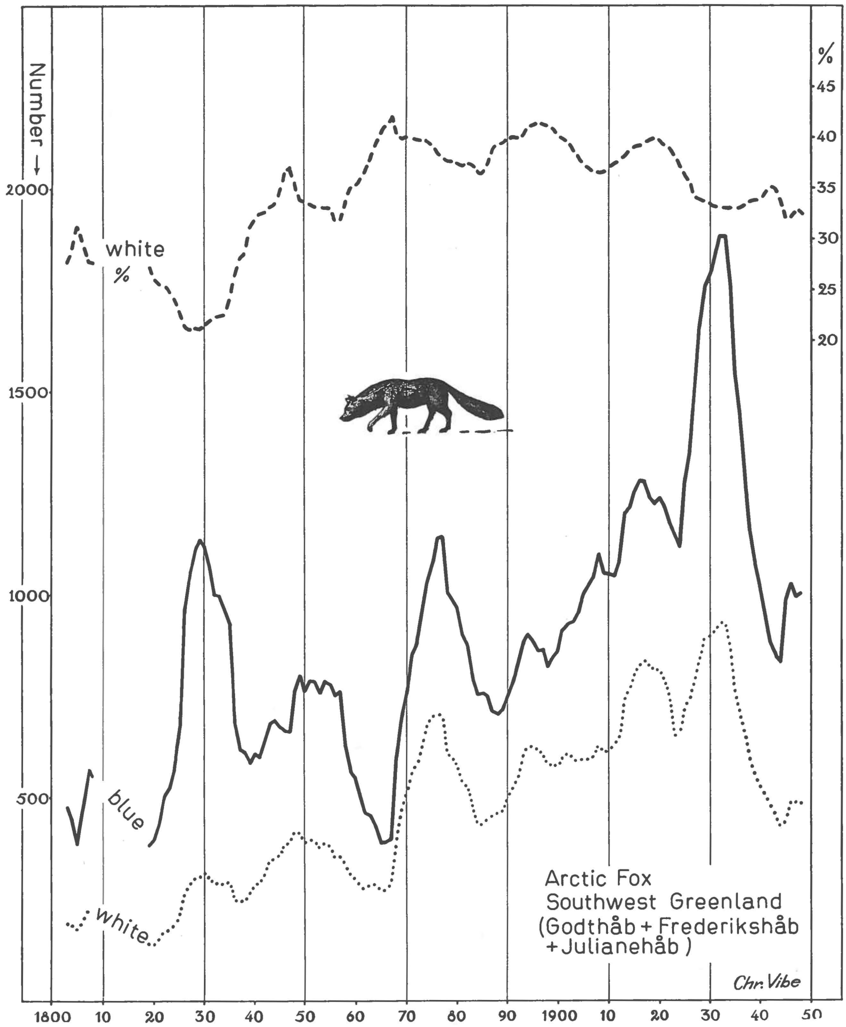



Fig. 27. Purchases of blue and white Arctic Foxes in Southwest Greenland in 10-year sliding averages. The top curve shows fluctuations in white percentage. See text p. 45.

Down collected from Eider nests has for many years been an important trade commodity. Den kongelige grønlandske Handel (The Royal Greenland Trade Department) purchases down from the Greenlanders in an untreated (i.e. roughly cleaned) condition. This method of trading appears to have been fairly uniform since the start of colonial accounts. Consequently, through these accounts, we may form a picture of the fluctuations in down production from 1793 until the present time. Resident Danish officials have been allowed to buy a smaller quantity for their own use, and it probably happened that now and then various quantities were bought privately; however, this was hardly enough to change the upward or downward trend of the curves. Furthermore, the curves of down production follow other biological curves so exactly that, under all circumstances, they give important information on fluctuations in the population of Eider as a whole.

Inasmuch as the Eider has its breeding places both within the area of the Baffin Bay Ice, and within the area of the East Greenland Ice, it must be assumed that the quantitative fluctuations of the bird are influenced by the occurrence of both ice masses in Davis Strait.

In fig. 26 are shown the fluctuations in down production in 10-year sliding averages for a number of districts in West Greenland, together with a curve of the production of Eider skin rugs in Southwest Greenland. Down production must correspond to live population, while rug production indicates the bag taken in the wintering grounds (Eider + King Eider).

We note steep drops in down production around 1810–20, around 1840, and around 1865. The same drops are recognized in the curve of blue Arctic Fox for West Greenland, see fig. 27. In the case 1810–20, drift-ice observations from Davis Strait are few in number; we know that there was a great deal of ice in some years. The two latter periods coincide with great occurrences of drift-ice in southern Davis Strait late in the summer.

From the middle of the 19th century right up until about 1930, the West Greenland breeding population dropped considerably. It is during the same period that the great advance of East Greenland Ice (the pulsation stage) occurred, bringing the Ringed Seal and Polar Bear in great numbers from East Greenland as far as Julianehåb.

The drop in the Upernavik district does not coincide with the drop in the south, and this appears to be because birds from the south field move north to the centre field, in order to be north of the reach of the cold East Greenland Current.

For many years the view has prevailed that the heavy and constant drop in the Eider population was due to hunting as well as to the collection of down and eggs, and this view was strengthened when down production increased some time after the protection act. Undeniably, hunting and subsequent preservation may have played a certain rôle. However, as the Harp Seal (see fig. 41) also kept away from parts of West Greenland (Frederikshåb to Disko Bugt) during the same long period, it would seem that attention should be directed more toward the drift-ice and currents than toward hunting.

As long as West Greenland was dominated by a cooler climate with a moderate advance of East Greenland Ice in Davis Strait (the drift-ice stagnation stage, figs. 8 and 42) the coast Godthåb-Disko Bugt was the preferred summer field for the Eider and the Harp Seal. With the greater influence of the drift-ice masses and the cold Arctic water after 1860 (the drift-ice pulsation stage), the ecological stability ceased in southern Davis Strait and the Eider and the Harp Seal moved northward.

That the East Greenland Ice had such an unfortunate influence in Davis Strait during this drift-ice stage was due to its arriving later in the year and in greater quantity than usual, and that it drifted farther north than usual. Also the currents were stronger.

When considering the curves figs. 26 and 27 it is striking to note that after 1865 the Eider curve declines while the blue fox curve rises, and that the latter now alternates with the former. *The breeding Eider moves away from Southwest Greenland, but the Arctic Fox stays and is able to profit by the new ecological conditions created by the change in climate towards Atlantic conditions in Davis Strait.*

In spite of great decrease in the breeding population, the Eider continued to winter in considerable number in Southwest Greenland. Many of them, apparently, must have come from the areas north of Melville Bugt or from the west. Even when, in 1880–1900, down production was at a minimum in the entire south field, the Eider continued to arrive in their winter quarters in considerable numbers. At the turn of the century, R. Müller (1906) calculated the hunting take in all of West Greenland at about 150.000 Eider, of which a good many were probably King Eider. Most of these birds, apart from the King Eider, appear to have come from the northern parts of the centre field (Melville Bugt), and from the north field around Thule. Den danske literære Grønlands-Ekspedition led by Mylius-Erichsen (1903–04) observed great quantities of breeding Eider in both places. During the following years, Greenlanders at Upernavik began to take advantage of the breeding areas in Melville Bugt.

Eider were now to be found there in great quantities. However, as at the same time a small increase was apparent in down production at Sukkertoppen, fig. 28 (1900–1925), a beginning move of the Eider population of West Greenland to the south must have taken place—in the same way as the Harp Seal began returning to Disko Bugt from the north, fig. 41. Nevertheless, the breeding population of Eider in Southwest Greenland remained low. Not until after about 1930 did a general increase of down production start in the south field. Although the protection act played a part in this, the decrease of the East Greenland Ice was without doubt the chief factor. The "pulsation stage" ceased about 1910.

The production of rugs made of bird skins gives some indication of the locations of the winter feeding areas, and the intensity of hunting. These rugs are made from the plumage of Eider, King Eider, Cormorant, and Brünnich's Guillemot. The most popular are the beautiful neck

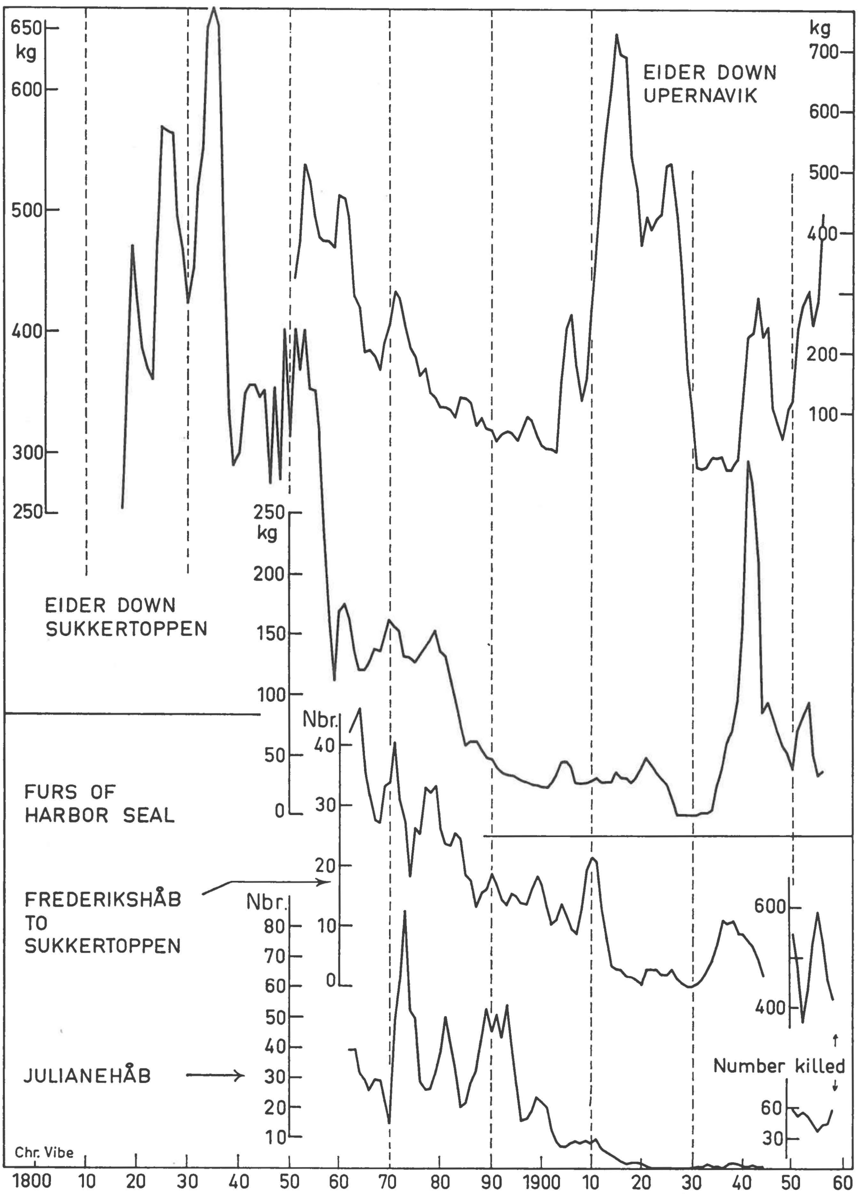



Fig. 28. Eider-down and Harbor Seal furs (see p. 72) in 3-year sliding averages.

skins of Eider and King Eider in full mating dress. The Cormorant is not numerous in Greenland, and Guillemot rugs are not especially valuable and were not purchased. Consequently, it may be taken for granted that the majority of rugs bought by the Greenland stores are made of skins from Eider or King Eider, or from a mixture of both.

In fig. 29 are shown curves of rug production at Julianehåb, Godthåb + Frederikshåb, Sukkertoppen, and Holsteinsborg — and the down production at Upernavik to Disko Bugt.

All curves of rug production show low takes of Eider around 1912–16. This was a period with moderately cold winters (which cannot have been particularly unpleasant for Eider, and did not restrict them to narrow openings in the ice). Down production at Upernavik was high at the same time, suggesting that many Eider had returned to their breeding grounds in the centre field after the winter.

In the period 1918–24, winters in West Greenland were unusually cold, and take of Eider high all over West Greenland. They were probably greatly exploited, being harassed by the cold and having to gather in fewer and fewer openings in the ice, where they are very vulnerable. There was much drift-ice both early and late in the summers. Down production fell at Upernavik, though not to any perilous extent.

After that time the hunting bag fell sharply (1926), and down production rose once more at Upernavik; the latter may be partly due to the small amount of hunting, but may also be the result of better wintering conditions in the winter area.

During the following years it is clear that the preservation regulations changed the curve. It was no longer permitted to collect down in unlimited quantities, and the birds were partially protected during breeding. The curves before and after the introduction of preservation are not immediately comparable.

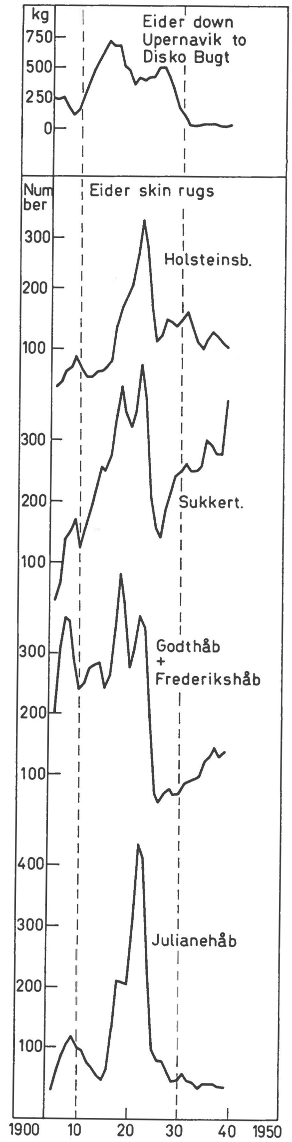



Fig. 29. Purchases of Eider-down and Eider-skin rugs in 3-year sliding averages.

After 1930 down production rose again all along the west coast, in spite of limited collecting possibilities. It is possible that protection during the breeding season had a small part here, but it is more feasible to ascribe the increase to the return of more normal conditions in Davis Strait after the end of the great drift-ice masses. The drift-ice stage (1860–1910) greatly hampered the production in Davis Strait.

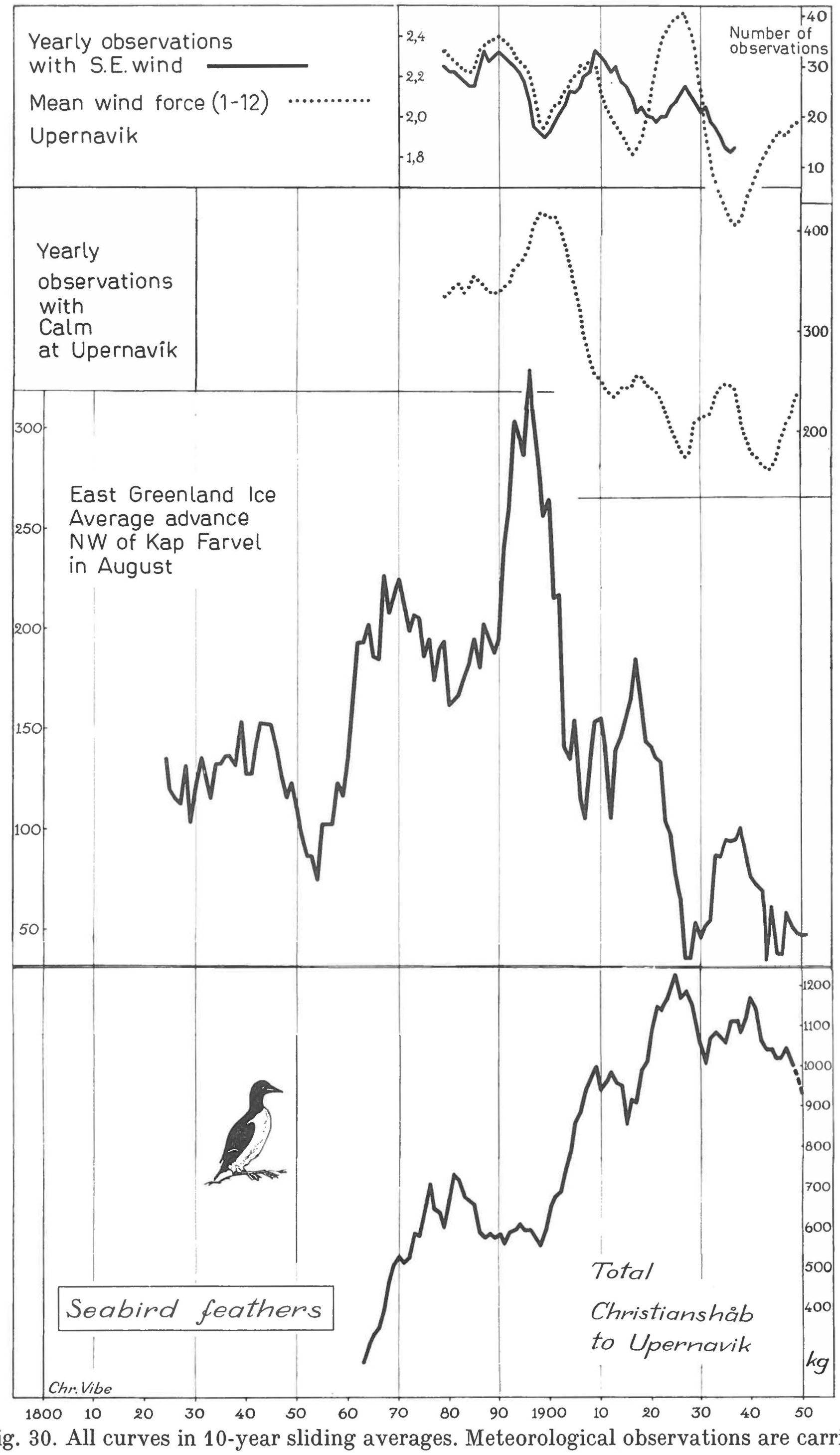



Fig. 30. All curves in 10-year sliding averages. Meteorological observations are carried out three times daily. The scale to the left of the ice-curve shows nautical miles. See text p. 50.

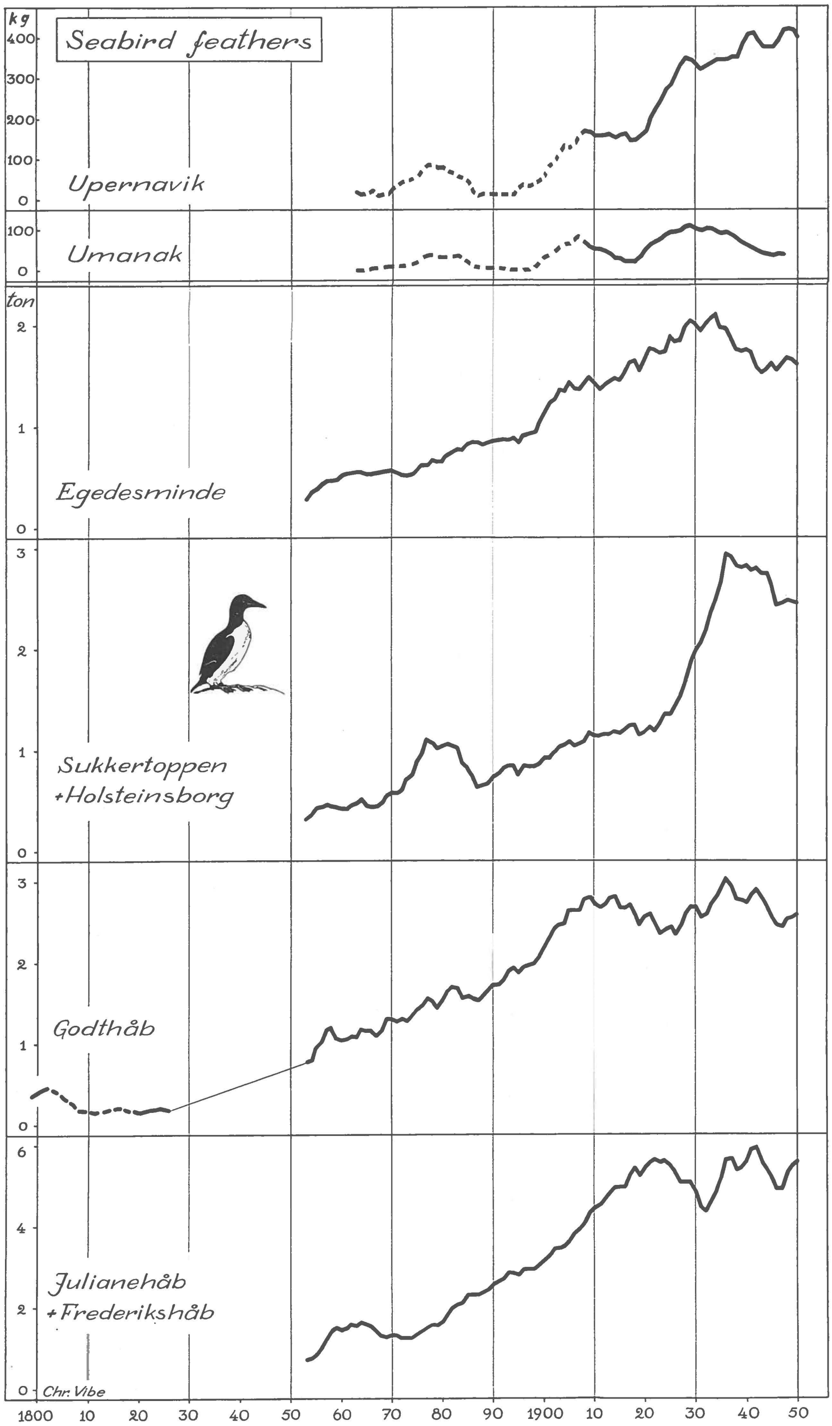



Fig. 31. All curves in 10-year sliding averages. The sea birds at Upernavik, Umanak and Egedesminde are mostly hunted during summer and autumn – and at Holsteinsborg to Julianehåb mostly during winter.

At bottom of fig. 30 is shown a curve of sea bird feathers purchased between Disko Bugt and Melville Bugt, where to-day the sea birds have their main breeding places in West Greenland. The stock of breeding sea birds increases with decreasing August drift-ice, and this is true of the whole period covered by the curve as well as of the single periods.

It is further seen that the number of Brünnich's Guillemots and Gulls killed in West Greenland was small during the whole period 1800–1900 when the Eider was most widely distributed in the south field. When after 1900 the number of Eider began to rise in the central and northern regions, the number of other sea birds also increased in these regions.

This shows that before 1900 when the Eider's main breeding area was Southwest Greenland, the number of other sea birds was small in Greenland. After 1900 Eiders moved north to Northwest Greenland, where the populations of other sea birds increased, too.

These movements show us that before 1860, as long as the Canadian Current dominated the climatical conditions in eastern Davis Strait, sea birds were scarce in Northwest Greenland. When the East Greenland Current (and the Irminger Current) began to advance far north in the Strait (after 1860), the populations of sea birds increased north of Disko Bugt.

Fig. 31 shows that the number of sea birds breeding in Northwest Greenland increased simultaneously with the number of sea birds wintering in Southwest Greenland. It further shows that they winter farther south during cold periods (1920 and 1940) than during mild ones (1930).

Sea bird feathers originate mainly from Brünnich's Guillemot, *Uria lomvia lomvia* (LINNAEUS), but feathers of other sea birds may be included.

## The number of inhabitants in West Greenland

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1805 | 1840 | 1860 | 1880 | 1901 | 1921 | 1938 | 1960 |
| 6.046 | 7.877 | 9.648 | 9.720 | 11.190 | 13.401 | 16.969 | 28.332 |

A stagnation occurred in the population 1860–1880, especially in southern West Greenland. No doubt this was caused by the same climatic change (the drift-ice pulsation stage) which resulted in serious declines in the populations of Harp Seal (p. 69, fig. 42), Greenland Whale and Eider (p. 93, fig. 51), and Reindeer (p. 167, fig. 89).

# THE RINGED SEAL

For thousands of years the Ringed Seal (*Phoca hispida* Schreb.) has been very important game for the Eskimos of the areas north of the Arctic Circle; it has always been present here, even during the four–five months of darkness when it could be hunted from the winter ice. It is found along all Greenland coasts as well as in the drift-ice, and in winter it has breathing holes up through the fiord ice. The young are born on the ice in dens under snowdrifts.

The Greenland Whale also played a large and decisive rôle for people of the Thule Culture during a certain period, but even then the Ringed Seal must have provided the supply of furs and fresh meat during the months of darkness, as whale hide cannot be fashioned into tents, kayaks or umiaks.

In spite of its wide distribution the Ringed Seal is very sensitive to changes in its biotope, like all other Arctic animals. Originally, the fur records of the Royal Greenland Trade Department distinguished between "ordinary seals" and "other seals". The "ordinary seal" is doubtless the Ringed Seal, the Greenlander's natseq. The fur records show an amazing conformity from district to district, see curves fig. 32 and fig. 33. Each fluctuation in the records can be followed along the coast, indicating that each year the Greenlanders caught a certain surplus of the population, and that the curves give a reliable indication of the relative density of the seal population. In years with a large population hunting was easy, and more seals were caught than in years with low density. The uniformity of the curves from district to district seems further to indicate that we can disregard disease, laziness, bad weather, etc. which have often been given as reasons for poor catch.

The graphs reproduced here give a vivid impression of the inhabitants' standard of living from place to place during more than a hundred and fifty years. They also show how climatic conditions have developed in Davis Strait during the same period.

In years when the Atlantic climate advances far north in Davis Strait along the coast of West Greenland, the Ringed Seal is scarce in West Greenland, e.g. the periods before 1810 and around 1930, drift-ice melting stages, see fig. 32.

Colonization of Upernavik was attempted 1771 and 1805, but again abandoned. Further, owing to the scarcity of the breeding Ringed Seal the Polar Bear was scarce in Northwest Greenland in the beginning of the 19th century, see fig. 35.

It would appear that the Baffin Bay area south of Melville Bugt and the Disko Bugt and the Egedesminde-Holsteinsborg coast are not main centres for the catch of wintering Ringed Seals during relatively mild periods (the drift-ice melting stages). The Ringed Seal stays in the northern or western part of Baffin Bay where the winter ice is solid enough for its den. In a period before 1810 the winter climate of Northwest Greenland must have been milder than to-day.

After 1810–20 followed a long cold period (the drift-ice stagnation stage).

Sea mammals are very vulnerable in cold winters when they are in danger of suffocating under the ice. Most of them, therefore, migrate, but generally the Ringed Seal is able to keep its breathing holes open throughout the winter. If the winter is too cold and the ice too thick, life becomes difficult for the very young seals and they leave the thick ice to make for the clearings and tidal cracks.

In exceptionally cold winters the clearings freeze in North Greenland, and even the old Ringed Seal will suffer and may have to make for the ice edge in eastern Baffin Bay and Davis Strait.

In 1817, the important climatic change set in in Baffin Bay. The ice masses drifted away and new drift-ice did not arrive in such large quantities as before. It stagnated in northern regions. Simultaneously many Ringed Seals and Polar Bears arrived in northern West Greenland. The catch of seals rose considerably at all places between Egedesminde and Umanak, later also at Upernavik, which was re-established as a colony in 1826. Many of these Ringed Seals must have come from northern Baffin Bay. The period (1810–60) must have been hard for the people living north of Kap York when the seal left the fiords.

During the same stagnation period the East Greenland Ice stayed partly away from Davis Strait. In the Julianehåb district the catch of Ringed Seal and Polar Bear stagnated simultaneously. Both species stayed on the east coast.—Some may have left for northern Iceland?

About 1865 the catch of Ringed Seal started to decrease in Disko Bugt, and as the Harp Seal, too, stayed away from Disko Bugt for a long period, there may be a common cause for these two events.

As for the Harp Seal this situation was brought about by the great advance of the East Greenland Ice and cold surface water northwards into Davis Strait during summer, which set in at the same time and continued until about 1910. Also many Eiders abandoned breeding in West Greenland.

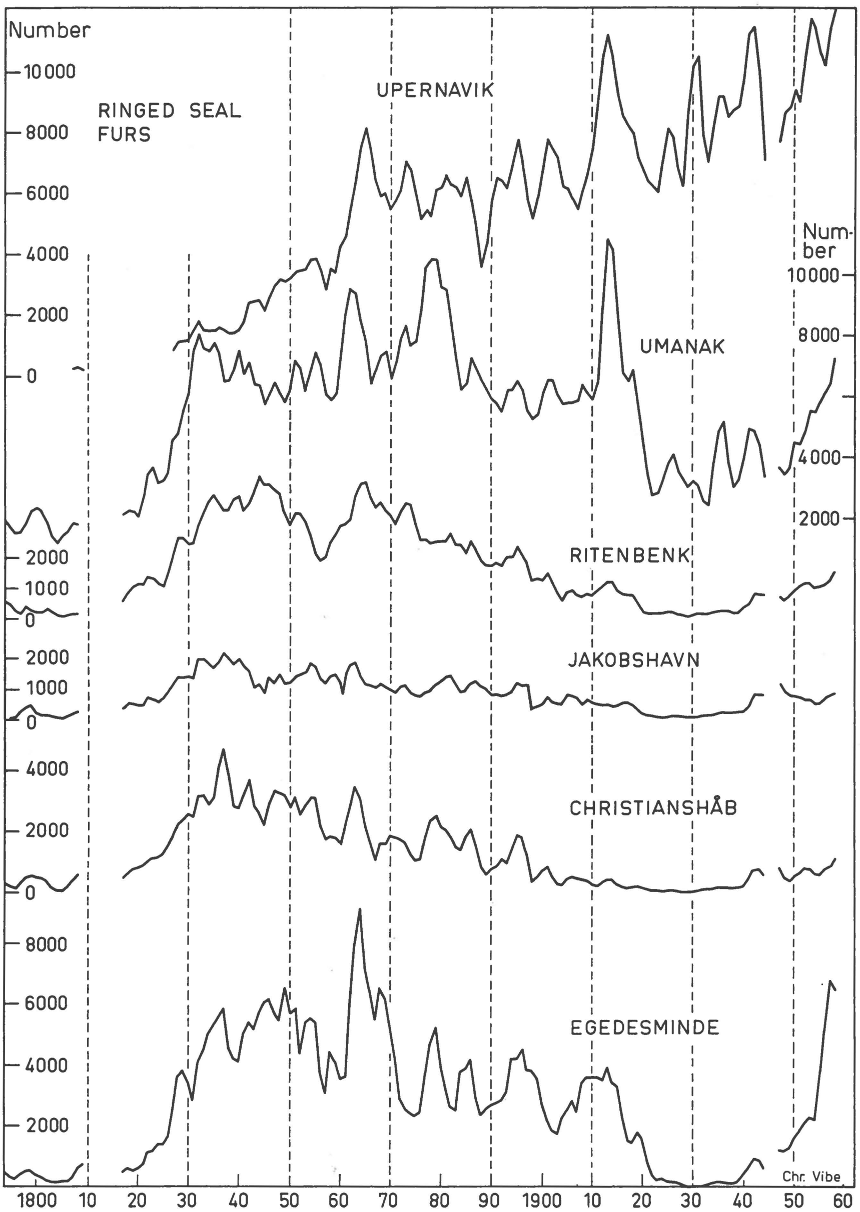



Fig. 32. Fluctuations in the catch of Ringed Seal in Northwest Greenland, until 1945 according to purchase of furs by the Royal Greenl. Trade Dep. From 1946 the curves show the number of Ringed Seals actually caught, according to hunting statistics. All curves in 3-year sliding averages.

Simultaneously, much Atlantic deep water advanced far north into Davis Strait and encountered the Canadian Current in more northern regions than before. This enabled the young Ringed Seals to stay farther north during winter; the catches increased at Upernavik simultaneously with the decrease in Disko Bugt. The production centre moved farther north. Also the sea birds moved north.

At the same time, the great drift-ice advance forced many Ringed Seals to leave the coasts of East Greenland. In large numbers they went south with the drift-ice and round to the west coast to Julianehåb Bugt. There the catch rose in step with the amount of drift-ice. Julianehåb saw an unparalleled wealth of seal, see bottom curve fig. 33 and the curves fig. 36.

To the Eskimo population of the Angmagssalik district this was a catastrophe. Their catches failed because the seal went elsewhere. Presumably this was mainly true of the young seals that could not keep their breathing holes open through the heavy winter ice resulting from the solid drift-ice belt. But the fact that also many Polar Bears left East Greenland shows that old breeding Ringed Seals were periodically scarce.

These East-Greenland seals appear to have reached all the way to Holsteinsborg during the drift-ice maximum 1890–1900, fig. 33. The masses of drift-ice had cooled off the West Greenland fiords to such an extent that the winter ice was heavy enough and had a solid snow cover for the Ringed Seal to breed. At this time, dens of Polar Bear were found in the Julianehåb and Holsteinsborg districts, R. MÜLLER 1906, p. 275, indicating that many old and breeding Ringed Seals now hibernated in Southwest Greenland. In early spring the Polar Bear takes a special interest in Ringed Seal dens.

During the period following 1920, the Ringed Seal catch rose steadily at Angmagssalik, and also at Scoresbysund. The East Greenland Ice came in smaller amounts to Davis Strait, and the Ringed Seal and the Polar Bear remained on the east coast.

In the same period the catch also rose steadily in the Upernavik district, and it is also known that the catch was good north of Melville Bugt. The mild winter climate in Northwest Greenland made it possible for the Ringed Seal to winter far to the north in larger numbers than usual.

In 1939–41, at which time the author was staying in the Thule district, it was interesting to note that the Ringed Seals there were generally small, while the large seals were to be found far north in Kane Bassin and at the coast of Ellesmere Island. From these areas young seals migrated to the outer coasts of the Thule district where open water, owing to currents, is more frequent. The old seals could keep open their breathing holes in the heavy ice more easily and stayed where they were, and the Polar Bear stayed with them.

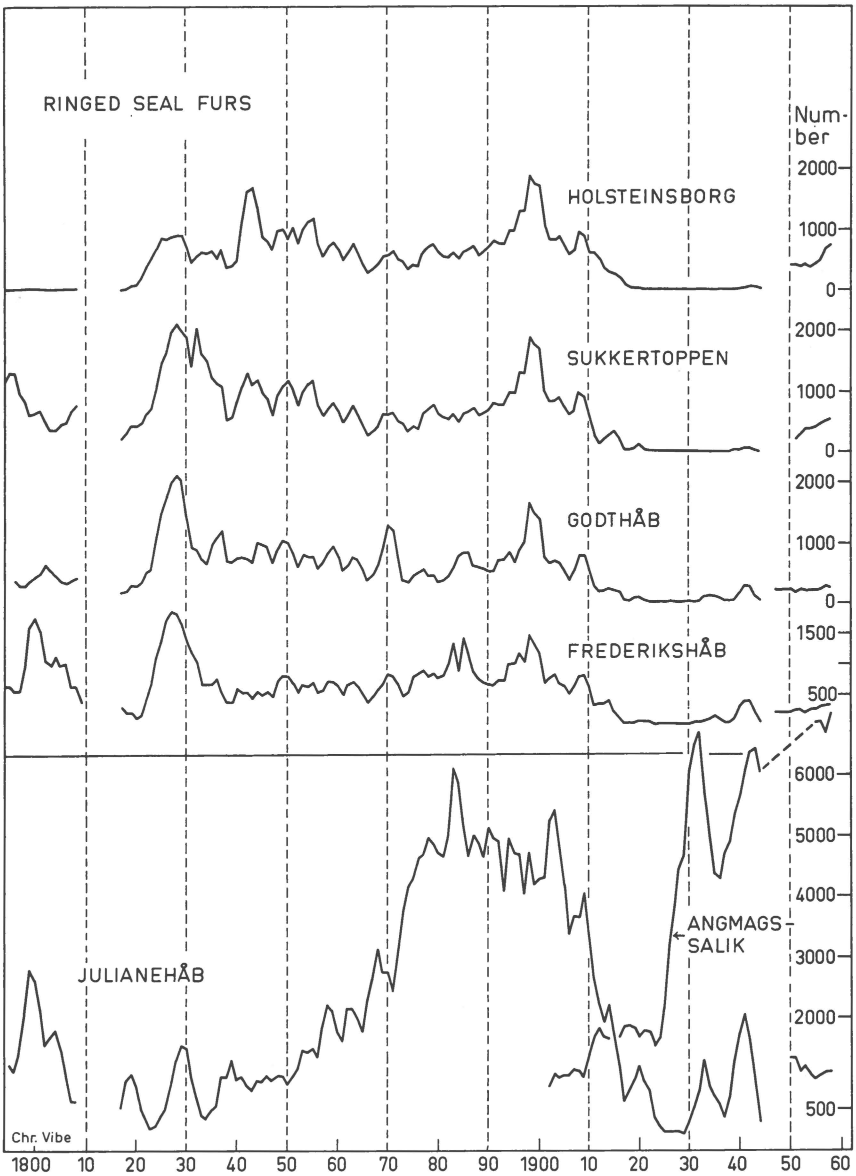



Fig. 33. Fluctuations in the catch of Ringed Seal in Southwest Greenland and Angmagssalik, according to the purchase of furs by the Royal Greenland Trade Department. After 1946, the curves show the number of Ringed Seals actually caught, according to hunting statistics. All curves in 3-year sliding averages.

From Umanak south to Julianehåb, the Ringed Seal declined steadily after 1920. This numerical decline can be seen from the small and short quantitative fluctuations.

It may seem strange that the Harp Seal catch increased in Central West Greenland while the Ringed Seal catch decreased. However, the catch of Harp Seal is to-day as continuous in the summer as in the winter (PH. ROSENDAHL 1961 p. 18), owing to the present warmer winters. The Ringed Seal does not find the ice and the snow patches stable enough for its den.

After 1950, the number of Ringed Seals killed at Umanak and Egedesminde rose again. The winters are now becoming colder, and as a result the young Ringed Seals move southwards in larger numbers than before.

The winter 1963/64 was fairly cold in Northwest Greenland as the Baffin Bay Ice blocked parts of the coast. In February/March the author visited Holsteinsborg and talked to people from Upernavik and Egedesminde, where an unusually high number of young Ringed Seals were caught, presumed to have come from other places. They left again when the drift-ice disappeared from the coast.

# THE POLAR BEAR

The most important food of the Polar Bear (*Thalarctos maritimus* Phipps) is the Ringed Seal. In Greenland it has three important breeding places today, i.e., Northeast Greenland (Alwin Pedersen 1934) and the shores of Melville Bugt and Kane Bassin.

It is most often found with small cubs on the firm winter ice along the coasts of the breeding places mentioned. Around 1900, females with cubs were also seen in the drift-ice near Julianehåb in Southwest Greenland. R. Müller 1906 p. 275 mentions finds of Polar Bear dens in this district and north of Holsteinsborg.

Lone Polar Bears may be found all over Greenland, although the animal is rare along the west coast between Frederikshåb and Disko. On the latter stretch it is now found only every other year, or more rarely. In a few cases it has been found on and near the ice cap under circumstances indicating that from time to time stragglers wander across the inland ice (from east to west?).

Most of the Polar Bears reaching the west coast of Greenland from the south, north, or east are presumably shot at the settlements. As there is no connection between the drift-ice of the East Greenland Current and that of the Canadian Current, Polar Bears drifting with the drift-ice south of Greenland must either go ashore and go north or perish. It is unlikely that they are able to reach the drift-ice in the Canadian Current, which to-day is usually more than 100–200 miles away.

Around 1738, the Polar Bear was found in West Greenland north of Holsteinsborg. In his diary for March 1738, Poul Egede writes that white bears come to the island Disko across the ice from the American side (Egede 1734–1743 p. 59).

To the Eskimo population, the Polar Bear was always a desired prey, the skin being used for clothing and trading. From before 1800 to 1950, the skin was purchased in the stores of the Royal Greenland Trade Department as a monopoly commodity, so that it is safe to assume that the majority of the bag in the monopolized area was purchased and registered. As all Polar Bear skins in Thule are used for winter trousers for men and children, skins from there have evaded the stores. In Upernavik, Scoresbysund, and Angmagssalik some skins are used for the same purpose. In the other parts of Greenland, skins of Seal, Dog and Reindeer are preferred for clothing.

During the operations of the private Norwegian and Danish hunting companies in East Greenland in the first half of the 20th century, a number of Polar Bears were shot; some of these that normally would have appeared in the Greenland stores were thus sent elsewhere.

The hunt for Polar Bear around Greenland was never particularly great, perhaps owing to the fact that a large number of the East Greenland Polar Bears keep far out in the drift-ice where they cannot normally be reached from land. The yearly bag lies at present, 1964, around 100 animals, including the weather stations with 15–20 and Thule with 20–30 bears a year, although an exact figure cannot be given.

The curves fig. 34–36 are based on figures extracted from the source mentioned p. 15.

Figures from Northwest Greenland for the years 1811, 1824–26, 1872, 1880, from Southwest Greenland 1798, 1835, 1867, 1871–72, 1880, and from Angmagssalik 1911, are not available and have only been estimated. In the period before 1823 a number of half pelts and parts of furs were purchased. In these cases, 2 half pelts or parts of furs are considered equal to 1 whole fur. Cub pelts have apparently not been purchased.

The curves shown represent 3-year sliding averages for Northwest Greenland (Upernavik through Egedesminde), Southwest Greenland (Holsteinsborg through Julianehåb), and East Greenland (Angmagssalik since 1897 and Scoresbysund since 1928), respectively. Part of the skins registered at Julianehåb is purchased from hunters coming from the Angmagssalik district.

It will be seen from the curves that the Polar Bear catch as a whole was rising in Northwest Greenland until approximately 1865, while falling in Southwest Greenland during the same period. The position was then reversed. After about 1865 the bag rose in Southwest Greenland and dropped in Northwest Greenland. After 1930 the bag was poor all over West Greenland but still high in East Greenland.

This brings to mind the drift-ice conditions in Baffin Bay and Davis Strait and off East Greenland. Before 1817 the moving drift-ice blocked Baffin Bay during the summer (and kept moving through the winter?). The Atlantic climate penetrated far north into Davis Strait. The Ringed Seals were few in Greenland from Holsteinsborg to Upernavik fig. 32. They stayed north of Melville Bugt—as did the Polar Bear. It was a poor period for the Eskimo population of West Greenland. Presumably the hunting was better north of Melville Bugt.

In southern West Greenland small numbers of Polar Bears arrived on the East Greenland Ice, but most of the bears stayed on the east coast—as they do to-day.

After 1817 the drift-ice stagnated in the northern part of Baffin Bay during winter and the Ringed Seals and Polar Bears appeared in northern West Greenland in great numbers, fig. 35.

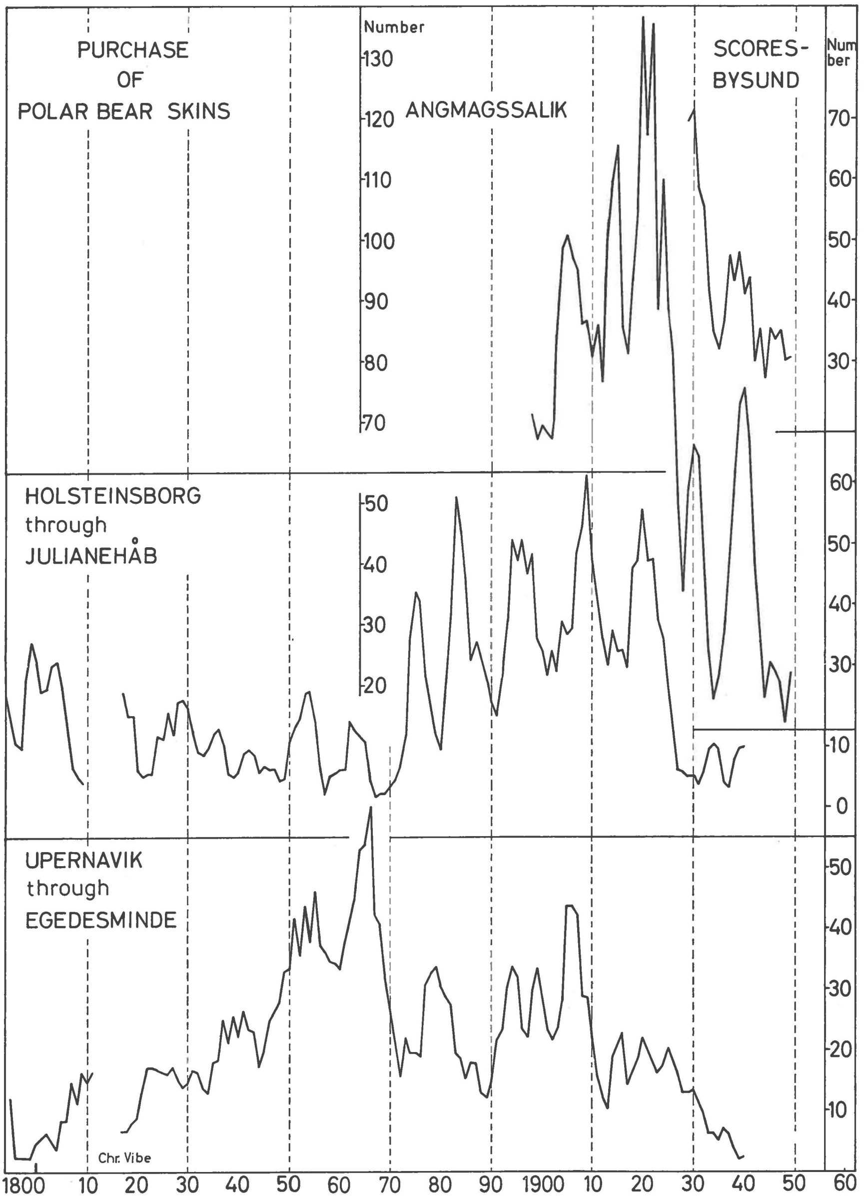



Fig. 34. Purchase of Polar Bear furs in Northwest, Southwest and East Greenland, by the Royal Greenland Trade Department. Curves in 3-year sliding averages.

Simultaneously the East Greenland Ice stagnated off East Greenland during winter. The eastern Ringed Seals had to make for the ice edge far out into Greenland Sea—or along the north coast of Iceland. During the whole "drift-ice stagnation stage" 1810–60 the Ringed Seals and Polar Bears were scarce in Southwest Greenland, see fig. 36.


Fig. 35. Fluctuations in the catch of Polar Bear in Northwest Greenland and of Ringed Seal at Egedesminde, according to the purchase of furs by the Royal Greenland Trade Department. After 1946, the Ringed Seal curve shows the number of seals actually caught, according to hunting statistics. All curves in 3-year sliding averages.

The Polar Bear bag curve for Northwest Greenland resembles the bag curve of Ringed Seal for Egedesminde, fig. 35 (which was rising until about 1864, and then fell) and the Narwhal bag curve at Umanak fig. 44 (which culminated in 1866).

During the following period (the drift-ice pulsation stage 1860–1910), the Ringed Seal decreased in the central districts of West Greenland but increased in the northern districts. It is thus obvious that the winter climate was becoming milder farther and farther northwards in Davis Strait and Baffin Bay. The Polar Bear decreased slowly south of Melville Bugt.

During the same period vast quantities of drift-ice were released from the Arctic Ocean and carried by the East Greenland Current into the Atlantic around Kap Farvel to southern Davis Strait. The bag of Ringed Seal at Julianehåb increased far beyond the usual level, as did the Polar Bear bag. The explanation seems to be that the fast moving large ice masses off East Greenland served the Ringed Seals and Polar Bears as means of transportation and took them away from East Greenland. It was to be a time of severe hunger in East Greenland.

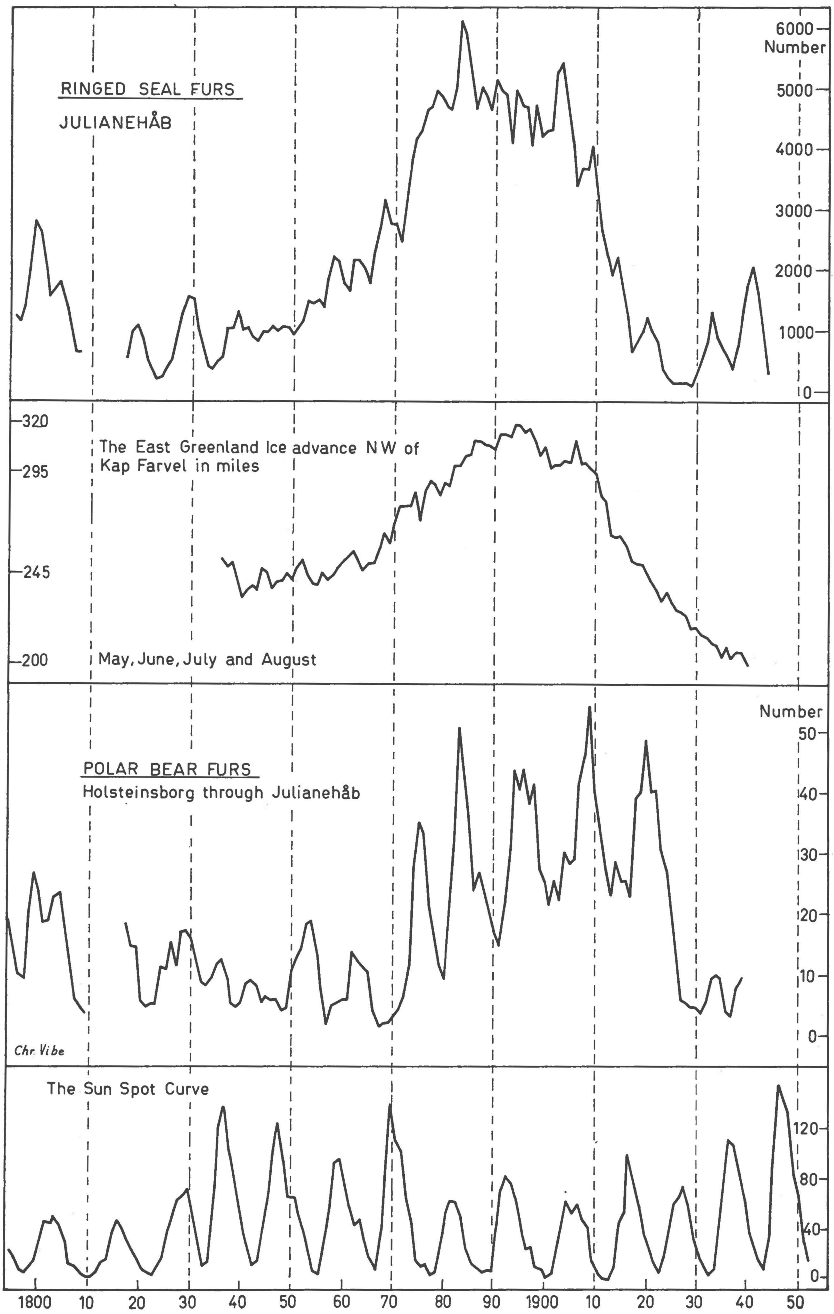



Fig. 36. Fluctuations in the catch of Ringed Seal at Julianehåb and of Polar Bear in Southwest Greenland, according to purchase of furs by the Royal Greenland Trade Department. Curves of Ringed Seal and Polar Bear in 3-year sliding averages. Curve of East Greenland Ice in 31-year sliding averages. The figures to the right of the sun-spot curve are "Wolf-figures".

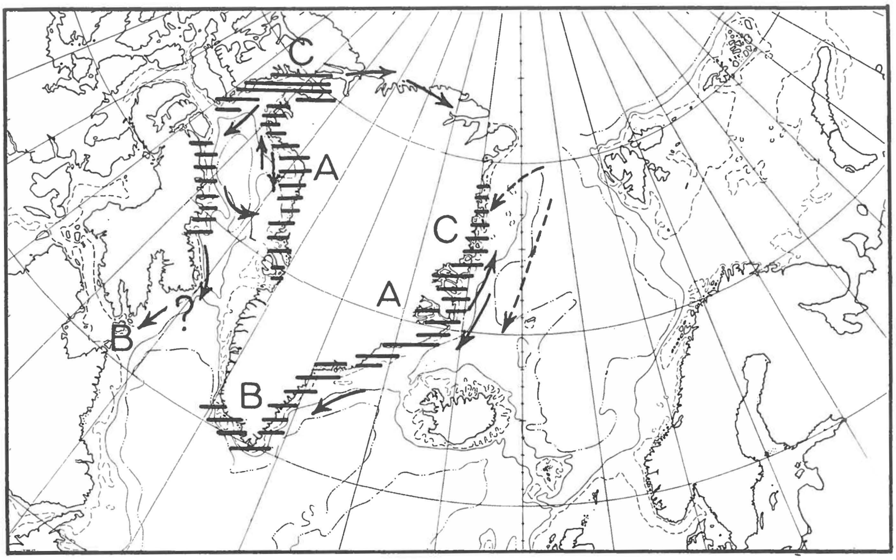



Fig. 37. Polar Bear habitats during different drift-ice stages. A. Stagnation stage. B. Pulsation stage. C. Melting stage. Arrows indicate migration routes. The route through Wandel Dal, Peary Land, was observed by EIGIL KNUTH.

