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The Atlantic walrus (*Odobenus rosmarus rosmarus*) in West Greenland

*Erik W. Born, Mads P. Heide-Jørgensen
and Rolph A. Davis*



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The Atlantic walrus (*Odobenus rosmarus rosmarus*) in West Greenland

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In the early part of the 20th century Atlantic walrus (*Odobenus rosmarus rosmarus*) occurred abundantly between approximately 66°N and 70°45'N in Central West Greenland from September until mid June. Between September and December several hundred walrus were hauled out on small islands and promontories between the entrance to Nassuttooq (Nordre Strømfjord, approx. 67°30'N) and approximately 67°45'N, south of the settlement of Attu. From 1911, the hunt for walrus at terrestrial haul out sites was intensified, and by the late 1930s the walrus had abandoned the terrestrial haul outs in this area. Between 1911 and the early 1940s, the catches of walrus in western Greenland (excluding the Avanersuaq/Thule area) increased rapidly, reaching a maximum of more than 600 animals reported for 1938 and 1940. Mainly reproductive females were caught and the proportion of unretrieved kills was high. Between the early 1940s and the mid 1960s catches decreased rapidly, apparently reflecting a decrease in the stock of walrus wintering off Central West Greenland. Between 1965 and 1987, the recorded annual catch in western Greenland south of 76°N averaged 56 walrus (SD = 19.7; range 19–101 animals). It is estimated that during this period the total number of walrus removed by hunting was about 100 per year. Comparisons of the results of systematic aerial surveys conducted in early spring of 1981, 1982, 1984, 1990 and 1991 over the walrus wintering grounds at Central West Greenland revealed no trend in abundance. The line transect methods used in the 1990 and 1991 surveys gave higher and more robust estimates of abundance than the strip censuses used in the previous surveys, and resulted in estimates of abundance of about 500 walrus (not corrected for submerged animals). The stock structure of the total walrus population in the Baffin Bay and Davis Strait regions is obscure. However, this study has shown that the numbers of walrus in Central West Greenland are much lower than historical levels, and that walrus in this area are vulnerable.

Key words:

Atlantic walrus, *Odobenus rosmarus*, West Greenland, distribution, catch, aerial surveys, line transect.

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Introduction

Although Atlantic walrus (*Odobenus rosmarus rosmarus*) have occasionally been observed along the entire coast of western Greenland from approximately 60°N (Winge 1902) to 81°45'N (Greely 1888), two areas of concentration have been identified: (1) the Avanersuaq (Thule) area in Smith Sound and northern Baffin Bay, where they occur year round (Vibe 1950, Finley & Renaud 1980) and (2) the shallow banks along the coast of Central West Greenland between approximately 66°N

and 70°45'N where they occur mainly in winter and spring (Freuchen 1921, Vibe 1956). Although the degree of mixing between the walrus in these two concentration areas remains basically unknown, the two groups have geographically disjunct winter distributions and very different catch histories. Thus it seems reasonable to evaluate their status separately. In Central West Greenland, the increased catches of walrus from about 1911 until about 1940 (Vibe 1956) apparently resulted in a rapid decline in the wintering stock (Vibe 1956, Mansfield 1973). Winge (1902), Freuchen (1921), Vibe (1956), Reeves (1978) and Born (1990 a) present information on

Table 1. Overall weather conditions recorded at flight level during aerial surveys of walrus in western Greenland, 1981–1991.

Period	Temperature °C	Wind force m/s
17–24 March 1981	– 2 to – 9	14–19
10–24 March 1982	– 9 to –30	3–19
24–31 March 1984	–12 to –19	15–19
9–14 April 1990	– 5 to –13	10–20
19–24 March 1991	– 7 to –24	10–20

the distribution and abundance of walrus in western Greenland. In this paper, we review the historical and recent distribution, abundance and catches of walrus in western Greenland south of approximately 76°N (excluding the Avanersuaq/Thule area). Estimates of abundance obtained from systematic aerial surveys conducted in April 1990 and in March 1991 over the walrus wintering grounds in Central West Greenland are presented and compared to estimates of abundance from the early 1980s.

Materials and methods

Information on distribution and catch

Information on the historical and present distribution of walrus in western Greenland was obtained from both published and unpublished written sources, and through interviews with residents of Central West Greenland. In 1982 residents of Kangerluk (Diskofjord), Qeqertarsuaq (Godhavn), Kitsissuarsuit (Hunde Ejland), Kangaatsiaq and Sisimiut (Holsteinsborg) (Figs 1–2) were interviewed about catch and distribution of walrus. In 1988, a similar survey was carried out in Kangerluk and Qeqertarsuaq by Erling Josefsen (Greenland Home Rule, Department of Wildlife). In 1985 and 1990, respectively, Rune Dietz (Greenland Environmental Research Institute, Copenhagen) and Aqqalu Rosing-Asvid (Greenland Fisheries Research Institute, Copenhagen) interviewed the hunters of the Upernavik area. Miscellaneous information concerning walrus was obtained during the authors' stay in the Upernavik and Sisimiut areas in 1988–1990. A questionnaire survey of hunters and other residents in western Greenland resulted in the completion of 32 forms from Aasiaat, Sisimiut, Ikerasaarsuk and Maniitsoq containing information on observations and catches of walrus in 1988 and 1989. In 1988 and 1989, questionnaires were distributed to the major fishing companies and fishing organizations in Central West Greenland. Three completed forms were returned. Information on catches since 1954 was extracted from the summarized Greenland Hunters Lists of Game, HLG (Anon. 1954....1987; for

explanation of HLG *cf.* Kapel 1975) which were published annually by the Ministry for Greenland (Copenhagen) between 1954 and 1984. For the period 1985–1987, information on catch of walrus was obtained from the unpublished summaries of the HLG compiled by the Greenland Home Rule (Nuuk). Miscellaneous information on walrus, for example catch, occurrence and trade in walrus products, was extracted from Meddelelser fra Direktoratet for den Kongelige Grønlandske Handel, Beretninger og Kundgørelser fra Grønlands Styrelse and Grønlands Landsråds Forhandlinger (1899 1990) which are published annually.

In the annual reports (Beretninger og Kundgørelser fra Grønlands Styrelse), walrus hides purchased by the Royal Greenland Trade Department (KGH) were given as the actual number of hides (in some cases also number of half hides) from 1908/09 until 1939, whereafter the total amount of hides traded was given by weight. Information from five years for which both the number and total weight of hides are presented indicates that the average mass of a hide was about 70 kg (655 hides = 46200 kg). However, the average hide mass varied between 48 kg and 92 kg over the years (Source: Anon. 1934, 1935, 1936 a, 1950, 1954). To obtain the number of hides traded in years where only total weight of hide was given, we applied a conversion factor of 70 kg per hide.

Ages of a few walrus sampled from the Inuit subsistence catch in Central West Greenland (1982–1984) were estimated by counting annual layers in the cementum of 200 µm thick longitudinal sections prepared from lower molariform teeth, as described by Mansfield (1958).

Aerial surveys

Survey areas

Systematic aerial surveys over the walrus wintering grounds in Central West Greenland were conducted in March 1981, 1982, 1984 and 1991 and in early April 1990 (Figs 6–8; later). Between 17 and 24 March 1981, surveys were conducted between 65°N and 70°N and between 56°30'W and the western coast of Greenland. In 1982, two surveys were conducted: In the period 10–20 March 1982, surveys were flown from 63°N to 69°N and between 56°W and the western coast of Greenland. Between 21 and 24 March 1982, the areas between 66°N and 69°30'N, and between the coast and 56°W were surveyed. In both periods, the surveys along the western coast of the island of Disko (Qeqertarsuaq) were designed as reconnaissances. In the period 29 to 31 March 1984, the ice covered waters between 66°15'N and 70°10'N and between 56°W and 54°W were surveyed. On 24 March a reconnaissance was flown between 66°N and 70°30'N along 55°W and 55°30'W. In 1990, the areas from 66°30'N north to 71°30'N, and between 56°W and the western coast of Greenland were surveyed systematically on 9, 10 and 14 April. In 1991 the areas between 66°30'N

Table 2. Summary of survey timing, equipment and procedures during aerial surveys of walrus in western Greenland, 1981–1991.

Period	Type of aircraft	Navigation	Altimeter	Altitude (m)	Speed (km/h)	Observer stations
17–24 March 1981	deHavilland Twin Otter	GNS-500 Global Navigation	Radar	150	222	R. front and L. rear
10–24 March 1982	deHavilland Twin Otter	GNS-500 Global Navigation	Radar	150	222	R. front and L. rear
24–31 March 1984	Piper Navajo PA-31	VHL-Omega Navigation	Radar and barometric	250	220	R. and L. rear
9–14 April 1990	Partenavia Observer PN-68	TransPak Global Positioning	Radar and barometric	229	203	Bubble windows R. and L. rear seat
19–24 March 1991	Partenavia Observer PN-68	TransPak Global Positioning	Radar, barometric and GPS	213	156	Bubble windows R. and L. rear seat

and 70°15'N, and between 56°W and the western coast of Greenland were surveyed on 19, 20, 23 and 24 March.

Survey procedures

Overall weather conditions recorded at flight level during the surveys are summarized in Table 1. Information on ice conditions was obtained from NOAA satellite images provided by the Danish Meteorological Institute.

The type of aircraft, navigation equipment, target altitude and speed varied between surveys (Table 2).

The surveys in 1981, 1982 and 1984 were designed as strip censuses, whereas line transect methods were applied in 1990 and 1991.

In 1981 and 1982, the width of the strips was 1600 m, with 800 m on each side of the flight track. Inclinerometers were used to determine, and periodically verify, the accuracy of the transect width. Two observers each recorded into portable tape recorders all sightings of marine mammals counted both on transect (within 800 m of the flight track) and off transect. There was a 200 m wide "blind zone" directly beneath the aircraft. This blind zone was excluded from the transect width in all calculations. Information on sightings included numbers, group and age structure, sex, behavior, and associated remarks about position and time of sighting, habitat, sea and ice conditions, and visibility.

In 1984 the lightning conductors on the trailing edge of the wings of the low-winged Piper Navajo were used for subdividing each half-strip width: Zone 1 closest to the flight track was from 180 m to 630 m from the track line (half strip width: 450 m), zone 2 was from 630 to 1300 m (width: 670 m), and zone 3 was from 1300 m to 2620 m (width: 1320 m). In 1984, the same type of information as obtained in 1981 and 1982 was recorded by each observer on data sheets.

In 1990 and 1991 observations of walrus were made from each of the bubble windows mounted on each side of the aircraft, whereas observations of weather and ice conditions were recorded by the pilot (Table 2). The observers and the pilot recorded their observations on independent tape recorders. When activated, the tape recorders received a synchronized time signal from an

Epson HX-100 computer. During playback of the tapes, the time signals tagged the observations. The bubble windows allowed the observers to make observations of animals on the track line straight below the aircraft. Perpendicular angle to all walrus groups was measured by inclinometer when passing abeam. Rounding off of inclinometer angles was purposely avoided. Distance to the observations from the track line was calculated from:

$$\text{distance} = \text{altitude} \cdot \tan(90 - \text{angle}) \quad (1)$$

Visibility and sea state were also recorded, and surveys were aborted when the sea state exceeded 5 (Beaufort scale). The surveys were carried out by the same observers sitting in the same seats, and the same pilot in both years.

Analysis of aerial survey data

For calculations of densities in 1981 and 1982, only walrus on the transect (*i.e.* observed between 100 and 800 m from the track line) were included (total strip width = 1400 m), and for 1984 only observations made in the inner zone were included (total strip width = 900 m). For comparative reasons, similar estimates of densities were calculated for 1990 and 1991 assuming a half-strip width from 100 to 800 from the flight track (total strip width: 1400 m). For these years, estimates of abundance were also calculated assuming a total strip width of 1000 m (from 0 to 500 m on each side of the flight track).

Strip census estimates of density, abundance and their associated variances in 1981, 1982 and 1984 were calculated using the ratio method described by Caughley & Grigg (1981) for transects of unequal length. Strip census estimates for 1990 and 1991 followed methods described for surveys with transects of equal length (*ibid.*).

Line transect estimates of the densities of walrus were carried out based on theory and techniques described in Burnham *et al.* (1980). For the calculation of the probability detection function, $f(x)$, and its associated empirical variance, we used the computer package "Distance" developed by Laake *et al.* (1991). Perpendicular distances to groups of walrus were truncated at a maxi-

mum strip width of 1000 m (W), and sightings within 200 m from the flight track were omitted. The 1-term cosine Fourier series model (the linear combination of a series of cosine functions):

$$g(x) = 1/W + a \cdot \cos(\pi \cdot x / W) \quad (2)$$

was chosen to fit the perpendicular distances and scaled to integrate to 1 to derive the $f(x)$ which was evaluated at $f(0)$ to obtain the Effective Search half-Width (ESW).

The goodness of fit of the probability functions was tested by calculating the chi-square distance between the observed and the expected values for data pooled at intervals of 100 m.

The mean group size was used to calculate the actual density of walruses, and the estimate of the density of walruses, D , is:

$$D = \frac{N \cdot f(0) \cdot C}{2 \cdot L} \quad (3)$$

where N is the number of sightings of groups, C is the mean group size and L is the linear distance (in km) that was searched. Empirical variances of $f(0)$, N and C were calculated following Burnham *et al.* (1980) and Laake *et al.* (1991).

Stratum variance of walrus density and abundance was estimated according to Burnham *et al.* (1980):

$$\text{var}(D) = D^2(\text{CV}(f(0))^2 + \text{CV}(N)^2 + \text{CV}(C)^2) \quad (4)$$

where CV is the coefficient of variation calculated as the standard error in proportion to the mean.

In order to avoid negative lower confidence limits it was assumed that D has a log normal distribution and 95% confidence intervals were constructed using the method developed by Burnham *et al.* (1987) where the lower and upper confidence limits are D/V and $D \cdot V$, respectively, and:

$$V = \exp[1.96 \sqrt{\{\text{var}(\ln D)\}}] \quad (5)$$

where

$$\text{var}(\ln D) = \ln[1 + \text{var}(D)/D^2] \quad (6)$$

Due to the low number of observations, we pooled the sightings of walruses by stratum and year to achieve a more robust probability detection function for calculating estimates of abundance in 1990 and 1991. The same procedure was used when calculating the mean group size. Pooling of data by year and strata for calculating a common $f(0)$ and mean group size, C , is justified by the use of the same observers in both years.

The goodness of fit of the hazard rate, the half-normal, the negative exponential and the uniform model (Fourier series) on the perpendicular distance data was tested on

the observation data between 200 m and 1000 m. The uniform model gave the best fit of the distance data according to chi-square statistics and it also gave the lowest coefficient of variation of $f(0)$. It was therefore chosen for the density estimations.

Stratification

For calculations of the abundance of walruses, densities were extrapolated to two areas which include most of the suitable walrus habitats in Central West Greenland: 1) a southern area (Sisimiut-Aasiaat) between 66°15'N and 68°15'N, and 54°30'W and 56°00'W (Total = 14323 km²); 2) and a northern area (west of Disko) between 69°30'N and 70°30'N, and 55°00'W and 56°00'W (Total = 4794 km²). These strata (Fig. 6 A; later) include about 95% of all walrus sightings made during the surveys in 1981–1991. In 1981 and 1982 the northern stratum was not surveyed systematically, hence for these two years estimates of number of walruses within this stratum were obtained by simple extrapolation of walrus densities on survey track to total stratum area.

Results

The occurrence of walruses in western Greenland south of 76°N before and after 1975 is described by area from south to north.

Distribution before 1975

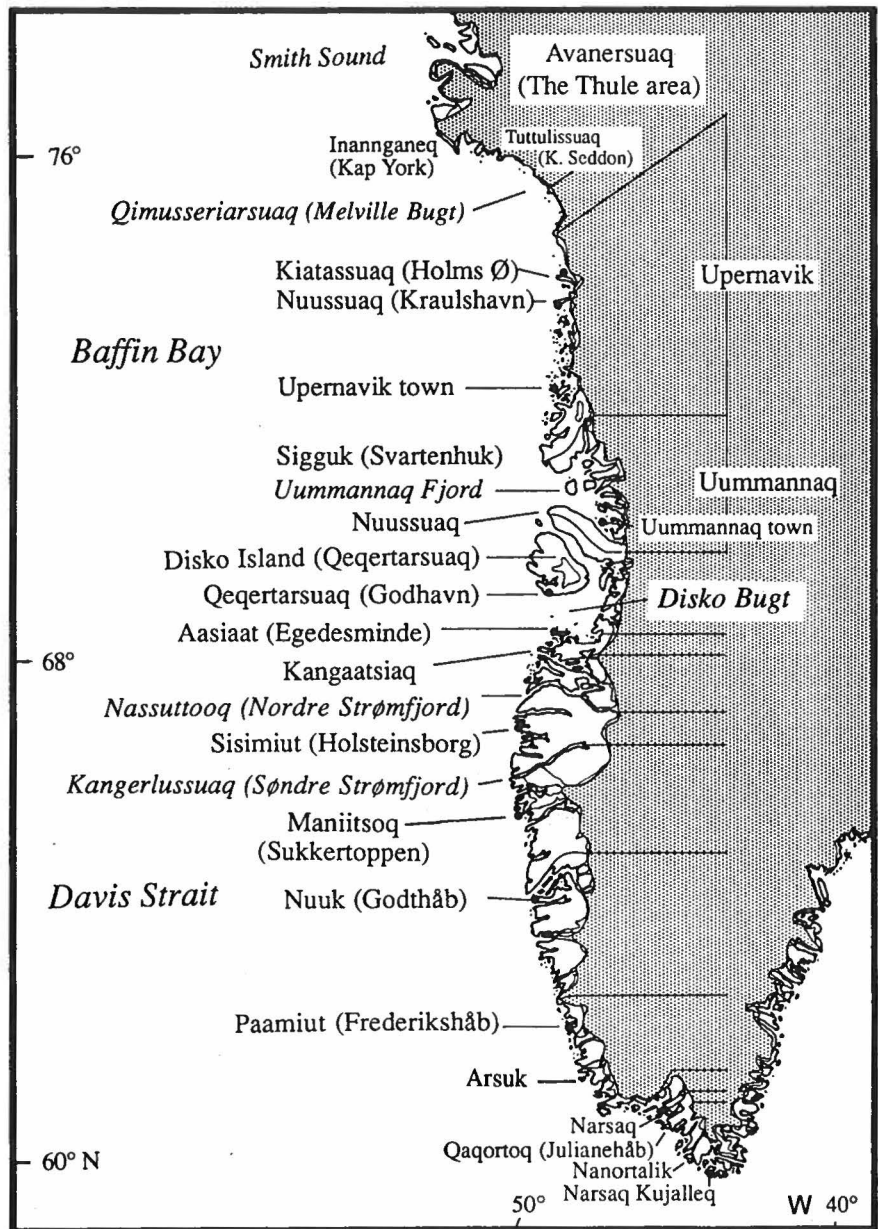
Southwestern Greenland, south of Maniitsoq (Sukkertoppen)

Walruses have never been common in southwestern Greenland but stragglers occasionally were reported from this area (Müller 1906). Winge (1902) reported the observation of a walrus near Nanortalik in the winter of 1828–29 and near Narsaq Kujalleq (Frederiksdal, Fig. 1) in 1880. Stragglers were sometimes observed in fall near Kangeq, at the entrance of Nuup kangerlua (Godthåbsfjord, Fig. 2), and they have also been reported to haul out on land at Aarfiorfik west of the sound of Nipisat and at Kaarusuk (Fig. 2; Bendixen & Bobé 1921a). In 1924, a walrus was observed in the Nuup kangerlua (Oldendow 1935).

