

**Updated Assessments of the Central Stock of Minke Whales
in the North East Atlantic**

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Abstract

Assessments of the Central stock of minke whales developed at earlier NAMMCO Scientific Committee meetings are updated given further data in the form of new estimates of abundance from surveys. Results obtained do not differ greatly from those of earlier analyses if variance weighted estimates of abundance from 3 sets of surveys over the past 20 years are used. HITTER based assessments suggest that the Central stock of minke whales is close to its pre-exploitation level (not less than 10% below this). However, if the only estimates of abundance from the 2007 surveys are used, HITTER assessments suggest that the Central stock of minke whales is within the range of 70 to near 100% of its pre-exploitation level, depending on the possible MSYR and abundance estimate values used. Projections are provided for various levels of constant annual catches for the next 10 years..

Introduction

The purpose of this paper is to update assessment results presented to earlier NAMMCO Scientific Committee meetings regarding the Central stock of minke whales (NAMMCO 1999, 2003). The primary new information for these analyses is further estimates of abundance from sighting surveys carried out in 2007.

The assessment tool used for this purpose is the HITTER-FITTER package (de la Mare 1989, Punt 1996). This package is based upon a sex- and age-structured production model which assumes a constant pattern of age-specific selectivity of catches. As the length of the time series of abundance estimates in any one case is generally very limited, analyses focus on HITTING either a variance-weighted average of the available abundance estimates or the most recent observed estimate for each of a set of input values for $MSYR^{1+}$ (1%, 2% and 4%).

These analyses are repeated for the lower 5%ile of this averaged abundance estimate, and 10-year projections under different possible future catch options are shown.

Data

Catch Data

Sex-disaggregated catch data available for these assessments are given in Tables 1 and 2. For the high catch cases, the assumed bycatch, struck and lost and illegal unreported catch values were summed and then divided equally between males and females. Odd numbers of catch were split with one extra male and one extra female in alternate years. Between 1997 and 2003, if the number of bycatch, struck and lost and illegal unreported catch for the Central Medium stock was odd, the female catch was assumed to be one greater than the male catch¹.

Absolute Abundance Estimates

Absolute abundance estimates of the total (1+) population are listed in Table 3. The inverse variance weighted values and the corresponding lower 5%ile (obtained by weighting the logs of the abundance estimates by the squared inverses of their CVs) which are used for HITTER assessments are also listed. For estimates used for the Central Medium Stock there are eight options: two possible results for the CIC area from an aerial survey, and four possible results for the non-overlapping balance of the region dependent on whether or not all sighting effort is used, and which of two analysis methodologies is applied. For results chosen to present in Table 3, the option of using all effort was adopted, and then the options providing highest and lowest abundance estimates selected from the four possibilities remaining.

Model Assumptions and Parameter Values

HITTER

The parameter values assumed for the HITTER runs are given in Table 4. In all cases the maximum sustainable yield level ($MSYL^{exp}$) is expressed in terms of the exploitable component of the stock and taken to be $0.6K^{exp}$ (the exploitable component of carrying capacity). Density dependence is assumed to act upon the exploitable component of the stock. The maximum sustainable yield rate ($MSYR^{1+}$) is expressed in terms of the total (1+) population and the model is fit abundance estimates taken to represent the total (1+) population size. In addition, carrying capacity (K) is assumed to remain unchanged over the period considered. The minimum age at maturity is set at 3 and the minimum age at

¹ Note that the accuracy of these statements for data new to this assessment has still to be verified with data providers.

recruitment is set at 1. These choices were made for consistency with previous HITTER assessments of these stocks considered by the NAMMCO Scientific Committee (NAMMCO 1999; Cunningham and Butterworth 2003).

For projections under future catches, the sex ratio of such catches is assumed to be 1:1.

Results

HITTER Applied to the North Atlantic minke whales in the coastal Icelandic area (CIC)

- The HITTER results for the CIC area using variance weighted average estimates for 1998 are given in Tables 5a,b for both the CIC and CIC-high catch series.
- The corresponding population trajectories and projections for the CIC stock are given in Figures 1a,b,c, though only for the two extreme cases of HITTING the variance weighted average estimate of 29594 in 1998 and the lower 5%ile of the estimate in 2007 (6850) for the CIC catch series. In Figure 1a and subsequent corresponding HITTING with fixed *MSYR* plots, the trajectory corresponding to the lowest *MSYR* value lies highest on the left hand side of the plot.
- The HITTER results for the CIC area using the observed estimates in 2007 are given in Tables 6a,b for both the CIC and CIC-high catch series.

HITTER Applied to the North Atlantic minke whales in the Central Medium area

- The HITTER results for the Central Medium area using variance weighted average estimates in 1998 are given in Tables 7a,b.
- The corresponding population trajectories and projections for the Central Medium stock are given in Figures 2a,b,c, though only for the two extreme cases of HITTING the higher estimate of 48855 in 2007 and the lower 5%ile of the lower estimate in 2007 (13779) for the CM catch series.
- The HITTER results for the Central Medium area using the observed estimates in 2007 are given in Tables 8a,b.

Discussion

The updated assessments do not change the perceptions of the status of this resource reported in Cunningham and Butterworth (2003) when the variance weighted average estimates are used. Irrespective of the value assumed for $MSYR^{l+}$, past catches have had little impact on the population, which is currently close to its pre-exploitation level K . After 10 years, an annual catch of up to 400 whales would not see the population reduced below its assumed MSY level of $0.6K$ (Tables 5b, 7b).

However, when the most recent estimates of the CIC or Central Medium stocks are used, the perception of the status of the resource does change. Although the population is estimated to be currently above its assumed MSY level of 0.6K, it is possible that the population could currently be as low as 0.7K (Tables 6a, 8a). After 10 years, an annual catch of 100 whales would not see the population reduced below its assumed MSY level of 0.6K (Tables 6b, 8b).

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Table 1. Historic sex-disaggregated catch series for North Atlantic minke whales in the coastal Icelandic area (CIC) (from NAMMCO 1999, updated in recent years by Nils Øien pers. commn and Gisli Vikingsson pers. commn.). The ‘High’ catch case takes into account possible additional unreported bycatch (maximum of 5 animals annually) and struck and lost animals treated as 100% mortalities. Illegal unreported catch (maximum of 10 animals annually) is also included in the ‘High’ catch case during the period of total ban in Iceland (1986-2002). This and other catch (struck and lost or bycatch) of unknown sex is split evenly between sexes. In years for which data are not given, the catch is zero.

