Biological parameters and the seasonal and spatial distribution of minke whale catch off west Greenland, 1987-2006

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ABSTRACT

Here we present an analysis of the past twenty years (1987 – 2006) of minke whale catch reports for spatial and temporal distribution of the catches, size, sex ratio and measurements of the caught animals and the foetuses. The minke whales were caught in the area between Nanortalik and Uummannaq, with most whales caught in the central and southern municipalities and less in the north. The peak catch period was later in the southern municipalities than further north. The proportion of females in the catch was significantly higher than the proportion of males. There was no difference in the estimated length of the males and females. About half of all the females, for which the absence/presence of foetus had been reported, had a foetus. There was no significant trend in the ratio of females to males among the foetuses. There was a linear increase in the mean length of the foetus from March to October. A similar trend was found in minke whale foetuses of whales caught in other parts of the North Atlantic.

INTRODUCTION

Minke whales (*Balaenoptera acutorostrata*) have been caught in West Greenland through most of the twentieth century. Earlier by Norwegian and Danish whaling ships and since 1975 by Greenlandic hunters operating under aboriginal subsistence quotas through the International Whaling Commission, IWC. There are a number of earlier reports on the distribution of catches (e.g. Christensen 1977; Kapel 1977, 1978; Kapel and Larsen 1982, 1983; Larsen 1981; 1986; Witting 2001; Kingsley 2005) and analyses of biological samples from the catches in West Greenland (e.g. Christensen 1974, 1975; Larsen and Kapel 1981, 1982, 1983; Witting 2000). Here we analyse the past 20 years of minke whale catch reports for spatial and temporal distribution of the catches, size and sex distribution, the yield of the hunt and the measurements of foetuses in the caught animals. The first ten years of this data series were also analysed by Witting (2000).

METHODS

The municipalities provided hunters with forms designed to collect the information described in section IV of the Schedule of the International Convention for the Regulation of Whaling, 1946 (IWC 2006). These forms were filled out with operational information of each minke whale hunt. The information used for this study includes catch position (including position on whales struck but lost), sex, estimated length, presence/absence of milk and presence/absence of a foetus including its length and sex.

Not all catch reports contained information on all parameters and when information was missing, we analysed the data available and reported the sample size for the given parameter.

In order to investigate the spatial and temporal distribution of the catches, the study area was divided into three main areas (Figure 1 and 1a-c): North (NW, 75.0˚N - 67.5˚N), Central (CW, 67.5˚N - 63.0˚N) and South (SW, 63.0˚N - 60.0˚N). Given the small size of the catcher boats we assumed that whales with no reported catch position were caught within the catch area of the vessels home harbour (NW, CW or SW).

To test for the effect of catch area and catch month on the sex ratio, as well as the interaction between the months and catch areas, we used a Generalized Linear Model (GLM) assuming a binominal distribution (S-plus 6.1).

We compared the monthly length of minke whale foetuses obtained in this study with similar whaling data from Norway, Iceland and Canada obtained from the IWC database.

RESULTS

A total of 2877 catch reports were analysed, spanning the period from 1987 to 2006. The database contains an average of 144 catch reports per year. The quotas and the catch have increased at the end of the period, with the largest quotas since 1998 and the highest catches since 2003 (Figure 2).

Table 1 is an overview of the information provided by the hunters in the catch reports. The majority of reports were missing information on one or more parameters.

The whales were caught earlier in the CW and NW catch areas with a peak catch period in July-Aug and later in the SW catch area with a peak in September (Figure 3).

There was a significant difference in the number of whales caught in the three catch areas (χ^2=114.3; P<0.001; df=2), with most whales caught in the central area (CW, N=1108), fewer in the southern area (SW, N=879) and least in the northern area (NW, N=659). Figure 1a-c shows the reported positions of males and females caught in the three areas and table 2 shows the number of catch reports with information on position, catch area, sex and catch month.

There were significantly more years with more females than males caught (Wilcoxon's test: Z=17.49, P<0.01) and there was a significantly higher proportion of females than males in the total catch (ANOVA, nonpar, 2-way, H=22.92, P<0.001, df=1, Barnard et al. 2001), with the average female proportion being 0.76. This skewed sex ratio in the West Greenlandic minke whale catch is also illustrated by the accumulated catches being higher than the 50:50 line marked for comparison in figure 4.

There was a significant effect on the sex ratio of the catch month (P = 0.003, Table 3), and catch area (P = 0.017, Table 3). Table 4 indicates that there may be a smaller fraction of females from December through February (average of 0.66), a high fraction from March through May (average of 0.87), and an intermediate female fraction from June through November (average of 0.75). And table 5 indicates that the fraction of females in the West Greenland catches might decline from the south to the north. There was no significant interaction between catch area and month (P = 0.754, Table 3).