The Maniitsoq – Aasiaat area (approx. 65°30'N to approx. 68°30'N)

Walruses occurred regularly near the West Greenland coast between Aqissemiaq (south of Attu, Fig. 2) and Kangaamiut (approx. 65°50'N; Birket-Smith 1924). Between November and April–May they occurred along the coast between Kangaamiut and Illutalik (Fig. 2). In the

Fig. 1. Map of western Greenland with names of places mentioned in the text. Borders of municipalities are shown.



latter area hunting took place in March (Bendixen & Bobé 1921b).

According to Fabricius (1780), the entrance of Nordre Isortoq was the most important area for walrus in West Greenland. Rink (1877) stated that “the walrus is only rarely met along the coast with the exception of the tract between 66°N and 68°N latitude, where it occurs pretty numerously at times”. The regular occurrence of walrus in this area was also reported by Müller (1906), Freuchen (1921), Anon. (1944), and Vibe (1956) for example.

In late September and October, walrus appeared at the entrance of Kangerlussuaq (Søndre Strømfjord), close

to the town of Sisimiut (Holsteinsborg) and at the entrance to Nassuttooq (Nordre Strømfjord; Müller 1906). These areas were reported to be rich in the bivalve *Serripes (Cardium) groenlandicus* (Winge 1902), a principal walrus food item (e.g. Vibe 1950). From fall to spring walrus occurred at islands in Nordre and Søndre Bredbugt – a little north of Sisimiut (Müller 1906), and also at Kangaarsuk (Bendixen & Bobé 1921c; Figs 2–3). They were hunted in April–May at Maniitorssuaq about 10 km south of Sisimiut (Bendixen & Bobé 1921c; Fig. 3). Mainly mixed herds of adult females with young and subadults occurred in the shallow coastal waters in these

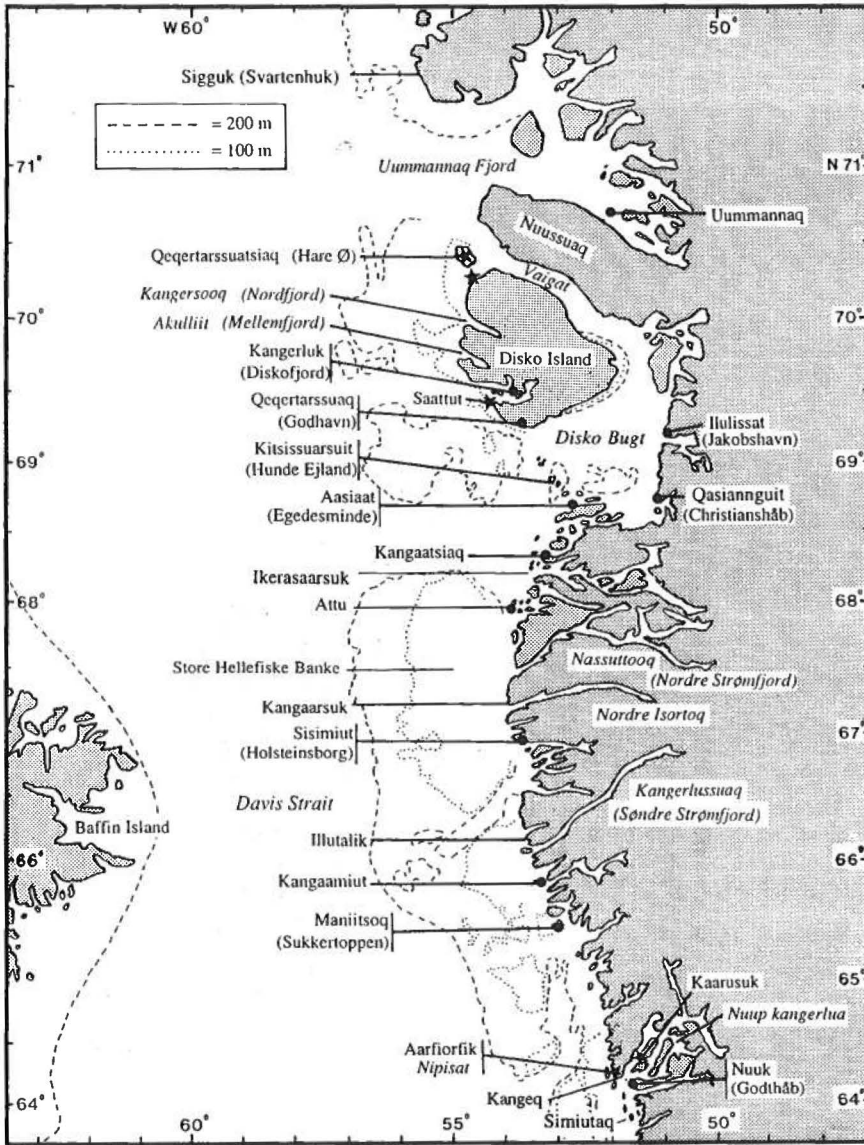


Fig. 2. Map of the central parts of western Greenland with names of places mentioned in the text. Some of the terrestrial haul out sites used earlier by walrus are shown (★; see also Fig. 3).

areas. Although adult males also occurred along the coast, they were reported to prefer offshore areas with deeper water (Müller 1906, 1912).

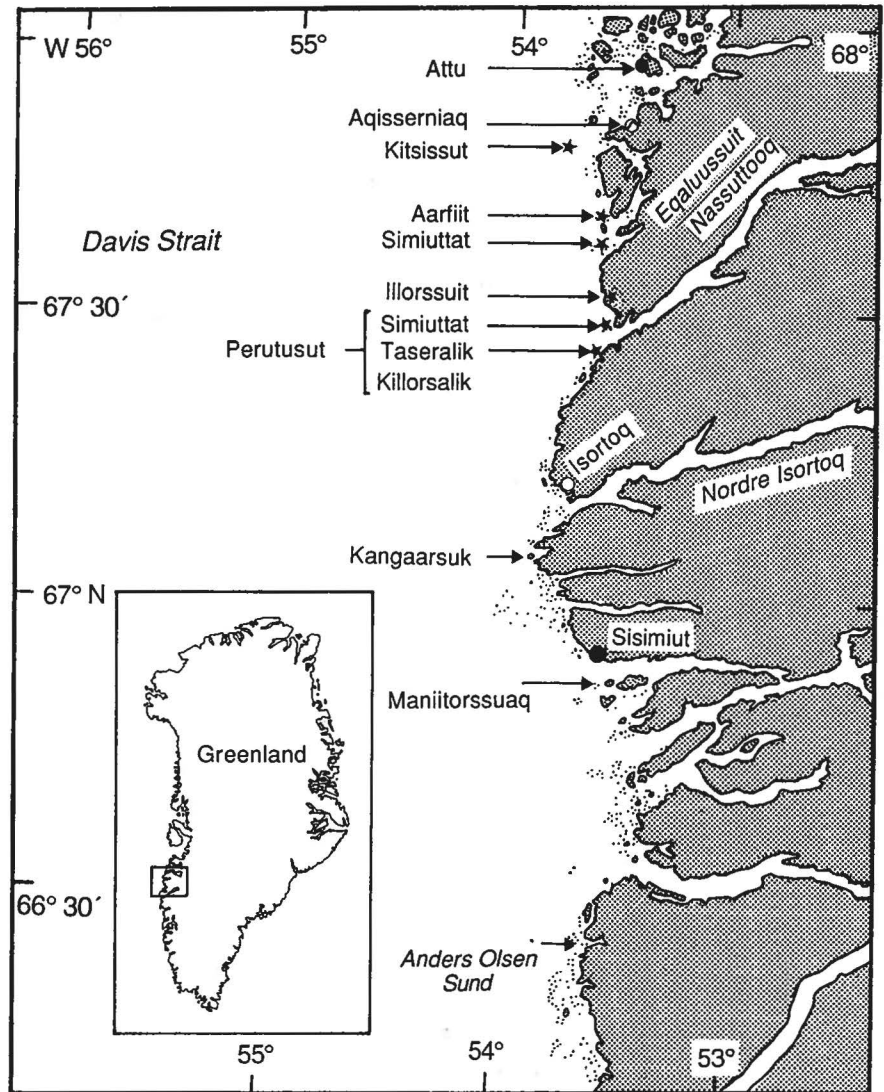
Terrestrial haul-outs (“uglit”) in the Maniitsoq – Aasiaat area

Walruses hauled out on land in several places in western Greenland between approximately 67°25'N and 67°47'N in an area devoid of humans between October and April-May (Müller 1906). The Canadian Inuit use the term “uglit” (plural: “uglit”) to denote a site on land where walruses haul out (e.g. Mansfield 1958). In Greenland there is no specific term for such a site (H.C. Petersen,

pers. comm. 1992), so for convenience the Canadian term is used here.

According to Jensen (1879 cited by Winge 1902), the first groups of walruses reappeared at the entrance to the fjord of Nassuttooq in late August, and in September they hauled out on the islands of Perutusut. The largest islands in this group where walruses occurred on land were: Taseralik, Killorsalik and Simiuttat (Müller 1906, 1912, 1914; Fig. 3). During summer these islands were also used as a meeting place by Greenlanders coming from north and south (Kramer 1992). Beginning in September, walruses hauled out north of Nassuttooq on the promontory of Illorssuit, and on the islands of Kitsissut and at Aarfit (Osterman & Porsild 1921; Fig. 3). According to Müller (1912) and Hedegaard (1914) they also hauled out

Fig. 3. The Nassuttooq-Attu area with terrestrial haul out sites (★) used by walrus until the late 1930s. ● = Towns; ○ = Abandoned settlements.



on the islands of Simiuttat off Eqaluussuit (Gamle Egedesminde; Fig. 3).

Strong tidal currents kept the entrance to Nassuttooq ice free all winter (Freuchen & Salomonsen 1961), and walrus food items were present in this area. Müller (1896, 1898) reported that walrus killed on Taseralik had been feeding on *S. groenlandicus*. Apparently both males and females of all age groups were present at the uglit at Nassuttooq (Müller 1906, 1912). Müller (1906) observed hair shed on the cliffs, and speculated that the walrus hauled out on Taseralik for the moult. Mating was observed in the Nassuttooq area where parturition was reported to occur in February and March or later (Brummersted 1890). According to Müller (1906), who stated that he did not observe walrus mating during a visit to the islands on 17 to 22 September 1897, the birth season usually was in March and April when females with either

near term foetuses or newborn calves were caught. However, females with newborns were also caught at other times of the year, even in October. Although adult females could be encountered near land in the birth season, they usually delivered in the offshore pack ice to the west and northwest (*ibid.*). Hedegaard (1914) observed how some females gave birth during the fall hunt at the uglit.

According to Anon. (1938), the majority of the walrus which hauled out near Attu were males; and all adult females were pregnant. When walrus hauled out on the promontory of Illorsuit or on Perutusut (Fig. 3), some individuals were found several hundred meters from the shore or far up on the cliffs (Müller 1912, Hansen 1958). According to Hedegaard (1914) the walrus left the islands in November-December. Whereas Freuchen & Salomonsen (1961) state that the number of walrus in this area increased in February, presumably

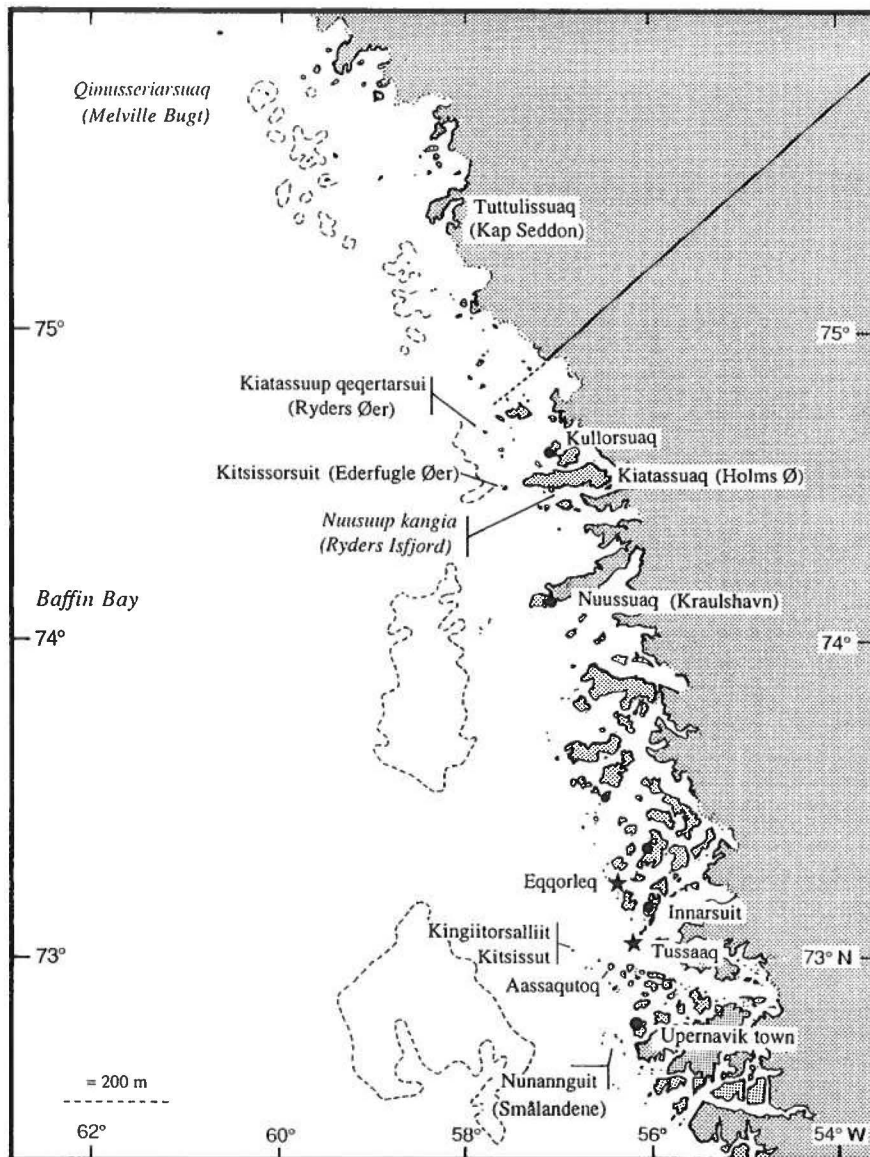


Fig. 4. Map of the Uummannaq and Upernavik areas with names of places mentioned in the text. Terrestrial haul out sites used earlier by walruses (★) and the border between the municipalities of Upernavik and Avangersuaq/Thule are shown.

due to immigration of animals from the Hudson Strait region.

Hansen (1958) stated that the walruses hauled out on Kitsissut every year, whereas their occurrence on Illorsuit was more variable. This is contradicted by a statement in Anon. (1938), that although the walruses occurred along the same stretch of coast every year, they never hauled out on the same ugli in two consecutive years. According to Hansen (1958) the walruses would haul out every fall only on Kitsissut. The reason given was that this was the only area where walrus carcasses left after the hunt were removed by waves in rough weather during the intervening period. At the other ugli it took several seasons to wash away smelling walrus

remnants and the walruses would avoid these areas. However, Hedegaard (1914) observed walruses that hauled out close to old walrus carcasses at Kitsissut.

On 21 September 1897, about 300 animals were estimated to be present at Taseralik (Müller 1906). However, in terms of numbers of walruses coming ashore, Kitsissut and Illorsuit apparently were the most important of the haul out sites in western Greenland. In 1919, an estimated 600 to 800 walruses hauled out on the promontory of Illorsuit (Hansen 1958). In the fall of 1929, 600 to 700 animals were present on the islands south of Attu (Anon. 1930). Until the mid-1930s, "large herds" were observed annually on the small islands near Attu during fall (Anon. 1959a). The last recorded catch of walruses on land in

this area was made in 1937, when 16 animals were reported at Attu (Anon. 1938).

Around the mid-1930s the walrus only hauled out at Kitsissut. They had abandoned all uglit south of Kitsissut (*ibid.*). The walrus used the more offshore uglit of Kitsissut until at least 1940 (U. Lennert, pers. comm. 1982), but thereafter they no longer hauled out on land, although they might have been present in the vicinity of their old uglit. Information from residents in Central West Greenland indicates that due to persecution the walrus rarely frequented the terrestrial haul out sites after the late 1930s, and since the early 1950s no one has observed walrus hauled out on land (this study). Without giving details Anon. (1980) mentions that walrus may still haul out at the entrance to Nassuttooq, in the Kangaarsuk area, and at Anders Olsen Sund to a limited extent (Fig. 3). This statement has not been verified in our study.

Offshore distribution in the Maniitsoq – Aasiaat area

According to Müller (1906) the walrus retreated in April from the coastal regions to the edge of the Davis Strait pack ice (“the West Ice”; in western Greenland this term is used traditionally for the Davis Strait-Baffin Bay pack ice; e.g. Hammer 1921), about 40–60 km offshore, where “American fishermen” reported them to be abundant in the summer. In June, walrus were observed in the loose pack ice at the northern margin of Store Hellefiske Banke (Müller 1912; Fig. 2). On 6 July 1819, Parry (1821) observed a herd of walrus at 67°44'N, 57°51'W (water depth: ca. 220 m). Apparently the walrus followed the westward retreat of the edge of the West Ice. According to Vibe (1956) walrus occurred from March until June in the eastern edge of the West Ice off the coast between Sisimiut and Aasiaat.

Information on the biology and behavior of walrus in these areas is scarce. In February males and females occurred together, whereas by late April adults were segregated by sex (Anon. 1938). By then the adult males occurred further offshore and in denser ice than females with young (Anon. 1957). This indicates that mating occurred in February and continued until sometime in April. The first calves were born around 15 May, but most calves were born in late May and in early June (Anon. 1938). During a hunting trip on 28–30 May 1937 off Sisimiut mainly females and young were encountered in the margin of the Davis Strait pack ice (Hansen 1937). The walrus occurred alone or in groups of up to 10 animals. During this trip both females with newborn calves and females with near term fetuses were caught. Several of the animals killed had *Astarte crenata* attached to their vibrissae, and siphons of *Mya* sp. and fragments of snails were found in faeces on the ice. All the walrus had empty stomachs except for pebbles and a single cuticulum of an *Ascidia* (*ibid.*). Walrus caught in this area on other occasions often had stomachs full of bivalves (U. Lennert, pers. comm. 1982). According to

Anon. (1951) walrus were no longer found at the margins of the West Ice around mid-June, after the females had migrated north.

The Aasiaat-Qeqertarsuaq (Hare Ø) area (approx. 68°30'N to approx. 70°30'N)

Walrus were rarely seen near Aasiaat and in the Disko Bugt (Winge 1902 quoting letters from Giesecke 1807 and Rudolph 1840). They were, however, observed close to the settlement of Qeqertarsuaq (Godhavn) as early as October (Winge 1902). Walrus were abundant at the entrance to Kangerluk (Diskofjord) and were often observed near Kangersooq (Nordfjord) on the northwestern coast of Disko (Freuchen 1921). Occasionally, they hauled out on the small island of Saattut at the entrance to Kangerluk (Fig. 2) during the last century (Winge 1902), and the first half of this century. However, according to hunters, walrus have avoided this area after the construction in 1954 of a LORAN station close to Saattut (this study). Since 1932 walrus were caught from April until mid-June, 50–80 km west of Disko, at the margin of the pack ice (Rosendahl 1967). In June 1886 large herds were observed near Qeqertarsuaq-Hare Ø (Winge 1902). According to Hedegaard (1914) walrus occasionally hauled out on land at Qeqertarsuaq and on the northern coast of Disko.