Year	CIC		CIC-High		Year	CIC		CIC-High	
	M	F	M	F		M	F	M	F
1930	5	5	7	8	1970	112	81	114	84
1931	3	3	6	5	1971	121	98	124	100
1932	3	3	5	6	1972	115	87	117	90
1933	3	3	6	5	1973	78	64	81	66
1934	3	3	5	6	1974	61	63	63	66
1935	3	3	6	5	1975	89	80	92	82
1936	1	0	3	3	1976	114	87	116	90
1937	1	0	4	2	1977	106	88	109	90
1938	0	0	2	3	1978	85	114	87	117
1939	0	0	3	2	1979	111	87	114	89
1940	0	0	2	3	1980	121	81	123	84
1941	7	7	10	9	1981	119	82	122	84
1942	7	7	9	10	1982	127	85	129	88
1943	7	7	10	9	1983	117	87	120	89
1944	7	7	9	10	1984	100	78	102	81
1945	7	7	10	9	1985	94	51	97	53
1946	18	15	20	18	1986	0	0	7	8
1947	27	18	30	20	1987	0	0	8	7
1948	56	43	58	46	1988	0	0	7	8
1949	56	48	59	50	1989	0	0	8	7
1950	18	15	20	18	1990	0	0	7	8
1951	20	18	23	20	1991	0	0	8	7
1952	21	19	23	22	1992	0	0	7	8
1953	20	18	23	20	1993	0	0	8	7
1954	20	18	22	21	1994	0	0	7	8
1955	24	27	27	29	1995	0	0	8	7
1956	23	21	25	24	1996	0	0	7	8
1957	24	21	27	23	1997	0	0	8	7
1958	23	21	25	24	1998	0	0	7	8
1959	24	21	27	23	1999	0	0	8	7
1960	30	23	32	26	2000	0	0	7	8
1961	71	34	74	36	2001	0	0	8	7
1962	78	50	80	53	2002	0	0	7	8
1963	69	54	72	56	2003	23	13	26	15
1964	114	48	116	51	2004	10	15	12	18
1965	80	62	83	64	2005	20	14	23	16
1966	87	77	89	80	2006	34	25	36	28
1967	135	87	138	89	2007	14	28	17	30
1968	219	206	221	209	2008	27	7	29	10
1969	93	66	96	68					

Table 2. Historic sex-disaggregated catch series for North Atlantic minke whales in the Central medium area (from NAMMCO 1999, updated in recent years by Nils Øien pers. commn and Gisli Vikingsson pers. commn.). The ‘High’ catch case takes into account possible additional unreported bycatch (maximum of 5 animals annually) and struck and lost animals treated as 100% mortalities. Illegal unreported catch (maximum of 10 animals annually) is also included in the ‘High’ catch case during the period of total ban in Iceland (1986-2002). This and other catch (struck and lost or bycatch) of unknown sex is split evenly between sexes. In years for which data are not given, the catch is zero.

Year	Central Medium		Central Medium - High		Year	Central Medium		Central Medium - High	
	M	F	M	F		M	F	M	F
1930	5	5	7	8	1970	203	159	205	162
1931	3	3	6	5	1971	172	131	175	133
1932	3	3	5	6	1972	204	166	206	169
1933	3	3	6	5	1973	250	127	253	129
1934	3	3	5	6	1974	143	109	145	112
1935	3	3	6	5	1975	180	221	183	223
1936	1	0	3	3	1976	175	110	177	113
1937	1	0	4	2	1977	107	88	110	90
1938	0	0	2	3	1978	146	162	148	165
1939	0	0	3	2	1979	166	118	169	120
1940	0	0	2	3	1980	198	120	200	123
1941	7	7	10	9	1981	129	117	132	119
1942	7	8	9	11	1982	212	109	214	112
1943	7	7	10	9	1983	164	125	167	127
1944	7	7	9	10	1984	136	149	138	152
1945	7	7	10	9	1985	113	123	116	125
1946	18	15	20	18	1986	6	46	13	54
1947	27	18	30	20	1987	12	42	20	49
1948	56	43	58	46	1988	4	1	11	9
1949	59	52	62	54	1989	1	0	9	7
1950	18	15	20	18	1990	5	0	12	8
1951	20	18	23	20	1991	5	2	13	9
1952	21	19	23	22	1992	8	0	15	8
1953	20	18	23	20	1993	7	8	15	15
1954	20	18	22	21	1994	8	38	15	46
1955	25	33	28	35	1995	6	38	14	45
1956	26	21	28	24	1996	12	40	19	48
1957	25	21	28	23	1997	1	29	10	39
1958	23	21	25	24	1998	9	58	16	66
1959	33	28	36	30	1999	10	59	19	68
1960	37	32	39	35	2000	25	42	33	49
1961	120	61	123	63	2001	5	43	13	50
1962	164	125	166	128	2002	6	39	13	47
1963	114	105	117	107	2003	26	45	29	47
1964	208	114	210	117	2004	14	39	16	42
1965	194	206	197	208	2005	27	16	30	18
1966	181	173	183	176	2006	32	21	34	24
1967	315	159	318	161	2007	15	29	18	31
1968	386	350	388	353	2008	34	36	36	39
1969	171	120	174	122					

Table 3. Abundance estimates for minke whales from surveys, and composite estimates obtained therefrom for use in HITTER analyses.

Stock	Year	Estimate	CV	Comments
CIC	1987	19200	0.28	NAMMCO 2003, Borchers 2003.
	2001	43600	0.19	NAMMCO 2003, Borchers 2003.
	2007	10680	0.27	Original blocks including all observers Vikingsson and Gunnlaugsson pers. comm. (SC/60/PFI 12)
	2007	6850		Lower 5%ile
	2007	15055	0.36	Using only experienced minke whale observers Vikingsson and Gunnlaugsson pers. comm. (SC/60/PFI 12)
	2007	8327		Lower 5%ile
	1998	25173		Variance weighted average, using 10680 estimate
	1998	20131		Lower 5%ile
	1998	29594		Variance weighted average, using 15055 estimate
	1998	23349		Lower 5%ile
Central Medium	1987	25800	0.212	NAMMCO 2003, Borchers 2003. Based on Icelandic and Norwegian ship surveys, and Icelandic aerial survey.
	2001	63500	0.158	NAMMCO 2003, Borchers 2003, Gunnlaugsson et al. 2003. Based on Icelandic ship and aerial surveys.
	2007	23480	0.324	Paxton and Gunnlaugsson pers. comm.
	2007	13779		Lower 5%ile
	2007	48855	0.357	Paxton and Gunnlaugsson pers. comm.
	2007	27156		Lower 5%ile
	1998	42104		Variance weighted average, using 23480 estimate
	1998	34676		Lower 5%ile
	1998	46343		Variance weighted average, using 48855 estimate
	1998	38079		Lower 5%ile

Table 4. Biological and operational parameter values assumed for HITTER runs for Minke Whales.