Once the great ice advances ceased, the large numbers of Ringed Seal and Polar Bear in Southwest Greenland also terminated. These remained at the east coast of Greenland and at Svalbard.

Simultaneously the bears of Northwest Greenland moved northwest to Ellesmere Island and to the regions north of Kane Bassin, from where some went around North Greenland to Peary Land, see fig. 37.

To-day Polar Bear mothers with small cubs are regularly seen in the drift-ice off Northeast Greenland, less numerous in Melville Bugt, and Kane Bassin. Many are seen off the east coast of Ellesmere Island, south of 79° N. According to Canadian Wildlife Service (1965), dens are regularly found on northeastern Baffin Island.

All through its extensive area of distribution the Polar Bear is closely related to the population of *old breeding* Ringed Seals, and occurs in numbers when Ringed Seals are plentiful.

If we compare the sun-spot curve with the Polar Bear curve for Southwest Greenland for the period 1870–1930, during which time the fluctuations are very evident, we find that they tend to alternate, fig. 36. The sun-spot curve may influence the acceleration of the drift-ice, which serves the Polar Bear as biotope and as means of transportation.

The climatic conditions of to day on both sides of southern Greenland are too unstable for the country to maintain a very great population of Ringed Seal and Polar Bear. Breeding in dens, these animals need a constant Arctic climate without periods of thaw and melting of snow in winter.

# THE HARP SEAL

## (WITH REMARKS ON BEARDED SEAL, HOODED SEAL, AND HARBOR SEAL

The Harp Seal (*Pagophilus groenlandicus* (ERXLEBEN)) lives at the edge of the drift-ice belt, from Newfoundland via Greenland to Svalbard and the White Sea. It is a migrating seal, with a northern distribution in summer and a southern distribution in winter, although it does not normally go beyond the Arctic seas. In February/March they gather at three main places on the drift-ice to breed (Newfoundland, Jan Mayen, White Sea). After the breeding period, young and old Harp Seals migrate in herds toward the north and spread out over all accessible parts of the Atlantic area of the Arctic Ocean, fig. 38. They are lean, and eat themselves fat along the Arctic coasts before the sexually mature animals gather again during the next winter around the breeding grounds.

Most Harp Seals are away from Greenlandic waters from the middle of March until the middle of May when they dwell on the breeding grounds at Newfoundland and Jan Mayen. In the middle of May they return to the west coast of Greenland, and from then until medium June they arrive in Disko Bugt and migrate as far as Thule. Their preferred summering grounds are at present Disko Bugt and the Umanak-Upernavik districts, and to some extent also the Thule district, in East Greenland the Angmagssalik district. They leave the northern areas in November-December, spreading in winter along the west coast, preferably between Disko and Holsteinsborg (PH. ROSENDAHL 1961 p. 18), fig. 40.

The curves figs. 39, 41, and 42 graph F register in 3-year sliding averages the purchase of skins of seals other than Ringed Seal. The curves include Harp Seal, Bearded Seal (*Erignathus barbatus* O. FABR.), Hooded Seal (*Cystophora cristata* ERXL.), and Harbor Seal (*Phoca vitulina* L.); however, the Harp Seal is vastly in the majority. The accounts do not distinguish between the individual species of seal until 1861. During the period 1861–70, for example, Harp Seal skins accounted for some 83 per cent of skins (other than Ringed Seal) purchased at the colonies from Sukkertoppen to Upernavik, and 70 per cent from Godthåb to Julianehåb, where relatively many Hooded Seals were caught.

In fig. 42 graphs G and H Harp Seal is treated separately, and so are Bearded Seal and Hooded Seal in fig. 43.

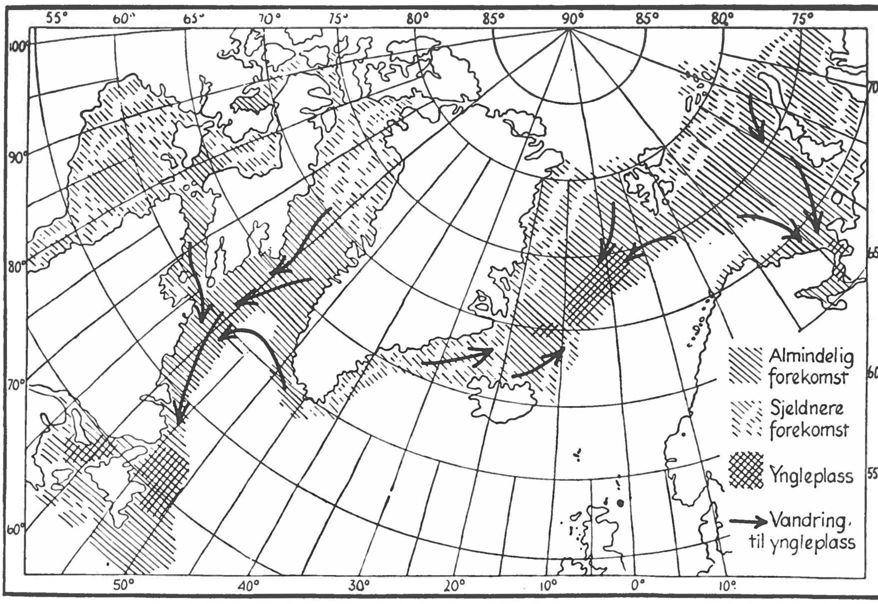



Fig. 38. Summering grounds, migration routes, and breeding places of Harp Seal. After FRIDTJOF NANSEN 1924.

At Julianehåb and Frederikshåb, a large number of skins were prepared and sold as "boat skins" and "water skins". "Boat skins" were usually made of Hooded Seal and are included in the figures for Hooded Seal (fig. 43). "Water skins" were usually made of Harp Seal and are included in the figures for Harp Seal (fig. 42 graph G).

It should be noted that the Greenlanders themselves used many skins of all kinds, and consequently only the surplus reached the stores. Since, however, the fluctuations are repeated from colony to colony, it may be presumed that this surplus fluctuated in step with the actual occurrence. During good years, there was a greater surplus to be converted into other goods. The curves after 1946 (figs. 41–42) are based on the hunting statistics (fangstlisterne) so that they reflect the total catch without regard to the consumption. This shows that the consumption of skins among the Greenlanders is quite considerable.

In a period before 1810, the Harp Seal (and the breeding Arctic Eider) avoided the central areas of West Greenland (e.g. Sukkertoppen) on its summer migration and occurred in numbers in the northern areas from Disko Bugt to Upernavik, culminating about 1807. The period before 1810 was relatively mild in Davis Strait (drift-ice melting stage). The Arctic animals moved north.

After 1817 the drift-ice in Baffin Bay stagnated in northern regions, and during the subsequent period until 1860, the East Greenland Ice

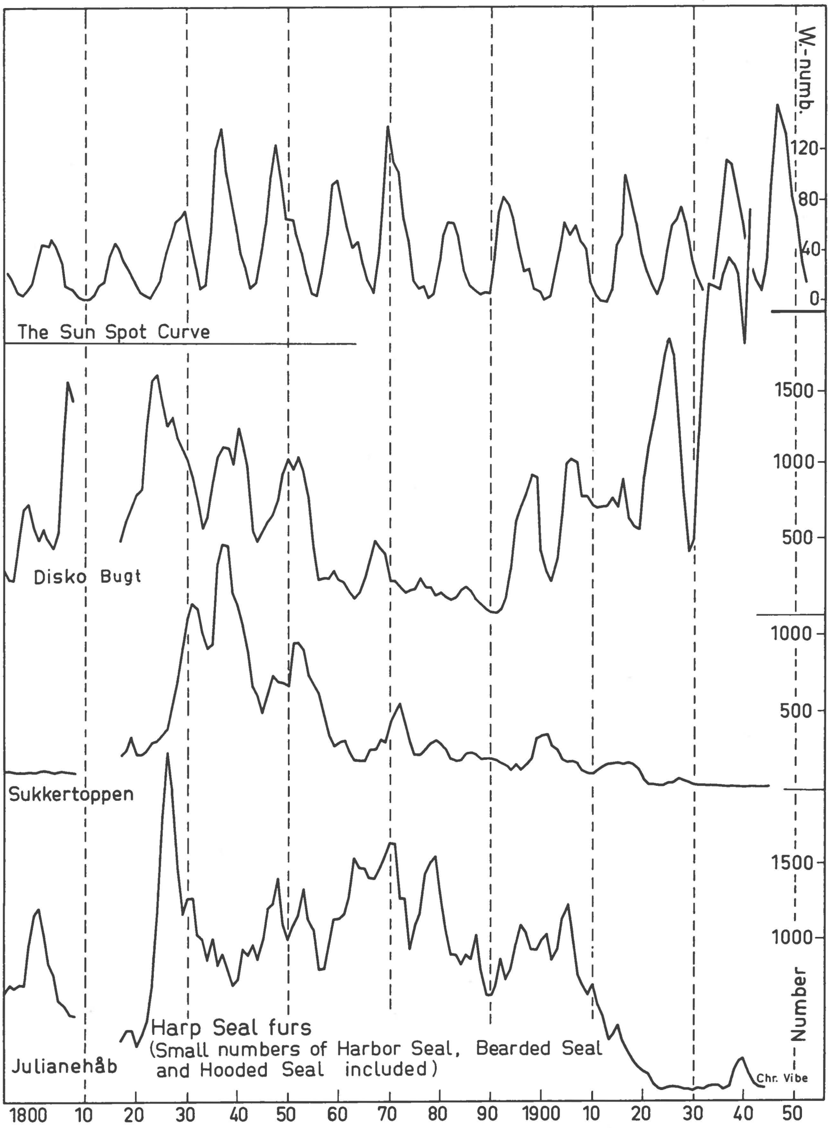



Fig. 39. Purchase of Harp Seal furs in Southwest Greenland, by the Royal Greenland Trade Department. Curves in 3-year sliding averages. Small numbers of other seals are included, see text p. 63. A great part of skins purchased at Julianehåb 1860–1910 were most likely skins of Hooded Seal, cf. fig. 43.

kept back somewhat (drift-ice stagnation stage). This suggests a weakening of the cold East Greenland Current in Davis Strait—and a wide extension of the Canadian Current across Baffin Bay toward Greenland during winter. The Reindeer were numerous all the way from Upernavik to Godthåb making it likely that the Atlantic deep water did not penetrate very far north during this period. The mixed area between Atlantic and Canadian Arctic waters came to be located at Southwest Greenland and north as far as Disko Bugt. There lay the productive field of the summer. Both the blue Arctic Fox and the Eider occurred in great numbers in Southwest Greenland, and the Harp Seal made for the same area, stopping its migration to the north at Disko Bugt. The water must have been too cold in the area north of Disko Bugt.

The occurrence of Harp Seal (and Hooded Seal) was not constant. The great drops in the bags in Disko Bugt around 1834, 1844, and 1856 (at approx. 11-year intervals) correspond with small peaks in the Upernavik district. As drift-ice advances increase in size, the Harp Seal moves farther north, probably because the mixed area is then located farther to the north. This becomes clear during the subsequent period.

During the "drift-ice pulsation stage" after 1860, the Harp Seal moves from Central West Greenland and Disko Bugt north to the Umanak district, fig. 41. It is still too cold for it at Upernavik, where it appears only in very small numbers.

It is characteristic of this period that both Central West Greenland and Disko Bugt are depopulated of Harp Seal. The reason must be sought in the beginning mass advance of the East Greenland Ice in Davis Strait,

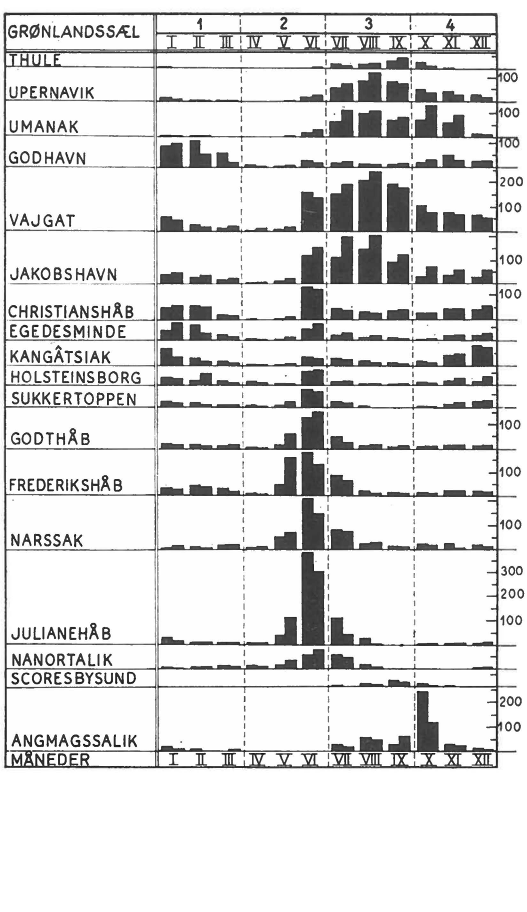



Fig. 40. "The time of the annual arrival of the Harp Seal, the length of its stay at, and its departure from Greenland, as also the hunting intensity, illustrated by the figures showing the average annual catch per 100 hunters in the three-year period 1948/49–1950/51. The arrival from the Newfoundland nursery grounds is seen to take place in May–June. The animals are seen to move southwards again from the north, making for the nursery grounds late in winter". (Figure and text after PH. ROSENDAHL 1961 p. 18).

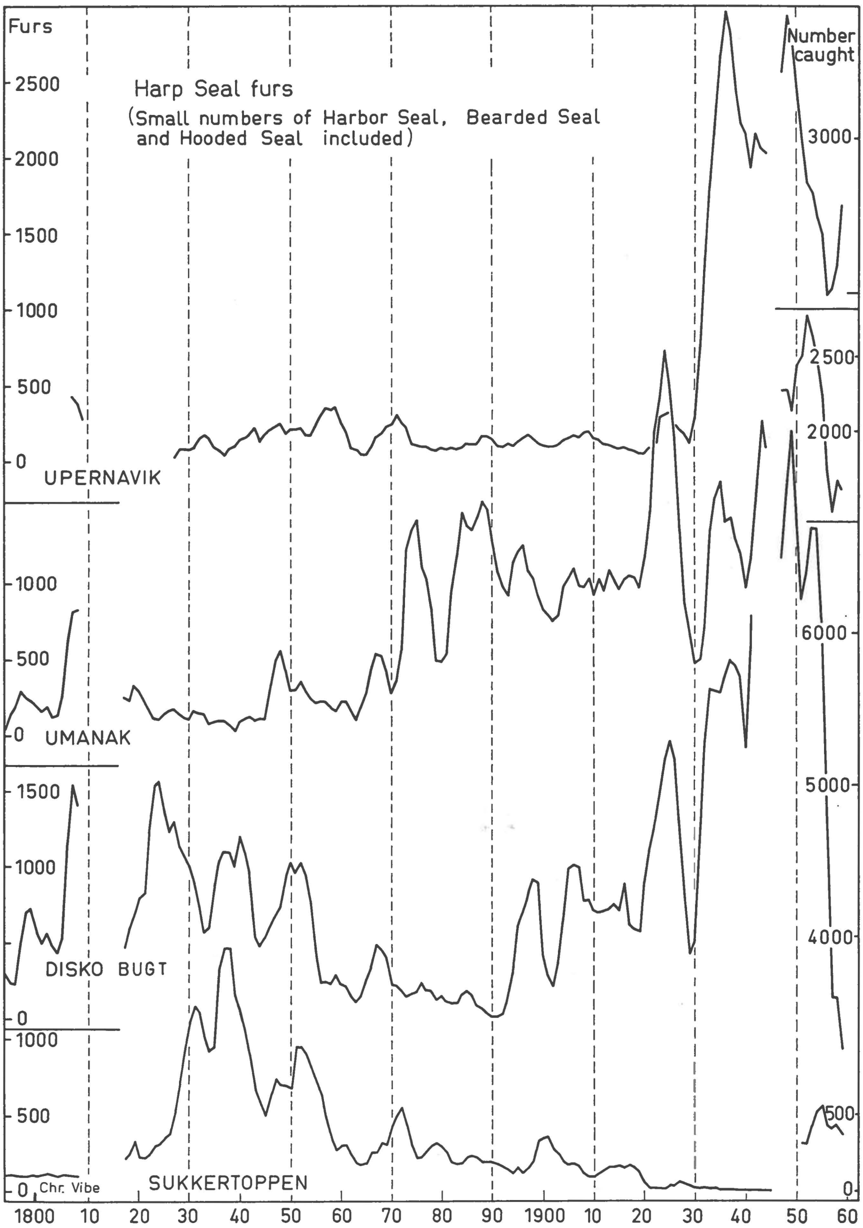



Fig. 41. Purchase of Harp Seal furs in Northwest Greenland, by the Royal Greenland Trade Department. After 1946 the curves indicate the number actually caught, according to hunting statistics. Small numbers of other seals are included, see text p. 63. Curves in 3-year sliding averages.

forcing the Atlantic deep water farther north before it was able to penetrate to the surface. This is the same period during which the population of breeding Eiders declines in West Greenland.

During the period 1895–1920, the late drift-ice decreases in southern Davis Strait. The Harp Seal moves into Disko Bugt and now has its principal distribution in the Disko Bugt–Umanak area.

In the period 1910–50 (the drift-ice melting stage) the southernmost Harp Seals (and Hooded Seals?) leave all the southern districts. The situation is similar to that before 1810. In mild periods the Harp Seals avoid southern West Greenland. Around 1940 some returned to Julianehåb but did not stay, fig. 39.

In the area between Disko Bugt and Upernavik the Harp Seals progressed greatly during this period, and even reached all the way to Thule (VIBE 1950, p. 64).

Fig. 42 shows the seal curves at West Greenland and Newfoundland in relation to drift-ice and sun-spots. A-B-C indicate the "stagnation stage", the "pulsation stage", and the "melting stage", respectively. Graph F shows the purchase of Harp Seals and Hooded Seals (and a few Bearded Seals and Harbor Seals). The number of Hooded Seals may be small, too. Graphs G and H show Harp Seals only. G shows the purchased number and H shows the number caught.

Graph F parallels the sun-spot curve for the period 1820–60 (the drift-ice stagnation stage). During the succeeding drift-ice stages, when Davis Strait experienced an Atlantic climate, the Harp Seal curve (graph G) alternates with the sunspot curve (with the exception of the period before 1910 and that after 1910 which coincide with the transition driftice stage B-C, when the amount of drift-ice is the same as in stage A).

It is worth noting that the rhythm of the biological curve changes simultaneously with a profound shift in the climate in Davis Strait.

After 1920, the catch of Harp Seals was fairly large in West Greenland until 1950. In the period 1953–63 the catch was reduced to half, graph H. A natural increase was to be expected during the sun-spot minimum around 1960, but failed.

Fig. 42 bottom curve shows the catches at Newfoundland according to THOR IVERSEN 1927 p. 18, (I) by sail ships and steamers, (J) by steamers. It appears that years with great catches at Newfoundland are followed by years with small catches at Greenland. However, it cannot safely be concluded that the decrease in the Greenland catches is due to the increase in the Newfoundland catches; it is possible that the Harp Seal stays away from Greenland under certain drift-ice conditions.

Fig. 43 top shows a curve of the year temperature at Upernavik. The low temperature until 1925 seems to be a direct consequence of the great masses of East Greenland Ice in southern Davis Strait during the drift-ice pulsation stage (bottom curve). After 1925 the year temperature is at a higher level.

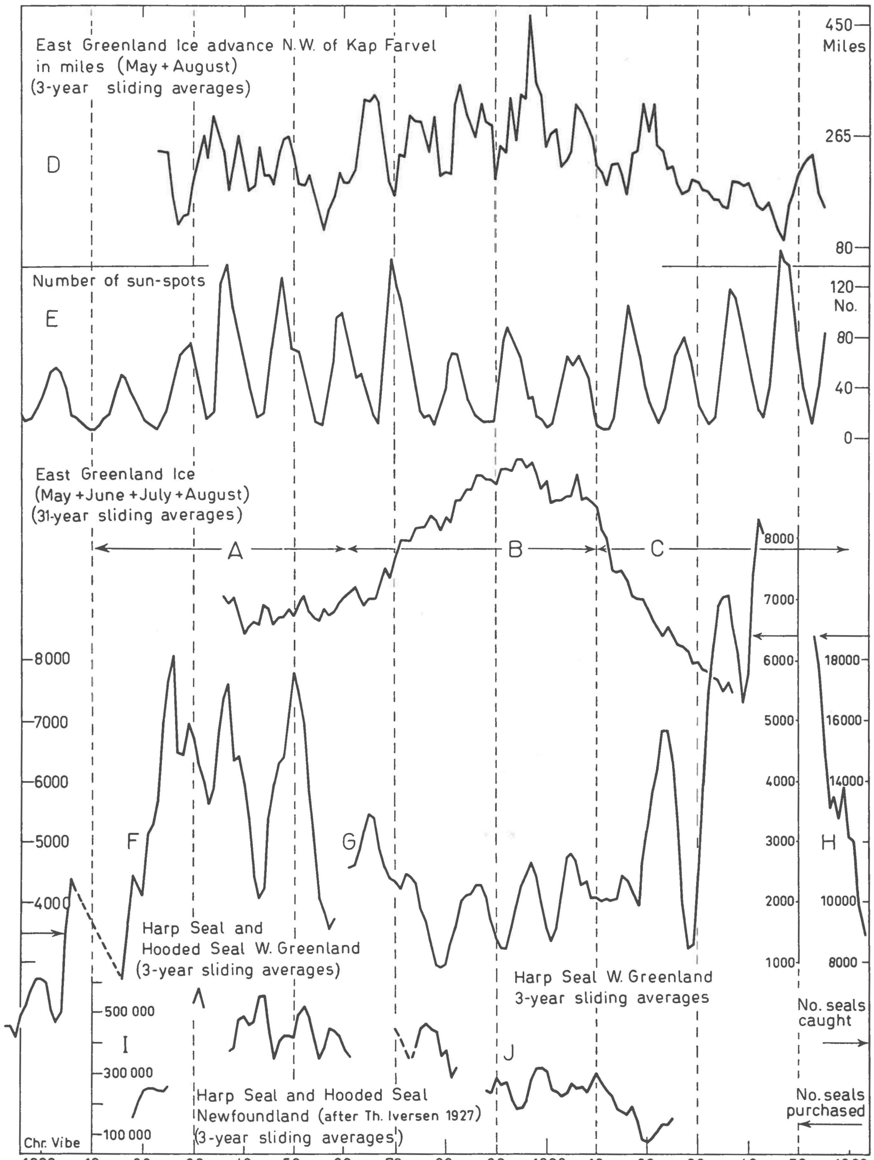



Fig. 42. See text p. 68.

The curve of the East Greenland Ice advance in southern Davis Strait in August (late drift-ice) demonstrates that each advance coincides with a decrease in the temperature at Upernavik.

The curves of the purchase of *Bearded Seals* and *Hooded Seals* show that in the single years the catch is greatest when the late drift-ice advance is smallest.

Many of these seals arrive in Davis Strait with the drift-ice early in the spring, and when the East Greenland Ice comes early, there will be little ice in August.

A comparison between the Hooded Seal curve and bottom drift-ice curve (the latter in 31-year sliding averages) may suggest that the Hooded Seal visited Davis Strait preferably during the drift-ice pulsation stage (1860–1910). The population began declining at West Greenland simultaneously with the decrease in East Greenland Ice in Davis Strait. After 1910 the Hooded Seal thus seems to prefer feeding grounds outside West Greenland.

The writer has not had opportunity to compare the Greenland Hooded Seal catch to the catch elsewhere.

During the warm post-glacial period the Harp Seal occurred in Danish waters, off southern Norway and in the Baltic.

The following is quoted from MAGNUS DEGERBØL 1933, p. 623: "It is rather surprising to find the Harp Seal (*Phoca groenlandica* O. FABR.) represented . . . The occurrence of this animal of the high north, which nowadays keeps especially to the belt of drift-ice out to the open sea, is rather inexplicable in our Stone Age, when the climate was even warmer than now. At that time, the Harp Seal was not only found in the inner Danish waters, but has been identified right up to the Baltic, round about Öland. According to HOLMQUIST (1912), these Harp Seals are conspicuously small. Owing to the relatively large numbers, this writer considers that they have not been accidentally immigrated individuals; there must have been a permanent colony round Öland, but not a relic of the Glacial Age. Thus it would be reasonable to suppose that the Harp Seal had come from there to Danish waters. In that case it might have been expected that the Danish remains of this seal had belonged to small animals, but this is not so. It is, thus, more likely that the Danish Harp Seal came from the north as a winter visitor. This view is also supported by the fact that in South Norway, in Vistehulen near Stavanger, remains of the Harp Seal from the Early Stone Age have come to light. That the Harp Seal in the Baltic in the Stone Age cannot be regarded as a relic-form from the Glacial Age like the Ringed Seal (*Phoca hispida* SCHREB.), seems evident from PIRA's examination of the seal bones from "Stora Förvar" on Stora Karlsö near Gotland, 1926.

In the deepest, i.e. the oldest layers were found remains of Grey Seal and Ringed Seal, whereas the Harp Seal was not represented. Bones of this latter animal were not found until the middle layers were examined. It is obvious that if the Harp Seal were a relic form, its bones would have been most numerous, or at any rate would have been present, in the oldest layers".

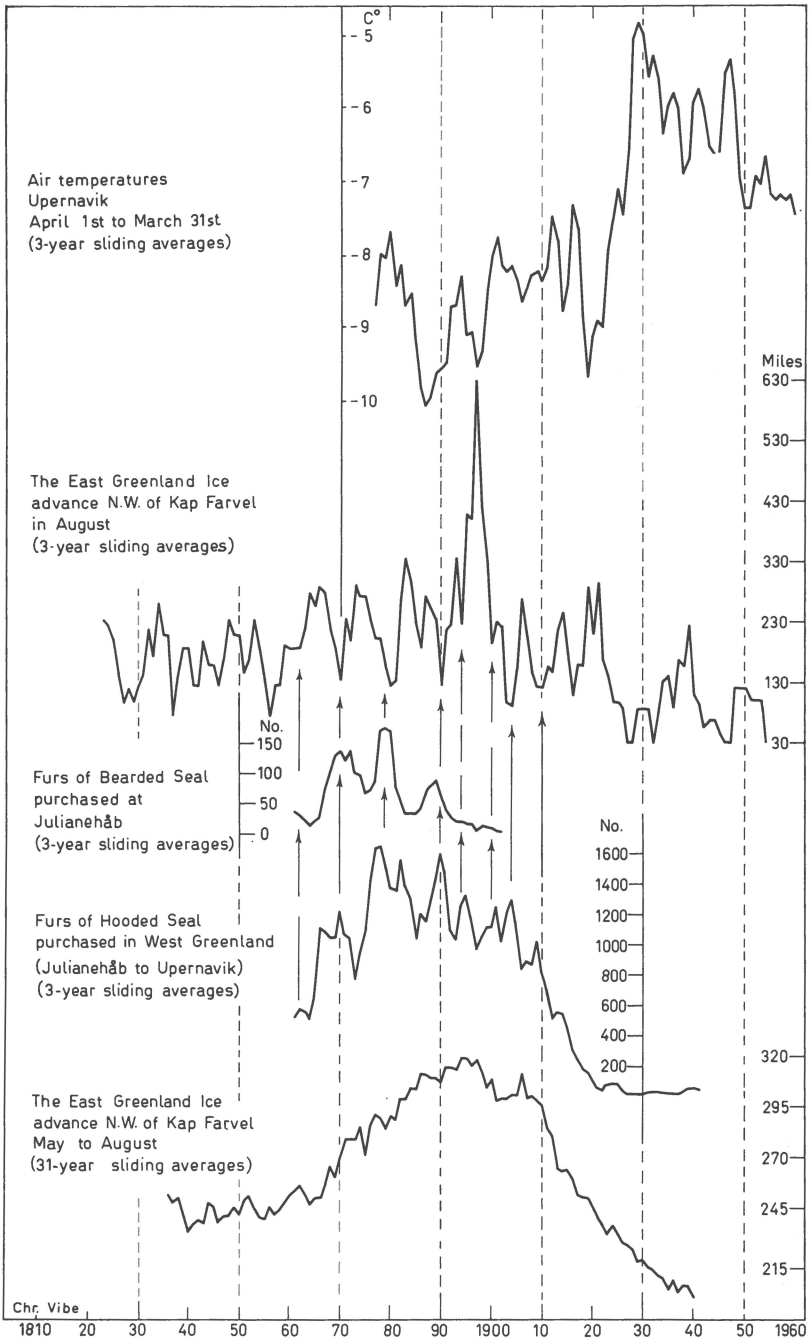



Fig. 43. See text pp. 68–70.

It is worth noting that the Harp Seal did not occur in the Baltic nor in other Danish waters until the beginning of the warm post-glacial period, and that its massive occurrence stopped again after the end of that period. (ULRIK MØHL has kindly informed the author that bones of Harp Seal are found at rare intervals in Danish kitchen-middens also from later periods).

The White Whale, too, occurred in Denmark during the warm post-glacial period, although only a single specimen is known, see p. 76.

In rare cases during our times (1902–03), the Harp Seal has gone in great numbers as far south along the west coast of Norway as Helgeland, which NANSEN ascribed to the unusual ice conditions in the Barents Sea. During the same winters, accidental visitors are thought to have been seen in Danish waters, where it normally does not occur at present (H. WINGE 1908).

Nautisk Meteorologisk Årbog states in regard to the drift-ice situation in the summer of 1901: "In the N.-rn Atlantic the cold water and icebergs of the Polar current were carried further to the E. than during a long span of preceding years, while a sudden cold wave rolled across N.-rn Europe in the beginning of June."

There was very little East Greenland Ice in Davis Strait during the summer 1901. In the subsequent years the ice arrived in spring and drifted farther north than usual, fig. 9. The whole period around 1900 was both in East and West Greenland characterized by great climatic fluctuations. In Northeast Greenland the extreme climatic situation caused the Reindeer to become extinct. In Northwest Greenland the populations of breeding sea birds began to increase, fig. 28 (Upernavik) and fig. 30 (bottom). The Greenland Whale almost disappeared from the Atlantic Arctic region. Its preferred biotope became and remains to-day the Beaufort Sea north of Alaska from where it migrates to Bering Sea for wintering.

The possibility cannot be rejected that similar climatic situations periodically prevailed during the Stone Age, as suggested by M. DEGERBØL. Here, too, we may have the explanation why Man did not arrive in Greenland until the climatic situation had become stable.

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Fig. 28 shows two curves representing the purchase of **Harbor Seals**. The curves decline similar to the Eider down curves, and indicate that the Harbor Seal does not thrive in periods with much drift-ice or much cold surface water in southern Davis Strait.

# THE NARWHAL AND THE WHITE WHALE

Both the Narwhal (*Monodon monoceros* L.) and the White Whale (*Delphinapterus leucas* (PALL.)) have throughout the centuries been important quarry for the Eskimo kayak hunters; the meat, blubber, and mattak have been greatly in demand, and the tusk of the Narwhal has been a good trading commodity.

Both are strictly Arctic species; they migrate south in the winter along the west coast of Greenland. In cold periods they may be seen off southernmost Greenland. In warm periods it is assumed that they stay in the northern regions or go westwards at a higher latitude and cross Davis Strait north of Holsteinsborg or at Disko. The Narwhal is frequently seen with the White Whale, but rarely goes as far south as the latter.

As the Narwhal has always been eagerly hunted and as its tusk has been a good trading commodity, it is possible to follow its occurrence in Northwest Greenland as far back as 1793, see fig. 44. Until 1830 the purchases of Narwhal tusk were given in numbers of tusks, followed by pounds (1 Danish pound = $^1/_2$ kg). As the monopoly of the Royal Greenland Trade Department has always been strictly maintained, it is safe to assume that the greater part of the Narwhal tusks acquired have landed in the stores. In 1950 monopolized trade ceased to exist. However, hunting statistics for Narhwals and White Whales began 1901. The fluctuations in the catches follow fairly regularly the fluctuations in the curve of kilograms of Narwhal tusks purchased, see the graphs fig. 44.

Simultaneously with the acceleration in current activity and drift-ice advance in southern Davis Strait about 1860, the catch of Narwhals increased at Umanak. When the catch decreased at Umanak it increased at Upernavik.

The southwards migrating Narwhal follows the border of the Canadian Current. In periods with great northern advances of the West Greenland currents the Narwhal stays at a higher latitude for a longer period during autumn and winter.

The Narwhal is still very common, but as it is sensitive to the fluctuations in the sea currents, it has today moved its southern boundary farther north.

The quantitative fluctuations of Ringed Seal and Narwhal often alternate in Northwest Greenland. The Narwhal departs early in cold winters, while in return additional numbers of young Ringed Seals arrive which are displaced by heavy ice in Melville Bugt or in the regions west of Baffin Bay.

A comparison with the temperature curves shows that the catch of Narwhal (and White Whale) in the northern districts of West Greenland generally follows the positive fluctuations of the temperature, also the upward trend of the temperature curves. It must also be because of the rising temperature and increasing inflow of Atlantic water into Davis Strait that, in certain periods, the catch decreases at Umanak but in turn increases further north at Upernavik and Thule. The purchase of Narwhal tusks at Umanak had its peak in 1865. From then on the catch fell in favour of Upernavik, which showed progress until around 1920–40. Around 1950, both the purchases of Narwhal tusks and the figures of Narwhal and White Whale catches for Umanak and Upernavik were at a minimum, while the purchases of Narwhal tusks were high at Thule. The summer temperature was relatively high in 1950 at Upernavik. This may be the reason for a longer stay and a greater catch at Thule.

As the Narwhal on the breeding grounds lives chiefly on Arctic Cod (*Boreogadus saida* LEP.), Greenland Halibut (*Reinhardtius hippoglossoides* WALB.) and certain crustaceans (Decapoda), and the White Whale mostly on the two former (VIBE 1950), these animals, unlike the Greenland Whale, are dependent upon the coasts and the sea bottom. They must, therefore, move away when the winter ice forms along the coast. The White Whale moves south at an early point. The Narwhal is much later.

With respect to their migrations, toward the south early in the winter and toward the north late in winter, there is much similarity between the Narwhal and the Greenland Whale. According to ESCHRICHT and REINHARDT 1861, the Greenland Whale arrived fairly regularly at Holsteinsborg in December during the period 1800–1830, and moved back north in February/March. It arrived earlier in cold winters and later in mild ones, and accordingly, departed later and earlier.

According to RYBERG (quoted by H. WINGE 1902, p. 508) the White Whale could be seen every year all the way down to Julianehåb, at the close of the last century (1876–90). Around 1940 it was rarely seen at Godthåb. At Sukkertoppen it appeared for many years in the middle of October and was hunted to a considerable extent. However, in the beginning of the late 1920's, the White Whale arrived later and departed earlier. M. DEGERBØL 1930, p. 142 quotes a letter, Oct. 2., 1929 from N. L. NIELSEN, Sukkertoppen: "The White Whale has during the last three years showed up here middle of November (previously middle of

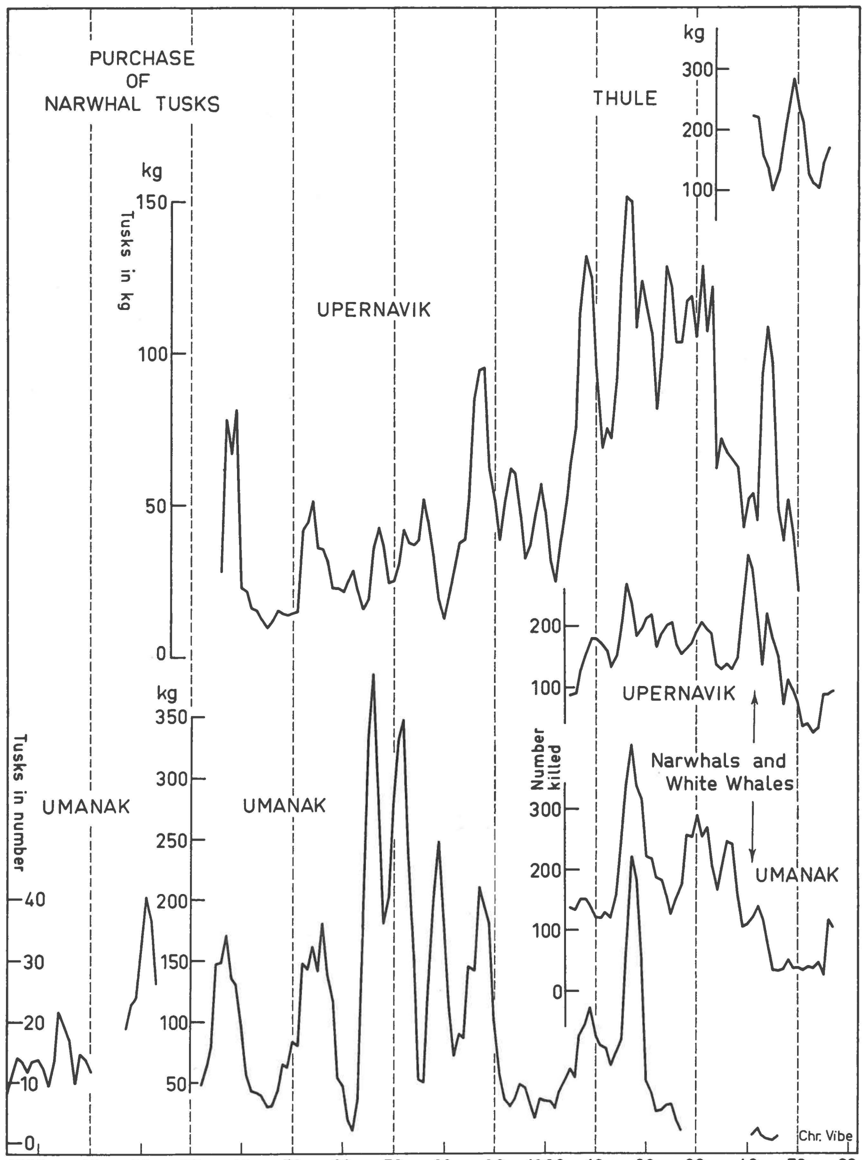


Fig. 44. Before 1830 the curve shows the number of Narwhal tusks purchased by the Royal Greenland Trade Department. After 1830 the curves show the purchase of tusks in kg.
The numbers of Narwhals and White Whales killed at Upernavik and Umanak are from hunting statistics, beginning 1901. All curves in 3-year sliding averages.

October) and departs again as early as January (previously April or early May)". Shortly after, whaling was abandoned at Sukkertoppen. During the period 1935–38, only five White Whales were caught there.

The White Whale now winters further north or it goes westwards at a higher latitude. In Disko Bugt it is still a common winter guest, and is caught in hundreds in "savssat" (openings in the ice produced by currents). It was common in the Thule district in the summers of 1939–41, when the present author was living there, and was seen with young. However, the majority of the White Whales stayed still further north in summer, and herds arrived from the north to Inglefield Bredning in September and October. Small numbers winter in the northern part of Baffin Bay, according to an eye-witness account by HANS NIELSEN. The following is quoted from VIBE 1950, p. 84:

"Even if the Narwhal and the White Whale leave the inner regions of Thule district in winter, both whales are, however, supposed to winter in small numbers in Baffin Bugt. Settlement manager HANS NIELSEN who has spent more than twenty years in Thule thus tells that on February 6th 1923 he saw a herd of White Whales at a fairly great distance at sea west of Kap Parry, where there is ice cover only exceptionally. A White Whale was shot and contained a foetus about 2 m long. Mr. HANS NIELSEN presumes that both the Narwhal and the White Whale normally stay at sea in smaller numbers throughout the winter".

The occurrence of the White Whale in Denmark in the palaeolithic age, from which a single bone is known, WINGE 1899, p. 311, must be considered as an indication that in those days, to a greater extent than now, drift-ice had occasionally a wide easterly diffusion over the Greenland Sea. As often indicated in the present paper the Arctic animals show the greatest fluctuations during periods when the Atlantic influence is at its highest.

The White Whale has been seen four times at the Faroes, viz., in 1898, 1903, 1920, according to M. DEGERBØL 1940, and in 1964, according to verbal information by captain JOH. LARSEN.

In the fall of 1964 one and in 1965 two White Whales were caught in Danish waters.

With regard to the present change in climate, B. E. ERIKSSON emphazises that this is associated with the inflow of increased southern winds toward the Arctic: "The extension of the drift-ice has been found to depend on the wind. A westerly shifting of the wind convergence line of the Norwegian Sea results in southern winds here, spreading the ice of the Greenland current toward the east, and at the same time spreading over the Barents Sea the ice advancing off South Cape of Spitsbergen", B. E. ERIKSSON 1943, p. 197. See further p. 72.

# THE WALRUS

The Walrus (*Odobenus rosmarus* L.) feeds on the bivalves of the sea bottom, especially *Cerripes groenlandicus* CHEMNITZ, *Mya truncata* L., *Astarte borealis* (CHEMNITZ) and *Saxicava arctica* L. Consequently, it is dependent on the wide areas of level bottom on which these bivalves occur in sufficient quantity at a depth of approx. 10–80 meter, VIBE 1950. However, it is not out of the question that the Walrus may look for food at greater depths.

In the summer, it is rarely seen south of Upernavik district. Its chief foraging grounds in the present time are the area between Littleton Ø and Kap York, where it is numerous in the summer and where it winters in some numbers along the edge of the land ice facing Baffin Bay.

Its winter grounds stretch south to Holsteinsborg district. The Walruses staying in fall and winter in the West-Greenland waters between Disko and Holsteinsborg are according to P. FREUCHEN (1921) assumed to come from the west side of Davis Strait. Their routes of migration are not completely known. They could equally as well come from northwestern Baffin Bay.

Fig. 45 shows the purchase of Walrus tusks by the Royal Greenland Trade Department at Sukkertoppen through Egedesminde for the years 1861–92 and 1901–18, and at Godhavn through Upernavik for the years 1864–89. These curves do not include the tusks used by the Greenlanders for tools. The last parts of the curves show the number of Walruses caught according to the hunting statistics.

Until 1932, the catch at West Greenland was carried out from kayaks along the coast, from boats at the landing places of the Walrus, or by dog sledge on the winter ice. In all cases, the hunt was dangerous and hard, and only small numbers of animals were caught.

In 1932, Walrus hunting was begun by schooner and rather large motor boats in the Baffin Bay Ice off Godhavn, Egedesminde, and Holsteinsborg districts during the spring months of April–June. At that time, the Walruses stay at the edge of the Baffin Bay Ice, in Greenland called "Vestisen", along with their new-born young. The use of the larger craft increased the catch' considerably. While formerly rarely more than 150

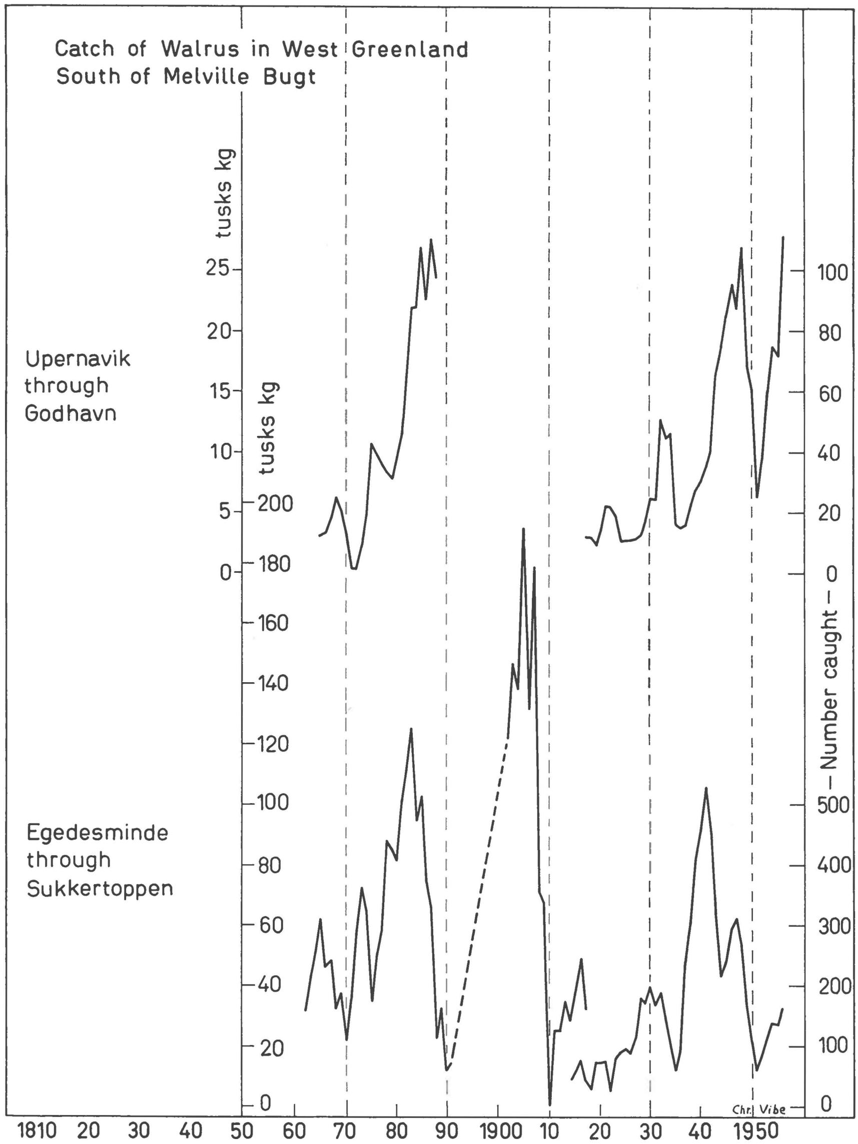


Fig. 45. The first parts of the curves show the fluctuations in the purchase of tusks. After 1917 (upper curve) and 1914 (lower curve) they show the number of Walruses actually caught. All curves are in 3-year sliding averages.

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Fig. 46. Spring migration of Walrus from the winter grounds in southern Melville Bugt to the summer grounds in Thule district (hatched area). North of Etah some of them either proceed to Kap Kent, or they cross Smith Sund to other feeding grounds along the east coast of Ellesmere Island. The drawn line indicates the usual limit of the shore-fast ice in late winter and spring. The arrows indicate migration route. After VIBE 1950.

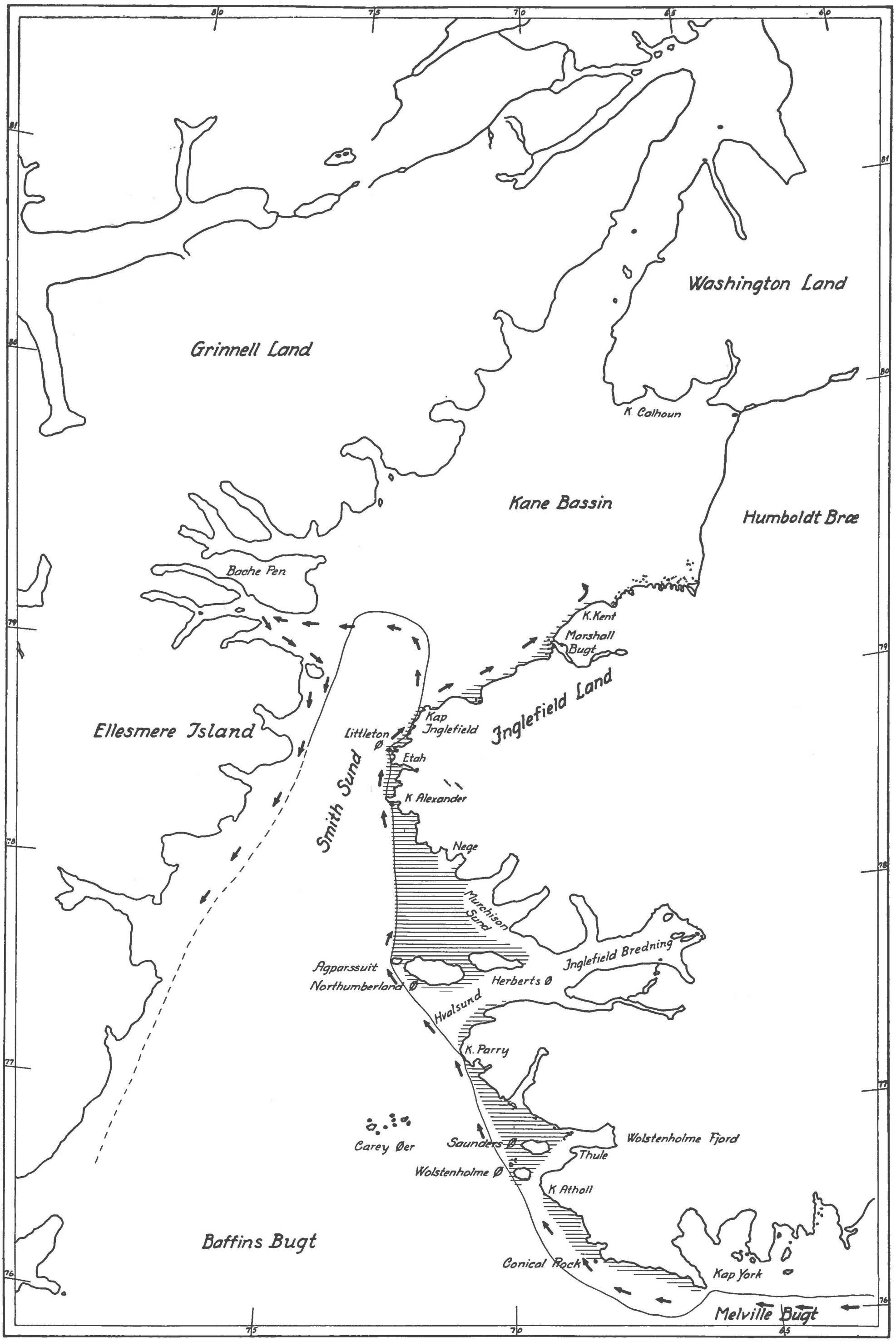

Washington Land
Grinnell Land
K Calhoun
Kane Bassin
Humboldt Bræ
Bache Pen.
K. Kent
Marshall Bugt
Jnglefield Land
Kap Jnglefield
Littleton Ø
Etah
Ellesmere Jsland
Smith Sund
K Alexander
Nege
Murchison Sund
Jnglefield Bredning
Aparssuit
Northumberland Ø
Herberts Ø
Hvalsund
K. Parry
Carey Øer
Saunders Ø
Wolstenholme Fjord
Thule
Wolstenholme Ø
K Atholl
Baffins Bugt
Conical Rock
Kap York
Melville Bugt

Fig. 46.

Walruses were caught in the best years, the catch soon increased to approx. 500 for the best years.

Regardless of method of hunting, the occurrence of Walrus has always been subject to great fluctuations in West Greenland and has varied in the same way as that of the other migrating sea mammals.

In the present time many Walruses winter on the grounds south of Melville Bugt during periods with lively movements in the East Greenland Ice in southern Davis Strait early in spring (May). Simultaneously, the Baffin Bay Ice is only slightly extended toward Greenland, and there is much open water in eastern Davis Strait.

During periods with late drift-ice (August) in southern Davis Strait and much Baffin Bay Ice in spring, the catches of Walrus are poor in West Greenland. This may be due to difficult hunting conditions, but more probably the reason is a decline in the Walrus population wintering in the coastal waters of West Greenland because of the solid Baffin Bay Ice.

How and where the population is able to save itself through severe ice periods is not clear, since it is not found farther south at West Greenland.

However, as both sides of Baffin Bay and Davis Strait must be considered as a geographic and faunistic whole, it is assumed that the Walrus, usually wintering off West Greenland, stays out in the Strait or crosses the Strait in severe ice winters to join the population at southeastern Baffin Island, thus following the same westbound direction as the Greenland Whale, see map fig. 53. (Concerning the biology of the Walrus in the eastern Canadian Arctic see A. W. MANSFIELD 1958).

Today a good many Walruses winter in the northern waters of Baffin Bay, VIBE 1950, but the majority of the Baffin Bay summer population is assumed to leave the Thule area in autumn and cross to the waters around Lancaster Sound from where some may cross Baffin Bay for West Greenland. During severe drift-ice years off West Greenland these Walruses must once more cross Davis Strait and go to southern Baffin Island.