The Uummannaq-Upernavik areas (approx. 70°30'N to approx. 76°N)

Only few walrus wintered along the coast of the Uummannaq and Upernavik areas. At the beginning of the 20th century few were killed between November and March off the western point of the peninsula of Nuussuaq (approx. 70°45'N) in the Uummannaq area (Bertelsen *et al.* 1921; Fig. 2). Northward migrating walrus were commonly present along the edge of the fast ice in the Uummannaq area from early spring through the summer (Freuchen 1921), but they rarely entered the Uummannaq Fjord where the water is deep (Winge 1902, Freuchen 1921).

Further north, migrants occurred along the ice edge at the outer archipelago of the Upernavik area during spring (Fig. 4). Occasionally, walrus also were observed closer to the mainland coast (Winge 1902, Freuchen 1921, Bryder *et al.* 1921). In particular they were often observed at Nuusuup kangia (Ryders Isfjord, approx. 74°30'N; Bryder *et al.* 1921) and near the town of Upernavik (Freuchen 1921) where they were caught in November. In October they were found around Kiatassuup qeqertarsui (Ryders Øer, approx. 74°45'N) in the southern part of Qimusseriarsuaq (Melville Bugt; Freuchen 1921) and in December, between Kiatassuaq (Holms Ø) and Nuussuaq (Kraulshavn; Fig. 4) (Vibe 1956). In November walrus sometimes hauled out on the small islands near Eqqorleq (Bryder *et al.* 1921), and in June they were hunted near the islands of Kitsissorsuit (Ederfugle

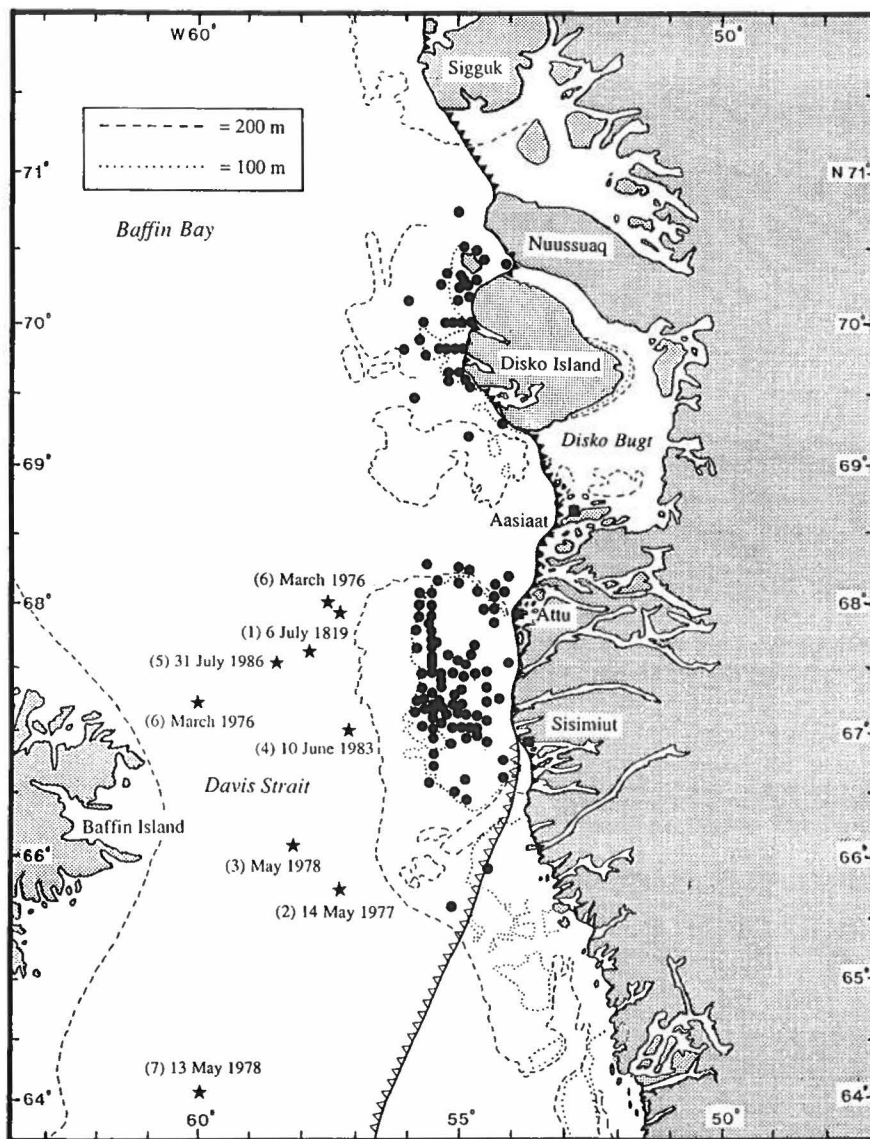


Fig. 5. Distribution of walrus groups (on and off transect observations) sighted during aerial surveys in March-April 1981 1982, 1984, 1990 and 1991 in relation to bathymetry. ● = walrus group. ▲▲▲▲ = edge of land fast ice; △△△△ = average position of the edge of the Davis Strait pack ice (modified from McLaren & Davis 1983). Observations of groups of walrus made from vessels (1-6) and aircraft (7) operating in Davis Strait in March-July are shown (★): (1) Parry 1821; (2) MacLaren Atl. Ltd. 1977; (3) "several" Anon. 1978a; (4) 3-4 yr. old in 1 km broad zone of ice, 1983; this study; (5) walrus with 6 cm long tusks on ice, 1986; this study; (6) Turl 1987; (7) MacLaren - Marex 1979.

Øer; *ibid.*). According to Freuchen (1921) and Vibe (1950) walrus crossed Qimusseriarsuaq far offshore during their spring migration north into the Smith Sound region. Occasionally during the open water season, however, a few stragglers occurred near Tuttulissuaq (Kap Seddon, approx. 75°20'N) in Qimusseriarsuaq (Freuchen 1921). On 21 July 1894 walrus were seen in several places at 75°50'N in Qimusseriarsuaq (Ohlin 1895).

Distribution after 1975

Southwestern Greenland

A few walrus stragglers have been reported from southwestern Greenland in recent years. Two were taken in Narsaq in 1979; one was killed at Nanortalik in 1979 and another in 1983 (Anon. 1954...1987). In September 1992 a walrus was shot near Nanortalik (A. Rosing-Asvid pers. comm. 1993). Between 15 and 28 August 1992, a sub-adult walrus was observed several times in the fjord of Arsuk (Fig. 1; L. Reimers, *in litt.* 1992). In early July 1982 a walrus was caught at Kangeq near Nuuk, where walrus had not been taken since 1965 (Anon. 1982). In

Table 3. Walrus group sizes observed during aerial surveys in western Greenland, 1981–1991.

Year	Month	Group size (animals/group)				Source
		Mean	SD	Range	N (groups)	
1981	March	1.74	1.15	1–7	35	This study
1982	March	1.68	0.99	1–3	25	This study
1982	April	1.67	1.01	1–8	36	Born <i>et al.</i> 1982
1984	March	1.57	0.88	1–5	47	Born 1988
1990	April	1.77	0.93	1–3	13	This study
1991	March	1.55	0.89	1–5	31	This study

September 1990 an adult male walrus was observed at Rype Ø (64°07'N, 51°42'W) near Nuuk; and one was observed at Simiutaq (64°03'N, 51°31'W) on 26 August 1992 (H. Siegstad, *in litt.* 1992; Fig. 2).

Central West Greenland between Maniitsoq and Qeqertarsuatsiaq (approx. 65°30'N to approx. 70°30'N)

Walrus still occupy their former wintering range in the margin of the West Ice, between approximately 66°N and approximately 70°45'N. Apparently their occurrence in this area is determined by the availability of shallow feeding grounds and suitable ice for hauling out.

From February until late May they are found in the pack ice about 30 to 100 km off the coast between Sisimiut and Kangaatsiaq (approx. 68°15'N). The timing of the catches in the Uummannaq and Upernavik areas indicates that these walrus move north along the coast of western Greenland. However, scattered observations offshore in the Davis Strait from March–July suggest that some contact may exist during spring between the walrus at western Greenland and those occurring along eastern Baffin Island (Fig. 5). Occasionally, single animals are killed in Central West Greenland in July–September. For example, one was shot in August 1986 at Kitsissuarsuit (Hunde Ejland, approx. 68°45'N) and another in September 1989 (this study).

According to residents of Qeqertarsuaq (Godhavn) and Kangerluk the walrus arrive at the banks off the west coast of Disko in October–November. Although they can occur from February until April at the entrance to Kangerluk, they apparently prefer to winter further north off Akullit (Mellemfjord, 69°45'N; Fig. 2) and Kangersooq (Nordfjord) on northwestern Disko and around Qeqertarsuatsiaq (Hare Ø). Subadults and females with young were reported to occur closer to the coast than males (this study). According to the same sources, walrus are never observed moving southward south of Qeqertarsuaq during fall, whereas those wintering near the northwest coast of Disko are believed to move north in May. Observations made during seven aerial reconnaissances flown along the coast between Qeqertarsuaq (Godhavn) and

Sigguk (Svartenhuk, approx. 71°20'N) in the period 6 April to 12 May 1982 indicated that the walrus progressively moved north in the shear zone between the fast ice and the pack ice (Born *et al.* 1982).

Systematic aerial surveys conducted in 1981, 1982, 1984, 1990 and 1991 between 64°N and 71°30'N showed that the wintering habitat of the walrus in Central West Greenland is limited to the edge of the pack ice between approximately 66°N and 71°N (Fig. 5). Although the 1981 aerial surveys sampled all of Davis Strait and much of Baffin Bay (see MacLaren & Davis 1981: fig. 1) walrus were not observed in any offshore areas apart from those shown in Fig. 6A.

The walrus off Central West Greenland prefer areas with dense pack ice. During the surveys in 1981 and 1982 walrus were observed in areas where the ice cover exceeded 7/10, and in 1984 in areas with more than 6/10 ice cover. In 1990 all groups were found in areas where the ice cover was 7.5/10 or greater. In 1991, 82% of the groups were in areas with 7.5/10 ice cover or more.

Furthermore, the walrus in Central West Greenland are mostly confined to waters less than 100 m deep, between the consolidated pack ice in the Davis Strait and the open water along the coast of western Greenland (Fig. 5). Several of the walrus food items (*e.g.* *Cardium ciliatum*, *Hiatella arctica*, *Mya truncata* and *Astarte borealis*, *cf.* for example Vibe 1950) are found on the shallow banks off western Greenland (Marin ID 1978). According to the walrus hunters, walrus taken between Sisimiut and Aasiaat and along the western coast of Disko often have bivalves in their stomachs. In April 1982 two walrus that had been feeding on sand eel (*Ammodytes sp.*) were shot about 50–65 km west of Sisimiut (Born *et al.* 1982).

Most walrus observed during the aerial surveys were either single or in pairs. The largest group consisted of 8 animals (Table 3).

A mean group size of 2.09 walrus (SD = 1.58; range: 1–5 animals; N = 11) obtained during ship-based surveys in April 1982 and 1990 (Dietz 1982, Born 1990 b) did not differ significantly ($P > 0.05$) from the mean group sizes obtained during the aerial surveys. Occasionally, larger congregations of walrus are observed off Central West Greenland. In 1976 a herd of about 200 was seen off Akullit (Mellemfjord) on the west coast of Disko (R.

Table 4. Sex and age classification of walrus observed during aerial surveys in western Greenland, 1982–1991.

Year	Month	Adults	Ad. F	Subad. (2–5 yr.)	Calves (1 yr.)	Age and Sex undet.	N (animals observed)	Source
1982	April	42	7	5	6	0	60	Born <i>et al.</i> 1982
1984	March	32	0	5	0	37	74	Born 1988
1990	April	6	1	3	0	14	24	This study
1991	March	9	3	0	3	32	47	This study

Møbjerg, *in litt.* 1977). On 14 February 1979 “hundreds” of walrus were observed in the open water off Nassut-

toog (P. Brandt, pers. comm. 1989). In February 1981, 100–200 walrus were observed in the edge of the West

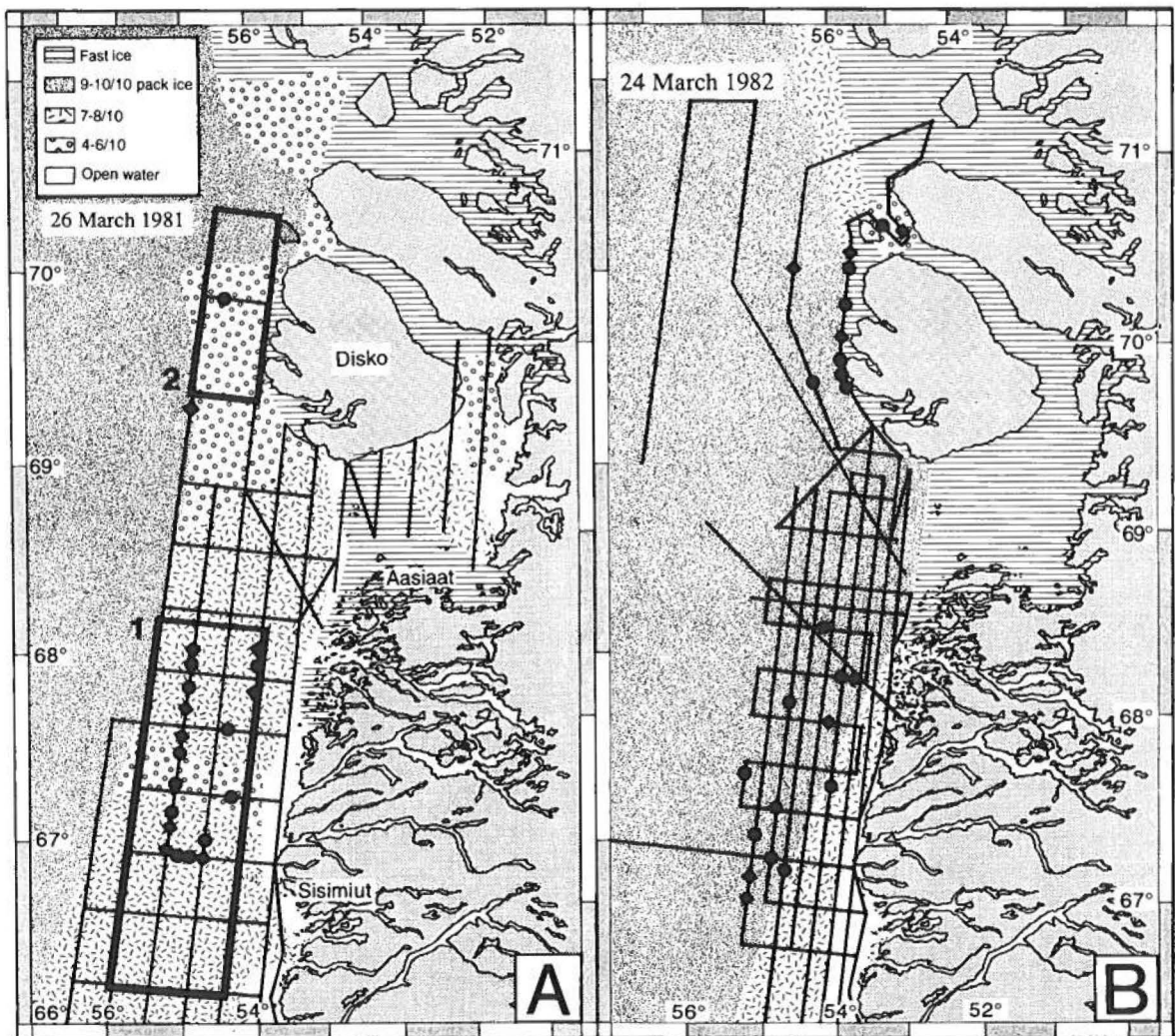


Fig. 6. A: Transects flown, strata (1 and 2), and sightings of walrus groups during aerial surveys off Central West Greenland, 17–24 March 1981. Ice conditions on 26 March 1981 are shown. Fifty walrus were observed (15 on transect) within the strata. ● = groups on transect; ◆ = groups off transect. Stratum borders are indicated by heavy lines. B: Transects flown and sightings of walrus groups during two aerial surveys off Central West Greenland, 10–24 March 1982. Ice conditions on 24 March 1982 are shown. First survey: 21 walrus observed (17 on transect); second survey: 17 walrus observed (12 on transect) within the two strata. ● = groups on transect; ◆ = groups off transect. Ice code: see A.

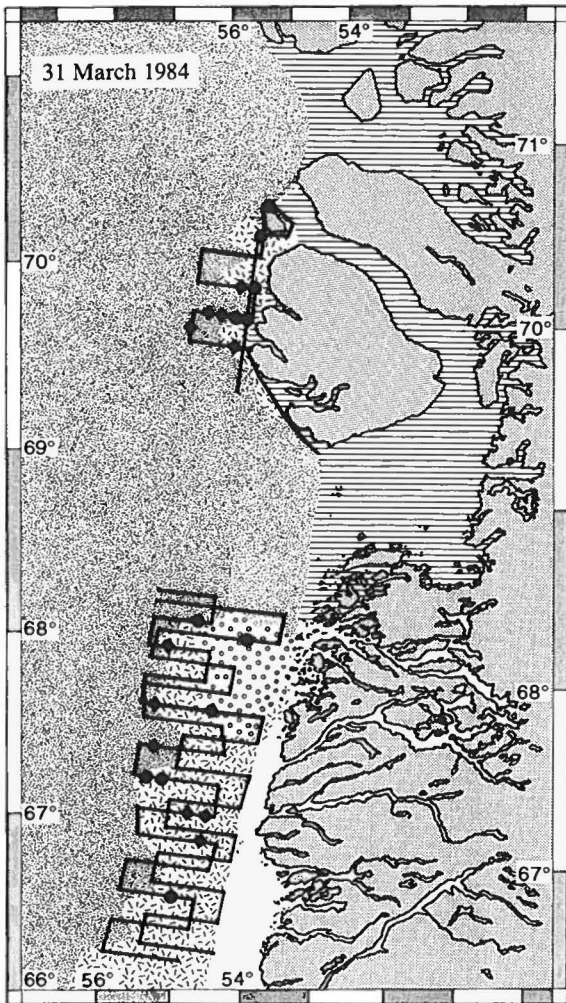


Fig. 7. Transects flown and sightings of walrus groups during aerial surveys off Central West Greenland, 29–31 March 1984. Ice conditions on 31 March 1984 are shown. A total of 34 walrus observed (11 on transect). ● = groups on transect; ◆ = groups off transect. Strata and ice code: see Fig. 6A.

Ice about 60 km west of Nassuttooq (H. Pedersen, *in litt.* 1982). Between 24 and 29 May 1988 a total of about 130 walrus – predominantly males – were observed in the pack ice about 90 km west of Attu (K. Lennert, *in litt.* 1988).

Walrus of all age groups, except newborn, were identified during the aerial surveys off Central West Greenland (Table 4). Apparently newborn calves are no longer observed in this area. Only one hunter reported having seen a walrus birth; that happened off Mellemfjord in May 1954 (this study). During recording of underwater sounds in the dense pack ice at 67°15'N, 54°30'W close to where walrus had been observed shortly before, faint sequences of taps and knocks characteristic of displaying adult males (*e.g.* Ray & Watkins

1975) were recorded between 14 and 18 April 1990. This suggests that walrus mate in this area (Born 1990 b).