Stock	CIC Stock	Central Medium Stock	
Maximum age class	20	20	
Natural mortality rate (taken here to be age-independent)	0.09	0.09	Most recent estimate from Table 5.2.2 NAMMCO (1999)
Female age at 50% maturity ²	7	7	Most recent estimate from Table 5.2.2 NAMMCO (1999)
Female age at 95% maturity	12	12	
Female age at 50% recruitment	5.5	5.5	
Female age at 95% recruitment	11.5	11.5	
Male age at 50% recruitment	5.5	5.5	
Male age at 95% recruitment	11.5	11.5	Table 5.2.1 / Central value from Table 5.2.2 NAMMCO (1999)
Minimum age at maturity	3	3	
Minimum age at recruitment	1	1	
First year of simulation	1930	1930	
Last year of catches in simulation	2008	2008	

² Corresponds to age at first parturition – 1 year

Table 5a. Statistics of population trajectories which hit the weighted average (29594 or 25173) and corresponding lower 5%ile (23349 or 20131) total (1+) population sizes in 1998 for various values of $MSYR^{1+}$ for the CIC stock of minke whales, for the base case (CIC) and 'high catch' (CIC-High) scenarios. Results are shown for MSY , RY_{2008} , the pristine (pre-exploitation) total population size (K^{1+}), and the current status of the mature female component of the population relative to pristine (N_{2008}^{mat}/K^{mat}).

	Weighted average and lower 5%ile using 15055 in 2007				Weighted average and lower 5%ile using 10680 in 2007			
	CIC		CIC-High		CIC		CIC-High	
$MSYR^{1+}(\%)$	29594	23349	29594	23349	25173	20131	25173	20131
MSY^{exp}								
1	178	143	180	145	154	126	155	127
2	353	280	354	281	301	242	302	244
4	750	591	750	591	637	509	637	509
K^{1+}								
1	31526	25365	31774	25623	27160	22209	27415	22474
2	30016	23818	30145	23954	25626	20639	25759	20781
4	29518	23270	29529	23281	25095	20049	25106	20060
RY_{2008}								
1	54	55	62	62	54	55	62	62
2	35	36	45	47	36	38	46	48
4	20	18	29	29	20	20	29	29
N_{2008}^{mat}/K^{mat}								
1	0.94	0.92	0.93	0.91	0.93	0.91	0.92	0.89
2	0.98	0.98	0.98	0.97	0.98	0.97	0.97	0.96
4	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Table 5b. Hitting weighted average (29594 or 25173) and lower 5%ile (23349 or 20131) total (1+) population sizes in 1998 for various values of $MSYR^{1+}$ for the CIC stock of minke whales, for the base case and ‘high catch’ scenarios and projecting forward under future annual catches of 0, 50, 100, 200 and 400 animals from 2009 to 2018. Results are shown for the mature female component of the population.

		$MSYR^{1+}(\%)$	N_{2008}^{mat}/K^{mat}	N_{2018}^{mat}/K^{mat}				
				$C_{2009+}=0$	$C_{2009+}=50$	$C_{2009+}=100$	$C_{2009+}=200$	$C_{2009+}=400$
Weighted average using 15055 in 2007	CIC	$N^{1+}=29594$						
		1	0.94	0.96	0.94	0.92	0.89	0.83
		2	0.98	0.99	0.98	0.96	0.93	0.86
		4	1.00	1.00	0.99	0.97	0.94	0.87
		$N^{1+}=23349$						
		1	0.92	0.94	0.92	0.90	0.86	0.78
		2	0.98	0.99	0.97	0.95	0.91	0.82
	4	0.99	1.00	0.98	0.96	0.92	0.84	
	CIC-high	$N^{1+}=29594$						
		1	0.93	0.95	0.93	0.92	0.88	0.82
		2	0.98	0.99	0.97	0.96	0.92	0.86
		4	0.99	1.00	0.99	0.97	0.94	0.87
		$N^{1+}=23349$						
		1	0.91	0.93	0.91	0.89	0.85	0.77
2		0.97	0.99	0.97	0.95	0.90	0.82	
4	0.99	1.00	0.98	0.96	0.92	0.84		
Weighted average using 10680 in 2007	CIC	$N^{1+}=25173$						
		1	0.93	0.95	0.93	0.91	0.87	0.80
		2	0.98	0.99	0.97	0.95	0.91	0.84
		4	0.99	1.00	0.98	0.96	0.93	0.85
		$N^{1+}=20131$						
		1	0.91	0.93	0.91	0.89	0.84	0.75
		2	0.97	0.99	0.97	0.94	0.89	0.79
	4	0.99	1.00	0.98	0.95	0.91	0.81	
	CIC-high	$N^{1+}=25173$						
		1	0.92	0.94	0.92	0.90	0.86	0.79
		2	0.97	1.00	0.97	0.95	0.91	0.83
		4	0.99	1.00	0.98	0.96	0.93	0.85
		$N^{1+}=20131$						
		1	0.89	0.92	0.90	0.88	0.83	0.74
2		0.96	0.99	0.96	0.94	0.89	0.79	
4	0.99	1.00	0.98	0.95	0.91	0.81		

Table 6a. Statistics of population trajectories which hit the estimated 15055 or 10680 and corresponding lower 5%ile (8327 or 6850) total (1+) population size in 2007 for various values of $MSYR^{1+}$ for the CIC stock of minke whales, for the base case (CIC) and 'high catch' (CIC-High) scenarios. Results are shown for MSY , RY_{2008} , the pristine (pre-exploitation) total population size (K^{1+}), and the current status of the mature female component of the population relative to pristine (N_{2008}^{mat}/K^{mat}).

