Catch statistics for belugas in West Greenland 1862 to 1999

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ABSTRACT

Information and statistics including trade statistics on catches of white whales or belugas (*Delphinapterus leucas*) in West Greenland since 1862 are presented. The period before 1952 was dominated by large catches south of 66° N that peaked with 1,380 reported kills in 1922. Catch levels in the past five decades are evaluated on the basis of official catch statistics, trade in mattak (whale skin), sampling of jaws and reports from local residents and other observers. Options are given for corrections of catch statistics based upon auxiliary statistics on trade of mattak, catches in previous decades for areas without reporting and on likely levels of loss rates in different hunting operations. The fractions of the reported catches that are caused by ice entrapments of whales are estimated. During 1954-1999 total reported catches ranged from 216 to 1,874 and they peaked around 1970. Correcting for underreporting and killed-but-lost whales increases the catch reports by 42% on average for 1954-1998. If the whales killed in ice entrapments are removed then the corrected catch estimate is on average 28% larger than the reported catches.

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INTRODUCTION

Hunting of white whales or belugas (*Delphinapterus leucas*) in West Greenland has been the subject of controversy because of indications that the catches exceed sustainable levels (Heide-Jørgensen and Reeves 1996, Butterworth *et al*. 2002, Heide-Jørgensen and Acquarone 2002, Innes and Stewart 2002). Several regulations have been introduced during the 1990s with the intention of reducing the catches. Since 17 October 1995 the catch of belugas from larger vessels has been restricted, so that vessels from 25 to 50 Gross Register Tons (GRT) are only allowed to catch belugas for their own consumption, not for sale. Vessels from 50 to 79.9 GRT are only allowed to take 2 belugas per year. Furthermore, the drive hunt (which was a significant factor in the total catch of belugas) was prohibited in 1995.

The catch statistics for belugas go back to 1862 but are not complete and have never incorporated animals that are killed but lost. Especially for the most recent decades, the quality of the catch statistics has fluctuated because of a large number of catches that are not included in the statistics. This fraction of unreported catches and the number of killed-but-lost whales cannot be estimated precisely, but estimates can be made under certain assumptions. The catch history of belugas in West Greenland has, together with abundance estimates, recently been used for modeling the dynamics of this stock and for predictions of sustainability of future harvest levels (Butterworth *et al*. 2002, Innes and Stewart 2002, Alvarez-Flores and Heide-Jørgensen MS 2000). For the modeling of the

population trajectory it is essential that the actual removals caused by humans be estimated as accurately as possible. Erroneous removal levels will result in unrealistic predictions of the productivity of the stock.

In this compilation the uncorrected catch statistics are presented together with corrections previously applied (*e.g.* Kapel 1983, Born and Kapel 1986, Born 1987). There has been systematic underreporting caused either by an absence of catch reports from some municipalities during certain periods or by a general trend towards underreporting. In an attempt to correct for these biases two levels of corrected catches are introduced for the period after 1954 (*low* and *medium options*). Finally, a third level (*high option*) corrects the catches for an estimate of killed-but-lost whales in different catching operations. The three levels are intended as options for modeling different scenarios of the dynamics of the population.

Catch statistics for belugas and narwhals (*Monodon monoceros*) from Greenland include catches that are taken from whale pods that are entrapped in the ice. It has been suggested that mortality in ice entrapments occasionally is part of the natural mortality (Siegstad and Heide-Jørgensen 1994). To allow for analyses of removals without catches in ice entrapments these are shown separately from the mortality genuinely caused by humans.

MATERIAL AND METHODS

Available statistics

The main sources for data on beluga catches in Greenland are the official catch statistics. Statistics on purchasing of mattak (whale skin) can under certain assumptions be converted to numbers of whales killed. The number of lower jaws collected from the harvest provides a minimum estimate of the number of whales that were killed.

Catch statistics before 1993

This compilation utilises statistics on beluga catches in West Greenland between 1862 and 1891 from Winge (1902) and Anon. (1944), between 1907 and 1951 from Heide-Jørgensen (1994) and Anon. (1944), between 1954 and 1974 from Kapel (1977), between 1975 and 1990 from unpublished statistics from the Ministry of Greenland, Kapel (1983), Kapel and Larsen (1984), Kapel (1985), Born and Kapel (1986), Born (1987) and Heide-Jørgensen (1994). For the periods 1862-1921, 1934-1948 and 1954-1963 catches were reported for the period 1 April through 31 March, but for the tabulation here all catches were allocated to the first of the years reported.

Catch statistics after 1992

A booklet called 'Piniarneq' in which the hunters note their catches has since 1993 provided catch figures. It operates with a hunting season from 1 October to 30 September but data are compiled following calendar years.