The Uummannaq-Upernavik areas

The present distribution of walrus in the Uummannaq and Upernavik areas is similar to the historical distribution. They are not numerous in these areas and they appear to be mainly transient, although some are found during winter in cracks and leads in the shear zone between the fast ice and the Baffin Bay pack ice (this study).

Walrus occur from February to April at the islands of Kingiitarsalliit, Aassaqtoq and Nunannguit (Smålandene, 72°46'N) between the town of Upernavik and the settlement of Tussaaq (R. Dietz, *in litt.* 1986; Fig. 4). A large herd of walrus was observed at Nunannguit in February 1989 (A. Rosing-Asvid, *in litt.* 1990). Only one or two walrus are caught annually at the town of Upernavik. Few walrus are observed at Kitsissut near the settlement of Tussaaq in October–November, and in March–April. Walrus are reported to be rare at Innarsuit (*ibid.*), where they are hunted along the fast ice edge in spring (Haller 1978). According to Haller, who stated that walrus rarely occur in the Upernavik area, they can be found in December at the westernmost point of the peninsula of Nuussuaq (approx. 74°N). Walrus occur during the open water season at Kiatassuaq (Holms Ø) and Kiatassuup qeqertarsui (Rydere Øer) (*ibid.*). Walrus which migrate southward are observed in October and November off the northwestern point of Nuussuaq (R. Dietz *in litt.* 1986). In this area, where walrus can be taken in December, a few are also taken in June–July. Between three and five walrus are killed annually at the settlement of Nuussuaq (A. Rosing-Asvid, *in litt.* 1990). In June 1983, a female and a newborn that still had an umbilical cord were caught between the town of Upernavik and Nuussuaq (R. Dietz *in litt.* 1986). Walrus are rare at Kullorsuaq (Djævelens Tommelfinger, approx. 74°38'N), but are sometimes caught at the ice edge in spring. In May–June they are observed swimming north along the ice edge south of Tuttulissuaq (Kap Seddon, approx. 75°20'N) in Qimusseriarsuaq. The hunters report that in this area the walrus feed on bivalves. In November–December they are observed moving southward along this ice edge. (A. Rosing-Asvid, *in litt.* 1990). An observation of walrus in late August 1991 north of Tuttulissuaq was reported by hunters, who caught an orphaned calf in late August at Tuttulissuaq (A. Rosing-Asvid pers. comm. 1992).

This scattered information indicates that few walrus winter in the Uummannaq and Upernavik areas. Although there are indications that during spring some walrus move north in the shear zone between the land fast ice and the Baffin Bay pack ice, a “large scale” spring migration north along the western coast of Greenland as indicated in Freuchen (1921) is not witnessed in present times.

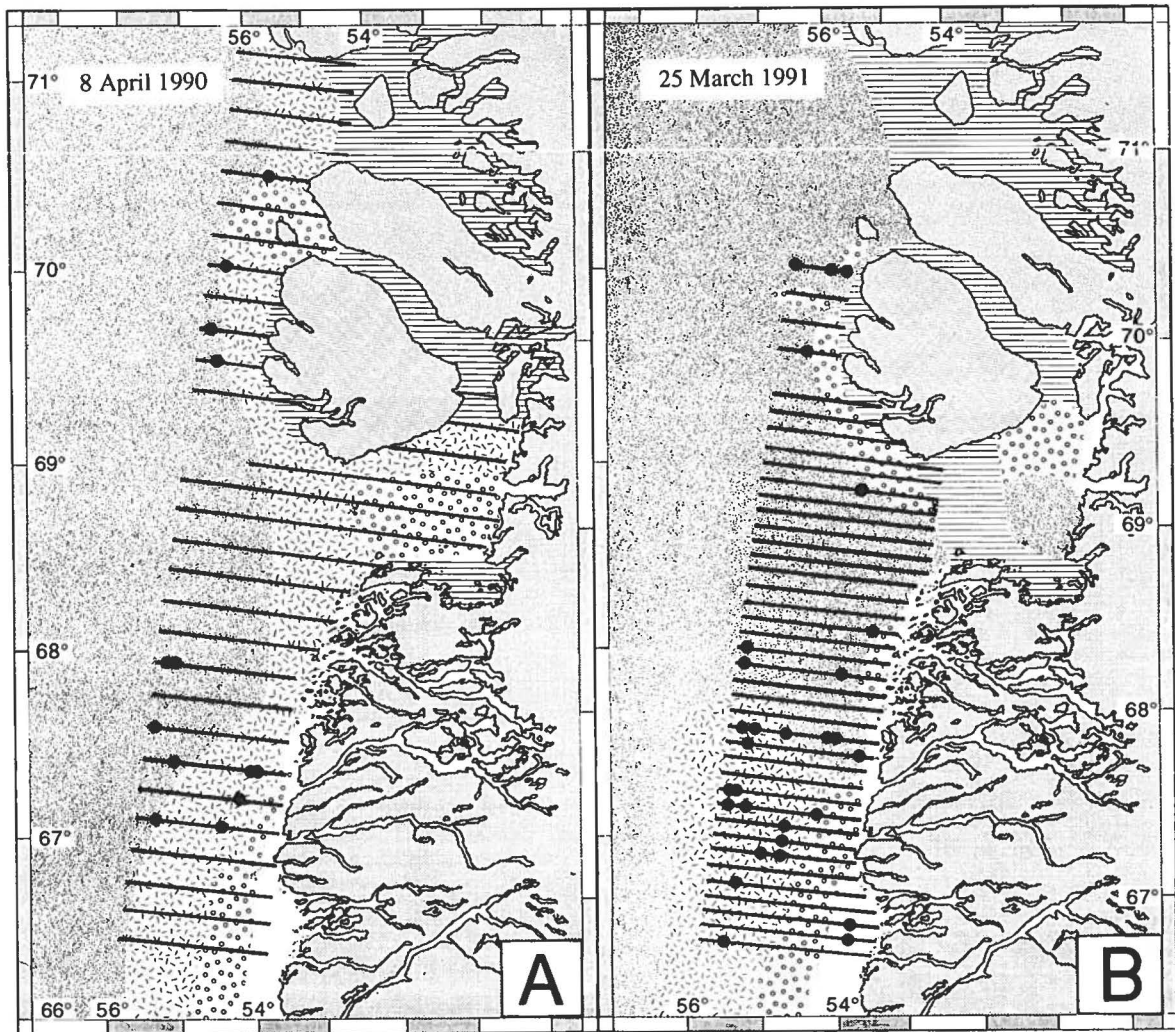


Fig. 8. A: Transects flown and sightings of walrus groups during aerial surveys off Central West Greenland, 9–14 April 1990. Ice conditions on 8 April 1990 are shown. A total of 24 walrus were observed. ● = walrus groups within distance of ca. 1300 m from flight track. Strata and ice code: see Fig. 6A. B: Transects flown and sightings of walrus groups during aerial surveys off Central West Greenland, 19–24 March 1991. Ice conditions on 25 March 1991 are shown. A total of 47 walrus were observed. ● = walrus groups within distance of ca. 1300 m from flight track. Strata and ice code: see Fig. 6A.

Table 5. Strip census estimates of abundance of walrus in two strata (see Fig. 6A) in western Greenland, 1981–1991.

Year	Strip width (m)	Cover-age (%)	Southern area (Sisimiut-Aasiaat)				Northern area (west of Disko)				
			No. walrus observed	Density (ind./km ²)	Abundance	CV*	No. walrus observed	Density (ind./km ²)	Abundance	CV	
1981	1400	12	14	0.008	112	0.75	4	1	0.005	24**	–
1982	1400	29	12	0.003	42	0.41	10	17	0.036	173**	–
1984	900	8	5	0.005	72	0.32	3	6	0.042	201	0.56
1990	1400	7	11	0.011	156	0.41	8	3	0.008	38	0.82
1991	1400	13	26	0.014	193	0.26	4	7	0.033	137	0.47
1990	1000	5	11	0.015	220	0.42	5	4	0.015	63	0.51
1991	1000	10	30	0.022	314	0.20	3	5	0.034	138	0.37

*: Coefficient of variation; **: Estimate of abundance based on crude extrapolation (see: Materials & methods).

Table 6. Reactions of walrus to the passing of the aircraft during aerial surveys in western Greenland, 1981–1991.

Year	Groups (N)	Percentage of groups hauled out			Escaped into water (% walrus on ice)		Percentage diving of walrus in water % (N = ind. in water)
		Total	On transect*	Off transect	On transect	Off	
1981–82	49	84	72	95	67	21	11 (8)
1984	34	100	100	100	27	17	0 (0)
1990–91	43	88	86	100	28	17	100 (5)

On transect*: 1981–82 and 1990–91 within 800 m from flight track; 1984 = within 630 m.

Estimates of abundance of walrus wintering off Central West Greenland

Transects flown and observations of walrus made during the aerial surveys are presented in Figs 6–8. The estimates of abundance based on strip census methods for 1981–1982 and 1990–1993 (strip width of 1400 m) are not significantly different ($P > 0.05$; Table 5), revealing no trend in abundance since 1981.

During all surveys more than 82% of all walrus groups observed were hauled out on ice; and proportionally more walrus observed off transect were on ice (Table 6). Between 27% and 67% of hauled out walrus on transect escaped into the water and dived, obviously as a reaction to the aircraft (Table 6). In 1984, the walrus in some cases escaped into the water several hundred meters in front of the aircraft. During the 1990–1991 surveys, faecal staining on ice floes close to where walrus were seen in water and turbulence at the sea surface indicated that these animals had been scared into the water by the approach of the aircraft.

During the 1990–1991 surveys, groups of walrus on ice were observed out to a maximum distance of about 1300 m. There was, however, an under-representation of

observations within the nearest 200 m (Fig. 9). This was especially the case for walrus “on ice”, presumably reflecting the avoidance response mentioned above. Beyond 200 m, the frequency of observations decreased gradually (Fig. 9). These findings indicate that during these surveys the basic assumption in strip censuses of equal probability of detection over the entire strip width is violated.

Due to a significant under-representation of sightings beyond 500 m, strip census estimates of abundance in 1990 and 1991 were also calculated assuming a half strip width of 500 m from the track line (total strip width = 1000 m). On average, the resulting estimates of abundance were 43% higher (range: 1–66%) than the corresponding estimates based on a half strip width between 100 and 800 m from the flight track (Table 5).

The 1990–1991 estimates of abundance based on the line transect method were 55% (range: 23–77%) higher than the corresponding best estimates based on strip census technique assuming a 1000 m wide strip (Table 5 and 7). The line transect estimates of abundance, which did not differ significantly between 1990 and 1991 ($P > 0.05$; Table 7) indicate that the point estimate for both strata of the visible population of walrus wintering in Central

Fig. 9. Distribution of distances from track line of walrus sightings (1990 and 1991 survey combined; N = 39) with the probability detection function based on the Fourier series model (see: Materials & methods).

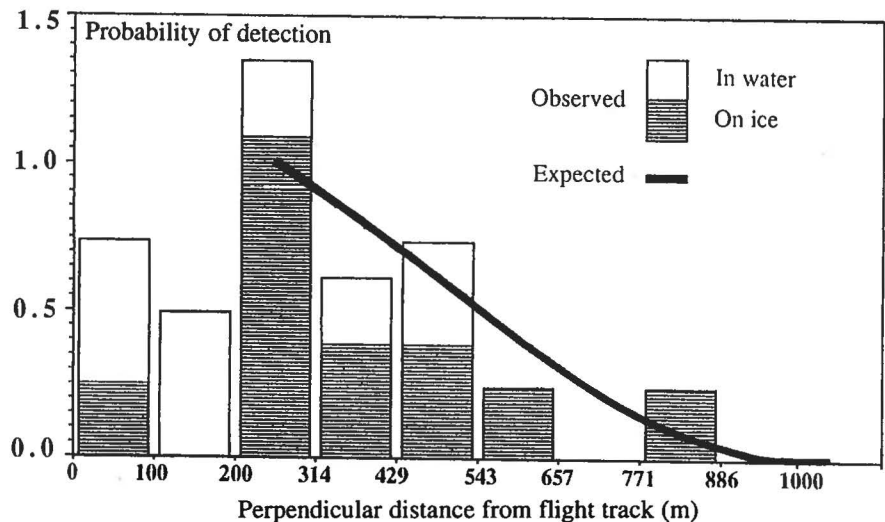


Table 7. Summary statistics for the line transect estimation of abundance of walrus in the two strata off Central West Greenland based on aerial surveys in 1990 and 1991. The "Effective Search half-Width" (ESW) was estimated by fitting a Fourier series model to the frequencies of sighting distances in 1990 and 1991 combined. Sightings within 200 m and beyond 1000 m from the flight track were omitted. Confidence intervals are given as 95% CI.

AREA	Southern area (Sisimiut-Aasiaat)		Northern area (west of Disko)	
	1990	1991	1990	1991
Area (km ²)	14323	14323	4794	4794
Effort (L km)	719	1374	266	156
No. of sightings (N)	7	14	2	3
Sighting rate (N/L)	0.010	0.010	0.007	0.019
Coefficient of variation	0.39	0.33	0.65	0.58
Overall mean pod size (N=39, C)			1.615	
Coefficient of variation			0.090	
ESW (1/f(0), m)			306	
Coefficient of variation (CV)			0.080	
Density (D, walrus/km ²)	0.026	0.027	0.019	0.051
Confidence interval (CI)	0.012–0.056	0.014–0.053	0.006–0.062	0.018–0.149
Abundance estimate	367	387	91	244
Confidence interval (CI)	175–798	198–755	29–297	84–714
Coefficient of variation (CV)	0.40	0.35	0.66	0.59

West Greenland between approximately 66°15'N and 70°30'W is about 500 animals.

Catch of walrus in western Greenland

Traditionally, walrus were hunted from kayak, and often the skin-covered boats – umiat – were used for transportation (e.g. Müller 1906, Hedegaard 1914, Anon. 1938, Rosendahl 1967). A limited number of walrus were also taken during winter at their breathing holes in new ice for example along the western coast of Disko (Anon. 1922 a), along ice edges (Anon. 1931), or when they hauled out on the land-fast ice (Hedegaard 1914).

According to Rink (1877), the annual walrus catch in western Greenland hardly exceeded 200 animals in the first half of the 19th century. The catch in South Greenland (i.e. south of Sisimiut) was estimated to be 10–20 per year at the beginning of this century (Müller 1906).

Of most significance were the Greenland walrus hunts at the haul out sites in fall, and from 1932 the catch of walrus offshore during spring and early summer. Foreign whalers and sealers also caught walrus along the coast of western Greenland. These three types of hunting operations are described in more detail in the following.

The hunt at the terrestrial haul outs

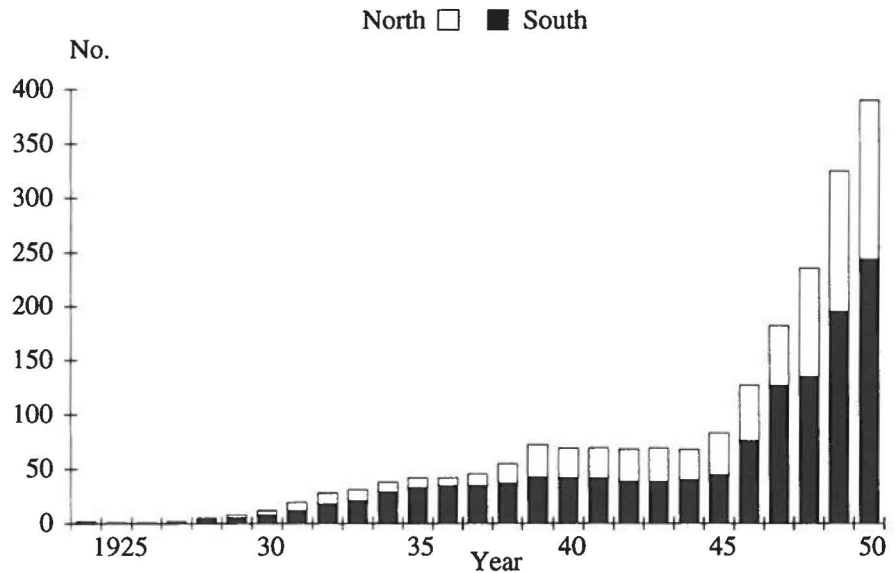
According to Müller (1906) the Norsemen probably hunted walrus at the haul out sites in the Nassuttooq (Nordre Strømfjord) area (Fig. 4). Traditionally, Greenlanders from Attu and the nearby settlement of Aqis-erniaq, but also from other areas, gathered every fall to

participate in a co-operative walrus hunt at the uglit at the entrance to Nassuttooq. During these hunts umiat and kayaks were used for transportation (Müller 1906, Anon. 1938). According to Anon. (1928) people from all areas participated in the co-operative hunts which lasted only few days. Before 1911, one or two cooperative walrus hunts were conducted early in the fall (usually in October) at Kitsissut. To prevent over-exploitation, animals which hauled out on this island later in the season were not hunted. Instead, the hunters moved further south to hunt at other uglit (Anon. 1938). The Greenlanders waited until the animals had settled on land, and to minimize losses only walrus which had moved far up on land were shot (*ibid.*). However, Hedegaard (1914) witnessed hunts at the uglit where walrus were shot at indiscriminately. Many severely wounded walrus escaped into the sea, and Hedegaard considered losses to be high. After the first kill the walrus would disappear and haul out on other uglit (*ibid.*). However, in 1897 Müller (1906) observed that although walrus had been killed at the uglit of Simiuttat (Perutusut), they hauled out on land at the same site shortly after.

The annual catches were highly variable. In 1898, 44 walrus were caught (Anon. 1900), and in this area more than 200 animals were killed in 1905 (Anon. 1907). Although not specifically stated in these sources, information given by Müller (1912) indicates that these catches were taken on the uglit.

To encourage the development of modern fisheries, the Greenland Administration established a fish processing plant and stationed a motorized schooner in Attu in 1911 (Anon. 1911, Mattox 1973). This schooner also served as an auxiliary vessel during the walrus hunts at the uglit (*ibid.*), and the manager of the fishing plant was supposed to be leading the hunts (Anon. 1938). The vessel trans-

Fig. 10. Motorized vessels belonging to Greenlanders in western Greenland, 1924–1950. North = areas between Sisimiut (Holsteinsborg) and Upernavik. South = areas south of Sisimiut (Source: Mattox 1973).



ported the hunters, their families, umiat and kayaks and other equipment to the hunting grounds, and brought the hunting products back to Attu. To reduce the risk of scaring the walrus by engine noise, the vessel anchored about 7–10 km from the haul outs (Anon. 1938, Hansen 1958). Hunting at the uglit usually occurred in October–December (Anon. 1939a). For the period 1911–1937, a total catch of 1737 walrus was recorded for hunts at the uglit (Anon. 1938). This represents a minimum for the catches in these areas. Due to sickness and inclement weather the vessel was not used during the co-operative hunt in 1912. However, some hunters killed more than 100 walrus from which only tusks, a little blubber and two hides were salvaged (Anon. 1914). Another fall (year not stated) only three of 80 walrus killed at Kitsissut were retrieved due to bad weather (Hansen 1958). For 1919 a catch of 200 animals was reported (e.g. Anon. 1938). The figure for this catch, which was taken on the promontory of Illorssuit, only included walrus with fairly large tusks, whereas all the smaller individuals that were killed were never counted (Hansen 1958). Furthermore, the catches reported in Anon. (1938) do not include walrus that were killed in these areas by Greenlanders coming from the Sisimiut area (Anon. 1928). Despite the use of a large vessel the annual catch was still very variable due to the adverse weather conditions prevailing during fall (e.g. Anon. 1910, 1913a, 1915, 1925). Adverse weather not only limited access to the haul outs, but also influenced the number which could be killed or retrieved (Müller 1906, Hansen 1958).