# THE GREENLAND WHALE
## MASS OCCURRENCE AND STAGNATION

The history of the Greenland Whale (*Balaena mysticetus* L.) is one of our most important sources for the understanding of the ecological conditions of the Arctic animals through the ages. During work with biological fluctuations in Greenland it became clear that the reason for the quantitative fluctuations of many Arctic animals was to be sought in changing conditions of temperature, precipitation, drift-ice, and currents in the Arctic Ocean and adjacent waters. It appeared then that similar conditions must have influenced the Greenland Whale and may — possibly to a greater extent than whaling — be the cause of the catastrophic reduction of this valuable baleen whale from about 1740 to 1900.

Therefore, the author found it both interesting and necessary to study the history of the Greenland Whale in the seas around Greenland. Unfortunately, considerations of time and space made it necessary to limit this point to a brief summary, and it must then be left for later studies to give the topic the deeper scientific treatment it so definitely deserves.

In recent time it has been feared that the Greenland Whale would eventually become extinct because of remorseless persecution by whalers. This is not the case, but to-day large quantities of heavy drift-ice, often arriving late in summer, prevent a new increase of population in the Atlantic area.

To-day, the Greenland Whale is seen and killed regularly in small numbers by the Eskimo population of Alaska. It is seen in Hudson Bay and in the sounds of the Northwest Passage (verbal information, J. Tener 1965), and in Davis Strait off Godhavn. "It is now regularly seen at the ice edge off Godhavn from autumn till spring. It is said that it is not unusual to see 3–4 specimens lying asleep on the surface of the water", Peter Dalager in "Grønlandsposten" 1943, p. 187. October 23rd 1943 a Greenland Whale was seen in Thule harbour (North Star Bay), "Grønlandsposten" 1943, p. 285. In 1940 a young specimen hovered around the mouth of Scoresby Sund, where an older specimen was also observed on a few occasions during June 1964 (verbal information, H. Brønlund 1964). In the latter case, the whale foraged in the open clearing between

Kap Tobin and Kap Brewster until the ice disappeared from the fiord, whereupon it left.

In August 1953, STEEN MALMQUIST observed two large whales in the drift-ice at 76° N and 40 miles east of the southernmost part of Store Koldewey. The edge of the drift-ice was some 100 miles away. For many years Greenland Whales had not been seen in these waters. The two whales in question emerged through an opening in the ice, breathed a few times, disappeared again under the ice and came up later in another opening. During the autumn of 1953 very little drift-ice occurred along the coast of East Greenland.

According to W. J. MAHER and N. J. WILIMOSKY, 1963, the Eskimo population of Point Barrow carries out some hunting of the Greenland Whale in April–June and September–October during the spring migration of the whale toward the northeast and its autumn migration toward the southwest. The biggest yearly catch since 1928 was 17 animals in 1953. Altogether, the bags were:

| | | |
|---|---|---|
| 1931–40: | 56 | Bowheads (Greenland Whales). |
| 1941–50: | 43 | — — |
| 1951–60: | 59 | — — |

To reach the summer feeding grounds in the Arctic Ocean west of Banks Island and in the sounds of the Northwest Passage, the Greenland Whale must pass along the open lead between the shore-fast ice and the drift-ice outside. Here it is forced within the reach of the Eskimo. The above-mentioned authors write on this subject:

"In addition to abundance of whales, the factors which appear to be responsible for the variation in annual catch are the distance from the shore to the open lead, the width of the lead, the length of time the lead remains open, and wind conditions. For ideal whaling the lead should be close to the shore for easy access with whaling gear, and it should remain open and narrow so that the whales are forced to pass near the shore-fast ice. Wind direction and velocity affect the width of the lead as well as the roughness of the water. The Eskimos do not hunt whales in rough weather. . . . The Eskimos pursue every whale that comes within one or 2 hundred yards of the shore-fast ice".

As will be seen from the above, Eskimo whaling at Alaska to-day is dependent upon very specific ice conditions: Whaling is impossible both when the shore-fast ice stretches too far out to sea, and when the drift-ice lies too close to the shore-fast ice and closes the lead.

As for the Atlantic area, it was shown in the preceding that the occurrence of drift-ice varies a great deal, SPEERSCHNEIDER 1931 and KOCH 1945. The Greenland Whale has not always had easy access to its summer feeding grounds, which have not always had the same ex-

Fig. 47. Fragment of a skull of Greenland Whale excavated at Thule Air Base, 25 m above sea level and 560 m from the coast, see text p. 83.

tension during the productive period of the year — and the same must be true of its winter grounds.

A review of the history shows that the Basques hunted the Biscay Whale (*Balaena glacialis* BONNAT) in the Bay of Biscay and in the North Atlantic during the centuries when the Eskimos hunted the Greenland Whale in the area between Alaska and the Atlantic, and when Herring fishery flourished in Danish waters. The Herring, the Biscay Whale, and the Greenland Whale have all fluctuated greatly in occurrence. That all three were made the object of pursuit on a large scale at the same time, would seem to indicate that a mutual cause may be found.

From Greenland two finds of bones prove that the Greenland Whale has existed in Davis Strait and Baffin Bay during certain periods, long before Man reached these parts from the west.

One find was made during excavations at Holsteinsborg during the summer of 1963. H. C. PEDERSEN, Holsteinsborg, has informed the author that a whale bone, which proved to be the back of the head of a Greenland Whale, was found 60 m above sea level. In the same place, a settlement, presumably from the Sarqaq Culture period, was found at 17 m above sea level.

The other find was made during excavations at Thule Air Base in 1952. The author received in the summer a telegram from major STÆR-

MOSE to the effect that the bone of a "Mastodon" had been found. When visiting Thule shortly afterwards the author saw the location and the bone, which is seen in the photograph fig. 47. It was found in the permafrost, at the bank of the river bed, 6 m under the surface of the earth, 560 m from the sea, and 25 m above sea level and proved to be the back of the head of a Greenland Whale. It is now in the Zoological Museum of Copenhagen.

The age of these whale bones has not been determined.

On the shores of Alaska, whale bones originating from a period 1500–1000 B.C. have been found, J. L. GIDDINGS and H.-G. BANDI 1962. The first whale harpoons originate from Alaska and are dated to a period shortly before the birth of Christ (HELGE LARSEN in letter 29th December 1965).

Around 900–1100 A.D. the great Eskimo whaling epoch flourished at Alaska and spread during the same centuries to Northwest Greenland, MATHIASSEN 1934, HOLTVED 1944, LARSEN and RAINEY 1948.

Around 1200 A.D. drift-ice began to arrive in Iceland more frequently than formerly, indicating that a period with great climatic fluctuations had begun. The ice of the Arctic Ocean broke up and drifted southwards in greater quantities than previously.

The migration of the Thule Culture people from Alaska to Greenland precedes this period.

In the region around Baffin Bay the Thule Culture people faced a climate that proved to be very favourable for whale hunting in certain periods, and very unfavourable in other periods.

In September 1965 the present author visited Point Barrow on the north coast of Alaska, and while talking with two Eskimo whalers, AL HOPSON and TOM BROWER, he obtained a vivid impression of the importance of certain very specific ice conditions for successful whaling from the umiaq. The Alaskan whalers made it clear that these conditions very seldom failed to occur, but if they did and the whale stayed away, the situation was severe and people starved.

Regarding Greenland, good whaling must have depended on similar ice conditions to those at Alaska, i.e., a firm ice cover along the coast and a narrow open lead between it and the drift-ice outside. Such ice conditions must have existed periodically along the shores of Inglefield Land, the Thule district proper, from southern Melville Bugt to the region around Holsteinborg. When the whale wintered in these regions or passed the coast in autumn and spring, it had to either stay or pass between the coastal ice and the drift-ice, where it was easily caught.

In two cases the Greenland Whale would stay away, i.e. 1) when the Baffin Bay Ice failed to come close enough to the shore, and 2) when it came too close, causing the leads to freeze up.

*In the first case* whaling was difficult and was replaced by seal hunting by kayak.

It is worth noting that during the period 1200–1350, with great climatic fluctuations, kayak hunting greatly improved and the Inugsuk Culture emerged around Upernavik and spread to the north and south, TH. MATHIASSEN 1934, E. HOLTVED 1944.

In the regions around Baffin Bay, the Eskimo hunter met a new and valuable animal of prey not formerly known in Alaska, the Harp Seal. This seal is a summer guest in Baffin Bay in periods with prevailing Atlantic climate. It may very well be the encounter with this new animal that encouraged the special development of the kayak in a period with much open water in Baffin Bay, making whale hunting impossible most of the year.

Some whaling people preferred to follow the whale along the coasts of the Arctic Ocean. They reached Peary Land. Here EIGIL KNUTH in 1948 found the famous Peary Land whaling boat, dated back to the 15th century (EIGIL KNUTH 1965, p. 172).

*In the second case*, when Baffin Bay froze over, the Greenland Whale was forced to leave the coasts of Greenland earlier in winter and cross Davis Strait to the shores of southern Baffin Island and eastern Labrador—just as in the cold period of the 19th century.

Simultaneously the Eskimos of West Greenland moved southwards in search of new hunting fields. Vesterbygden was wiped out by their southern advance, about 1350–60 (IVAR BAARDSON).

In the last decades of the 16th century, the Greenland Whale was discovered wintering at Newfoundland, where it became known as "Grand Bay Whale", ESCHRICHT and REINHARDT 1861, p. 460. In the summer 1616 it was seen in great numbers in the northern regions of Baffin Bay by WILLIAM BAFFIN. At the same time it was caught in large numbers near the coast of Spitsbergen. The southern occurrence off Newfoundland shortly before 1600 and the concentration of whales in northern Baffin Bay and at Spitsbergen shortly after 1600 lack explanation, unless the whales were excluded from their usual wintering and summering grounds by heavy and partly unbroken ice.

Around 1640 the drift-ice decreased at Iceland, see fig. 48. Simultaneously the Greenland Whale stayed away from the shores of Spitsbergen and moved to the new ice edge, where it was difficult to hunt it. In the next drift-ice periods the whale did not return to the shores of Spitsbergen. The ice-movements must have altered in intensity and direction. The summer fields of the Greenland Whale moved closer to Northeast Greenland. Presumably the ice moved faster.

The main summer feeding ground of the Greenland Whale off Northeast Greenland seems to be *the continental slope between 200 and 1000 m.*

*When this area is covered by drift-ice, the whale is forced away and must either find other summer grounds or die from starvation*, and in severe ice years many youngs may thus have succumbed.

An extensive literature is available on European whaling at Spitsbergen and Greenland, based on hunting reports and documents in Holland, England, Germany, and Denmark/Norway. This material decidedly deserves further study from the ecological and climatical points of view. The curves shown overleaf on Dutch whaling in Greenland Sea and Davis Strait are based on numerical material given by ZORGDRAGER 1723: 1670–1719, BRANDLIGT 1843: 1720–36, "EUROPISCHE MERCURIUS": 1737–50, "NEDERLANDSCHE JAARBOEKEN": 1751–80, BRANDLIGT 1843: 1781–1802. Information and numerical material on British whaling are taken from "The Northern Whale-Fishery" in "Narrative of Discovery and Adventure in the Polar Seas and Regions" by JOHN LESLIE, ROBERT JAMESON and HUGH MURRAY 1835 p. 461, "A History of the Whale Fisheries" by J. T. JENKINS 1921, and papers by T. SOUTHWELL 1881–1905.

Through the above-mentioned sources it has been possible to set up a list of the Dutch catch of Greenland Whale for most of the years from 1670 to 1797. Where one or two years are missing in the sequence (because of events of war), the average of the preceding and the subsequent years has been used. Where three years are missing in the sequence, the average is used for the two preceding and the two subsequent years. The years from which information is missing are: 1672–74, 1691, 1759–61, 1775, 1781–82, and 1795. There is often a slight difference in whaling figures from the different sources, apparently owing to the fact that all ships did not come home at the same time. It may be possible to improve the numerical material by critical review of additional documents.

Some uncertainty is involved in the evaluation of the amount of blubber brought home. For 1677 the yield is shown in "Quartele Speck", and for 1719 in "Vaten Speck". The measures appear to be identical, but it is somewhat uncertain whether they have actually represented the same quantity in the case of all ships and through all years. Neither can it be established with certainty that all whales caught have been Greenland Whales, inasmuch as a few other whales may now and then have been caught, e.g., Biscay Whale, Humpback Whale, and Sperm Whale. It is certain, however, that the Greenland Whale was the first target, and this animal was the main profit of the entire whaling industry.

Whaling products were so important on the European market that all possibilities were utilized to the absolute limit. Many whales attracted many ships, while on the other hand, poor whaling results called for cautionary measures. In order to evaluate the number of whales we may take a look at the number of ships that went whaling, the number of whales caught in all or per ship, and the quantity of blubber and baleen (whalebone) brought home.

It would seem offhand that the number of whales caught would appear to give the best indication of the size of the whale population, and the fluctuations in same. This is true taken over a number of years, but is not valid for the individual year. The take of the individual year is essentially an indication of whether the whale *was easy or hard to catch*, and this in turn depended on the ice conditions of each particular year.

If conditions forced the Greenland Whale to concentrate along the outer edge of the ice, it was easy to catch but was also lean and undernourished because of food shortage. In such years, great catches could be made, apparently without impairing the population as a whole. In other years the ice spread early and the whale had early access to its summer feeding grounds behind the drift-ice, so the ships had difficulty following them and the population was naturally able to increase.

Jenkins 1921, p. 121, writes: "The ice between Spitzbergen and Greenland was called West-ice, and the whales in it West-ice Whales. After the slaughter at Smeerenburg these West-ice Whales became very cunning and shy. The other whales, though not differing in appearance, were more abundant in unusual years when the ice east of Spitzbergen and Nova Zembla drifted in greater quantity and with smaller and flatter floes much lower down than in ordinary years. Such an unusual year in which there was great abundance of this peculiar whale was called South-ice year, and the whale a South-ice Whale. This South-ice Whale was not so shy and cunning as the West-ice Whale, and was even, after a hundred years' slaughter, still more easy to catch than the other.

From this it would appear that South-ice years have been exceptional, otherwise this whale would have changed its habits, like the West-ice Whale".

When the so-called "South-ice Whales" were less shy than the so-called "West-ice Whales", the explanation is undoubtedly that the former were hard pressed by the advancing Siberian drift-ice and brought to starvation point, while the latter lived in the scattered drift-ice of the Greenland Sea.

Fig. 48 curve A shows the amount of drift-ice (in 10-year sliding averages) at Iceland 1600–1910; the coordinate indicates number of weeks multiplied by number of areas with ice based on Lauge Koch 1945, pp. 254–257. Curve B shows the number of Dutch ships taking part in whaling at Spitsbergen, in Greenland Sea and after 1719 in Davis Strait, given in averages for the years 1670–79, 1680–89, 1690–99, 1700–09, 1710–19, 1720–29, 1730–39, 1740–49, 1750–59, 1760–69, 1770–79, 1780–89, and 1790–97. Curve C shows the number of whaling ships sent out from Hull, given in averages for the years 1772–76, 1777–81, 1782–86, 1787–91, 1792–94, 1795–1806, 1807–13, 1814–24, 1825–34, 1835–44, and 1845–52, Jenkins 1921, p. 312. Curve D shows (in 10-year sliding averages) the number of whales caught by Dutch ships.

The dotted curve E indicates the great whaling period in the early 17th century on the coast of Spitsbergen. This whaling boom coincides with the first of the five drift-ice advances that took place between 1600 and 1910. Additionally, many whales were killed during the second and third drift-ice advances. The drift-ice advances are indicated by the numbers I, II, III, IV, and V.

The good whaling result during the great drift-ice advances is assumed to have been brought about by heavy ice in the Arctic Ocean and the Greenland Sea keeping the whale from its usual feeding places. As a result whales were forced together in limited areas and were easily killed.

The curves on fig. 49 show in 3-year sliding averages the number of whales killed per ship, and the drift-ice north of Iceland. Both curves display maxima with approximately 11-year intervals. The whale curve peaks precede the drift-ice peaks by some years because ice off Iceland results from an earlier ice-concentration at Spitsbergen.

Fig. 50 also demonstrates how the ice curve (A) often is one or several years behind the whale curve (D). Curve (F) shows the quantity of blubber per whale and demonstrates that the quantity of blubber brought home per whale is usually at its lowest when many whales were killed.

It is seen from curve (F) that the quantity of blubber brought home per whale was considerably larger around 1690 than around 1790. The number of whales killed dropped considerably during the latter years. The most reasonable explanation seems to be that there were fewer years (17 years) with drift-ice during the first half of the 18th century than during the last half of the century (29 years). The summer and winter biotopes of the whale were highly restricted in the Atlantic area. The whale was killed before it aged. The decline in the blubber curve indicates that the proportion of young whales increased in the catches—or that the whale starved during drift-ice years. (In some periods other species may have been hunted, or part of the blubber may have been left).

The temperature curve at Trondheim (G) appears to alternate with the blubber curve (F). However, these curves may not be immediately comparable.

The European whaling epoch in Davis Strait was created by climatic factors more than by historical ones. Around 1600 an alteration in the climate created heavy concentration of ice *north* of Baffin Bay and *north* of Spitsbergen. The Baffin Bay was still open for ships 1616 when Baffin discovered it. When the ice began to advance southwards

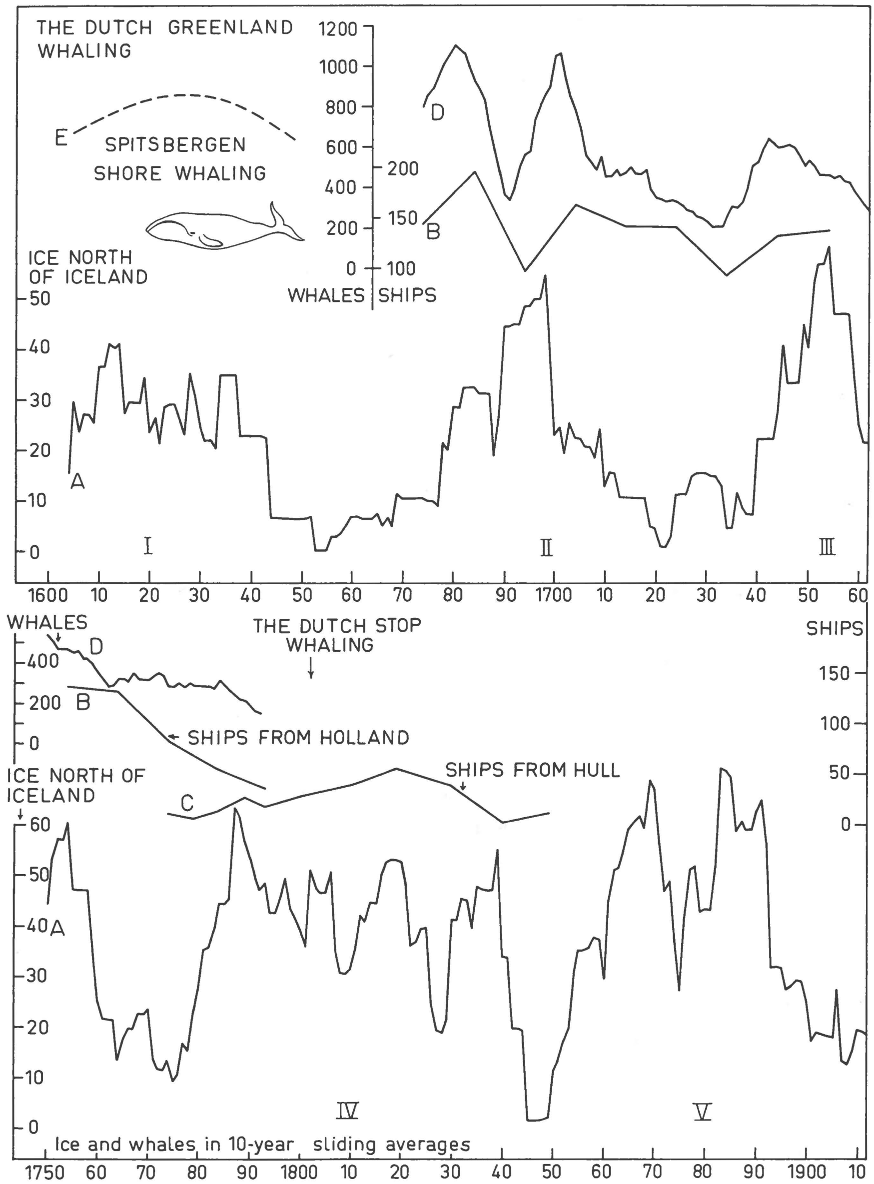



Fig. 48. Curves of ice and whales in 10-year sliding averages.

A. Amount of drift-ice north of Iceland (number of weeks multiplied by number of areas with ice), according to data from LAUGE KOCH 1945, p. 254–57.
I – II – III – IV – V indicate great drift-ice periods at Iceland.

B. Number of whaling ships from Holland.

C. Number of whaling ships from Hull.

D. Number of whales caught by Dutch ships, according to various sources, see the text p. 86–88.

E. The dotted curve indicates the time of the first great whaling period at Spitsbergen.

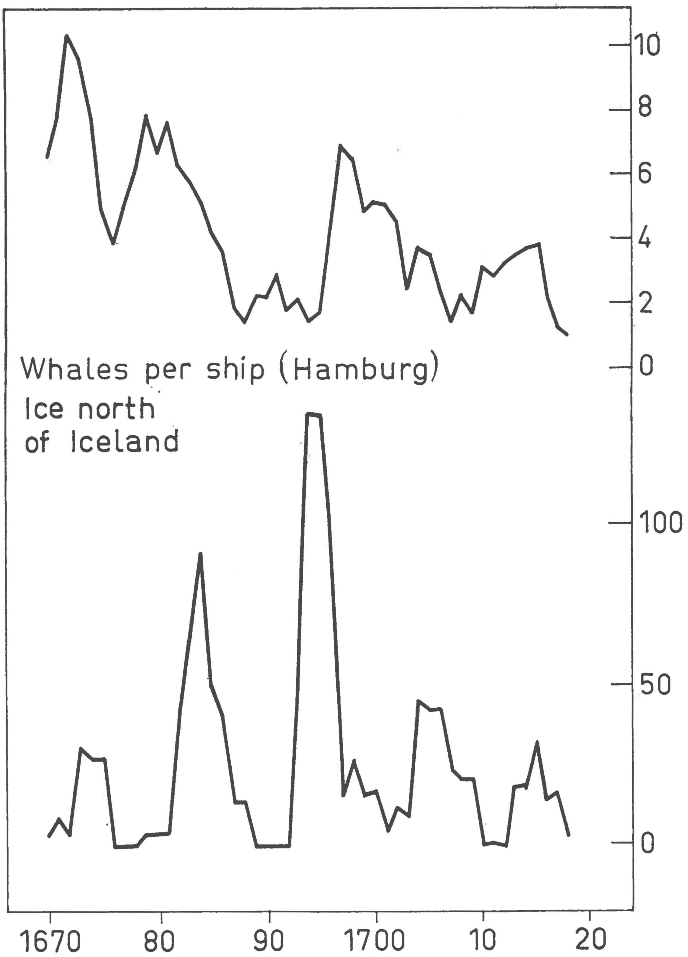



Fig. 49. Curves in 3-year sliding averages. Ice-curve according to data from LAUGE KOCH 1945 (number of weeks multiplied by number of areas with ice). Whale curve according to data from ZORGDRAGER 1723.

it was closed. (The Eskimo sledge route across Melville Bugt ceased around 1600, HOLTVED 1944 p. 186). In the years 1616–1718 very few whaling ships visited Davis Strait.

JENKINS 1921, p. 168 mentions that (regular) whaling began in Davis Strait in the year 1719, and that most activity took place off the south side of Disko. At that time, and during the subsequent 98 years, Baffin Bay was blocked by drift-ice to such an extent that the whale was forced to long stays along the ice edge in Davis Strait, giving the whalers the chance of an easy catch. During the summer the whaling ships usually went as far north as Melville Bugt. They were unable to follow the whale to its summer grounds in the northern Baffin Bay.

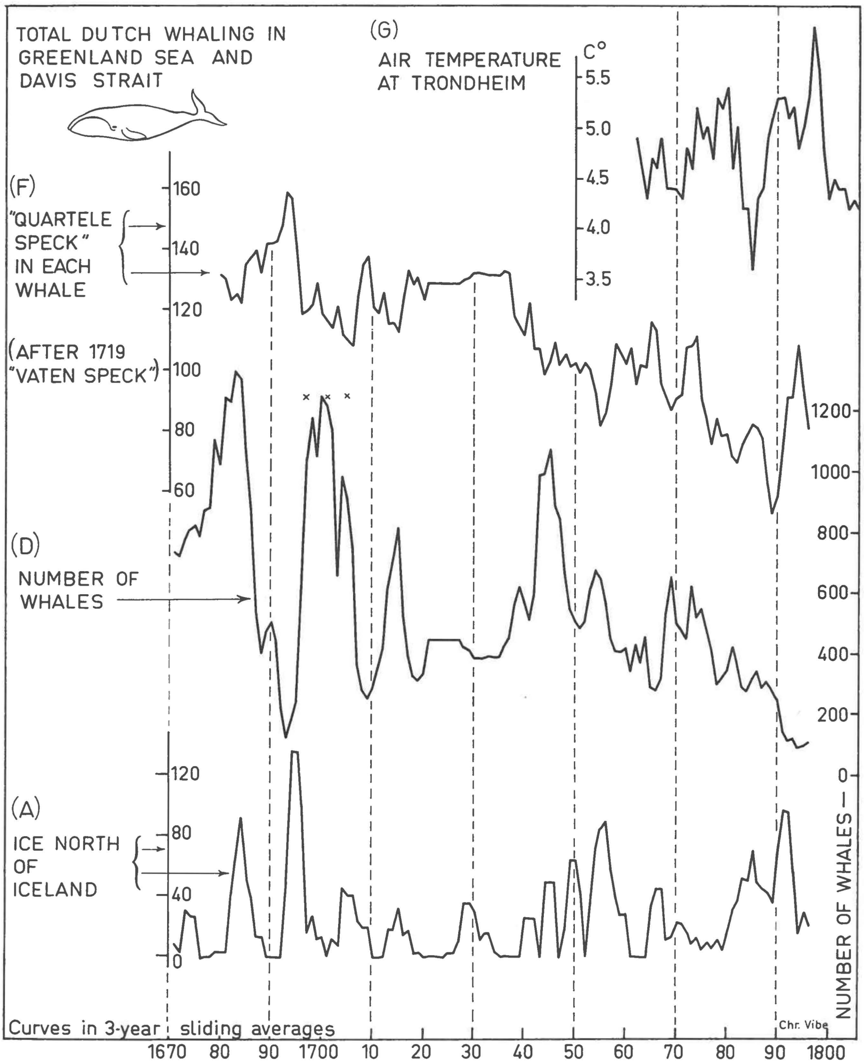



Fig. 50. Curves in 3-year sliding averages.

A. Number of weeks multiplied by number of areas with ice at Iceland, according to data from Lauge Koch 1945.

D. Total number of whales caught by Dutch ships at Spitsbergen and in Greenland Sea – after 1719 also in Davis Strait. xxx indicate 4-year periods in number of whales and in amount of blubber.

F. Amount of blubber in each whale, based on figures from different sources, see text p. 86.

G. Based on figures from A. Røstad 1955, p. 10.

In 1817 "there was only a narrow channel between the "Storis" and the west ice in the southern part of Davis Strait", Speerschneider 1931, p. 10. The great extension of the "west ice" in southern Davis Strait was due to the breaking up of the Baffin Bay Ice that summer. In that year the first two whaling ships crossed Melville Bugt to the northern Baffin Bay area, MARKHAM 1873.

In regard to the wintering of the Greenland Whale in the 19th century, R. BROWN 1868, p. 545, writes: "It thus appears that they winter (and produce their young) all along the broken water off the coast of the southern portions of Davis Strait, Hudson's Strait, and Labrador. The ice remaining longer on the western than on the eastern shore of Davis Strait, and thus impeding their northern progress, they cross to the Greenland coast". P. 544: "It is rarely found on the Greenland coast south of 65°, or north of 73°; indeed I have only heard of one instance in which it has been seen as far north as the Duck Islands near the entrance of Melville Bay, and even for a considerable distance south of that it can only be looked upon as an occasional straggler. However, after crossing to the western shore of Davis Strait, it occasionally wanders as far as the upper reaches of Baffin's Bay. The great body, however, leave the coast of Greenland in June, crossing by the "middle ice" in the latitude of Svarte Huk (Black Hook) in about lat. 71°30′N."

The diagrams fig. 51 show the decrease of down production and whaling in the last half of the 19th century. When the drift-ice started coming in greater quantity than usual (drift-ice pulsation stage) and advanced far north late in the summer, this entailed hardship for the Greenland Whale, the Eider, and the Harp Seal in Davis Strait. They moved their summer fields farther north. For the whale new grounds opened in the Northwest Passage and Beaufort Sea.

During the final period of whaling in the Atlantic area it is obvious that infertility contributed to the decline of the whale. FRIDTJOF NANSEN 1924, p. 137 writes:

"It appears as though the whale migrated toward the north along the edge of ice — preferably a way in the ice — at the end of March, in other words at the same time as the Harp Seal gathers, and in April; and toward fall, in August and September, it would in turn go south along the east coast of Greenland. However, as mentioned, there were not many of them left, and those that were there appeared to breed but little, they *were rarely seen mother and young together.* (Emphasized by the present author.) The well-known whaler Captain GRAY says that during the many years he went whaling in these waters he saw no more than six females with young, and he never caught a single whale that did not have marks of having been wounded before by harpoons".

This shows plainly enough that the period of the Greenland Whale was ebbing. The population in the Atlantic was no longer renewed, and finally whaling was based on a population of old whales. Infertility is a feature we find with many animals during periods of starvation.

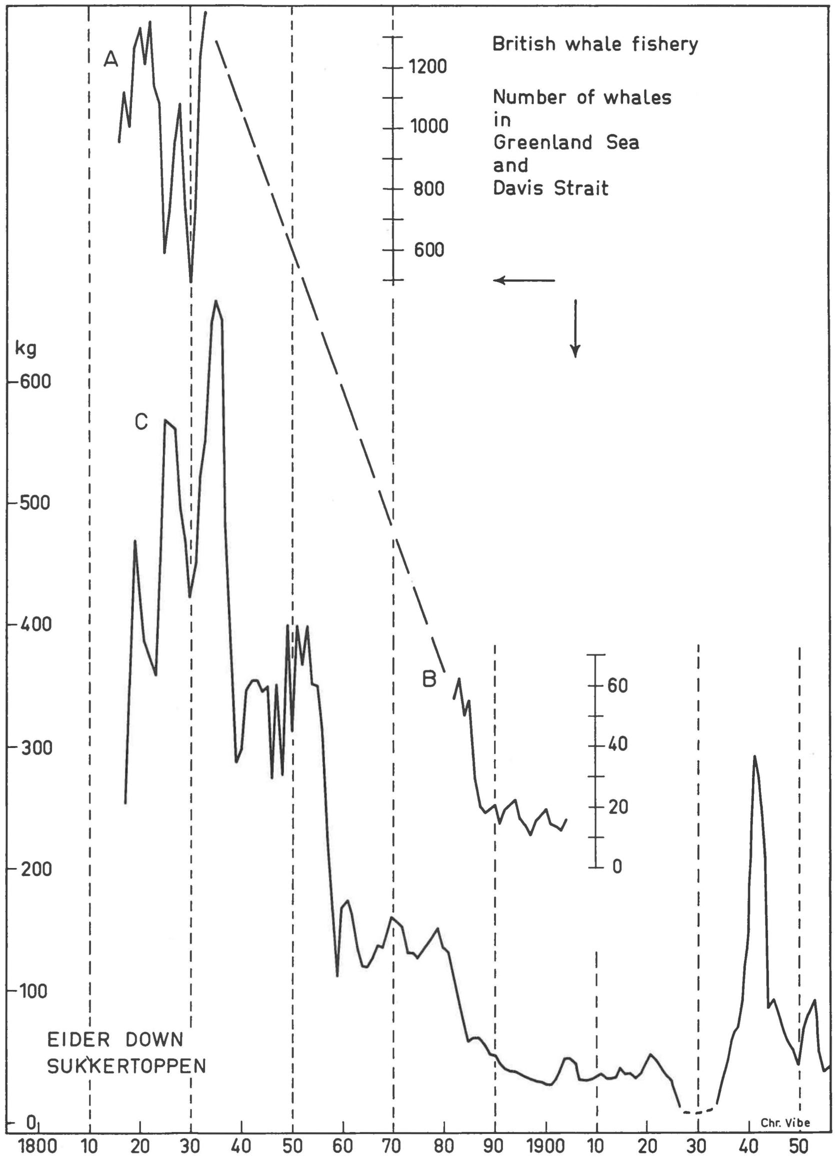



Fig. 51. Curves in 3-year sliding averages.

A. British catch of Greenland Whale in Greenland Sea and Davis Strait 1815–34, based on figures from Leslie, Jameson and Murray 1835 p. 461.

B. British catch of Greenland Whale 1881–1905, based on figures from Southwell 1906 p. 47.

C. Purchase of Eider-down at Sukkertoppen, by the Royal Greenland Trade Department.

Nansen poses the question: "But what is the reason why these large animals can stay away so completely from certain areas while they may still remain, and even in quite considerable numbers, in other areas not so far removed? Is it, as many believe, that they learn to avoid the areas where they are most persecuted, and that f. inst. in this case, the whales take refuge further inside the drift-ice where they are harder to get at?"

NANSEN then answers the question by implying that the whale population consisted of several geographically separate tribes: "Probably it happened that first the large tribe of whales which stayed in summer near the coast of Spitsbergen was exterminated; that did not take so many years. Then the tribe was hunted that stayed in the sea further west along the edge of the "west-ice" (East Greenland Ice), until that too was exterminated, and then those were hunted up that had their summer stay further into the drift-ice, closer to the east coast of Greenland".

This hypothesis is hardly valid. The history of the Greenland Whale shows (as assumed by SIGURD RISTING 1922, p. 85) that special conditions of currents, drift-ice, and production in the Arctic seas were the deciding factors in its mass occurrence in different places at different times.

The Greenland Whale disappeared from area after area when these conditions changed. The increasing advances of drift-ice destroyed the biotopes, forced the whale away from its best feeding grounds in the northern Atlantic area and made it difficult for it to escape whalers.

In 1845 whaling began north of Alaska. It is tempting to consider the opening of the new whaling field in the west as a consequence of the heavy ice pulsations into the Atlantic in the last half of the 19th century—creating more open water in the western Arctic Ocean.

## Concluding Remarks on Drift-Ice Stages, Whale Fisheries, etc.

In the following survey of the drift-ice stages, the conclusions reached by the author are given. The conclusions were arrived at from the study of the literature (referred to above) on the ecology of the Greenland Whale and the varying locations of its summer and winter grounds, on the occurrence of drift-ice, and on the histories of the Eskimo whaling culture, of the European whale fisheries, of the Norse settlements in Greenland, and of the Musk Ox and Reindeer.

Fig. 52 shows the occurrence of drift-ice at Iceland:

*No drift-ice* at Iceland may mean a cold period where the ice stagnates in northern waters, e.g. before 1150, about 1360, and 1550.

*Much drift-ice* may mean the beginning of a warmer climate, when the ice breaks up in the Arctic Ocean, e. g. after 1200, after 1600, after 1740, and after 1860.

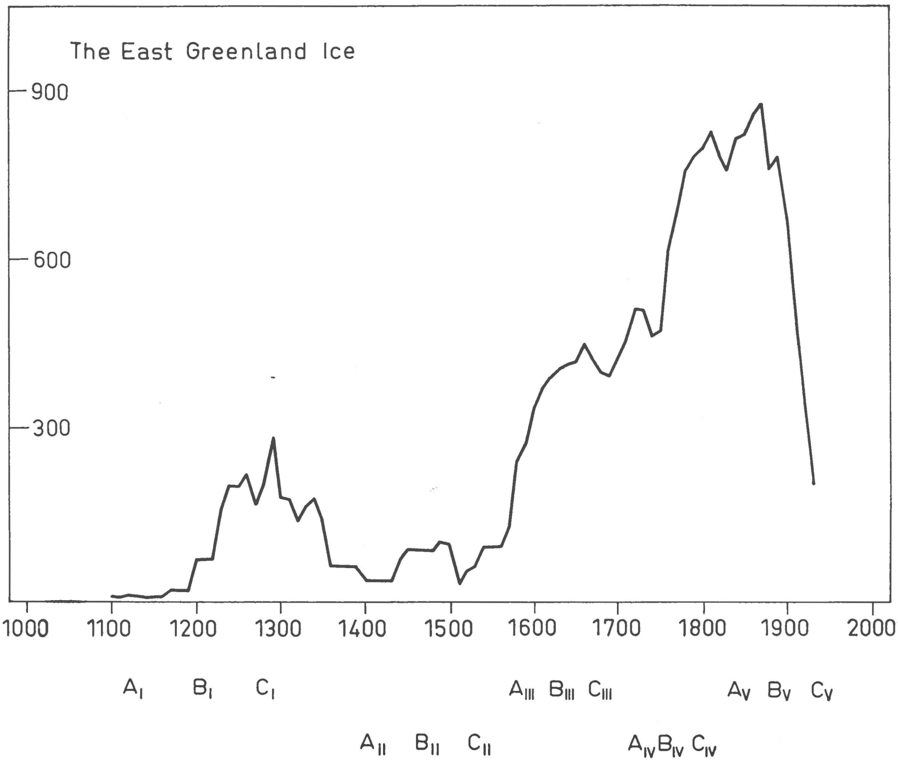



Fig. 52. Occurrence of drift-ice north of Iceland, in 31-year sliding averages (Weeks with ice multiplied by areas with ice, based on LAUGE KOCH 1945 pp. 249–257). Capital letters at the bottom indicate the drift-ice stages.

*Little drift-ice* may mean a warm period with little ice in the Arctic Ocean, e. g. around 1500 and after 1920.

The main summer feeding grounds of the Greenland Whale seem to be the sea above the continental slope between 200 and 1000 m. When this area is covered by heavy drift-ice, the whale is forced away and starves.

In *very cold periods* (*stagnation stages*) when the ice did not drift out of the Arctic Ocean, but melted along the borders, the whale was forced to remain in the Northwest Passage area and on the northern borders of the Atlantic Ocean.

A whaling culture in Alaska implies little or no agitation in the ice, but melting of the ice along the borders of the Arctic Ocean, opening the lane north of Alaska to allow the whale to reach the "Arctic Life Circle".

The 200 m line of depth, the "*Arctic Life Circle*" of USPENSKII 1965, runs closely along the shores of northern Alaska. Here, on its spring and autumn migrations, the whale came within reach of the Eskimo.

In *mild periods* with heavy movements in the Arctic Ocean ice (*pulsation stages*) the drift-ice drifts into the Atlantic, and the whale has

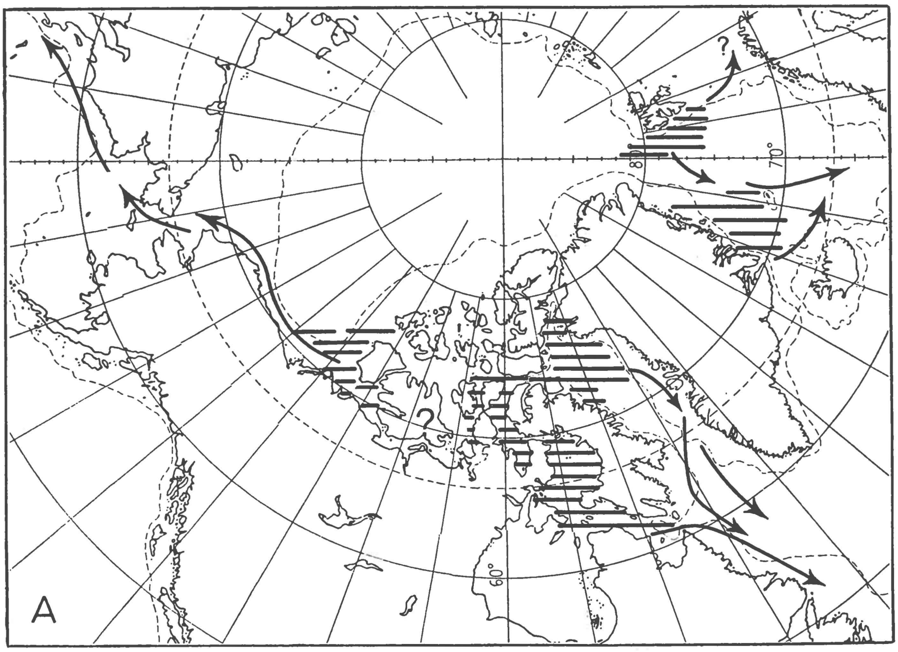



Fig. 53. Estimated summer grounds and winter migration routes of the Greenland Whale during drift-ice stagnation stages.

limited access to its main feeding grounds. It is starving and the population declines.

In *very mild periods* with little ice in the Arctic Ocean (*melting stages*) the whale has easy access to its main feeding grounds along "the Arctic Life Circle", and it is difficult—or impossible—for the Eskimo to hunt it.

$A_I$ **Drift-ice stagnation stage** (? to approx. 1150). The climate is relatively cool and stable. The summer grounds of the Greenland Whale in Beaufort Sea and north of Greenland are threatened by heavy sea ice. The whale is forced to stay in Baffin Bay and the Atlantic. The Eskimos follow it to Baffin Bay. Along the Eskimo immigration route to Greenland Reindeer hunting plays an important rôle. The early Thule Culture (in Inglefield Land) displays more of an inland character than the subsequent phases (E. HOLTVED 1944, p. 187).

(England has relatively cold winters for a long period before 1150 (H. H. LAMB, *in* JOHNSON and SMITH 1965 p. 18)).

$B_I + C_I$ **Drift-ice pulsation and melting stages** (approx. 1150–1340). The climate is warmer with greater fluctuations in temperature and precipitation. The ice of the Arctic Ocean breaks up and drifts into the Atlantic in larger amounts than before. The whale goes north. Whaling is often difficult around Baffin Bay. The Harp Seal migrates north in

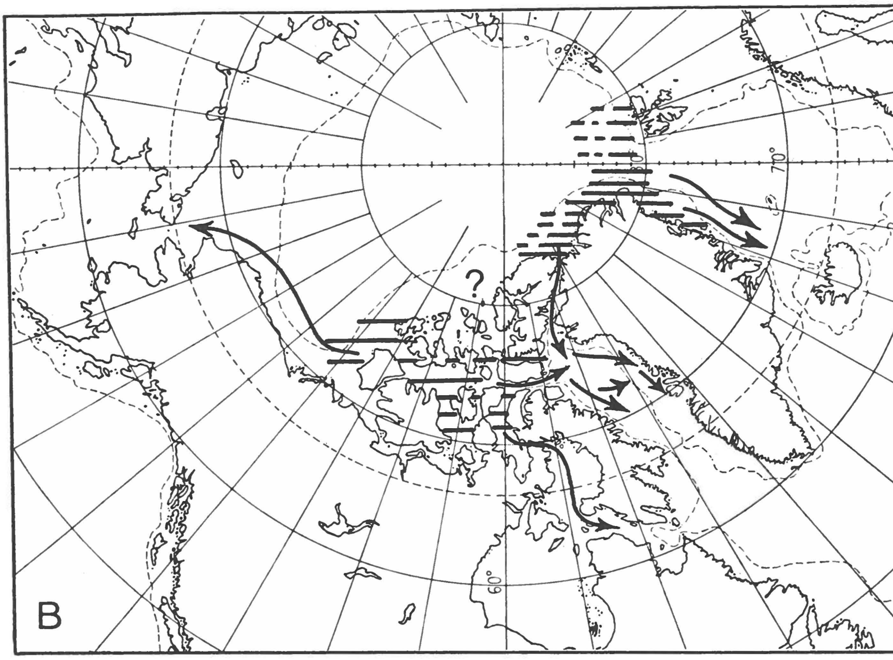



Fig. 54. Estimated summer grounds and winter migration routes of the Greenland Whale during melting stages with little drift-ice in the Arctic Ocean.

Baffin Bay in summer (in order to get north of the advancing East Greenland Ice as during the drift-ice stages 1860–1960, see fig. 41). This valuable seal can only be hunted by kayak and comes to play a decisive rôle in the development of the Inugsuk Culture in West Greenland.

The wet climate is unfavourable for land mammals in Central East Greenland.

$A_{II}$ **Drift-ice stagnation stage** (approx. 1340–1450). The climate is relatively cold and dry. Four cold winters occur in Iceland between 1348 and 1355, L. Koch 1945, p. 251. Reindeer occur in West Greenland south to Julianehåb. The Inugsuk people migrates south. Vesterbygden is overrun about 1350. Eskimos reach Angmagssalik.

$B_{II} + C_{II}$ **Drift-ice pulsation and melting stages** (approx. 1450–1560). The climate is relatively warm (and wet?). The Musk Ox is absent or scarce in Central East Greenland. Eskimo whalers go round North Greenland and arrive in Peary Land. At the end of the pulsation stage the Harp Seal and the Ringed Seal leave Julianehåb district and migrate north, the former to the west coast, the latter to the east coast. (Same situation as after 1920, fig. 33 and fig. 41). The Norse settlement "Østerbygden" dies out (owing to scarcity of seals?). The Inugsuk people in Angmagssalik follow the seal northwards and reach Northeast Greenland.

$A_{III}$ **Drift-ice stagnation stage** (approx. 1560–1600). The Greenland Whale winters in more southerly regions than usual (Newfoundland, Northeast Iceland, North Norway?). The climate of Northeast Greenland is more stable than before. The Musk Ox population increases slowly. Eskimos arrive in Northeast Greenland from the north.

$B_{III}$ **Drift-ice pulsation stage** (approx. 1600–1650). The climate is relatively warmer with more precipitation. The heavy drift-ice in the Arctic Ocean advances into the Atlantic in larger amounts than before. The Greenland Whales are prevented from reaching their usual summer grounds and gather in Baffin Bay and Spitsbergen waters, where European whalers have an easy catch. Thule sledges no longer cross Melville Bugt (owing to much snow?).

$C_{III}$ **Drift-ice melting stage** (approx. 1650–1690). After 1650 the drift-ice is more open and the whale leaves the coast of Spitsbergen and stays in the drift-ice off East Greenland. European whaling flourishes in the Greenland Sea, and the Eskimo whaling flourishes in the coastal waters of Northeast Greenland.

$A_{IV}$ **Drift-ice stagnation stage** (approx. 1690–1740). The climate is cool, stable and dry. The Reindeer thrives in West Greenland, also in the Julianehåb district. European whalers make large catches along the ice edge off Northeast Greenland. Whaling begins in Davis Strait where whales from the Northwest Passage area spend the winter.

$B_{IV}$ **Drift-ice pulsation stage** (appr. 1740–1780). Eskimo whaling almost ceases in Northeast Greenland. The whale is kept away from the coast by heavy drift-ice. New peoples arrive in Northeast Greenland from the south. European whalers make good catches along the ice edge, but the whales are smaller (owing to scarcity of food?).

After 1757 West Greenland has heavy winter precipitation and very mild winters. The Reindeer population is reduced to a minimum. Cod occurs in West Greenland. In Northeast Greenland Musk Ox and Reindeer become scarce.

$C_{IV}$ **Drift-ice melting stage** (approx. 1780–1810). This stage seems to be a mere continuation of the preceding stage. The weather is unstable owing to much agitation in the drift-ice. Increasing drift-ice off Northeast Greenland prevents the whale from reaching its summer grounds. The whale population decreases. The Dutch abandon whaling. The Ringed Seal is relatively scarce in northern West Greenland and has presumably gone north.

$A_{V}$ **Drift-ice stagnation stage** (approx. 1810–60). The climate is relatively cold, dry and stable in Northwest, North and Northeast Greenland. The East Greenland Ice stagnates in northern waters in the summer. During several years it does not appear in Icelandic waters, and in Davis Strait it does not advance far north. The stable winter climate is favourable for the Reindeer in West Greenland north of Frederikshåb and for the Reindeer and Musk Ox in Northeast Greenland. The little Eskimo population of Northeast Greenland dies out in the beginning of the period, presumably owing to scarcity of Ringed Seals in the cold winters. The clearings freeze up owing to little current activity.

After 1817 most of the drift-ice stays north of Baffin Bay which is navigable. The main European whaling takes place in the Northwest Passage area. English whaling flourishes.

$B_V$ **Drift-ice pulsation stage** (approx. 1860–1910). The climate is warmer with much precipitation and with great fluctuations. Whaling decreases and is terminated in Greenland Sea and Baffin Bay. 1845 whaling begins north of Alaska. Unstable winters are very unfavourable for the Reindeer population in West Greenland and parts of the Northwest Passage area. The Northeast Greenland Reindeer becomes extinct and the Musk Ox population stagnates. The East Greenland Ice advances farther north into Davis Strait than previously known. A great number of Ringed Seals and Polar Bears arrive in southwestern Greenland with the drift-ice.

$C_V$ **Drift-ice melting stage** (approx. 1910–60). The climate is relatively warm with some precipitation. The drift-ice of the East Greenland Current decreases. The Irminger Current dominates climate and production in Davis Strait. The Cod multiply in Greenlandic waters. The Harp Seal arrives in summer in northern Baffin Bay and stays in West Greenlandic waters during winter. Populations of Ringed Seals, White Whales, Narwhals and sea birds increase in Northwest Greenland. The Greenland Whale is again seen in Davis Strait, off East Greenland, and in Spitsbergen waters. The whale population north of Alaska is again increasing. Northeast Greenland has ample vegetation. The population of Musk-Ox increases, except during periods with little winter ice in the Greenland Sea and consequent much winter precipitation in Northeast Greenland. Between 1938 and 1966 several severe catastrophes struck the healthy stock.

$A_{VI}$ **Drift-ice stagnation stage** (approx. 1960–?). The winters are again relatively stable in West Greenland. The Reindeer population increases. The Ringed Seal and Eider populations increase in northern and central West Greenland. The Cod fisheries in northern West Greenland decrease.

## Sales of Guns and Ammunition in Greenland.

From the graphs p. 100 fig. 55, it is understood that the fact that the Greenlanders got *guns* and *ammunition* cannot be the direct cause of the heavy declines which often occur in the populations of game. It seems more likely to be the richer occurrence of game and fish which provided the financial background for the Greenlanders' purchase of new guns and more ammunition. The life of a gun in Greenland is only few years.

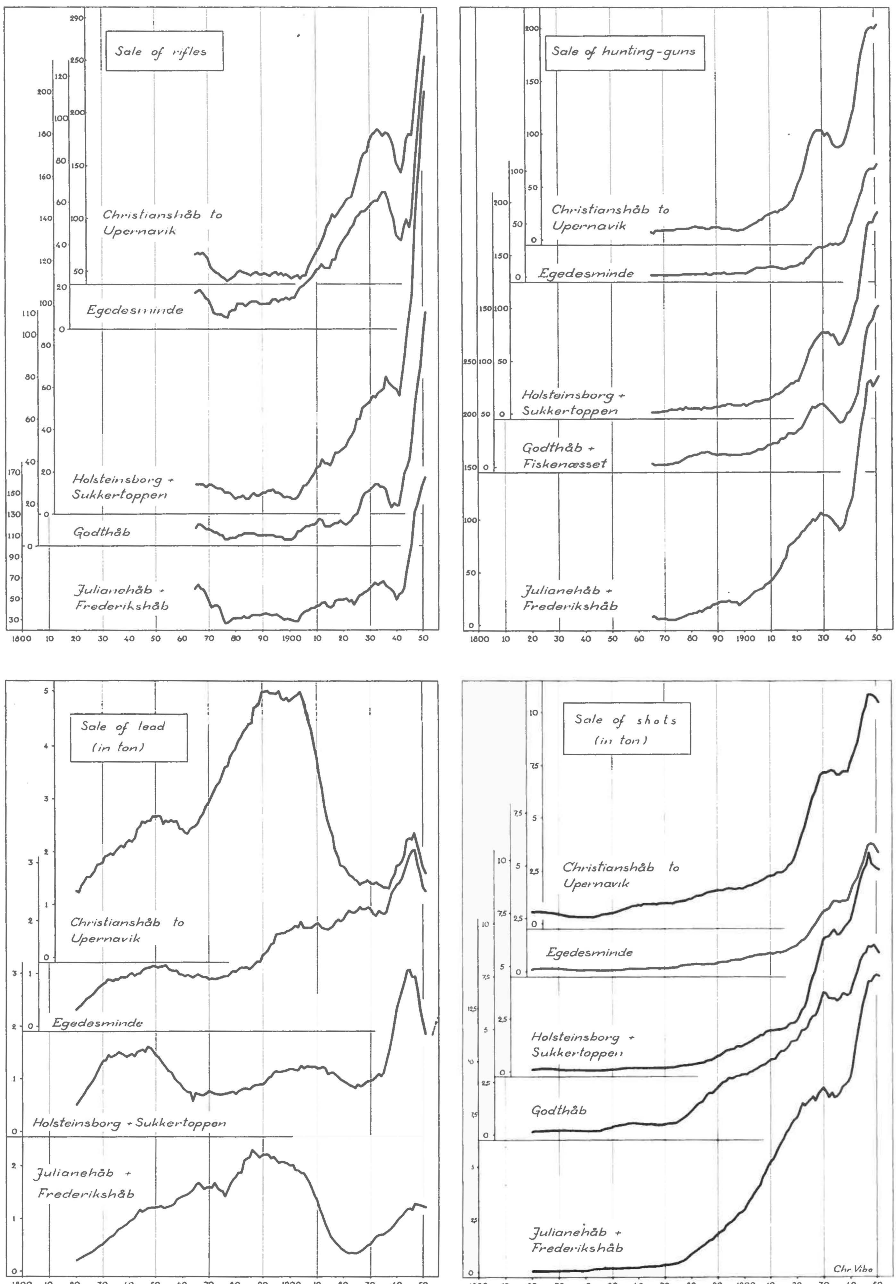



Fig. 55. Sales of rifles, shotguns, lead, and shots in Greenland. Graphs in 10-year sliding averages.