There was no significant difference in the length estimates of caught females and males (ANOVA, nonpar, df=1, P>0.05, H=0.52, Barnard et al. 2001). Most catches (Females: 64% and Males: 79%) of both genders were between 600 and 800 cm. Only 1 % of the caught animals had an estimated length of 1000 – 1300 cm. These larger animals were both females and males. Four percent of the catches were between 300 and 400 cm (Figure 5). It is important to note that the length measurements are estimates made by the hunters at the flensing site. Some might use a measuring device and others estimate the length by eye. The length of the whales caught by M/V Kato (a Norwegian minke whale catcher boat operating in West Greenland between 1976 and 1985) measured by biologists on board, were significantly longer than the lengths reported by the Greenlandic hunters in this study, with average lengths of 798 cm and 712 cm respectively (ANOVA, nonpar., 1-way, H=7.50, P<0.001, df=1, Barnard et al. 2001).

About half (51 %) of all caught females (not only mature females), for which the presence/absence of a foetus had been reported, had a foetus and 19% of the caught females, for which the presence/absence of milk had been reported, had milk (Table 6). The sex ratio of the foetuses was slightly skewed towards more males than females (Figure 6) with an average of 54 % males and there were significantly more years with more male foetuses than female foetuses in the catch (Wilcoxon's test: Z=7.89, P<0.01). However, there was no significant difference in the number of male and female foetuses through the study period (ANOVA, nonpar., 2-way, H=0.42, P>0.05, df=1, Barnard et al. 2001). The estimated length of the majority (78 %) of the foetuses was between 30 and 150 cm. The length estimates had a range of 7 to 526 cm, however the largest value is unrealistic and probably a mistake (Figure 7). Figure 8 shows the positive relationship between the length of the foetus and the month of the catch for different minke whale catches in the North Atlantic. They all seem to be similar size over catch month, except for the Icelandic foetuses, that seem larger than the rest, which

could suggest and earlier conception time for these whales. However, the length difference in not significant (ANOVA, nonpar., 1-way, H=5.62, P=0.26, df=4, Barnard et al. 2001).

DISCUSSION

Catch area and season

The Norwegian catcher boat, M/V Kato, operated in West Greenland during the summer from 1976 to 1984, keeping record of its sightings and its catches. The vast majority of the minke whales caught by or observed from M/V Kato from 1976 to 1983 were in the northern area (NW) and north of the central area (CW), as outlined in this paper (Kapel and Larsen 1982, 1983a, 1983b; Larsen and Kapel 1982). In contrast, M/V Kato's catches from 1984 were made in the central catch area, even though the boat searched in the northern area as well (Larsen 1986). In the present study, we show that Greenlandic hunters catch considerable numbers of minke whales in all three areas. Differences to the catch of Kato could be explained either by Greenlanders taking minke whales closer to shore or by differences in the seasonality of the catches (see below).

Kingsley (2005) reported that most minke whales were caught in the central and southern areas and less in the north. However, Kingsley (2005) referred only to the catch reports that associated the catch with a position with Latitude and Longitude, and thus could be biased by hunters in the north being less prone to use GPS.

This study suggests that the minke whale distribution shifts from the northern and central area during July and August to the southern area during September (Figure 3). Such a distribution shift is consistent with the fact that M/V Kato whaled in West Greenland from June to late August or early September, and caught most of the whales in the northern and northern central area. The itinerary of M/V Kato was probably planned for optimising catches during the time when the density of whales was higher and the weather was stable enough to travel safely from Norway to West Greenland and back. The lack of minke whale catches in the south area by M/V Kato could be explained if the density peak in this area is in September, as observed in this study, the time M/V Kato was heading home to Norway.

In summary, minke whales are caught in all three areas of West Greenland, with the vast majority of the catches south of 70° north (Disko Island), and there is a shift in September, when less whales are caught in the northern and central catch areas and more whales are caught in the southern catch area. A few whales are still available for the hunters in December. Whaling for minke whales in Greenland is not legal during January, February and March, and therefore we can not say much about the presence or absence of whales at this time of the year (Greenland Home Rule 2005). However, the presence of a few catch reports for this period suggest that at least some minke whales can be found in Greenland during the winter months.

Similar spatial and temporal patterns were observed for the catch of fin whales (Simon *et. al* 2007).

Greenlandic whalers are also fishermen and hunters of a variety of species. Thus, whaling is done in on opportunistic basis depending on the availability of whales and a number of factors that are very difficult to quantify. Such factors include the weather conditions, the human population density, the number of whaling boats equipped with a harpoon canon (catches of

these boats were not limited by regional quotas during the time of the study), the number of licences for collective hunt given in the area (approximately 25% of the quota for West Greenland is given to skiffs from areas where boats with harpoon canon cannot satisfy the demand of whale meat), proximity to trading places and fishing seasons for other species. It is reasonable to assume that much of these factors affect the three catch areas used in this study in a similar way, especially south of 70° N. Therefore, it is likely that the distribution of the catches reflects the spatial and temporal distribution of the whales.