The disturbance caused by an increased use of motorized vessels during the hunts at the uglit, in particular by hunters coming from Sisimiut, was a cause for concern (Anon. 1928). In the fall of 1920, for example, there were many walrus on the uglit south of Attu but they were scared into the water by the approach of the motorized

vessels and as the sea was too rough they could not be hunted from umiat (Anon. 1922 b). The use of motorized vessels during the walrus hunts increased the range of the hunters coming from Attu and from Sisimiut, respectively, resulting in an overlap of hunting areas. Until 1923, the vessel from Attu only took walrus at Simiuttat (67°36'N), and later only at Kitsissut. Traditionally, people from the Sisimiut area did not hunt walrus north of Nassuttooq (67°27'N). However, after the introduction of motorized vessels they also hunted further north (Anon. 1938). Apparently, as a result of this development the co-operative hunting practice deteriorated and conflicts arose between people coming from different areas. For example, it was claimed that the hunters from Sisimiut shot at the walrus at long range at the uglit, and that after three years (period not stated) the walrus had abandoned the uglit of Simiuttat (Anon. 1938).

Offshore catches

In 1909 it was suggested that one of the Greenland Administration's schooners be used to catch walrus offshore, and in 1910 an attempt was made in the Davis Strait with limited success. The schooner was not motorized and due to difficulties in navigating the pack ice only two walrus were taken (Anon. 1910, Müller 1912). In 1911 the Local Political Council (Landsrådet) requested that a 60 GRT motorized vessel belonging to the Greenland Administration be used to catch walrus in the West Ice (Anon. 1913 b). It was stated that while the conditions forced foreign sealers operating off western Greenland to discard much of the walrus meat and blubber, it was possible to use these products in Greenland if the Greenlanders took walrus offshore (*ibid.*). Apart from an unsuccessful attempt in the fall of 1920 to use a motorized vessel for hunting in the Upernavik area (Anon. 1922

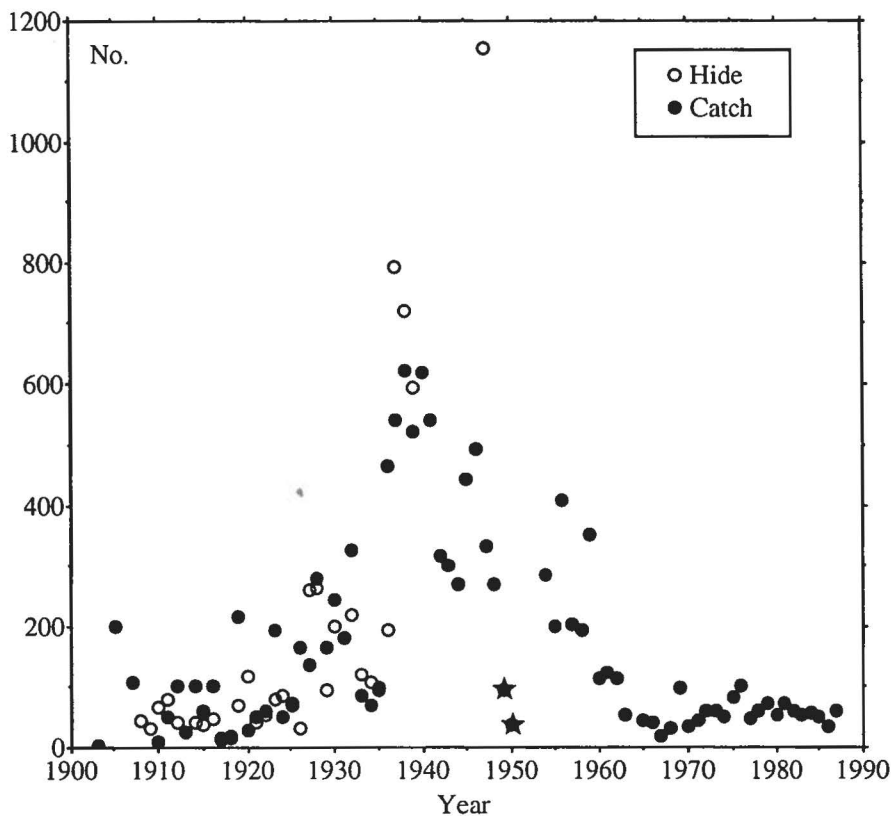


Fig. 11. Reported catch of walrus in western Greenland (except the Avanersuaq/Thule area), 1900–1987 (Source: Anon. 1954...1987). Walrus hides traded by the Royal Greenland Trade Department are also shown (Source: Beretninger og Kundgørelser vedrørende Grønlands Styrelse). ★ = incomplete reports.

b), Greenlanders did not use motorized vessels to take walrus offshore until 1932 (Anon. 1933, Anon. 1944, Vibe 1956, Rosendahl 1967). The Greenland Administration supplied the hunters with the vessels free of charge, provided that the hunters paid for fuel and worked without salaries during the hunt and the processing of hunting products. Each hunter was paid a share of the income from the sale of products to the Royal Greenland Trade Department (Rosendahl 1967). Each vessel had between 23 and 29 men on board who participated in the hunt (Anon. 1938). During the summer of 1932, two offshore hunting trips were made by the 100 GRT vessel *Sigrid* of Aasiaat with a catch of 40 walrus and other marine mammals. During the same period 71 walrus and other marine mammals were landed by the 50 ton vessel *Hvalen* of Qeqertarsuaq. In addition 15 more walrus were landed in this town in 1932 (Anon. 1933, Anon. 1938, Rosendahl 1967). This started the Greenlanders' offshore catches of walrus where in the following seasons both vessels owned by the Greenland Administration and privately owned motorized vessels participated (Rosendahl 1967). On a loan with low interest rates obtained from the Greenland Administration, Greenlanders in Aasiaat bought a vessel which was used both for fishing, in particular Greenland shark (*Somniosus microcephalus*), and for hunting walrus in the West Ice in the spring (*ibid.*). In the fall of 1934 and the spring

of 1935, this boat took 24 walrus (Anon. 1936 b). Greenlanders in Attu bought a motorized vessel for the walrus hunt in 1938. This boat alone landed a total of 300 walrus in 1939 and 1941 (Rask 1993).

From the late 1920s the number of motorized vessels owned by Greenlanders increased rapidly (Mattox 1973, Rask 1993; Fig. 10). According to Mattox (1973) the number of motorized boats in western Greenland increased from one in 1925 to 390 in 1951. In 1939, 42% of the privately owned motorized vessels were registered in Sisimiut and Aasiaat. In 1949 this figure was 57.5%. A major reason for the relatively large number of motorized boats in these towns was that in these areas hunting, particularly of walrus, could be combined with fishing (Rask 1993).

During the 1930s the offshore catch of walrus was intensified (Fig. 11; Plates I-II). A particularly large catch in 1937 was explained by the fact that the edge of the West Ice was unusually close to the coast from January until June (Anon. 1938). In the spring of 1938, two vessels took a total of 151 walrus off the coast of Disko (Anon. 1939 b), and in 1939 the privately owned vessel from Aasiaat landed 153 walrus (Anon. 1940). According to the Hunters' Lists of Game (HLG) the highest catches were taken in 1938 (625 walrus) and 1940 (621 walrus), respectively, whereafter the catches decreased an average of 3% per year until about 1965. Accord-

Plate I. Walrus hunt in the West Ice presumably in the late 1930s. Photographer unknown. Copyright: Arktisk Institut, Denmark.



ing to the HLG, a total of 12306 walrus have been landed in western Greenland (Avanersuaq/Thule area not included) between 1900 and 1987 (last year of reporting). Due to loss of mortally wounded and killed walruses, and under-reporting of the landed catch (see below), this figure represents an absolute minimum of the total number of walruses removed during the period. The numbers and the weights of walrus hides exported from Greenland also indicate that in some years more walruses were landed than reported in the HLG (Fig. 11).

About 89% of the total catch have been reported from the communities between Sisimiut and Nuussuaq in Central West Greenland (between 67°N and 70°30'N); 74% were reported from Aasiaat, Attu and Sisimiut alone. About 7% of the total catch were reported for the Uummannaq and Upernavik areas, and only about 4% for the areas south of Sisimiut.

Since about 1965 the reported catches of walruses have remained low. For the period 1965–1987, the annual catch of walruses in western Greenland according to the HLG has averaged 56 animals (SD = 19.7, range: 19–101, N = 23 annual reports; Plate III). However, by about 1975 there was a general decrease in numbers of hunters reporting catches (Fig. 12). To compensate for this development, the catch figures reported for 1979–1985 in the published HLGs include estimates for catches not reported. Hence, catch figures since 1975 are not reliable.

The numbers of reports received from Sisimiut – traditionally an important walrus hunting community – have been particularly inadequate in recent years. For example, in 1983 and 1984, an estimated 10 walruses were caught in Sisimiut each year according to the HLG, 40 and 74 walruses were taken, respectively, according to information obtained from residents in Sisimiut (this study).

No quantifiable data exist on the hunting loss (animals killed or fatally wounded and not retrieved) for the West Greenland walrus hunt. Hansen (1937) participated in a hunting trip to the West Ice off Sisimiut on 28 to 30 May 1937. During this trip, a total of 48 adults, two dead and four living calves were retrieved. Only little of the meat was brought back. Walruses which were swimming among ice floes and could not be pursued were shot at, and several escaped mortally wounded (*ibid.*, Anon. 1938). Hansen (1937) therefore estimated that losses were considerable. The hunting practice was similar on board the other vessels, and often walruses were not harpooned before being shot (Anon. 1938). A hunting loss of 32% was calculated by Orr *et al.* (1986) for the open water hunt in Foxe Basin (Canada). Freeman (1974–75) found a loss rate of 20 to 30% for the open water hunt conducted from Peterhead boats at Southampton Island (Hudson Bay). Loss rates as high as 50% during similar kinds of hunts were reported by Smith & Taylor (1977) from southeastern Baffin Island. The similarity between



Plate II. Flensing of walrus in the West Ice presumably in the late 1930s. Photographer unknown. Copyright: Arktisk Institut, Denmark.



the hunting practices in Canada and in western Greenland, respectively, indicates that presumably an overall loss rate (proportion of all animals struck that are not retrieved) of 30% can be applied to the catches recorded for West Greenland.

The hunting season in the West Ice lasted from March until late May or early June (Anon. 1939 a). However, the ice conditions frequently did not allow offshore navigation until May (Anon. 1952 a). South of Aasiaat walrus were and still are caught in March-May with a peak in April (Fig. 13 A; Plate III). The catch of walrus on the northern walrus ground west of Disko is between February and May (Fig. 13 B). A peak in February presumably reflects that walrus are caught from the ice edge by hunters going on dog sled to Akulliit (Mellemfjord) and Kangersooq (Nordfjord) on northwestern Disko (Fig. 2). This walrus hunting activity has, however, decreased

during the last few years, according to information obtained in 1988 from hunters in Qeqertarsuaq and Kangerluk (this study).

According to Anon. (1957), the males occurred further offshore sometime in April (probably after the mating season). Because the females were found closer to the coast and hence in areas with less severe ice conditions, reproductive females were selectively hunted (*ibid.*). According to Anon. (1938), the majority of the catch consisted of pregnant females and females which had given birth shortly before they were killed. The sex composition of the catch was further skewed because females were considered to be economically more valuable because they yielded relatively more blubber than males, and because the skin of newborn calves and fetuses was particularly good for making thong. Furthermore, because they had fewer cracks, female tusks were better

Plate III. A 20 ton fishing vessel searching for walrus in the pack ice off Sisimiut, April 1982 (Photo: R. Dietz).

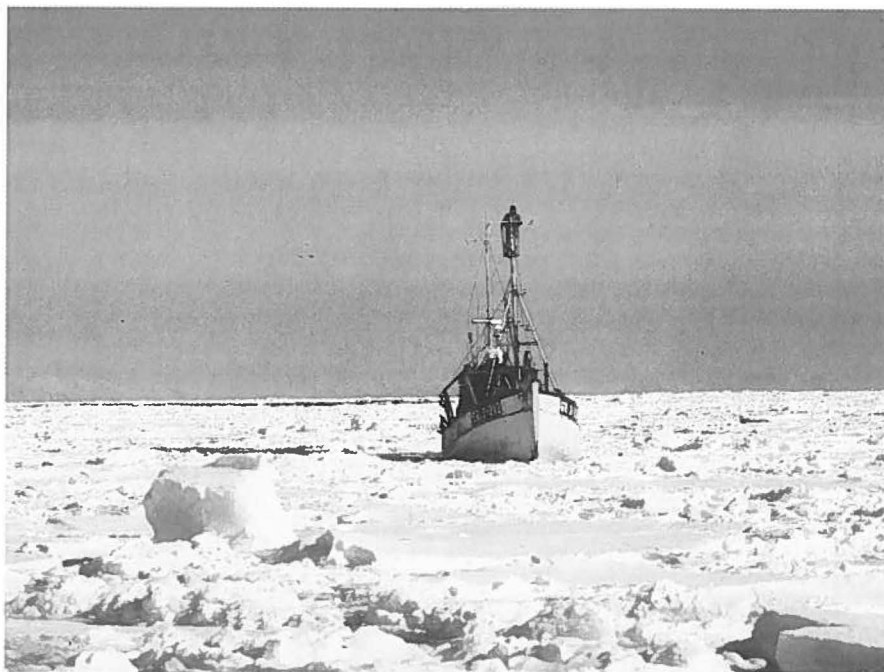
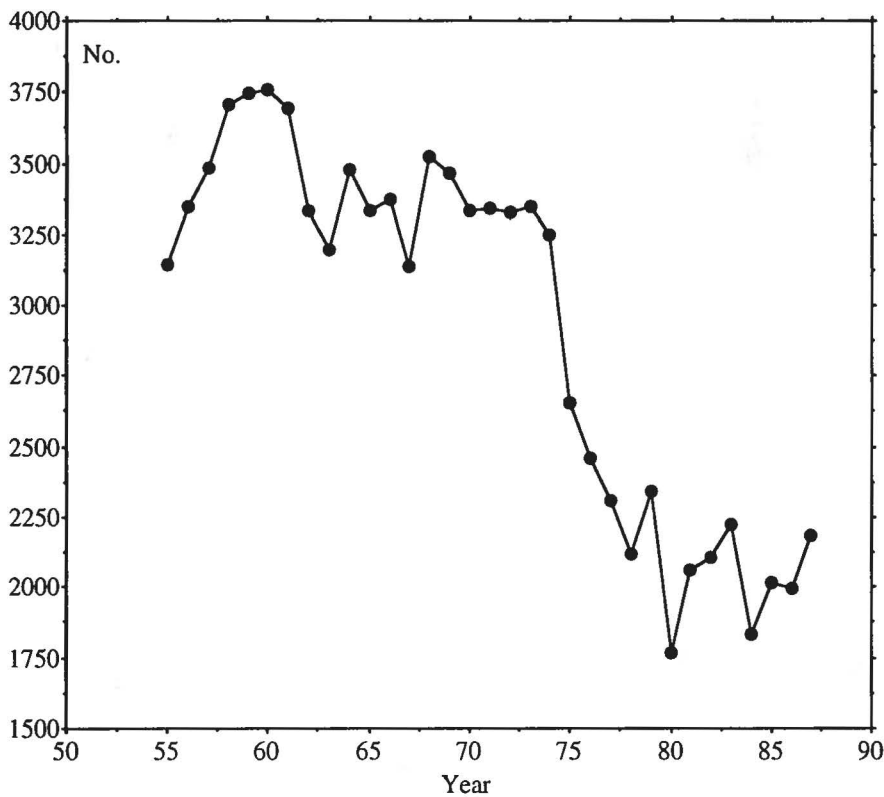


Fig. 12. Number of hunters reporting catches in the Hunters' Lists of Game (1954–1987) in western Greenland south of 76°N.



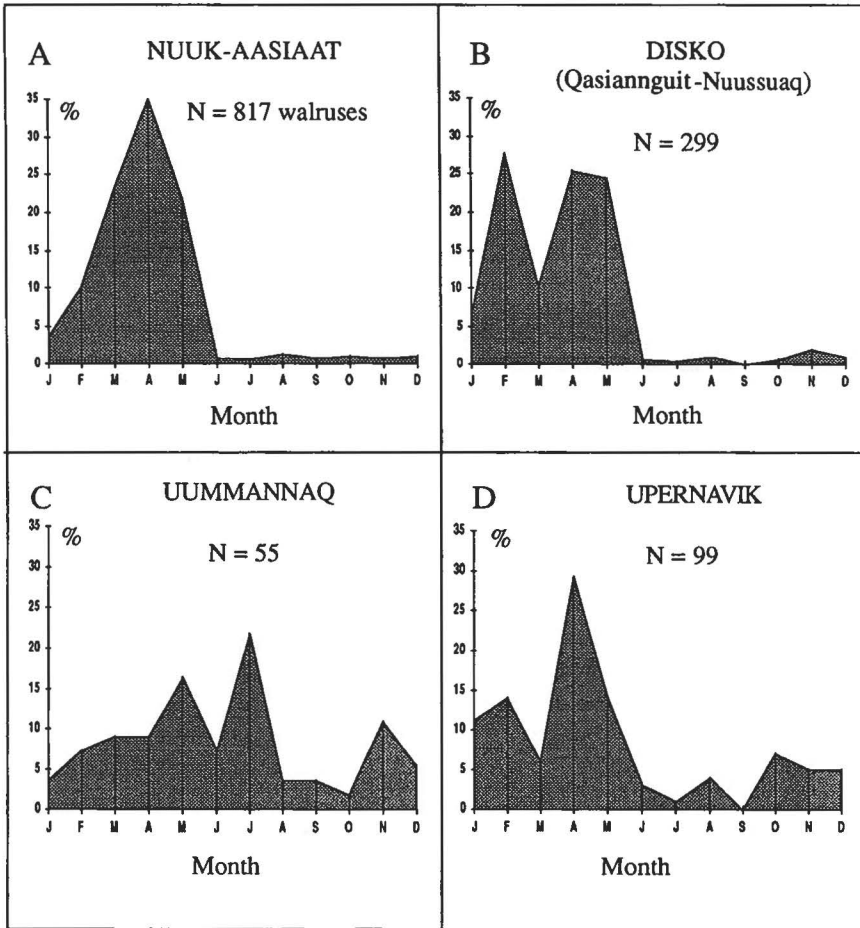


Fig. 13. Distribution by month of walrus catch in western Greenland between approximately 64° and 76°N, 1950–1983 (Hunters' Lists of Game, unpublished).

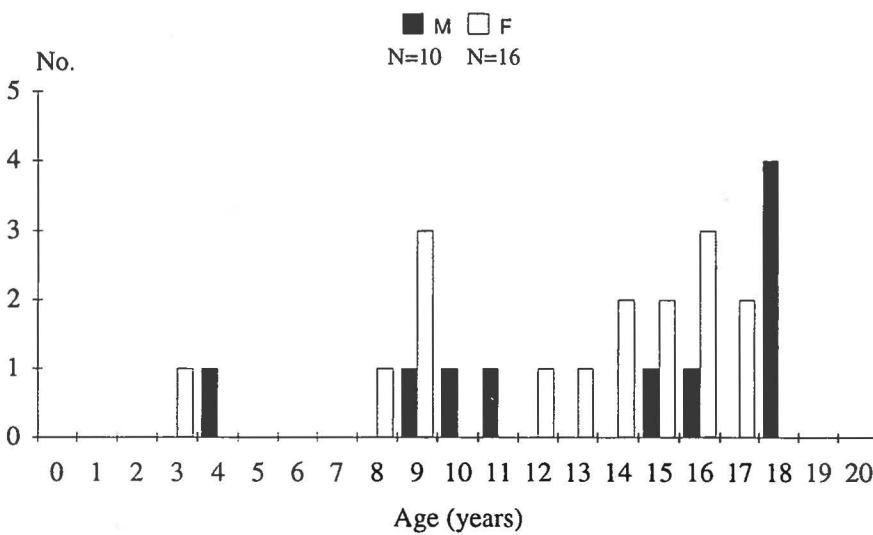


Fig. 14. Age composition of a sample of the walrus catch taken in March and April 1982–1989 off Sisimiut-Attu.

than male tusks for making tools etc. (*ibid.*). Walrus hide constitutes 9–10% (Chapskii 1936, Rörvik 1952) to 12% (Knutsen and Born in press) of the total body weight. Hence, an average mass of 70 kg per hide traded in Greenland (see Materials and methods) indicates that on average the total body weight of the walrus was 580–780 kg. This is in accordance with the information that the majority of the catch consisted of females and young.

