Resource assessment and projections for the belugas off West Greenland using the population model of HITTER-FITTER

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ABSTRACT

The population model of the HITTER-FITTER package is applied to compute trajectories for single and two stock scenarios for the beluga population wintering off West Greenland. Values of $MSYR^{1+}$ from 1% to 4% are considered, with results computed to hit best estimates and lower 5%-iles for total abundance in 1999. Twenty year projections show that even for the most optimistic of these options in the single stock case, the resource is rendered extinct within 20 years if recent estimated annual catch levels of some 700 are continued. A time series of relative abundance information from surveys indicates that $MSYR^{1+}$ may be no more than 0.5%. All scenarios considered are suggestive of a heavily depleted resource for which catch levels need to be substantially reduced to secure against possible further reduction of the population.

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INTRODUCTION

The abundance of belugas (*Delphinapterus leucas*) wintering off West Greenland appears to have been declining over the last two decades at least (Heide-Jørgensen and Reeves 1996), most likely as a result of overharvesting. This is indicated by the strong downward trend in a relative index of abundance provided by survey data that are available for seven of the years since 1981. Recently Heide-Jørgensen and Acquarone (2002) have applied line transect theory, together with an estimate of *g(0)* (the proportion of animals on the survey trackline that are sighted) to calculate an estimate of absolute abundance of 7,941 (cv=0.32) belugas wintering off West Greenland during 1998/99. Assessments of this resource are made more difficult by possibly complicated stock structure and uncertainty as regards the assigning of catch and abundance data between what may be more than one stock (Alvarez and Heide-Jørgensen MS 2000).

A formal assessment of the West Greenland beluga population has only recently been attempted by Alvarez and Heide-Jørgensen (MS 2000). They use a simple discrete generalized logistic model without any age- or sex-structure, and conclude that this population is robustly estimated to have been reduced to less than 30% of its abundance some 50 years ago, and has a high probability of extinction if harvesting continues at current levels. The HITTER-FITTER package (de la Mare 1989, Punt 1996) has been applied to assess the population status of a number of whale stocks (*e.g.* Butterworth and Punt 1992, Geromont and Butterworth MS 2000). The BALEEN II population dynamics model underlying this package is age- and sex-structured and assumes a constant pattern of age-specific selectivity of catches; the density-dependent response to population reduction is assumed to be reflected entirely by an increase in fecundity (the product of pregnancy and first-year survival rates) and is modelled by the Pella-Tomlinson form (see Punt 1999 for a full mathematical description of the model). This paper describes the application of the HITTER-FITTER package to assess the status and productivity of the West Greenland beluga resource. We use the "hitting with fixed *MSYR*" option to calculate the value of pre-exploitation abundance, *K,* which "hits" the absolute abundance estimate for each of three stock scenarios and for a number of fixed values of *MSYR* (the maximum sustainable yield rate, which is the ratio of maximum sustainable yield to the population size at which this occurs *viz*. the maximum sustainable yield level, *MSYL*). Furthermore, we also use the "hitting" option to compute population trajectories consistent with the relative abundance trend information, but conditioned on the criterion that such trajectories pass through a specified estimate of abundance for 1999.

To evaluate the effect of future catch levels on the population, a series of 20-year projections are performed under a range of constant catch scenarios.

DATA

Historic catch data

The catch data used for the analyses in this paper are listed in Appendix 1. The information underlying this comes from Heide-Jørgensen and Rosing-Asvid (2002). Tables 3 and 4 of that paper provide estimates for most years during the 1862-1951 period. Catches listed as south of 66° N by Heide-Jørgensen and Rosing-Asvid are not included in the "South" column of Appendix 1 of this paper, given those authors' suspicion that a separate stock found in this area was extirpated through overexploitation. Hence "South" catches for 1862-1951 included in the analyses of this paper incorporate only those catches listed under Sisimiut by Heide-Jørgensen and Rosing-Asvid (2002). Table 5 of Heide-Jørgensen and Rosing-Asvid (2002) provides catch estimates for the 1954-1999 period; this paper uses the average (rounded to an integer) of the "medium" and "high" estimates in that Table. Appendix 1 of this paper also reports Heide-Jørgensen and Rosing-Asvid's estimates when adjusted to exclude takes from ice entrapments from total catches.

The information indicated above does not provide catch levels for all years, so assumptions are needed to fill in missing values. The approach used was to input the average of the values two years before and two years after any break in the time series, for each intervening year. As catches were presumably taken before the time of the first catch recorded for each area, a linear trend from zero in 1800 to the time of that first record was assumed. Appendix 1 distinguishes catch values based on actual records from those developed from the assumptions above by showing the latter in italics for each of the "North", "Central" and "South" regions.

Catches from separate stocks as assumed under a two-stock model are allocated as (North + 0.5 Central) for the "Upper" stock, and (South + 0.5 Central) for the "Lower" stock. HITTER-FITTER requires catches disaggregated by sex. A 50/50 sex ratio was assumed for this purpose (and also for the projections into the future considered subsequently); when the total caught was an odd number, the extra animal was classified as a female.

Abundance data

The estimates of absolute abundance used in these analyses are developed from information in Heide-Jørgensen and Acquarone (2002), and particularly Table 2 thereof. These absolute abundance estimates are taken to apply to the start of 1999. In the two-stock model, the combined estimate for strata 1-3 is used for the

"Upper" stock. Similarly, the combined estimate for strata 4-7 is used for the "Lower" stock.