North of 70° N, in the municipalities of Uummannaq and Upernavik, the human population density is considerably lower, larger towns are scarce and there are no boats equipped with harpoon canon. Therefore the relatively low number of catches from this area is not necessarily due to low numbers of animals.

Sexual bias

As in the present study Christensen (1975), Larsen and Kapel (1981, 1982) and Witting (2000) also reported a larger proportion of females (59-85 %) than males in the catches. Larsen and Kapel (1981) analysed the catch data from 1979 and suggested that the skewed sex ratio could be an effect of sexual segregation within Greenlandic waters. However, even though we found a significant difference in the sex ratio between the three areas, there was always a skewed sex ratio with min 0.72 females in the catch. The skewed sex ratio then could have the following three explanations: 1. Sexual segregation with more females than males migrating to west Greenlandic waters. 2. Hunters preference for females. 3. A larger proportion of females than males in the population.

Hunters targeting females is unlikely given the lack of obvious sexual dimorphism of this species, the lack of obvious benefits from hunting females and the costs of missing potential catches to other boats by being selective.

A higher proportion of females in the population is also unlikely due to the fact that both this study and Larsen and Kapel (1982) observed that the sex ratio of the foetuses is not biased toward females. As did Larsen and Kapel (1982), this study found more male than female foetuses. However, in neither study was the difference significant.

Length and reproduction

The difference in the length measurements made onboard Kato and those reported from the Greenlandic hunters suggest either that the hunters (in this study) might be underestimating the length slightly or that M/V Kato caught larger whales, whaling further off shore.

Larsen and Kapel (1982) found no significant differences between the length of female and male minke whales. They described mean lengths of 764 cm for females and 755 cm for males, with a peak for both sexes at 800 cm. These values are remarkably similar to the ones obtained in this study (peak length 700 – 800 cm) where there was no significant difference either.

Earlier studies showed that the females have a pregnancy rate of 0.95-0.99 (Larsen og Kapel 1982; Christensen 1981). This study can neither support nor argue against this, as we have no information about early pregnancies. However, 51% all females for which the presence/absence of a foetus was reported had a foetus developed enough for the hunters to

notice it. This suggests that the pregnancy rate is higher than 50%. We did not have any information on the maturity of the females therefore these numbers include all females and not only the mature individuals.

There seem to be a clear trend for foetuses to increase in length as the year progresses, with the smallest mean sizes in April - May and the largest means in October – December. This would suggest that conception occurs somewhere between December and April, and pregnancy last one year or less. We can not say much about the length of foetuses during January, February and March because the whaling season (and the availability of whales, perhaps) limited our data set for this time of the year (Greenland Home Rule 2005).

The foetal lengths reported by the hunters in this study were consistent with the values presented by Larsen and Kapel (1982) for foetuses caught from late June to early September in 1979 – 1980. The development is similar to the foetus size development reported from other minke whale fisheries in the North Atlantic. This suggests a common trend in the conception time in minke whales from different parts of the North Atlantic.

Lactation rates may be confounded by the fact that it is forbidden to hunt females accompanied by calves (Greenland Home Rule 2005). However, 19% of the females for which the presence/absence of milk was reported were lactating, suggesting that a significant number of females are indeed lactating. A closer investigation of the seasonality of lactation is planned.

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TABLES

TABLE 1. Number of catch reports with information about the parameters relevant to this study. N = 2,877 reports submitted by hunters

	N	% of total
Month	2688	93
Length	2443	85
Sex	2612	91
Milk	636	22
Foetus	1392	48
Foetus sex	544	19
Foetus length	650	23
Position	1335	46
Catch area	2646	92
Meat	215	7
Mattak	1216	42
Grooves	1211	42
Total weight	1358	47

TABLE 2. A total of 2646 catch reports contained information, so that we were able to allocate them to one of the three catch areas. This table is showing the number of these that also contained information on position and sex of the animals.

Catch reports with information on:	N	% of total
Positions	1335	46
Catch area	2639	92
Catch area and sex	2569	89
Catch area , sex and month	2515	87

TABLE 3. Result of the Generalized Linear Model testing the effect of Catch area and Catch month on the sex ratio as well as the interaction between the paramenters: Month and Catch area

	df	Deviance	P
Catch area	2	8.115	0.0173
Month	1	2.389	0.0122
Month:Catch area	2	0.510	0.775

TABLE 4. The fraction of females in the catches for each month of the year. The sample size (N) for each month is given.

	N	Female fraction
January	9	0,67
February	19	0,63
March	16	0,88
April	63	0,81
May	169	0,89
June	260	0,78
July	504	0,75
August	552	0,73
September	477	0,73
October	312	0,77
November	87	0,79
December	43	0,67

TABLE 5. The fraction of caught females in the three whaling areas.