A small sample taken 45 to 100 km offshore between 67°15'N and 68°15'N of the spring catch (March–April 1982–1989) in the Sisimiut–Attu area indicates that old and large walrus are selectively hunted (Fig. 14), although the aerial surveys show the presence also of other age classes in the area.

Catch of walrus in the Uummannaq and Upernavik areas

In the Uummannaq and Upernavik areas walrus are either caught when they winter in the shear zone between the fast ice and the Baffin Bay pack ice (West Ice), or when they move along the ice edge in spring (Fig. 13 C & D). The seasonal distribution of the catch indicates that relatively many “late stragglers” are taken in the Uummannaq area (Fig. 13 C). The annual catch of walrus in the Uummannaq and Upernavik areas decreased between 1940 and 1987. If the aberrant year 1987, when an unusual high catch of 53 walrus reported from Upernavik (Anon. 1954...1987) is excluded from the analysis, this decline is significant ($P < 0.01$). The average annual catch prior to 1960 (1940–1959) in the Upernavik and Uummannaq areas combined was 21.9 animals (SD = 10.7; range: 3–45 animals; $N = 18$ annual reports). Between 1960 and 1987 the catch averaged 11.1 walrus per year (SD = 9.7; range: 4–56 animals; $N = 28$ annual reports). The difference between the average catch during the two periods is significant ($t = 3.540$; $P < 0.05$). Over the entire period, the catch in the Uummannaq area has amounted to about 20% of the total catch of walrus in the two areas.

Catch of walrus on eastern Baffin Island

Baffin Island communities are likely to be hunting walrus from the same stock as do the Inuit of Central West Greenland. Loughrey (1959) estimated a take of walrus on Baffin Island of 240 per year, and Dowler (1976, in Reeves 1978) gave an estimate of 120–170 per year landed in Iqaluit (Frobisher Bay), Lake Harbour, Pangnirtung and Broughton Island. In the settlements of Clyde River, Broughton Island, Iqaluit, Pangnirtung and Lake Harbour in the southeastern Baffin Island region, the average annual catch of walrus during the period 1972 to 1985 totalled 108 walrus (Richard & Campbell 1988).

Catches by foreign whalers and sealers

Both British and Norwegian whalers and sealers caught walrus in the Davis Strait and Baffin Bay regions to obtain hides, blubber and tusks. Many of the walrus were taken along the coast of western Greenland. Between 1859 and 1910, at least 3734 walrus were taken in the Davis Strait and Baffin Bay regions by British whalers searching primarily for Bowhead whales (*Balaena mysticetus*). A substantial proportion of these walrus were caught during late spring and early summer off Sisimiut and Disko (Ross & MacIver 1982). As their data were extracted from log-books of 145 voyages (6% of the voyages during the period), the actual catch of walrus by British whalers was probably much higher. Information in Müller (1912) indicates that in 1906 British whalers took 300–400 walrus in the West Ice off Greenland.

Apparently, the British whaling operations in these areas ceased in 1910 (Ross & MacIver 1982), although the presence of Scottish whalers was reported from western Greenland in 1911 (Anon. 1913 a). However, by that time Norwegian sealers and whalers commenced their walrus hunt along the coast of western Greenland. Norwegians caught walrus in the West Ice between Sisimiut and Disko, often at the western edge of the Store Hellefiske Banke about 80 km offshore. Later in the summer walrus were also taken in the Cumberland Peninsula region on eastern Baffin Island (e.g. Isachsen 1922, Isachsen & Isachsen 1932, Vollan 1951). A single Norwegian vessel took walrus off western Greenland in 1910 (Müller 1912). The Norwegian offshore operations in western Greenland continued until World War I, and were resumed for the period 1919–1923 (Isachsen & Isachsen 1932, Vollan 1951). Prices on walrus hides dropped in 1921 and the Norwegian sealers discontinued their walrus hunt in the Davis Strait until 1931 when two vessels again took walrus there (*ibid.*).

Generally, the information on the position and the magnitude of the Norwegian catches of walrus at the beginning of this century is inadequate. Catches were not reported by area but by port of landing in Norway (Isachsen 1922), and the Norwegian system of registration of catches was not organized until 1924 (T. Øritsland *in litt.* 1992). In some years the Norwegian catch of walrus off western Greenland was high. In 1910 a single vessel took 260 walrus off western Greenland (Müller 1912). Norwegian sealers also caught walrus in this area in 1911, 1912 and 1913 (Vollan 1951). One vessel made “good” catches of walrus there in 1911 and 1912 according to Hoel (1950), and in 1919 one vessel caught 225 walrus in the same area (Isachsen & Isachsen 1932). According to Freuchen (1921), a Norwegian sealer took many walrus at Qeqertarsuaq (Hare Ø) in 1919. A single sealer got a “medium” catch of walrus in 1921, and other ships continued their operations in western Greenland until 1923 (Vollan 1951). During two hunting trips in 1931 two sealers took a total of 816 walrus (in-

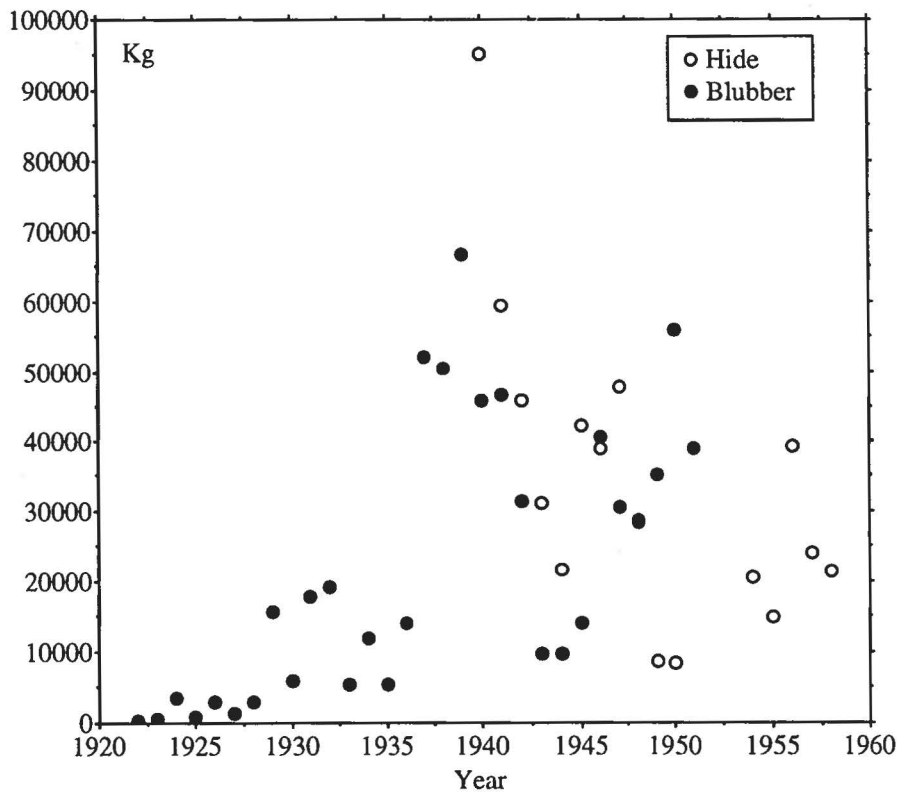


Fig. 15: Amount of walrus hide and blubber traded by the Royal Greenland Trade Department, 1922–1958 (Source: Beretninger og Kundgørelser vedrørende Grønlands Styrelse).

cluding 6 live calves) in western Greenland (Isachsen & Isachsen 1932) where in 1939 one vessel took 186 walrus (including 1 live calf; Archives of the Directorate of Fisheries; T. Øritsland *in litt.* 1992). However, in 1949 and 1951 a Norwegian sealer caught 623 and 1175 walrus, respectively, in the Davis Strait and Baffin Bay areas (*ibid.*). Also another vessel took some hundreds of walrus in 1951 (Jennov 1952). The exact positions of the high catches in 1949 and 1951 are not well documented. However, information reported by Rörvik (1952) and Vibe (1956) indicates that they were primarily taken in the northern Baffin Bay region. These latter catches led to a Norwegian hunting regulation in 1952 (Anon. 1952 b) which totally banned the take of walrus by Norwegians anywhere.

The fact that foreign sealers made large catches of walrus close to the west coast of Greenland was used in Greenland as an argument for commencing the “rational” exploitation of walrus by Greenlanders, involving the use of motorized vessels (*e.g.* Müller 1906, 1912).

The Greenland trade in walrus products

Walrus were caught for their hide, blubber and tusks (*e.g.* Müller 1912). In Greenland the meat was also used for human consumption and as food for sled dogs (Anon. 1951, Vibe 1950, 1956).

Prior to 1897 the walrus ivory traded to the Royal Greenland Trade Department (see Vibe 1967) was only intended for the domestic market. However beginning in 1897 tusks were also exported from Greenland (Anon. 1899).

Salted walrus hides, which were used for various industrial purposes (*e.g.* Müller 1912, Oldendow 1935, Rasmussen 1952), were exported by the Royal Greenland Trade Department (*e.g.* Anon. 1912; Figs 11 and 15). The average weight of a walrus hide traded in western Greenland was about 70 kg (see Materials and methods). Hede-gaard (1914) stated that in Greenland an average walrus hide weighed approximately 75 kg, although the hides of large males weighed considerably more. This is very similar to information in Chapskii (1936) that the average weight of salted hides was 74 kg in the Kara Sea where the catch consisted primarily of walrus females and sub-adults.

The maximum recorded number of hides exported in

any year was 1155 in 1947 (Anon. 1948). Based on an average hide weight of 70 kg, the 95 000 kg of hide listed in 1939 (Fig. 15) would represent about 1357 walrus. According to the HLG however, a total of only 522 walrus were caught in this year. Early in the period of high exploitation of walrus in Greenland, the European market already had difficulty disposing of the supply of hides coming from Greenland (Anon. 1937). During World War II (U. Lennert, pers. comm. 1982) and shortly thereafter walrus hides were imported by the United States for technical purposes (Rasmussen 1952). Walrus hides were for example used for making transmission belts used in various industries (U. Lennert, pers. comm. 1982). By about 1960 there was no longer a market for walrus hides (Anon. 1961).

Oil extracted from the blubber of walrus and other marine mammals was exported by the Royal Greenland Trade Department (Fig. 15). A drop in oil prices on the international market in about 1930 led to a general decrease in the amount of marine mammal blubber purchased by the Royal Greenland Trade Department. However, this trend was not apparent at Sisimiut, where the trade in blubber increased during the 1930s due to the large catches of walrus (Anon. 1946). Between 1955 and 1962 the price of seal and walrus blubber in Greenland was reduced by half, and blubber was no longer bought by the Royal Greenland Trade Department after 1962 (Anon. 1963).

Walrus hunting regulations in western Greenland

Changes in walrus hunting practices, and in particular the high catches in 1937, led to a discussion in the Local Political Council (Landsrådet) where it was proposed to regulate the walrus hunt (Anon. 1938). However, hunting regulations were not introduced until 1949 when walrus in the West Ice were protected between 20 May and 31 December (Vibe 1956). New hunting regulations came into force in 1956. From 1 June to 1 January all hunting of males along the coast and in the West Ice from 66°N to 75°N was forbidden. From 1 April to 1 January no females and calves may be taken in the same area (Anon. 1956). Walrus were not allowed to be hunted at the islands Kitsissut and Aarfiit in Kangaatsiaq municipality between 15 October and 31 January. According to Anon. (1959 a,b) this paragraph was removed in 1959. These regulations were amended in 1978 (Anon. 1978 b). There is no quota for boats smaller than 40 tons, but since 1978 boats larger than 40 tons have been permitted to catch five walrus per year. There is a requirement that hunters land and salvage 100% of the captured walrus (Anon. 1978 b). The hunting of walrus in Greenland is only permitted to licensed Greenlanders and Danish citizens resident in Greenland who have hunting and fishing

as a fulltime occupation (*ibid.*). According to a special regulation (Anon. 1990) it is allowed to hunt walrus in the municipality of Kangaatsiaq between 1 February and 14 October.

Discussion

Past and present distribution

Walrus depend on a suitable substrate for hauling out and on access to shallow feeding areas. They can break through ice that is about 20 cm thick, but if the ice cover becomes thicker they must relocate to areas with moving pack ice (e.g. Fay 1982, 1985). Between Nuussuaq (70°45'N) and Inannganeq (Kap York; approx. 76°N) at the margin of the "North Water" polynia, the dense Baffin Bay pack ice lies close to the shore fast ice, leaving the walrus only limited space to overwinter in the Uummannaq and Upernavik areas. Off Sisimiut-Disko the eastern edge of the pack ice is somewhat less dense than that further north in Baffin Bay (*cf.* Danish Meteorological Institute 1976, McLaren & Davis 1981). This ice covers the shallow banks that support concentrations of walrus food items. Thus both ice and food conditions are favorable for walrus to overwinter off Central West Greenland between approximately 66°30'N and 70°45'N.

The distribution of walrus during the surveys reported in this study was consistent. In winter it was disjunct: some animals were seen between approximately 66°N and 68°15'N while others were found along the west coast of Disko between approximately 69°30'N and 70°30'N. They were absent from the entrance of Disko Bugt where water depths exceed 200 m. Hence, the recent winter distribution of walrus off Central West Greenland is similar to that indicated by historical information from the 19th and 20th centuries. The major difference is their present absence from terrestrial haul out sites.

Timing of migration

Apparently, the timing of the seasonal arrival and departure of walrus in Central West Greenland changed during the 20th century. At the turn of the century they reportedly arrived as early as late August, although the major influx apparently occurred in September-October. They stayed in the edge of the West Ice at least until early June. Nowadays, they are reported to arrive in October-November and to leave the area in May. We suggest that this change in timing may have been caused partly by a change in climate. By about 1920 sea temperatures increased in southwestern Greenland (e.g. Vibe 1967, Hovgård & Buch 1990). It is likely that prior to the mild period walrus were forced to move southeast towards their wintering areas in western Greenland earlier in the autumn due to the relatively early formation of dense

pack ice in Baffin Bay. Also, their spring migration northward would have been delayed by the later ice break-up. The milder climate since about 1920 might explain the arrival of walruses to Central West Greenland later in fall and their earlier disappearance during spring. Increased fishing and hunting activity along the west coast of Greenland during the same period also may have influenced the walrus migration.

At the beginning of the 1970s, trawling for shrimp was initiated in offshore areas where the water depth is between 200 and 450 m. (Pedersen 1990). These areas include the western slope of the Store Hellefiske Banke. In winter and spring walruses occur on this bank in areas where water depths are less than 100 m. Since the late 1980s, about 25 trawlers above 800 GRT and some smaller vessels operate during early spring close to the edge of the West Ice, whenever ice conditions allow. Walruses are observed from these ships, and also hunted to an unknown extent (this study). The extent to which operations by these ships influence the distribution of walruses, either because of underwater noise or by the mechanical impact of trawling on the walrus feeding grounds remains undetermined.

Reasons for changes in walrus catches after 1920

After the 1920s the number of motorized vessels increased rapidly in western Greenland (*e.g.* Mattox 1973). To facilitate the development of modern fisheries the Greenland Administration offered loans to Greenlanders with favorable conditions for investment in motorized vessels (*ibid.*). The increase in the number of motorized boats was primarily related to a change in the Greenland economy towards fishing, stimulated by a climate related invasion of Atlantic cod (*Gadus morhua*) in southwestern and western Greenland. Between 1910 and 1935 there was also a relatively intensive Greenland fishery for halibut (*Hippoglossus hippoglossus*) on Store Hellefiske Banke (*e.g.* Smidt 1983). However, as the trade of walrus products to the Royal Greenland Trade Department was still economically profitable, and because large catches could only be taken by motorized vessels operating offshore in the spring, the increase in number of boats in the Aasiaat-Sisimiut area was also motivated by a wish to increase the catch of walruses (Rask 1993). The hunting of walruses during spring was combined with fishing activities later in the season (Rosendahl 1967).

During cold winters the edge of the Baffin Bay pack ice lies close to the coast (Vibe 1967). Apparently, the mild weather after about 1920 made ice conditions at the edge of the West Ice less severe during spring, thereby facilitating the access by vessels to walrus habitats. Hence, the combination of the increased size of the fleet of motorized fishing vessels and lighter ice conditions

during spring may have had an synergistic effect causing the catch of walruses in Central West Greenland to increase rapidly during the 1920s.

Undoubtedly, increased hunting at the terrestrial haul out sites caused the walruses to abandon them. However, it can not be determined whether a group of walruses that hauled out on land was simply extirpated or whether these animals learned to avoid the uglit and to instead winter in the edge of the West Ice.

Vibe (1956) and Mansfield (1973) stated that the decline in the Greenland catches of walruses after 1940 reflected a decline in the walrus population. There is no evidence of a reduced hunting effort during the period of declining catches after approximately 1940. On the contrary, despite the difficulty of selling walrus hides on the European market (experienced already by the late 1930s; Anon. 1937), and despite the drop in international oil prices in 1930 (Anon. 1946), the trade of walrus hides and oil to the Royal Greenland Trade Department remained high in Central West Greenland (this study). This supports the statements by Vibe and Mansfield (*ibid.*).

From the beginning of the 1960s there was an increase in fishing activity in Greenland. In particular commercial shrimping was initiated in Central West Greenland (Mattox 1973, Horsted 1978). After the early 1950s the revenue of fishing products, compared with that of hunting products, increased rapidly in western Greenland (Mattox 1973). The Royal Greenland Trade Department stopped purchasing hides and blubber in 1962 (Anon. 1963, Mattox 1973), and this policy reduced the incentive for Greenlanders to hunt walruses (this study).

Walrus hunting practices in the Uummannaq and Upernavik area differ appreciably from those in the more southern districts. In the Uummannaq and Upernavik area, walruses were and are still caught by boat during fall, and from the ice edge during winter and spring; larger vessels are not used for walrus hunting. Nevertheless, the development in walrus catches since 1940 has paralleled that in the areas further south. We conclude that the decline in the catch of walruses in western Greenland south of 76°N reflects three factors: (1) A reduction in the walrus population between 1940 and 1960, (2) an overall reduction in walrus hunting effort since the early 1960s, and (3) a decline in efficiency of the reporting system since the mid 1970s.

Estimates of abundance based on survey results

Due to relatively large coefficients of variation, the strip-census estimates for 1981–1982 and 1990–1991 involving the same strip widths, are not adequate for detecting trends in numbers of walruses wintering off western Greenland.