The estimates of abundance precision used in these analyses are developed from the presentation of the survey data at the NAMMCO Working Group meeting in Oslo June 2000 (NAMMCO 2001). The original presentation of a standard error of 0.04 used for the g(0) estimate of 0.175 takes only one of the sources of variability in the estimate into account (viz. the proportion of time for which the animals are potentially visible - this was subsequently revised in the published presentation of the survey data (Heide-Jørgensen and Acquarone 2002)). Allowance also needs to be made for the sampling variability in the proportion (p) of visible pods on the trackline that are missed by observers (8 out of 16 recorded on video). Treating this probability of seeing a visible pod on the trackline as binomially distributed yields estimates of $\hat{p}={}^{8}/_{16}=0.5$, $\hat{\sigma}^2=n\cdot\hat{p}(1-\hat{p})=4$, so that $cv(\hat{p}) = 0.25$. Incorporating this additional factor into the variance estimation process in Heide-Jørgensen and Acquarone (2002) (under the assumption of no covariance with the other factors considered in that process) yields abundance estimates as follows:

Total:
7,941 cv = 0.41 Lower 5%-ile = 4,181
"Upper" stock :
4,401 cv = 0.43 Lower 5%-ile = 2,242
"Lower" stock :
3,540, cv = 0.50 Lower 5%-ile = 1,634

These lower 5%-iles were computed under the assumption of distribution lognormality, with the variance of the lognormal given by $\ln(1+CV^2)$. The values have been used for the HITTER runs reported below.

Heide-Jørgensen and Acquarone (2002) provide relative abundance values for the years 1993, 1994, 1998 and 1999 in their Table 2, and relative abundance values for the 1981, 1982 and 1991 were provided in Heide-Jørgensen *et al*. (1993). The surveys from 1981 and 1982 have subsequently been re-analysed, yielding estimates of 3,302 (cv = 0.29) for 1981 and 2,389 (cv = 0.17) for 1982 (Heide-Jørgensen, pers. comm.). This information is used in runs of HITTER which attempt to estimate *MSYR* from these data, rather than treating it as a fixed value input.

MODEL ASSUMPTIONS AND PARAMETER VALUES

HITTER is run assuming knife-edge recruitment at age 1, *i.e*. all animals equally susceptible to harvest. The maturity ogive is similarly assumed to have a knife-edge form, with an age at first parturition of 7, which is towards the upper end of the range accepted by the NAMMCO Scientific Committee (NAMMCO 2001, Table 1).

The NAMMCO Scientific Committee also developed estimates of annual male and female survival rates of 0.82 and 0.85 respectively, based on ageing from counts of layers in teeth (NAMMCO 2001). These estimates must be negatively biased. This is because the Scientific Committee also reports an annual pregnancy rate of 0.31, which implies that mature female survival rate must exceed 0.845 if the population is to have the capacity to grow in the absence of harvesting. This is in the extreme case of no natural mortality between birth and first parturition; were that taken into account, this minimum bound on the mature female survival rate would be even higher. A possible reason for the biased estimates is undercounting of layers as a result of tooth wear. In these circumstances, the annual rate of natural mortality was set equal to 0.1 for all ages. This seems a plausible value for a "small" whale, and the computations to follow are in any case not very sensitive to this choice.

Density dependence was assumed to act on the total (1+) population, and estimates of abundance were taken to correspond to this same component of the population. The *MSY* level ($MSYR^{1+}$) was set at 60% of the pre-exploitation total population size.

RESULTS

Key parameters of population trajectories which hit the best estimate and corresponding lower 5%-ile total (1+) 1999 population estimates for various values of ($MSYR^{1+}$) for the two different stock structure scenarios considered are given in Tables 1a-c. Table 1a gives es-

Table 1a. Parameters of population trajectories which hit the best estimate (7,941) and corresponding lower 5%-ile (4,181) total (1+) population sizes in 1999 for various values of $MSYR^{1+}$ for the single stock scenario ("Total" catches) for beluga whales off West Greenland. Results are shown for MSY, RY_{2000}, the pristine (pre-exploitation) total population size (K^{1+}), and the current status of the mature component of the population relative to pristine (N^{mat}_{2000}/K^{mat}). Bracketed figures reflect the consequences of excluding estimates from the catch series of the number of whales taken in ice entrapments.

	N^{1+}_{1999}	
MSYR*$^{1+}$ *(%)	**7,941**	**4,181**
MSY		
1	366 (342)	355 (332)
2	508 (469)	493 (456)
4	652 (582)	625 (557)
RY_{2000}		
1	95 (95)	41 (41)
2	210 (208)	99 (99)
4	437 (425)	227 (224)
K^{1+}		
1	60,952 (57,035)	59,103 (55,300)
2	42,373 (39,103)	41,056 (37,959)
4	27,155 (24,232)	26,052 (23,216)
(N^{mat}_{2000}/K^{mat})		
1	0.11 (0.12)	0.06 (0.06)
2	0.15 (0.16)	0.08 (0.08)
4	0.20 (0.23)	
	0.10 (0.11)	

Table 1b. Parameters of population trajectories which hit the best estimate (4,401) and corresponding lower 5%-ile (2,242) total (1+) population sizes in 1999 for various values of $MSYR^{1+}$ for the "Upper" stock for the two stock scenario for beluga whales off West Greenland. Results are shown for MSY, RY_{2000}, the pristine (pre-exploitation) total population size (K^{1+}), and the current status of the mature component of the population relative to pristine (N^{mat}_{2000}/K^{mat}).