Purchasing of mattak

Data on purchasing of mattak is available from Heide-Jørgensen (1994), Upernavik Museum (in litt.) and the Greenland Sta-

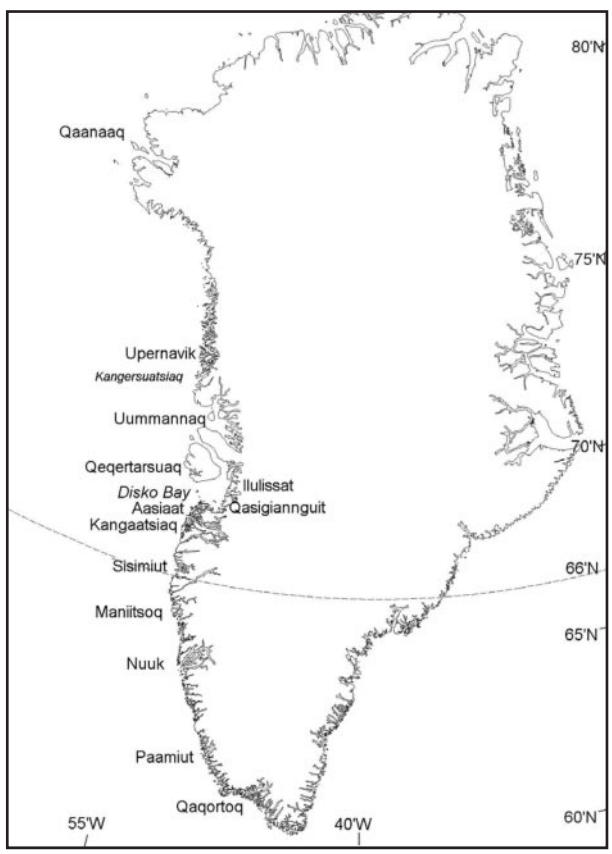

Fig. 1. *Map of West Greenland with important towns, settlements and localities indicated.*

tistics (in litt.). From the three northernmost communities Uummannaq, Upernavik and Qaanaaq (see Fig. 1) most mattak is purchased by factory facilities. The average mattak yield per whale was estimated as 70 kg for belugas in Upernavik based on measurements in the field (Heide-Jørgensen 1994).

Collection of jaws
Lower jaws have been collected from the catches of belugas as part of the harvest monitoring program by the Greenland Institute of Natural Resources since 1992.

Allocation of catches to areas
For the period up to 1951 the catches from the southernmost areas, Qaqortoq, Paamiut, Nuuk and Maniitsoq, are combined under 'South of 66° N'. It is suspected that a separate stock found in this area was extirpated through exploitation (Heide-Jørgensen 1994). For the period after 1954 the catches are split into three areas of West Greenland. The northern area includes Qaanaaq (formerly Avanersuaq but changed to Qaanaaq in 1997), Upernavik and Uummannaq. The central area or Disko Bay includes Qeqertarsuaq, Ilulissat, Qasigiannguit, Aasiaat and Kangaatsiaq. The southern area includes Sisimiut, Maniitsoq, Nuuk, Paamiut and Qaqortoq.

Allocation of catches by species
Catches of narwhals and belugas were combined in the annual statistics before 1906 (Winge 1902, Heide-Jørgensen 1994) and in the statistics on average catches before 1939 (Anon. 1944). For the years with combined statistics, catches from Sisimiut and south are all considered to be belugas because of the rare occurrence of narwhals in this area (Winge 1902, Heide-Jørgensen 1994). For the areas north of Sisimiut, Winge (1902) stated that the catch was predominantly belugas and Anon. (1944) claimed that, based on trade in narwhal tusks, narwhals only constituted about 20% of the catch north of Sisimiut. When comparing beluga and narwhal catches for 1954-1970 (Anon. 1953-1971) the proportion of belugas taken north of Sisimiut was about 75%. That value is applied for the proportion of belugas taken north of Sisimiut during 1862-1905 and for average catches reported during 1906-1934.

Corrections for underreporting after 1954
Known catches that are not included in the reports or catches that can be derived from statistics on trade in whale products were added to the catch reports to improve the completeness of the reports.

To correct for catches in areas and periods without reporting where catches are known to have occurred, two levels of correction factors (*low* and *medium options*) were applied. The two options are intended to correct for systematic negative bias in the reporting.

For 1954-1974 a *low* and a *medium option* correct for lack of catch reports from Qaanaaq. During the 21 years with reporting there were only 8 years with data from Qaanaaq and of these 6 years were reported to be incomplete (Table 1). The average annual catch of belugas over the 8 years was 63 (95% CI: 18-109).

For 1975-1985, corrections were based on the reported trade in mattak. The correlation between the number of whales caught and the amount of mattak purchased in the 1980s showed that approximately 65% of the mattak harvested was sold to factories (Heide-Jørgensen 1994). From 1981 through 1985, reports exist of the mattak yield in Upernavik (see Table 2), almost all of it from belugas (Heide-Jørgensen 1994). If the mattak yield represents 65% of the catches of belugas (Table 1) then it can be calculated that 550, 466, 464, 455 and 128 belugas were caught during 1981-1985 in Upernavik. Reported catch was 81% (Table 1) of this estimated catch on average in Upernavik, so this was chosen as a correction factor for reported catches in Upernavik (*low option*) and in all areas (*medium option*).