Several factors may have influenced the point esti-

mates of abundance for the different years: (1) Different and incompatible survey methods were used, (2) ice conditions and timing of the surveys varied between years, resulting in differences in the number of walrus present within the study area, (3) variable weather conditions affected the proportion of walrus hauled out on ice at the time of the survey, and (4) numbers of walrus sightings, which in all surveys were small, varied by chance. Each of these possibilities is considered, in turn, below.

A Piper Navajo was used for the surveys in 1984. This aircraft is not ideally suited for aerial surveys because parts of the search image are obstructed by the low wings. Presumably, this caused us to underestimate abundance, particularly since some swimming walrus would almost certainly have been missed. During the surveys in 1981 and 1982, which were conducted at 150 m altitude (Table 2), the visual appearance and engine noise of the Twin Otter may have scared more walrus into the water. A larger proportion of walrus may have dived in front of the plane during these surveys. The relatively slow speed used in 1991 may have increased the probability of detecting walrus.

Although the ice conditions at West Greenland appear to have been particularly severe during the winters of 1982 and 1984 (Rosenørn *et al.* 1984), all surveys revealed that walrus winter in areas with dense ice cover. We do not think that the ability of walrus to winter in Central West Greenland was seriously affected even during the severe winters in the early 1980s. Weather conditions, however, influence the numbers of walrus that are hauled out on ice (*e.g.* Fay & Ray 1968) and this affects the detectability of walrus from aircraft. Apparently, the weather conditions during the 1990 and 1991 surveys did not differ significantly from conditions during the earlier surveys. In any event, we have no factual basis for evaluating the effect of weather conditions on the estimates of abundance in the various surveys.

Strip census estimation relies on the assumption of equal probability of detection of animals across the strip width. This assumption was not met in aerial surveys of walrus off western Greenland because: (1) Hauled out animals were observed at greater distances from the flight track than were animals in water, and (2) the probability of detecting walrus decreased gradually at distances greater than about 200 m. In surveys in the Bering and Chukchi Seas walrus groups on ice were likely to be detected up to 930 m from the flight track, whereas the probability of detecting a group in water decreased beyond 230 m (Estes & Gilbert 1978). To overcome the problem of unequal probability of detection, a half strip width of about 200 m could be used. However, for aerial surveys of low-density areas, such as for example off Central West Greenland, it is desirable to include even distant observations in the calculations of abundance. In our study, a smaller strip width would reduce the coverage and increase the variance of the abundance estimates to an unacceptable degree. However, information from the sighting distance distribution allowed us to im-

prove the strip census estimates. A reduction of the half strip to 500 m from the track line, and hence excluding areas beyond 500 m where observations were clearly not representative, resulted in an increase in the estimates of abundance and in relatively smaller coefficients of variation.

By applying a line transect method to the walrus survey data, the estimates of abundance were further improved. This method made it possible to compensate for a gradual decrease in detectability of walrus beyond 200 m and to exclude the area close to the flight track where walrus showed avoidance reactions. We calculated one common probability detection function for walrus in water and for walrus hauled out. This was done despite indications that the probability detection function differs for these two behavioral categories. Using a common detection function complicates corrections of estimates of abundance which involve haul out/on surface/submergence behavioral factors. It is, however, possible to use the line-transect method either by operating with two probability detection functions, one for hauled-out animals and one for animals in water, or by excluding walrus in the water. In our case, the general scarcity of sightings did not allow such refinements.

Because walrus in water were detected less effectively, the figures for the abundance of walrus in western Greenland represent minimum estimates. Furthermore, the estimates are not corrected for walrus that were under water and therefore could not have been seen. While feeding, walrus can be submerged for about 85% of the time (surface:subsurface ratio = 1:6.5; Fay 1982, Born and Knutsen 1990). However, correction of the estimates to compensate for submerged walrus is complicated by the fact that we did not obtain unbiased estimates of the proportions of walrus in water and on ice. This is due to the fact that, first, walrus in water were not effectively detected beyond about 200 m, and, second, close to the flight track they were apparently scared into the water.

Stock discreteness

Our study indicates that the number of walrus wintering in Central West Greenland has decreased markedly during the 20th century. However, the connection between walrus occurring there and walrus from other parts of Baffin Bay and Davis Strait areas is poorly known. However, some indications about stock relationships are available. Freuchen (1921) reported the capture of a walrus in Avanersuaq (the Thule area) that had an old harpoon head of a particular design imbedded in the skin. Seventeen years earlier, this walrus had been harpooned at Nuussuaq (Uummannaq area) in western Greenland. Inuit of Pond Inlet (northeastern Baffin Island) often found harpoon heads of a west Greenland type in walrus (Freuchen 1935). Walrus caught in Avanersuaq

often carried rifle bullets and harpoon heads thought to have originated from Baffin Island and from the Upernavik area (Vibe 1950). According to Bisset (1967), walrus have been caught in the Pond Inlet-Arctic Bay region with rifle bullets of a foreign type (Greenland ?) in them.

Freuchen (1921) and Vibe (1950, 1956) suggested that the walrus from Central West Greenland moved northward during May and June to join the walrus wintering in the northern Baffin Bay – Smith Sound region. In October there appeared to be a southward movement along the eastern coast of Baffin Island and the northwestern coast of Greenland. From Baffin Island the animals were believed to move across Davis Strait to reappear in the central parts of West Greenland in the fall. Vibe (1967) assumed that the majority of the Baffin Bay summering population moved from the Avanersuaq area in the fall to Lancaster Sound, and from there some crossed the Baffin Bay to western Greenland. Walrus off Central West Greenland were believed to stay in the Davis Strait pack ice or to cross the strait and join the population at southeastern Baffin Island in severe winters (*ibid.*).

Loughrey (1959) and Mansfield (1973) noted the more sedentary habits of the Atlantic walrus compared to the Pacific walrus, and Mansfield (1973) questioned whether the large-scale, counter-clockwise migration cycle in the Baffin Bay – Davis Strait area suggested by Freuchen (1921) and Vibe (1950) actually occurred. Mansfield (*ibid.*) also indicated that walrus apparently had become scarce along the coasts of northeastern Baffin Island. In this area the Inuit did not witness any southward movement according to Bisset (1967). Koski & Davis (1979) and Koski (1980) did not find any indication of a southward fall movement along the northeastern coast of Baffin Island during their systematic aerial surveys.

From the dates when walrus appeared at various locations, Dunbar (1956) suggested that the Hudson Bay, Hudson Strait and Frobisher Bay groups might comprise one large population. He suggested that the population moves into Hudson Strait in the spring and out again in late fall, wintering perhaps in the neighborhood of the ice edge in Davis Strait, where they may well join the walrus occurring off Central West Greenland, as also suggested by Freuchen & Salomonsen (1961) and Mansfield (1973). It is still not clear, however, whether walrus from eastern Hudson Strait mix with walrus in Hudson Bay (Orr & Rebizant 1987).

Born *et al.* (1982) found indications of a northward movement in spring along the western coast of Disko. Whereas scattered observations of walrus in May-July in the middle of Davis Strait suggest that some walrus cross the Davis Strait from Greenland to Canada.

Indications that walrus no longer move in large numbers southward in the fall neither along the northeastern coast of Baffin Island nor along the northwestern coast of Greenland may imply that numbers have decreased sub-

stantially and that walrus nowadays occur in more sedentary groups.

A study of mitochondrial DNA variation in walrus including a limited number of specimens from the Avanersuaq and Sisimiut area, respectively, indicates that the group of walrus in Avanersuaq perhaps is separate from that further south (Cronin *et al.* in press).

Walrus remain widely distributed in northern Baffin Bay, Smith Sound and the Lancaster Sound region. The majority of walrus from these areas winter in the North Water polynya and in several small open-water areas in the Canadian High Arctic and off northwestern Greenland, possibly to as far south as the Disko area (perhaps even further). A connection between this group and those occurring along southeastern Baffin Island and in Hudson Strait can, however, not be excluded.

The shallow feeding banks off Central West Greenland provide important wintering habitat for walrus. A comparison between historical and recent information on occurrence, abundance and exploitation indicates clearly that the number of walrus in this area and the extension of undisturbed wintering habitat available to them have declined during the 20th century. Increased fishing activities since the 1960s in areas where walrus winter, and catches which remain high relative to the estimates of abundance, pose a threat to the survival of walrus in Central West Greenland.

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References

- Anonymous 1899. Meddelelser fra Direktoratet for den kongelige grønlandske Handel. I:68.
- Anonymous 1900. Meddelelser fra Direktoratet for den kongelige grønlandske Handel. I:97.
- Anonymous 1907. Meddelelser fra Direktoratet for den kongelige grønlandske Handel. I:9.

- Anonymous 1910. Beretninger of Kundgørelser vedrørende Kolonierne i Grønland. Nr. 1:132,134.
- Anonymous 1911. Beretninger of Kundgørelser vedrørende Kolonierne i Grønland. Nr.3:269.
- Anonymous 1912. Beretninger of Kundgørelser vedrørende Kolonierne i Grønland. Nr. 1:299.
- Anonymous 1913a. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 1:14,16.
- Anonymous 1913b. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 3. Punkt 7 & 9:127,128.
- Anonymous 1914. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 1:168.
- Anonymous 1915. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 1:294.
- Anonymous 1922a. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 2:493.
- Anonymous 1922b. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 1:467.
- Anonymous 1925. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 3:322.
- Anonymous 1928. De grønlandske Landsraads Forhandlinger. Punkt 27:158.
- Anonymous 1930. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 2:451.
- Anonymous 1931. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 3:712.
- Anonymous 1933. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 1:18.
- Anonymous 1934. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 2:249.
- Anonymous 1935. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 2:509.
- Anonymous 1936a. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 2:688.
- Anonymous 1936b. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 2:691.
- Anonymous 1937. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 2:997.
- Anonymous 1938. De grønlandske Landsraads Forhandlinger 1938–47. Punkt 8. Regulering af Hvalrosfangst: 52–62.
- Anonymous 1939a. De grønlandske Landsraads Forhandlinger: 117.
- Anonymous 1939b. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 1:215.
- Anonymous 1940. Beretninger og Kundgørelser vedrørende Styrelsen af Grønland. Nr. 1:374.
- Anonymous 1944. Beretninger vedrørende Grønlands Styrelse, Nr.1. Sammen drag af statistiske oplysninger om Grønland. III: 561–665.
- Anonymous 1946. 24. Afsnit. Indkøb af grønlandske produkter. Beretninger vedrørende Grønlands Styrelse, No. 1. Sammen drag af statistiske oplysninger om Grønland VI: 779–788, 893.
- Anonymous 1948. Beretninger vedrørende Grønlands Styrelse. Nr 1:102.
- Anonymous 1950. Beretninger vedrørende Grønlands Styrelse, Nr. 1:126.
- Anonymous 1951. Grønlands Landsraads Forhandlinger 1951. Nr. 3:137.
- Anonymous 1952a. Grønlands Landsraads Forhandlinger 1952. Nr. 3:200.
- Anonymous 1952b. Forbud mod fangst af hvalros. Kongelig resolusjon av 20. juni 1952. Oslo, Norway.
- Anonymous 1954. Beretninger vedrørende Grønlands Styrelse, Nr. 8:64.
- Anonymous (1954...1987). Sammen drag af Grønlands Fangstlister (Summaries of Hunters' Lists of Game). Until 1984 Ministeriet for Grønland. After 1985 Erhvervsdirektoratet, Nuuk.
- Anonymous 1956. Vedtægt om regulering af hvalrosfangst i Davisstrødet og Baffinsbugt. – Kundgørelser vedrørende Grønland. Afsnit 16, Gruppe 13, lb.nr. 12.
- Anonymous 1957. Grønlands Landsraads Forhandlinger 1957. Nr. 2:222.
- Anonymous 1959a. Spørgsmål vedrørende fredningsreglerne for hvalros. Grønlands Landsraads Forhandlinger 1959. Nr. 3:136.
- Anonymous 1959b. Bilag 2 Landsrådsforhandlinger vedr. ophævelse af par. 7: 217.
- Anonymous 1961. Grønlands Landsraads Forhandlinger 1961. Nr. 2:24.
- Anonymous 1963. Grønlands Landsraads Forhandlinger 1963. Nr. 2a:38–47.
- Anonymous 1978a. Summary Environmental Impact Statement for Exploratory Drilling in the Davis Strait Region. – Unpubl. report by Imperial Oil Ltd., Aquitaine C. of Canada Ltd. Canada Cities Service Ltd., January 1978: 83 pp.
- Anonymous 1978b. Landsrådsvedtægt om ændring af landsrådsvedtægt om regulering af hvalrosfangst i Davisstrødet og Baffinsbugt. Grønlandsk Lovsamling, Serie A, nr.3.
- Anonymous. 1980. Havpattedyr, p. 51. – In: Holsteinsborg. Sisimiut kommune. Natur- og kulturforhold. Min. f. Grønland 1980: 88 pp.
- Anonymous. 1982. Hvalros skudt ved Kangeq. – Sermitsiaq Nr. 28, 1982:28.
- Anonymous 1990. Summary of Fish & Wildlife Regulations in Greenland. – Greenland Home Rule, Wildlife Management, DK-3900 Nuuk, June 1990:2 pp.
- Bendixen, O. & Bobé, L. 1921a. Godthaab Distrikt – In: Amstrup, G. C., Bobé, L., Jensen, Ad.S & Steensby, H. P. (eds.). Grønland i Tohundredeaaaret for Hans Egedes Landing Vol. 2:176–196. – Meddr Grønland LXI:795 pp.
- Bendixen, O. & Bobé, L. 1921b. Sukkertoppen Distrikt – In: Amstrup, G. C., Bobé, L., Jensen, Ad.S & Steensby, H. P. (eds.). Grønland i Tohundredeaaaret for Hans Egedes Landing Vol. 2: 95–175. – Meddr Grønland LXI: 795 pp.
- Bendixen, O. & Bobé, L. 1921c. Holsteinsborg Distrikt – In: Amstrup, G. C., Bobé, L., Jensen, Ad.S & Steensby, H. P. (eds.). Grønland i Tohundredeaaaret for Hans Egedes Landing Vol. 2: 2–94. – Meddr Grønland LXI: 795 pp.
- Bertelsen, A., Porsild, M. P. & Ostermann, H. 1921. Ummanaq Distrikt. – In: Amstrup, G. C., Bobé, L., Jensen, Ad.S. & Steensby, H. P. (eds.). Grønland i Tohundredeaaaret for Hans Egedes Landing Vol.1: 342–429. – Meddr Grønland LX: 567 pp.
- Birket-Smith, K. 1924. Ethnology of the Egedesminde district. – Meddr Grønland 66: 484 pp.
- Bisset, D. 1967. Northern Baffin Island: an area economic survey. Vol. 2. – Department of Indian Affairs and Northern Development, Ottawa: 131 pp.
- Born, E. W. 1988. Distribution and abundance of walrus (*Odobenus rosmarus*) wintering off Central West Greenland in 1984. – Teknisk rapport – Grønlands Hjemmestyre. Afdelingen for Levende Ressourcer. Nr. 2 – november 1988: 15 pp.
- Born, E. W. 1990a. Distribution and numbers of Atlantic walrus (*Odobenus rosmarus*) in Greenland. – In: Fay, F. H., Kelly, B. P. & Fay, B. (eds.). The Ecology and Management of Walrus Populations. – Report of an International Workshop. Seattle, Washington, USA, October 1990: 95–153. U.S. Marine Mammal Commission, Washington D.C.:186 pp.
- Born, E. W. 1990b. Hvalrosundersøgelser i Vestisen på m.s. "Adolf Jensen", 9. til 19. april 1990. Togtrapport. – Unpublished report. Miljø- og naturforvaltningen. Grønlands Hjemmestyre, Pilestræde 52, DK-1016 Copenhagen K, Denmark: 8 pp.
- Born, E. W., Dietz, R. & Heide-Jørgensen, M. P. 1982. Catch and distribution of walrus (*Odobenus rosmarus*) in West Greenland. – I.C.E.S. C.M. 1982/N:10: 27 pp.
- Born, E. W. & Knutsen, L. Ø. 1990. Satellite tracking and behavioral observations of Atlantic walrus (*Odobenus rosmarus*) in NE Greenland in 1989. – Teknisk rapport –