# THE ARCTIC FOX

The Arctic Fox (*Alopex lagopus* L.) is a circumpolar species, living along the coasts of the Arctic Ocean, on all Arctic islands, and in the tundras of Europe, Asia, and America.

In general, it is very versatile in its choice of food. In its breeding period, it is linked to its special biotopes, but in winter it seeks nourishment in widely differing ways and roams far and wide for the berries, Ptarmigan, and Lemmings, as well as for the fish, bivalves, and crustaceans, etc. of the littoral zone. It is to be found inland, and high in the mountains, along coasts, on islands, and on the drift-ice far at sea, and in the middle of Greenland's ice cap.

F. W. Braestrup (1941) points out that "a certain ecological differentiation seems to exist between Arctic Foxes dependent on lemmings and such as live in places where these rodents are not found. The latter are to a very large extent dependent on the products of the sea, and therefore they may be designated as "coast foxes" as opposed to "lemming foxes"." In the same treatise, Braestrup points out that the Arctic Foxes of Greenland are subject to great quantitative fluctuations, and that foxes frequently immigrate to West Greenland from surrounding lemming biotopes.

In his study of the conditions of the Arctic Fox in Greenland, in the field, and of the numerical material, the present author has time and again been able to confirm view points set forth by Braestrup.

It has proved practical to differentiate between blue foxes and white foxes, in that the majority of the category "lemming foxes" are white.

The blue fox rarely occurs in the tundra today, where the white fox has its greatest distribution, K. Fetherston 1947, p. 17.

In size (average) the white fox of the tundra is placed halfway between the largest and the smallest blue foxes of the coast, fig. 57. Small white foxes occur in small numbers among the small blue foxes from the Thule area, and large white foxes occur rarely among the large blue foxes on Bering Island, where the hunters try to exterminate them, H. Johansen 1949, p. 7.

In parts of Greenland where there are breeding possibilities for both blue and white fox, the same litter of pups may include both blue and white pups—and at times a grey one. The grey foxes, fig. 56 B, do not seem to be very fit for survival; they are most frequent immediately after an invasion by white fox, e.g., at Thule, and disappear again the following years. In farms, on the other hand, they may be used for breeding. Mr. L. Lamberth (1953), who has for many years managed a fox farm in West Greenland, based exclusively on wild foxes caught in the vicinity of Godthåb, writes: "The Arctic Fox, as it occurs in Greenland, is found in two colours, blue and white, and transition phases between these colours are found both in nature and in the fur farms. By crossing blue and white fox, both blue and white pups are obtained, but at times also grey ones. When these are used again for breeding, more grey pups will be found in the litters, but also blue and white ones." — "In the summer blue and white foxes are pretty much the same colour, although a trained eye can easily see which ones will turn blue and which ones remain white when winter arrives".

In 1946 Ivar Johansson began his breeding experiments with blue foxes from Alaska and blue and white foxes from Greenland (probably Northeast Greenland). He concludes (1951, pp. 265–269) "that the white fox is homozygous for its colour type, and consequently when two white foxes are paired the offspring is exclusively of that type. The same is true of the colour type of the Alaskan fox. If white fox is paired with blue fox, the result is blue foxes which are heterozygotes for the white fox factor, regardless whether the blue fox is from Greenland or Alaska. When such heterozygotes are paired with white foxes, a segregation takes place according to Mendel's law, and 50 % of the pups will be blue foxes, and 50 % white foxes."

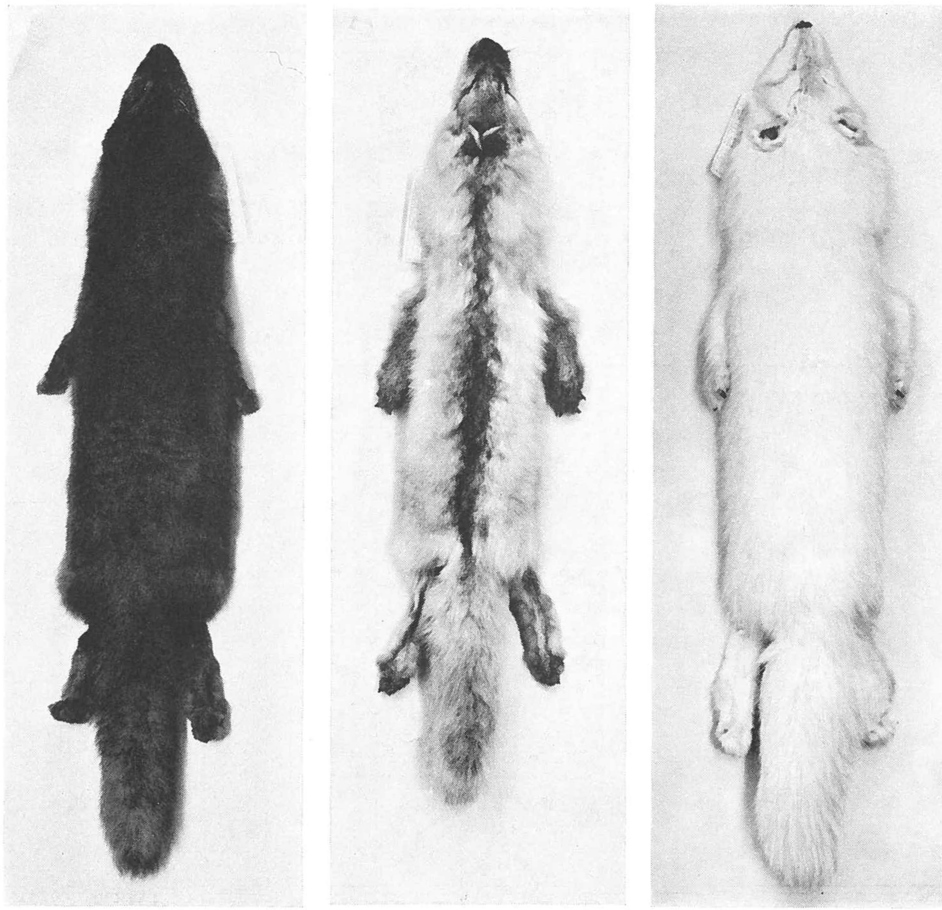
Pairings between heterozygous blue foxes resulted in 376 litters of which 2217 foxes were blue and 731 were white, i. e. the ratio of blue to white was 3,03 to 1, very close to the calculated ratio.

According to Johansson, the colour type of the blue fox is not wholly dominant over that of the white fox. The heterozygous blue foxes are of lighter colour than the homozygous ones. Probably the former often appear as "grey" foxes.

Ivar Johansson writes p. 267 that the white fox is more inclined to suffer from convulsions (white fox disease) than the blue fox. This may be one of the reasons why it is difficult for the white fox to survive under changing ecological conditions outside of the tundra biotope.

The present author has had occasion to see a large number of skulls of the Arctic Fox from most of the localities around the Arctic Ocean. The material has been made available through the courtesy of the zoological collections in Stockholm, Lund, Gothenburg, Oslo, Tromsø, Copenhagen, London, Moscow and Washington. Material has been collected over many years and varies greatly with regard to information about sex, colour, and date, particularly the older material.

The Scandinavian skull material is mostly crania from roaming foxes, the majority of which is normally males. In the material from Greenland and Svalbard many "kummerforms" are represented, i. e. skulls of not full-grown individuals.



A B C

Fig. 56.

A. Fur of blue Arctic Fox from Arsuk, Southwest Greenland.

B. Fur of grey Arctic Fox from Disko Bugt, West Greenland.

C. Fur of white Arctic Fox from Thule, North Greenland, presumably an emigrant from Ellesmere Island. All furs are from the hunting season 1954/55, borrowed from The Royal Greenl. Trade Dep. for photographing.

In order to eliminate "kummerforms" and very young individuals, all specimens with a Crista sagittalis Breadth of more than 10 $^0/_0$ of Zygomatic Breadth (see fig. 58) have been sorted out. The remaining material of full-grown skulls is shown in Table I.

In a material thus sorted, consisting of males and females, the males will be in excess of the females. Due to the sexual dimorphism the females will always show a lower "C. S. $^0/_0$" than the males, and the difference between the sexes is greatest in a population of small foxes. But the method makes it possible to compare the tooth size to the size of the "ideal" or full-grown skull, fig. 57.

Table I. *Alopex lagopus* L. Full-grown skulls.

| | | Number of Crania | Condylobasal Length | Zygomatic Breadth | Total tooth measure $P_1+P_2+P_3+P_4+M_1+M_2$ | Condylobasal Length in °/₀ of total tooth measure |
|---|---|---|---|---|---|---|
| Scandinavia | ♂+♀ | 29 | 125,5 | 69,6 | 53,4 | 235 |
| Iceland | — | 4 | 121,0 | 68,0 | 53,7 | 225 |
| Bering Island | — | 22 | 127,9 | 69,9 | 55,9 | 229 |
| Medney Island | — | 19 | 126,5 | 68,8 | 57,2 | 221 |
| Pribilof Island | — | 29 | 126,7 | 70,2 | 52,3 | 242 |
| St. Lawrence Island | — | 12 | 122,7 | 67,6 | 54,5 | 224 |
| Northern Hudson Bay 1921–24*) | — | 35 | 122,2 | 68,7 | 54,1 | 226 |
| Boothia Peninsula 1953 | — | 37 | 119,7 | 68,1 | 53,9 | 222 |
| Siberia | — | 15 | 120,8 | 67,7 | 53,8 | 225 |
| N. E. Greenland 1906–08 | — | 16 | 120,9 | 66,6 | 54,7 | 221 |
| N. E. — 1928–55 | — | 28 | 120,6 | 68,1 | 54,0 | 223 |
| S. E. Greenland | — | 20 | 119,0 | 66,1 | 52,3 | 227 |
| Spitsbergen (Svalbard) | — | 17 | 117,0 | 68,0 | 50,6 | 231 |
| S.W. Greenland blue only; | 48♂+19♀ | 67 | 115,3 | 65,5 | 51,5 | 224 |
| S.W. — white only; | 45♂+15♀ | 60 | 117,5 | 66,8 | 52,2 | 225 |
| N.W. — blue only; | 27♂+11♀ | 38 | 112,9 | 63,7 | 50,0 | 226 |
| N.W. — white only; | 65♂+12♀ | 77 | 119,7 | 68,1 | 53,0 | 226 |

*) Fifth Thule Expedition.

In a sex dated material the determining of the "C. S. °/₀" makes it possible to compare the stages of growth of two populations, fig. 65.

Fig. 57 shows the proportion between tooth size and skull size in the "ideal" skull material from Table I. Some populations deviate more than others from the 224 °/₀ line, i.e. those of Svalbard, Scandinavia and Pribilof Islands. It is characteristic for the islands of Svalbard and Pribilof that considerable immigrations of white foxes have taken place in fairly recent times, and it is assumed that this also happened in Scandinavia. The white fox immigration was favoured by a change in the climate, a change which altered (delayed?) the time of the food maximum and thus may have disturbed the harmonic proportion between teeth and skull. These questions call for further investigation.

The Arctic Fox of the islands in the northern Atlantic belongs to *the smallest group* (demonstrated by ZALKIN 1944). Where this group is most characteristic, it has a low white percentage.

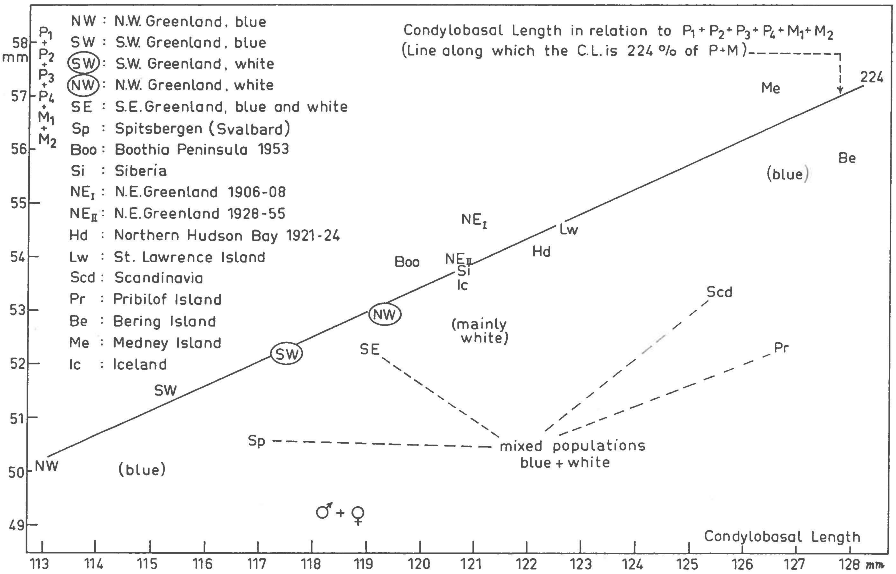



Fig. 57. Measurements of skulls of *Alopex lagopus* from biotopes around the Arctic Ocean. Same skull material as listed in Table I.

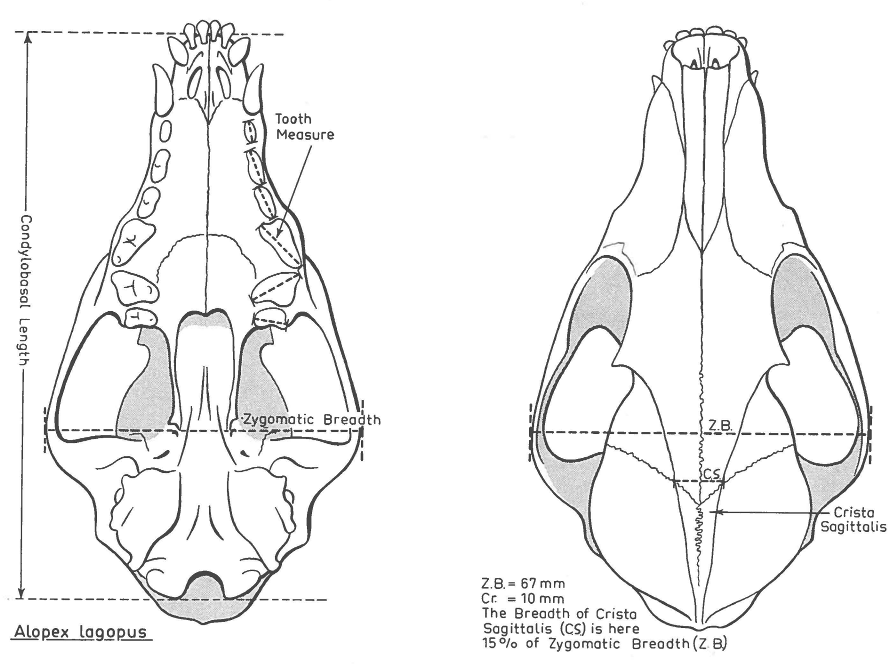



Fig. 58. Broken lines indicate where the measures are taken. The skull to the right is from an immature Arctic Fox from West Greenland. Crista sagittalis is broad and flat. The breadth (C.S.) is measured at the points where it crosses Margo frontalis x parietalis.

The Arctic Fox of the islands and coasts in and around the Bering Sea belongs to *the largest group*. This group too, where it is most characteristic, has a low white percentage.

The Arctic Fox of the tundra and mountain biotopes of the continents and Northeast Greenland belongs to *the middle group*, where at present the white percentage is close to 100.

## The White Arctic Fox or the Tundra Fox.

**Biotope:** The Arctic mountain fields, and tundras where Lemming (*Lemmus* and *Dicrostonyx*) are found.

**The White Arctic Fox,** in its typical form, is a specialized Arctic Fox which is particularly adapted to life inland and to the hunting of Lemming, Hare, and Ptarmigan and other birds. It is subject to strong competition on the part of individuals of its own species, or to extreme natural conditions, so that *only the best-equipped individuals survive*. In regard to size, it takes its place in the middle group, in that it is smaller than the blue fox from the biotope around Bering Sea, and it is larger than the blue fox from the biotope around the Greenland Sea. Everywhere in West Greenland it is *larger than the blue fox*. Its large size requires abundant food late in the year; also it grows its winter fur at a late point (November/December) fig. 67, after heavy cold has set in—and after snow has fallen and lakes and rivers have frozen over.[1]) During hunger periods late in winter following Lemming maxima, the white fox roams far and wide for food, and then often invades the coastal and insular biotopes by way of the drift-ice, and competes with the blue fox.

During climatic periods that are critical for the coastal biotopes, the white fox can often succeed in conquering grounds at the expense of the blue fox. By virtue of steady reinforcements from the tundra-biotope, it may even survive for a number of years on the coastal biotopes.

However, as these biotopes cannot satisfy the large food requirements of the white fox during the period when it grows its winter fur late in the fall (the Lemming is not found here), the white fox will always be a weak animal on the coastal and island biotopes.

The white fox is considered a biological race — a hunting specialist that probably emerged at the time when the Lemming conquered the tundra, before or after the last glacial period. The question then presents itself whether there is any connexion between the colour of the white fox and the late date it grows winter fur. This question calls for closer investigation.

[1]) This point needs further investigation. The low white percentage in December, fig. 67, may indicate a high death-rate of white foxes in bad pelts.

The white fox is subject to great quantitative fluctuations which follow corresponding fluctuations in the Lemming population (Elton, Braestrup *et al.*).

These fluctuations seem to be dependent on the climate and are in part long-term fluctuations over 1–2 sun-spot periods, and partly short-term fluctuations of about 3–4 years, $^1/_3$ of a sun-spot period.

The Arctic mountain fields and tundras include the extensive areas of America, Asia, and Europe, located north of the tree-growth limit or above the timber line, where the climate is continental and stable. The average temperature for the month of July is below 10° C. The winter is of consistent coldness, without long periods of thaw, and the ground is covered by a moderate layer of snow throughout the winter.

In the tundra the permafrost remains close to the surface. On the mountain fields the ground may be so dry that it is not hardened by winter frost. Summer precipitation being low, the water from the melting snow banks constitutes the chief water supply. Without the permafrost slowly giving off water by melting during the summer, large areas in the Arctic would be desert-like in character.

The characteristic plants of mountain field and tundra are *Salix*, *Betula*, *Vaccinium*, *Empetrum*, *Cassiope*, *Polygonum*, *Dryas*, *Gramineae* and *Cyperaceae*, which have a wide distribution and serve as principal food for the plant-eating animals of the mountain field and tundra.

The Lemming is the principal food of the white Arctic Fox and is widely distributed all over the Arctic area, from Scandinavia via Siberia, northern Canada and its adjacent Arctic islands to North and Northeast Greenland. It is divided into different genera (*Lemmus*, *Dicrostonyx*).

To the Lemming a stable climate is of vital importance. This small rodent builds its nest in summer in ground caves or under rocks, where it is protected against the Arctic Fox, the Gyr-Falcon, the Long-tailed Scua and the Snowy Owl, all of which are its enemies. This is the time when the Lemming is most exposed during foraging expeditions in the open.

However, when the snow drifts of autumn settle along terraces and in creek beds, the Lemming will leave its ground caves and build winter nests of grass or heather above ground, under the snow. Here it spends the winter and digs long passages under the snow for foraging. The first litter is born in the winter nests under the snow in April (observed by the author in Northeast Greenland) or even earlier.

It is absolutely vital for the Lemming that the constant winter frost is not interrupted by thaw and rain, which break down the snow drifts and freeze into ice on the cold ground. When, as occasionally, this happens the Lemmings perish in great number. Thus, it is quite impossible for the Lemming to thrive without stable climatic conditions.

When adverse climatic conditions occur the white tundra fox is unable to obtain any surplus of food for producing young. It goes hungry during wet winerrs that are poor in Lemming and may starve to death.

But the wet winter gives the tundra and the mountain fields a new water reserve. The vegetation recovers and the Lemming is able to multiply during the following dry period. In a dry period following a wet one the Lemming, the Reindeer, the Musk Ox, the Ptarmigan, and the Hare will usually increase their populations.

The white fox requires abundant food late in the year, i.e. October-November, or around the period when the Lemmings abandon cave life and emerge above ground to build winter nests under the snow. When this takes place, food is easily accessible, allowing the white tundra fox a period in which to grow its winter fur. Hunters from Northeast Greenland (STEEN MALMQUIST and FINN CHRISTOFFERSEN) inform the author that the fur of the white fox was not usually of high quality before about December, (see footnote p. 106).

The white fox is absolutely predominant in the tundra. Foxes of blue colour may occur, but only in small numbers, and then more frequently in the coastal areas. These blue foxes may originate from emigrants from near-by island and coastal biotopes (K. FETHERSTON 1947) — or more likely — they may be a small remnant of a large population of a now nearly extinct big blue Arctic Fox that formerly lived on the more or less ice-free shores of the Arctic Ocean. See further p. 110.

Before and after 1890 some of the Arctic biotopes were influenced by much precipitation, owing to violent agitation in the drift-ice late in summer, much to the detriment of the Lemming and the white Arctic Fox. In the Baffin Bay area of Canada and Greenland and in northern Labrador, the population of white Arctic Fox stagnated, figs. 79–80.

After 1900 the exceptionally intense movements in the drift-ice weaken. The tundra receives less precipitation, but has a good ice, snow, and water reserve from preceding years—and now provides better conditions for the Lemming. The white Arctic Fox takes advantage of this to multiply and advance far beyond the tundra. It reaches all the biotopes of the blue coastal fox, except Medney Island in the Bering Sea. It cross-breeds throughout with the local blue fox and may to some extent displace the latter for some time, particularly in locations where the growth period is sufficiently long for it to bring up young and complete the growth of its winter fur.

All over the vast tundra area of **Europe, Siberia, Canada,** and **Northeast Greenland** the White Arctic Fox is of a uniform character. The Arctic Fox of the Canadian tundra was named *innuitus* by MERRIAM 1903. MERRIAM considered the Arctic Fox of northern Labrador to be another subspecies and named it *ungava.* See further p. 149.

In **Greenland** the White Arctic Fox or the Tundra Fox is predominant on the Lemming biotope, i. e., North and Northeast Greenland—treated in detail p. 128 ff.

In the **Scandinavian** mountain area the ecological conditions are somewhat different to those from the tundra. Here food is plentiful and more varied. Many juvenile individuals survive. The cranium is long in relation to the teeth, fig. 57.

These animals live in Finmark and on Hardangervidda. Foxes of blue colour are most common in the coastal area, foxes of white colour predominant in the mountain (Sigurd Johnsen 1947). Their food consists of berries, Lemmings, birds and beach fauna. The Scandinavian Arctic Fox is, at present, in strong competition with the Red Fox and is consequently not very numerous.

All cranium material studied varies greatly in methods of collection, and is poorly dated. The fact that the Scandinavian blue fox prefers the coasts while the white fox prefers the high mountains, suggests that they are each specialized in their own directions, and that we are dealing with two original populations, i.e.: The blue coastal fox which was formerly widely distributed, and the white tundra fox from the continent—and hybrids between these. The combination of long skull/small teeth occurs most frequently in localities with mixed populations, see p. 104.

The Scandinavian Arctic Fox was given the name *lagopus* by Linné 1758: "Habitat in alpibus Lapponicis, Sibiria". The blue Arctic Fox is considered a variant by Linné: "Variat Cærulescente colore", Fauna Svecica, editio altera, auctior, 1761, p. 4.

## The Blue Arctic Fox or the Coast Fox.

**Biotope:** The Arctic coasts of the Pacific and Atlantic Oceans.

**The Blue Arctic Fox** is a typical coastal and insular fox. It is content with the food it can find in the tidal zone of the beach, on the breeding grounds of the marine mammals, and the coastal bird cliffs, and berries from the mountain fields. If abundant food is available during its entire growth period, it can bring up large litters of pups. With plenty of food, the mutual competition is insignificant and the natural selection mild.

The average quality of the fur is generally low. The size is adjusted to the length of the nutritional period, and it is, therefore, large in the south with a long growth period, and small in the north with a short growth period. In favourable winters many juvenile and poorly qualified individuals survive even though they have not been able to complete growth before food shortage. In Greenland, the winter fur grows rapidly (October/November), i.e. before heavy cold and food shortage set in, caused by the coasts icing over. In winter it stays close to the littoral zone of the beach, seeking its food at ebb tide, but it may also invade the grounds of the white fox in small numbers.

The cold of the polar regions keeps the Red Fox and other competitors in check. The blue fox (and to some extent the white fox) is, therefore, the sole utilizer of the coastal biotopes of the Arctic.

During other climatic periods of the past, the blue coastal fox was relatively more common along the coasts of the Arctic Ocean. After the middle of the 19th century the blue fox began to decrease in number in relation to the white fox in western Arctic. "Hudson's Bay Company records suggest that there has been a decrease in the relative number of blue foxes in the Mackenzie River delta region since the middle of the nineteenth century", ELTON 1949. In West Greenland the white percentage began to increase around 1840, see fig. 69, Julianehåb and Holsteinsborg. This was due to arrival of much East Greenland Ice late in summer, which destroyed the coastal biotope of the blue Arctic Fox in Davis Strait—or changed the time of the food maximum.

In Northwest and Northeast Greenland the white percentage was low 1860–1910, see top curve fig. 69, owing to a relatively wet climate in these regions, brought about by much agitation in the Arctic Ocean Ice north of Greenland (the drift-ice pulsation stage). The period was bad, too, for the Reindeer.

After 1910 the agitation in the Arctic Ocean Ice decreased (drift-ice melting stage), and a dry climate was established along the northern coasts. The populations of white tundra foxes increased and the relative number of blue coast foxes decreased. To-day only a few big blue Arctic Foxes are left in Eastern Arctic, i.e.: Baffin Island, Northeast Greenland, Iceland (and northern Scandinavia), and they are mixed with white foxes from the tundra.

The continental climate of Asia and North America has divided the Arctic coast-biotope into two parts:

I) the coasts around the Bering Sea and its islands.

II) the coasts around the Greenland Sea and its islands.

At the same time, the blue fox has been divided into two isolated groups, on two biotopes that are located at different degrees of latitude and which offer growth periods of different lengths, and different kinds of food. The growth period is longest around the Bering Sea, where the blue fox attains its largest size; it is shortest around the Greenland Sea, where the blue fox is smallest.

Continuous fluctuations in climate and in occurrence of drift-ice subject the blue fox, especially in the Atlantic area, to great quantitative fluctuations.

## The Arctic Fox on the Islands in the Bering Sea.

By "The Bering Sea" is meant the sea between the Aleutians, Kamchatka, and Bering Strait. Islands that are of special interest in this thesis are the Commander Islands: Bering Island and Medney Island, located approximately 55° N., east of Kamchatka. A little further to the north and closer to Alaska are the Pribilof Islands: St. George Island, St. Paul Island, Walrus Island, and Otter Island, located at appr. 57° N. A little to the north of 60° N are St. Matthew Island and Hall Island. Still further north is St. Lawrence Island, just north of 63° N.

All these islands are located north of the limit of tree growth. The average temperature for July on the Commander Islands is 9° C (H. Johansen 1949). The sea around the Commander Islands never freezes up, and the average air temperature for January is −4° C. The drift-ice does not at present reach the Commander Islands, although it is not impossible that this may have been the case in earlier times, during drift-ice pulsation stages.

Drift-ice reaches the Pribilof Islands regularly in the spring and may partly surround the islands until early May. The northernmost islands: St. Matthew and St. Lawrence Islands may be troubled by drift ice until June, but as a rule are free from ice during the remaining summer months.

The season when the Arctic Fox may expect to find abundant food is longest in the south, shortest in the north. Consequently, we find the largest Arctic Fox on the southern islands and the smallest on the northern ones.

The biotopes of the Bering Sea are, in general, rich in food, and the Arctic Fox living there is the largest fox within the species. Four races are described, living isolated (?) on islands with different kinds of food. The difference between three of them, however, is so insignificant, and so much a result of ecological and other factors, that it is doubtful whether the division into 3 genetic races can be maintained.

On all the islands the Arctic Fox lives predominantly on the products of the sea: the fauna of the beach, the eggs and young of sea birds, and on some of the islands, also on the carcasses of large numbers of fur seals (*Callorhinus ursinus cynocephalus* (Walbaum)), which go to the islands year after year to breed. These islands are, in particular, Bering Island and the Pribilof Islands.

Only a small number of fur seal breed on Medney Island, and on the northernmost islands, i.e. St. Matthew, Hall Island, and St. Lawrence Island, the seals do not breed at all.

On **Medney Island,** white foxes are unknown, and do not occur among the blue foxes (H. Johansen 1949). The chief food of the blue fox is beach fauna, although to some extent they also eat carrion of fur seals. The food is not quite as plentiful as on Bering Island, and mutual competition and natural selection are more severe. This fox has a better quality of fur than the Bering Island fox, and has a well-developed, strongly-built cranium. The Medney Island blue Arctic Fox was named *seminovi* by OGNEV 1931.

On **Bering Island** foxes of white colour are seldom found, and even then are very quickly exterminated. It is not impossible that in the past white foxes from the tundra biotope have had access to the island via the drift-ice, which does not reach this far today. The Bering Island Arctic Fox is a large and usually well-developed blue fox. Its chief food is carrion of fur seals, and the fauna of the beach (H. JOHANSEN 1949). The cranium is a little longer in relation to the teeth than on Medney Island, see fig. 57. The Arctic Fox on Bering Island was named *beringensis* by MERRIAM 1903.

On the **Pribilof Islands,** white foxes occur more commonly than on the preceding island, but here, too, they are exterminated systematically. The drift-ice passes the islands regularly. In the 1870's the white percentage on Pribilof Islands was around 20, ELLIOT 1872–76.

The Pribilof Arctic Fox is a large and usually well-developed blue fox, living principally on the fauna of the beach and carrion of fur seal. Characteristic of this fox is the long Condylobasal Length in relation to the teeth. This character may be due to the fact that the original blue population was disturbed by an invasion of white foxes from the continent. A simultaneous change in the climate may have altered the biotope. (A trend in the same direction is found in the Arctic Foxes in Svalbard and Scandinavia, see fig. 57).

HENRY W. ELLIOTT writes about the blue fox on Pribilof Island: "In regard to these foxes the Pribylov natives declare that when the islands were first occupied by their ancestors, 1786–87, the fur was invariably blue; that the present smoky blue, or ashy indigo colour, is due to the coming of white foxes across on the ice from mainland to the eastward. The white-furred wulpes is quite numerous on the island to-day. I should judge that perhaps one-fifth of the whole number were of this colour; they do not live apart from the blue ones, but evidently breed "in and in"." (Memoranda of collections made by HENRY W. ELLIOTT: Pribylov Islands: 1872 to 1876, inclusive.)

The Arctic Fox on the Pribilof Islands was named *pribilofensis* by MERRIAM 1903.

The three populations of Arctic Fox mentioned above, found on the islands in the Bering Sea, are very closely related. The small difference between them may be due to a variation in white percentage and in the time for the beginning of the food maximum.

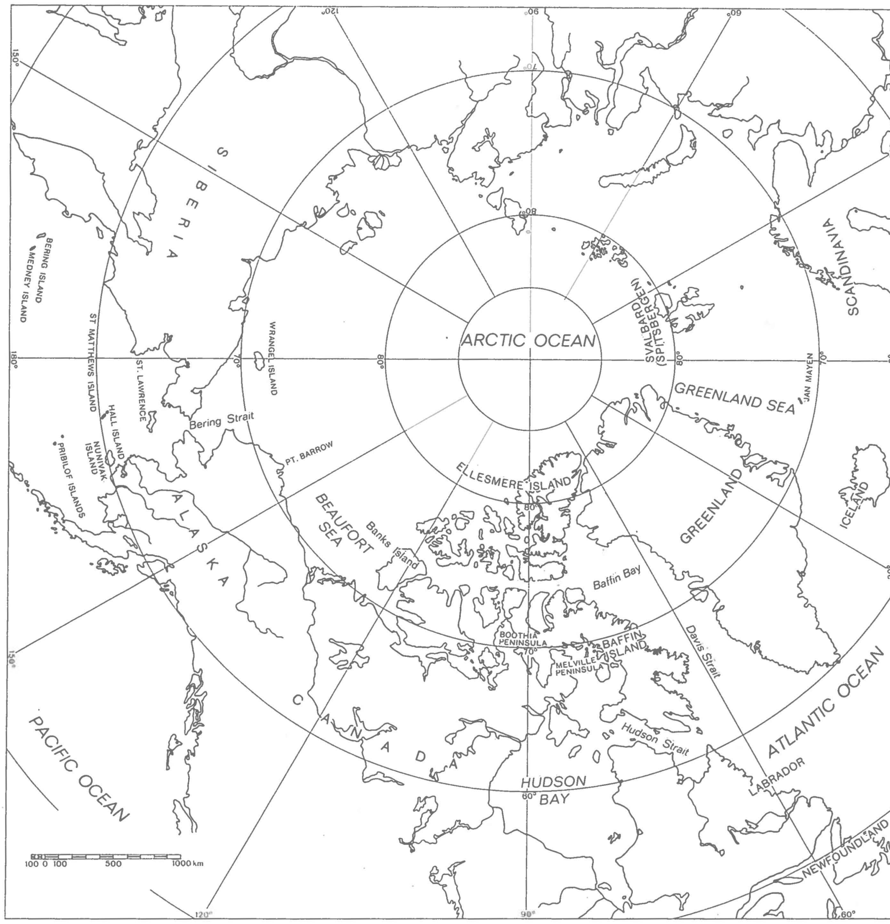



Fig. 59. The Arctic Ocean with adjoining continents and islands.

On the northern islands of the Bering Sea, white fox occur in larger numbers than blue fox; on **St. Matthew** appr. 80 % white in 1963, and on **St. Lawrence** 99.4 % in 1956–1961, information from F. H. Fay.

The most important food are invertebrates of the beach and sea birds. As the drift-ice passes these islands regularly, it must be presumed that white foxes from the tundra have frequent access and are responsible for the high white percentage. The author has examined 30 crania from St. Lawrence. The measurements of teeth and cranium (Condylobasal Length and Zygomatic Breadth) are so close to the measurements of white foxes from Arctic Canada and Siberia that it is presumed that immigration occasionally takes place from the continent via the drift-ice, a connection which may possibly have been more lively in the past than at present.

The author has discussed this question with F. H. FAY, who writes in a letter dated May 10, 1964: "BRAESTRUP's (1941) and your remarks about extensive immigrations of foxes from Canada are especially interesting to me because I have found very little evidence of long-distance movements in my data from St. Lawrence Island foxes. In fact, I am fully convinced that most of the island foxes never leave the islands and that there are very few immigrants from other areas each year. I am aware that some foxes do travel long distances over the ice, but I suspect that this is not a general condition and that it involves only a small percentage of each population, probably a few of the young animals. We have had some success in recognizing immigrants on St. Lawrence Island by their different parasite fauna, and I wonder if this might be possible also in Greenland".

Even if immigration is not of great importance at the present time, the high white percentage and the skull characters suggest that the Arctic Fox on St. Lawrence is closely related to the white Arctic Fox of the continent. Like in parts of Greenland and in Svalbard and Iceland, the Arctic Fox on the northern islands of the Bering Sea is a mixed population consisting of the original blue coastal fox and emigrant white foxes from the tundra biotope.

The name *hallensis*, proposed by MERRIAM 1900 for the Arctic Fox on Hall Island, requires re-evaluation.

## The Arctic Fox on the Islands around the Greenland Sea.

The other important coastal biotope of the Arctic Fox is constituted by the islands around the Greenland Sea: Greenland, Iceland, Svalbard, and Jan Mayen. (Scandinavia, see p. 109). Northeast and part of North Greenland are not a proper coastal biotope, but belong to the biotope of the mountain fields and tundras (cf. p. 109 and p. 128) and are inhabited by the Lemming. The rest of Greenland consists of typical coastal biotopes with fiords, and coasts which are open in summer and more or less frozen over in winter.

The coastal biotope ranges from appr. 60° N (South Greenland) to appr. 81° N (North Svalbard).

Average air temperatures in °C for the years 1946–55 are:

| | Akureyri | Ivigtut | Upernavik |
|---|---|---|---|
| January | 0.6 | −5.9 | −16.5 |
| July | 11.0 | 9.5 | 5.3 |

Surface temperatures of the sea in C°:

| | North of Iceland[1]) 1868–1953 | Davis Strait[2]) 1946–55 |
|---|---|---|
| June | 6 to 7 | 2 to 3 |

[1]) W. KRAUSS 1958. [2]) Nautisk Meteorologisk Årbog.

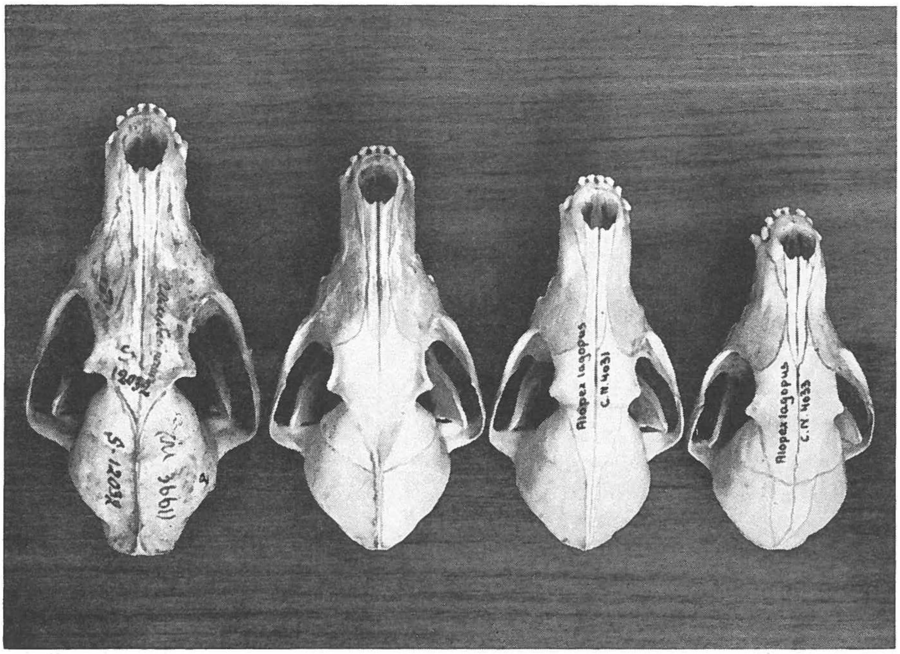



Fig. 60. Skulls of Arctic Fox (Zoological Museum, Copenhagen).
A Medney Island S 12032 — 14 XII 1918 ♂ blue, C. L. 135,7.
Breadth of Crista sagittalis 1 % of Z. B.
B Murchison River Area, Canada, early February 1953 ♂ white, C. L. 120,8.
Breadth of Crista sagittalis 4 % of Z. B.
C Neqe, Thule Area, C. N. 4031 — 25 III 1941 ♂ blue, C. L. 113,0.
Breadth of Crista sagittalis 8 % of Z. B.
D Kap Atholl, Thule Area, C. N. 4033 — 10 III 1940 ♂ blue, C. L. 104,5.
Breadth of Crista sagittalis 24 % of Z. B.

This extensive island and coastal area provides the Arctic Fox with bivalves, snails, crustaceans, and fish (*Mallotus villosus*, *Boreogadus saida*), and the bird cliffs of the coastal zone have abundant eggs and young.

But a coastal biotope of high latitudes and Arctic conditions has the disadvantage that the fiords and coasts freeze up in fall and winter, at the same time as the sea birds leave their breeding grounds and fly south. This limits the food supply, considerably reducing the growth period of the Arctic Fox.

The Arctic Foxes around the Greenland Sea (except in Northeast Greenland) and Baffin Bay belong to the group of smallest animals, fig. 60 C and D. They are all subject to considerable differences in sizes and fluctuations in numbers, caused by changes in the ecological conditions under which they live. The white percentage fluctuates a great deal.

The longest growth period is near the open sea, Iceland, Southwest Greenland, and parts of Svalbard. There, the Blue Arctic Fox attains the largest size. In the Thule and Scoresbysund districts the fiords freeze up early. Here and on Jan Mayen the blue Arctic Fox is small. The ice formation limits the food supply, entailing an early cessation of its growth. This also means that the coastal Arctic Fox must complete growth of winter fur before heavy cold sets in as there will not be sufficient food for this later.

All biotopes around the Greenland Sea are invaded at intervals by white foxes from surrounding tundras and mountain fields.

In cases, however, where the foreign biotope does not offer satisfactory conditions, the stay of invading foxes is brief. For example, the growth period may be too short for the white fox to complete the growth of its winter fur. This seems to be the case in the Thule area. Here the blue fox is small, and the Tundra Fox is unable to remain.

On the other hand, when the foreign biotope offers satisfactory conditions, enabling the white fox to complete normal growth of winter fur, the invading foxes are able to settle and breed on the biotopes of the blue fox. The white percentage of the area may rise to around 50 per cent or more, in some areas to 80 per cent or more. This contributes to the present high white percentage in the populations of Arctic Fox in Southeast Greenland, Svalbard, Iceland and Scandinavia — and parts of West Greenland.

When the white fox usually is more common on poor biotopes than the blue one, this must be due to a steady stream of white immigrants from the tundra or inland biotope. The white fox is more hardy and more of a roamer than is the blue fox.

In **Svalbard** today the white fox predominates. Out of 54 crania received from the Norwegian hunter BJARNE NORDNES from the hunting season 1962/63, 44 were from white and 10 from blue fox, giving a white percentage of 81.5. As drift-ice is always present at Svalbard, roaming white foxes from the tundra biotope of the continent have easy access there, and today the possibilities of nutrition are sufficient for this animal to survive and breed, although it does not attain the same size as on the tundra.

Svalbard is rich in cliffs with breeding Little Auk and other sea birds. The sea ice around the islands is a breeding place for numerous Ringed Seals and a biotope for the Polar Bear.

The skull of the Arctic Fox in Svalbard is characterised by the great Condylobasal Length in relation to the teeth. This may indicate that we are dealing with a mixed population here, fig. 57. The long growing season of to-day enables the Tundra Fox to survive in Svalbard.

The Arctic Fox of Svalbard was named *spitzbergenensis* by Barret Hammilton and Bonhote 1898.

**Iceland** has a large population of Arctic Fox, too. This country usually has at present ice-free coasts and a rich bird life inland. The Arctic Fox in Iceland is bigger than that of Svalbard. The proportion of blue to white is unknown. Pennant (1784) names it Sooty Fox. Bechstein (1799) states: "Sein Balg ist allenthalben schwärzlich (dusky)". Alfred Newton 1864 states: "Nearly all the foxes retain their dark livery the year round".

Thus it seems that the Arctic Fox in Iceland is usually known as a blue fox. Inhabitants in Iceland have informed the present author that both blue and white foxes are common today.

The Arctic Fox in Iceland was named *fuliginosus* by Bechstein 1799.

On **Jan Mayen** most foxes are blue and small. They live mainly on sea birds, and resemble the blue foxes of the sea bird cliffs of Scoresby Sund.

The **Greenland** Arctic Fox was named *groenlandicus* by Bechstein 1799. "Eine sehr kleine Art, die Grönland bewohnt". It is treated in detail below.

## The Arctic Fox in Greenland.

Through Den kgl. grønlandske Handel (The Royal Greenland Trade Department), a considerable number of skulls of Arctic Foxes from all trading posts in Greenland was procured during 1952, 1953 and 1954. These skulls were purchased (along with the furs) from Greenlandic hunters, who were supplied with labels printed with Greenlandic and Danish texts, on which they were requested to give information as to name, locality, date, colour and sex of the fox. An additional label could be filled in with information as to the method of hunting employed and the stomach contents of the foxes.

Somewhat over a thousand skulls were acquired from western Greenland, out of which 973 supplied all information required for the present study.

This skull material is separated as follows:

| | | | | | | |
|---|---|---|---|---|---|---|
| 182 | blue | ♂ | from | Southwest | Greenland | (Including Central West |
| 149 | — | ♀ | — | — | — | Greenland on map fig. 68.) |
| 98 | white | ♂ | — | — | — | |
| 67 | — | ♀ | — | — | — | |
| 122 | blue | ♂ | — | Northwest | Greenland | (Including Thule Area on |
| 123 | — | ♀ | — | — | — | map fig. 68.) |
| 135 | white | ♂ | — | — | — | |
| 97 | — | ♀ | — | — | — | |
| 973 | | | | | | |

Table II.

| *Alopex lagopus* L. *Southwest Greenland* (Including central West Greenland on map fig. 68) | Number of Crania | Condylobasal Length | Zygomatic Breadth | Breadth of Sagittal Crest | Largest measure of $P_2+P_3$ | Largest measure of $P_1+P_4+M_1+M_2$ | Total tooth measure | $P_2+P_3$ in % of total tooth measure | Breadth of Sagittal Crest in % of Zygomatic Breadth | Condylobasal Length in % of total tooth measure |
|---|---|---|---|---|---|---|---|---|---|---|
| — Blue ♂♂ | | | | | | | | | | |
| Pups caught November | 74 | 112,7 | 62,7 | 11,1 | 15,2 | 35,9 | 51,1 | 29,7 | 17,7 | 220 |
| — — Dec.–Mar. | 52 | 113,2 | 63,3 | 10,2 | 15,1 | 36,1 | 51,2 | 29,5 | 16,1 | 221 |
| Adults............... | 56 | 115,0 | 65,8 | 7,5 | 15,4 | 36,5 | 51,9 | 29,7 | 11,4 | 222 |
| | 182 | 113,6 | 63,9 | 9,6 | 15,2 | 36,2 | 51,4 | 29,6 | 15,0 | 221 |
| — Blue ♀♀ | | | | | | | | | | |
| Pups caught November | 51 | 110,7 | 62,0 | 11,3 | 15,0 | 35,6 | 50,6 | 29,6 | 18,2 | 219 |
| — — Dec.–Mar. | 46 | 109,9 | 62,1 | 11,2 | 14,7 | 35,1 | 49,8 | 29,5 | 18,4 | 220 |
| Adults............... | 52 | 111,3 | 63,7 | 9,2 | 14,9 | 35,5 | 50,4 | 29,6 | 14,5 | 221 |
| | 149 | 110,6 | 62,6 | 10,6 | 14,9 | 35,4 | 50,3 | 29,6 | 17,0 | 220 |
| — White ♂♂ | | | | | | | | | | |
| Pups caught November | 20 | 112,5 | 63,8 | 11,2 | 15,1 | 35,8 | 50,9 | 29,7 | 17,6 | 221 |
| — — Dec.–Mar. | 30 | 113,4 | 64,2 | 8,6 | 15,2 | 36,2 | 51,4 | 29,6 | 13,4 | 221 |
| Adults............... | 48 | 117,4 | 67,0 | 6,0 | 15,7 | 36,7 | 52,4 | 30,0 | 9,0 | 224 |
| | 98 | 114,4 | 65,0 | 8,6 | 15,3 | 36,2 | 51,5 | 29,7 | 13,2 | 222 |
| — White ♀♀ | | | | | | | | | | |
| Pups caught November | 13 | 111,2 | 62,4 | 10,8 | 14,7 | 35,3 | 50,0 | 29,4 | 17,3 | 222 |
| — — Dec.–Mar. | 16 | 110,4 | 62,4 | 11,5 | 14,8 | 35,2 | 50,0 | 29,6 | 18,4 | 221 |
| Adults............... | 38 | 112,1 | 64,6 | 8,8 | 15,0 | 35,5 | 50,5 | 29,7 | 13,6 | 222 |
| | 67 | 111,2 | 63,1 | 10,4 | 14,8 | 35,3 | 50,1 | 29,6 | 16,5 | 222 |

Judging from the material collected, more males are caught in Southwest Greenland than females, of both white and blue foxes. This is presumably due to the fact that the biotope is very extensive and not uniformly covered by hunters, and since the males roam more than the females, more males are caught.

In Northwest Greenland where the biotope is very small and the feeding possibilities of the blue fox are essentially limited to the coasts, both sexes are equally exposed to hunting, and the same numbers of males and females are caught. Of the white foxes, however, as in South-

Table III

| *Alopex lagopus* L. *Northwest Greenland* (Including Thule Area on map fig. 68) | Number of Crania | Condylobasal Length | Zygomatic Breadth | Breadth of Sagittal Crest | Largest measure of $P_2+P_3$ | Largest measure of $P_1+P_4+M_1+M_2$ | Total tooth measure | $P_2+P_3$ in $^0/_0$ of total tooth measure | Breadth of Sagittal Crest in $^0/_0$ of Zygomatic Breadth | Condylobasal Length in $^0/_0$ of total tooth measure |
|---|---|---|---|---|---|---|---|---|---|---|
| — Blue ♂♂ | | | | | | | | | | |
| Pups caught November | 31 | 110,6 | 61,9 | 10,8 | 14,6 | 34,7 | 49,3 | 29,6 | 17,5 | 224 |
| — — Dec.–Mar. | 49 | 112,0 | 62,8 | 9,3 | 14,8 | 34,5 | 49,3 | 30,0 | 14,8 | 227 |
| Adults............... | 42 | 112,6 | 64,3 | 7,9 | 14,9 | 34,5 | 49,4 | 30,2 | 12,3 | 228 |
| | 122 | 111,7 | 63,0 | 9,3 | 14,8 | 34,6 | 49,4 | 29,9 | 14,8 | 226 |
| — Blue ♀♀ | | | | | | | | | | |
| Pups caught November | 31 | 106,1 | 59,1 | 13,9 | 14,4 | 33,4 | 47,8 | 30,1 | 23,5 | 222 |
| — — Dec.–Mar. | 60 | 106,8 | 60,4 | 11,5 | 14,2 | 33,4 | 47,6 | 29,8 | 19,0 | 224 |
| Adults............... | 32 | 108,5 | 62,3 | 9,7 | 14,2 | 33,5 | 47,7 | 29,8 | 15,4 | 227 |
| | 123 | 107,1 | 60,6 | 11,7 | 14,3 | 33,5 | 47,8 | 29,9 | 19,3 | 224 |
| — White♂♂ | | | | | | | | | | |
| Pups caught November | 34 | 115,1 | 63,4 | 10,6 | 15,3 | 35,9 | 51,2 | 29,9 | 16,5 | 225 |
| — — Dec.–Mar. | 39 | 117,2 | 65,9 | 9,7 | 15,7 | 36,8 | 52,5 | 29,9 | 14,7 | 223 |
| Adults............... | 62 | 119,8 | 68,5 | 4,9 | 16,0 | 37,0 | 53,0 | 30,2 | 7,2 | 226 |
| | 135 | 117,4 | 65,9 | 8,4 | 15,7 | 36,6 | 52,3 | 30,0 | 12,8 | 225 |
| — White♀♀ | | | | | | | | | | |
| Pups caught November | 28 | 109,5 | 61,9 | 14,5 | 14,6 | 35,0 | 49,6 | 29,4 | 23,4 | 221 |
| — — Dec.–Mar. | 31 | 110,9 | 62,8 | 11,0 | 15,1 | 35,0 | 50,1 | 30,1 | 17,5 | 221 |
| Adults............... | 38 | 113,5 | 64,9 | 9,2 | 15,3 | 35,1 | 50,3 | 30,2 | 14,3 | 226 |
| | 97 | 111,3 | 63,2 | 11,6 | 15,0 | 35,0 | 50,0 | 30,0 | 18,4 | 223 |

west Greenland, mostly males are caught, but these have to some extent immigrated from Canada (and Northeast Greenland).