	Using 15055 and lower 5%ile in 2007				Using 10680 and lower 5%ile in 2007			
	CIC		CIC-High		CIC		CIC-High	
$MSYR^{1+}(\%)$	15055	8327	15055	8327	10680	6850	10680	6850
MSY^{exp}								
1	95	60	97	62	72	53	74	55
2	181	105	183	108	131	90	133	93
4	384	213	384	213	273	176	273	175
K^{1+}								
1	16870	10606	17187	10978	12739	9324	13087	9711
2	15412	8957	15548	9159	11157	7660	11324	7895
4	15123	8397	15116	8387	10750	6919	10741	6906
RY_{2008}								
1	55	53	62	58	55	51	60	56
2	42	54	52	64	48	59	59	68
4	19	17	28	26	18	16	27	26
N_{2008}^{mat}/K^{mat}								
1	0.87	0.75	0.85	0.72	0.81	0.69	0.78	0.66
2	0.96	0.89	0.94	0.86	0.93	0.84	0.90	0.80
4	0.99	0.99	0.99	0.98	0.99	0.98	0.98	0.97

Table 6b. Hitting the estimated 15055 or 10680 and corresponding lower 5%ile (8327 or 6850) total (1+) population size in 2007 for various values of $MSYR^{1+}$ for the CIC stock of minke whales, for the base case and ‘high catch’ scenarios and projecting forward under future annual catches of 0, 50, 100, 200 and 400 animals from 2009 to 2018. Results are shown for the mature female component of the population.

		$MSYR^{1+}(\%)$	N_{2008}^{mat}/K^{mat}	N_{2018}^{mat}/K^{mat}				
				$C_{2009+}=0$	$C_{2009+}=50$	$C_{2009+}=100$	$C_{2009+}=200$	$C_{2009+}=400$
Using 15055 in 2007	CIC	$N^{1+}=15055$						
		1	0.87	0.90	0.87	0.84	0.78	0.66
		2	0.96	0.98	0.95	0.92	0.85	0.72
		4	0.99	1.00	0.97	0.94	0.88	0.75
		$N^{1+}=8327$						
		1	0.75	0.80	0.75	0.70	0.61	0.41
		2	0.88	0.95	0.89	0.84	0.72	0.50
	4	0.99	1.00	0.95	0.89	0.78	0.56	
	CIC-high	$N^{1+}=15055$						
		1	0.85	0.89	0.86	0.83	0.77	0.65
		2	0.94	0.98	0.94	0.91	0.85	0.72
		4	0.99	1.00	0.97	0.94	0.88	0.75
		$N^{1+}=8327$						
		1	0.72	0.78	0.73	0.68	0.59	0.40
2		0.86	0.93	0.88	0.82	0.71	0.49	
4	0.98	1.00	0.95	0.89	0.78	0.56		
Using 10680 in 2007	CIC	$N^{1+}=10680$						
		1	0.81	0.85	0.81	0.77	0.69	0.53
		2	0.93	0.97	0.92	0.88	0.79	0.61
		4	0.99	1.00	0.96	0.92	0.83	0.65
		$N^{1+}=6850$						
		1	0.69	0.75	0.70	0.64	0.53	0.31
		2	0.84	0.92	0.85	0.79	0.66	0.40
	4	0.98	1.01	0.94	0.87	0.73	0.46	
	CIC-high	$N^{1+}=10680$						
		1	0.78	0.83	0.79	0.75	0.67	0.52
		2	0.90	0.96	0.91	0.87	0.78	0.60
		4	0.98	1.00	0.96	0.92	0.83	0.65
		$N^{1+}=6850$						
		1	0.66	0.72	0.67	0.62	0.51	0.30
2		0.80	0.90	0.83	0.77	0.64	0.39	
4	0.97	1.01	0.94	0.87	0.73	0.46		

Table 7a. Statistics of population trajectories which hit the weighted average (46343 or 42104) and corresponding lower 5%ile (38079 or 34676) total (1+) population sizes in 1998 for various values of $MSYR^{1+}$ for the Central Medium stock of minke whales, for the base case (CM) and 'high catch' (CM-High) scenarios. Results are shown for MSY , RY_{2008} , the pristine (pre-exploitation) total population size (K^{1+}), and the current status of the mature female component of the population relative to pristine (N_{2008}^{mat}/K^{mat}).

	Weighted average and lower 5%ile using 48855 in 2007				Weighted average and lower 5%ile using 23480 in 2007			
	CM		CM-High		CM		CM-High	
$MSYR^{1+}(\%)$	46343	38079	46343	38079	42104	34676	42104	34676
MSY^{exp}								
1	283	236	284	238	259	218	260	219
2	556	460	557	461	506	420	508	422
4	1177	967	1177	967	1069	880	1070	881
K^{1+}								
1	49937	41800	50191	42063	45757	38466	46016	38733
2	47321	39133	47456	39275	43117	35774	43255	35920
4	46344	38077	46361	38093	42104	34671	42120	34688
RY_{2008}								
1	83	82	90	90	83	82	90	89
2	64	66	74	76	65	67	75	78
4	48	48	58	57	48	48	58	57
N_{2008}^{mat}/K^{mat}								
1	0.92	0.90	0.91	0.89	0.91	0.89	0.90	0.88
2	0.97	0.96	0.96	0.95	0.96	0.95	0.96	0.95
4	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98

Table 7b. Hitting weighted average (46343 or 42104) and lower 5%ile (38079 or 34676) total (1+) population sizes in 1998 for various values of $MSYR^{1+}$ for the Central Medium stock of minke whales, for the base case and ‘high catch’ scenarios and projecting forward under future annual catches of 0, 50, 100, 200 and 400 animals from 2009 to 2018. Results are shown for the mature female component of the population.