For 1986-88, corrections of total catches were provided in the official statistics, but since they were not applied to certain areas it seems more appropriate to make corrections for specific municipalities. In the official statistics from the Greenland Home Rule, bulk corrections of 75, 90 and 275 are applied for 1986, 1987 and 1988 respectively. These numbers were used to correct all areas and they are not included in this compilation. For the same reason a block estimate of 750 belugas taken in 1992 in all munic-

Table 1. Catches of belugas from official reports by municipality with corrections for under-reporting (in parentheses) for 1954 to 1998. The year 1999 only covers the period from January through September. The column 'under-reporting' shows the sum of the corrections for under-reporting or 'ALL' if it is a general correction factor for all areas. 'Disko Bay' includes the municipalities Kangaatsiaq, Aasiaat, Qasigiannguit, Ilulissat and Qeqertarsuaq. The catches before 1975 are extracted from Kapel (1977), between 1975 and 1990 from unpublished statistics from the Ministry of Greenland, Kapel (1983), Kapel and Larsen (1984), Kapel (1985), Born and Kapel (1986), Born (1987) and Heide-Jørgensen (1994), and from 1993 to 1999 from 'Piniarneq'.

YEAR	QAA-NAAQ	UPER-NAVIK	UUMMAN-NAQ	DISKO BAY	SISIMIUT	MANIITSOQ	NUUK	PAAMIUT-QAQORTOQ	UNDER-REPORTING	TOTAL	MORTALITY IN ICE ENTRAPMENT
1954		16	61	1,774	23					1,874	1,774
1955		10	3	275	11	1				300	
1956		9	8	373	29	5				424	
1957		6	11	391	95					503	
1958		3	4	182	35	1				225	
1959		12	12	243	42					309	50
1960		13	6	179	17		1			216	
1961	32	15	6	219	47	1	11	14		345	
1962	85	9	7	186	23	8	11			329	
1963	75	18	12	93	8	12	11			229	
1964	125	4	6	166	8	4	18			331	
1965	150	20	53	214	24	18	9			488	
1966		25	88	398	24	13	12	1		561	
1967		34	66	369	76	47	4			596	50
1968		97	65	1,013	46	38				1,259	234
1969		111	36	661	100	40	30			978	
1970	17	334	6	1,133	10	24				1,524	1,050
1971	2	238	3	328	123	4	41			739	
1972		293	25	362	135	11	14	1		841	
1973		262	33	581	121		70			1,067	
1974	21	195	15	512	135	8	25	2		913	
1975	(47) 50	150	19	268	130	4	33		(47)	654	

Table 1. Continued.

YEAR	QAA-NAAQ	UPER-NAVIK	UUMMAN-NAQ	DISKO BAY	SISIMIUT	MANIITSOQ	NUUK	PAAMIUT-QAQORTOQ	UNDER-REPORTING	TOTAL	MORTALITY IN ICE ENTRAPMENT
1976	(37) 50	77	12	953	72		48		(37)	1,212	653
1977	(36) 50	240	49	379	43	13	65		(36)	839	
1978	20	104	44	452	77	5	17			719	
1979	25	250	22	379	35	12	18			741	
1980	30	191	100	412	109	45	1			888	
1981	76	343	95	340	62	23	78			1,017	
1982	127	329	17	313	95	13				894	100
1983	(10) 53	(165) 233	19	(100) 194	(50) 99	2	1		(325)	601	
1984	21	(60) 333	15	(150) 352	(25) 25	16	1		(235)	763	220
1985	190	(135) 188	6	(75) 177	(25) 25	17	8		(425)	611	
1986		(335) 500	4	114		2			(335+ALL 75)	695	
1987		550	13	29		8	6		(ALL 90)	696	
1988		125		125					(ALL: 25)	275	125
1989		(311) 427	2	(18) 30		40			(339)	499	
1990	(2) 2	(346) 346	8	(591) 684		23			(939)	1,063	500
1991	(50) 50	(400) 400		(100) 100					(550)	550	
1992		(661) 661		(26) 26					(687)	687	
1993	119	(169) 339	26	194	80	25	14	1	(169)	798	
1994	24	(90)188	19	239	105	38	3	2	(90)	618	
1995	84	(111) 194	18	301	116	56	10	1	(111)	780	
1996	7	86	21	245	131	26	25	1		542	
1997	16	162	28	243	101	7	18	1		576	
1998	51	162	38	312	125	19	30	7		744	
1999	21	42	14	116	30	4	6	6		239	

ipalities (Heide-Jørgensen 1994) is ignored. No official statistics are available for 1991 and 1992.

For 1986-1992, two corrections are needed to include catches from Qaanaaq and Sisimiut. The mean of reported catches during 1978 to 1985 (Table 1) was 68 (95% CI: 16 to 119) in Qaanaaq and 70 (95% CI 46 to 94) in Sisimiut. The *low* and the *medium option* are the addition of the lower and upper bounds, respectively, of the confidence interval to the reported catches in Qaanaaq (1990-91 excepted) and Sisimiut.