	N^{1+}_{1999}	
MSYR*$^{1+}$ *(%)	**4,401**	**2,242**
MSY		
1	227	221
2	318	310
4	402	389
RY_{2000}		
1	50	18
2	115	50
4	248	120
K^{1+}		
1	37,908	36,840
2	26,522	25,798
4	16,761	16,191
(N^{mat}_{2000}/K^{mat})		
1	0.10	0.05
2	0.13	0.06
4	0.18	0.09

timates for the one stock scenario, and Tables 1b-c for the Upper and Lower stocks in the two-stock scenario. Quantities of management interest reported for each scenario are the maximum sustainable yield *MSY*, the current replacement yield (the year 2000 catch necessary to keep the population at its current level - RY_{2000}), the pristine (pre-exploitation - 1801) total population size (K^{1+}), and the current status of the mature female component of the population relative to pristine (N^{mat}_{2000}/K^{mat}). Figures 1a-c show plots of the population trajectories corresponding to the best estimate results in Tables 1a-c respectively.

Depletion statistics (N^{mat}_{2000}/K^{mat}) for the mature female component are presented in Table 2 as an index of the predicted response of the population to different levels of future harvest. Results are shown for the single stock scenario, when hitting the best estimate (7,941) and correspon-

Table 1c. Parameters of population trajectories which hit the best estimate (3,540) and corresponding lower 5%-ile (1,634) total (1+) population sizes in 1999 for various values of $MSYR^{1+}$ for the "Lower" stock in the two stock scenario for beluga whales off West Greenland. Results are shown for MSY, RY_{2000}, the pristine (pre-exploitation) total population size (K^{1+}), and the current status of the mature component of the population relative to pristine (N^{mat}_{2000}/K^{mat}).

	N^{1+}_{1999}	
$MSYR^{1+}$ (%)	**3,540**	**1,634**
MSY		
1	141	136
2	195	186
4	257	244
RY_{2000}		
1	48	20
2	97	43
4	191	90
K^{1+}		
1	23,545	22,648
2	16,220	15,535
4	10,727	10,171
(N^{mat}_{2000}/K^{mat})		
1	0.13	0.06
2	0.17	0.08
4	0.22	0.10

ding lower 5%-ile (4,181) of total (1+) population size in 1999 for 3 values of $MSYR^{1+}$ under various constant catch (C_{2000+}) levels (ranging from 100 to 700 animals) over the next 20 years (2001 to 2020). Corresponding plots of these projections are shown in Figs 2a-b.

The HITTER option of estimating $MSYR^{1+}$ for the single stock scenario was also attempted by making use of the time series of relative abundance information. HITTER treats all such data points as having identical cv's - this does not seem a particular problem, as the cv's given for these estimates (Heide-Jørgensen *et al*. 1993, Heide-Jørgensen and Acquarone 2002) are all quite similar. For the case of hitting the best estimate of 7,941, the estimate of $MSYR^{1+}$ is 0. This follows whether or not the results from the two earliest surveys (1981 and 1982), whose comparability with the later surveys is questionable, are taken into account. Indeed, for the full set of results, the model would prefer an estimate of productivity ($MSYR^{1+}$) which is negative!

To obtain some insight into the reliability of this result (in terms of its precision), a simpler approach was pursued. This involved comparing the slope of a log-linear regression of the survey estimates against time with corresponding estimates of this slope from model fits for different values of $MSYR^{1+}$, for the case where the population model hits the best estimate of population size for the single stock scenario. For the case where only the five surveys between 1991 and 1999 are considered, the 95% confidence limits on this slope for these surveys are -0.15 to 0.02 per annum. Over a range of $MSYR^{1+}$ from 0% to 10%, the slopes of the population model trajectories increase from -0.07 to +0.01, *i.e.* they lie completely within the range of the confidence limits for the survey data, so essentially these provide no discrimination between realistic possible values for $MSYR^{1+}$. However, if the two earlier surveys (1981 and 1982) are also included in this exercise, the upper confidence limit on the slope estimate is then -0.05 yr^{-1}, intermediate between the values of -0.056 for the population model with $MSYR^{1+}$ = 0%, and -0.048 when $MSYR^{1+}$ = 1%. In this instance then, one can say that the relative abundance data are consistent only with an $MSYR^{1+}$ estimate of about 0.5% or less.