		$MSYR^{1+}(\%)$	N_{2008}^{mat}/K^{mat}	N_{2018}^{mat}/K^{mat}				
				$C_{2009+}=0$	$C_{2009+}=50$	$C_{2009+}=100$	$C_{2009+}=200$	$C_{2009+}=400$
Weighted average using 48855 in 2007	CM	$N^{1+}=46343$						
		1	0.92	0.94	0.93	0.92	0.90	0.86
		2	0.97	0.98	0.97	0.96	0.94	0.90
		4	0.98	1.00	0.99	0.98	0.96	0.91
		$N^{1+}=38079$						
		1	0.90	0.92	0.91	0.90	0.87	0.82
		2	0.96	0.98	0.97	0.95	0.93	0.88
	4	0.98	1.00	0.98	0.97	0.95	0.90	
	CM-high	$N^{1+}=46343$						
		1	0.91	0.93	0.92	0.91	0.89	0.85
		2	0.96	0.98	0.97	0.96	0.94	0.90
		4	0.98	1.00	0.99	0.98	0.96	0.91
		$N^{1+}=38079$						
		1	0.89	0.92	0.91	0.89	0.87	0.82
2		0.95	0.98	0.96	0.95	0.92	0.87	
4	0.98	1.00	0.98	0.97	0.95	0.89		
Weighted average using 23480 in 2007	CM	$N^{1+}=42104$						
		1	0.91	0.93	0.92	0.91	0.89	0.84
		2	0.96	0.98	0.97	0.96	0.93	0.89
		4	0.98	1.00	0.98	0.97	0.95	0.91
		$N^{1+}=34676$						
		1	0.89	0.92	0.90	0.89	0.86	0.81
		2	0.95	0.98	0.96	0.95	0.92	0.86
	4	0.98	0.99	0.98	0.97	0.94	0.88	
	CM-high	$N^{1+}=42104$						
		1	0.90	0.93	0.91	0.90	0.88	0.84
		2	0.96	0.98	0.97	0.96	0.93	0.89
		4	0.98	1.00	0.98	0.97	0.95	0.91
		$N^{1+}=34676$						
		1	0.88	0.91	0.89	0.88	0.85	0.80
2		0.95	0.97	0.96	0.94	0.93	0.86	
4	0.98	0.99	0.98	0.97	0.95	0.89		

Table 8a. Statistics of population trajectories which hit the estimated 48855 or 23480 and corresponding lower 5%ile (27156 or 13779) total (1+) population size in 2007 for various values of $MSYR^{1+}$ for the Central Medium stock of minke whales, for the base case (CM) and 'high catch' (CM-High) scenarios. Results are shown for MSY , RY_{2008} , the pristine (pre-exploitation) total population size (K^{1+}), and the current status of the mature female component of the population relative to pristine (N_{2008}^{mat}/K^{mat}).

	Using 48855 and lower 5%ile in 2007				Using 23480 and lower 5%ile in 2007			
	CM		CM-High		CM		CM-High	
$MSYR^{1+}(\%)$	48855	27156	48855	27156	23480	13779	23480	13779
MSY^{exp}								
1	294	174	296	176	154	104	156	106
2	584	331	585	333	289	181	290	184
4	1244	694	1244	694	600	354	600	354
K^{1+}								
1	52054	30817	52336	31138	27302	18266	27636	18746
2	49688	28168	49806	28313	24571	15424	24727	15646
4	49010	27318	49006	27316	23644	13951	23643	13954
RY_{2008}								
1	83	81	90	88	81	73	87	78
2	63	71	74	82	74	89	85	98
4	48	47	58	56	46	43	56	53
N_{2008}^{mat}/K^{mat}								
1	0.92	0.85	0.91	0.84	0.83	0.71	0.82	0.69
2	0.97	0.94	0.96	0.93	0.92	0.83	0.91	0.81
4	0.98	0.97	0.98	0.97	0.97	0.95	0.96	0.94

Table 8b. Hitting the estimated 48855 or 23480 and corresponding lower 5%ile (27156 or 13779) total (1+) population sizes in 2007 for various values of $MSYR^{1+}$ for the Central Medium stock of minke whales, for the base case and ‘high catch’ scenarios and projecting forward under future annual catches of 0, 50, 100, 200 and 400 animals from 2009 to 2018. Results are shown for the mature female component of the population.

		$MSYR^{1+}(\%)$	N_{2008}^{mat}/K^{mat}	N_{2018}^{mat}/K^{mat}				
				$C_{2009+}=0$	$C_{2009+}=50$	$C_{2009+}=100$	$C_{2009+}=200$	$C_{2009+}=400$
Using 48855 in 2007	CM	$N^{1+}=48855$						
		1	0.92	0.94	0.93	0.92	0.90	0.86
		2	0.97	0.98	0.97	0.96	0.94	0.90
		4	0.98	1.00	0.99	0.98	0.96	0.92
		$N^{1+}=27156$						
		1	0.85	0.89	0.87	0.85	0.82	0.75
		2	0.94	0.97	0.95	0.93	0.89	0.82
	4	0.97	0.99	0.98	0.96	0.92	0.85	
	CM-high	$N^{1+}=48855$						
		1	0.91	0.94	0.93	0.92	0.90	0.86
		2	0.96	0.98	0.97	0.96	0.94	0.90
		4	0.98	1.00	0.99	0.98	0.96	0.92
		$N^{1+}=27156$						
		1	0.84	0.88	0.86	0.84	0.81	0.74
2		0.93	0.96	0.94	0.93	0.89	0.82	
4	0.97	0.99	0.98	0.96	0.92	0.85		
Using 23480 in 2007	CM	$N^{1+}=23480$						
		1	0.83	0.87	0.85	0.83	0.79	0.71
		2	0.92	0.96	0.94	0.92	0.88	0.79
		4	0.97	0.99	0.97	0.95	0.91	0.83
		$N^{1+}=13779$						
		1	0.71	0.76	0.73	0.70	0.64	0.53
		2	0.83	0.90	0.87	0.84	0.77	0.64
	4	0.95	0.99	0.95	0.92	0.85	0.71	
	CM-high	$N^{1+}=23480$						
		1	0.82	0.86	0.84	0.82	0.78	0.71
		2	0.91	0.95	0.93	0.91	0.87	0.79
		4	0.96	0.99	0.97	0.95	0.91	0.83
		$N^{1+}=13779$						
		1	0.69	0.74	0.71	0.69	0.63	0.52
2		0.81	0.89	0.86	0.83	0.76	0.63	
4	0.94	0.99	0.95	0.92	0.85	0.71		