- Grønlands Hjemmestyre. Afdelingen for Levende Ressourcer. Nr. 20 – oktober 1990: 68 pp.
- Brummersted 1890, letter *vide* Winge (1902).
- Bryder, H., Porsild, M. P. & Ostermann, H. 1921. Upernavik Distrikt. – In: Amdrup, G. C., Bobé, L., Jensen, Ad.S. & Steensby, H. P. (eds.). Grønland i Tohundredeåret for Hans Egedes Landing Vol. 1: 430–516. – Meddr Grønland LX: 567 pp.
- Burnham, K. P., Anderson, D. R. & Laake, J. L. 1980. Estimation of density from line transect sampling of biological populations. – Wildlife Monographs 72: 203 pp.
- Burnham, K. P., Anderson, D. R., White, G. C., Brownie, C. & Pollock, K. H. 1987. Design and analysis methods for fish survival experiments based on release-recapture. – American Fisheries Society Monograph 5.
- Caughley, G. 1977. Sampling in aerial survey. – J. Wildl. Manage. 41: 605–615.
- Caughley, G. & Grigg, G. C. 1981. Surveys of the distribution and density of kangaroos in the pastoral zone of South Australia, and their bearing on the feasibility of aerial survey in large and remote areas. – Aust. Wildl. Res. 8: 1–11.
- Chapskii, K. K. 1936. The walrus of the Kara Sea. Results of an investigation of the biology, geographical distribution, and stock of the walrus of the Kara Sea and Novaya Zemlya. – Transactions of the Arctic Institute. Vol LXVII, Leningrad 1936 (Translated by F. H. & B. Fay).
- Cronin, M. A., S. Hills, E. W. Born & J. C. Patton. Mitochondrial DNA variation in Atlantic and Pacific walrus. – Can. J. Zool. In press.
- Danish Meteorological Institute 1976. West ice investigations. Part 1. West ice histograms 1959–1974. – Danish Meteorological Institute, Nautical Department, Copenhagen: 204 pp.
- Dietz, R. 1982. Rapport over feltarbejde foråret 1982 (Report on field work – spring 1982). – Unpubl. report from Danbiu ApS – Hellerup. Greenland Fisheries Research Institute, Tagensvej 135, 2200 Copenhagen N, Denmark: 16 pp. (In Danish).
- Dowler, D. H. 1976. Average marine mammal harvest 1973–1975. Northwest-Territories. – (Unpublished tables received from H. R. Trudeau, Fish. and Marine Service, Yellowknife): 2 pp. (cited in Reeves 1978).
- Dunbar, M. J. 1956. The status of the Atlantic walrus *Odobenus rosmarus* (L.) in Canada. – Int. Union. Protect. Nature. Proc. 5th Meet., Copenhagen 1954:59–61.
- Estes, J. A. & Gilbert, J. R. 1978. Evaluation of an Aerial Survey of Pacific Walrus (*Odobenus rosmarus divergens*). – J. Fish. Res. Board. Can. 35: 1130–1140.
- Fabricius, O. 1780. Fauna groenlandica. Hafniae, Lipsiae; Joannis G. Rothe. (Translated from Latin to Danish by O. Helms, 1929): Fauna groenlandica. Pattedyr og Fugle. – Det Grønlandske Selskabs Skrifter VI: 168 pp.
- Fay, F. H. 1982. Ecology and Biology of the Pacific Walrus, *Odobenus rosmarus divergens* Illiger. – North American Fauna, No. 74. U.S. Department of the Interior Fish and Wildlife Service: 279 pp.
- Fay, F. H. 1985. *Odobenus rosmarus*. Mammalian Species No. 238. – The American Society of Mammalogists: 1–7.
- Fay, F. H. & Ray, C. 1968. Influence of climate on the distribution of walrus, *Odobenus rosmarus* (Linnaeus). I. Evidence from thermoregulatory behavior. – Zoologica 53: 1–18.
- Finley, K. J. & Renaud, W. E. 1980. Marine Mammals inhabiting the Baffin Bay North Water in Winter. – Arctic 33 (4): 724–738.
- Freeman, M. M. R. 1974–75. Studies in maritime hunting II. An analysis of walrus hunting and utilization: Southampton Island, N.W.T. 1970. – Folk 16–17:147–158.
- Freuchen, P. 1921. Om Hvalrossens Forekomst og Vandringer ved Grønlands Vestkyst (Distribution and migration of walrus along the western coast of Greenland). – Vidensk. Medd. Dansk Naturhist. Foren. København Vol. 72: 237–249. Translated: Fish. Res. Board Can. Transl. Ser. 2383:14 pp.
- Freuchen, P. 1935. Mammals, Part II. Field notes and personal observations. – Rept. Fifth Thule Exped., 2 (2–4):68–278.
- Freuchen, P. & Salomonsen, F. 1961. Det arktiske År. – Gylden-dal, København:382 pp.
- Greely, A. W. 1888. Report of the Proceedings of the U.S. Expedition to Lady Franklin Bay, Grinnell Land. Vol. 1:545 pp. Vol. 2: 738 pp. – Government Printing Office, Washington.
- Haller, A. A. 1978. The spatial organization of the marine hunting culture in the Upernavik district, Greenland. – Ph.D. Thesis. Faculty of Graduate Studies. The University of Western Ontario. London, Ontario:282 pp.
- Hammer, R. 1921. Almindelig oversigt. – In: Amdrup, G. C., Bobé, L., Jensen, Ad.S & Steensby, H. P. (eds.). Grønland i Tohundredeåret for Hans Egedes Landing Vol. 1: 1–174. – Meddr Grønland LX: 567 pp.
- Hansen, M. 1958. Letter to the Ministry for Greenland 7 March 1958 concerning the walrus hunt at the terrestrial haul out sites in western Greenland. MfG j.nr. 1731–02-04. – Greenland Fisheries Research Institute, Tagensvej 135, 2200 København N, Denmark: 3 pp (In Danish).
- Hansen, P. M. 1937. Unpublished field journal, 1937. – Greenland Fisheries Research Institute, Tagensvej 135, 2200 København N, Denmark.
- Hedegaard, A. T. 1914. Bemærkninger i anledning af det i Det Grønlandske Selskab d. 22. marts 1911 af justitsraad R. Müller holdte foredrag om rationel hvalrosfangst. – Det Grønlandske Selskabs Aarskrift 1913:3–21.
- Hoel, A. 1950. Ishavsfangst-Fangstnæring. – In: J. Strøm (ed.). Norsk Fiskeri og Fangsthåndbok, Oslo; Bind I: 707–861. – Alb. Cammermeyers Forlag.
- Horsted, Sv. Aa. 1978. Rejerner ved Grønland. – Fisk & Hav 78. Danmarks Fiskeriundersøgelser 1978: 71 pp.
- Hovgård, H. & Buch, E. 1990. Fluctuation in the Cod Biomass of the West Greenland Sea Ecosystem in Relation to Climate. – In: K. Sherman, L. M. Alexander & B. D. Gold (eds.). Large marine ecosystems: Patterns, processes, and yields.:36–43. American Association for the Advancement of Science. Washington: 242 pp.
- Isachsen, G. 1922. Norske fangstmænds færder til Grønland. – Norske Geografiske Selskabs Aarboek 1919–1921, Oslo:p. 19.
- Isachsen, G. & Isachsen, F. 1932. Norske fangstmænds og fiskerens færder til Grønland 1922–1931. – Norges Svalbard-og ishavsundersøkelser. Meddelelser Nr. 18:21–74.
- Jennov, J. G. 1952. Letter of 4 April 1952 concerning Norwegian walrus catches in the Davis Strait and Baffin Bay areas in 1949 and 1951. – Archives of the Arctic Institute, Copenhagen:1 p.
- Jensen, J. A. D. 1879, letter *vide* Winge (1902).
- Kapel, F. O. 1975. Recent research on seals and seal hunting in Greenland. – Rapp. P.-v. Réun. Cons. int. Explor. Mer. 169: 462–478.
- Knutsen, L. Ø. & Born, E. W. in press. Body growth in Atlantic walrus (*Odobenus rosmarus rosmarus*) from Greenland. – J. Zool. (Lond.).
- Koski, W. R. 1980. Distribution and migration of marine mammals in Baffin Bay and eastern Lancaster Sound, May – July 1979. – Unpubl. report by LGL Ltd. for Petro-Canada Explorations, Calgary, Alberta, December 1980: 317 pp.
- Koski, W. R. & Davis, R. A. 1979. Distribution of marine mammals in northwest Baffin Bay and adjacent waters, May–October 1978. – Unpubl. report by LGL Ltd. for Petro-Canada, Calgary, May 1979: 304 pp.
- Kramer, F. E. 1992. "Om at udelede sig blandt saa mange Skjønheder en Brud". Aasiviit-sammenkomsterne på Tasertalik i Sisimiut-distriktet. – Tidsskr. Grønland, 1992(3):77–97.
- Laake, J. L., Buckland, S. T., Anderson, D. R. & Burnham, K. P. 1991. Distance sampling: Abundance estimation of biological populations. Colorado Cooperative Fish and Wildlife Research Unit. – Colorado State University, Fort Collins, Colorado 80523.
- Loughrey, A. G. 1959. Preliminary investigation of the Atlantic walrus *Odobenus rosmarus rosmarus* (Linnaeus). – Can. Wildl. Serv., Wildl. Manage. Bull. Ser. 1. No. 14:123 pp.

- MacLaren Atlantic Limited 1977. Report on primary data collected for the 1977 Davis Strait biological programme and analysed prior to December, 1977. – Unpubl. report to Imperial Oil Ltd., Aquitane Co. of Canada Ltd. and Canada Cities Services Ltd., Arctic Petroleum Operators Association. Project Nos. 134 and 138 February, 1978.
- MacLaren-Marex Inc. 1979. Report on aerial surveys of birds and marine mammals in the southern Davis Strait between April and December 1978. – Unpubl. report to ESSO Resources of Canada Ltd. and Canada Cities Service Ltd., Arctic Petroleum Operators Association, Project Numbers 146, Vol III: Marine Mammals. February 1979.
- Mansfield, A. W. 1958. The biology of the Atlantic walrus, *Odobenus rosmarus rosmarus* (Linnaeus) in the eastern Canadian Arctic. – Fish. Res. Board. Can. MS Rept. Ser. (Biology) No. 653:146 pp.
- Mansfield, A. W. 1973. The Atlantic walrus *Odobenus rosmarus* in Canada and Greenland. – In: Seals. Proc. Work. Meet. Seal. Spec. Threatened Depleted Seals World, Survival Serv. Comm. IUCN 18–19 Aug. 1972. Univ. Guelph. Ont. Can. IUCN Publ. New Ser., Suppl. Pap. 39: 69–79.
- Marin ID (Marine Identification Agency ApS) 1978. Bundinvertebrater på Store og Lille Hellefiskebanke og i Holsteinsborgdybet. Part 1 and 2. Unpubl. report to the Ministry for Greenland. 1 Del, tekst: 102 pp. 2 Del, artslister: 134 pp.
- Mattox, W. 1973. Fishing in West Greenland 1910–1966. The development of a new native industry. – Meddr Grønland 197(1):344 pp. + Appendix:125 pp.
- McLaren, P. L. & Davis, R. A. 1981. Distribution of marine mammals in southern Baffin Bay and northern Davis Strait, March 1981. – Unpubl. report for the Arctic Pilot project, Calgary, by LGL Ltd., Toronto, October 1981:85 pp. + 7 plates.
- McLaren, P. L. & Davis, R. A. 1983. Distribution of wintering marine mammals off West Greenland and in southern Baffin Bay and northern Davis Strait, March 1982. – Unpubl. report for the Arctic Pilot Project, Calgary, by LGL Ltd., Toronto, July 1983:98 pp.
- Müller, R. 1896–1898, letter *vide* Winge 1902.
- Müller, R. 1906. Vildtet og Jagten i Sydgrønland. H. Hagerups Boghandel, København: 519 pp.
- Müller, R. 1912. Om rationel hvalrosfangst. – Det Grønlandske Selskabs Aarskrift 1910–1911, 2. Hefte:97–117.
- Müller, R. 1914. Bemærkninger til udstedsbestyrer Hedegaards artikel om rationel hvalrosfangst. – Det Grønlandske Selskabs Aarskrift 1913:23–28.
- Ohlin, A. 1895. Zoological observations during Peary Auxiliary Expedition 1894, Mammals. – Biologisches Centralblatt 15:163–168.
- Oldendow, K. 1935. Hvalros *Trichechus rosmarus*. – In: Naturfredning i Grønland.: 245–264. Det Grønlandske Selskabs Skrifter IX: 389 pp.
- Orr, J. R. & Rebizant, T. 1987. A summary of information on the seasonal distribution and abundance of walrus (*Odobenus rosmarus*) in the area of north Hudson Bay and western Hudson Strait, NWT, as collected from local hunters. – Canadian Data Rept. of Fish. and Aquat. Sci. No 624:16 pp.
- Orr, J. R., Renoy, B., & Dahlke, L. 1986. Information from hunts and surveys of walrus (*Odobenus rosmarus*) in northern Foxe Basin, Northwest Territories, 1982–1984. – Can. Manusc. Rept. Fish and Aquat. Sci. No. 1899: 24 pp.
- Ostermann, H. & Porsild, M. P. 1921. Egedesminde Distrikt. – In: Amdrup, G. C., Bobé, L., Jensen, Ad.S., & Steensby, H. P. (eds.). Grønland i Tohundredeåret for Hans Egedes Landing Vol. 1: 1–90. – Meddr Grønland LX: 567 pp.
- Parry, W. E. 1821. Journal of a Voyage for the Discovery of a Northwest Passage from the Atlantic to the Pacific. – John Murray, London Vol. 1:179 pp.
- Pedersen, S. A. (ed.) 1990. Vigtigste grønlandske fiskeressurcer: Status og biologisk rådgivning. – Upubliceret rapport til Grønlands Hjemmestyre fra Grønlands Fiskeriundersøgelser, februar 1990:116 pp.
- Rask, S. 1993. De første erhvervsmotorbåde. Om fangstens betydning for udviklingen i industrifiskeriet. – Tidsskriftet Grønland 1993(3): 100–118.
- Rasmussen, B. 1952. Om beskyttelse av hvalross. – Upubl. rapport, 20. januar 1953, bearbejdet fra notat af 6. juni 1952. Archives of Marine Research Institute, Bergen: 6 pp.
- Ray, G. C. & Watkins, W. A. 1975. Social function of underwater sounds in the walrus *Odobenus rosmarus*. – Rapp. P.-v. Réun. Cons. int. Explor. Mer 169: 524–526.
- Reeves, R. 1978. Atlantic walrus (*Odobenus rosmarus rosmarus*): A literature survey and status report. – U.S. Dep. Int. Fish and Wildl. Serv., Wildl. Res. Rept. 10:41 pp.
- Rink, H. 1877. Danish Greenland Its People and Its Products. – Henry S. King and Co., London: 468 pp.
- Richard, P. R. & Campbell, R. R. 1988. Status of the Atlantic walrus, *Odobenus rosmarus rosmarus*, in Canada. – Canadian Field-Naturalist 102(2): 337–350.
- Rörvik, NN 1952. Rapport angående reise med S/F "Polarquest" på hvalrossfangst i Davisstredet, 4. april 1952. – Archives of Marine Research Institute, Bergen: 7 pp.
- Rosendahl, Ph. 1967. Kajakmænd jager hvalros. Jakob Danielsen. En grønlandsk maler. – Rhodos, København: 355 pp.
- Rosenørn, S., Fabricius, J., Buch, E. & Horsted, Sv. Aa. 1984. Isvintre i Grønland. – Tusat/Forskning i Grønland, 1984/2: 2–9.
- Ross, W. G. & MacIver, A. 1982. Distribution of the kills of Bowhead whales and other sea mammals by Davis Strait whalers 1829–1910. – Report for Arctic Pilot Project, January 1982: 75 pp.
- Smidt, E. L. B. 1983. Om overgangen fra fangst til fiskeri i Vestgrønland. – Tidsskriftet Grønland Nr. 5: 125–144.
- Smith, T. G. & Taylor, D. 1977. Notes on marine mammals, fox and polar bear harvest in the Northwest Territories 1940 to 1972. – Fish. Mar. Serv., Tech. Rept. No. 694. Environment Canada, Ottawa: 37 pp.
- Turl, C. W. 1987. Winter Sightings of Marine Mammals in Arctic Pack Ice. – Arctic 40(3): 219–220.
- Vibe, C. 1950. The Marine Mammals and the Marine Fauna in the Thule District (Northwest Greenland) with Observations on the Ice Conditions in 1939–41. – Meddr Grønland 150(6): 115 pp.
- Vibe, C. 1956. The walrus west of Greenland. – In: Int.Union. Protect. Nature Proc. 5th Meet., Copenhagen 1954: 79–84.
- Vibe, C. 1967. Arctic animals in relation to climatic fluctuations. – Meddr Grønland 170(5): 227 pp.
- Vollan, O. 1951. Ishavsfangst. Selfangsten fra Sunnmøre gennem femti år. – Alb. Cammermeyers Forlag, Oslo: 189–190; 223–224; 241.
- Winge, H. 1902. Grønlands Pattedyr. – Meddr Grønland 21(2): 319–521.

A phytogeographical study of the vascular plants of northern Greenland – north of 74° northern latitude

CHRISTIAN BAY

Bay, C. 1992. A phytogeographical study of the vascular plants of northern Greenland – north of 74° northern latitude. – Meddr Grønland, Biosci. 36, 102 pp. Copenhagen 1992-12-22.

The phytogeography, flora, and vegetation of northern Greenland, north of 74°N have been investigated. The study area comprises the northern part of high arctic Greenland. The distribution of the 218 taxa of vascular plants has been mapped and classified into 14 distribution types with 16 subtypes. Based on the larger plant material obtained during the intensive botanical exploration of the area in the last decade the delimitation of the phytogeographical units as defined by Seidenfaden and Sørensen (1937) and Böcher *et al.* (1959) has been tested.

The delimitation of the floristic province North Greenland, north of 79°30'N, has been confirmed, now divided, however, into a coastal and an inland district based on the distribution of selected species which in North Greenland are restricted to the interior. The coastal district is considered the polar desert zone in high arctic Greenland.

The delimitation of the districts in the floristic province Northwest Greenland has been accepted, whereas the delimitation of the originally proposed districts in the floristic province Northeast Greenland has been altered. Here the border between the continental and the oceanic floristic province has been moved in an eastward direction. Further, the northern district in the continental province is divided into two districts based on a marked floristic limit by Bessel Fjord (76°N), where several low arctic species have their northern limit, thus giving a total of four districts in continental Northeast Greenland. No evidence for maintaining the subdivision of the oceanic floristic province in Northeast Greenland at Wollaston Forland has been found. This limit is expected to be found south of the study area.

Four taxa new to the flora of Greenland have been recognized or found: *Puccinellia bruggemanni* Th. Sør., *Phippsia algida* (Sol.) R. Br. ssp. *algidiformis* (H. Sm.) L. & L., *Geum rossii* (R. Br.) Ser., and *Pedicularis sudetica* Willd. ssp. *albolabiata* Hult. giving a total of 121 taxa known from North Greenland north of 79°30'N. The total number of taxa in Northwest and Northeast Greenland north of 74°N is 161 and 194, respectively. Five different types of high arctic distribution are recognized in Greenland.

A classification of the vegetation based on detailed description of the vegetation and few analyses in Northwest, North, and Northeast Greenland is given. Two vegetation maps (scale c. 1:2, 380000) based on NOAA-satellite images showing the degree of plant cover in eastern North Greenland and Northeast Greenland, north of 75°N lat., are presented.

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The benthos zonation of the Disko Fjord, West Greenland

MICHAEL K. SCHMID and DIETER PIEPENBURG

Schmid, M. K. & Piepenburg, D. 1993. The benthos zonation of the Disko Fjord, West Greenland. – Meddr Grønland, Biosci. 37, 21 pp. Copenhagen 1993-6-3.

Whereas faunistic knowledge of the Greenland benthos is quite complete on the larger scale, more detailed community studies of the bottom fauna in the numerous Greenlandic fjords are relatively scarce. The benthos of the Disko Fjord on the west coast of Disko Island (West Greenland) was sampled using a van-Veen grab. Benthos communities were distinguished by cluster analysis and multidimensional scaling. The zonation pattern mainly reflects a bathymetrical gradient, but the spatial distribution of the fauna is also influenced by the strong aestival river runoff at the origin of the fjord. The resemblances between zones in terms of diversity, abundance, biomass, and faunistic composition were related to possible causes in terms of hydrography, sediment heterogeneity, and temporal patterns of ice cover and primary production. Aspects of zoogeography, trophic structure, and reproduction ecology were also considered in the discussion of community distribution and composition.

Key words:

benthos, Disko Fjord, community, zonation.

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An annotated checklist to the birds of Greenland

DAVID BOERTMANN

Boertmann, D. 1994. An annotated checklist to the birds of Greenland. – Meddr Grønland, Biosci. 38, 63 pp. Copenhagen 1994-03-28.

The most recent total account of the birds of Greenland was published in the late sixties (Salomonsen 1967). Since that, major changes have been recorded in the status and occurrence of several species. One species have disappeared (Barrow's Golden eye) and 28 new vagrants have been added to the list.

This checklist gives a current account on the birds occurring in Greenland. 235 species have been recorded. About 58 are well established breeders, c. 17 are regular (some numerous) visitors and the rest are more or less rare vagrants. Some of the visitors may breed occasionally and some are probably in the initiating phase of an immigration to Greenland. Although many vagrants have only been recorded once, some of them may occur more commonly or even annually.

The present status is described for each species and if possible also population numbers and trends. When relevant, issues as subspecies, habitats and migration are discussed or described briefly.

Keywords: birds, Greenland, status, distribution, population trends, population numbers, phenology.

BIOSCIENCE 38 . 1994
ISBN 87-601-4129-8

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Overview of the special issue “Studies of white whales (*Delphinapterus leucas*) and narwhals (*Monodon monoceros*) in Greenland and adjacent waters”

RANDALL R. REEVES, RUNE DIETZ and ERIK W. BORN

Reeves, R. R., Dietz, R. & Born, E. W. 1994. Overview of the special issue “Studies of white whales (*Delphinapterus leucas*) and narwhals (*Monodon monoceros*) in Greenland and adjacent waters”. – Meddr Grønland, Biosci. 39: 3–11. Copenhagen 1994-04-22.

This overview introduces the collection of papers on the Distribution and abundance; Exploitation and status; Habitat use and behaviour; and Life history, stock identity and toxicology of white whales (*Delphinapterus leucas*) and narwhals (*Monodon monoceros*) in Greenland and adjacent waters. It includes brief summaries of the 19 included papers and calls attention to ongoing and future studies on the same or related subjects.

Key Words:

White whale, beluga, *Delphinapterus leucas*, narwhal, *Monodon monoceros*, Greenland, eastern Canadian Arctic, Svalbard.

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Tarling, D. H. 1967. The palaeomagnetic properties of some Tertiary lavas from East Greenland. – *Earth and Planetary Science Letters* 3: 81–88.

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