DISCUSSION

For the range of $MSYR^{1+}$ values considered in Table 1a for the single stock scenario, pre-exploitation 1801 population size is estimated at between about 25,000 to 60,000 belugas. Note that estimates of pre-exploitation numbers are much more sensitive to the value assumed for $MSYR^{1+}$ than to that for the 1999 abundance. Fig. 1 shows that projecting trajectories as far back as the year 1801 does not qualitatively in-

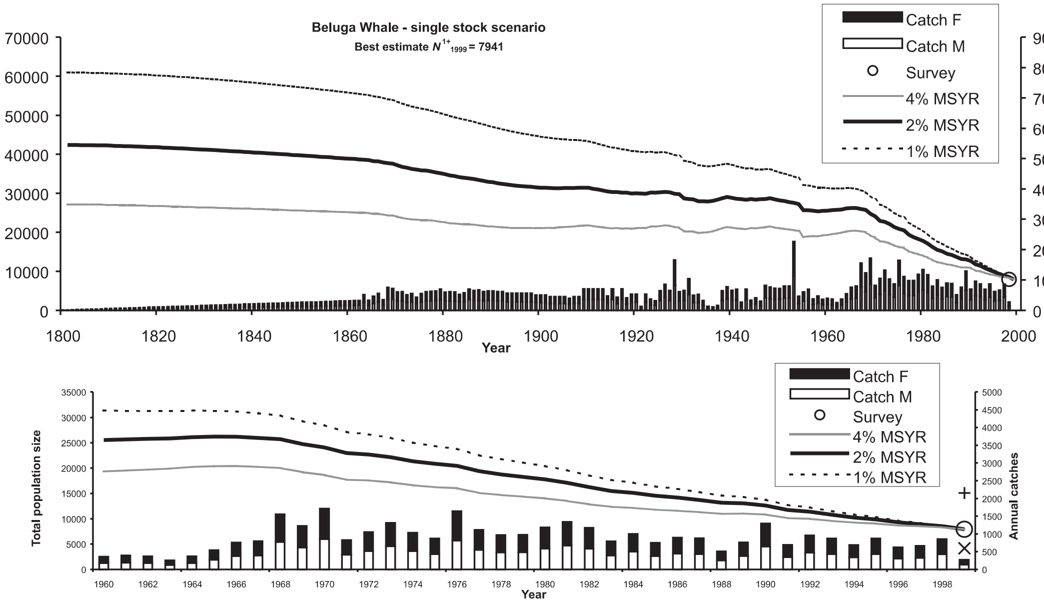

Fig. 1a. *Total (1+) population trajectories for the single stock scenario ("Total" catches) from 1801 to 1999 when hitting the 1999 best estimate of population size of 7,941 for MSYR^{1+} values of 1%, 2% and 4%. The second vertical axis shows the annual catches over this period. The lower figure is a magnified version of the top figure and shows the best estimate of 1999 abundance with 90% confidence intervals.*

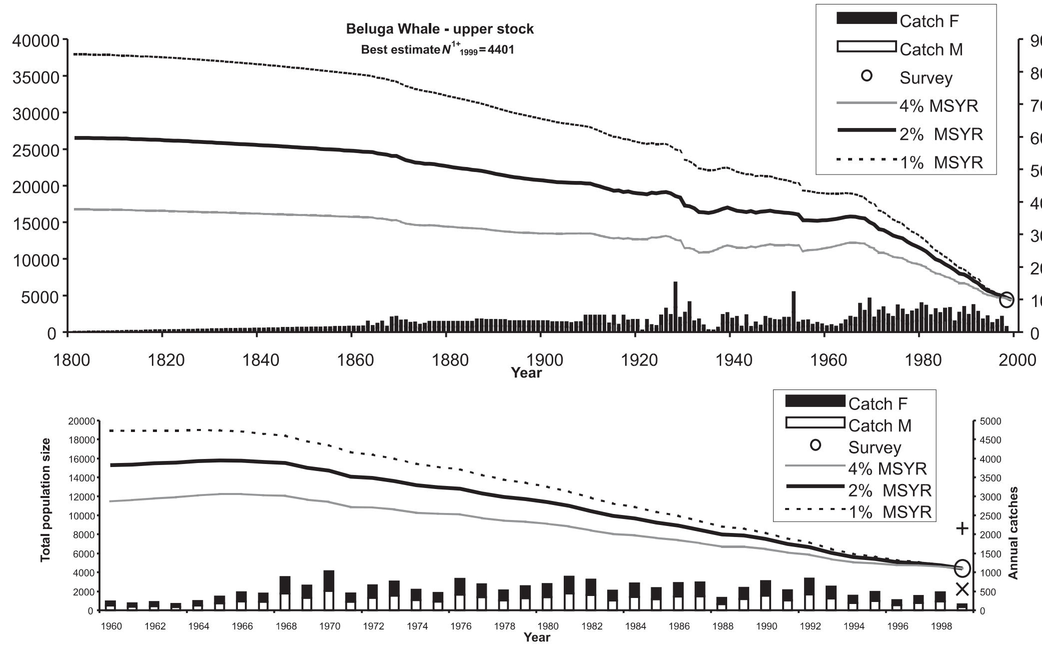

Fig. 1b. *Total (1+) population trajectories for the "Upper" stock in the two stock scenario from 1801 to 1999 when hitting the 1999 best estimate of population size of 4,401 for MSYR^{1+} values of 1%, 2% and 4%. The second vertical axis shows the annual catches over this period. The lower figure is a magnified version of the top figure and shows the best estimate of 1999 abundance with 90% confidence intervals.*

fluence the overall population assessment. The single stock model estimates of a total 1954 population size of approximately 20,000 to 35,000 belugas are similar to the results of Alvarez and Heide-Jorgensen (MS 2000) who estimated a 1954 "initial" population size of 30,000 belugas.