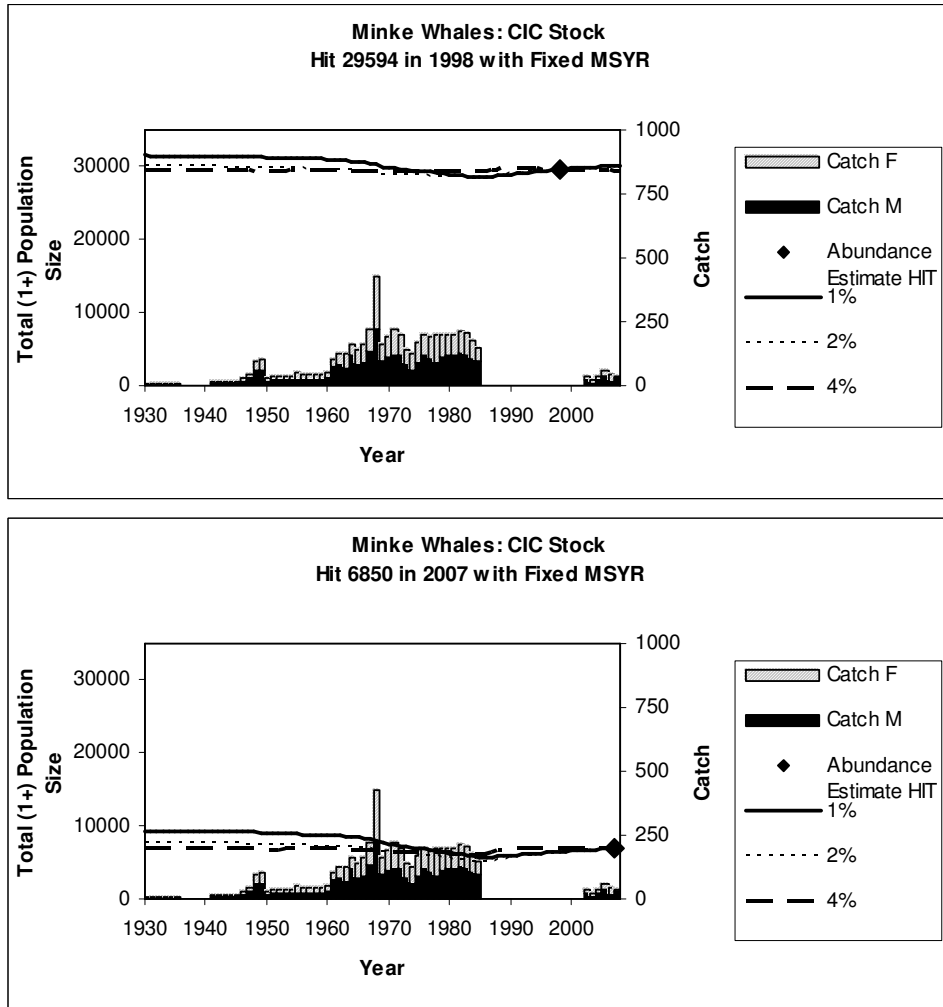


Figure 1a. Total (1+) population trajectories from 1930 to 2008 for the minke whale CIC stock when assuming a total population size of 29594 in 1998 (upper panel) or 6850 in 2007 (lower panel) for $MSYR^{1+}$ values of 1, 2% and 4%. The trajectory corresponding to the lowest MSYR lies highest on the left hand side of this and similar following plots. Annual catches are indicated at the bottom of the plot.

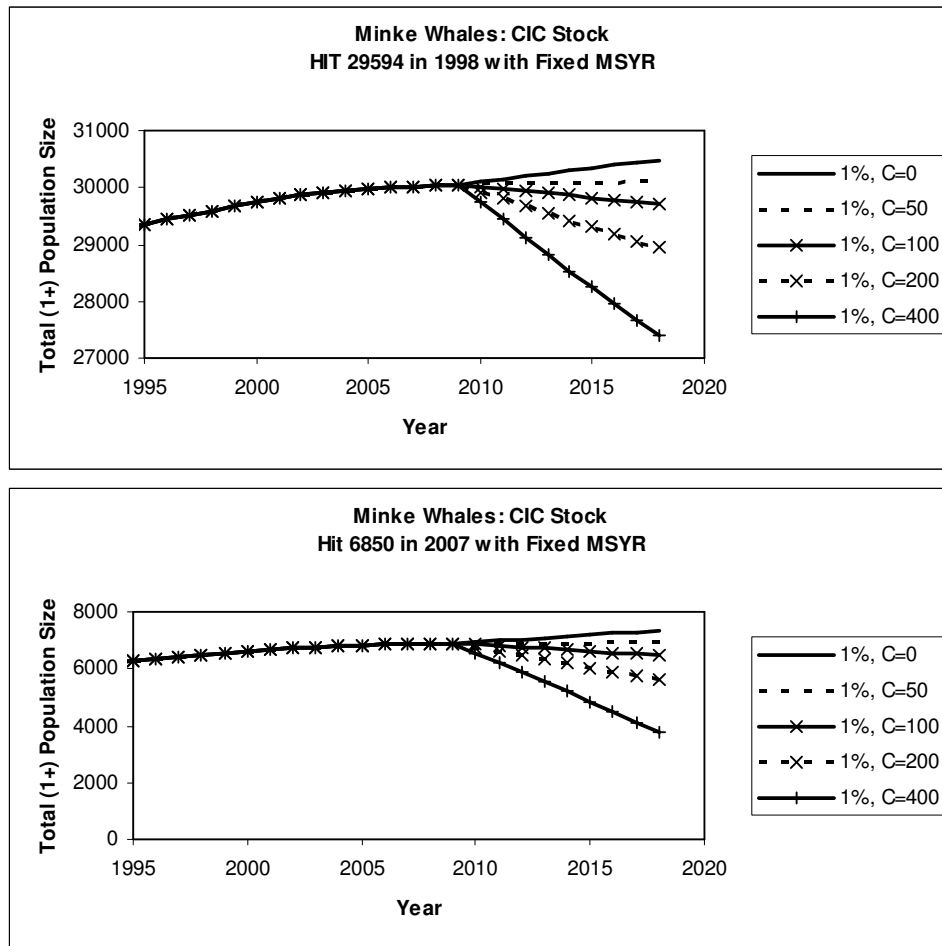


Figure 1b. Total (1+) population trajectories in the minke whale CIC stock when hitting a best estimate of $N_{1998}^{1+} = 29594$ (upper panel) or $N_{2007}^{1+} = 6850$ (lower panel) for $MSYR^{1+} = 1\%$ for future annual catches of 0, 50, 100, 200 and 400 animals. Note that the vertical axis minimum in the upper panel is 27000 animals and not zero.