Correction for losses

The bulk of the catches of belugas in West Greenland are taken either in a drive fishery or by shooting in open water, along ice edges or in ice cracks. There are also a limited number of net catches. During the drive fishery, the whales are shot in shallow water after being driven to the shore. Few whales escape the drives and those that sink might be retrieved either by hooks in the following days or when floating to the surface. The losses during the drive fishery are therefore considered minimal and a catch correction factor of 1.10 has been applied to the reported catches to correct for whales lost during drive fishery operations. The drive fishery was the most important way of hunting belugas in Qaanaaq and Upernavik until it was banned in 1995 (effective from the 1996 hunting season).

Shooting whales in open or ice-covered waters (=non-drive fishery) usually takes place over deep water and wounded whales are in many cases not retrieved. The non-drive fishery therefore has a much larger proportion of lost whales and a catch correction figure of 1.30 (see Discussion) was applied to the statistics from this type of hunting. This hunt type is practiced in all areas south of Upernavik and from 1996 even in Upernavik and Qaanaaq.

Table 2. Purchases (in tons) of beluga mattak per area (data from 1965-1992 from Heide-Jørgensen (1994), Upernavik 1975-1978 from Upernavik Museum and from 1994 to 1998 compiled by Greenland Statistics).

Year	Ilulissat	Qeqertarsuaq	Uummannaq	Upernavik	Qaanaaq	Total
1965					1.5	1.5
1966				0.1	5.3	5.4
1967				0.1	3.9	4.0
1975				2.9		2.9
1976				0.4	11	11.4
1977				9.1	14	23.1
1978				2.8	6	8.8
1979					14	14
1980					14	14
1981				25.0	26.5	51.5
1982				21.2	24.0	45.2
1983				21.1	12.8	33.9
1984				20.7	21.9	42.6
1985				5.8		5.8
1986				1.7		1.7
1987	0	0	4.4	32.6	?	37
1988	0	4.9	7.3	27.3	2.4	41.9
1989	0	0.8	31.0	19.3	?	51.1
1990	16.4	2.3	63.6	18.5	9.2	110.0
1991	0	1.4	29.4	26.1	15.1	72.0
1992	0.8	6.7	13.3	46.3	12.2	79.3
1994		0.2		13.2	0.2	13.6
1995				13.6	5.9	19.4
1996	0.05	1.7				1.7
1997		1.5	0.05	1.1		2.6
1998		2.2	0.01	15.7*	1.9	19.7

* incl. 6.2 tons purchased by a factory vessel.

Therefore a *high option* for the catch statistics after 1954 (applied to the *medium option*) includes a correction of the harvest in northern municipalities (Qaanaaq and Upernavik) of 1.10 of the catches until 1995 and a correction factor in all other areas of 1.30 to adjust for losses during the catch operations.

Ice entrapments
Data on ice entrapments were extracted from Siegstad and Heide-Jørgensen (1994) and an option for subtracting the entrapment mortality from the reported catches is given for the period 1954-1999. For the period 1862-1953, entrapment mortality is reported inconsistently and is therefore not subtracted from the reported catches.

RESULTS

Period 1862-1905
Statistics were available for some of the years from Sisimiut and south (1874-1890) where all catches can be considered to be belugas (Table 3). For the areas north of Sisimiut annual catch data were available for 1862 through 1877 but only for belugas and narwhals combined. Some statistics on average catches over periods without annual reports are presented here as a supplement to the annual reports of catches (see Table 4). Two ice entrapments are known from Disko Bay 1898 and 1899 involving either belugas or narwhals (Table 3).

Period 1906-1951
Catches that were reported for the combined period 1926-29 in Kangersuatsiaq (in southern Upernavik District) were spread over the four years in question (Table 3).

All entrapment records were from Disko Bay but only the reports from 1906, 1915 and 1951 were specified as belugas, whereas the others may have included both belugas and narwhals. The catch in the ice entrapment in 1943 might be reflected in the statistics for 1942 but several of the other ice entrapment catches do not match a similar number in the catch statistics (Table 3)

Period 1954-1974
This period is probably the most reliable of the catch series, but still there are some clear deficiencies, one of which is the fragmentary reporting from Qaanaaq. The only correction that can be applied to the reported catches is the addition of estimated catches for Qaanaaq in the years without reports for that area. The lower and upper 95% confidence interval for the years with catches in Qaanaaq (see Materials and Methods) were therefore added to give a *low* and a *medium option* for corrections, respectively (see Table 5). For the central and southern areas the *low* and *medium options* listed in Table 5 are the same as the reported catches.