Comparison of annual historic catch data for the past three decades (for which catches increased markedly – see Fig. 1) with model estimates of the maximum sustainable yield for the beluga resource (whether considered as one or two stocks) suggest that the resource has been harvested at unsustainable levels over this period, resulting in a recent sharp decline in population size. The resource is assessed to be biologically overexploited (below its *MSY* level) and is estimated to currently be less than 20%, perhaps even as low as 6%, of its pre-exploitation

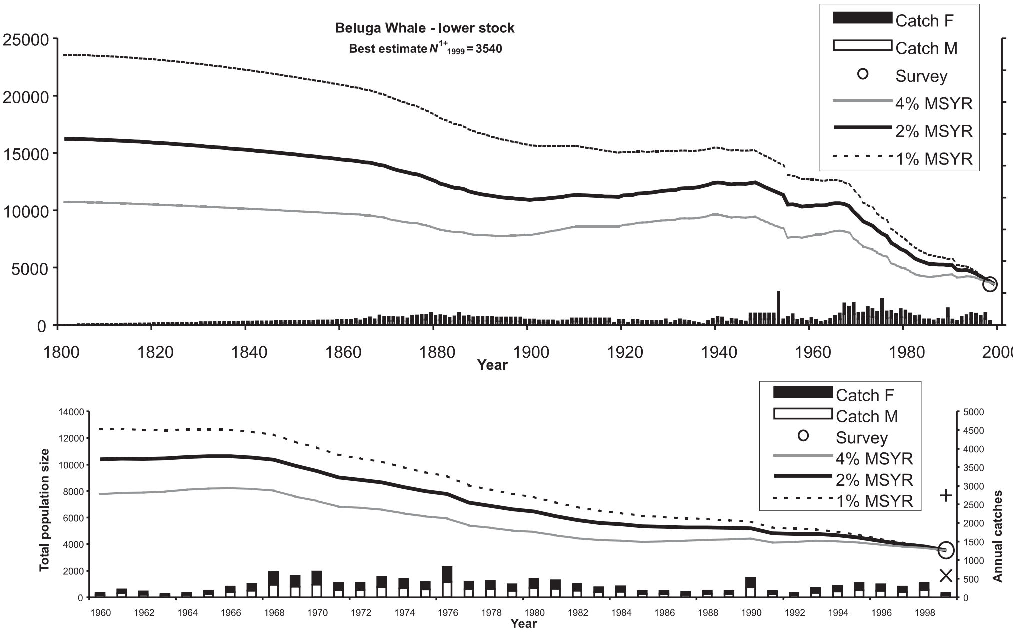

Fig. 1c. *Total (1+) population trajectories for the "Lower" stock in the two stock scenario from 1801 to 1999 when hitting the 1999 best estimate of population size of 3,540 for $MSYR^{1+}$ values of 1%, 2% and 4%. The second vertical axis shows the annual catches over this period. The lower figure is a magnified version of the top figure and shows the best estimate of 1999 abundance with 90% confidence intervals.*

level. These results change only marginally if catches taken from ice entrapments are treated as natural mortality (Table 1a). Even if one considers a particularly optimistic scenario, with Heide-Jørgensen and Rosing-Asvid's (2002) "low" catch estimates (without ice entrapments) for 1954-1999 substituted for the average of "medium" and "high" values in Appendix 1 which are used for the baseline calculations of this paper, the range of 6% to 20% for resource depletion mentioned above would improve to no more than 7% to 26%.

If harvesting continues at the 1990's unsustainable level of some 700 animals per annum, the resource is predicted to become extinct within 20 years. Model estimates of the current replacement yield for the resource range from 41 to 437 animals per year under the single stock scenario. The range in these estimates is attributable to both uncertainty regarding the correct choice of the $MSYR^{1+}$ value and uncertainty associated with the estimate of absolute abundance.

Table 2: Depletion statistics (N^{mat}_{2000}/K^{mat}) for the mature female component of the population when hitting the best estimate (7,941) and corresponding lower 5%-ile (4,181) total (1+) population sizes in 1999 for various values of $MSYR^{1+}$ for the single stock scenario ("Total" catches) and projecting forward to 2020, assuming constant future catches (C_{2000+}) of 100, 400 and 700 animals per annum.

$MSYR^{1+}$ (%)	N^{mat}_{2000}/K^{mat}	N^{mat}_{2020}/K^{mat}		
		C_{2000+}100	C_{2000+}400	C_{2000+}700
N^{1+}_{1999}= 7,941				
1	0.11	0.12	0.02	0.00
2	0.15	0.22	0.07	0.00
4	0.20	0.48	0.24	0.01
N^{1+}_{1999}= 4,181				
1	0.06	0.05	0.00	0.00
2	0.08	0.09	0.00	0.00
4	0.10	0.24	0.00	0.00