	N	Female fraction
NW	620	0,72
CW	1083	0,75
SW	1001	0,81

TABLE 6. The proportion of females with milk or foetus of the females with information of absence/presence of milk and foetus.

	Milk	Foetus
N reported	636	1392
N positive	118	716
% positive of total reported	19	51
Mean / yr	11,80	35,80
SD	10,60	23,03

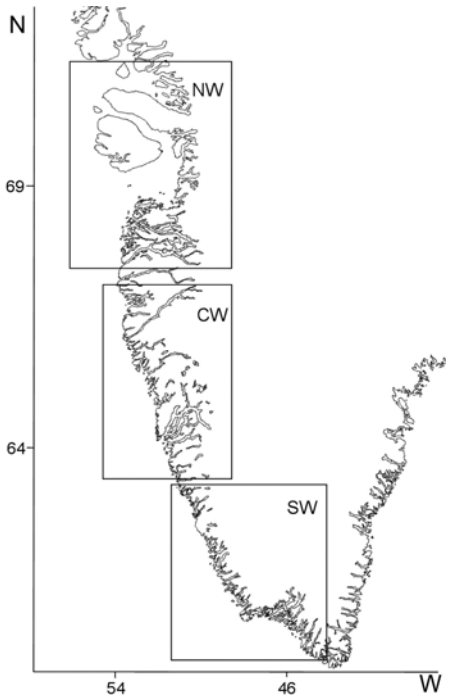
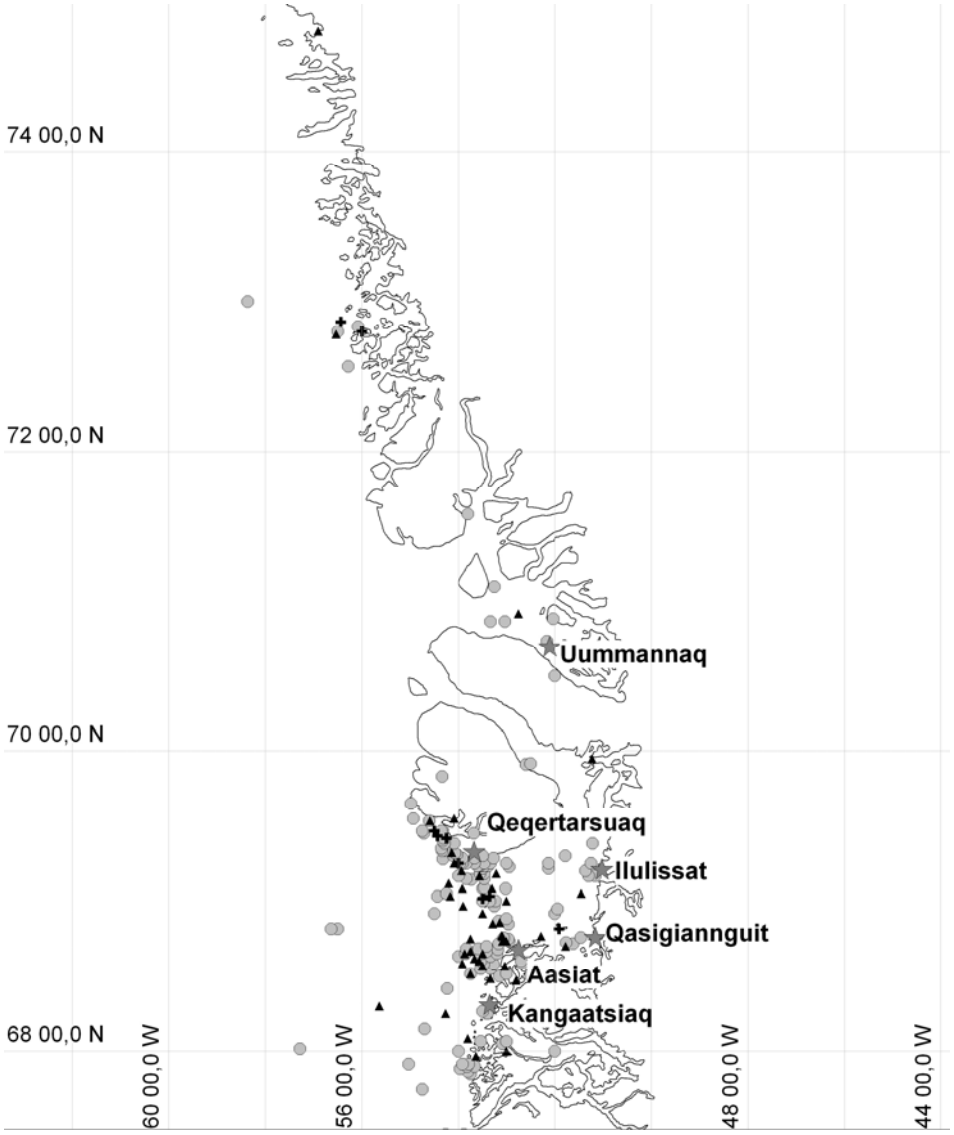


FIGURE 1. Maps of the catch areas. **a.** Catch area NW, covering the northern most villages catching minke whales in west Greenland. **b.** Catch area CW, covering the central villages. **c.** SW, covering the southern most villages. The stars indicate the locality of the main city of the municipalities. Open circles indicate the position of caught female minke whales, black triangles indicate the position of caught male minke whales and the catches with unknown sex is indicated with a cross. Only catches with reported position are mapped (46% of total catches).