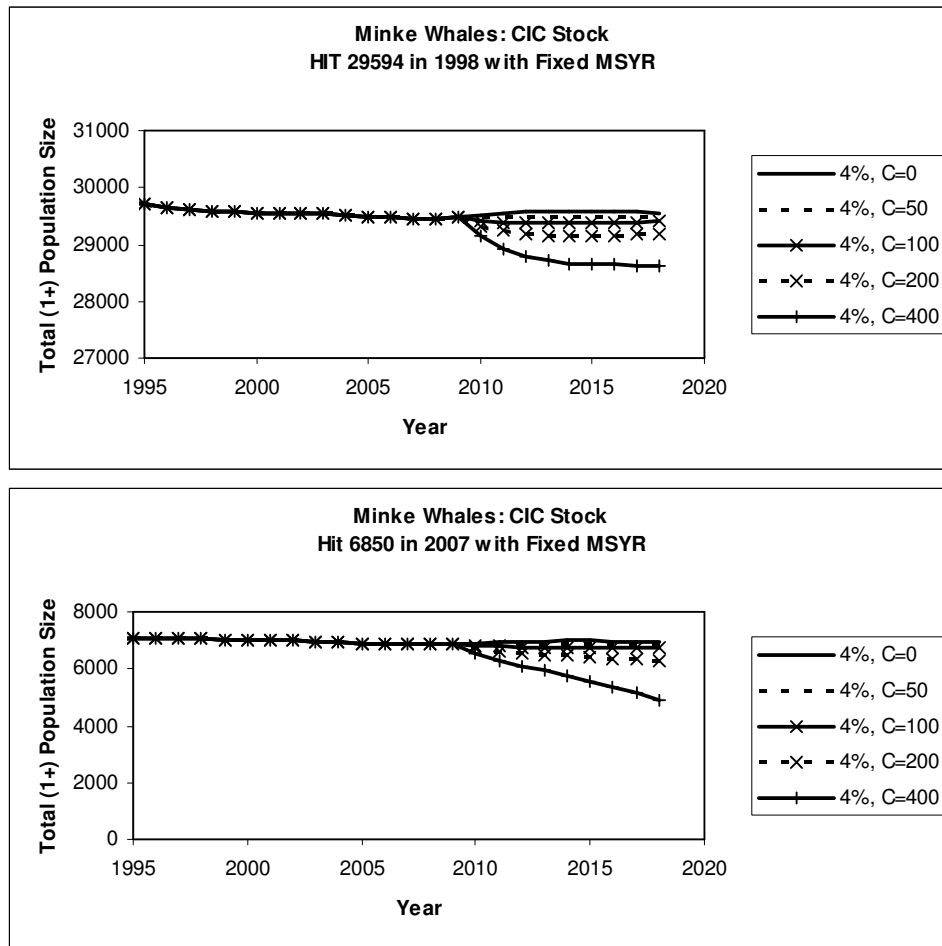


Figure 1c. Total (1+) population trajectories in the minke whale CIC stock when hitting a best estimate of $N_{1998}^{1+} = 29594$ (upper panel) or $N_{2007}^{1+} = 6850$ (lower panel) for $MSYR^{1+} = 4\%$ for future annual catches of 0, 50, 100, 200 and 400 animals. Note that the vertical axis minimum in the upper panel is 27000 animals and not zero.

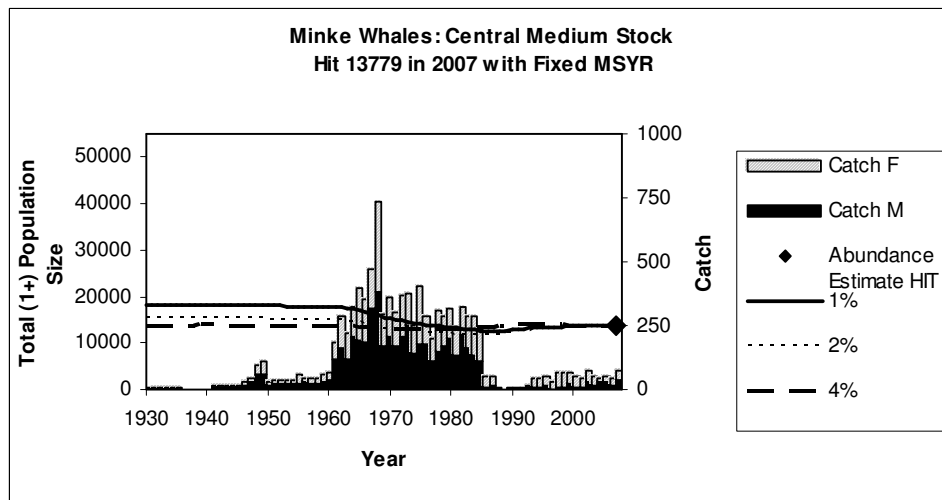
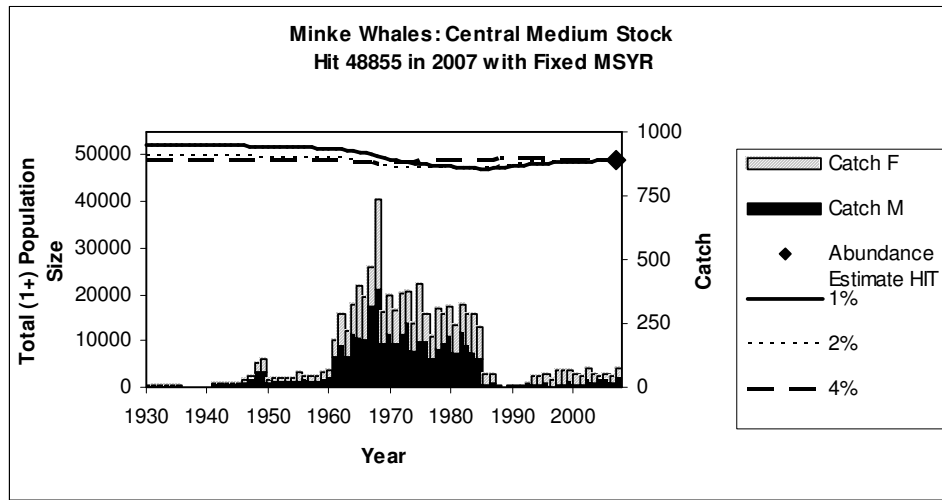


Figure 2a. Total (1+) population trajectories from 1930 to 2008 in the minke whale Central Medium stock when assuming a total population size of 48855 (upper panel) or 13779 in 2007 (lower panel) for $MSYR^{1+}$ values of 1, 2% and 4%. The trajectory corresponding to the lowest $MSYR$ lies highest on the left hand side of this and similar following plots. Annual catches are indicated at the bottom of the plot.