The blue fox and the white fox differ in size (see figs. 61–64), especially in Northwest Greenland where direct immigration of large white foxes takes place. These white foxes come from biotopes with Lemmings, which are not found in western Greenland. They must therefore adapt to a new way of life without their chief source of food, i.e., the Lemming. Many perish or are caught in traps, but some survive and continue to breed under the new conditions. This can only be done at the expense of growth of winter fur and growth in size. Their descendants have a poorer fur and are smaller than the immigrants, approaching the blue fox in mode of life and in size, especially in Southwest Greenland. The average size of the adult white fox thus decreases from north to south, proportionally to the distance from the invasion areas.

In the case of the blue fox the reverse takes place in that this animal increases in size from north to south. The reason for this is that the growth period is prolonged in tune with the decreasing degrees of latitude.

To throw further light on the questions touched upon above, the material has been broken down according to northern and southern districts, i.e., Northwest Greenland (Thule area through Christianshåb district) and Southwest Greenland (Egedesminde district to Kap Farvel), and distinction is made between white and blue, male and female, young from November, young from December through March, and old individuals. This has only been made possible thanks to a large and well-collected material.

## Condylobasal Length and Zygomatic Breadth.

The schemes fig. 61 and fig. 62 show the two principal measurements of size, for young caught in November (plus a few from ultimo October), young caught in December/March, and old animals. That females in Southwest Greenland are larger in November than in December/March may be because the smaller females from inland do not reach the hunting grounds on the coast until after November, while the young males begin their roaming existence at an earlier stage. In certain districts hunters do not reach the inland biotope before December.

The schemes show further that the growth in size continues during fall and winter and takes a new jump the following summer. A study of the teeth (see fig. 63 and fig. 64) shows that a natural selection of larger individuals may also be involved.

In Southwest Greenland there is little difference in size between blue and white young animals during their first summer and winter. They live under the same ecological conditions and grow at the same pace, although the white have a slight lead. This difference becomes more marked in the course of the following summer, after which the white foxes are decidedly the larger. This may suggest that the white Arctic Fox continues its growth in size for a longer period than does the blue. However, it may also be that a tougher selection takes place among the white foxes than among the blue ones, and it may also be that immigration by old white foxes may be involved.

In Northwest Greenland there is a considerably greater difference between blue and white. The blue is much smaller than in Southwest

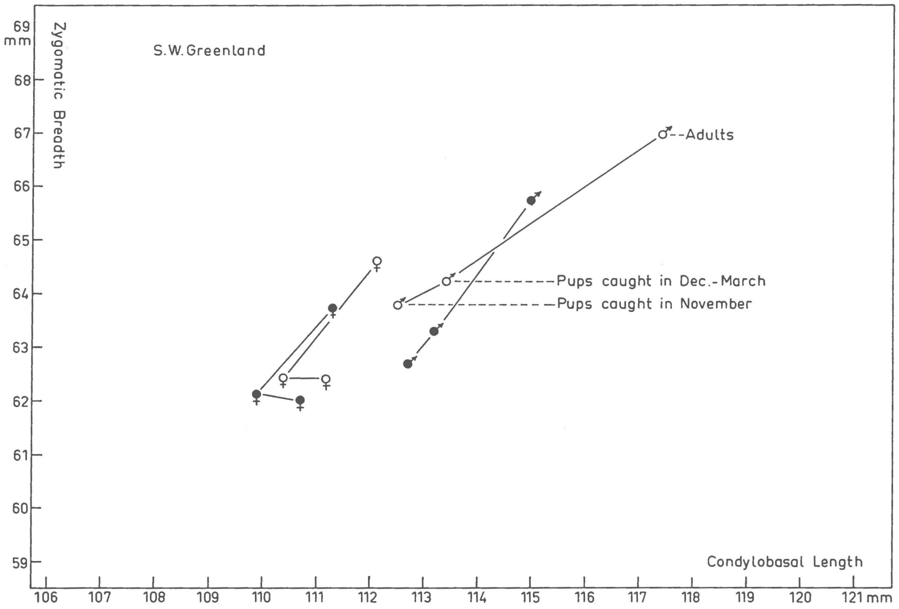



Fig. 61. Southwest Greenland (including Central West Greenland on map fig. 68). Numerical material in Table II p. 118.

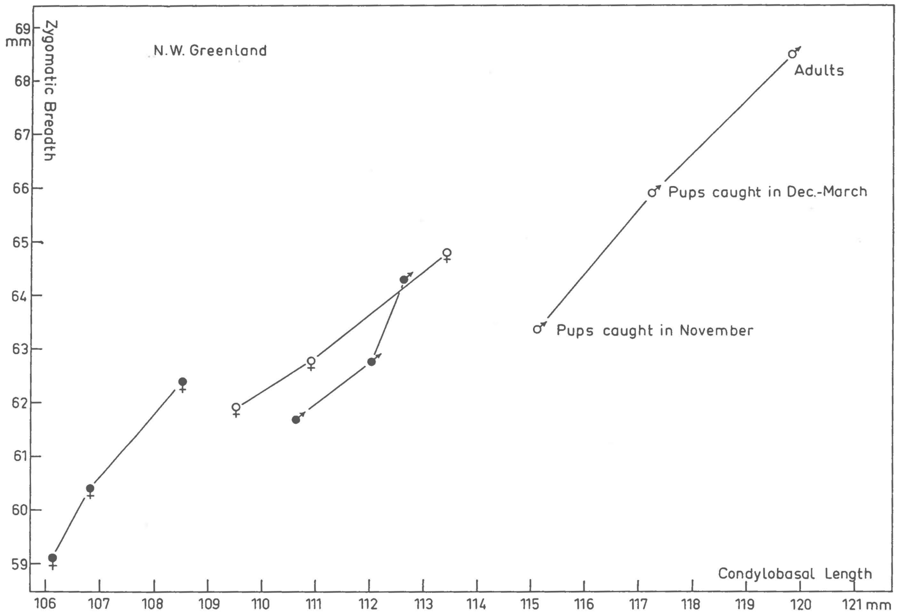



Fig. 62. Northwest Greenland (including Thule Area on map fig. 68). Numerical material in Table III p. 119.

Greenland, and the white is much larger than the white of Southwest Greenland.

It is worth noting that the white young foxes of November in Northwest Greenland are also considerably larger than the corresponding blue ones, although they must have grown up under similar ecological conditions. The difference in size in Northwest Greenland leads one to assume that we have here a white fox racially different from the small blue fox living in the same area, to which it is superior in numbers.

## Tooth Size.

The schemes fig. 63 and fig. 64 show the sum of the measurements of $P_1+P_2+P_3+P_4+M_1+M_2$ in relation to the Condylobasal Length. These measurements give the same general impression as the preceding tables. As to size of teeth, too, white and blue differ much in Northwest Greenland and are more similar in Southwest Greenland.

Among the permanent teeth, $P_2+P_3$ move into place last. Often there is not enough room for them in the jaw so that they are placed at an angle and slightly overlap each other. This happens when the growth of the cranium stops prematurely. In addition, the mutual relationship of the teeth varies somewhat, in that $P_2+P_3$ are frequently small, often, however, large in proportion to the other teeth. The measurements taken are the largest measurements of each of the teeth $P_1+P_2+P_3+P_4+M_1+M_2$ of the right upper jaw. In cases where the row of teeth has been incomplete in the right upper jaw, the teeth in the left upper jaw have been measured. By "largest measurements" are meant the length of $P_1+P_2+P_3$, diagonal measure of $P_4$ and breadth of $M_1+M_2$, see fig. 58. These measurements were chosen because in practice they are easily accessible and may be taken with great exactitude.

The mean tooth size varies with age. Presumably foxes from inland, where they are usually small, do not reach the coastal hunting grounds until late in the winter. Young coastal females from November are larger than young inland females caught in December/March, while the males apparently start roaming earlier. On an average, old foxes have larger teeth than young ones, and this is true of both males and females, blue and white, and in both districts. Consequently, a selection of large individuals with large teeth must take place.

The difference in size between young and old is greatest among the white foxes, also as far as the teeth are concerned, suggesting a tougher selection among the white than among the blue, and possibly, immigration of the white fox into both Northwest and Southwest Greenland.

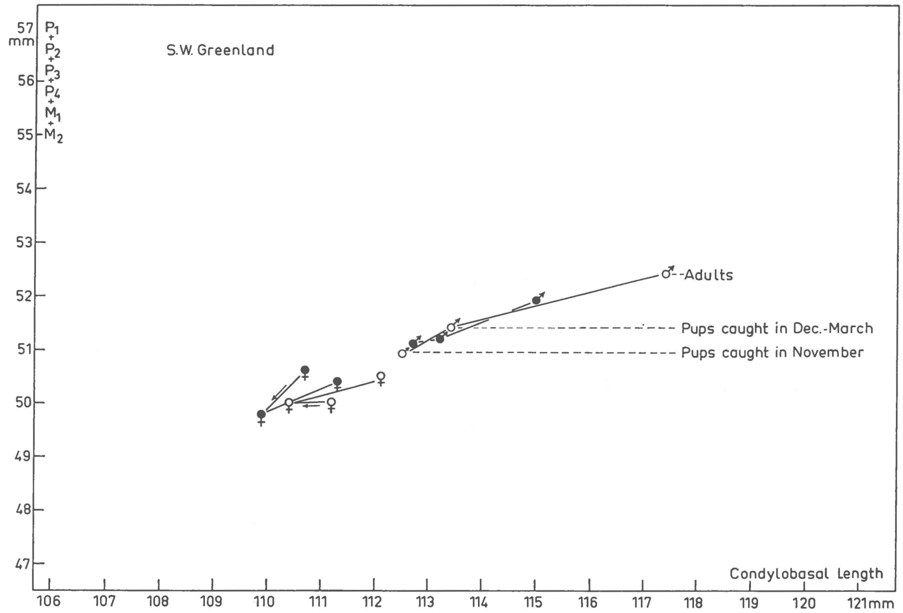



Fig. 63. Southwest Greenland (including Central West Greenland on map fig. 68). Numerical material in Table II p. 118.

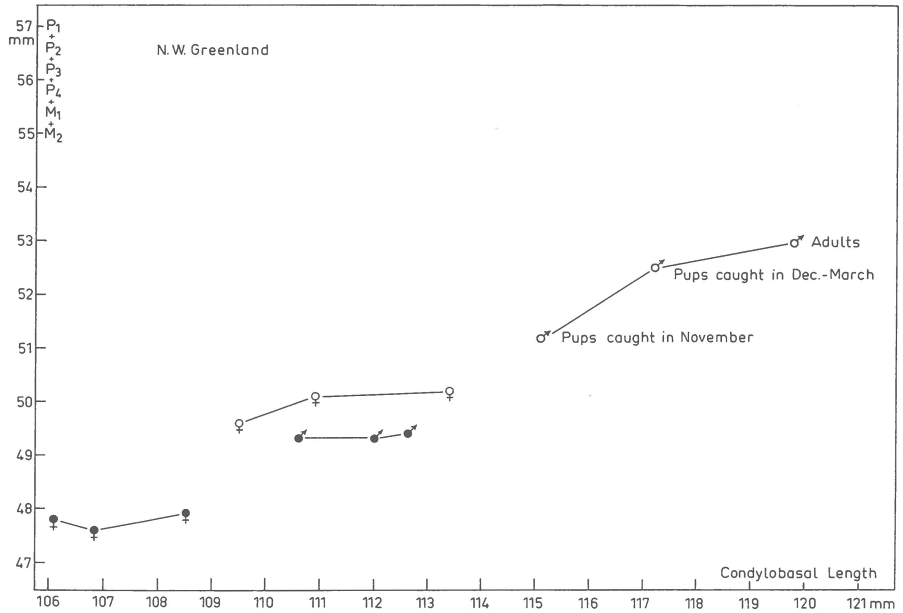



Fig. 64. Northwest Greenland (including Thule Area on map fig. 68). Numerical material in Table III p. 119.

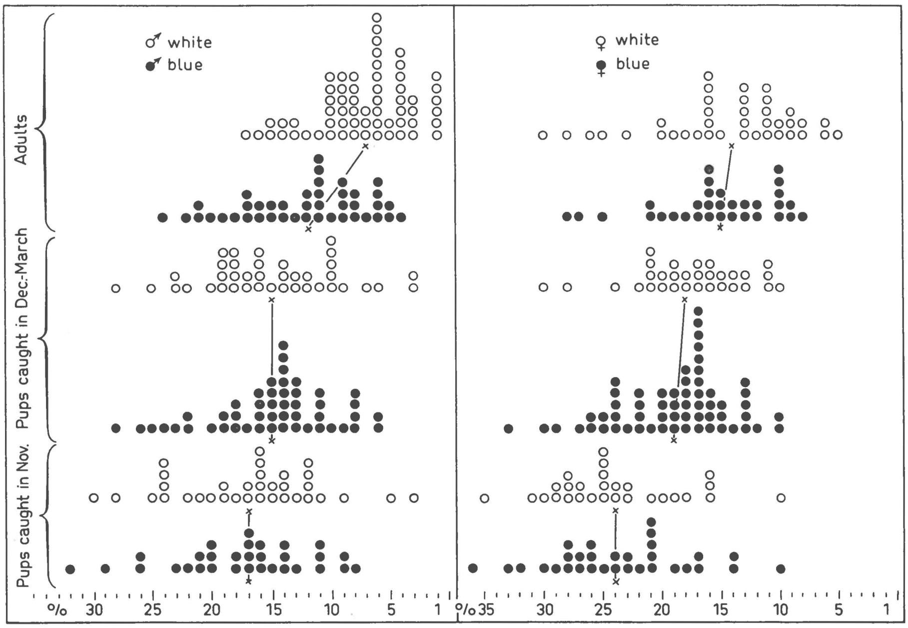



Fig. 65. Breadth of Crista sagittalis in $^0/_0$ of Zygomatic Breadth. Skulls Table III, N.W. Greenland.

## A Comparison between White and Blue Foxes of Northwest and Southwest Greenland.

One condition for comparing different populations must be that they are at the same "stage of growth", i.e., that they have matured to an equal extent at the time of collecting. In the following, therefore, all specimens with prominent juvenile features, i.e., specimens with a *Crista sagittalis* Breadth of more than 10 per cent of Zygomatic Breadth (fig. 58), are eliminated. This leaves 242 individuals, Table I bottom.

Fig. 65 shows the "stage of growth" of each specimen in Table III.

Out of 135 white males 65 are "full-grown".
– – 122 blue – 27 – – .
– – 97 white females 12 are "full-grown".
– – 123 blue – 11 – – .

It will be seen from fig. 66 that the full-grown blue fox of Northwest Greenland, with regard to tooth size, lies on the average well below the blue fox of Southwest Greenland — and that in regard to Condylobasal Length, the blue fox is also considerably smaller in the north than in the south. In both districts, the measurements of the white fox are larger than those of the blue fox. In addition, it will be noticed that we meet

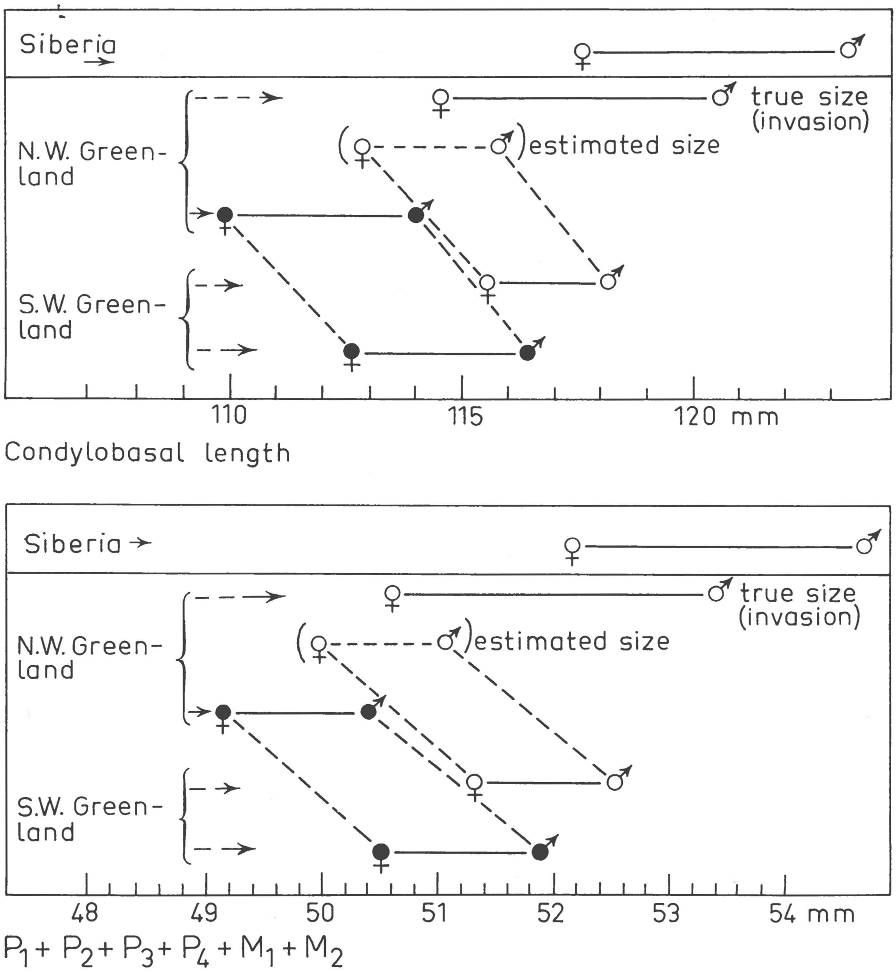



Fig. 66. Based on the numerical material in Table I bottom.

the greatest difference between female and male in Northwest Greenland, both in the size of the teeth and in the Condylobasal Length. This strongly suggests an invasion of large white foxes from a foreign biotope, especially males.

White foxes that have grown up in Northwest Greenland must be in the same size proportion to those from Southwest Greenland as the blue foxes. This is indicated in fig. 66 by "estimated size". Above this is shown the true size of white foxes found in Northwest Greenland, and at the top is shown the white tundra fox (7 females and 9 males from Siberia).

In Northwest Greenland we have a medium-sized white fox and a much smaller blue fox. The white population in Northwest Greenland is mixed with large white immigrants.

These facts support the theory that white and blue foxes are racially different, that the white fox of West Greenland has come into the country from the northwest (and northeast) and has spread out over the biotopes of the blue fox south to Southwest Greenland, and that its superiority in size may be due to constant reinforcement from the original biotope.

Even though the immigrating and breeding white foxes share the same ecological conditions as the blue foxes native to West Greenland, two populations still exist and have not merged in spite of centuries of cross-breeding.

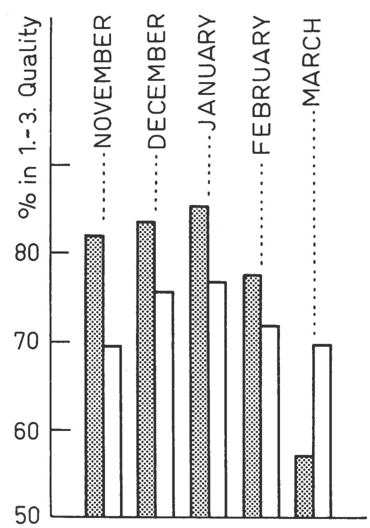
It is not difficult to recognize the invasion foxes in West Greenland: 1) They are predominantly white, as the white percentage on the tundra biotope is close to 100. 2) They are always larger than the local foxes. 3) They are predominantly adult foxes because the main emigration from Canada takes place in springs succeeding a favourable breeding season. 4) They are predominantly males, because these are more vagrant than the females.

Offspring born and growing up in Greenland must share the conditions of the blue fox, as there are no Lemmings in West Greenland. In Southwest Greenland, where growth conditions are best, the white foxes more closely approach the blue, both with regard to size and to other characteristics. Here the white percentage fluctuates the least, and here both the white and the blue foxes have had opportunities for survival through hundreds of years.

It is interesting to observe the fluctuations of the white percentage in the Godthåb district, (figs. 69 and 72). It jumped around 1840, and the white percentage thereafter fell gradually up to the present day. Around 1840, the local fox population suffered a considerable loss, simultaneously with a loss in the Eider population and with great advances of drift-ice late in summer. Inland, the climate was stable, the Reindeer population increased, and the white inland fox as well was able to hold its own. It took the blue fox 100 years to regain the terrain lost to the white fox.

The blue Arctic Fox of Northwest Greenland is the smallest of all the blue Arctic Foxes in existence. This small blue fox is particularly linked to the Little-Auk breeding places of the Thule district, where there is plenty of food in the summer, but where, on the other hand, the coasts freeze up quickly in the fall and heavy cold sets in early. It has therefore based its existence on fast growth in size and early growth of winter fur. Toward the south it is found to and including Disko Bugt, where in the summer sea birds are a part of its nutrition. In the winter, in all areas, it must turn to the tidal zone of the coast where a little food is always to be found at ebb tide. The meat depots and flensing places of the Greenlanders on the sea ice also play a rôle here, and to some extent, the mountain berries.

In Southwest Greenland lives a somewhat larger blue fox which in its breeding season is predominantly linked to the tidal zone of the coast, while in fall and winter it also turns to the mountain berries and wintering sea birds. Its growth period is somewhat longer than in the north, but even so, not long enough for a full and harmonious growth.




Total:

| | | | | | |
|---|---|---|---|---|---|
| Number blue : | 2017 | 946 | 449 | 697 | 387 |
| Number white: | 1092 | 517 | 297 | 479 | 285 |
| % of white : | 35 | 28 | 40 | 41 | 42 |

Fig. 67. Furs of blue and white Arctic Fox purchased and sorted at Holsteinsborg to Julianehåb 1948–53.

Juvenile forms of the blue fox are caught in large numbers in both Northwest and Southwest Greenland; in Northwest Greenland this is a result of the food supply disappearing too soon because of the early winter and the sea birds leaving the cliffs, and in Southwest Greenland because of the destructive influence on the beach fauna of late summer drift-ice, which also causes the fiords to freeze up early.

In spite of scarcity of food many juvenile specimens survive in the relatively mild climate of to-day. The natural selection in the blue fox population seems to be insignificant.

Fig. 67 shows that the blue fox has the highest percentage of good furs November to January; the white fox December to February. In March the fur of the blue fox fades with the return of sunlight. The low white percentage in December may be due to a severe natural selection early in winter in the white fox population. The death-rate of small white foxes may be higher than that of small blue ones.

In **Southeast Greenland**, which is blocked by drift-ice most of the year, the Arctic Fox occurs infrequently. It is more common a little further north around Scoresby Sund, where Brünnich's Guillemot and Little Auk are found, as well as Lemmings. Both blue and white foxes occur over the entire stretch of coast from Kap Farvel to Scoresby Sund. As a rule, the white is usually large, and the blue small. Of a total of 117 skulls from this stretch of coast, only 20 were full-grown. Unfortunately, the cranium material from this area is insufficiently labeled as to sex and colour, but there is hardly any doubt that the most full-grown foxes are white immigrants from the Lemming-biotope north of Scoresby Sund.

Conditions are very reminiscent of Northwest Greenland, which also has many immigrant white foxes. Scoresby Sund is at the moment a typical area with a mixed population. More clearly defined are the conditions in North-east and North Greenland, between Scoresby Sund and Kane Bassin. This area is populated by Lemming, and the white Tundra Fox is clearly predominant. It has an almost unbroken extension from Siberia through Arctic North America and Northeast Greenland.

### The White Arctic Fox or the Tundra Fox in Greenland.

The Tundra Fox has the same breeding area in Greenland as the Lemming, *Dicrostonyx groenlandicus* TRAIL, i.e., North and Northeast Greenland, from Washington Land via Peary Land to somewhat south of Scoresby Sund. Both have come from Ellesmere Island to North Greenland across Nares Sound, where the solid winter ice has provided a convenient immigration road. The Lemming has not as yet been able to advance south of Kane Bassin, where the Inglefield Land of today would provide an excellent biotope for it. It may have been prevented in coming here by geographic factors, in that Humboldt Bræ is nearly 100 km wide, apparently a greater distance than the Lemming has been able to overcome. Climatic conditions may also have been a hindrance in the past.

In Southeast Greenland, on the other hand, we know that the Lemming has been stopped by climatic factors; the coast there is not only characterized by an unstable winter climate with frequently recurring thaw in the middle of winter and subsequent ice cover over the country, but also by cold, humid summers. The Hare, too, is absent on this coast, and the population of Arctic Fox is sparse. M. DEGERBØL (1937) did not find the Hare south of latitude 68°45′N or the Collared Lemming south of latitude 69° N.

The first direct studies we have of the Tundra Fox in Greenland were made by A. L. V. MANNICHE during the Danmark Expedition.

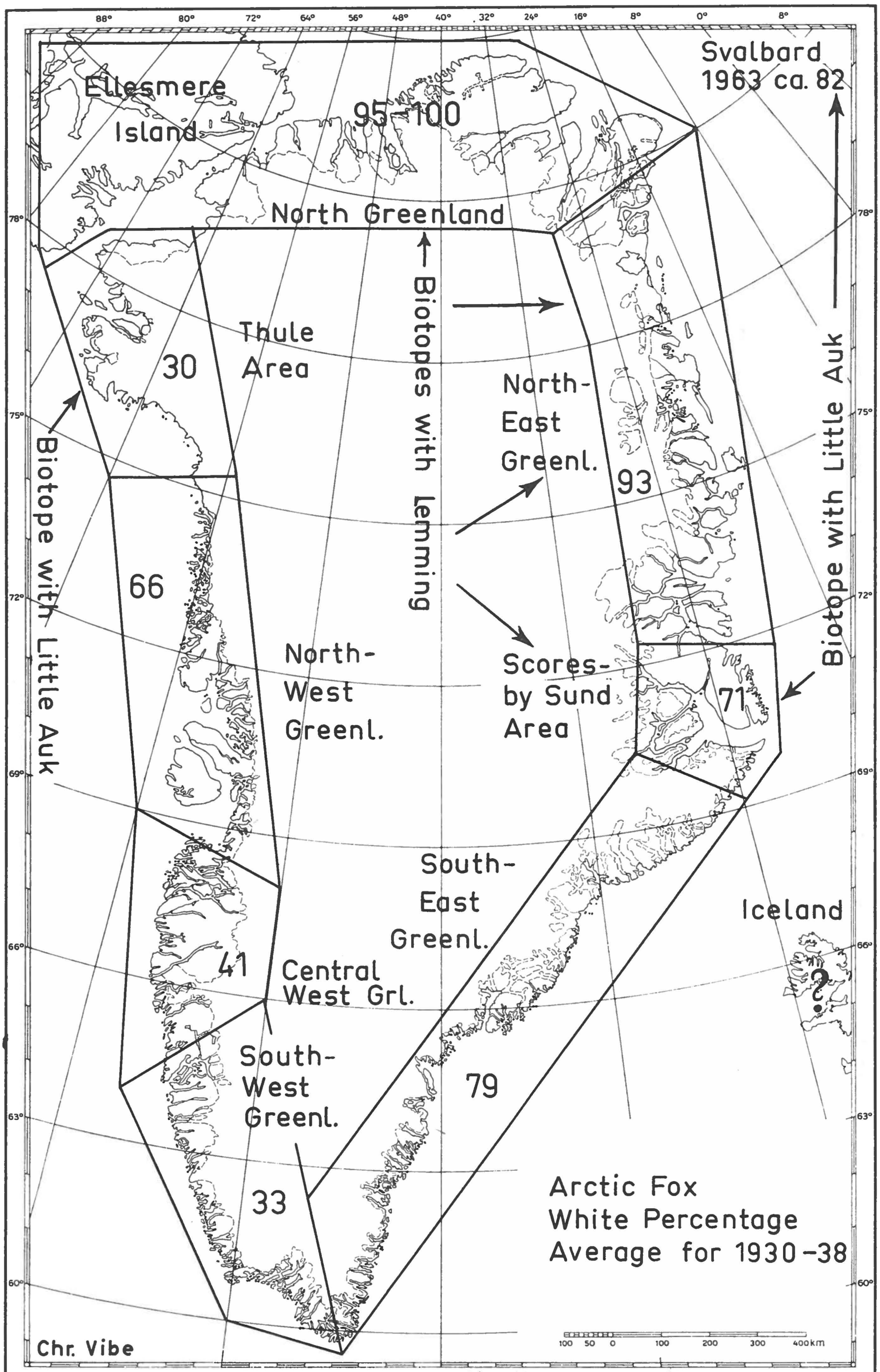



Fig. 68. Map showing the white percentage in the populations of Arctic Fox in different areas. Figures for Ellesmere Island and North Greenland are estimated.

MANNICHE stayed at Danmarks Havn in Northeast Greenland from the summer of 1906 through the summer of 1908. During this expedition, 76 foxes with pure winter coats were caught. Of these, 45 were white and 31 blue, i.e., a white percentage of 59.4.

Since the Danmark Expedition the white percentage has risen gradually. J. G. JENNOV (1945) gives the following summary calculated from results of hunters' activities and of expeditions:

| | | | | | |
|---|---|---|---|---|---|
| "1906–08 | (Danmark-Expeditionen) | white | percentage | appr. | 60 |
| 1908–10 | (2 Norwegian hunting expeditions) | — | — | — | 69 |
| 1919–24 | (Østgrønlandsk Kompagni) | — | — | — | 82 |
| 1922–23 | (Anni-Expeditionen) | — | — | — | 81.4 |
| 1926–30 | (Various Norwegian hunting operations) | — | — | — | 90.5 |
| 1929–38 | (Østgrønlandsk Fangstkompagni Nanok) | — | — | — | 92.5" |

This considerable rise in the white percentage of Northeast Greenland has rightly provoked a great deal of attention, especially since the white percentage has risen at the same time in Northwest Greenland and other places., see fig. 78, Upernavik.

The blue fox living in Northeast Greenland at the time of the Danmark Expedition was equal in size to the white fox — or bigger.

The presence of large blue foxes in Northeast Greenland is most easily explained by assuming that the coastal biotope was previously much larger, extending as far as the Arctic Ocean, and more productive. The Greenland Whale and the Walrus were once very numerous. When they decreased on the shores of Northeast Greenland, a principal winter food supply of the blue fox (stranded carcasses) was also closed.

The question must, however, also be seen in relation to decreasing movements of the drift-ice in the Greenland Sea late in summer (and winter), and to a reduction in precipitation after 1900. This made the autumn and winter climate more stable and gave the Lemming better conditions in the continental Arctic area. The white Tundra Fox increased in number and, via inland ice and drift-ice, the surplus spread out over the adjacent coastal biotopes. At the same time as the white percentage rose, the average size went down. Numerous individuals with juvenile features survived. This may suggest that conditions on the tundra improved and that the natural selection became less severe.

The favourable climate on the tundra after 1900 caused the white Tundra Fox to continue appearing in West Greenland. It used several routes of immigration (as shown by BRAESTRUP 1941), i.e.: 1) the drift-ice from Baffin Island via Davis Strait to the central parts of West Greenland, 2) the drift-ice from Northeast Greenland, around Kap Farvel to the Julianehåb district, 3) the sea ice from Ellesmere Island and Washington Land to nearby Thule district, and 4) the ice cap from East to West Greenland — used by a rather small number.

White foxes have in several cases been encountered on the ice cap (J. P. Koch, cited by Braestrup 1941). American officers have told the present author that white foxes often visited weather stations on the ice cap, and in 1950 about 15 white foxes were observed at the Victor ice cap station (J. N. Malaurie, personal communication).

It is probable that the white foxes seen on the ice cap came from Northeast Greenland, but no proof is available. However, cranium measurements of white foxes of Northwest Greenland prove that a good many of these can *not* have grown up there, but must have immigrated from biotopes with Lemmings. They may have come from Baffin Island, 300–600 km away across the Baffin Bay Ice, but they may also have come from Northeast Greenland, 700–800 km distance across the inland ice. How many get across alive must depend on the size of the population in Northeast Greenland and precipitation on the ice cap.

When, in 1955, the author asked udstedsbestyrer (settlement manager) Fritz Fencker at Claushavn in Disko Bugt where the big white foxes were caught, he answered: "The biggest white foxes are caught in Tulivkatlandet (the Tulivkat area), where they are said to come from the ice cap. They are big, old, white, and wonderfully white in the fur. They are caught in November. The first blue foxes caught are also big, and their fur is lighter than usual. Later in the year and in the spring, both white and blue foxes are smaller, and the blue are darker in the fur. Grey bastards also occur in the district. Fox hunters from Egedesminde think, moreover, that they can tell the difference between the white foxes that have come across the drift-ice from the west and those that have come across the ice cap from the east, the former coming later when the Baffin Bay Ice drifts close to shore in December-January. Their fur is thinner under the belly because they often have to swim through new ice, and they often have yellow spots of blubber in the fur because they eat carrion or seal blubber from the meals of the Polar Bear".

Fencker's statement suggests that the white fox of Northeast Greenland reaches Northwest Greenland early in the fall. The same is true of the big white foxes that arrive in the Thule district where they are seen at the heads of the fiords in October (see p. 132). These foxes, then, must have started their migration at a time when they were in good condition after the summer, while the foxes from the west had probably gone hungry for some time before the ice formed a bridge across Baffin Bay, allowing them to reach Greenland.

K. Faester (1945) assumes that the increase in percentage of "summer skins" between 1929 and 1938 was due to the milder climate.

The explanation seems to be that the death-rate was lower than usual owing to the mild winters. Normally foxes with poor furs die early in winter.

F. W. BRAESTRUP has described in detail the occurrence of "mad foxes" in West Greenland and connected these with the immigration of white fox. The present author has frequently heard Greenlandic hunters tell of mad foxes, which may be either white or blue. According to fox hunter AKVILAS LUNDBLAD from Kangâtsiaq, mad foxes were particularly frequent during the years 1925–30, a period of above average fox catches all over West Greenland and with maximum white percentage in Northwest Greenland. Mad foxes never yield good furs, thus they are simply tied to a stone and lowered into the sea.

As also pointed out by BRAESTRUP, after approximately 1900 the invasion into Northwest Greenland has been rather considerable. The large white invasion foxes are easily recognizable in the hunting bags. During the years 1939–41, the present author stayed in the Thule district and had occasion to observe this invasion directly. In the inner areas of Inglefield Bredning the invasion foxes appeared as early as the last half of October. Here, presumably, foxes from Washington Land were involved. Later in the winter, February–March, a larger invasion arrived at the outer shore, having travelled directly across the ice from Ellesmere Island. During sledding trips to Ellesmere Island in the spring of 1940, fox tracks were seen all over the ice, and a single white fox was observed on the sea ice near Ellesmere Island. Bear tracks were always accompanied by fox tracks. West of Ellesmere Land a white Tundra Fox was found killed by Wolf.

The Polar Eskimos were well acquainted with these invasions and called the big white foxes "Canada Foxes", as distinct from their own "foxes from the land of the humans".

In May-June 1941, the author undertook a trip to Washington Land north of Kane Bassin. South of this bay the Lemming is not found, while it is common in Washington Land. Although it was not directly observed on this occasion, its excrement was seen in the passages of many ground caves. The Eskimos were completely familiar with the existence of the Lemming there. Fox tracks were seen on the sea ice between Inglefield Land and Washington Land.

It has further been proved by BRAESTRUP (1941, p. 24) that the catches of the white fox in the Thule and Upernavik districts reach a climax approximately every four years, corresponding to the white fox in a typical Lemming area. From Upernavik, the invasion foxes migrate southward during the same and following years. They consist predominantly of old males, but females and young foxes may also occur. They breed in favourable years and may mate with the local blue and white

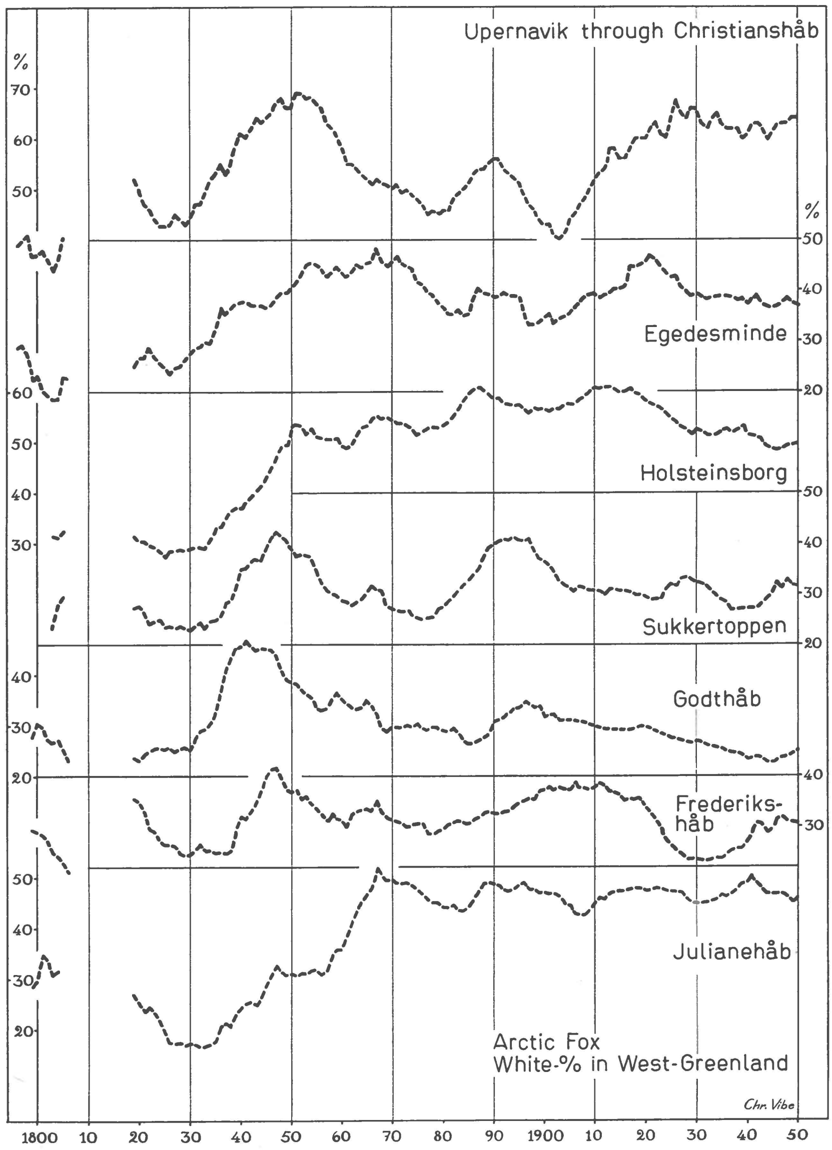



Fig. 69. The fluctuations in white percentage in West Greenland, in 10-year sliding averages.

foxes. In the autumn after a spring invasion of white foxes grey-coloured individuals occur. The young, as a rule, grow into smaller and weaker individuals than the parent white Tundra Foxes. Without Lemmings, these large foxes are in a difficult situation; the growth season in West Greenland is too short, thus they do not become fully grown and do not attain a full growth of winter fur as early as the blue fox does.

## The Quantitative Fluctuations of the Arctic Fox in Greenland.

As the work of analyzing the quantitative fluctuations of the game populations of Greenland has proceeded, the author has been faced with many new problems, which have increased in number each time an old problem has been solved. It is not possible to explain game fluctuations simply as the result of varying persecution by Man or beasts of prey. In the case of some species, e.g., Ptarmigan and Arctic Fox, the present amount of predation plays no rôle in the fluctuations of population. In both of these animals, the breeding activities are spread out over very large areas where they are rarely disturbed by Man. In 1912, the land council of South Greenland (Sydgrønlands landsråd) decided to preserve the Arctic Fox from April 15th to October 1st, and in 1913, the land council of North Greenland (Nordgrønlands landsråd) did the same. During the subsequent 30 years, the average catch was considerably larger than during a corresponding period before the preservation; however, the reason for this may equally well be ascribed to the general climatic improvement which started in 1920. After 1940, the fox catch dropped to the same level as before the introduction of preservation. Ptarmigan were preserved in 1924 from May to August 15th in the area south of Nordre Strømfjord, but not farther north. During the great Ptarmigan years which started around 1948, these birds were very numerous all over West Greenland, and subsequently decreased in number throughout the whole area. F. W. BRAESTRUP (1941, p. 74) shows that the Ptarmigan population has always been subject to great fluctuations. Preservation has not altered this situation, see further p. 150–52.

F. W. BRAESTRUP also discusses a number of factors that are considered to have an influence on the quantitative fluctuations of the Arctic Fox in Greenland. It is not possible to point to definite factors that are solely responsible. The Arctic Fox is most versatile in its choice of food, but the "food", too, is dependent on the climate.

The Arctic Fox curves figs. 70–76 show three periods of increasing catches (1830, 1875, and 1930) along the west coast from Julianehåb to Disko Bugt. Actual increases in population must have occurred here as the greater catches involve all districts and both blue and white fox. The two latter periods, from which temperature observations are available, show a simultaneous increase in spring temperature at the stations of Godthåb, Jakobshavn and Upernavik. We may conclude from this that the increase in catch is favoured by a milder climate during the breeding season. Presumably the cold Canadian Current had little extension towards West Greenland during the critical season.

Somewhat different was the state of affairs around 1850 and 1920, when great catches were made in the southern districts while the north-

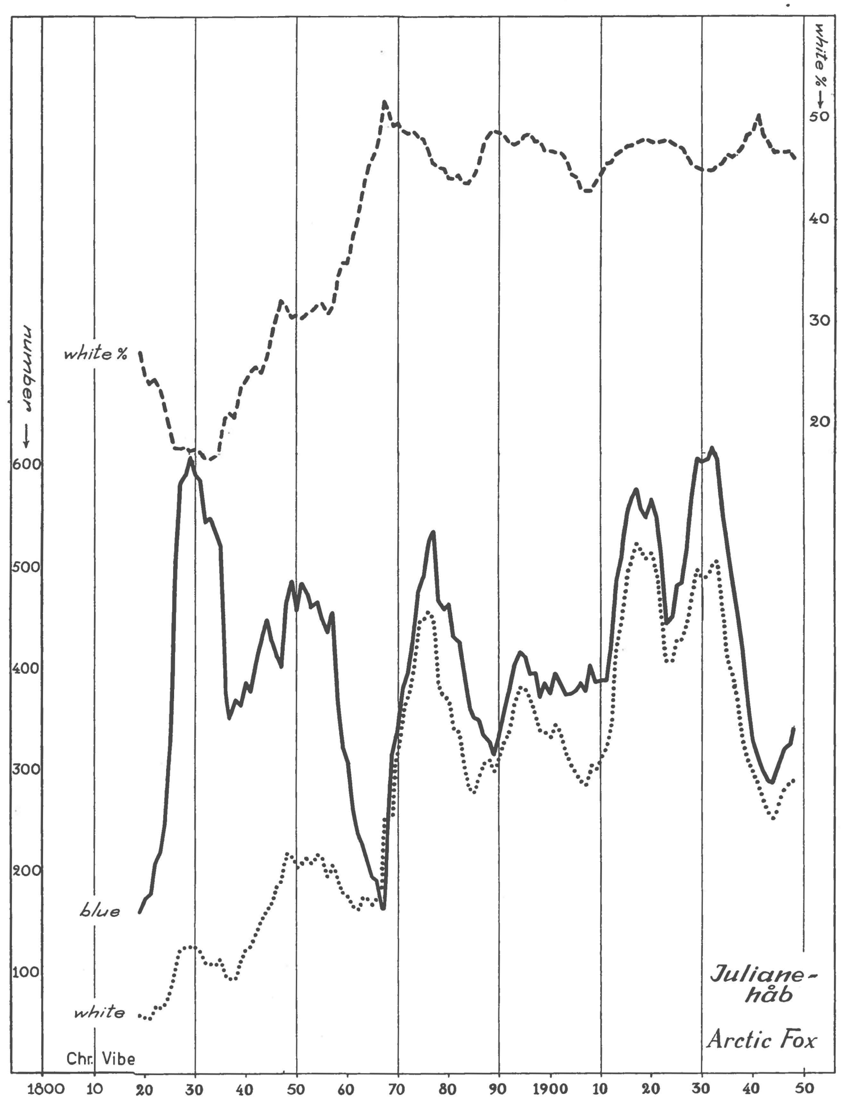



Fig. 70. Furs of blue and white Arctic Fox purchased in the Julianehåb district by The Royal Greenland Trade Department, in 10-year sliding averages.

ern districts showed minima, which indicates that the Canadian Current then had a large extension towards northern West Greenland during the critical season. The climate was relatively dry and the white percentage rose, indicating that a dry climate is more important for the white than for the blue fox. From the records of sea bird feathers and Eider skin rugs we can see that the bird bags increased in Southwest Greenland, too, during the cold period 1920, as the sea birds then wintered farther south. We therefore cannot eliminate the possibility that the great fox


Fig. 71. Furs of blue and white Arctic Fox purchased in the Frederikshåb district by the Royal Greenland Trade Department, in 10-year sliding averages.

catches during the cold periods of Southwest Greenland may be due to the presence of many sea birds. L. LAMBERTH has informed the author that his experiences at the farm in Godthåb show that during the years with few sea birds the blue fox litters were small and barrenness was frequent, while the white fox was usually less affected.

Although the mild climate culminated in southern West Greenland around 1930, the peak was not manifested in Northwest Greenland until around 1940. The great catches of blue fox at Godhavn, fig. 74, northern Disko Bugt, fig. 75, and Thule, fig. 80, and of sea birds at Upernavik (summer catches), fig. 31, all indicate this.

It should be further mentioned that the peak of the mild period in northern Davis Strait at the beginning of the last century was around 1840, when the catches of blue fox culminated at Egedesminde, fig. 74, while the peak further south occurred as early as 1830, fig. 72. The simultaneous expansion of drift-ice in the southern part of Davis Strait (late summer, 1840) had a disastrous effect on the beach fauna there. Even more catastrophic was the effect of the drift-ice around 1867 when the blue fox population decreased to a minimum in the south,

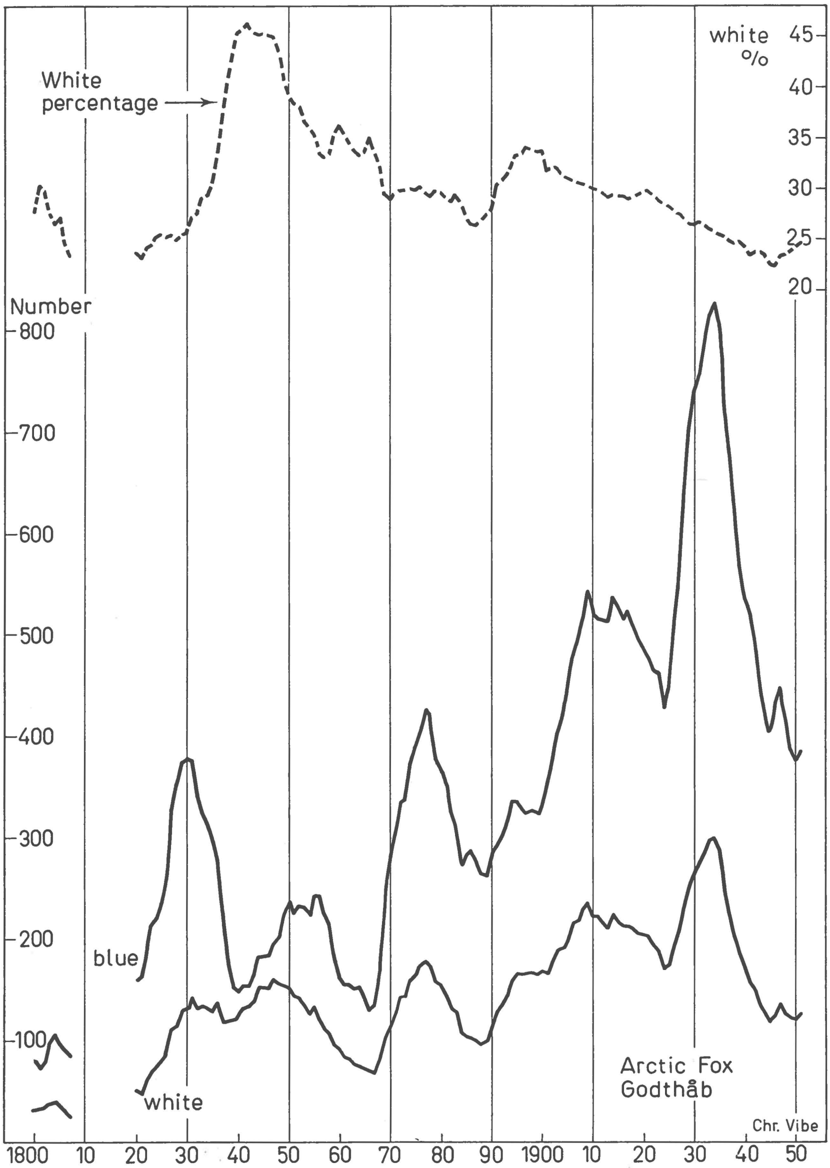



Fig. 72. Furs of blue and white Arctic Fox purchased in the Godthåb district by the Royal Greenland Trade Department, in 10-year sliding averages.

fig. 72. At the same time, the blue fox reached a maximum in Upernavik, fig. 78, approx. 11 years—or one sun-spot cycle—later than in Southwest Greenland.

Also the white foxes suffered losses in Southwest Greenland around 1867, but being more robust and more closely linked to the inland, their

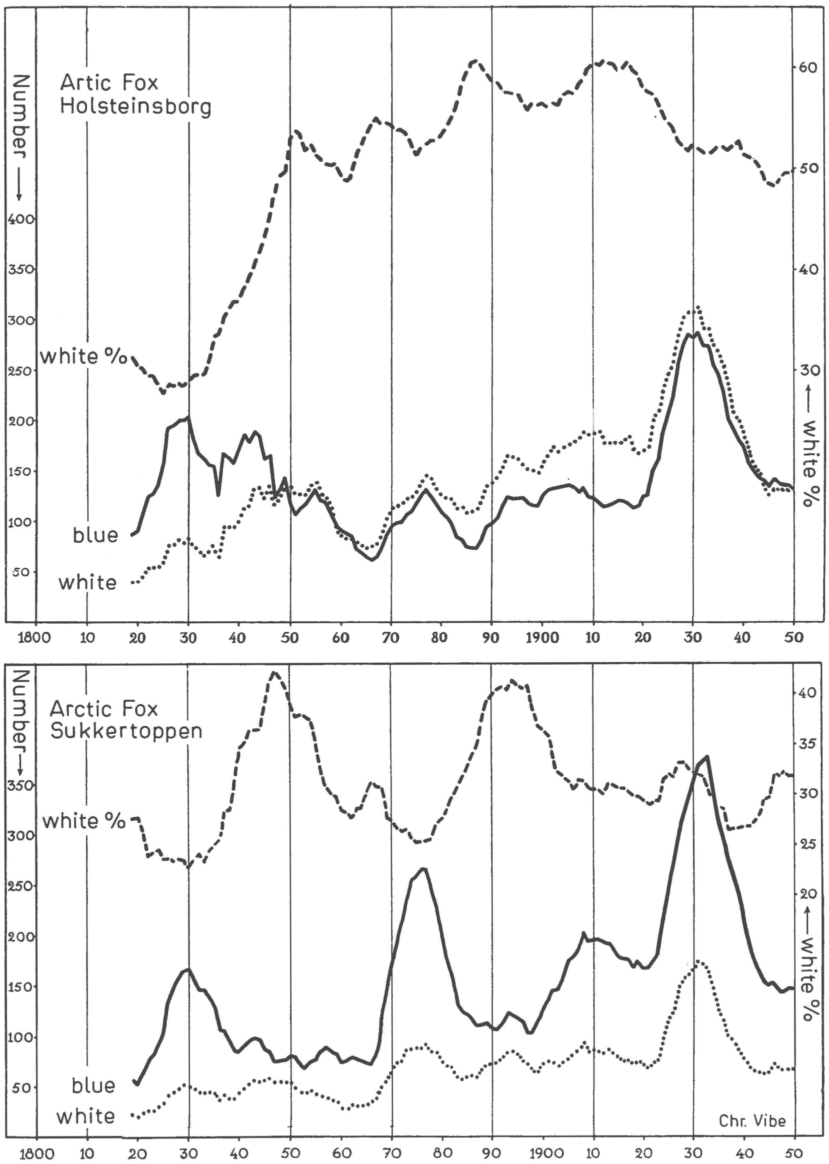



Fig. 73. Furs of blue and white Arctic Fox purchased in the Sukkertoppen and Holsteinsborg districts by The Royal Greenland Trade Department, in 10-year sliding averages.

decrease was comparatively smaller than that of the blue. Thus the white percentage actually rose.

In the Disko Bugt area the blue Arctic Fox seems to profit by a high spring temperature. Simultaneously the catch of *Mallotus villosus* culminates, figs. 76 and 82.