1a.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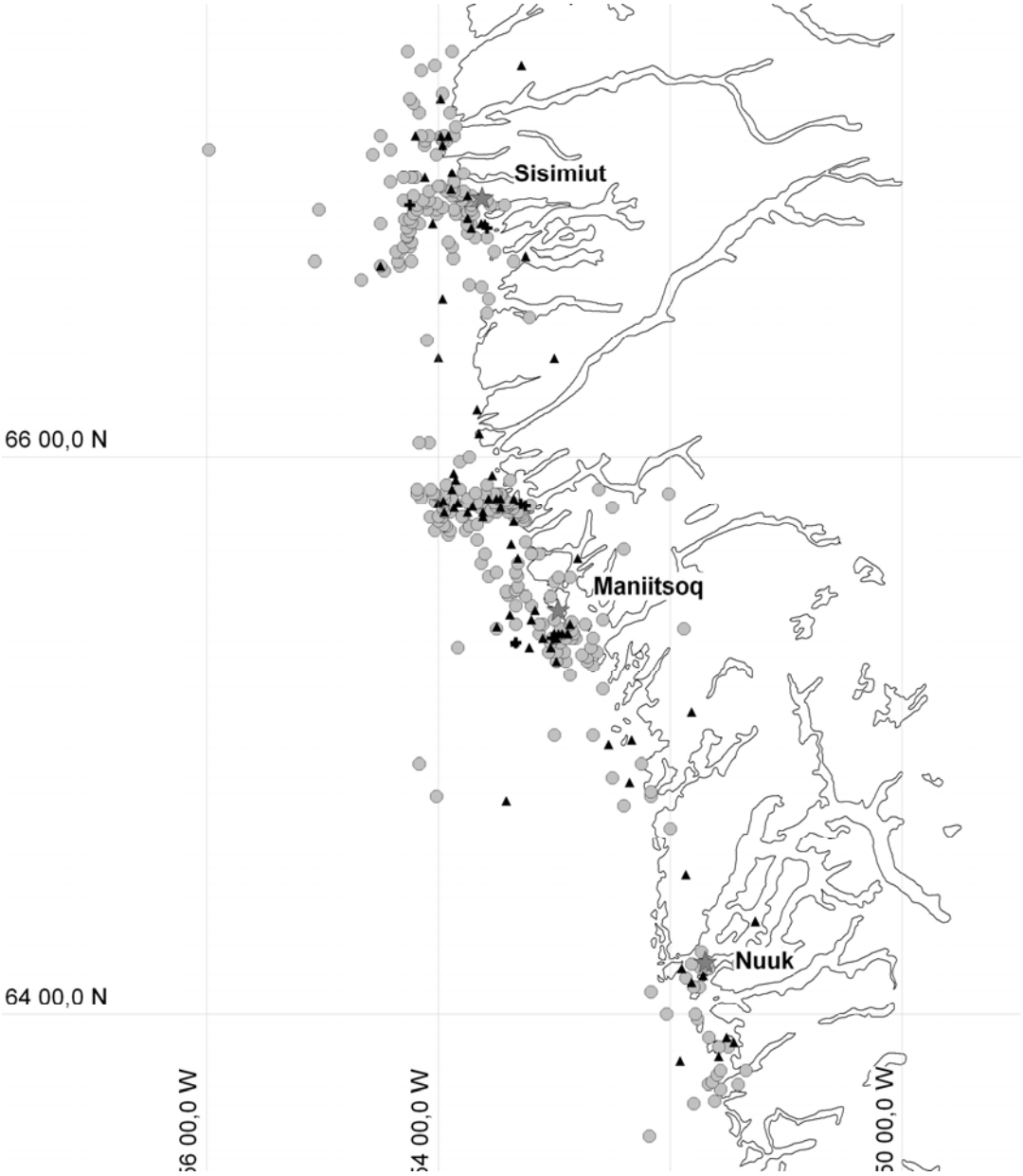
1b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