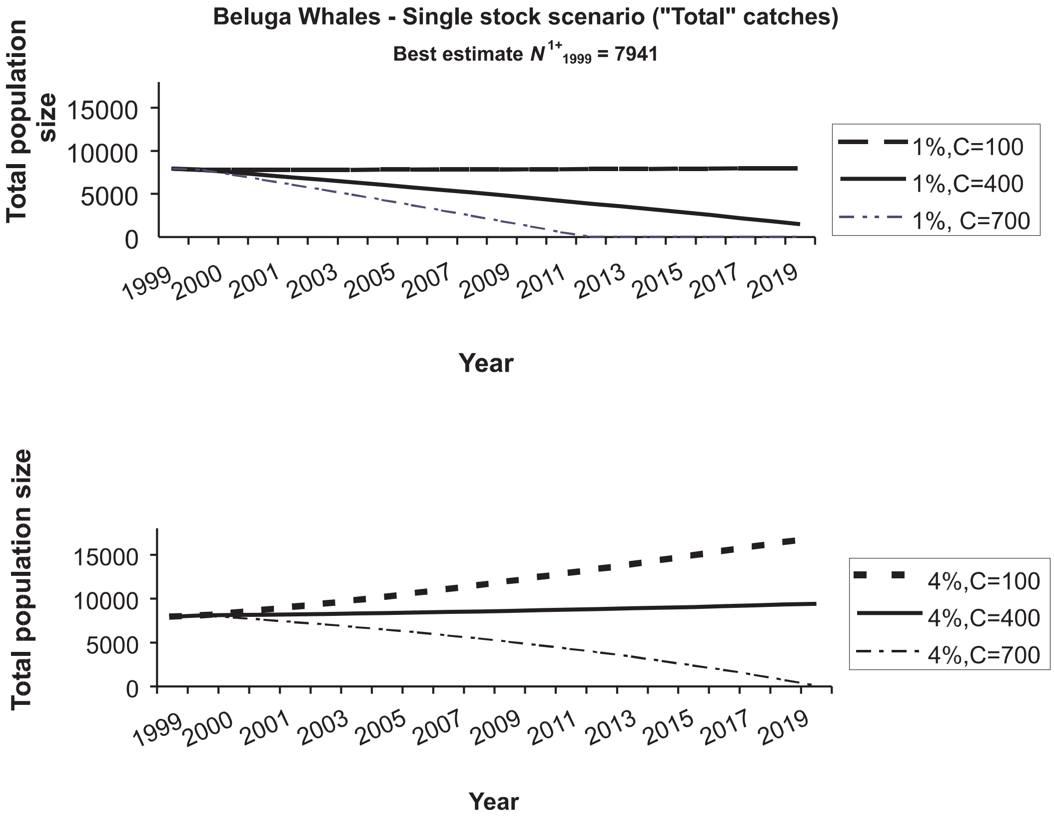

Fig. 2a. *Total (1+) population trajectories for the single stock scenario when hitting the 1999 best estimate of population size of 7,941 using MSYR*$^{1+}$ *= 1 % (top graph) and 4% (lower graph) for future catches of 100, 400 and 700 whales per annum.*

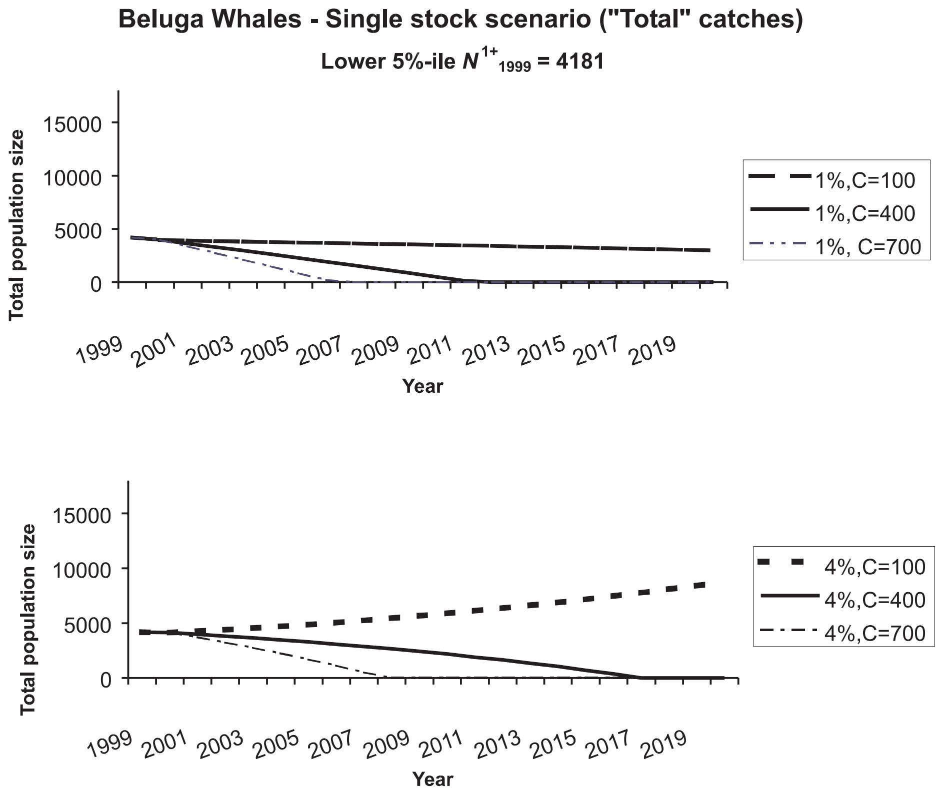

Fig. 2b. *Total (1+) population trajectories for the single stock scenario when hitting the lower 5%-ile for the 1999 population estimate of 4,181 using MSYR*$^{1+}$ *= 1 % (top graph) and 4% (lower graph) for future catches of 100, 400 and 700 whales per annum.*

Quantitative results quoted in the two preceding paragraphs are conditional on the assumption that $MSYR^{1+}$ lies between 1% and 4%. Relative abundance time-series data suggests that $MSYR^{1+}$ is low, perhaps no more than some 0.5%. This seems on the low side for a small whale, and may reflect non-comparability within this time series or an extended period of poor recruitment conditions. But it does serve to caution and counter against arguments that might otherwise be raised that $MSYR^{1+}$ could exceed 4%, and hence that the results quoted in this paper are overly pessimistic.