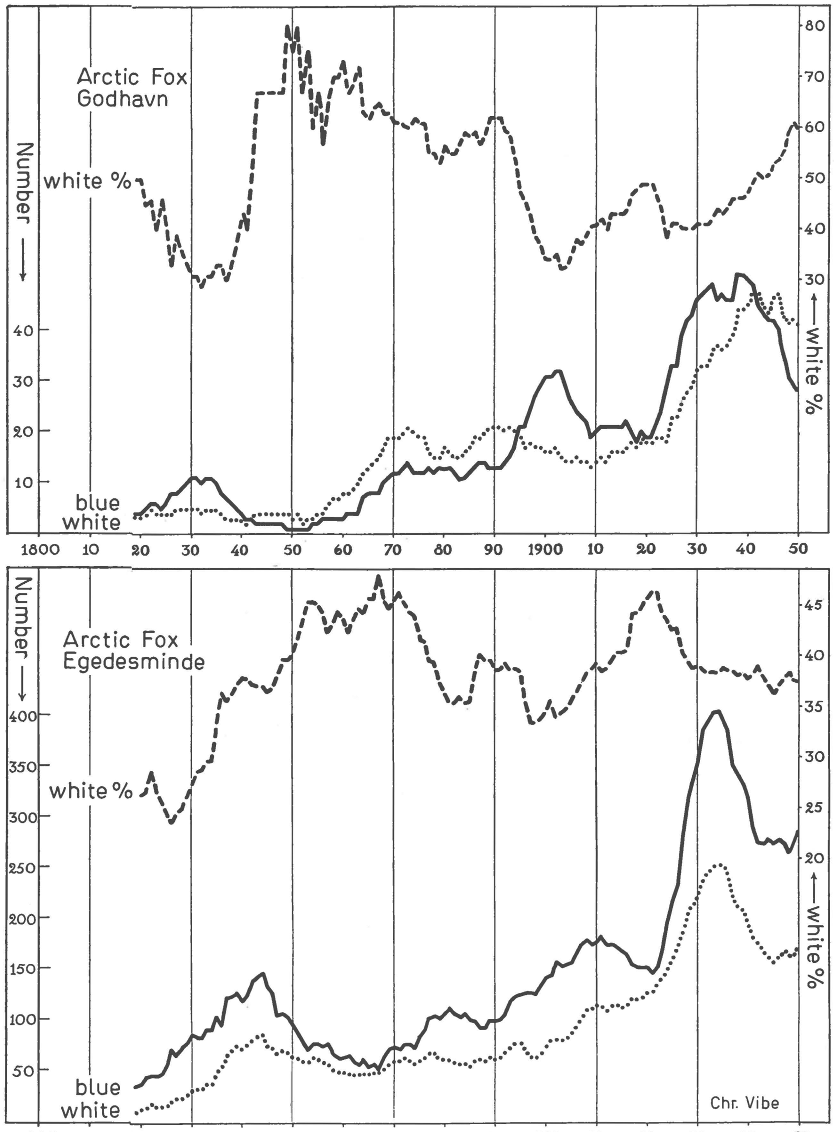



Fig. 74. Furs of blue and white Arctic Fox purchased in the Egedesminde and Godhavn districts by The Royal Greenland Trade Department, in 10-year sliding averages.

During the "drift-ice pulsation stage" after 1860 the increase in the blue Arctic Fox population in Disko Bugt is greatest in the northern part of the bay. The northward move of the production area in Disko Bugt may be due to a shift in prevailing currents and winds, fig. 77. A comparison with the sea bird feather curve, fig. 30, shows that the

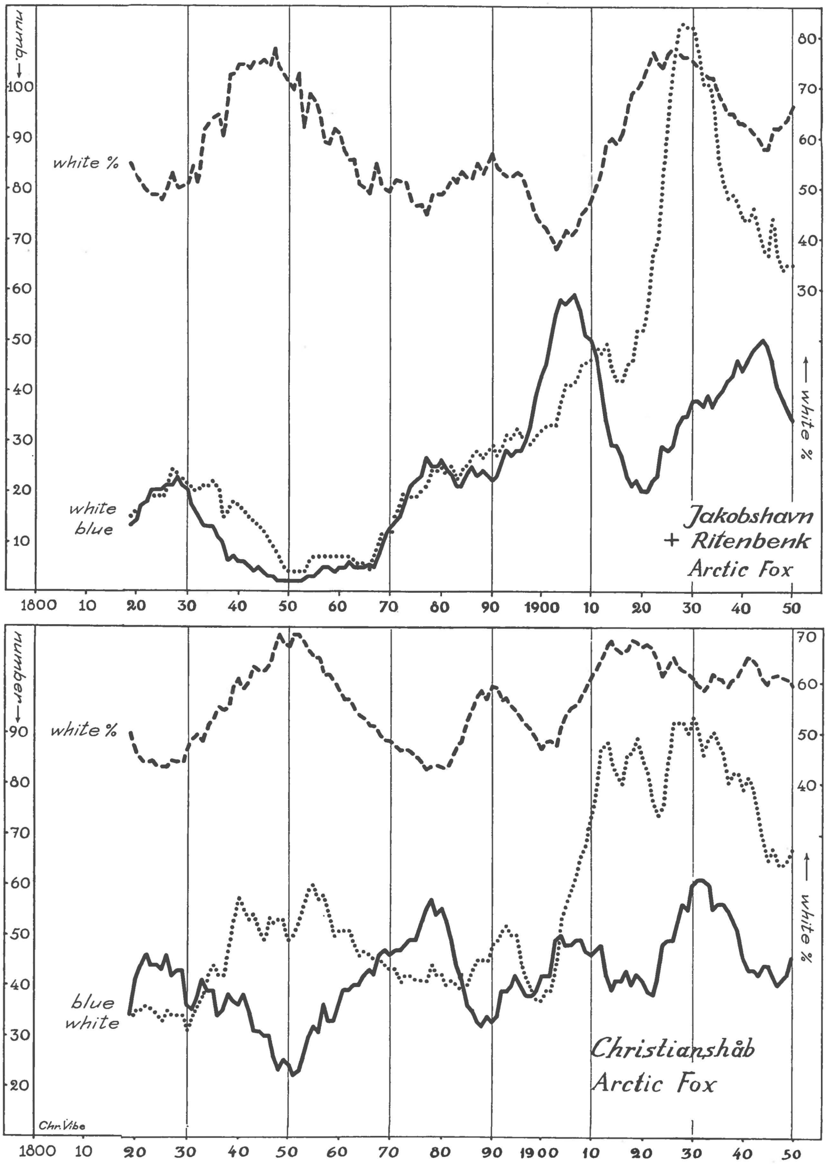



Fig. 75. Furs of blue and white Arctic Fox purchased in the Disko Bugt districts by The Royal Greenland Trade Department, in 10-year sliding averages.

bird catches in northwestern Greenland fluctuate in the same way as the blue fox catches in northern Disko Bugt.

In Northwest Greenland, the fluctuations in white percentage are unlike those of Southwest Greenland. At Upernavik, fig. 78, a distinct increase in the white fox population is noted for 1930 when the blue

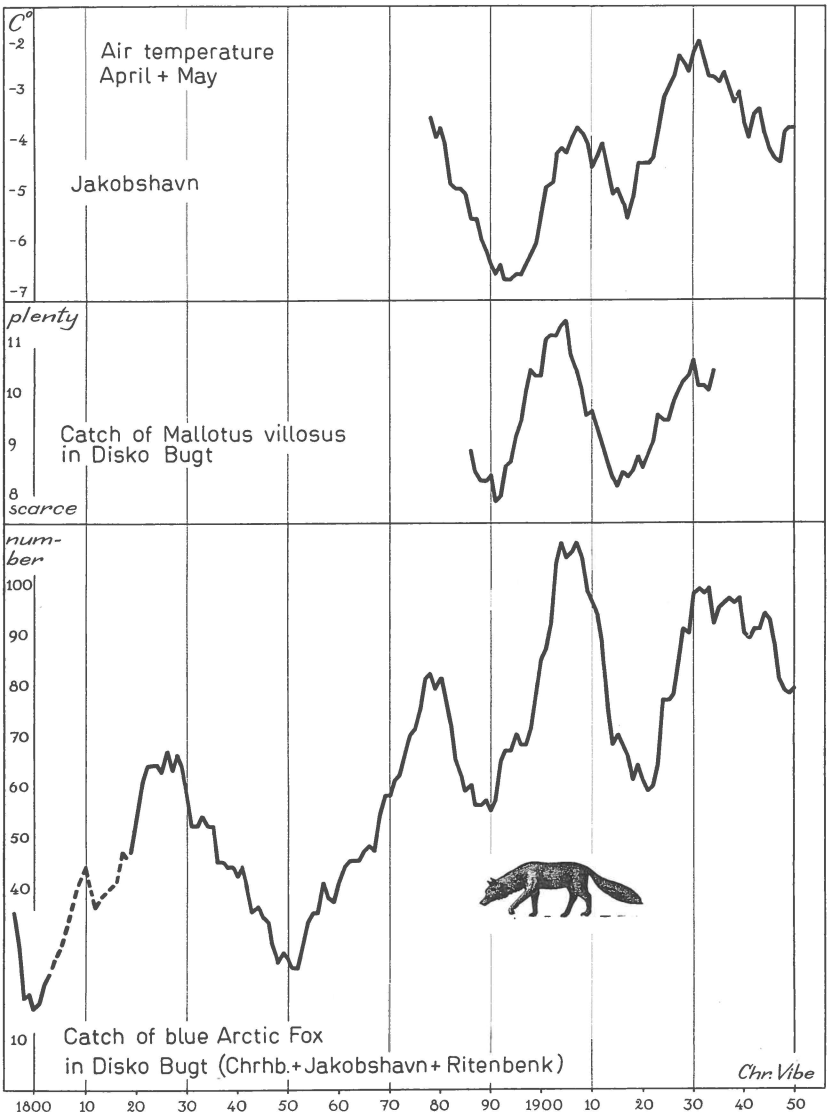



Fig. 76. Curves in 10-year sliding averages. The size of the catch of *Mallotus villosus* is determined from statements in the colonial reports to the Royal Greenland Trade Department (extremely scarce = 0–3, scarce = 3–6, normal = 6–9, plentiful = 9–12).

fox is on the decline. This must be due to immigration from tundra biotopes outside Greenland.

As Northwest Greenland presumably gets the greater part of its immigrant white foxes from Arctic Canada, the catch in Canada deserves some attention. In fig. 79 the top curve shows the catch of white fox

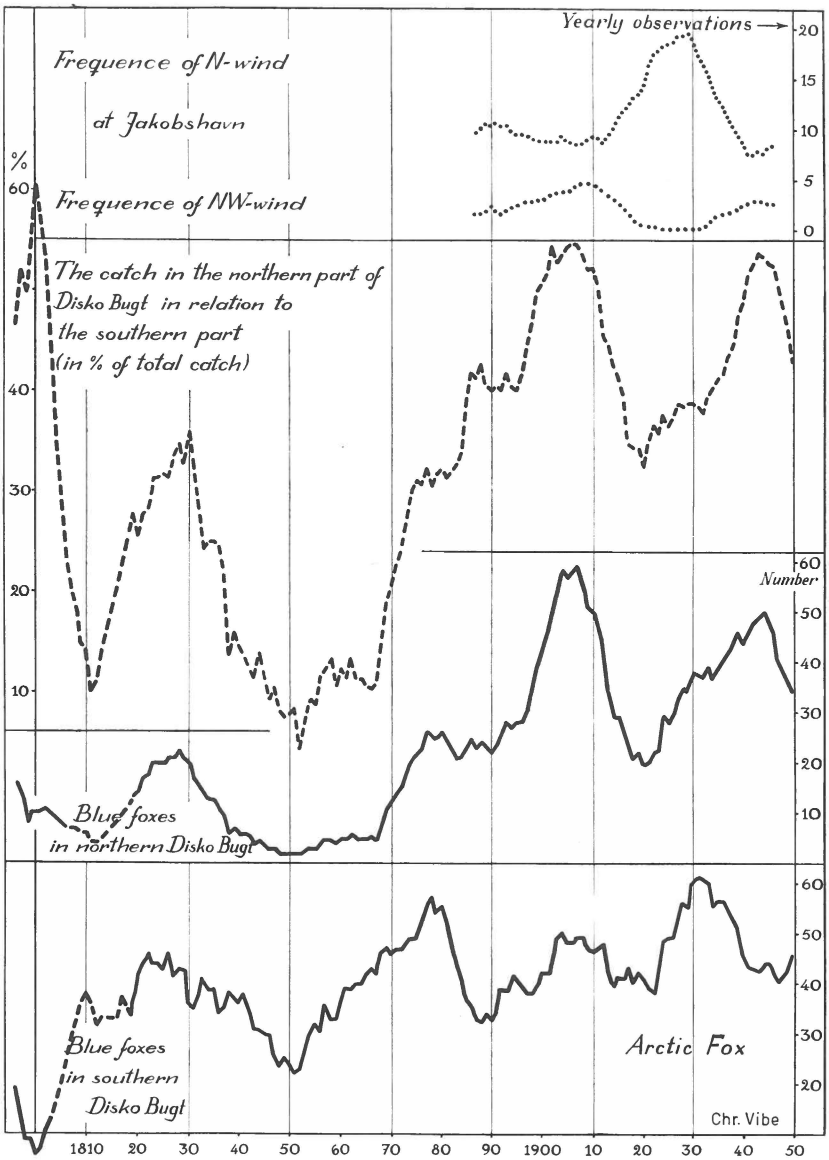



Fig. 77. Curves in 10-year sliding averages.

(plus a few blue ones)[1]) in Labrador, and below this is shown the catch of white fox at Upernavik. The Labrador statistics up to 1925 have been published by C. ELTON (1942), and the Hudson Bay Company has been kind enough to give the figures for the years 1926 to 1955.

[1]) According to ELTON (1942) and FETHERSTON (1947) the white percentage of the Arctic Fox in northern Labrador averaged 98,8 % during the period 1834–1923.

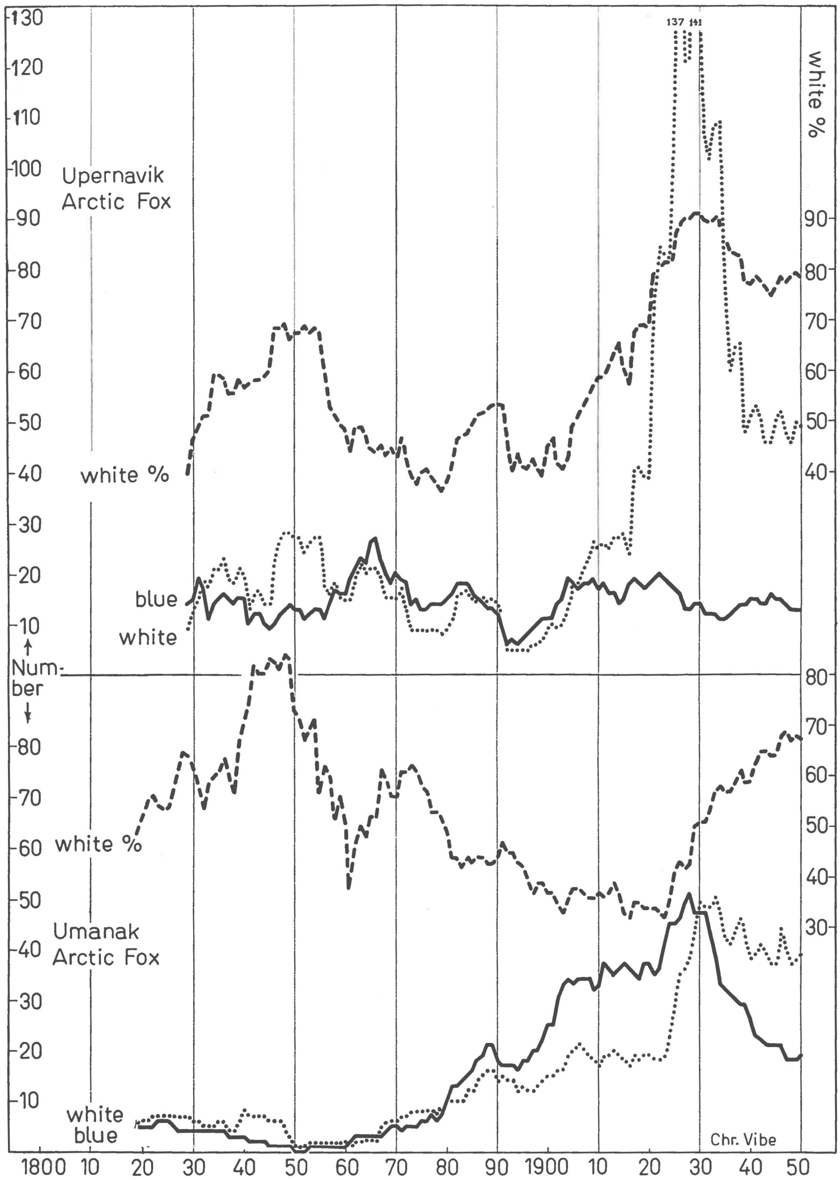



Fig. 78. Furs of blue and white Arctic Fox purchased in the Umanak and Upernavik districts by the Royal Greenland Trade Department, in 10-year sliding averages.

The agreement between these two curves suggests that a uniform climate prevails over large parts of the eastern Canadian Arctic and Northwest Greenland. A comparison with the precipitation curve for Upernavik (third curve from the top) shows that there are good fox catches in years with low precipitation, probably because the Lemming has its best breeding and wintering conditions during dry summers and winters.

In West Greenland, as one moves south from Upernavik the precipitation picture changes until at Ivigtut it is very nearly the opposite of that of Upernavik (see fourth curve from the top). Thus north and west of Baffin Bay the population curve of the Tundra Fox, which prefers a dry climate, alternates with the precipitation curve of Upernavik. South of Disko Bugt the population curve alternates with the precipitation curve of Ivigtut. See also the Reindeer curve, fig. 94.

In the central parts of western Greenland, however, the white fox is under the influence of the climate of both areas, so that in Christianshåb, curves of white fox catches reach a peak in years when there is low precipitation in either the northern or the southern part.

With this in mind, we can see why the fluctuations in white percentage are opposite in Northwest and Southwest Greenland (see fig. 80; top two curves show the fluctuations in white percentage at Upernavik and Julianehåb, respectively).

Thus, in all areas the white fox obtains the greatest advantage from a continental climate. In Greenland it prefers inland biotopes, but in the winter it must move to the coast in order to survive. Once there, it shares the conditions of and interbreeds with the blue fox.

The curves in fig. 80 show that the white percentage at Julianehåb parallels the August drift-ice, which has its greatest extension in Davis Strait during years with relatively dry winters in Southwest Greenland, fig. 22.

The fox curve for Labrador (fig. 80 bottom) alternates with the August drift-ice in Davis Strait, and thus also alternates with the white percentage at Julianehåb.

The blue fox, on the other hand, obtains most of its food along the shore and thus benefits from a climate with relatively mild winters and long seasons with open water.

In fig. 81 the black columns show the areas of West Greenland where the blue fox population is relatively great or shows a maximum in the periods with sun-spot minima. It is seen that the productive area

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Fig. 79. Fluctuations in catches of white foxes in Labrador, Upernavik and Christianshåb and in number of yearly days with precipitation at Upernavik and Ivigtut. All curves in 3-year sliding averages. The catch is entered for the year when the skins were shipped home. As the hunt takes place in winter, most of the furs are from foxes born during the preceding summer. In some years, the ship may have stayed away from some of the settlements. The skins were then brought home in the succeeding year. The numerical material for the Labrador fox curve has been made available through the courtesy of C. E. Elton, A. W. F. Banfield and Leslie M. Tuck.

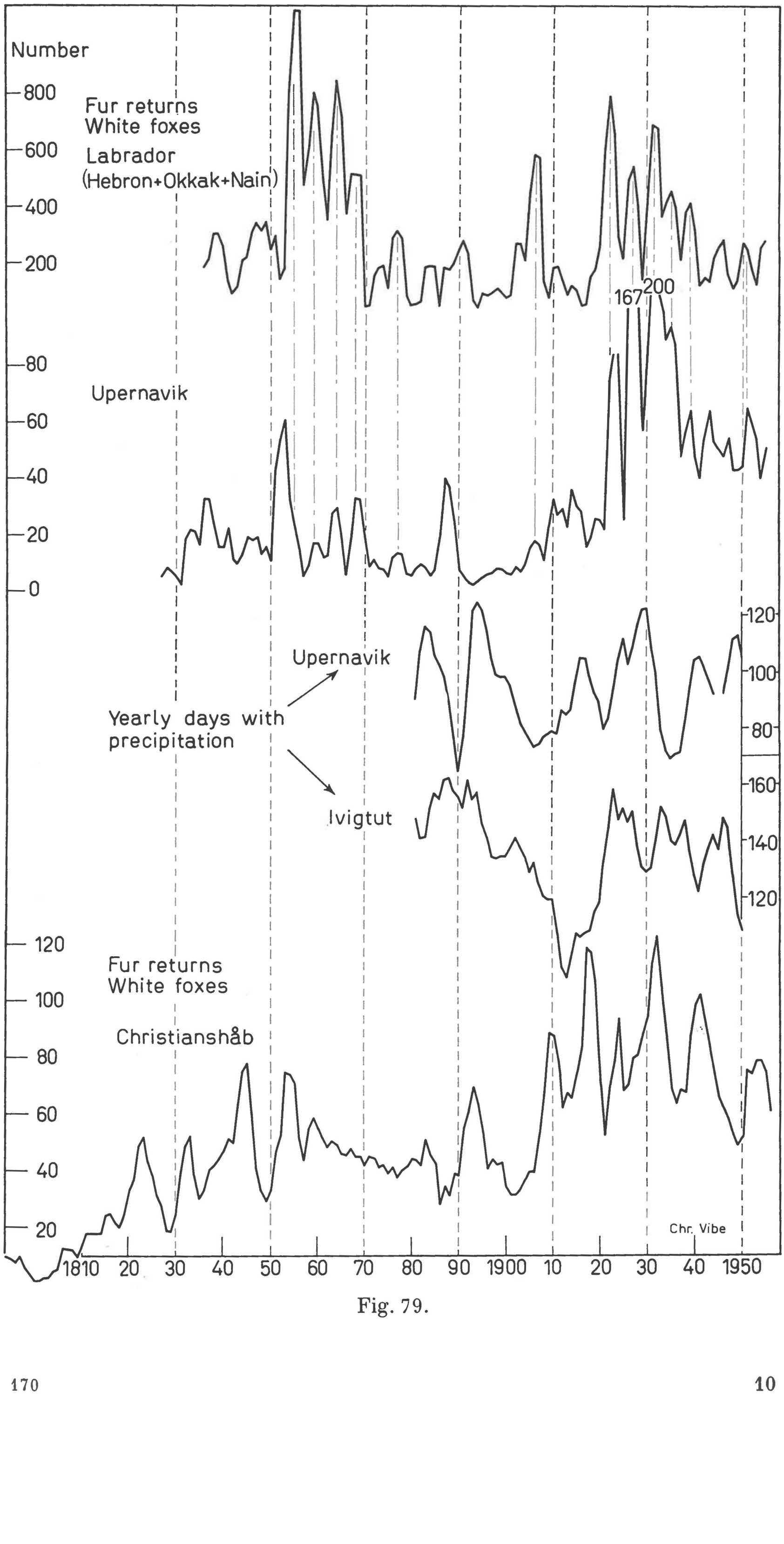

Number
800
600
400
200
Fur returns
White foxes
Labrador
(Hebron+Okkak+Nain)
167
200
80
60
40
20
0
Upernavik
Upernavik
Yearly days with
precipitation
Ivigtut
120
100
80
160
140
120
120
100
80
60
40
20
Fur returns
White foxes
Christianshåb
Chr. Vibe
1810
20
30
40
50
60
70
80
90
1900
10
20
30
40
1950

Fig. 79.

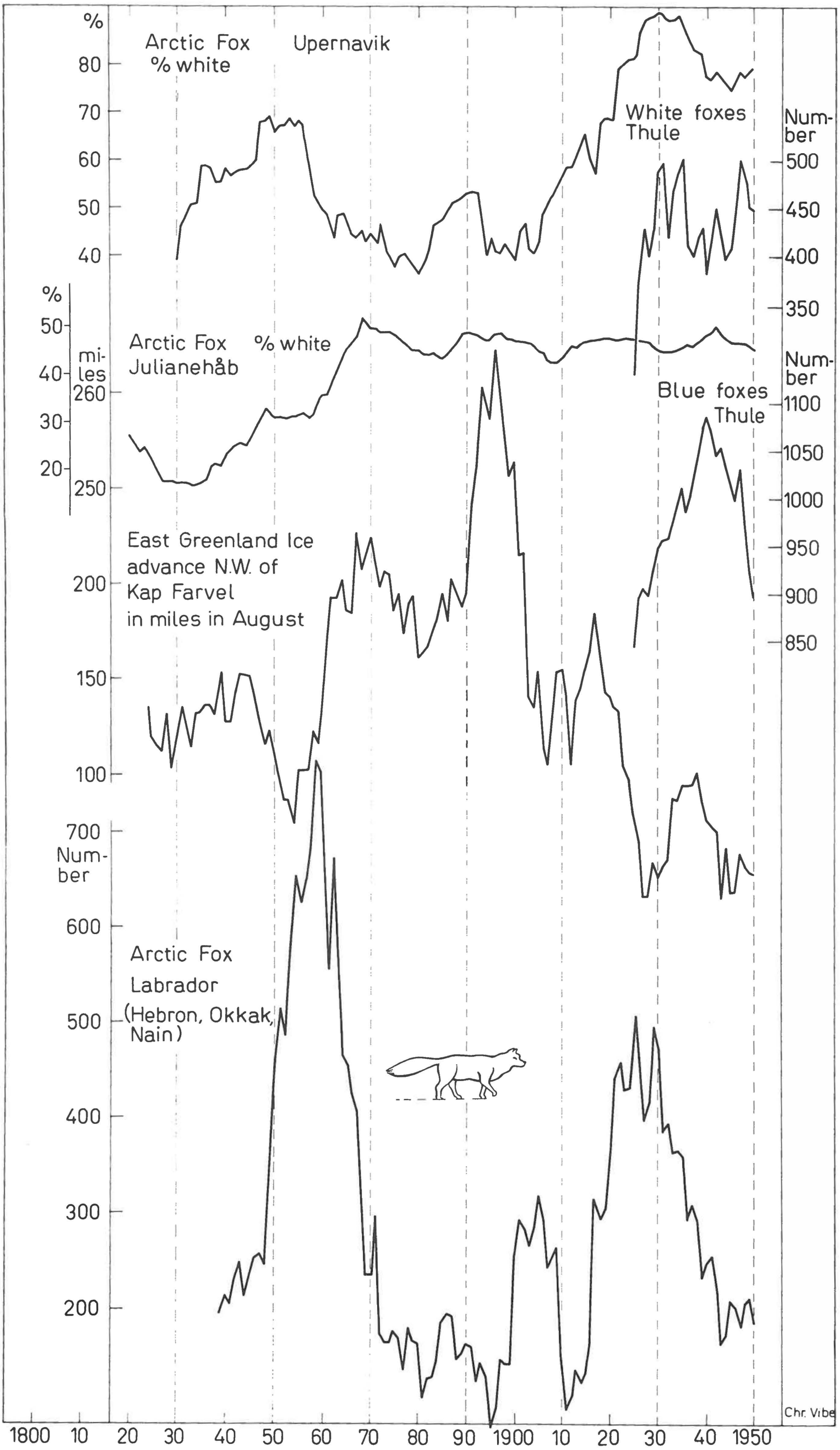



Fig. 80. All curves in 10-year sliding averages. See text p. 144.

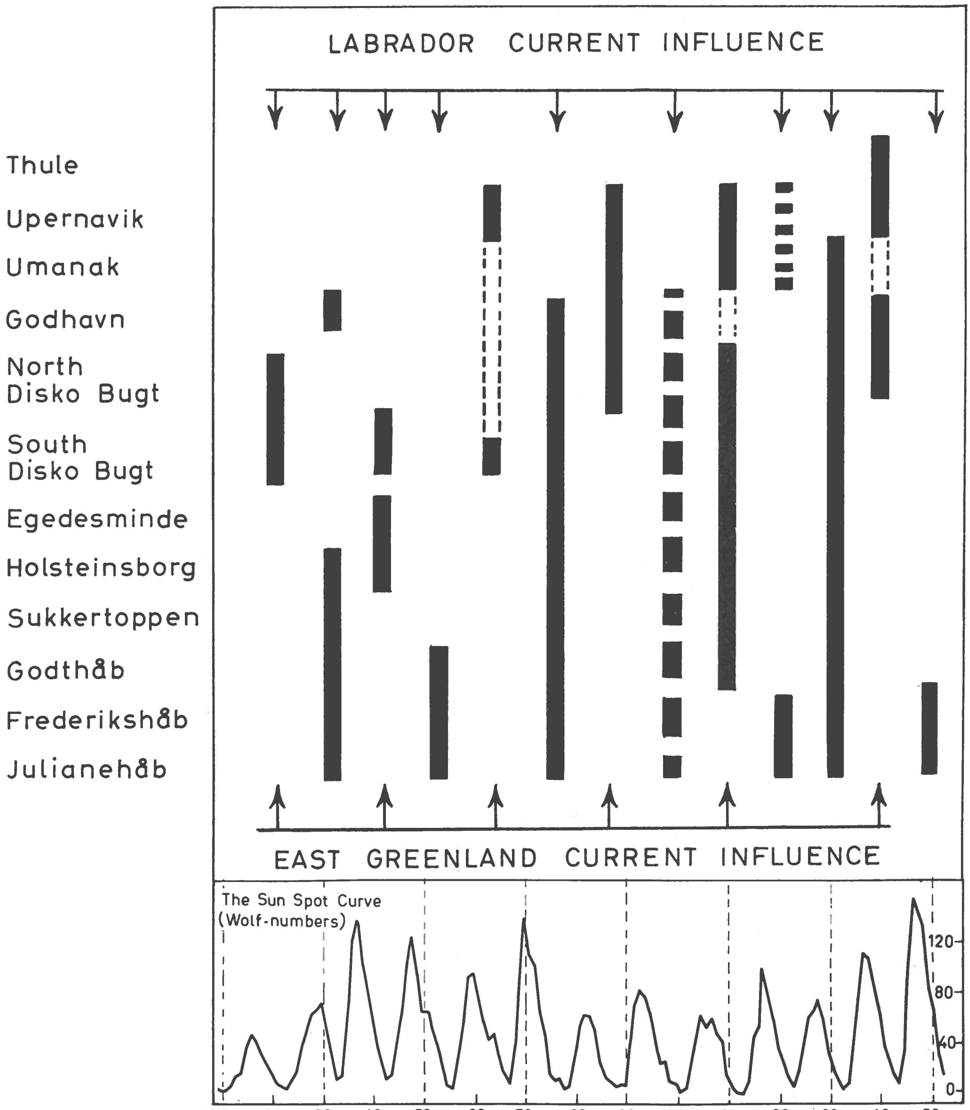



Fig. 81. The black columns show the areas where the blue fox population is relatively great or shows a maximum in periods with sun-spot minima. Labrador Current, read Canadian Current.

alternates between the northern and southern districts and that a shift takes place around 1930 — for reasons unknown. Confer p. 45.

In the northern districts the limiting factor is the cold water and drift-ice in the Canadian Current during the winter and spring. In the southern districts it is the cold water and drift-ice from the East Greenland Current.

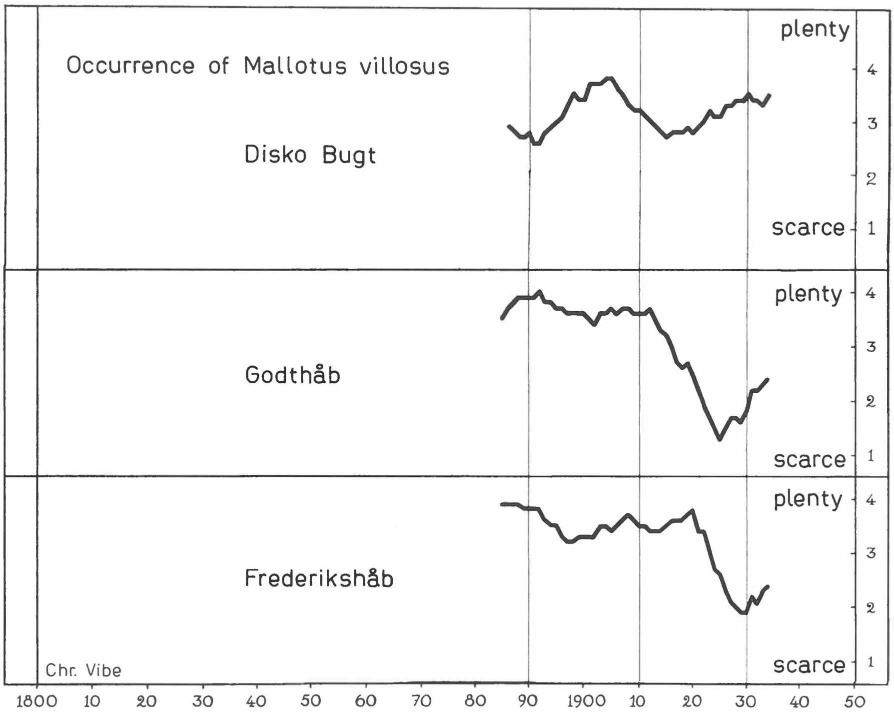



Fig. 82. For explanation see below. (Note, the scale at bottom is slightly larger than in the preceding figures).

In the first half of the 19th century the Canadian Current had a strong influence in Davis Strait, whereas since 1860 the eastern side of Davis Strait is mainly dominated by The East Greenland Current (and The Irminger Current).

Fig. 82 shows the catch of Capelin (*Mallotus villosus* Müll.) according to the colonial reports. For each year the catch is classified by a figure between 1–4. The curves are in 10-year sliding averages.

The Capelin curve for Disko Bugt parallels the temperature curve and the blue Arctic Fox curve, as shown fig. 76. It shows a maximum around 1905 and 1930.

At Godthåb and Frederikshåb the Capelin curve shows a minimum around 1930, when the curve of the blue Arctic Fox shows a maximum. The Capelin leaves Southwest Greenland in the mild years, but the blue Arctic Fox stays and is now able to profit by the new ecological conditions created by the change in climate towards Atlantic conditions in Davis Strait. Confer figs. 26 and 27, and p. 45.

## Concluding Remarks on the Arctic Fox.

As will be seen from the preceding pages, the present author agrees with the viewpoint set forth by BRAESTRUP 1941 and discussed by ELTON 1949, i. e. that the blue and the white Arctic Foxes are different in so many ways that it seems reasonable to regard them as biological races. Each constitutes a cline with a wide range of distribution. They live on different biotopes, and each biotope is favoured by special climatic conditions.

The tundras of Europe, Siberia and North America are the main biotopes of the *White Arctic Fox.* The tundra biotope is rarely reached by the blue foxes from the coasts. The white percentage approaches 100. The white fox living in the tundra must be regarded as the best representative of the white Arctic Fox described from Lapland by LINNÉ 1758.

The coast of northern Scandinavia, and the islands in the northern Atlantic and in Bering Sea are the main biotopes of the *Blue Arctic Fox*, the blue variant of LINNÉ 1746 (*Caerulescens*, Blåräf) and LINNÉ 1761 (Variat *Caerulescente* colore).

Medney Island is the only biotope of the *Blue Arctic Fox* that has not been reached by white foxes from the tundra. The white percentage is 0. Thus the Medney Island Arctic Fox must be regarded as the best representative of the Blue Arctic Fox.

Where, during periods with climatic fluctuations, white and blue foxes occur on the same biotope, hybridation takes place—and mixed populations are created. The hybrids will disappear again when a new stabilizing of climate favours one of the two biotopes.

The Arctic Fox is thus represented by two biological races and a widely distributed hybrid form:

The White Arctic Fox or Tundra Fox: *Alopex lagopus lagopus L.*

The Blue Arctic Fox or Coast Fox: *Alopex lagopus caerulescens L.*

The hybrid form: *Alopex lagopus* (*lagopus x caerulescens*).

Blue Arctic Foxes in all Greenland, Iceland, Jan Mayen and Svalbard are living far below optimal ecological conditions, owing to the special drift-ice conditions of to-day.

During a "drift-ice stagnation stage" the population of Blue Arctic Fox culminates in southern West Greenland and that of White Arctic Fox in southern Canadian Arctic, e.g. 1850–60.

During a "drift-ice pulsation stage" the ecological conditions are disturbed everywhere. The Blue Arctic Fox thrives best in central and northern West Greenland and the White Arctic Fox in the central ? and northern tundras of Canada, e.g. 1860–1920. In many areas both blue and white populations decline.

During a "drift-ice melting stage" the population of Blue Arctic Fox culminates in all West Greenland and that of White Arctic Fox in all eastern Canadian Arctic and North Northeast Greenland, e.g. 1930–40. The surplus of white foxes stray far and wide, invading distant islands and coastal biotopes of the continents favoured by the drift-ice.

Today, the islands in Bering Sea and North Atlantic and the eastern and western coasts of the continents, including Scandinavia, have more or less mixed populations of Arctic Fox.

## THE PTARMIGAN

### QUANTITATIVE FLUCTUATIONS IN WEST GREENLAND

F. W. BRAESTRUP 1941, p. 74 shows a curve of the quantitative fluctuations of the Ptarmigan in West Greenland. In the present paper fig. 84, a curve is reproduced in 3-year sliding averages, based on BRAESTRUP's numerical material from Julianehåb, Frederikshåb, and Godthåb, and it has been extended to 1954, on the basis of observations by FINN SALOMONSEN, AVGO LYNGE, JENS ROSING, and the author (0 = extremely scarce; 3 = numerous). The sun-spot curve is reproduced at the bottom, and in the middle is shown the advance of the East Greenland Ice in Davis Strait early and late in the summer (May + August). Fig. 83 shows the fluctuations in the yearly number of days with precipitation at Ivigtut and Upernavik, respectively.

It will be seen that the drift-ice curve alternates with the sun-spot curve: previous to sun-spot maximum the advance of the drift-ice in Davis Strait is slight. At the same time, it will be noted that the Ptarmigan curve alternates with the drift-ice curve: with slight advance of the drift-ice in Davis Strait, the Ptarmigan is numerous in Southwest Greenland.

The reason for this must be favourable wintering and breeding conditions. The climate during the breeding period should first of all be dry, and there should be little snow or rain in the winter (AVGO LYNGE 1951, p. 140).

Comparing the Ptarmigan curve for Southwest Greenland with the curves giving the number of days with precipitation, we find the Ptarmigan maximum around 1890 matched by a precipitation minimum at Upernavik (Northwest Greenland), while the other maxima are matched by precipitation minima at Ivigtut (Southwest Greenland) — Ptarmigan

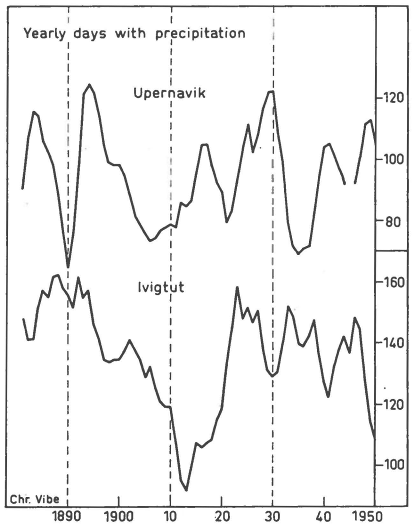



Fig. 83. Fluctuations in number of yearly days with precipitation at Upernavik (Northwest Greenland) and Ivigtut (Southwest Greenland) in 3-year sliding averages.

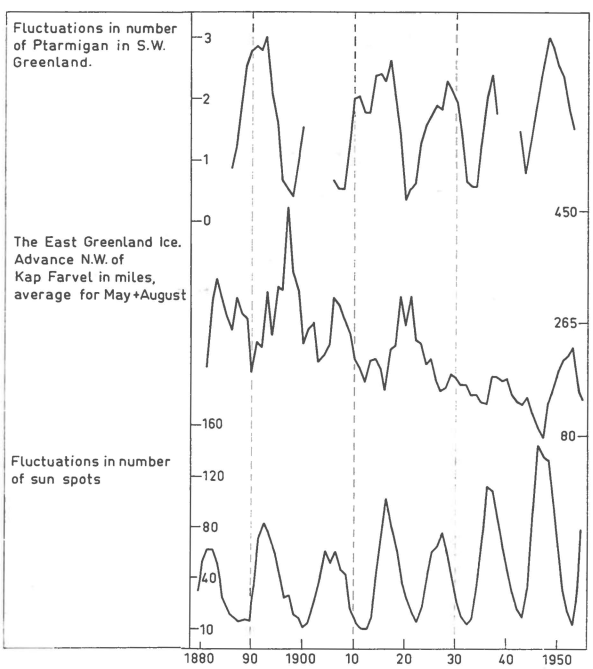



Fig. 84. The Ptarmigan curve, Southwest Greenland, seen in relation to drift-ice and sun-spots. The Ptarmigan curve and the drift-ice curve in 3-year-sliding averages.

are numerous when there are few days with precipitation in either Northwest or Southwest Greenland, or both.

We must presume, here, that the 1890 maximum in Southwest Greenland was considerably augmented by Ptarmigan from the north or west, inasmuch as the conditions of precipitation in Southwest Greenland itself do not appear to have been favourable to the Ptarmigan.

FINN SALOMONSEN (1950) has proved by means of ringing that Ptarmigan may migrate from Disko Bugt to Southwest Greenland. He has also proved (1950) that the West Greenland Ptarmigan races are also found west of Davis Strait.

K. N. CHRISTENSEN, a sheep-farm manager, who has spent many years at Julianehåb, informed the present author it was his firm conjecture that many of the wintering Ptarmigan of the district came from Baffin Island, because large flights of these birds would often appear on the outer islands before appearing inland. These Ptarmigan may have come from Nunarssuit to the northwest.

AVGO LYNGE (1951) states that Greenlandic huntsmen claim in the past to have seen Ptarmigan come migrating in from the west, and they assume that during the "big Ptarmigan years", the birds come from the west as well as from other directions.

During the period 1886–1954 six major peaks occur in the Ptarmigan curve — at average intervals of about 11 years.

# MUSK OX, REINDEER, AND MAN IN PREHISTORIC TIMES

As the Musk Ox need a dry and stable winter climate, its distribution was most likely restricted to dry continental areas far from the Atlantic during the humid centuries of the Glacial Ages. When the continental climate spread towards the Atlantic, the Musk Ox could follow and inhabit the zones near the retreating ice cap, where permafrost and water from the melting ice prevented total drying of the land.

In Europe and Asia the Musk Ox became extinct, while the Reindeer survived. The Musk Ox had no defence against Man and Dog, while the Reindeer could escape by flight.

On the uninhabited Canadian Arctic Islands and in North-Northeast Greenland the advantage of the dry climate is to-day on the side of the Musk Ox.

The Reindeer requires lichen for winter food, and lichen growing on stones and soil requires rain or fog. The Reindeer, when isolated in the northern regions, may survive for several generations but will degenerate and will not be able to survive during exceptionally wet winters. Finally it becomes extinct, e.g. *Rangifer tarandus eogroenlandicus* DEGERBØL, about 1900 and Queen Charlotte Island's Reindeer, *R. t. dawsoni* SETON, about 1910.

The main food of the Musk Ox, willow, grass and sedges, requires no precipitation when water is available from melting snow patches, permafrost, glaciers, and ice caps. The Musk Ox will thrive and survive as long as sufficient water is available for the vegetation.

If ever the Musk Ox existed in West Greenland it must have been during the time *before* the Atlantic period. The advance of the Atlantic climate, through Davis Strait and the Northwest Passage, then made the Musk Ox (and the Reindeer?) extinct in West Greenland and on Baffin Island. The populations in Ellesmere Island and North Greenland became isolated north of the wet zone where the winter precipitation from the open Baffin Bay and Greenland Sea could not reach. Here the Musk Ox survived.

In comparatively recent time the Reindeer populations in Ellesmere Island and Northeast Greenland were separated by a dry climatical period in North Greenland, and the races *Rangifer tarandus pearyi* ALLEN and *R. t. eogroenlandicus* DEGERBØL developed.

Sometime after the end of the Atlantic period the Musk Ox spread south again into continental Canada, and on the way it encountered Man. To Man the Musk Ox meant a new prey, in search of which he increased his territory to northernmost Greenland.

No doubt, it was the Musk Ox that made it possible for the Palaeo-Eskimo to immigrate to Greenland, as suggested by H. P. STEENSBY 1916 and later proved by EIGIL KNUTH.

Man immigrated into North Greenland approximately 2500–2000 B.C., E. KNUTH 1965 p. 275 and H. TAUBER 1964 p. 222. The period is remarkable because at that time a shift in climate was developing in Europe. The postglacial warm period had come to an end, and, what is of interest in this connection, the regular occurrence of Harp Seal in Danish waters had ceased, see p. 70. This indicates that the great climatic fluctuations in the North Atlantic regions had become less extreme. The heavy precipitation on the coastal lands around Baffin Bay decreased. The Musk Ox could go south and Man could go north.

EIGIL KNUTH has proved that during the centuries following the first appearance of Man in North Greenland, this country was inhabited several times by the Independence I peoples. They were Musk Ox hunters. The Reindeer was absent. However, KNUTH found antlers. The immigration of Man may have been preceded by Wolf.

The Independence II People arrived in North Greenland around 1200–1000 B.C. At that time the Reindeer was present, too. The old cultural periods in North Greenland ebbed away around 500 B.C.

On its southward wanderings the Musk Ox avoided both the west and the east side of Baffin Bay. It is known neither on Baffin Island nor in West Greenland.

On the east side of Baffin Bay the Musk Ox reached Melville Bugt and then stopped, for reasons unknown. There are three possible causes, terrain, climate, and Man.

The terrain is not favourable. There are about 300 km in a straight line from Kap York to the first fairly large island south of Melville Bugt, Holms Ø. However, many small islands lie on the way, so the distance might have been accomplished.

There is, periodically, much deep snow in Melville Bugt. In the spring of 1941 Polar Eskimo sledgers told the author of 1–$1^1/_2$ m deep snow on the stretch Kap York–Djævelens Tommelfinger. In periods with much open water in Baffin Bay and much winter precipitation, the Musk Ox has been unable to invade West Greenland.

In this connection it should be mentioned that the Hare is common north of Kap York, but 1940 and 1967 not found east of the cape where the snow may be too deep during winter. The large extension of the glaciers in Melville Bugt indicates that a moist climate often prevails in this region. It is therefore very conceivable that the adverse climate made the Musk Ox end its southern migration at Melville Bugt, where in the Atlantic period, the ice cap may very well have reached much farther into the sea than to-day.

1967 two very small skulls of Musk Ox ♂♂ were found on Pingorssuit, east of Kap Atholl, Thule district.

In 1948, the Polar Eskimo ODAQ found a Musk Ox skull in De dødes Fjord, Kap York, at the ascent of the sledge path to the glacier, which was revealed by the melting of the ice edge. LARS OSTERMANN, outpost manager of Savigssivik, informed M. DEGERBØL, who had the find sent to the Zoological Museum of Copenhagen. Nothing but the skull was found, a fact suggesting that the ice spread over the terrain after its death. We do not know when the ice advanced. This Musk Ox ♂ skull is larger than the two Pingorssuit skulls and must originate from a (later?) period with more moisture and better vegetation. It is the southernmost find of Musk Ox on the east side of Baffin Bay.

Finally it may be that it was Man who stopped the Musk Ox north of Melville Bugt. We may take the possibility into consideration that the northern route to West Greenland became open for Musk Ox and Man at the same time. If so, the former had no chance of survival.

Other things indicate that West Greenland only became open for land mammals fairly late. The Lemming and the Ermine never penetrated into West Greenland. In 1941 the author found many signs of the existence of the Lemming in Washington Land north of Kane Bassin. This vigorous rodent has as yet been unable to reach Inglefield Land, 90 km away. The same is true of the Ermine. This may be due to the open water in Smith Sund and a previous large westward extension of Humboldt Bræ.

The emergence of Man in West Greenland around 1400 B.C. is an indication that at that time the climate was sufficiently dry for land game to thrive in West Greenland in large numbers. The foehn wind was prominent and the glaciers were retreating in Melville Bugt, where the new islands became stepping stones for animals and Man. The Reindeer may have reached West Greenland across Davis Strait long before that time.

Reindeer and Man may also have reached West Greenland from the southeast. However, if so, the Musk Ox and the Lemming would have had the same chance.

The Sarqaq People mainly hunted Reindeer and lived in West Greenland for some hundred years (1400–800 B.C.). They disappeared when the climate became wet again, LARSEN and MELDGAARD 1958, TAUBER 1964.

The situation when the Sarqaq People disappeared was characterized by much the same conditions which prevail at the end of a modern Reindeer period. The now extinct *Rangifer t. eogroenlandicus* DEGERBØL was a "kummerform" weakened during a long and mostly dry period with scarcity of lichen for winter food. It became extinct in East Greenland in the middle of a wet period around 1900, simultaneously with an invasion of Wolves from Canada. The Sarqaq Reindeer was a "kummerform", too, M. DEGERBØL 1959 p. 71, and the Wolf was present in West Greenland during the end ? of Sarqaq time, when a new wet period began. A canine tooth of Wolf was found at Itivnera by JENS ROSING and determined by M. DEGERBØL, not yet published.

When the West Greenland climate became dry again, the Dorset People immigrated around 100 B.C. They, too, were Reindeer hunters. They disappeared around 400 A.D., when the humid climate returned.

The Norsemen arrived in Southwest Greenland in 985. They came from the east in their ships, and colonized the Julianehåb district (Østerbygden — the East Settlement) and the Godthåb district (Vesterbygden — the West Settlement) within an amazingly short time. They report nothing about drift-ice during their first 150 years of colonization in Greenland, nor during their Vinland voyages; hence we may assume that troublesome drift-ice did not appear. Indeed, the drift-ice situation was hardly serious during the beginning and the end of the Norse epoch. "The inhabitants of Herjolfsnes were in communication with Europe, if ever so little, throughout the 15th century", P. NØRLUND 1924, p. 254.

However, no drift-ice in Davis Strait does not mean a warm climate, but a cold, dry, and stable one (stagnation stage).

It may be interesting to compare the favourable centuries of the Norse epoch to a favourable Reindeer period of recent time. The Reindeer period 1820–60 was characterized by little drift-ice, and it drifted farther to the west than usual in southern Davis Strait (SPEERSCHNEIDER 1931, p. 51). West Greenland had much wind activity (RINK 1857 I, p. 45) and few days with precipitation, see fig. 21.

The climate shifted around 1860. In the following period, the drift-ice advanced far north into Davis Strait early and late in summer. West Greenland had much precipitation, and particularly Northwest Greenland had many calm days. The weakened Reindeer population starved in winters with much snow and ice, and presumably little foehn activity.

Much evidence suggests that a cool and dry climate with prevailing foehn activity characterized the beginning of the Norse epoch. Summer drift-ice was rarely occurring off Iceland ("drift-ice stagnation stage"). The Reindeer and domestic animals had favourable conditions in the mountains. Kongespejlet 1926 p. 57 mentions violent winds of short duration (foehn) and long periods with fine weather (1220–30 A. D.).

The middle of the Norse epoch was characterized by increasing advance of drift-ice. The appearance of drift-ice off Iceland in our time is an indication of climatic fluctuations in the North Atlantic and in Davis Strait. Warm and wet periods alternate with cool and dry ones ("drift-ice pulsation stage"). But as long as the drift-ice arrives in spring and does not advance far north in Davis Strait the climatic situation does not get serious. Without this moderately humid period in the middle of the Norse epoch, due to the "drift-ice pulsation stage" around 1300, the Norsemen would not have been able to go on breeding cattle for so many centuries.

J. Iversen 1934, p. 356, presents the theory that a large-scale attack of moth larvae (*Eurois occulta* L.) struck the Norse settlement of Vesterbygden with fatal results, eating the vegetation. It is hard to imagine that such an attack could play any appreciable part in the final extermination of the Norsemen of Vesterbygden. Firstly, all areas are not equally hard-hit, and secondly the attacks occur often in summers when the vegetation is able to regenerate. In June 1932 when Iversen saw an attack, Godthåb had 14 days of precipitation, while the average for 1920–39 for June is 9.

On the other hand, around 1350 the climate was about to shift and become more dry. Ivar Baardson (1350–60) tells about migrating Reindeer in the East Settlement. Reindeer go south in dry periods. The fact that Reindeer were abundant in Southwest Greenland at that time indicates that the climate was relatively dry and stable. When Ivar Baardson visited the West Settlement just after its extermination (by Eskimos? 1350–60), he found the Norse animals living in the mountains, still.