All entrapments involving belugas took place in Disko Bay. In January 1955 there was a large ice entrapment during which more than 3,000 belugas were killed (Table 1). Since the reported catches came from a settlement close to the site of the entrapment and the catches were taken in winter it is assumed that all catches in Disko Bay reported from that year were whales taken in the ice entrapment. In 1960 an entrapment in Disko Bay included 100 narwhals or belugas and it is thus assumed that 50 belugas were taken in the entrapment. In March 1967 some belugas were entrapped and 50 reported catches are attributed to ice entrapment mortality. In February 1968 an entrapment was reported and the catch for that month of 234 belugas was attributed to ice entrapment.

Period 1975-1985
This was a period where an increasing proportion of catches were not reported and where corrections for underreporting are needed. The annual catch in Qaanaaq has previously been estimated to be 50/yr for 1975-1977 and the difference between the reported catches and this estimate has been added to correct for underreporting (Kapel 1983). There are no estimates of unreported catches for 1978-1982. For 1983-1985, estimates of underreporting have previously been added to the reported statistics for some of the municipalities (Born and Kapel 1986, Born 1987, Table 1 column 'Underreporting').

In January 1976, 653 belugas were reported caught in an ice entrapment in Disko Bay. In 1982, 50 to 200 belugas were taken in Disko Bay in an entrapment in February and we arbitrarily assume that 100 whales were taken from this entrapment. In February 1984, 200 belugas

Table 3. Catches of belugas in West Greenland between 1862 and 1951 compiled from Winge (1902), Anon. (1944) and Heide-Jørgensen (1994). The catches are divided into three areas; 'South of 66° N' including Qaqortoq, Paamiut, Nuuk and Maniitsoq, 'Sisimiut' (included in the area 'South' in Table 1), 'Central' including Disko Bay and 'North' including Uummannaq, Kangersuatsiaq and Upernavik. No data are available from other areas. Catches before 1906 are corrected for the combined reporting of narwhals by assuming that 100% of the catches were belugas in the areas 'South of 66° N' and 'Sisimiut', and that 75% were belugas in the 'Central' and 'North' areas (see text). All entrapments were from the 'Central area' (see Siegstad and Heide-Jørgensen 1994).

Year	South of 66° N	Sisimiut	Central	North	Total	Ice entrapments	Year	South of 66° N	Sisimiut	Central	North	Total	Ice entrapments
1862			136	98	234		1913	596				596	
1863			130	107	237		1914	670				670	
1864			211	215	426		1915	500			100	600	25-33
1865			106	136	242		1916	450				450	
1866			215	154	369		1917	150			60	210	
1867			288	180	468		1919	1,100		40		1,140	
1868			166	83	249		1920	200				200	40
1869			409	248	657		1922	1,380		50	25	1,455	
1870			317	308	625		1923	874				874	
1871			307	198	505		1924	950			100	1,050	
1872			308	205	513		1925	950			100	1,050	
1873			264	149	413		1926	1,500			425	1,961	
1874	280	96	319	134	733		1927	700			636	1,336	
1875	472	94	218	116	806		1928	100			436	536	
1876	734	169	240	141	1,115		1929	76			1,436	1,512	
1877	652	153			652		1930	33			311	344	
1878	592	172			592		931			40	575	615	
1879	832	178			832		1932			183	823	1,006	

Table 3. continued

Year	South of 66° N	Sisimiut	Central	North	Total	Ice entrap-ments	Year	South of 66° N	Sisimiut	Central	North	Total	Ice entrap-ments
1880	694	236			694		1933				196	196	100
1881	487	140			487		1934	25	13		252	290	50
1882	446	157			446		1935	9	47			56	100
1883	393	148			393		1936	6	65	20	48	139	
1884	291	71			291		1937	4	41	49	22	116	
1885	672	121			672		1938	8	8	19	127	162	
1886	417	240			417		1939	6	34	178	434	652	
1887	445	94			445		1940	5	99	186	490	780	
1888	317	118			317		1941	2	78	326	253	659	
1889	330	74			330		1942	1	36	380	273	690	
1890	423				423		1943	3	27	146	91	267	340
1898						22	1944	1	20	324	355	700	
1899						80	1945	2	56	238	41	337	Some
1906	400				400	6	1946	5	11	207	190	413	
1907	90		150		240		1947	0	9	189	98	296	
1908	109				109		1948				122	122	
1909	161				161		1950				24	24	
1910	98				98		1951				17	17	173
1911	300				300								

Table 4. Average catches of belugas in four areas as reported in Anon (1944). The catches are divided into three areas; 'South of 66° N' including Qaqortoq, Paamiut, Nuuk and Maniitsoq, 'Sisimiut' (included in the area 'South' in Table 3), 'Central' including Disko Bay and 'North' including Uummannaq and Upernavik. Catches are corrected for the combined reporting of narwhals by assuming that 100% of the catches were belugas in the areas 'South of 66° N' and 'Sisimiut', and that 75% were belugas in the 'Central' and 'North' areas (see text).