Whichever way one considers these results, however, they clearly give cause for considerable concern, given that current catch levels are almost certainly well above what a now heavily depleted resource can sustain. Broadly they suggest that harvest levels need to be reduced substantially, perhaps to as low as 100 animals per annum for the entire West Greenland stock, to secure against possible further reduction of the population over the immediate future.

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APPENDIX 1

Beluga catches in West Greenland as used for the population model. Data are based upon Heide-Jørgensen and Rosing-Asvid (2002), as detailed in the text. Interpolations/extrapolations for years for which no data are available are shown in italics. The basis for these inferences is also detailed in the text. The "South" region includes Sisimiut but excludes catches south of 66° N; the "Central" region includes Disko Bay; and the "North" region Uummannaq, Kangersuatsiaq and Upernavik. For the two stock scenario, catches for the "Upper" stock are taken to be "North + 0.5 Central", and for the"Lower" stock as "South + 0.5 Central". Bracketed figures under Total reflect excluding estimates of whales taken in ice entrapments (only instances where this results in differences are shown).

Year	South	Central	North	Total	Upper	Lower
1801	*1*	*2*	*2*	5	3	2
1802	*3*	*4*	*3*	10	5	5
1803	*4*	*7*	*5*	16	9	7
1804	*5*	*9*	*6*	20	11	9
1805	*7*	*11*	*8*	26	14	12
1806	*8*	*13*	*9*	30	16	14
1807	*10*	*15*	*11*	36	19	17
1808	*11*	*18*	*13*	42	22	20
1809	*12*	*20*	*14*	46	24	22
1810	*14*	*22*	*16*	52	27	25
1811	*15*	*24*	*17*	56	29	27
1812	*16*	*26*	*19*	61	32	29
1813	*18*	*29*	*21*	68	36	32
1814	*19*	*31*	*22*	72	38	34
1815	*21*	*33*	*24*	78	41	37
1816	*22*	*35*	*25*	82	43	39
1817	*23*	*37*	*27*	87	46	41
1818	*25*	*39*	*28*	92	48	44
1819	*26*	*42*	*30*	98	51	47
1820	*27*	*44*	*32*	103	54	49
1821	*29*	*46*	*33*	108	56	52
1822	*30*	*48*	*35*	113	59	54
1823	*32*	*50*	*36*	118	61	57
1824	*33*	*53*	*38*	124	65	59
1825	*34*	*55*	*40*	129	68	61
1826	*36*	*57*	*41*	134	70	64
1827	*37*	*59*	*43*	139	73	66
1828	*38*	*61*	*44*	143	75	68
1829	*40*	*64*	*46*	150	78	72
1830	*41*	*66*	*47*	154	80	74
1831	*42*	*68*	*49*	159	83	76
1832	*44*	*70*	*51*	165	86	79
1833	*45*	*72*	*52*	169	88	81
1834	*47*	*75*	*54*	176	92	84
1835	*48*	*77*	*55*	180	94	86
1836	*49*	*79*	*57*	185	97	88
1837	*51*	*81*	*58*	190	99	91
1838	*52*	*83*	*60*	195	102	93
1839	*53*	*86*	*62*	201	105	96
1840	*55*	*88*	*63*	206	107	99

Year	South	Central	North	Total	Upper	Lower
1841	*56*	*90*	*65*	211	110	101
1842	*58*	*92*	*66*	216	112	104
1843	*59*	*94*	*68*	221	115	106
1844	*60*	*97*	*70*	227	119	108
1845	*62*	*99*	*71*	232	121	111
1846	*63*	*101*	*73*	237	124	113
1847	*64*	*103*	*74*	241	126	115
1848	*66*	*105*	*76*	247	129	118
1849	*67*	*107*	*77*	251	131	120
1850	*68*	*110*	*79*	257	134	123
1851	*70*	*112*	*81*	263	137	126
1852	*71*	*114*	*82*	267	139	128
1853	*73*	*116*	*84*	273	142	131
1854	*74*	*118*	*85*	277	144	133
1855	*75*	*121*	*87*	283	148	135
1856	*77*	*123*	*89*	289	151	138
1857	*78*	*125*	*90*	293	153	140
1858	*79*	*127*	*92*	298	156	142
1859	*81*	*129*	*93*	303	158	145
1860	*82*	*132*	*95*	309	161	148
1861	*84*	*134*	*96*	314	163	151
1862	*85*	136	98	319	166	153
1863	*86*	130	107	323	172	151
1864	*88*	211	215	514	321	193
1865	*89*	106	136	331	189	142
1866	*90*	215	154	459	262	197
1867	*92*	288	180	560	324	236
1868	*93*	166	83	342	166	176
1869	*95*	409	248	752	453	299
1870	*96*	317	308	721	467	254
1871	*97*	307	198	602	352	250
1872	*99*	308	205	612	359	253
1873	*100*	264	149	513	281	232
1874	96	319	134	549	294	255
1875	94	218	116	428	225	203
1876	169	240	141	550	261	289
1877	153	*290*	*168*	611	313	298
1878	172	*290*	*168*	630	313	317
1879	178	*290*	*168*	636	313	323
1880	236	*290*	*168*	694	313	381
1881	140	*290*	*168*	598	313	285
1882	157	*290*	*168*	615	313	302
1883	148	*290*	*168*	606	313	293
1884	71	*290*	*168*	529	313	216
1885	121	*290*	*168*	579	313	266
1886	240	*290*	*168*	698	313	385
1887	94	350	208	652	383	269
1888	118	350	208	676	383	293
1889	74	*328*	*214*	616	378	238
1890	96	*328*	*214*	638	378	260
1891	96	*328*	*214*	638	378	260