Overgrazing in dry periods did not kill the animals, but they became "kummerforms". More serious were wet winters with much snow which often may have reduced the stock of domestic animals considerably.

The domestic animals survived during the long period of comparatively stable climatic conditions after 1350, though weakened by hunger. They became extinct when this period was ebbing away—and was succeeded by increasing climatic fluctuations around 1500—or some decennia before.

There is a clear correlation between the disappearance of the Norse Culture in Southwest Greenland, the northward migration of the Eskimo population of Angmagssalik, and the eastward migration of the Eskimo whalers along the coast of North Greenland. Eigil Knuth's Eskimo whaling boat in Peary Land is dated to the period around 1476. The drift-ice pulsation and melting stages around 1450–1550 may have resulted in much precipitation in Southeast and Southwest Greenland during winter, sealing the fate of the Norse domestic animals and forcing the Eskimos of Angmagssalik to go north.

Once the stock of domestic animals had died from starvation in snow winters, the Norse population was entirely subjected to the fluctuations in the seal population.

M. DEGERBØL, 1929, p. 192, shows that the Norsemen, at least during certain periods, lived on hunting marinc mammals rather than on cattle and sheep breeding.

The wet period around 1500 was succeeded by a very cold one – and in cold winters Harp Seal, Ringed Seal, and Polar Bear stay away from southernmost West Greenland.

Very little is known of the actual time the Musk Ox and Reindeer immigrated into East Greenland. Future excavations of the Palaeo Eskimo settlements will presumably provide important information on this subject. However, we may estimate the periods in which the climate was suitable for land mammals.

One condition for a good Musk Ox and Reindeer period in East Greenland is stagnation in the ice-movements late in summer and autumn, creating unbroken ice-cover of the Greenland Sea and stable winters with low precipitation.

This condition was often missing during the drift-ice pulsation stage 1860–1910. Indeed, that period seems to have constituted one of the worst dangers ever known to the land mammals of East Greenland.

At one time the Reindeer was widely distributed throughout East Greenland. It lived on the now humid coast of Southeast Greenland and in the now extremely dry country around Fakse Sø in the interior of Gåseland, where in 1958 the author found an ancient meat depot built by an Eskimo Reindeer hunter, fig. 85. Reindeer bones were still present. The hunter had split them to get the marrow.

Owing to a dry climate in the north and a wet climate in the south the Reindeer became isolated in Central East Greenland. About 1900 the wet climate spread to Central East Greenland and the Reindeer became extinct. It may have been near extinction several times.

The Musk Ox seems to have been common in Northeast Greenland during several periods. In the interior of Kejser Franz Josephs Fjord, NATHORST (1900 II, p. 145) found "near some Eskimo houses, an ancient Musk Ox skull which was probably brought there as a curiosity. This skull is so old that the horny substance is entirely gone; it is overgrown with lichen and so weathered that only the most solid parts are left, giving it the appearance of fossile skulls found in the deposits of glacial periods in Europe. That it dates before the presence of Eskimos here was obvious when it was compared with the skull of Polar Bear and the other bones of Reindeer, Seal, Dog, etc. found around the houses". This find may originate from an earlier Musk Ox period.

Fig. 85. Torben Andersen at an Eskimo meat depot at Fakse Sø in the interior of Gåseland, built by Eskimo Reindeer hunter.

In the summer of 1964, the author examined a fairly large collection of bones found on the ground around an Eskimo winter settlement at the entrance to Harefjord, and in two summer settlements near the heads of Rypefjord and Hurry Fjord, respectively. The settlements belong to the last stage of the Northeast Greenland Culture. Two graves near the Rypefjord and the Harefjord settlements contained well-preserved skeletons which were hardly more than a few hundred years old. (The last living Eskimos were encountered on Clavering Ø 1823 by Clavering, while none was found in Hurry Fjord by Scoresby in 1822.)

The majority of the bones was from Reindeer, a few from Whale, Walrus and Seal, none (except the one mentioned below) from Musk Ox. It is extremely unlikely that the latter lived in the vicinity during the last phase of Eskimo inhabitance in the area. (The bones have been examined by Ulrik Møhl).

In the middle of the summer settlement at Hurry Fjord, in front of one of the tent rings and surrounded by Reindeer bones and piles of collected driftwood, fig. 86, lay a fragment of a Musk Ox skull. The author noticed that it was very heavy. It gives the impression of having undergone a process of fossilization, and is of a consistency entirely different from the other bones, which were slight and light. The fragment, fig. 87 right, is now in the Zoological Museum of Copenhagen.

Fig. 86. The Eskimo tent place in Hurry Fjord where the first finder of the Musk Ox skull (fig. 87, right) had placed it together with collected drift-wood.

It is worth noting that both horn cores are missing. At a first glance they seem to have been knocked off, but this could hardly be so, the surfaces of the "fractures" on both sides are almost identical, suggesting that the "fractures" are caused by a natural process.

An ancient skull brought home from Northeast Greenland in 1908 by A. L. W. MANNICHE shows a deep furrow of weathering (?) at the top of each horn core, which will cause the latter to fall off, see photograph fig. 87, left.

After the disappearance of the horn cores, the skull from Hurry Fjord had somehow undergone a fossilization process, both preserving it and making it heavy. In this condition the skull was found by an Eskimo hunter and carried home to the settlement to be displayed as a curiosity, finally being placed in full view in front of the tent.

It seems that the origin of this find is still older than that of the skull described by NATHORST. However, nothing definite can be stated until its age has been established with more certainty. In addition, exca-

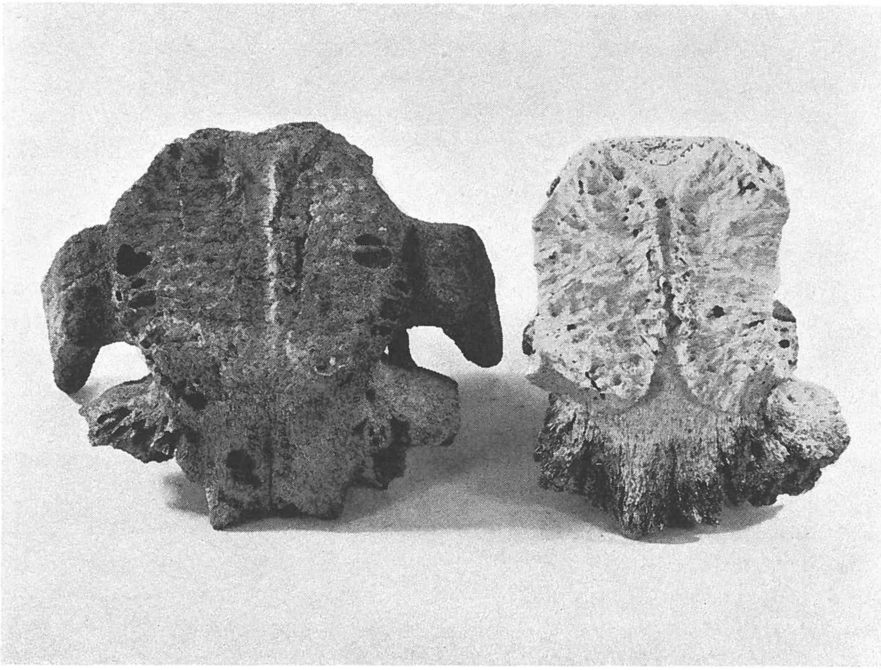


Fig. 87. Fragments of Musk Ox skulls, (left) collected in Northeast Greenland (Danmarkshavn?) 1908 by A. L. W. Manniche, (right) collected at an old Eskimo tent place in Hurry Fjord 1964 by the author.

vation of the old settlements at Scoresby Sund may reveal surprising finds.

However, the consistency of the skull indicates that it originates from an earlier date than any other bone material so far excavated from the settlements of the Neo-Eskimos in Northeast Greenland.

What caused the Musk Ox to become extinct in the southern parts of Northeast Greenland?

From Larsen's and Meldgaard's excavations in West Greenland we know that wet periods followed the disappearances of the Sarqaq People and the Dorset People. These wet periods may have been dangerous to the Musk Ox in Central East Greenland, just as they are to-day. Wet periods occurred 1200–1300 and around (1500?).

Yet the possibility cannot be dismissed that the very existence of the Sarqaq- and the Dorset Peoples in East Greenland may have represented a still greater danger to the Musk Ox than did the climate.

Around 1600 the Musk Ox was again trying to conquer Northeast Greenland (from the north and from inland refuges and nunataks?).

We presume that the migration of the Angmagssalik Eskimos to the north took place in the 15th and 16th centuries. Helge Larsen

(1934, p. 170) emphasizes that the first emigrants from the south to Clavering Ø did not hunt the Musk Ox. Bones of this animal were only found in the first phases of the Northeast Greenland Mixed Culture, which emerged around 1600, after the meeting of the Inugsuk People coming from the south with the Thule People coming from the north.

The arrival of a skin boat with Eskimo whale hunters in Pearyland about 1476 (EIGIL KNUTH 1965 p. 184) indicates open water in this region at that time. The same mild period may very well have brought too much snow to Northeast Greenland, dangerous to the Musk Ox. When the cold and dry climate returned around 1550, (the "drift-ice stagnation stage", $A_{III}$ in fig. 52 p. 95) the Musk Ox population increased in Central East Greenland and the Eskimos went south from North Greenland.

M. DEGERBØL, working on the bone material from both GLOB's and LARSEN's excavations in Northeast Greenland, found no indication that the Musk Ox lived in the Kong Oscars Fjord district (middle 17th century to around 1800). However, its bones were found sparsely on Clavering Ø from around 1600 to the 18th century. "Here, then, would seem to be proof that the musk ox had already reached Clavering Island about 1600, but the presence of so few bones might indicate that it was rare occurrence then". (DEGERBØL 1934, p. 174).

As long as the Neo-Eskimos remained in Northeast Greenland, the Musk Ox population had little opportunity of expanding, but it increased as soon as the last Eskimos had died out, somewhat after 1823.

The question arises why did Reindeer, Musk Ox, Hare, Lemming, Ermine, Wolf, and Man never reach Iceland on the drift-ice, when this journey is regularly made by the Polar Bear and the Arctic Fox. Perhaps the periods favourable to land mammals were too short to allow emigration from Greenland to Iceland?

# THE REINDEER IN WEST GREENLAND

A. W. F. BANFIELD 1961, p. 50, considers the present Reindeer of West Greenland, *Rangifer tarandus groenlandicus* GMLIN, to be the same as the American Tundra Caribou. It is strong and well-developed, and does not appear to have undergone any serious climatic depression periods after immigrating into Greenland.

M. DEGERBØL's (1959, p. 71) examination of the "Sarqaq" Reindeer (1400–800 B. C.) proves this to be a small "kummerform". The author therefore assumes that the present Reindeer immigrated directly across Davis Strait in fairly recent times.

Davis Strait is not a deterrent to a Reindeer invasion from Baffin Island to West Greenland. Normally, the Baffin Bay Ice ("Vestisen") during cold winters stretches right across Davis Strait, joining the Greenland coast between Holsteinsborg and Disko. The Arctic Fox and the Polar Bear use this route from Baffin Island to West Greenland, see F. W. BRAESTRUP 1941 and NIELS EGEDE 1934–43, p. 59.

In 1955, the present author joined a Reindeer hunt in the country south of Søndre Strømfjord with the Greenlandic Reindeer hunter LARS GOLIATSEN from Kangâmiut. On this occasion LARS GOLIATSEN mentioned that his grandfather, who was born around 1848, had told him that his great grandfather had in his young days lived at Ũmánârssuk. One year so much Baffin Bay Ice ("Vestis") came in along the coast that after Christmas no water was to be seen anywhere. In the spring, people drove their sledges far out on the ice where a herd of Reindeer was encountered, and some shot. They were very lean and the stomach contents consisted only of seaweed. No open sea was seen that winter. The Reindeer did not resemble the Greenlandic Reindeer in colour, and were assumed to have come from Baffin Island.

When HANS EGEDE came to West Greenland in 1721 there were Reindeer throughout the southernmost parts of the country, a fact suggesting that a dry, stable climate prevailed.

HANS EGEDE 1741, p. 35, writes of the many sunny days and the small amount of rain or snow they had in the country at that time: "In Greenland there is little rain or stormy weather . . . although it is much colder than in Norway less snow falls, especially in the fiords where snow is hardly ever found to lie half an ell thick on the ground".

This statement from 1741 is an interesting background for the information given in PEDER OLSEN WALLØE's diary for 1751 (L. BOBÉ 1927, p. 64). He mentions that Reindeer are becoming scarce in the Julianehåb district, and in his opinion the reason is the introduction of the gun and the Greenlanders' passion for shooting. But the catastrophe was soon to spread to the north, to the best and most stable Reindeer land of West Greenland.

NIELS EGEDE (L. BOBÉ 1943, p. 45) writes in his diary from Egedesminde and Holsteinsborg: "I have observed considerable change in the weather since I first came to Greenland, which was 1721, and until now, when we write 1761, the change has increased every year. The frost is the same, but the weather is not nearly as good and steady as before. Formerly, it rarely rained and the number of snow storms were no more than 20 a year. There were few storms or rainfalls in the summer, while now, on the other hand, there can be bad weather for more than the two thirds of the year and only one third good weather. The Greenlanders say the same".

The Greenlanders complained to NIELS EGEDE that hunting often failed for two to three years in a row, while before, this only happened in a single year every now and again.

Around 1770 conditions became still worse. Hunting failed altogether and many settlements were abandoned, or people died of starvation. NIELS EGEDE (1939, p. 260) writes on this subject from Holsteinsborg 1770: "Primarily, the people have now decreased so much yearly that many settlements are deserted, and places where I could previously count 50 families have now but five or six families". . . . "Secondly, in all regions there are hardly any Reindeer to be seen; the Greenlander who could previously shoot 40–50 Reindeer can now get only one or two; this bad situation has now lasted for 13 years".

NIELS EGEDE writes further that the big seals and whales are decreasing in numbers, and like the Greenlanders, he thinks they are moving elsewhere. The Greenlanders tell NIELS EGEDE that they have been told by their ancestors of periods in the past when hunting failed and many people starved to death. The latter statement suggests that wet and unstable climatic periods have now and then prevailed in West Greenland.

It is obvious from NIELS EGEDE's account that for a period before 1760–70 a cool and dry climate prevailed, and was replaced by a mild and humid climate with predominant southern and westerly winds: "A score of years ago we rarely had rain here, but almost clear air with northeasters, and as soon as Michaelmas Day (September 29th) came we got snow and frost which continued until the end of April or beginning of May, with steady northeasters and clear frost. Since then we have

Fig. 88. The West Greenland Reindeer (♂), Søndre Strømfjord, August 1959.

experienced a great yearly change; we have rain nearly every other day with southerly winds, and while in the past we always had dry weather we may now have rain and sleet right until Christmas, the winter at Christmas here now being no different from the winter in Denmark". NIELS EGEDE (1769, p. 261) relates further that blow-flies, berries and herbs have increased greatly in comparison to previous years, and he mentions the occurrence of large Cod in the southernmost part of Greenland.

The picture NIELS EGEDE draws somewhat resembles the situation in West Greenland after 1860 (and in some respect after 1920). The Reindeer managed well as long as the winter climate was cold and dry, in spite of poor vegetation; but the population was reduced as soon as the winter climate became humid, because then the vegetation was hidden under snow and ice.

In the southern part of West Greenland, the humid winter climate of the period made itself strongly felt and was reflected in the advance of the glaciers. O. FABRICIUS (minister in Frederikshåb 1768–73) gives an account of this phenomenon (quoted in English translation by A. WEIDICK 1959, p. 178):

"This ice spreads more and more every year, grows both from the ground upwards and from the middle to the sides and has already eliminated most of the land. Where it encounters high mountains it must stop until it overgrows them in height, whereafter it goes on without hindrance. The experiment has been tried of erecting a post on the bare land a good distance from the ice, and next year it was found to be overtaken by it. So swift is this growth that present-day Greenlanders speak of places where their parents hunted reindeer among naked hills which now are all ice. I myself have seen paths running up towards the interior of the country and worn in bygone days, but now broken off at the ice, which confirms the Greenlanders' statement. The glacier advances especially in the valleys and, where these reach the sea and the heads of the fiords (I mean the inner ends of the fiords) it becomes so dominating as to have great floes hanging over the water. Apparently part of the glacier, especially at the middle, is even and smooth, but part of it is most uneven, particularly where it borders upon the still bare land and at places where small hills are covered".

After 1770 the West Greenland Reindeer population was at a minimum until about 1815, when a great increase suddenly set in, see curves fig. 89. The reason for this new increase must be sought in the climate changing to more stable Arctic conditions in Davis Strait, i.e. the winters had less precipitation (and more foehn activity?).

However, the most important factor for the Reindeer was that the humid period had built up a solid water reserve in form of inland ice, snow deposits, and ground ice, which forwarded regeneration of the vegetation.

This fact, combined with a healthy Reindeer stock, made possible a rapid increase in the population. Around 1840, the annual purchases were about 3000 Reindeer skins at Godthåb, about 4000 at Sukkertoppen, about 6000 at Holsteinsborg, about 3500 at Egedesminde, and about 1000 between Disko Bugt and Melville Bugt. To this should be added the number of skins used or left by the hunters in the mountains. The Reindeer was not protected, but Reindeer hunting usually took place in the summer, July–September. North of Sukkertoppen where dog sledging is common, hunting was carried out in the winter, too. That the number of Reindeer killed in the Holsteinsborg district was much higher than in the Sukkertoppen district must be ascribed to winter hunts from Holsteinsborg — and to the fact that in the winter large numbers of Reindeer leave the southern grounds and migrate north to regions with less winter precipitation (see p. 175).

After 30 years' increase, the Reindeer curve culminated around 1845–50, and from then on it fell rapidly. The great Reindeer period was over by about 1860, and the Reindeer population was at a minimum again. The entire Reindeer period lasted for about 40 years.

It is remarkable that the Reindeer period 1820–60 did not include Frederikshåb where the bag was extremely small. The drift-ice 1830–50

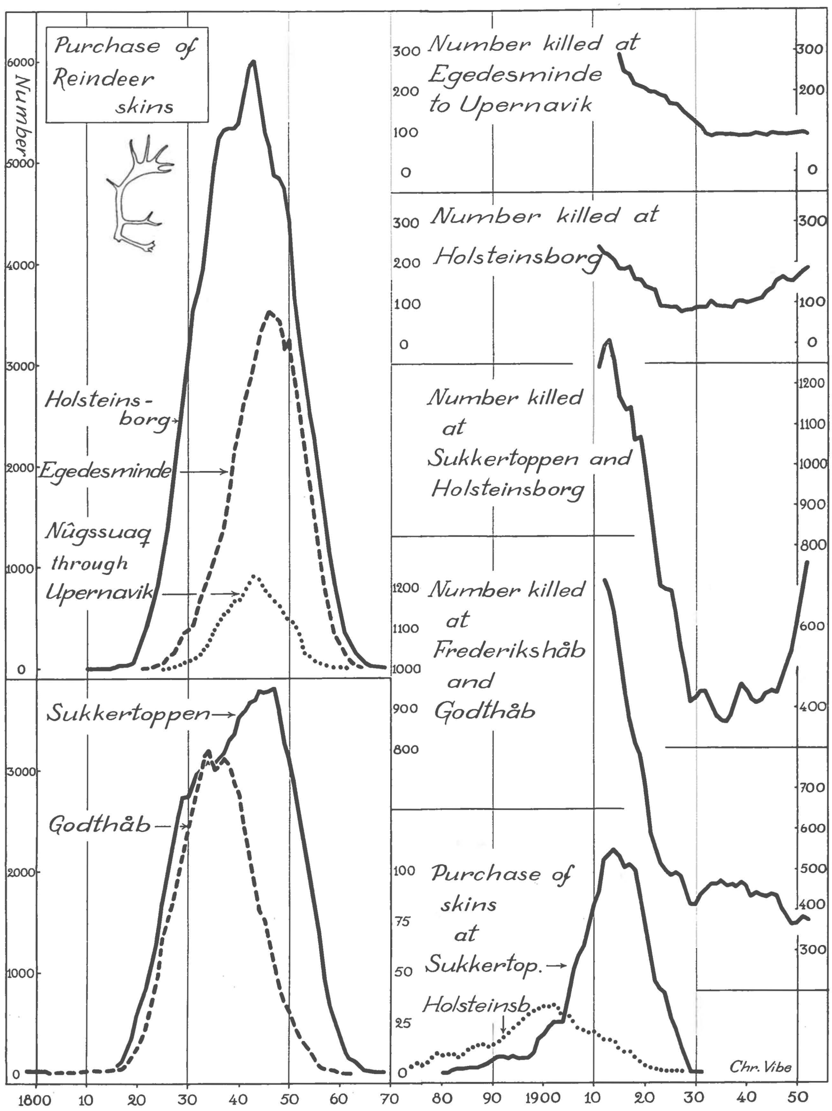



Fig. 89. Fluctuations in number of Reindeer skins purchased by the Royal Greenland Trade Department, and in number of Reindeer killed, according to hunting statistics. Curves in 10-year sliding averages.

spread to the west and did not advance far north in Davis Strait (Speerschneider 1931, p. 51). This indicates that the northern coast of West Greenland was mostly dominated by the cold Canadian Current, L in fig. 90 (the drift-ice stagnation stage). The productive area of the sea lay around 1850 in southernmost Greenland, where the three currents (I + E + L) mixed during early spring. The population of blue Arctic Fox (F) culminated here 1850, shortly after the culmination in the

Reindeer population in central West Greenland (R). The short period of a mild Atlantic climate which brought the Cod to Greenland in the end of the 1840's reached neither northern Davis Strait nor the central inland.

During the sun-spot minimum around 1840–45, the East Greenland Ice advanced in Davis Strait late in the summer but not far northwards. Late drift-ice coincides with relatively cold winters and little winter precipitation in West Greenland, fig. 22, p. 38. The dry winter climate was favourable to the Reindeer population.

The next sun spot minimum about 1855 brought little drift-ice only. Like 1835, the ice did not advance far north in Davis Strait where the climate remained dry, presumably too dry for the now very large Reindeer population. The rapid decline during this period may to some extent have been caused by overgrazing.

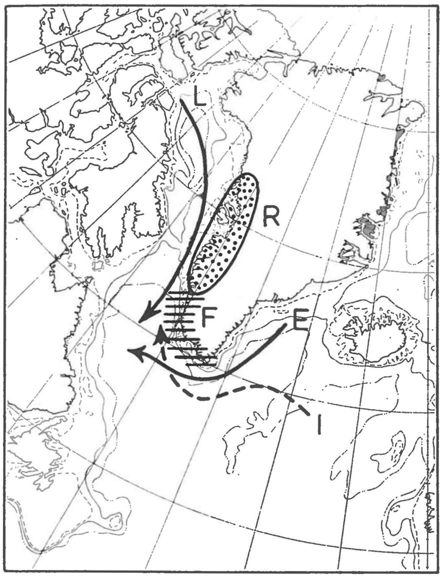
During the next sun-spot minimum around 1865 the East Greenland Ice moved in large masses far north in Davis Strait (the "drift-ice pulsation stage" begins). The production area of the sea, formerly situated in southern West Greenland, moved to northern West Greenland. The warm, deep water was forced north to southern Baffin Bay, where it penetrated to the surface. The population of blue Arctic Fox declined in southwestern Greenland but culminated at Upernavik, fig. 78.

A completely new climatic situation was created in Davis Strait and West Greenland around 1865, fig. 91. The northern advance of the West Greenland currents brought the wet Atlantic climate to Baffin Bay. To the Reindeer population this meant a long stagnation—but simultaneously new water and vegetation reserves were built up. The Reindeer population now had its optimum in North Greenland, fig. 91 R. According to KNUD RASMUSSEN 1905, p. 31, many Reindeer lived in the Thule district about and after 1865.

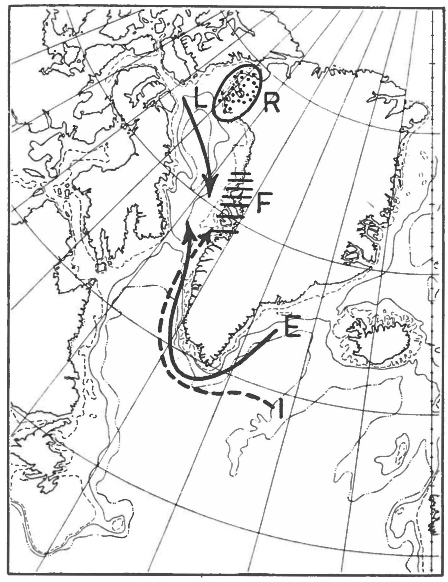
Cod occurred along the west coast during the 1820's and at the end of the 1840's, POUL HANSEN 1949, p. 6. A comparison of these brief Cod periods to the Reindeer curve for Godthåb shows that the Cod occurred at the beginning and at the end of the Reindeer period, but not in the middle.

During the middle of the Reindeer period cold water from north early in spring, and from south late in summer kept the Cod away. This situation returned with increasing current activity in the years before and around 1865 – and the Cod population stagnated for many years.

When the Reindeer population in West Greenland decreased after the middle of the past century, it also decreased west and north of Baffin Bay, but not until some decennia later. FLAHERTY (here quoted from BANFIELD 1961, p. 53) "reported the extirpation of the Reindeer on the Belcher Island about 1887, as a result of the tundra freezing during a prolonged sleet storm."




1850




1865

Fig. 90 (left) and 91 (right). L and E indicate the supposed extensions during the critical winter months of the Baffin Bay water (L) and the mixed Arctic and Atlantic water (E + I) around 1850 (drift-ice stagnation stage) and 1865 (drift-ice pulsation stage), respectively (based on occurrence of drift-ice, climatical and ecological conditions in Davis Strait).

F. Areas with maximum concentration of blue Arctic Foxes around 1850 and 1865.

R: Areas with maximum concentration of Reindeer around 1850 and 1865. In 1865 the Reindeer period had terminated in West Greenland but continued (or began) in the Thule area.

There wcre former a good Reindeer population in the Thule district, south of Kap Alexander and north of Kap York. This population decreased rapidly during winters with much snow and rain towards the end of last century, P. Freuchen 1911 pp. 141–46.

Also in the Northwest Passage territories many Reindeer succumbed during the decades around 1900 (Banfield 1961, p. 52). Banfield and other authors are of the opinion that the introduction of fire-arms, and more important, the whalers' meat requirements, were to blame (Banfield 1951, p. 14). However, these factors were hardly decisive considering the size of the territories and the fertility of the Reindeer. Banfield (1961, p. 46 and 48) shows two maps of the present and the former distribution of the Reindeer in Greenland and Canada. These clearly show that *R. t. groenlandicus* has declined in the very area of the Northwest Passage where in certain periods the Atlantic climate prevails. This periodically humid belt may contribute to the isolation of *R. t. groenlandicus* (in the south) from *R. t. pearyi* (in the north).

Fig. 92. Reindeer succumbed in the winter 1961–62. Søndre Strømfjord, West Greenland, see text p. 180.

On Inglefield Land, Ellesmere Island, and several of the North Canadian Islands some small populations of *R. t. pearyi* ALLEN lead a protected existence. Before reaching these territories, the winds from Baffin Bay must pass high mountains and ice caps, where the precipitation falls. North of the mountains the climate is dry, the vegetation sparse, and lichen growth very poor. The Reindeer are small and will hardly be able to survive if a series of catastrophic winters sets in.

A similar existence was led by the now extinct *R. t. eogroenlandicus* DEGERBØL, in Northeast Greenland. Periodically, the wet winter climate from the Atlantic reached the biotope and finally contributed to its extinction around 1900. See pp. 183–184.

As stated p. 184, Northeast Greenland was before 1900 invaded by Wolves from Canada where Reindeer catastrophes had deprived them

Fig. 93. Reindeer which died in its sleep in the winter 1961–62, Søndre Strømfjord, see text p. 180.

of their food. There is no doubt that these sudden attacks by Wolves contributed to the extinction of the Reindeer. The Musk Ox is more able to defend itself against the Wolf, and survived both the unfavourable weather conditions and Wolf attack.

Presumably the Independence, the Sarqaq, and the Dorset Culture peoples had the same reason to leave eastern Arctic Canada in the ancient time as had the Wolf. The Wolf immigrated first, then Man. The Wolf cannot stay long in North and Northeast Greenland and neither can Man.

In our time the Reindeer is non-existent in the Angmagssalik district, Southeast Greenland. The coast is open to the frequent humid winds from the Atlantic; the Arctic Hare is absent, and the Arctic Fox rare. However, during one or several periods in the past, the Reindeer did live in Southeast Greenland, as indicated by many finds of bones and antlers, H. Winge 1902, p. 466, M. Degerbøl 1957, p. 54. Nevertheless, we probably have to go back in time to about 1350 to find a climatic period sufficiently dry and long to form the basis of a Reindeer population of any size on this exposed coast.

The periods when the Reindeer had its greatest distribution southwards were around 1350, 1721?–40, and 1910–20, the two last of which are known to have been very dry. In Southeast Greenland, too, the climatic situation may have been favourable for the Reindeer during these periods. The last period (1910–20) was, however, not long enough for the Reindeer to emigrate to the Julianehåb and Angmagssalik districts. See further pp. 174–175.

After 1900 the purchase of Reindeer skins in West Greenland began to increase once more. A new Reindeer period was underway and culminated during a very dry climatical period around 1915. In spite of the introduction of preservation, a new decline could not be stopped; in 1924 Reindeer were preserved in Southwest Greenland from May 20th to July 20th, and in 1927 in all of West Greenland, from October 1st to July 31st.

The curves fig. 94 show at the top (A) the number of days with precipitation December–May for Jakobshavn, followed by (B) the Reindeer bag for the area Nûgssuaq/Upernavik. The 5–6 year cycles are seen to alternate for these curves. Most Reindeer are shot during dry periods.

Curve (C) shows the Reindeer bag for Sukkertoppen/Holsteinsborg. This curve deviates somewhat from that for the northern country owing to the fact that it is regulated by the precipitation curve (D) for the southern part of West Greenland (Ivigtut), which tends to alternate with that for the northern part of West Greenland.

Reindeer hunters agree that in most places the Reindeer draw nearer to the coast during dry periods, and hunting is easier. At the same time the Reindeer foraging grounds are vastly expanded when the Reindeer enters this new land near the coast and the fiords, where the vegetation has been allowed to regenerate in peace. Thus, the greater bag is more likely to be a result of the expanded territory than of easier hunting.

The period 1920–50 in West Greenland was characterized by a high temperature level, ample winter precipitation along the west coast, and frequent ice-covering of the coastal land, all caused by the advance of the Atlantic climate far north in Davis Strait along the Greenland coast.

During the entire period the Reindeer population was at a minimum all over West Greenland. The average yearly bag was below 1000 animals, in spite of the fact that the Reindeer was now preserved during ten months of the year (October–July). The bag was evenly distributed over the area between Frederikshåb and Holsteinsborg. In the northern districts the decline continued during the 1950's.

Since 1950 the Reindeer has been on the way up once more in Central West Greenland, but not north of Disko Bugt. Until now (1966), the bag has risen to about 4000 animals per year. This rise does not include the area north of Disko Bugt where the Reindeer population has stagnated since 1930. The Egedesminde and Christianshåb districts, too, have at present a poor Reindeer population, which is due no doubt, to climatic

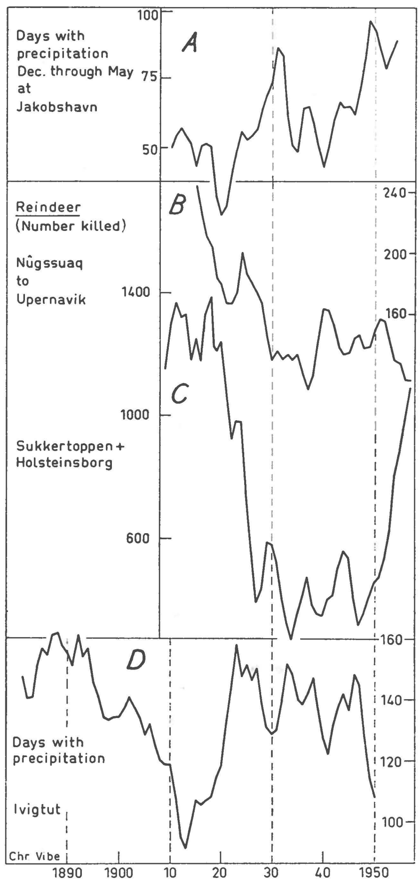



Fig. 94. Fluctuations in number of Reindeer killed, according to hunting statistics, seen in relation to fluctuations in number of days with precipitation at Jakobshavn (for the period December through May) and Ivigtut (for the year April through March). Curves in 3-year sliding averages. See text p. 172.

reasons. Fig. 94 (A) shows that Disko Bugt has more winter precipitation than previously.

In this connection it may be pointed out that the precipitation since about 1910 has been on the increase in Disko Bugt as compared to Southwest Greenland. The curve fig. 23 shows that Jakobshavn before 1910 could only show 40 per cent of the total number of days with precipitation at Jakobshavn + Godthåb, whereas after 1910 this was more than 55 per cent.

In the northwest territories of Canada, Reindeer carry out annual migrations from the tundra in the north to the forests in the south.

A. W. F. BANFIELD (1951, p. 3) characterizes the climate of the tundra as "long rigorous winters, with moderate to light snowfall". The summers are "moderately warm and dry, with five inches of rainfall or less". "The extreme low temperature of the caribou winter range was found to vary from $-60°$F. to $-45°$F., the lower temperatures being found in the central tundra. Most of the caribou migrate to the forested area in winter; very few remain on the central tundra, but some small bands may be found along the coasts. Annual snowfall is sixty inches or more on the central tundra, but is less in the coastal and forested areas".

Hence, the Canadian Reindeer wander from areas with a heavy snow cover to areas with a lighter cover, and it is most important that they reach areas with good lichen coverage in winter. They do not always return to the same wintering locality. "The usual custom is for the animals to return for several seasons to the same general locality, then to abandon it and spend several winters in a distant area. The reasons for these actions are not clearly understood. Weather and forest fires must be considered. It is probable, however, that failure of food supply upon frequented winter ranges necessitates movement to other areas". "As in the case of winter ranges, the same summer ranges are not frequented annually", BANFIELD 1951, p. 6.

Migrations to the tundra areas start in April and May; late in July and at the beginning of August Reindeer carry out summer migrations to the forest edge. In September they return to the tundra where, in October and at the beginning of November, mating takes place. They then start their winter migrations to the forests, arriving in December, and sometimes at the beginning of January.

Typical seasonal migrations will cease when the Reindeer decrease considerably in numbers. "It has been the general experience during the past century that where herds of caribou have decreased drastically in numbers, the remaining scattered groups cease to make definite regular movements and carry out local wanderings", BANFIELD 1951, p. 7.

Seasonal migrations were also carried out in West Greenland during the large Reindeer periods. As there are no forests with lichen coverage there to attract the Reindeer the animals wander in no special direction, but to the areas where the most suitable winter food is available.

IVAR BAARDSON (the middle of the 14th century) relates that in the autumn large numbers of Reindeer came to the island of Akia off Julianehåb. The island belonged to the Bishop of Gardar, and it was necessary to obtain his permission to hunt. This occurrence of Reindeer and their migration in southernmost Greenland suggests that the drift-ice in the

14th century did not drift far north into Davis Strait. The winter climate was favourable, without snow catastrophes. The same period may have been a favourable period for Reindeer in Southeast Greenland, too.

NøRLUND's (1924) excavations at Herjolfsnes show further that the harbour was visited by ships throughout the Middle Ages. This fact makes it clear that the drift-ice at Kap Farvel drifted west and not far north, a situation similar to the Reindeer period 1820–60.

At the present time the domestic Reindeer (introduced 1952 from Norway by the Royal Greenl. Trade Dep. by the aid of JENS ROSING) in the Godthåb district carry out autumn migrations to the inland. In March 1964 the Reindeer herdsman, INGVALD JÅMA, informed the author that in September/October Reindeer wander eastward to the winter locality. There they remain until the end of April, when they return to the summer pastures in the west. The winter food consists mainly of lichen, and the summer food of grass and sedges. The Reindeer herd at Itivnera amounts, at the present time (1964), to 3,500 animals — just about the number the area can support. Should the herd increase, it will be necessary to move the animals to the winter locality earlier in the year, and the lichen coverage will consequently suffer. If the lichen is eaten away or trampled down, it will take 30–40 years before it has again reached a length suitable for Reindeer, i.e. $^1/_2$–2 cm.

There is a large population of wild Reindeer in the area of Søndre Strømfjord, in the territories between the fiord and the ice cap towards south/south-east. In spite of periods of ups and downs, Reindeer have always existed in this region. Reindeer hunters relate that in early summer the animals stay far inland, but in autumn they come nearer to the fiord. However, as long as the number of Reindeer was not very large, no true seasonal migrations took place. The regular migrations towards the fiord and across, or around the head of the fiord to the area between Søndre and Nordre Strømfjord, did not start until the Reindeer population increased.

These migrations were observed for the first time on November 6th, 1959. In the course of one week numerous herds of Reindeer (estimated at 20–100 animals each) crossed the head of Søndre Strømfjord in a south-northerly direction. The animals were not in an exhausted condition. Colonel PERDUE of Sondre Strom Air Base, who observed the migrations, informed the author that the week before had been rainy with ice cover all over the surrounding area. The Reindeer came wandering in a slow stream. PERDUE showed a photograph of 15 Reindeer in a long row crossing the road that runs from the harbour to the air base. It is not known whether the migrations took place also at night. After that only a few Reindeer were seen. They dispersed quickly all over the northern area.

Fig. 95. Reindeer grazing ground around Søndre Strømfjord, March 1st 1964, at the beginning of the foehn storm, shown in fig. 97.

The animals all took the same route. They crossed the iced-up fiord off the mouth of the river, and then crossed the road between the air base and the harbour from where they disappeared in the mountains in the north.

Colonel PERDUE said that during the week when the migrations were carried out he roughly estimated that one animal per minute crossed the road. If one calculates 7 days at 10 daylight hours each, a total of 4.200 Reindeer crossed the fiord at this place. Other observers estimated the number of animals at a higher figure; however, no count was made.

It is an interesting observation that a sudden icing-up of the country was apparently the original cause of the migration. Ever since this time

Fig. 96. The country around Søndre Strømfjord Air Port during the foehn storm March 3rd 1964. The snow has evaporated and melted. Streams of water are flowing in the valleys.

the Reindeer have wandered constantly towards the north in November/December, returning in April/May.

In May 1961 the author visited the area around Søndre Strømfjord. It was then common to observe small herds of 3–8 animals migrating southwards, but keeping far inside the head of the fiord.

In February/March 1964 the author made a journey by sledge from the head of Søndre Strømfjord westwards through the Reindeer territories as far as Holsteinsborg. Approximately 100 Reindeer were observed along the route, all old males with a few young males in between. During an air reconnaissance flight on March 17th 1964 in the same area but closer to the ice cap, 300 Reindeer were observed, the major part being males. A few small herds of females kept apart from the rest; during this season the males and females usually part. The males, in particular, are inclined to stray; they push forward to the north and west during their winter migrations, whereas the females prefer to remain inland.

On February 28th 1964 at 12.20 p.m. the temperature at Søndre Strømfjord was $-26.1°$C, and the light snow layer on the small mountain lakes was 15 cm deep. Willow protruded through the snow everywhere, on the hills, and on many slopes the snow had been blown away. Reindeer were foraging in the hills, having no difficulty in finding food. There was a rich vegetation of lichen among hillocks of *Betula nana* and *Vaccinium uliginosum.* The layer of lichen was generally 2–3 cm high.

During the following five days two foehn storms came, each lasting approximately 30 hours, and the temperature rose to $+4.4$ and $+10.6°$C, respectively. All the snow melted, and the water either gushed down the mountain sides or remained among the tufts or in hollows, where it froze when the frost set in again, figs. 95–97.

After the second foehn storm with succeeding frost, about one third of the Reindeer pastures was iced up. However, the tufts were free of ice, and food was still easy to obtain. The Reindeer were seen in the same territory before and after the foehn. During the following days there was a light snowfall.

After the foehn storms, conditions in the mountains were the same along the whole sledge route westward to the head of the Akugdlek Fjord; the lakes were glassy, and about one third of the country was covered with ice. However, it was still possible for the Reindeer to graze. New foehn storms made the ice evaporate and disappear.

Further towards the west the foehn did not affect the snow to any great extent. The snow layer was 62 cm deep on the large lakes and in the valleys. No Reindeer were to be seen. On March 15th the snow layer on the water reservoir lake at Holsteinsborg was also 62 cm.

The territory preferred by the Reindeer for winter pastures was the area from the ice cap westward to a limit where the snow layer began to increase, and where it did not melt away or evaporate during the foehn storms. Apparently the storms did not destroy the pastures, on the contrary, they melted the snow masses and thus uncovered the tufts.

Fig. 97 shows the curves of the temperature fluctuations during the two foehn storms at Søndre Strømfjord and Holsteinsborg, respectively. They indicate that the effect of the foehn decreased in force from the air base to the coastal land. Its effect on the snow decreased, too.

When, formerly, the coastal land was good Reindeer country it is likely that the snow layer was less deep and that the foehn storms when reaching the coast were still in full force. This type of storm makes the snow evaporate or melt, and gives the Reindeer access to the vegetation.

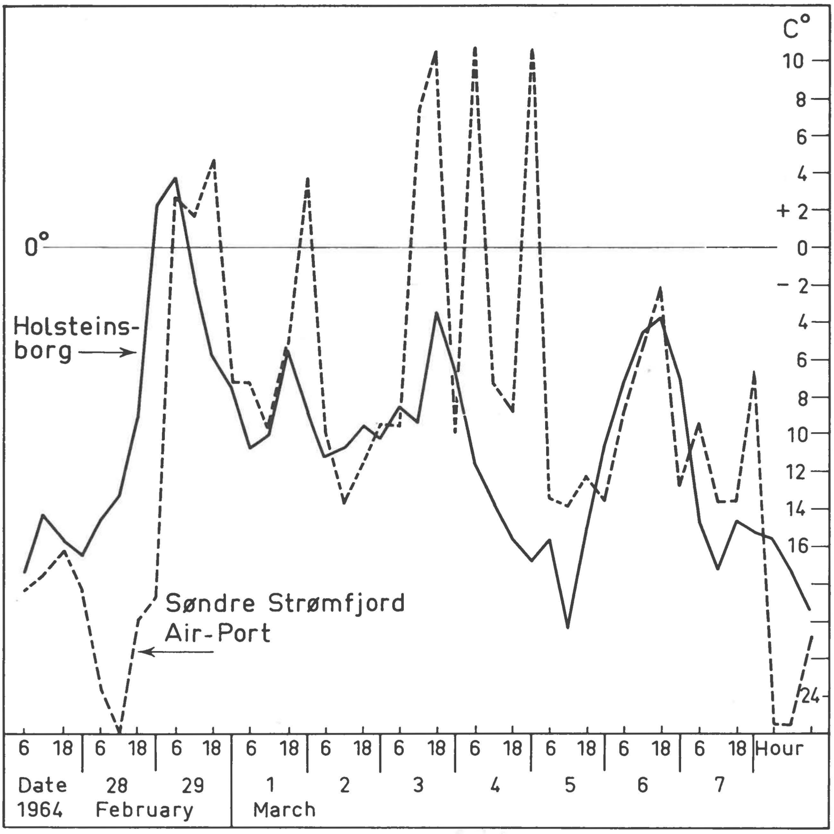



Fig. 97. The fluctuations in temperature at Holsteinsborg and Søndre Strømfjord Air Port during the foehn storm February 28th through March 7th, 1964.

It may seem strange that a new Reindeer period begins with such explosive force. However, we must bear in mind that animals surviving the catastrophic years are not degenerate, as there is enough summer pasture. It is the strongest individuals who survive the hard winters. When a stable climatic period sets in, the Reindeer territory is suddenly vastly expanded, and the vegetation in the new land has been growing undisturbed for years. With good nutrition, Reindeer calves may become pregnant in their first year, and Reindeer may have a calf every year. It is a much more fertile animal than the Musk Ox.

A Reindeer hunting people would not be able to survive very long in Greenland at present. The climatic fluctuations are too frequent and too pronounced.

The best Reindeer land at the present time is mountain slopes facing north. The southwestern winds from the sea are forced to give off moisture during their ascent across the coastal mountains, sparing the land behind the mountains from the snow masses of the winter. The country south of Søndre Strømfjord and Inglefield Land are famous examples.

In periods with many Reindeer in West Greenland dead animals are often found during winter, figs. 92 and 93. The cause of death may be age, starvation owing to ice-cover on the ground, wounds or disease. In the autumn of 1966 a dead Reindeer was found in the Søndre Strømfjord area. When its head was investigated by "Statens veterinære Serumlaboratorium", Copenhagen, the cause of death was found to be *Rabies*, which has often been found in Arctic Fox in Greenland. The dead Reindeer shown figs. 92–93 may have been bitten by a mad fox and died as a result of Rabies.

# PRESENT HISTORY OF THE MUSK OX IN NORTHEAST GREENLAND

The first historical account of the presence of the Musk Ox in Greenland is found in O. FABRICIUS: Fauna Groenlandica, 1780, p. 28. O. FABRICIUS lived in West Greenland near Frederikshåb 1768–73, and while there he was brought a piece of a skull, with one horn intact, hooves and tufts of hair which a Greenlander had found in the drift-ice.

FABRICIUS first thought the find represented the remains of a Yak Ox (*Bos grunniens* L.) that had drifted with the ice from Siberia; he mentions that the Greenlanders called it "Umimak". From this we may conclude that the Musk Ox has continued to live on in the mythology of Greenland. Along with a detailed description of the find, a drawing is reproduced showing the one horn of a Musk Ox male on a fragment of the skull, O. FABRICIUS 1788, p. 82. Later, FABRICIUS (1818, p. 61) realized he had been mistaken and described the find as being the remains of a Musk Ox which had drifted onto the ice from East Greenland. The fragment is now in the Zoological Museum of Copenhagen.

No mention has been made of the Musk Ox having been observed in East Greenland by whalers who, during the 17th and 18th centuries must have landed from time to time at different places in Northeast Greenland, since their best hunting grounds were off the coast between Shannon and Scoresby Sund. It is true that the ship owners forbade their captains to land in East Greenland, and that would not have been necessary had not the ships' company actually gone ashore now and then. Furthermore, the large crews of the whaling ships must have had a certain consumption of fresh water which could not always be obtained from the ice, and a strange animal such as the Musk Ox would certainly have excited attention, had it been observed.

Moreover, neither SCORESBY in 1822 nor CLAVERING in 1823 mentioned seeing the Musk Ox during their reconnaissance trips along the coasts between Scoresby Sund and Shannon. BRAUER (1888) has pointed out that SCORESBY found some thigh bones which might have come from Musk Ox at a deserted Eskimo settlement on Jameson Land. SCORESBY (1823) mentions finding bones of Seal, Walrus, Bear, Reindeer, Dog, Narwhal, and Whale, and adds: "the thighbone of some large animal was also met with, the species of which we could not determine". Scoresby's account of his trip bears witness to his interest and knowledge of animals as well as a keen power of observation. But, as no Musk Ox bones have been found since on the surface around the old Eskimo settlements in Scoresby Sund, it is most likely that Scoresby's thigh bones came from Reindeer, Polar Bear, Whalrus, Dog, or Eskimo.

The year after Scoresby's visit to Scoresby Sund Clavering mapped the area around Clavering Ø where, on the south side of the island he encountered the last Eskimos of Northeast Greenland. His description of this encounter is not detailed, and he appears to have regarded this merely as a fascinating experience. An interesting observation was made during a boat trip into Young Sund, when "A large bear was seen at a distance upon a hill which we all eagerly pursued; the animal, however, as soon as he saw us, set off at a gallop much exceeding our ideas of his speed, having imagined these animals to be slow and unwieldy; this was the first bear we had seen", Clavering 1830, p. 25.

It should here be noted that, at this stage of his voyage, Clavering was unfamiliar with the behaviour of the Polar Bear. He, quite naturally, thought "Bear" at the sight of any large animal at some distance. Although the Musk Ox had not been observed in East Greenland at the time, the possibility of confusion with a lone Musk Ox bull cannot be excluded. If, however, the Musk Ox had been common in the area, the Eskimos would have hunted it and its skin found in their tent.

Clavering mentions that he checked the tent thoroughly and that it was made of sealskin, which was also the material used for clothing and cover of the kayaks. He makes no mention of having observed other kinds of skin. In regard to Reindeer, he simply mentions that they were not found on that coast — contrary to Spitsbergen, from where he had just come.

All things considered, we have no proof that the Musk Ox lived on Clavering Ø in 1823. This, however, does not exclude the possibility that it may have lived in small numbers somewhere in Northeast Greenland.

With regard to the Reindeer, Larsen and Degerbøl (1934) mention that it was found on Clavering Ø throughout the period 1600–1800 but was rare around 1800. Many bones of Hare were found at this time — an animal not otherwise abundantly represented in the excavation material.

That the Reindeer was able to survive the presence of the Eskimo in Northeast Greenland much longer than could the Musk Ox may be due to the fact that the combination of Eskimo and Dog constituted a greater danger to the Musk Ox than to the Reindeer. Not until after Eskimo and Dog died out in Northeast Greenland could the Musk Ox become numerous. A future investigation will probably be able to reveal what rôle the introduction of the Dog into Northeast Greenland has played in relation to the Musk Ox. The Wolf, which was not associated with Man, was the worst enemy of the Reindeer.

Why did the Eskimo die out in Northeast Greenland? The "drift-ice pulsation and melting stages" 1740–1810 brought much precipitation to central West Greenland in the last half of the 18th century. The Reindeer became scarce in West Greenland. The same climatic situation may have prevailed in central East Greenland and have caused a serious decrease in the Musk Ox and Reindeer populations. A very cold climate followed, "the drift-ice stagnation stage" 1810–60. In cold winters the Ringed Seal will leave the fiords — and without the Musk Ox, Reindeer and Ringed Seal, Northeast Greenland is not a country for the Eskimo.

In Thule district the meat depots of the summer will usually come to an end about January/February. At this time Walrus hunting is commenced at the ice edge, and Seal hunting where currents have made open water — if there is an ice edge or any open water.

While waiting for open water the Eskimos of Thule will hunt the Hare. It is possible that the last Eskimos of Northeast Greenland did the same, and this may be the reason for the many Hare bones found at the last Eskimo settlements from a time when Musk Ox and Reindeer were scarce. The Hare population recovers more easily than those of the Musk Ox and Reindeer.

The first time the Musk Ox was observed with certainty in Northeast Greenland was on August 16th, 1869, when a lone bull was seen and shot on Shannon, Koldewey 1873, p. 325. At that time, the Musk Ox seems to have been common in Northeast Greenland, and from then on it was encountered by many expeditions from Peary Land in the north to Scoresby Sund in the south.

Thus it may be tempting to assume that the last fifty years of the nineteenth century was a period with favourable climatic conditions for game in Northeast Greenland. This assumption may be wrong, as climatic conditions in Northwest Greenland and Arctic Canada were unfavourable at that time.

The favourable period was in the first half and in the middle of the century, about 1830–60, when there was little movement in the drift-ice and when the winter climate was dry. The white Arctic Fox was caught in great numbers in Central West Greenland, and the white percentage in Northwest Greenland was at its maximum, see curves fig. 75.

About 1870–1900, the climate was wet and unstable in northern Davis Strait. This had an almost catastrophic effect on the Reindeer population of the Thule area — and also on the Reindeer population in parts of Arctic Canada. Scarcity of food forced the Canadian Arctic Wolves to emigrate. Two Wolves were observed at Umanak in West Greenland in the winter of 1868–69, and one was shot, H. WINGE 1902. ASTRUP in 1892 and PEARY in 1895 found indications of the presence of Wolves at Navy Cliff. In 1899, the presence of the Wolf in Northeast Greenland was proved by the Norwegian NAESØ, and one of these animals was killed by NATHORST (NATHORST 1900).

When KOLDEWEY 1869 visited Northeast Greenland the climate was about to change to the worse. The years 1860–1910 showed heavy movements in the East Greenland Ice, especially late in summer. To-day we know that this often means wet winters in Northeast Greenland, much snow and ice-cover on land — catastrophic conditions for the Musk Ox. An exception was perhaps a short period around 1890. Then again followed several bad years in which the Reindeer became extinct in Northeast Greenland, shortly after the Wolf invasion.

The Swedish explorer NATHORST was the last man to see the Reindeer of Northeast Greenland, in the year 1899. He expressed serious concern for their fate, fearing great losses through attacks by Wolves.