Years	South of 66° N	Sisimiut	Central	North
1887-1888	-	-	350	208
1890-1899	322	96	-	-
1892-1893	-	-	305	219
1900-1909	219	36	-	-
1903-1909	-	-	209	203
1910-1919	392	37	336	334
1920-1924	162	47	221	264
1925-1929	46	44	173	293
1930-1934	16	39	260	293
1935-1938	6	51	-	-

were taken in an entrapment in Disko Bay and again in April 1984, 20 belugas were taken in an entrapment in Uummannaq.

Period 1986-1992

The catch reporting system deteriorated during this period while the economic value of the mattak increased. Nothing is reported from Qaanaaq or Sisimiut for any of the years but there are reports from biologists of catches of 2 and 50 belugas in 1990 and 1991 in Qaanaaq (Table 1).

In 1986 a biologist recorded a catch of 450 to 550 belugas in the two northernmost settlements in Upernavik (Bodil Deen Petersen in litt. and later confirmed by the senior author) and the official statistics were therefore corrected to 500 for Upernavik in 1986 (see Table 5).

In 1989 the senior author observed catches of 427 belugas in Upernavik and approximately 30 in Disko Bay. The reported catches were 116 and 12 for the two areas thus the observed catches were used. Both observations indicate a significant degree of underreporting.

Similarly for 1990 and 1991, data on catches recorded by biologists were used instead of the relatively low reported catches. There was a large ice entrapment in Disko Bay in 1990 that alone accounted for a kill of approximately 600 belugas.

In 1992 a total of 46.3 tons of mattak was purchased in Upernavik. From that catch, 54 jaws were obtained and, in Disko Bay, an additional 26 jaws were collected (Table 6). Converting the mattak to the number of whales killed (70 kg mattak/whale, Heide-Jørgensen 1994) and adding the 26 jaws gave a total of 687 belugas, but there were definitely other unreported catches in West Greenland that year.

In April 1988, 100 to150 belugas were reported taken from an entrapment; therefore 125 belugas were arbitrarily assigned to ice entrapment mortality in 1988. In January 1990 about 500 belugas were taken in an ice entrapment in Disko Bay.

Period 1993-1999

In 1993 the new catch reporting system (Piniarneq) started to provide data. The mattak purchases in the northern municipalities (*i.e.* Qaanaaq, Upernavik and Uummannaq) were converted into catches of whales under the assumption of an average yielded amount of mattak per whale (Heide-Jørgensen 1994). The minimum catches thus derived from the mattak purchases were generally smaller than the numbers from the 'Piniarneq' catch-reporting scheme, indicating that not all mattak was purchased commercially. The exception was the catch in Upernavik where the mattak purchases yielded a much larger estimate of killed belugas

Table 5. Catches of belugas in three areas in West Greenland with three options for corrections of catch numbers. 'North' includes Qaanaaq, Upernavik and Uummannaq, 'Central' includes Disko Bay with the municipalities Kangaatsiaq, Aasiaat, Qasigiannguit, Ilulissat and Qeqertarsuaq, and 'South' includes Sisimiut, Maniitsoq and Paamiut. Last column show the catches with ice entrapments subtracted from the Central area. For 1954-1974 a *low* and a *medium option* correct for lack of catch reports from Qaanaaq. For 1975-1985 a correction factor for unreported catches is applied to Upernavik (*low option*) and to all areas (*medium option*). For 1986-1992 a *low* and a *medium option* correct for lack of catch reports from Qaanaaq and Sisimiut.

	NORTH			CENTRAL			SOUTH			TOTAL			TOTAL WITHOUT ICE ENTRAPMENTS		
YEAR	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
1954	95	186	217	1,774	1,774	2,306	23	23	30	1,892	1,983	2,553	118	209	247
1955	31	122	135	275	275	358	12	12	16	318	409	509	318	409	509
1956	35	126	140	373	373	485	34	34	44	442	533	669	442	533	669
1957	35	126	141	391	391	508	95	95	124	521	612	773	521	612	773
1958	25	116	128	182	182	237	36	36	47	243	334	412	243	334	412
1959	42	133	149	243	243	316	42	42	55	327	418	520	277	368	455
1960	37	128	142	179	179	233	18	18	23	234	325	398	234	325	398
1961	53	53	60	219	219	285	73	73	95	345	345	440	345	345	440
1962	101	101	112	186	186	242	42	42	55	329	329	409	329	329	409
1963	105	105	118	93	93	121	31	31	40	229	229	279	229	229	279
1964	135	135	150	166	166	216	30	30	39	331	331	405	331	331	405
1965	223	223	256	214	214	278	51	51	66	488	488	600	488	488	600
1966	131	222	262	398	398	517	50	50	65	579	670	844	579	670	844
1967	118	209	243	369	369	480	127	127	165	614	705	888	564	655	823
1968	180	271	311	1,013	1,013	1,317	84	84	109	1,277	1,368	1,737	1,043	1,134	1,433
1969	165	256	289	661	661	859	170	170	221	996	1,087	1,369	996	1,087	1,369
1970	357	357	394	1,133	1,133	1,473	34	34	44	1,524	1,524	1,911	474	474	546
1971	243	243	268	328	328	426	168	168	218	739	739	912	739	739	912
1972	336	427	475	362	362	471	161	161	209	859	950	1,155	859	950	1,155
1973	313	404	451	581	581	755	191	191	248	1,085	1,176	1,454	1,085	1,176	1,454
1974	231	231	257	512	512	666	170	170	221	913	913	1,144	913	913	1,144
1975	248	261	291	268	319	415	167	199	259	683	779	965	683	728	898
1976	154	165	184	953	1,134	1,474	120	143	186	1,227	1,442	1,844	574	608	760
1977	385	403	453	379	451	586	121	144	187	885	998	1,226	885	926	1,133
1978	188	200	229	452	538	699	99	118	153	739	856	1,081	739	770	970