Year	South	Central	North	Total	Upper	Lower
1892	96	305	219	620	372	248
1893	96	305	219	620	372	248
1894	96	*257*	*211*	564	340	224
1895	96	*257*	*211*	564	340	224
1896	96	*257*	*211*	564	340	224
1897	96	*257*	*211*	564	340	224
1898	96	*257*	*211*	564	340	224
1899	96	*257*	*211*	564	340	224
1900	36	*257*	*211*	504	340	164
1901	36	*257*	*211*	504	340	164
1902	36	*257*	*211*	504	340	164
1903	36	209	203	448	308	140
1904	36	209	203	448	308	140
1905	36	209	203	448	308	140
1906	36	209	203	448	308	140
1907	36	150	203	389	278	111
1908	36	209	203	448	308	140
1909	36	209	203	448	308	140
1910	37	336	334	707	502	205
1911	37	336	334	707	502	205
1912	37	336	334	707	502	205
1913	37	336	334	707	502	205
1914	37	336	334	707	502	205
1915	37	336	100	473	268	205
1916	37	336	334	707	502	205
1917	37	336	60	433	228	205
1918	37	336	334	707	502	205
1919	37	40	334	411	354	57
1920	47	221	264	532	375	157
1921	47	221	264	532	375	157
1922	47	50	25	122	50	72
1923	47	221	264	532	375	157
1924	47	221	100	368	211	157
1925	44	173	100	317	187	130
1926	44	173	425	642	512	130
1927	44	173	636	853	723	130
1928	44	173	436	653	523	130
1929	44	173	1436	1653	1523	130
1930	39	260	311	610	441	169
1931	39	40	575	654	595	59
1932	39	183	823	1045	915	130
1933	39	260	196	495	326	169
1934	13	260	252	525	382	143
1935	47	*147*	*130*	324	204	120
1936	65	20	48	133	58	75
1937	41	49	22	112	47	65
1938	8	19	127	154	137	17
1939	34	178	434	646	523	123
1940	99	186	490	775	583	192
1941	78	326	253	657	416	241
1942	36	380	273	689	463	226

Year	South	Central	North	Total	Upper	Lower
1943	27	146	91	264	164	100
1944	20	324	355	699	517	182
1945	56	238	41	335	160	175
1946	11	207	190	408	294	114
1947	9	189	98	296	193	103
1948	*15*	*688*	122	825	466	359
1949	*15*	*688*	*65*	768	409	359
1950	*15*	*688*	24	727	368	359
1951	*15*	*688*	17	720	361	359
1952	*15*	*688*	*93*	796	437	359
1953	*15*	*688*	*93*	796	437	359
1954	27	2040	202	2268 (228)	1222	1047
1955	14	317	129	459	288	172
1956	39	429	133	601	348	253
1957	110	450	134	693	359	335
1958	42	210	122	373	227	147
1959	49	280	141	469 (412)	281	189
1960	21	206	135	362	238	124
1961	84	252	57	393	183	210
1962	49	214	107	369	214	156
1963	36	107	112	254	166	89
1964	35	191	143	368	239	130
1965	59	246	240	544	363	182
1966	58	458	242	757	471	287
1967	146	425	226	797 (739)	439	358
1968	97	1165	291	1553 (1284)	874	679
1969	196	760	273	1228	653	576
1970	39	1303	376	1718 (510)	1028	690
1971	193	377	256	826	445	381
1972	185	417	451	1053	660	393
1973	220	668	428	1315	762	554
1974	196	589	244	1029	539	490
1975	229	367	276	872 (813)	460	412
1976	165	1304	175	1643 (684)	827	817
1977	166	519	428	1112 (1030)	688	425
1978	136	619	215	969 (870)	525	445
1979	89	519	373	980 (898)	633	348
1980	212	564	411	1186 (1097)	693	494
1981	223	466	652	1341 (1266)	885	456
1982	149	428	593	1170 (987)	807	363
1983	139	266	383	788 (745)	516	272
1984	58	482	463	1002 (672)	704	299
1985	69	204	481	753	583	171
1986	111	131	655	896	721	176
1987	124	34	718	875	735	141
1988	108	144	256	508 (364)	328	180
1989	154	35	576	764	594	171
1990	135	787	375	1296 (721)	769	527
1991	108	115	473	696	531	165
1992	108	30	819	957	834	123
1993	138	223	511	872	623	249

Year	South	Central	North	Total	Upper	Lower
1994	170	275	245	690	383	307
1995	211	346	313	869	486	384
1996	211	282	131	623	272	352
1997	146	280	237	663	377	286
1998	208	359	289	856	469	387
1999	53	134	89	275	156	120