There is reason to believe that the last Reindeer in Northeast Greenland were killed by Wolves, but this only occurred when a series of unstable winters with heavy snow had reduced the population.

In the period 1895–1900, the occurrence of East Greenland Ice in Davis Strait late in summer was heavier than ever known before or after. Such a heavy late occurrence of ice leaves the sea off Northeast Greenland open, and great masses of autumnal snow fall in the country (as e.g., the winters of 1938/39 and 1953/54, see pp. 186–190).

The Musk Ox, too, suffered during the wet winters. Presumably conditions were much better in Peary Land, North Greenland.

Very soon after 1900 the number of white Arctic Fox increased in Northwest Greenland and Eastern Arctic Canada, a fact which indicates that the climate of the Arctic again became stable and dry. The catch of white foxes continued to improve at Upernavik for the next 30 years, see fig. 78, and in Northeast Greenland the white percentage of the Arctic Fox rose steadily from approx. 60 to approx. 92 during the same span of years. This may be taken as an indication of favourable living conditions for the animals of the tundra.

The Musk Ox population in Northeast Greenland particularly thrived during the nineteen-twenties, thirties, and forties, apart from a few catastrophic winters.

At the same time, the fine population of white Arctic Fox provided the opportunity for considerable hunting activity by Danish and Norwegian trappers, and this included a good deal of Musk Ox hunting. Great activity by expeditions also took its toll of animals, and a considerable number of calves was exported from the country to Norway, Svalbard and Alaska and to zoological gardens. Living conditions, however, were so good and stable that the Musk Ox population did not suffer irreparable losses. LAUGE KOCH, ALWIN PEDERSEN, J. G. JENNOV, JAMES VAN HAUEN and many others tell of large herds with many calves and young animals in the nineteen-twenties and thirties. The animals were vigorous, well developed, with fine coats, and there is no doubt that the population was developing in a healthy and steady way.

Except for Man, the Arctic Wolf was the only enemy of the Musk Ox. In the early nineteen-thirties, the Wolf disappeared from East Greenland, perhaps partly because of depredation by trappers. In the years 1933 and 34, the Hare population suffered a serious set-back due to difficult wintering conditions, JENNOV 1945. This no doubt, was a catastrophe for the Wolf, and may have contributed to its extermination. In this connection, it is interesting to note that August 1933 was extraordinarily free of ice outside Northeast Greenland, L. KOCH 1945, p. 341, which resulted in an ice-covering of the coastal land during the following winter.

In order to thrive in Arctic regions the Wolf need the availability of several animals, preferably Hare, Reindeer, and Musk Ox. These are available on Ellesmere Island, where the present author in 1940 saw several Wolves that appeared to be thriving; but they have apparently never flourished in Northeast Greenland where the climatic fluctuations are more extreme.

Today, 1966, the Musk Ox is found between Peary Land and Scoresby Sund. Off this area the winter drift-ice has its greatest extension, and at the same time there are sufficiently large stretches of land to support a reserve of vegetation.

The Musk Ox has been encountered now and then south of Scoresby Sund. Tracks were seen in 1900 at Kap Dalton by SØREN JENSEN, and on two occasions ALWIN PEDERSEN saw tracks on the coastal stretch Kap Brewster–Kap Dalton in 1928. In 1956, a hunter at Kap Brewster told the present author that he had seen a lone Musk Ox bull that spring on the mountain plateau. 1963 Greenlandic hunters shot three south of Kap Brewster. However, only roving animals usually reach that far south, where the winter climate is generally too humid.

In the same way, the Musk Ox has a tendency to avoid regions where the vegetation is too dry because of lack of water reserve in the mountains. During dry summers birch withers too early and is not acceptable to the Musk Ox in this state. On the other hand, if birch is suitably fresh, it is a favourite food, along with willow. Although Gåseland, in the interior of the Scoresby Sund district, would appear to be well suited for Musk Ox, it is not found there. The author camped in the interior of Gåseland, accompanied by TORBEN ANDERSEN, in the summer of 1958, but saw no indication that the Musk Ox had been there. It was discovered that Reindeer had lived there many years ago, as we found stones from old Eskimo meat depots and Reindeer bones that had been split for marrow. In places where the ice cap, permafrost, or perennial snow banks disappear, the vegetation has too short a growing period, and the Musk Ox stays away.

Until 1938, the Musk Ox population in Northeast Greenland increased steadily, according to reports from expeditions and hunters. The winter of 1938–39, however, caused considerable losses to the population. Similar winters, with greater or lesser losses, occurred in 1941/42, in 1948/49, in 1953/54, in 1955/56, and in 1959/60. The worst, and geographically the most catastrophic winters, were in 1938/39 and 1953/54. These will be described in more detail, in order to demonstrate how exposed the Musk Ox population is in Northeast Greenland, south of Nordostrundingen, during unstable climatic periods.

Little is known of catastrophes in Peary Land and other parts of North Greenland and in Ellesmere Island (see p. 192). In these regions it is mostly the scarce vegetation that limits the number of Musk Oxen. The years around 1900 were rich in precipitation in North Greenland. Expeditions often reported Musk Ox along the north coast. But in the extremely dry climatic period around 1920 the Musk Ox was rare in northernmost Greenland. In 1921 LAUGE KOCH searched for it in vain on northern Peary Land where it previously had been found by PEARY, MAC MILLAN and BORUP. LAUGE KOCH expresses the opinion that it has gone south (1925 p. 102). It is to-day not living on Washington Land (visited by the author 1941) nor on Hall Land (visited by E. KNUTH and J. MØHL 1965).

The winter 1938/39 is described by FINN CHRISTOFFERSEN in Dansk Jagttidende 1963/64 as follows: "... this year, the high, frost-clear fall air which characterizes that time of year on these latitudes was lacking. The reason was that the broad belt of drift-ice normally found along the east coast had disappeared. Heavy ground-swell came in directly from the sea and shattered the new ice on the fiord as soon as it formed. Storms with rain and sleet streamed in over the country. We had never seen anything like it during our earlier visit in this area (Clavering Ø). The unusual weather had the effect of covering all vegetation with sleet and crusted snow, creating a hopeless situation for the game. Middle of November, the storms were still raging with undiminished force; ... the unusual weather which covered the land with ice and destroyed everything on the outer coast. The Musk Ox that were not destroyed during

Fig. 98. Musk Oxen on Jameson Land, August 1956. The Musk Ox is rare on the glaciated country in the background, south of Scoresby Sund.

that winter were forced into the hinterland, near the inland ice where the cold repelled the rain and sleet coming in from the ocean."

That same winter FINN CHRISTOFFERSEN and ELMAR DRASTRUP travelled the stretch Eskimonæs–Romer Sø and the former has verbally informed the author that these abnormal conditions generally prevailed all the way to Kronprins Christian Land.

In the yearly report from Eskimonæs for 1938/39 the leader of the station, IB POULSEN, writes: "The first permanent snow came as early as September. The aggregate snowfall of that month on this part of the coast was estimated at approx. $1^1/_2$ metres. A period of mild weather, with weeks of rain, was unable to remove the snow but formed an ice crust on it. On the outer coast, conditions were somewhat different, in that wind had here freed the ground from snow. In those parts, the rain combined with subsequent heavy frost formed an almost unbroken ice crust which covered all vegetation. There ice formations, on the snow as well as on the ground, made it extremely difficult for the plantivorous animals to find food. . . .

. . . The ice cover on the outer coast in October made it almost impossible for the Musk Oxen to find food, while they got along somewhat better further inland where the early snow lay between the plant cover and the ice crust, which the Musk Oxen were able to break through. In certain parts of the coast, f. inst. on Hochstetters Forland, virtual migration of Musk Oxen from the outer coast to the interior fiord area was observed. However, the oxen that had not pulled away from the outer districts must have had a very difficult winter, and undoubtedly many died from starvation. Hunters report having seen many, especially young animals, that had starved to death. Also it was reported that the animals encountered were so exhausted that in many cases they had been dulled by hunger and did not attempt to flee, nor did they react to people.

An investigation of the stomach contents of animals shot during April showed that the stomachs hardly contained any plant rests but much gravel and many small stones. It was further reported that the animals were so emaciated that a single person could easily have carried home the meat of a grown animal. A single new-born calf was observed left dead. A Musk Ox herd of 14 animals observed on August 4th, had no calves from either that summer or the previous year".

With regard to the winter 1953/54, sledge patrol driver STEEN MALMQUIST writes, "Grønland" 1955 p. 418: "The summer of 1953 proved to be one of the strangest known in Northeast Greenland for many years. There was hardly any East Greenland Ice off the coast, causing a heavy ground-swell to pound and undermine the coast, so that in many places 5–6 metres were eroded from the cliffs. . . . The following winter was very hard. There was an enormous snowfall, the like of which had not been seen for many years. This combined with 10 days of mild weather in February caused an ice crust to form on the snow cover, making it difficult for the Musk Ox to dig down to its food which consists chiefly of Arctic willow. The result was that many oxen succumbed to starvation, some cows bore their calves too early, and other calves presumably died soon after birth, being unable to obtain sufficient nourishment from their starving mothers. The Musk Ox population was taxed very heavily this winter, . . . Sledging, too, was made difficult by the deep snow, but in spite of the poor conditions, two sledging teams reached Station Nord, via Kronprins Christian Land and Nordostrundingen. . . . Another team reached across the ice cap to Dronning Louises Land, but under very difficult sledging conditions. But in the southern part, where the tall mountain walls gave protection against the wind, the snow was at its highest. Two sledging teams there were swimming in snow up to the waist, . . .". MALMQUIST informed the author that there had been many

Fig. 99. A Musk Ox herd (1 bull, 4 cows and 1 yearling) in the Rypefjord area 1964. The low vegetation consists mainly of willow (*Salix arctica* PALL.) and birch (*Betula nana* L.).

Hares on Jackson Ø during the icefree year 1953, but that later in the year these had completely disappeared.

In the summer 1954 the present author led an expedition to Northeast Greenland with the purpose of catching a number of Musk Ox calves for transfer to West Greenland. During a reconnaissance flight through Ørsteds Dal in the northern part of Jameson Land, which is one of the best Musk Ox grounds in East Greenland, 140 Musk Oxen were seen altogether pasturing in small herds. Among these only one calf was seen. Another reconnaissance flight through Grejsdalen on Andrées Land

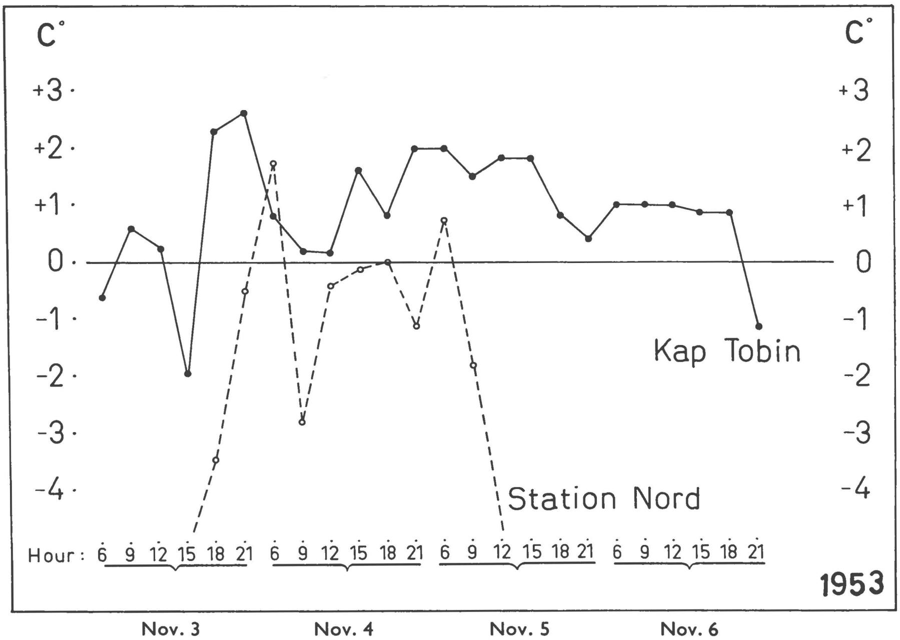



Fig. 100. Fluctuations in temperature at Kap Tobin and Station Nord during the mild period November 1953.

observed 146 Musk Oxen and 1 calf. On Ymer Ø 29 Musk Oxen were counted, among which there were two calves. In Mesters Vig valley 6 animals with 1 calf were seen. The calves were all taken to be yearlings. Around Mesters Vig were found 10 dead bulls, 3 dead cows, and 2 dead yearlings. Reports on dead Musk Oxen were received from the entire coast between Nordvestfjord and Danmarkshavn.

A report by the present author to the Ministry for Greenland (1954) states: "The reason for the high death rate among the Musk Ox population is due to an unusual amount of snow which has covered the winter pastures with 1 to 4 metres of snow on very large stretches of the coast. Furthermore, a warming in the weather occurred early in November followed by formation of ice-cover all along the coast to Station Nord, see fig. 100. Something similar was repeated in February. This has cut off the Musk Ox almost entirely from its food, resulting in a large number of old animals succumbing, the majority of the yearlings likewise, and practically all pregnant cows have miscarried last winter. In the northern districts, and in the areas nearest to the ice cap, however, conditions presumably have been less catastrophic; however, no studies on this are available".

As can be seen, all reports agree in regard to the cause of the Musk Ox catastrophes, i.e. very humid winters with snow, rain and ice cover

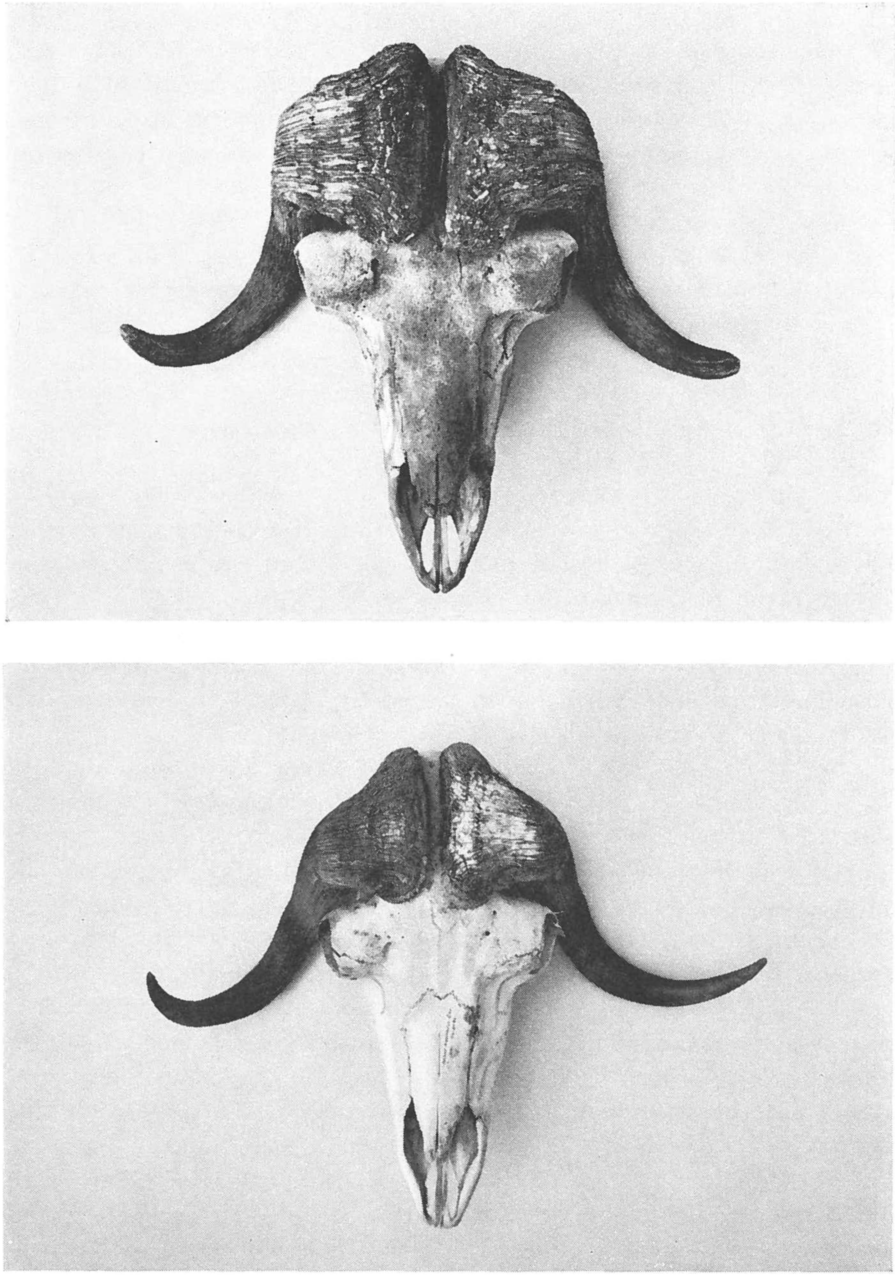


Fig. 101. Two Musk Ox skulls from two different biotopes in the Scoresby Sund area. At the top Jameson Land near Hurry Fjord, probably originating from the 1920's or 1930's. Condylobasal Length 503 mm. At bottom Rypefjord area probably originating from the 1950's. Condylobasal Length 435 mm. Jameson Land has more precipitation and a much better cover of vegetation than the Rypefjord area. Zoological Museum, Copenhagen.

on the ground. For both winters described, it is mentioned that the previous summer or autumn had little or no drift-ice off the coast, and that this had been the cause of much abnormal winter humidity.

Without the winter drift-ice, Northeast Greenland is an open coast with a very unstable, humid and raw winter climate, with consequent catastrophes for land mammals. With drift-ice lying close all along the coast and far out into the Greenland Sea, Northeast Greenland has a continental climate, i.e. good wintering conditions for land mammals.

It is still a question how far north the catastrophic winters go. They may influence not only Northeast Greenland but also parts of North Greenland and Ellesmere Island. In the spring 1940, the year after the Musk Ox catastrophe in Northeast Greenland, the present author saw 5 yearlings and 10 calves among a total of 121 Musk Oxen on western Ellesmere Island and southern Axel Heiberg Island, i.e., 4,1 % yearlings and 8,3 % calves. However the production of calves was not complete at the time of observation. The Reindeer and Hare population were in good condition, and there was no indication of any serious catastrophes having taken place in the preceding winters.

In 1954, the catastrophe year in Northeast Greenland, only 3 yearlings and no calves were observed among a total of 150 Musk Oxen on Fosheim Peninsula, Ellesmere Island, according to verbal information by J. TENER 1965. (See also J. TENER 1965 pp. 78–82).

In spring 1964 the Norwegian BJØRN STAIB Expedition ran into deep snow north of Ellesmere Island which presumably had come in from the Atlantic, according to information by MAX BREWER.

On a flight from Alaska to Denmark on September 19th, 1965, the author found Axel Heiberg Island, North Ellesmere Island and North Greenland covered with snow, but the big valleys of Peary Land, around Jørgen Brønlund Fjord, were still free of snow.

EIGIL KNUTH, who is the most expert authority on Peary Land, considers the region around Jørgen Brønlund Fjord to be good Musk Ox country, due to the dry climate. Presumably great Musk Ox catastrophes never occur here, but in certain periods the climate may be too dry — and the Musk Ox will degenerate — or go south.

The best living conditions for game in Ellesmere Island and North Greenland are considered to exist during the drift-ice pulsation and melting stages, and are created by a rise in precipitation and a consequent good vegetation. O. SVERDRUP saw large herds of Musk Oxen in western Ellesmere Island 1899–1902, and R. E. PEARY saw several in northern Ellesmere Island and North Greenland 1892–1909, the last part of the pulsation stage 1860–1910.

When the Independence peoples visited Peary Land it was most likely during drift-ice pulsation and melting stages.

# SUMMARY

Th. Thoroddsen 1916–17, C. I. H. Speerschneider 1931 and Lauge Koch 1945 demonstrated that the occurrence of East Greenland Ice in Davis Strait and north of Iceland varies strongly with respect to quantity, frequency and time of arrival, and that the advance of the East Greenland Ice in Davis Strait stops at varying northern latitudes.

The present work attempts an understanding of the climatic conditions fundamental to the existence of Arctic animals, determining both their distribution in Greenland and their periodic quantitative fluctuations.

The relative strengths of the Canadian, the East Greenland, and the Irminger Currents in Davis Strait determine the climatic conditions, the kind of production, and the geographical location of the production centre and its stability.

In the years 1810–1960 three different climatic periods can be distinguished, reflecting the three stages of the penetration of the East Greenland Ice into Davis Strait, i.e. 1) the *stagnation stage* 1810–60, 2) the *pulsation stage* 1860–1910, and 3) the *melting stage* 1910–1960?, cf. p. 7; for the time prior to 1800 see p. 95.

During all three drift-ice stages, the time of the year when drift-ice acceleration sets in varied from early to late summer, so that periods of chiefly early drift-ice alternated with periods with fairly late drift-ice, cf. fig. 9.

Early drift-ice must be considered a normal consequence of the arrival of the spring. Thus periods of early drift-ice were not catastrophic for the production in Davis Strait. But drift-ice late in the summer disturbs the normal seasonal rhythm and has a disastrous effect on the production, particularly in periods when the ice drifts far north in Davis Strait (pulsation stages).

In periods when the late drift-ice does not drift far north in Davis Strait (stagnation stages), the winter climate in Davis Strait is influenced mainly by the Canadian Current.

The precipitation is low, which is favourable for the mountain game, as for instance around 1840, a good Reindeer period. But the animal populations of the coast and sea decrease during the cold autumn and winter.

When the late drift-ice advances far north in Davis Strait, the climate in West Greenland is dominated by the East Greenland Current, and the ecological conditions are unstable, which is bad for all animal life in this part of the country, as for instance around 1865–70 and 1895.

In periods when the late drift-ice is scarce in southern Davis Strait, due to the influence of a higher temperature and the absence of drift-ice (melting stage), conditions similar to those of the "stagnation stage" are created but are less extreme. The years around 1940 were such a period, when the precipitation decreased in Southwest Greenland, fig. 22, but not enough to permit a new Reindeer period, and when the Cod fishery declined but still continued.

Drift-ice and cold water arriving late in the summer and advancing far north are the main reason for the catastrophic decline in the populations of Greenland

Whale, Harp Seal, and Eider in Davis Strait during the second half of the 19th century. Late drift-ice is, furthermore, responsible for the Reindeer and Musk Ox catastrophes in Northeast Greenland, and for the fluctuations in the white percentage of Arctic Fox in Greenland.

The ca. 22 year period for late or early drift-ice can be divided into shorter periods, as lighter drift-ice pulsations occur at intervals of about 11 years, 5–6 years, or 3–4 years, i.e. the sun spot period, half, or one third of the sun-spot period. Such periods are also recognized in the Greenlandic animal populations, but the intensity varies in geographically different areas.

The east and west sides of Baffin Bay and Davis Strait constitute one common living space for the sea mammals and certain sea birds of the area.

Their varying distribution is dependent on changing current and drift-ice conditions.

1) In periods with little movement in the drift-ice (stagnation stages) seals and Arctic Eider are mainly distributed on the east side of Davis Strait, and occur in large numbers off central West Greenland, like 1810–60.

2) In periods with large drift-ice advances (pulsation stages, e.g. 1860–1910) abnormal nutrition, breeding and wintering conditions are created, so that the populations partly stagnate and partly are forced north into the Umanak-Upernavik districts. Here, they avoid the areas in Central West Greenland which are influenced by the drift-ice.

3) In periods with small drift-ice occurrence and much Atlantic water in Davis Strait (melting stages), e.g. 1910–(60?), they move north to Melville Bugt and to the north/northwest side of Baffin Bay—and the Cod becomes more numerous in Davis Strait.

The breeding grounds of the **Eider** in West Greenland had its greatest southern extension during the first half of the nineteenth century. After that time the population suffered great losses because of heavy advances of East-Greenland Ice in Davis Strait late in the summer, especially around 1840 and in the long period 1860–1910. During periods with drift-ice late in summer the Eider had better opportunities for breeding in the northern parts of Davis Strait and Baffin Bay than in the south.

The great drop in the population of breeding Eider in Central West Greenland after the middle of the 19th century was caused more by currents and drift-ice conditions than by hunting.

The **Ringed Seals** of Greenland are divided into two large populations; one is associated with the Baffin Bay Ice, and the other with the East Greenland Ice. During the period before and after 1800, with strong movements in the Baffin Bay Ice, there were few Ringed Seals in northern West Greenland south of Melville Bugt. With increasing stagnation of the Baffin Bay Ice after 1817 the number of Ringed Seals began to rise in the central areas of West Greenland toward the north to Umanak, and after 1860, also in Upernavik.

During periods when the East Greenland Ice in Davis Strait made heavy advances late in summer, e.g. 1860–1910, the Ringed Seal of East Greenland followed with the drift-ice in great numbers round Kap Farvel to Julianehåb Bugt. These were presumably mainly young Ringed Seals, unable to winter in the heavy drift-ice on the east coast.

Since 1910, there has been little East Greenland Ice, and this has not advanced very far north into Davis Strait (the drift-ice melting stage). The East Greenland Ringed Seals remain on the east coast, where great numbers occur at Angmagssalik and Scoresby Sund. At the same time, the Ringed Seals of Baffin Bay are most numerous at Upernavik and Thule. Colder winters 1945–60 caused their number to increase once more in the central parts of West Greenland. A new drift-ice stagnation stage is developing.

The **Polar Bear** was on the increase in Northwest Greenland simultaneously with the increase of the Ringed Seal population in West Greenland after 1817. It arrived from the west or north side of Baffin Bay and decreased after 1868.

The Polar Bears of Southwest Greenland arrive via the East Greenland Ice, the greatest number being killed during the mass advances of the drift-ice in the period 1860–1910. Since that time drift-ice masses in Davis Strait have been smaller, and the Polar Bear has preferred to remain in East Greenland and in Svalbard, where hunting is now good. At Angmagssalik and Julianehåb this animal is closely associated with the drift-ice, and in a like manner, occurs in typical 11-year periods.

The **Harp Seal** is very sensitive to changes in biotope. During the great late summer advance of East Greenland Ice in Davis Strait, 1860–1920, the Harp Seal moved away from the central parts of West Greenland, going north to the Umanak district. When the drift-ice advance was arrested it returned. After 1930 it increased in number in the Upernavik and Thule districts, where it used to be rare. To-day the Harp Seal is a frequent winter guest along the coasts of West Greenland (drift-ice melting stage). It occurs in approx. 11-year periods, but often in different areas.

In mild winters the southern migration of the **Narwhal** and **White Whale** through Baffin Bay and Davis Strait is late. They either remain at Disko Bugt, or go west towards Baffin Island, without reaching Southwest Greenland.

During cold periods these whales arrive earlier, and move farther south along the West Greenland coastline before following the edge of the Canadian Current southwest to Baffin Island. The bag at Thule suggests that their migration (or the number of migrating whales) varies in step with drift-ice advances. The occurrence of the White Whale at Sukkertoppen is described by DEGERBØL and NIELSEN 1930.

The largest summering grounds of the **Walrus** are situated between Littleton Ø and Kap York in the northeastern part of Baffin Bay. Some also winter along the edge of the ice at Smith Sund where the sea is always open, owing to currents. Other summering grounds are situated on the northeast coast of Baffin Island. It is assumed that the Walrus from this summer territory often in mild winters occur on the east side of Baffin Bay, from Upernavik to Holsteinsborg, in the coastal area between shore-fast ice and drift-ice. During winters, when the Baffin Bay Ice lies close along the coast of West Greenland, these Walruses cannot stay here, but must cross Davis Strait and go southwest to southern Baffin Island. The migration conditions of the Walrus are still not clearly known.

Like all other Arctic animals, the **Greenland Whale** was very numerous during certain periods and less numerous during others. Its distribution and mass occurrence were determined more by movements in the drift-ice than by persecution from Eskimo and European whalers.

Its preferred summer grounds in the Greenland Sea and Beaufort Sea seem to be situated above the continental slope where the depth of the sea is between 200 m and 1000 m. As long as the drift-ice keeps off this strip or remains scattered, the whale will have good nutrition.

The development of the whaling culture depended on little or no movement in the Arctic Ocean Ice along the north coast of Alaska. In summer the ice melted along the border. The whale was forced to pass through narrow lanes to and from its summer grounds in Beaufort Sea. With such a drift-ice situation, the whale would come within reach of the Eskimo hunters during its spring and autumn migrations. Simultaneously the stagnation of the ice-movements in the Arctic Ocean made it possible for the whale to stay in the Northwest Passage area and northern Baffin Bay. During drift-ice pulsation stages the whale everywhere had limited access to its main feeding grounds and starved.

European whalers captured their largest number of whales on the Svalbard summering grounds during the drift-ice advances, when the animals were forced to remain along the edge of the compact drift-ice, and were consequently very lean. The mass advances of drift-ice late in summer during the period 1860–1920 seriously disturbed the summer and winter biotopes of the Greenland Whale and caused its catastrophic decline during the late 19th century. It became less fertile in the Atlantic area, and at the turn of the century its young were seldom seen.

At the time of the great drift-ice pulsations into the Atlantic during the last half of the 19th century, the old summer grounds of the Greenland Whale northeast of Alaska expanded. Simultaneously American whalers began sea-going whaling in this region.

After 1910 ecological conditions of the Greenland Whale improved (the slowly melting stage). To-day the whale is the object of some whaling during the spring and autumn migration by the Eskimo population of Alaska.

It is seen wintering in Davis Strait, and is occasionally observed in the drift-ice off East Greenland and Svalbard.

The **blue** and the **white Arctic Foxes** differ in so many ways that they are considered to be biological races, each constituting a cline with a wide distribution, and each favoured by specific climatic conditions.

On the coastal biotopes the white percentage may be close to O. On the tundra biotope it may be close to 100.

During stable climatic periods a certain balance exists between the white Arctic Fox of the tundra and the blue Arctic Fox of the coast.

During unstable climatic periods this balance is disturbed, as the climate now favours one biotope and now another, and the drift-ice advance to lower latitudes favours migration. The result is lively bastardation and creation of mixed populations which prevail nearly everywhere in coastal regions to-day.

Owing to the special drift-ice conditions of to-day the blue Arctic Fox (and the mixed populations) in Greenland and Iceland, on Jan Mayen and Svalbard, live under ecological conditions far below optimum.

There is no area in the Atlantic Arctic region that the white Arctic Fox has been unable to reach. Therefore, no coastal biotopes are to be found with a pure population of blue Arctic Fox. In spite of constant cross-breeding between white and blue foxes, owing to immigration into one another's biotopes, the two races do not fuse.

The approximately 11-year maxima in the **Ptarmigan** populations of West Greenland occur during periods with a minimum of days with precipitation in either Northwest or Southwest Greenland.

During the unstable periods of the Atlantic Age, when *we may assume that the drift-ice in Baffin Bay and the Greenland Sea was moving during the winter* owing to current activity, it is improbable that the **Musk Ox** was able to live in the coastal areas of East or West Greenland. Better conditions, however, were available in the protected areas of North Greenland and Ellesmere Island, where the winter humidity from the Atlantic occurred on rare occasions only.

When the colder climate set in, and *Baffin Bay and the Greenland Sea were covered with steady drift-ice*, the winters became sufficiently stable for the Musk Ox to migrate south to continental America and East

Greenland. In West Greenland the Musk Ox reached Melville Bugt on its southern migration. Around 1400 B.C. (see p. 14), Man reached West Greenland. From then on we may presume that further advance was checked by the presence of Man.

The dispersal of the Musk Ox from the north into Northeast Greenland may have occurred several times; i.e., in periods when winter drift-ice covered the Greenland Sea without late-year ice movements. These periods were often interrupted by shorter unstable intervals, caused by the northern advance of the Atlantic climate in the Greenland Sea and a consequently unstable winter climate, unbearable for the Musk Ox. Also the various hunting peoples inhabiting East Greenland may, from time to time, have exterminated the Musk Ox; an animal which, contrary to the Reindeer, is unable to hold its own against Man. It was only when Man became extinct in Northeast Greenland about 1823 that the Musk Ox achieved its present extension and number.

The increase in the Musk Ox population in Northeast Greenland after 1823 was favoured by the stable climatic conditions 1810–60 (the drift-ice stagnation stage). The subsequent unstable climatic period 1860–1910 (the drift-ice pulsation stage) is assumed to have been critical for the Musk Ox, as it was for the Reindeer in Northeast Greenland.

The first half of the melting stage (1910–60) was relatively stable, and for many years the Musk Ox enjoyed plentiful vegetation in winters with few snow catastrophes.

Since 1938/39, the Musk Ox population of Northeast Greenland has been severely damaged by catastrophes occurring at some years intervals, causing the death of many calves and old animals. The Greenland Sea lay open, without drift-ice, during part of the autumn and winter. Consequently great masses of snow fell over Northeast Greenland, alternating with rain and land glaciation, preventing the Musk Ox from reaching its winter food.

The present population of the large **West Greenland Reindeer** is assumed to have immigrated on the drift-ice across Davis Strait from Baffin Island after the Sarqaq period.

In stable and dry climatic periods (drift-ice stagnation stages), e.g. 1810–60, the Reindeer was very abundant in West Greenland (north of Frederikshåb), while in unstable and wet periods (drift-ice pulsation stages), e.g. 1860–1910, it was scarce.

During periods when the Reindeer is numerous in West Greenland, it undertakes seasonal migrations to find areas with little winter precipitation. Foehn storms are favourable for the Reindeer as they uncover the vegetation. In long periods with dry summers and sparse vegetation the Reindeer becomes a "kummerform".

Great quantities of snow and winter rain on the cold mountain prove to be catastrophic. Under such conditions the Reindeer starves and dies in great numbers. However, it does not degenerate as long as sufficient summer food is available.

The decrease in the Reindeer population occurs later north and west of Baffin Bay than in West Greenland.

In the Thule district the decades before 1900 were unfavourable. Pronounced winter precipitation reduced the Reindeer population — as in the countries around the Northwest Passage, where a wet winter climate from Baffin Bay advances in periods. Reindeer catastrophes in Canada gave rise to the emigration of Wolves to Greenland. A subsequent difficult period in Northeast Greenland caused the Wolf to become a dangerous enemy to the degenerate Reindeer (*R. t. eogroenlandicus* DEGERBØL), and contributed to its extinction around 1900, while the Musk Ox survived and enjoyed the advantage of a long succession of years with ample vegetation and good conditions for wintering during the 1920's and 1930's.

# RESUMÉ

Af undersøgelser foretaget af TH. THORODDSEN 1916–17, C. I. H. SPEERSCHNEIDER 1931 og LAUGE KOCH 1945 fremgår det, at Østgrønlandsisen optræder i Davisstrædet og ved Island i stærkt varierende mængde og hyppighed og til varierende årstid, og at den i Davisstrædet trænger nordpå til varierende breddegrad. I nærværende arbejde gøres et forsøg på at nå frem til en forståelse af de klimatiske forhold, der er grundlæggende for de arktiske dyrs eksistens, og som bestemmer disses udbredelse og periodiske mængdesvingninger i Grønland.

Styrkeforholdet i Davisstrædet mellem Den Canadiske Strøm, Den Østgrønlandske Strøm og Irmingerstrømmen spiller en afgørende rolle for klimaets beskaffenhed, produktionens art og produktionscentrets geografiske beliggenhed og stabilitet.

I perioden 1810–1960 kan der skelnes mellem tre forskellige klimaperioder, der kendetegnes ved forskellige stadier i Østgrønlandsisens fremtrængen i Davisstrædet: 1) Stagnationsstadiet 1810–60, 2) Pulsationsstadiet 1860–1910 og 3) Bortsmeltningsstadiet 1910–1960?, se p. 8; for tidsrummet før 1800 se p. 95–98.

Gennem alle drivisstadier har årstiden for accelerationen i drivisen varieret fra tidligt til sent på sommeren, således at en periode med fortrinsvis tidlig drivis ca. 11 år senere er blevet afløst af en periode med fortrinsvis sen drivis, se fig. 9.

Tidlig drivis må betragtes som en normal følge af forårets komme. Perioder med tidlig drivis har derfor ikke været katastrofale for produktionen i Davisstrædet. Drivis sent på sommeren bryder derimod årstidernes normale rytme og kan virke meget ødelæggende på produktionen, især når isen driver langt nordpå i Davisstrædet.

I tilfælde, hvor den sene drivis ikke driver langt nordpå i Davisstrædet (stagnationsstadiet), er vinteren i Davisstrædet i væsentlig grad under indflydelse af Den Canadiske Strøm. Vinternedbøren bliver ringe, hvilket er til gavn for fjeldets dyr, som f. eks. omkring 1840, der var en god renperiode. Men kystens og havets dyr lider da svære tab i kolde efterår.

I de tilfælde, hvor den sene drivis trænger langt nordpå i Davisstrædet, bliver klimaet i Vestgrønland domineret af Den østgrønlandske Strøm, og de økologiske forhold bliver ustabile til skade for alt dyreliv i denne del af landet, f. eks. omkring 1865–70 og 1895.

I de tilfælde, hvor den sene drivis er ringe i Davisstrædet på grund af mindre drivismasse (bortsmeltningsstadiet) opstår lignende forhold som under "stagnationsstadiet", men mindre udslagsgivende, f. eks. omkring 1940, hvor nedbøren aftog i Sydvestgrønland, fig. 22, men ikke nok til at fremkalde en ny ren-periode, og hvor torskefiskeriet gik tilbage, men ikke ophørte.

Det er især de ustabile tilstande som følge af drivisens forøgede fremtrængen sent på sommeren, der har været årsag til grønlandshvalens og ederfuglens katastrofale tilbagegang i sidste halvdel af det 19. århundrede i Davisstrædet og til svingningerne i polarrævens hvid-procent i Vestgrønland – ligesom den i Nordøstgrønland har været årsag til ren- og moskusoksekatastroferne i dette århundrede.

Den ca. 22-årige periode for sen eller tidlig drivis kan deles i mindre perioder, idet mindre isfremstød fremkommer med intervaller på ca. 11 år, 5–6 år eller 3–4 år, d.v.s. solpletperioden, halvdelen af denne eller en trediedel af denne. Lignende perioder genfindes i de grønlandske dyrepopulationer, men udslagene er forskellige i forskellige områder.

Østsiden og vestsiden af Davisstrædet og Baffin Bugt udgør et samlet livsrum for områdets søpattedyr og visse søfugle. Disses skiftende udbredelse er afhængig af vekslende strøm- og drivisforhold.

1) I perioder med ringe bevægelse i drivisen (stagnationsstadier) har sæler og ederfugle fortrinsvis en central udbredelse på østsiden af Davisstrædet—med store forekomster ved Grønland, f. eks. 1810–60.

2) I perioder med store drivisfremstød (pulsationsstadier) opstår unormale ernærings-, yngle- og overvintringsforhold, hvilket bevirker, at populationerne dels stagnerer, dels tvinges mod nord op i Umanak-Upernavik distrikterne udenfor de af drivisen påvirkede områder i Vestgrønland, f. eks. 1860–1910.

3) I perioder med ringe drivismasse og meget atlantisk vand i Davisstrædet (bortsmeltningsstadier) rykker de op i Melville Bugt og til nord-nordvestsiden af Baffin Bugt—og torsken rykker op i Davisstrædet i større mængde f. eks. 1910–(60?).

**Ederfuglens** ynglefelt havde den største udstrækning i Central-Vestgrønland i første halvdel af det 19. århundrede. Bestanden led svære tab under Østgrønlandsisens fremstød i Davisstrædet sent på året omkring 1840 og især i perioden 1860–1910. Under den sene drivis klarede ederfuglen sig bedre i de nordlige dele af Davisstræde og Baffin Bugt end sydpå. Den store nedgang i Central-Vestgrønlands bestand af ynglende ederfugle efter midten af det 19. århundrede må tillægges strøm- og drivisforholdene i langt højere grad end jagten.

Grønlands **ringsæler** deler sig i to store bestande, der er knyttet til henholdsvis Baffinbugtisen og Østgrønlandsisen. I perioden før og efter 1800 med stærk drift i Baffinbugtisen var der få ringsæler i nordlige

Vestgrønland syd for Melville Bugt. Med tiltagende stagnation i Baffinbugtisen efter 1817 begyndte ringsælerne at tiltage i de centrale dele af Vestgrønland mod nord til Umanak og efter 1860 også i Upernavik.

I perioder med store fremstød af Østgrønlandsisen i Davisstrædet sent på sommeren, f. eks. 1860–1910, fulgte Østgrønlands ringsæler i stort tal med drivisen rundt Kap Farvel til Julianehåb Bugt. Det må antages mest at have været unge ringsæler, der ikke kunne overvintre i den svære drivis på østkysten.

Efter 1910 har Østgrønlandsisen kun haft ringe ekspansion op i Davisstrædet (bortsmeltningsstadiet, hvorfor de østgrønlandske ringsæler forbliver på Østkysten, hvor de optræder talrigt ved Angmagssalik og Scoresbysund. Samtidigt er Baffin Bugts ringsæler talrigest repræsenteret ved Upernavik og Thule. 1945–60 bevirkede koldere vintre, at ringsælen igen begyndte at tiltage i de centrale dele af Vestgrønland. Et nyt drivisstagnationsstadie er under udvikling.

**Isbjørnen** begyndte at tiltage i Nordvestgrønland samtidigt med ringsælbestandens tiltagen efter 1817, hvor de stærke bevægelser i Baffin Bugts drivis ophørte. Den ankom fra vest- eller nordsiden af Baffin Bugt og var i tiltagen indtil ca. 1865, derefter i aftagen.

Sydvestgrønlands isbjørne kommer med Østgrønlandsisen og er blevet fanget i størst mængde under dennes massefremstød i Davisstrædet i perioden 1860–1910. Derefter har drivismasserne i Davisstrædet været mindre, og isbjørnene er fortrinsvis forblevet i Østgrønland og på Svalbard, hvor der nu er god fangst af disse dyr. Ved Angmagssalik og Julianehåb er isbjørnen nøje knyttet til drivisen og optræder ligesom denne i typiske 11-årige perioder.

**Grønlandssælen** er som alle arktiske dyr meget følsom overfor klimatiske ændringer i biotopen. Under det store fremstød sent på sommeren af Østgrønlandsisen i Davisstræde 1860–1910 trak den bort fra de centrale dele af Vestgrønland og gik nordpå til Umanak distriktet. Da drivisens fremstød ophørte, vendte den tilbage igen. Efter 1930 tiltog dens antal i Upernavik og Thule distrikterne, hvor den tidligere var sjælden. I nutiden er den en hyppig vintergæst langs kysterne af Vestgrønland. Den optræder i ca. 11-årige perioder, der som regel er geografisk forskudte i forhold til hinanden.

**Narhvalens** og **hvidhvalens** sydgående efterårstræk gennem Baffin Bugt og Davisstræde foregår sent i milde vintre, og hvalerne standser da ved Disko Bugt, eller de går vestover mod Baffin Island uden at nå ned til Sydvestgrønland.

I kolde perioder (stagnationsstadier) kommer de tidligere og trækker længere sydover langs kysten af Vestgrønland, før de følger randen af Den Canadiske Strøm mod sydvest til Baffin Island. Fangsterne ved Thule tyder på, at deres træk (eller talrighed) varierer i takt med drivisfremstødene. Hvidvalens forekomst ved Sukkertoppen er beskrevet af Degerbøl og Nielsen 1930.

**Hvalrossens** vigtigste sommerfelt ligger i den nordøstlige del af Baffin Bugt mellem Littleton Ø og Kap York, der ligeledes er et vigtigt vinterfelt takket være den altid åbne klaring i Smith Sund. Et andet sommerfelt ligger på nordøstkysten af Baffin Island. Det formodes at være hvalrosser fra dette felt, der i milde vintre træffes på østsiden af Baffin Bugt mellem Upernavik og Holsteinsborg i kystområdet mellem fastisen og drivisen udenfor. I vintre, hvor Baffinbugtisen ligger tæt langs den grønlandske kyst, tvinges disse hvalrosser bort. De formodes da at krydse Davisstrædet mod sydvest til det sydlige Baffin Island. Trækforholdene er stadig uafklarede.

Ligesom alle andre arktiske dyr har også **grønlandshvalen** i visse perioder været meget, i andre perioder mindre talrig. Dens geografiske udbredelse og masseoptræden har været betinget af bevægelserne i drivisen i langt højere grad end af eskimoernes og europæernes hvalfangst.

Dens vigtigste sommerfelter i Grønlandshavet og Beaufort Havet synes at ligge langs randen af kontinentalsoklen over 200 til 1000 meters dybde. Så længe drivisen ligger indenfor denne grænse eller holder sig spredt, har hvalen gode ernæringsmuligheder.

Hvalfangerkulturens udvikling ved Alaska var betinget af ringe bevægelse i Polhavets drivis, der om sommeren overvejende smeltede langs randen, hvorved hvalen blev tvunget til at passere gennem snævre revner langs kystisen til og fra sommerfeltet i Beaufort Havet. Herved kom den indenfor eskimoernes rækkevidde under forårs- og efterårstrækket. Stagnationen i Polhavets drivisbevægelser muliggjorde det samtidigt for grønlandshvalen at opholde sig i Nordvestpassage området og i den nordlige Baffin Bugt. Under drivis pulsationsperioder havde hvalen derimod allevegne begrænset adgang til sine vigtigste sommerfelter og sultede.

På sommerfelterne ved Spitsbergen opnåede de europæiske hvalfangere de største fangster i de store drivisperioder, hvor hvalen blev tvunget til at opholde sig udenfor iskanten. Den var da mager. Det var drivisens massefremstød sent på sommeren i perioden 1860–1910 og dennes ødelæggelse af sommer- og vinterbiotoperne i Grønlandshavet og Davisstrædet, der forårsagede grønlandshvalens katastrofale tilbagegang i sidste halvdel af det 19. århundrede. Dens formeringsevne nedsattes i det atlantiske område. I årtierne omkring 1900 var unger sjældne.

Samtidigt med de store udbrud af drivis i Atlanterhavet i sidste halvdel af forrige århundrede udvidedes grønlandshvalens gamle sommerfelter i det vestlige Polhav nordøst for Alaska, hvor fangsten optoges af den søgående amerikanske hvalfangerflåde.

Siden 1910 er grønlandshvalens økologiske forhold langsomt bedret. Den er genstand for nogen fangst fra den eskimoiske befolkning ved Alaska under forårs- og efterårstrækkene. Den ses overvintrende i Davisstrædet og ses nu og da om sommeren ved Østgrønland og Svalbard, men sommerfeltet udfor Nordøstgrønland er stadig lukket af drivisen.

**Den blå** og **den hvide polarræv** er forskellige på så mange måder, at de må betragtes som to biologiske racer, der hver for sig udgør en klin med en stor udbredelse, begunstiget af hver sine særegne klimaforhold.

På kystbiotoperne nærmer hvidprocenten sig 0. På tundrabiotoperne nærmer den sig 100.

Under stabile klimaperioder vil der herske en vis ligevægt mellem tundraens hvide og kystens blå populationer. Under ustabile klimaperioder forrykkes denne ligevægt, idet klimaet da snart begunstiger den ene, snart den anden biotop, ligesom drivisens fremtrængen til lavere breddegrader begunstiger vandring. Resultatet bliver livlig bastardering og opståen af blandede populationer, der idag er fremherskende næsten overalt i kystområderne.

På grund af de særlige drivisforhold i nutiden lever den blå polarræv (og blandingspopulationerne) overalt i Grønland og Island, på Jan Mayen og Svalbard under økologiske forhold, der ligger langt under optimum.

Der findes ingen steder i det atlantiske område, hvor den hvide tundraræv ikke har kunnet nå hen. Der findes derfor heller ingen kystbiotoper med en ren blårævepopulation. Til trods for stadig bastardering mellem hvide og blå polarræve ved indvandring til hinandens biotoper smelter de ikke sammen.

De ca. 11-årige maxima i **rype**-populationerne i Vestgrønland forekommer i perioder med minimum af nedbørsdage i enten Nordvest eller Sydvestgrønland.

I de urolige perioder af atlantisk tid, hvor *drivisen i Baffin Bugten og Grønlandshavet må antages at have været i drift om vinteren* på grund af større strømbevægelser, er det usandsynligt, at **moskusoksen** har kunnet leve i kystområderne af Øst- eller Vestgrønland, mens den har haft bedre livsbetingelser i de beskyttede områder af Nordgrønland og Ellesmere Island, hvor fugtigheden fra Atlanterhavet sjældent når hen, og hvor ca. fire måneders mørketid virker stabiliserende på vinterklimaet.

Med indtræden af et koldere klima og med aftagende bevægelser i *Baffin Bugts og Grønlandshavets drivis* blev vintrene tilstrækkeligt stabile til, at moskusoksen kunne vandre sydover til det kontinentale Amerika og Østgrønland. På sin vandring mod syd i Vestgrønland nåede moskusoksen på et eller andet tidspunkt frem til Nordkysten af Melville Bugt. Mennesket nåede frem til Vestgrønland ca. 1400 B.C., se p. 14. Fra da af må vi regne med, at menneskets tilstedeværelse i de for indvandring gunstige perioder var en væsentlig hindring for moskusoksens erobring af Vestgrønland.

Moskusoksens spredning fra nord ned i Nordøstgrønland kan være sket flere gange og da i perioder, hvor vinterdrivisen har haft en solid udstrækning over Grønlandshavet (uden isdrift sent på året). Den kan da være blevet udryddet igen i perioder med stærk isdrift i Grønlandshavet og et deraf følgende ustabilt vinterklima. Også de forskellige jægerfolk, der har beboet Østgrønland, kan periodevis have udryddet moskusoksen, idet denne i modsætning til renen har vanskeligt ved at hævde sig overfor mennesket. Først da mennesket bukkede under i Nordøstgrønland ca. 1823, kunne moskusoksen opnå sin nuværende udbredelse og talrighed.

Populationsforøgelsen var begunstiget af de stabile klimaforhold, der herskede under "drivis-stagnationsstadiet" 1810–60. Den efterfølgende ustabile klimaperiode 1860–1910, "drivis-pulsationsstadiet", må antages at have været lige så kritisk for moskusoksen, som den var det for renen i Nordøstgrønland.

I første halvdel af bortsmeltningsstadiet (1910–60) herskede et relativt stabilt klima i Nordøstgrønland, under hvilket moskusoksen gennem mange år nød godt af rigelig vegetation i vintre med ringe snedække og uden større overinsings-katastrofer.

Siden 1938/39 har **moskusoksebestanden** i Nordøstgrønland med nogle års mellemrum været ramt af alvorlige katastrofer med store tab af kalve og gamle dyr. Årsagen har været, at Grønlandshavet har ligget åbent (uden drivis) en del af efteråret. Dette har bevirket, at store snemængder er faldet over Nordøstgrønland, afvekslende med regn og overisning af landet, så moskusoksen ikke kunne nå ned til vinterføden.

Den nuværende store, **vestgrønlandske ren** formodes indvandret til Vestgrønland efter Sarqaqtiden og eventuelt direkte fra Baffin Island over Davisstrædet.

I stabile og tørre klimaperioder (drivis-stagnationsstadier), f. eks. 1810–60, er renen meget talrig i Vestgrønland. Den udfører da sæsonvandringer, idet den opsøger områder med mindre vinterfugtighed. Føhnvinde er gavnlige for den, idet de om vinteren får sneen til at fordampe eller smelte, så vegetationen bliver tilgængelig. I langvarige klimaperioder med tørre somre og sparsom vegetation bliver renen en "kummerform".

I ustabile og fugtige klimaperioder (drivis-pulsationsstadier), f. eks. 1860–1910, er renen fåtallig i Vestgrønland. Den sulter om vinteren på grund af megen sne og regn på koldt fjeld og deraf følgende overisning af kystlandet. Den kan da omkomme i stort tal, men den degenererer ikke, så længe der er føde nok om sommeren.

Nord og vest for Baffin Bugt kommer nedgangsårene senere end i Vestgrønland. Årtierne før 1900 var ugunstige i Thule distriktet på grund af megen vinternedbør, hvorunder renerne led store tab. Det samme skete i landene omkring Nordvestpassagen, hvor et fugtigt vinterklima fra Baffin Bugt periodevis har indpas.

De canadiske renkatastrofer gav stødet til udvandring af **ulve** fra Canada til Grønland. I en klimatisk vanskelig periode for den stærkt degenererede ren (*R. t. eogroenlandicus* DEGERBØL) i Nordøstgrønland blev ulven en farlig fjende for denne og bidrog til dens udryddelse omkring år 1900, mens moskusoksen klarede sig og siden nød godt af en lang række år med gode vegetations- og overvintringsforhold i 1920-erne og 1930-erne.

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Færdig fra trykkeriet den 6. september 1967.