Table 5. Continued.

	NORTH			CENTRAL			SOUTH			TOTAL			TOTAL WITHOUT ICE ENTRAPMENTS		
YEAR	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
1979	344	353	393	379	451	586	65	77	100	788	881	1,079	788	809	986
1980	357	382	440	412	490	637	155	184	239	924	1,056	1,316	924	978	1,215
1981	579	612	692	340	405	526	163	194	252	1,082	1,211	1,470	1,082	1,146	1,386
1982	536	563	623	313	372	484	108	129	168	957	1,064	1,275	857	905	1,068
1983	349	363	403	194	231	300	102	121	157	645	715	860	645	678	812
1984	432	439	486	352	419	545	42	50	65	826	908	1,096	606	621	723
1985	420	457	504	177	177	230	50	60	78	647	694	812	647	694	812
1986	520	623	686	114	114	148	48	96	125	682	833	959	682	833	959
1987	579	682	753	29	29	38	60	108	140	668	819	931	668	819	931
1988	141	244	268	125	125	162	46	94	122	312	463	552	187	338	390
1989	445	548	603	30	30	39	86	134	174	561	712	816	561	712	816
1990	356	356	393	684	684	889	69	117	152	1,109	1,157	1,434	609	657	784
1991	450	450	495	100	100	130	46	94	122	596	644	747	596	644	747
1992	677	780	858	26	26	34	46	94	122	749	900	1,014	749	900	1,014
1993	484	484	538	194	194	252	120	120	156	798	798	946	798	798	946
1994	231	231	258	239	239	311	148	148	192	618	618	761	618	618	761
1995	296	296	329	301	301	391	183	183	238	780	780	958	780	780	958
1996	114	114	148	245	245	318	183	183	238	542	542	704	542	542	704
1997	206	206	268	243	243	316	127	127	165	576	576	749	576	576	749
1998	251	251	326	312	312	406	181	181	235	744	744	967	744	744	967
1999	77	77	100	116	116	151	46	46	60	239	239	311	239	239	311

Table 6. Number of lower jaws from belugas that have been delivered since the obligatory jaw collection system was put in force in 1992.

	1992	1993	1994	1995	1996	1997
Qaanaaq		72				
Upernavik	54	339	47			
Uummannaq		15	4	9	1	
Qeqertarsuaq	24	10	17	10	5	
Ilulissat	2	6	67		4	
Aasiaat		18	3		10	
Kangaatsiaq				19	1	
Sisimiut		10	85	37	51	8
Maniitsoq		7	14		41	2
Total	80	477	237	75	113	10

than the reported catches in 1993-1998 (Table 1 and 2).

No reliable data exist on the trade in beluga mattak from Uummannaq, Disko Bay, Sisimiut or south of Sisimiut. Most mattak is sold directly by the hunters and no statistics are kept on the amount traded. Also, many fishing boats conduct an opportunistic hunt, which makes it difficult to get precise figures on the hunting levels.

For 1993, the collection of 339 jaws supported a mattak-derived estimate of 340 belugas in Upernavik (Table 6), twice as many as officially reported.

In 1994, the mattak purchases in Upernavik indicated a minimum catch of 188 belugas, exceeding the reported catch of 98 belugas (Table 1) and again showing a significant underreporting. For all other areas, the reported catches were larger than those derived from mattak purchases. When adding the corrected figure for Upernavik to the reported catches from all other areas an estimated total of 618 belugas were caught in West Greenland that year.

In 1995 there are records for trade in mattak only from the northern area and a total exceeding 19 tons was purchased, corresponding to an estimated hunt of 278 belugas.

In 1996 and 1997, only small amounts of mattak were purchased but in 1998 more than 15 tons were sold of which at least 9.5 tons (~136 belugas) were purchased in Upernavik. This is not in conflict with the reported catch of 162 whales. A factory ship purchased additionally 6.2 tons of mattak but the locations of the purchases are unknown and they can therefore not be compared with the reported catches. For 1999 the catch statistics only cover the period from January through September.

No ice entrapments of belugas have been reported in West Greenland since 1990.