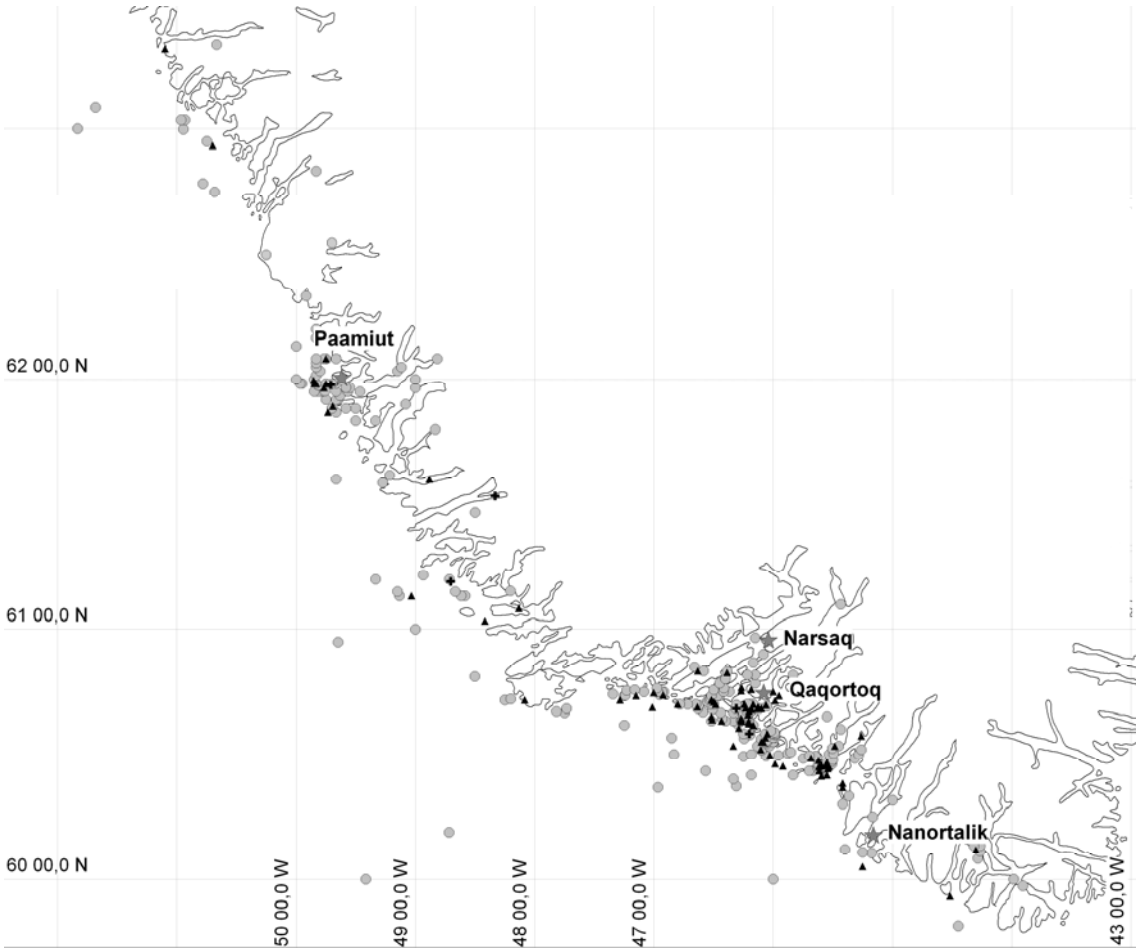
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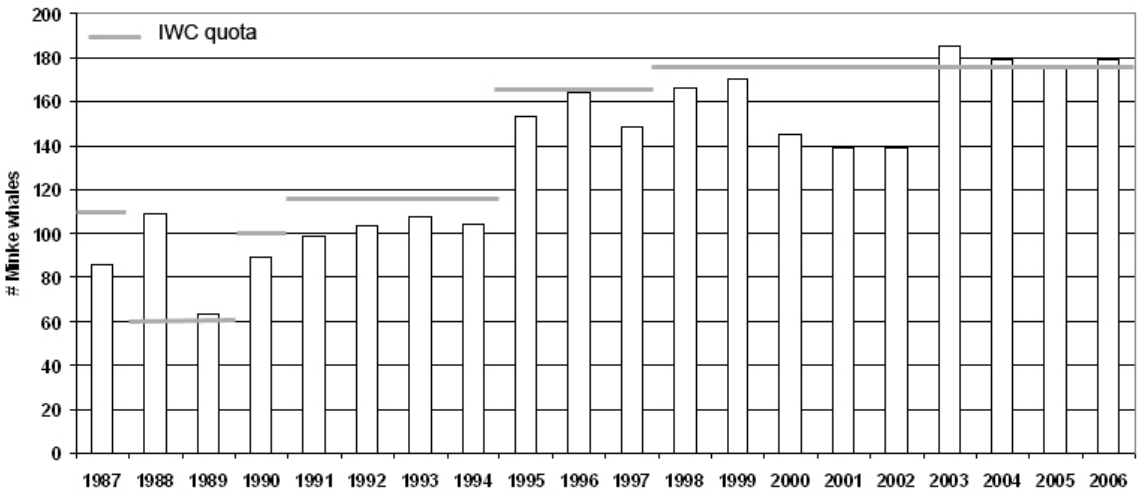