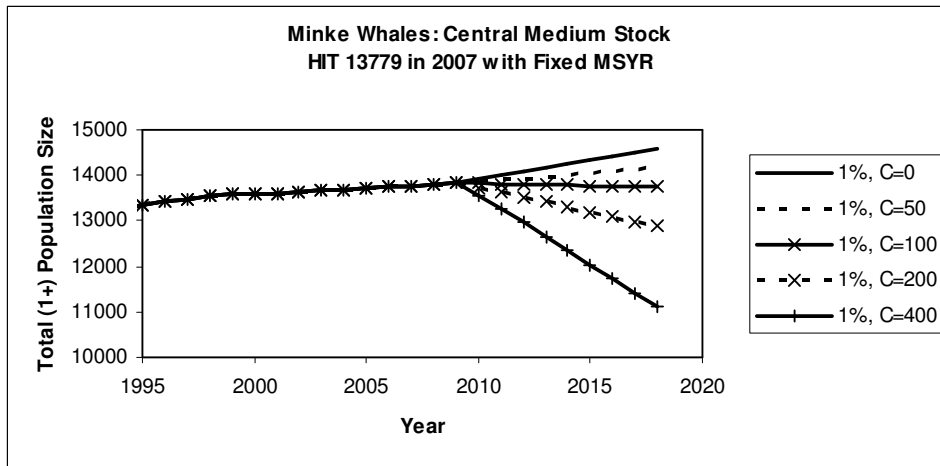
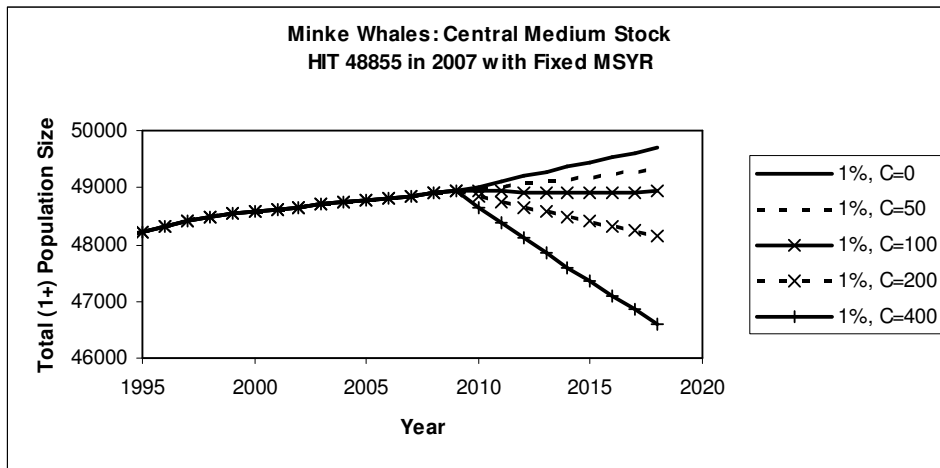


Figure 2b. Total (1+) population trajectories in the minke whale Central Medium stock when hitting a best estimate of $N_{2007}^{1+} = 48855$ (upper panel) or 13779 (lower panel) for $MSYR^{1+} = 1\%$ for future annual catches of 0, 50, 100, 200 and 400 animals. Note that the vertical axis minimum in the upper panel is 46000 animals and in the lower panel is 10000 animals - not zero in either case.

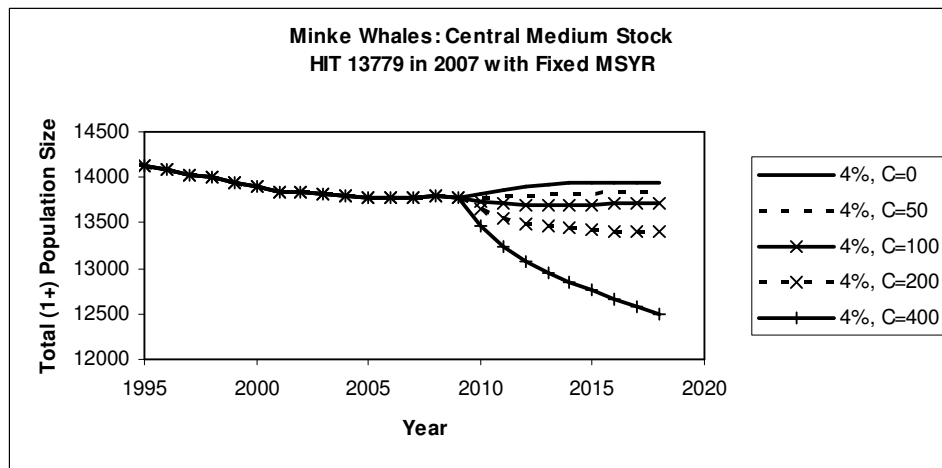
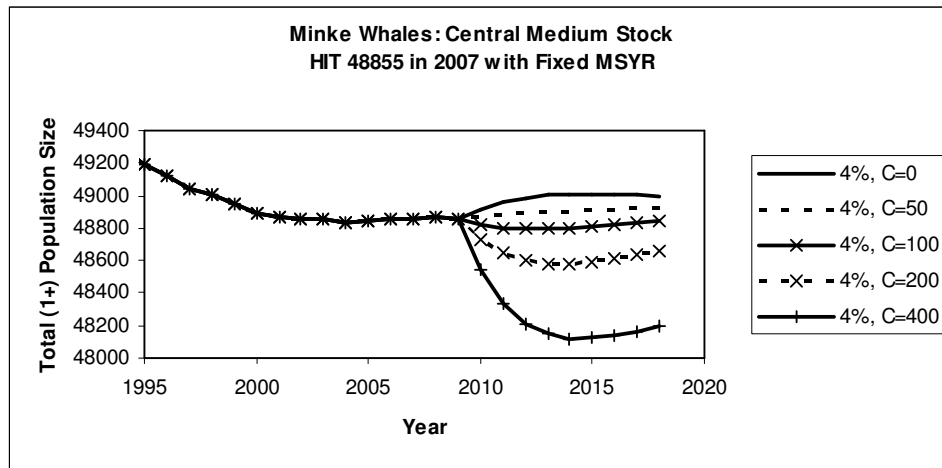


Figure 2c. Total (1+) population trajectories in the minke whale Central Medium stock when hitting a best estimate of $N^{1+}_{2007} = 48855$ (upper panel) or 13779 (lower panel) for $MSYR^{1+} = 4\%$ for future annual catches of 0, 50, 100, 200 and 400 animals. Note that the vertical axis minimum in the upper panel is 48000 animals and in the lower panel is 12000 animals - not zero in either case.