DISCUSSION

Complete statistics on catches of Monodontids from at least the last part of the 19th century probably existed at some time. Some of them may still be retrievable from archives whereas other parts of the statistics have been lost. A large number of old archives from southern Greenland were lost with the wreckage of the ship 'Hans Hedtoft' in 1959. The fragmentary statistics that are presented here indicate a long history of relatively high levels of beluga catch in West Greenland that probably started before 1862. For population modelling it will be necessary to interpolate years without reported catches, to spread out the average figures over the years involved and to assume some level of harvesting before 1862 (cf. Butterworth *et al*. 2002, Innes and Stewart 2002).

Despite the incomplete reporting the historic data clearly shows that some dramatic changes in the distribution and occurrence of belugas happened in south Greenland in the first dec-

ades of the 20th century. Catches south of 66° N dwindled during the 1920s probably as a result of over-harvesting. Because of the suspicion that these catches were taken from a now extinct stock, it seems reasonable to keep these catches separate from those taken further north in the present range of belugas. But it is also possible that there were other stocks of belugas that were depleted by intensive hunting in the last century. For example the settlement of Kangersuatsiaq periodically had high levels of autumn catches (>400/yr during 1926-1932, Heide-Jørgensen 1994), but few belugas have been seen or caught there after 1960.

For the period after 1954, the localities for the catches reported in the official catch statistics are registered by the settlement/town where the hunters live. However this is not necessarily where the catches took place, which introduces a bias, especially in the southern areas where hunters make hunting trips to northern whaling grounds. Thus catch reports from the southern municipalities may include catches from further north in other municipalities. This bias has increased in importance with the widespread use of motorized vessels since the 1960s. No corrections could be applied for this bias but the pooling of the catches into larger areas reduces its importance.

The use of the average of catches in one decade to adjust for underreported catches in a subsequent decade could mask both trends and the occasional large catches. There are, however, no reasons to believe that there have been long periods without catches in Qaanaaq and Sisimiut since both hunting effort and the market value of the mattak has steadily increased over the years and substantial catches are reported in years with statistics.

In the 1980s and 1990s a large proportion of the catches have been estimated from diverse sources. The worst years are 1991 and 1992 where no official statistics are available, but because of the arbitrary collection of official data in all years, an unknown and possibly very large fraction of the catches is not reported (*e.g.* no catches in Sisimiut from 1986-1992). The introduction of a new catch recording system, 'Piniarneq' seems to provide a wider geographical coverage of the catches than previous systems. It is not yet possible to determine whether this indicates a more complete reporting of catches, but at least observations from biologists in 1994, 1995, 1998 and 1999 in Upernavik confirm the information from 'Piniarneq' that catches remained low (<250 whales) in those years, although underreporting was still a problem.

The *high option* for corrected catch estimates includes a relatively low (10%) estimate for losses in the drive fishery hunt. No studies of losses have been conducted in Greenland but inferences can be made from studies in other areas. In the western Canadian Arctic, loss rates for belugas were estimated to be about 40%, corresponding to a catch correction factor of 1.67 (Burns and Seaman 1986). For narwhal hunting in open water in Canada, Weaver and Walker (1988) reported loss rates between 32% and 55%, or catch correction factors of 1.5 to 2.2. Roberge and Dunn (1990) reported catch correction factors for narwhals in Canada ranging from 1.11 in open water to 1.41 at ice cracks and 1.56 at the floe edge or ice edge. The estimate assigned here to losses in the non-drive fishery (catch correction factor of 1.30) in Greenland covers both the open water hunt and the hunt from ice cracks and the ice edge. It also covers the open-water hunt in late autumn just before freeze-up, which is a period where loss rates have not been estimated. If anything the correction factor of 1.30 applied here is negatively biased.

The two options for correcting for underreporting increase the average catches of belugas since 1954 by 3.3% for the *low option* and by 15.5% for the *medium option*. The *high option* that includes losses increases the catches by 42.0%. For modelling the dynamics of the population an average of the *medium* and the *high options* has been used (Alvarez and Heide-Jørgensen MS 2000, Butterworth *et al*. 2002). This compromise increases the average catch by 28.8%.

If the whales killed in ice entrapments are removed then the catch estimates corrected for losses and underreporting (*high option*) is 28.4% larger than the reported catches in the

same period. Choosing the same compromise between the *medium* and *high options* as above gives an average correction excluding ice entrapment mortality of 16.7%.

Since quantitative data on underreporting are not available for most years and data on losses have not been collected in Greenland, qualified guesses of actual catch levels have been required. The corrections proposed here are clearly in the lower range of the possible values and even the *high option* may be negatively biased. Data from some years indicate that less than half of the catches were reported, and the applied loss rates are certainly in the lower range of published values for other areas. It can, however, be argued that years with observed severe underreporting were exceptional years because they are from periods when the reporting scheme was undergoing change. Similarly it can be argued that the loss rates in Greenland are lower than those reported for Canada, because a larger proportion of the hunt takes place in the open water season and because hunters in Greenland may be more skilled. Thus until more accurate information becomes available, the relatively conservative corrections of catches used here seem most appropriate.

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