FIGURE 2. Yearly catches of minke whales off west Greenland from 1987 to 2006 with the annual catch limit set by the IWC (grey lines), given for aboriginal subsistence hunting.

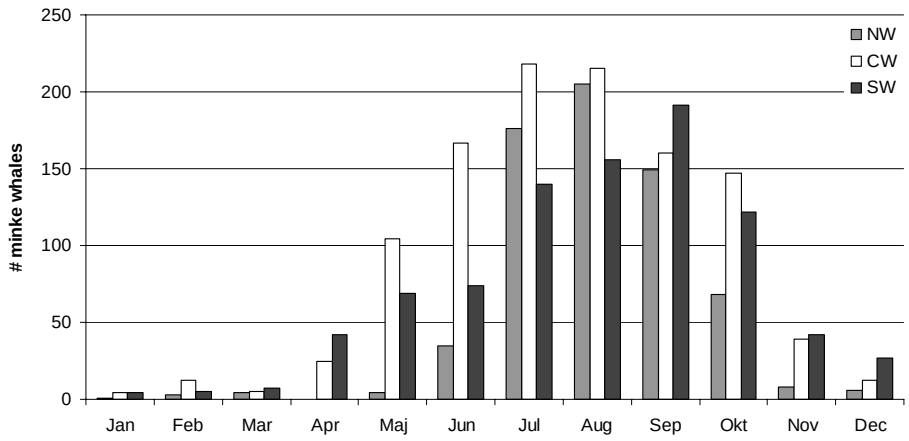

FIGURE 3. Distribution of catches in the three areas over the year.

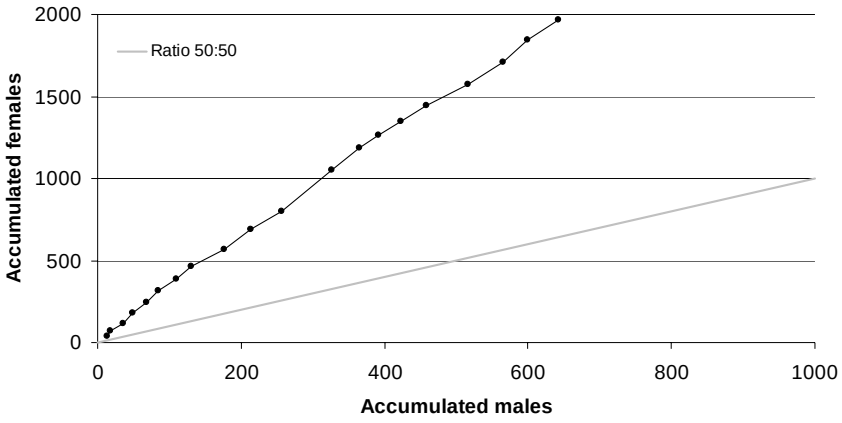

FIGURE 4. Cumulative male and female minke whale catches between 1987 and 2006, showing the proportion of females and males in the total catch. The dots indicate a new year and the grey line illustrates a sex ratio of 1:1.

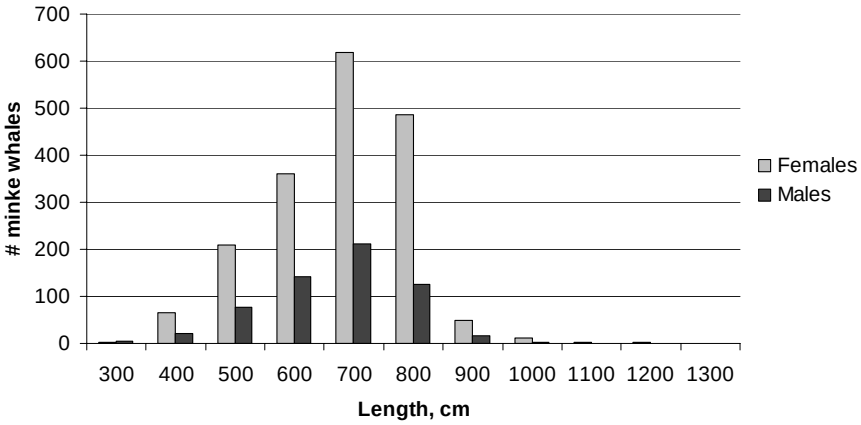

FIGURE 5. Distribution of the length (cm) of caught male and female minke whales.

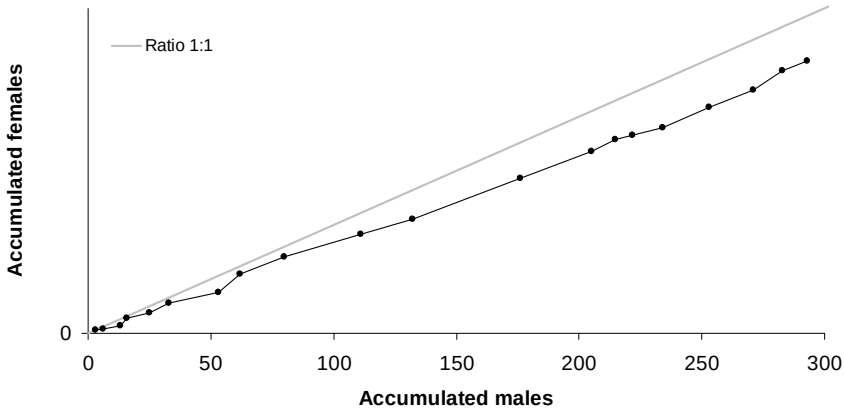

FIGURE 6. Cumulative number of male and female minke whale foetuses. The dots indicate a new year and the grey line illustrates a ratio of 1:1.

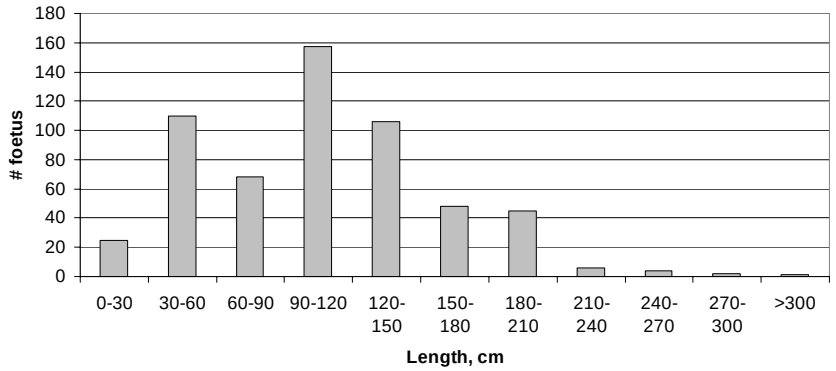

FIGURE 7. Length distribution of the foetuses in caught females.

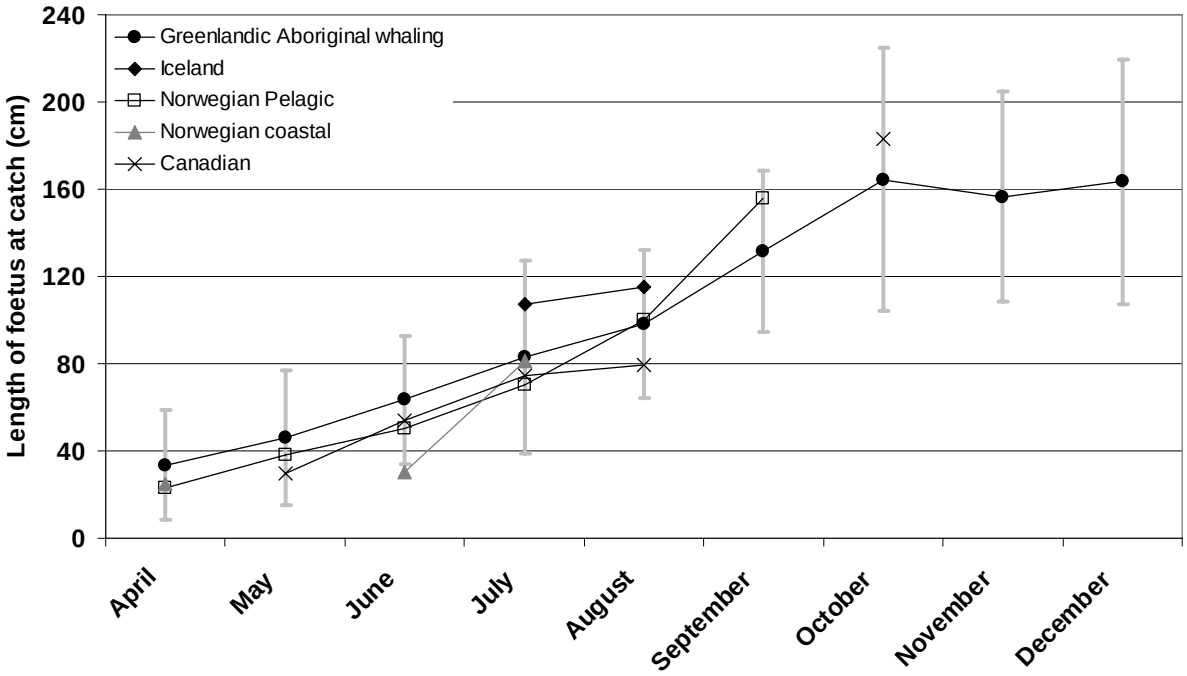

FIGURE 8. Development of the length of the foetuses over the months of the year in the Greenlandic catch studied in this paper, compared to other minke whale catches in the north Atlantic (Data from IWC database). The variance of the Greenlandic data is given in grey bars.